TVA TENNESSEE VALLEY AUTHORITY

1101 Market Street, Chattanooga, Tennessee 37402

CNL-22-083

September 13, 2022

10 CFR 50.90

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D.C. 20555-0001

Browns Ferry Nuclear Plant, Units 1, 2, and 3
Renewed Facility Operating License Nos. DPR-33, DPR-52, and DPR-68
NRC Docket Nos. 50-259, 50-260, and 50-296

Subject: **Supplement 5 to Request for License Amendment Regarding Application of Advanced Framatome Methodologies, and Adoption of TSTF-564 Revision 2 for Browns Ferry Nuclear Plant Units 1, 2, and 3, in Support of ATRIUM 11 Fuel Use at Browns Ferry (TS-535) (EPID L-2021-LLA-0132)**

Reference:

1. TVA letter to NRC, CNL-21-053, "Request for License Amendment Regarding Application of Advanced Framatome Methodologies, and Adoption of TSTF-564 Revision 2 for Browns Ferry Nuclear Plant Units 1, 2, and 3, in Support of ATRIUM 11 Fuel Use at Browns Ferry (TS-535)," dated July 23, 2021 (ML21204A128 and ML21204A129)

2. TVA letter to NRC, CNL-22-044, "Supplement 1 to Request for License Amendment Regarding Application of Advanced Framatome Methodologies, and Adoption of TSTF-564 Revision 2 for Browns Ferry Nuclear Plant Units 1, 2, and 3, in Support of ATRIUM 11 Fuel Use at Browns Ferry (TS-535) (EPID L 2021-LLA-0132)," dated April 8, 2022

In Reference 1, Tennessee Valley Authority (TVA) submitted a request for a Technical Specification (TS) amendment for the Browns Ferry Nuclear Plant (BFN), Units 1, 2, and 3. The proposed license amendments, in part, revise TS 5.6.5.b, "Core Operating Limits Report (COLR)," to allow application of Advanced Framatome Methodologies for determining core operating limits in support of loading Framatome fuel type ATRIUM™ [1] 11. Additionally, the license amendment request (LAR) requests adoption of Technical Specification Task Force (TSTF)-564-A, "Safety Limit MCPR," Revision 2, which is an approved change to the Improved Standard Technical Specifications, into the BFN TS. The proposed amendment revises the TS safety limit (SL) on minimum critical power ratio (MCPR) to reduce the need for cycle-specific changes to the value while still meeting the regulatory requirement for an SL.

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[1] ATRIUM 11 is a trademark or registered trademarks of Framatome, Inc., its affiliates and/or its subsidiaries in the United States of America and may be registered in other countries throughout the world. All rights reserved. Unauthorized use is strictly prohibited. Other names may be trademarks of their respective owners.

In Reference 2, TVA provided a supplement that described two separate condition reports from Framatome, Inc. (Framatome) that had the potential to impact analyses provided in Reference 1. Specifically, two erroneous values presented in Table 4.8 of ANP-3904P, Browns Ferry ATRIUM 11 Transient Demonstration, Revision 4, which was included as Attachment 16a of the Reference 1 request, were identified. ANP-3904P, Browns Ferry ATRIUM 11 Transient Demonstration, Revision 5, included as Attachment 16a, corrects the erroneous values discussed in Reference 2 and supersedes the previous revision in its entirety.

During the review of the Reference 1 LAR, the NRC staff identified proprietary marking discrepancies in some of the Framatome attachments. As a result, the affected reports, listed in the table below, have been corrected in attachments to this submittal. There were no technical changes associated with these corrections with the exception of the previously described Attachment 16a, ANP-3904P. Framatome Attachments 5a, 13a, and 14a from Reference 1 were unaffected. In the Reference 1 LAR enclosure, any references to a previous revision of the reports (see the left column below) should be replaced by their updated revision (see the right column below), and the enclosed revised reports supersede their previous revisions in their entirety. For the ease of review, the attachment numbers in this submittal match the previous Revision 1 attachments numbers.

Attachment #	Framatome Attachments from Reference 1 Requiring Revision	Framatome Attachments with Updated Revisions
6a	ANP-3854P, Revision 1, Browns Ferry ATRIUM 11 Equilibrium Cycle Fuel Cycle Design Report, Framatome Inc., June 2020 (proprietary)	ANP-3854P, Revision **2**, Browns Ferry ATRIUM 11 Equilibrium Cycle Fuel Cycle Design Report, Framatome Inc., **June 2022** (proprietary)
7a	ANP-3850P, Revision 0, Browns Ferry ATRIUM 11 Equilibrium Cycle Nuclear Fuel Design Report, Framatome Inc., May 2020 (proprietary)	ANP-3850P, Revision **1**, Browns Ferry ATRIUM 11 Equilibrium Cycle Nuclear Fuel Design Report, Framatome Inc., **April 2022** (proprietary)
8a	ANP-3860P, Revision 0, Mechanical Design Report for Browns Ferry ATRIUM 11 Fuel Assemblies Licensing Report, Framatome Inc., April 2021 (proprietary)	ANP-3860P, Revision **1**, Mechanical Design Report for Browns Ferry ATRIUM 11 Fuel Assemblies Licensing Report, Framatome Inc., **June 2022** (proprietary)
9a	ANP-3866P, Revision 0, ATRIUM 11 Fuel Rod Thermal-Mechanical Evaluation for Browns Ferry LAR Licensing Report, Framatome Inc., October 2020 (proprietary)	ANP-3866P, Revision **2**, ATRIUM 11 Fuel Rod Thermal-Mechanical Evaluation for Browns Ferry LAR Licensing Report, Framatome Inc., **August 2022** (proprietary)
10a	ANP-3859P, Revision 0, Browns Ferry Thermal-Hydraulic Design Report for ATRIUM 11 Fuel Assemblies, Framatome Inc., September 2020 (proprietary)	ANP-3859P, Revision **1**, Browns Ferry Thermal-Hydraulic Design Report for ATRIUM 11 Fuel Assemblies, Framatome Inc., **June 2022** (proprietary)
11a	ANP-3908P, Revision 3, Applicability of Framatome BWR Methods to Browns Ferry with ATRIUM 11 Fuel, Framatome Inc., July 2021 (proprietary)	ANP-3908P, Revision **4**, Applicability of Framatome BWR Methods to Browns Ferry with ATRIUM 11 Fuel, Framatome Inc., **June 2022** (proprietary)

12a	ANP-3905P, Revision 1, Browns Ferry Units 1, 2, and 3 LOCA Analysis for ATRIUM 11 Fuel, Framatome Inc., July 2021 (proprietary)	ANP-3905P, Revision **2**, Browns Ferry Units 1, 2, and 3 LOCA Analysis for ATRIUM 11 Fuel, Framatome Inc., **June 2022** (proprietary)
15a	ANP-3874P, Revision 2, Browns Ferry ATRIUM 11 Control Rod Drop Accident Analysis with the AURORA-B CRDA Methodology, Framatome Inc., March 2021 (proprietary)	ANP-3874P, Revision **3**, Browns Ferry ATRIUM 11 Control Rod Drop Accident Analysis with the AURORA-B CRDA Methodology, Framatome Inc., **June 2022** (proprietary)
16a	ANP-3904P, Revision 4, Browns Ferry ATRIUM 11 Transient Demonstration, Framatome Inc., July 2021 (proprietary)	ANP-3904P, Revision **5**, Browns Ferry ATRIUM 11 Transient Demonstration, Framatome Inc., **July 2022** (proprietary)

This letter contains Attachments 6a, 7a, 8a, 9a, 10a, 11a, 12a, 15a, and 16a that Framatome considers proprietary in nature pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) 2.390, “Public inspections, exemptions, requests for withholding,” paragraph (a)(4), and requests that they be withheld from public disclosure. Attachments 6b, 7b, 8b, 9b, 10b, 11b, 12b, 15b, and 16b, are the non-proprietary versions of the corresponding (a) attachments. Attachment 17 provides the revised Framatome affidavits supporting these proprietary information withholding requests. Accordingly, TVA requests that the information, which is proprietary to Framatome, be withheld from public disclosure in accordance with 10 CFR 2.390. Correspondence with respect to the copyright or proprietary aspects of the items listed above or the supporting Framatome affidavits should reference the corresponding report and should be addressed to Alan Meginnis, Framatome, Manager, Product Licensing, 2101 Horn Rapids Road, Richland, Washington 99354.

Lastly, as a result of the revised Framatome attachments, the Reference 1, Attachment 1 (TS Markups), Attachment 2 (TS Final Typed), and Attachment 3 (TS Bases Markup for BFN Unit 1), required a revision. The affected pages are provided in Attachments 1 through 3 of this submittal, and they replace the corresponding pages in Reference 1.

This letter does not change the no significant hazards consideration or the environmental considerations contained in Reference 1. Additionally, in accordance with 10 CFR 50.91(b)(1), TVA is sending a copy of this letter and the non-proprietary enclosures to the Alabama Department of Public Health.

There are no new regulatory commitments associated with this submittal. Please address any questions regarding this request to Stuart L. Rymer, Senior Manager, Fleet Licensing, at slrymer@tva.gov.

I declare under penalty of perjury that the foregoing is true and correct. Executed on this 13th day of September 2022.

Respectfully,

Digitally signed by Edmondson, Carla
Date: 2022.09.13 18:51:55 -04'00'

James Barstow
Vice President, Nuclear Regulatory Affairs & Support Services

Attachments:

1. Proposed TS Change Corrected Pages (Mark Ups) for BFN Units 1, 2, and 3
2. Proposed TS Change Corrected Pages (Final Typed) for BFN Units 1, 2, and 3
3. Proposed TS Bases Change Corrected Pages (Mark Ups for Information Only) for BFN Unit 1

6a ANP-3854P, Revision 2, Browns Ferry ATRIUM 11 Equilibrium Cycle Fuel Cycle Design Report, Framatome Inc., June 2022 (proprietary)

6b ANP-3854NP, Revision 2, Browns Ferry ATRIUM 11 Equilibrium Cycle Fuel Cycle Design Report, Framatome, Inc. June 2022 (non-proprietary)

7a ANP-3850P, Revision 1, Browns Ferry ATRIUM 11 Equilibrium Cycle Nuclear Fuel Design Report, Framatome Inc., April 2022 (proprietary)

7b ANP-3850NP, Revision 1, Browns Ferry ATRIUM 11 Equilibrium Cycle Nuclear Fuel Design Report, Framatome Inc., April 2022 (non-proprietary)

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8b ANP-3860NP, Revision 1, Mechanical Design Report for Browns Ferry ATRIUM 11 Fuel Assemblies Licensing Report, Framatome Inc., June 2022 (non-proprietary)

9a ANP-3866P, Revision 2, ATRIUM 11 Fuel Rod Thermal-Mechanical Evaluation for Browns Ferry LAR Licensing Report, Framatome Inc., August 2022 (proprietary)

9b ANP-3866NP, Revision 2, ATRIUM 11 Fuel Rod Thermal-Mechanical Evaluation for Browns Ferry LAR Licensing Report, Framatome Inc., August 2022 (non-proprietary)

10a ANP-3859P, Revision 1, Browns Ferry Thermal-Hydraulic Design Report for ATRIUM 11 Fuel Assemblies, Framatome Inc., June 2022 (proprietary)

10b ANP-3859NP, Revision 1, Browns Ferry Thermal-Hydraulic Design Report for ATRIUM 11 Fuel Assemblies, Framatome Inc., June 2022 (non-proprietary)

11a ANP-3908P, Revision 4, Applicability of Framatome BWR Methods to Browns Ferry with ATRIUM 11 Fuel, Framatome Inc., June 2022 (proprietary)

11b ANP-3908NP, Revision 4, Applicability of Framatome BWR Methods to Browns Ferry with ATRIUM 11 Fuel, Framatome Inc., June 2022 (non-proprietary)

12a ANP-3905P, Revision 2, Browns Ferry Units 1, 2, and 3 LOCA Analysis for ATRIUM 11 Fuel, Framatome Inc., June 2022 (proprietary)

12b ANP-3905NP, Revision 2, Browns Ferry Units 1, 2, and 3 LOCA Analysis for ATRIUM 11 Fuel, Framatome Inc., June 2022 (non-proprietary)

15a ANP-3874P, Revision 3, Browns Ferry ATRIUM 11 Control Rod Drop Accident Analysis with the AURORA-B CRDA Methodology, Framatome Inc., June 2022 (proprietary)

15b ANP-3874NP, Revision 3, Browns Ferry ATRIUM 11 Control Rod Drop Accident Analysis with the AURORA-B CRDA Methodology, Framatome Inc., June 2022 (non-proprietary)

16a ANP-3904P, Revision 5, Browns Ferry ATRIUM 11 Transient Demonstration, Framatome Inc., July 2022 (proprietary)

16b ANP-3904NP, Revision 5, Browns Ferry ATRIUM 11 Transient Demonstration, Framatome Inc., July 2022 (non-proprietary)

17 Affidavits for Attachments 6a, 7a, 8a, 9a, 10a, 11a, 12a, 15a, and 16a

cc: (Enclosures):

NRC Regional Administrator – Region II
NRC Project Manager – Browns Ferry Nuclear Plant
NRC Senior Resident Inspector - Browns Ferry Nuclear Plant
State Health Officer, Alabama Department of Public Health (w/o Enclosures 1 and 3)

ATTACHMENT 1

Browns Ferry Nuclear Plant (BFN)
Units 1, 2, and 3

Proposed TS Change Corrected Pages (Markups)

Insert A

24. BAW-10247P-A Supplement 2P-A Revision 0, Realistic Thermal-Mechanical Fuel Rod Methodology for Boiling Water Reactors Supplement 2: Mechanical Methods, Framatome Inc., August 2018.

25. ANP-10300P-A Revision 1, AURORA-B: An Evaluation Model for Boiling Water Reactors; Application to Transient and Accident Scenarios, Framatome Inc., January 2018.

26. ANP-10332P-A Revision 0, AURORA-B: An Evaluation Model for Boiling Water Reactors; Application to Loss of Coolant Accident Scenarios, Framatome Inc., March 2019.

27. ANP-10333P-A Revision 0, AURORA-B: An Evaluation Model for Boiling Water Reactors; Application to Control Rod Drop Accident (CRDA), Framatome Inc., March 2018 (as supplemented by Section 6.4 of ANP-3908P Revision ~~3~~ 4, Applicability of Framatome BWR Methods to Browns Ferry with ATRIUM 11 Fuel, Framatome Inc., ~~July 2021~~ June 2022).

28. ANP-10335P-A Revision 0, ACE/ATRIUM 11 Critical Power Correlation, Framatome Inc., May 2018.

29. ANP-10340P-A Revision 0, Incorporation of Chromia-Doped Fuel Properties in AREVA Approved Methods, Framatome Inc., May 2018.

30. ANP-3907P Revision 0, Application of BEO-III Methodology with the Confirmation Density Algorithm at Browns Ferry, Framatome Inc., April 2021.

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23. BAW-10247P-A Supplement 2P-A Revision 0, Realistic Thermal-Mechanical Fuel Rod Methodology for Boiling Water Reactors Supplement 2: Mechanical Methods, Framatome Inc., August 2018.

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25. ANP-10332P-A Revision 0, AURORA-B: An Evaluation Model for Boiling Water Reactors; Application to Loss of Coolant Accident Scenarios, Framatome Inc., March 2019.

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ATTACHMENT 2

Browns Ferry Nuclear Plant (BFN)
Units 1, 2, and 3

Proposed TS Change Corrected Pages (Final Typed)

5.6 Reporting Requirements (continued)

5.6.5 CORE OPERATING LIMITS REPORT (COLR) (continued)

21. ANP-10298P-A Revision 1, ACE/ATRIUM 10XM Critical Power Correlation, AREVA Inc., March 2014.

22. (Deleted).

23. NEDC-33075P-A, GE Hitachi Boiling Water Reactor Detect and Suppress Solution – Confirmation Density, Revision 8, November 2013.

24. BAW-10247P-A Supplement 2P-A Revision 0, Realistic Thermal-Mechanical Fuel Rod Methodology for Boiling Water Reactors Supplement 2: Mechanical Methods, Framatome Inc., August 2018.

25. ANP-10300P-A Revision 1, AURORA-B: An Evaluation Model for Boiling Water Reactors; Application to Transient and Accident Scenarios, Framatome Inc., January 2018.

26. ANP-10332P-A Revision 0, AURORA-B: An Evaluation Model for Boiling Water Reactors; Application to Loss of Coolant Accident Scenarios, Framatome Inc., March 2019

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29. ANP-10340P-A, Revsion 0, Incorporation of Chromia-Doped Fuel Properties in AREVA Approved Methods, Framatome Inc., May 2018.

30. ANP-3907P Revision 0, Application of BEO-III Methodology with the Confirmation Density Algorithm at Browns Ferry, Framatome Inc., April 2021.

5.6 Reporting Requirements (continued)

5.6.5 CORE OPERATING LIMITS REPORT (COLR) (continued)

26. ANP-10333P-A Revision 0, AURORA-B: An Evaluation Model for Boiling Water Reactors; Application to Control Rod Drop Accident (CRDA), Framatome Inc., March 2018 (as supplemented by Section 6.4 of ANP-3908P Revision 4, Applicability of Framatome BWR Methods to Browns Ferry with ATRIUM 11 Fuel, Framatome Inc., June 2022).

27. ANP-10335P-A Revision 0, ACE/ATRIUM 11 Critical Power Correlation, Framatome Inc., May 2018.

28. ANP-10340P-A Revision 0, Incorporation of Chromia Doped Fuel Properties in AREVA Approved Methods, Framatome Inc., May 2018.

29. ANP-3907P Revision 0, Application of BEO-III Methodology with the Confirmation Density Algorithm at Browns Ferry, Framatome Inc., April 2021.

5.6 Reporting Requirements (continued)

5.6.5 <u>CORE OPERATING LIMITS REPORT (COLR)</u> (continued)

24. ANP-10300P-A Revision 1, AURORA-B: An Evaluation Model for Boiling Water Reactors; Application to Transient and Accident Scenarios, Framatome Inc., January, 2018.

25. ANP-10332P-A Revision 0, AURORA-B: An Evaluation Model for Boiling Water Reactors; Application to Loss of Coolant Accident Scenarios, Framatome Inc., March 2019.

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27. ANP-10335P-A Revision 0, ACE/ATRIUM 11 Critical Power Correlation, Framatome Inc., May 2018.

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29. ANP-3907P Revision 0, Application of BEO-III Methodology with the Confirmation Density Algorithm at Browns Ferry, Framatome Inc., April 2021.

(continued)

ATTACHMENT 3

Browns Ferry Nuclear Plant (BFN) Unit 1

Proposed TS Bases Change Corrected Pages (Markups for Information Only)

BASES (continued)

REFERENCES

1. FSAR, Section 14.6.3.
2. FSAR, Section 4.3.5.
3. Deleted.
4. Deleted.
5. Deleted.
6. NRC No. 93-102, "Final Policy Statement on Technical Specification Improvements," July 23, 1993.
7. NEDO-24236, "Browns Ferry Nuclear Plant Units 1, 2, and 3, Single-Loop Operation," May 1981.
8. ~~NEDC-32484P, "Browns Ferry Nuclear Plant Units 1, 2, and 3, SAFER/GESTR-LOCA Loss-of-Coolant Accident Analysis," Revision 6, February 2005.~~Not used.
9. ~~ANP-3015(P), "Browns Ferry Units 1, 2, and 3 LOCA Break Spectrum Analysis," Revision 0, September 2011.~~ANP-3546P Revision 0, "Browns Ferry Units 1, 2, and 3 LOCA Break Spectrum Analysis for ATRIUM 10XM Fuel (EPU MELLLA+)," AREVA Inc., March 2017.
10. NEDC-33006P-A, "General Electrical Boiling Water Reactor Maximum Extended Load Line Limit Analysis Plus Licensing Topical Report," Revision 3, June 2009.
11. ANP-3905P Revision ~~1~~ 2, "Browns Ferry Units 1, 2, and 3 LOCA Analysis for ATRIUM 11 Fuel," Framatome Inc., ~~July 2021~~ June 2022.

BASES (continued)

REFERENCES

1. FSAR, Section 6.4.3.
2. FSAR, Section 6.4.4.
3. FSAR, Section 6.4.1.
4. FSAR, Section 6.4.2.
5. FSAR, Section 14.6.3.
6. FSAR, Section 14.6.5.
7. 10 CFR 50, Appendix K.
8. FSAR, Section 6.5.3.
9. 10 CFR 50.46.
10. TVA BFN System Design Criteria BFN-50-7032, Control Air System - Units 1, 2, and 3.
11. Memorandum from R. L. Baer (NRC) to V. Stello, Jr. (NRC), "Recommended Interim Revisions to LCOs for ECCS Components," December 1, 1975.
12. 10 CFR 50, Appendix A, GDC 34, GDC 35, GDC 36, and GDC 37.
13. ~~ANP-3377P Revision 3, Browns Ferry Units 1, 2, and 3 LOCA Break Spectrum Analysis for ATRIUM 10XM Fuel (EPU), August 2015.~~ANP-3546P Revision 0, "Browns Ferry Units 1, 2, and 3 LOCA Break Spectrum Analysis for ATRIUM 10XM Fuel (EPU MELLLA+)," AREVA Inc., March 2017.
14. NRC No. 93-102, "Final Policy Statement on Technical Specification Improvements," July 23, 1993.
15. GE-NE-B13-01755-2, "Relaxation of ECCS Parameters, Revision 2, December 1996.
16. ANP-3905P Revision ~~1~~ 2, "Browns Ferry Units 1, 2, and 3 LOCA Analysis for ATRIUM 11 Fuel," Framatome Inc., ~~July 2021~~ June 2022.

BASES

SURVEILLANCE REQUIREMENTS

SR 3.5.2.3 (continued)

In MODES 4 and 5, the RHR System may operate in the shutdown cooling mode to remove decay heat and sensible heat from the reactor. Therefore, RHR valves that are required for LPCI subsystem operation may be aligned for decay heat removal. Therefore, this SR is modified by a Note that allows one LPCI subsystem of the RHR System to be considered OPERABLE for the ECCS function if all the required valves in the LPCI flow path can be manually realigned (remote or local) to allow injection into the RPV, and the system is not otherwise inoperable. This will ensure adequate core cooling if an inadvertent RPV draindown should occur.

REFERENCES

1. ~~ANP-3377P Revision 3, Browns Ferry Units 1, 2, and 3 LOCA Break Spectrum Analysis for ATRIUM 10XM Fuel (EPU), August 2015.~~ANP-3546P Revision 0, “Browns Ferry Units 1, 2, and 3 LOCA Break Spectrum Analysis for ATRIUM 10XM Fuel (EPU MELLLA+),” AREVA Inc., March 2017.

2. NRC No. 93-102, "Final Policy Statement on Technical Specification Improvements," July 23, 1993.

3. ANP-3905P Revision ~~1~~ 2, “Browns Ferry Units 1, 2, and 3 LOCA Analysis for ATRIUM 11 Fuel,” Framatome Inc., ~~July 2021~~ June 2022.

ATTACHMENT 6a

ANP-3854P Revision 2

(Proprietary)

Browns Ferry ATRIUM 11 Equilibrium Cycle Fuel Cycle Design Report

ATTACHMENT 6b

ANP-3854NP Revision 2

(Non Proprietary)

Browns Ferry ATRIUM 11 Equilibrium Cycle Fuel Cycle Design Report

framatome

Browns Ferry ATRIUM 11 Equilibrium Cycle

ANP-3854NP
Revision 2

Fuel Cycle Design Report

June 2022

Nature of Changes

Item	Section(s) or Page(s)	Description and Justification
1	Page 4-1	Updated Reference 6

Contents

List of Tables

List of Figures

Nomenclature

Acronym	**Definition**
[ ]	the information contained within brackets is proprietary to Framatome Inc.
ACE	Framatome critical power correlation **[ ]**
BOC	beginning of cycle
BOL	beginning of life
BWR	boiling water reactor
CSDM	cold shutdown margin
EOC	end of cycle
EOFP	end of full power capability
FFTR	final feedwater temperature reduction
GWd/MTU	gigawatt days per metric ton of initial uranium
HEXR	hot excess reactivity
LHGR	linear heat generation rate
MCPR	minimum critical power ratio
MELLLA+	maximum extended load line limit analysis plus
MICROBURN-B2	Framtome Inc. advanced BWR core simulator methodology with PPR capability
MWd/MTU	megawatt days per metric ton of initial uranium
NEOC	near end of cycle (MCPR limit exposure breakpoint)
NRC	(United States) Nuclear Regulatory Commission
PLFR	part length fuel rod
PPR	Pin Power Reconstruction. The PPR methodology accounts for variation in local rod power distributions due to neighboring assemblies and control state. The local rod power distributions are reconstructed based on the actual flux solution for each statepoint.
R Value	the larger of zero or the shutdown margin at BOC minus the minimum calculated shutdown margin in the cycle
SLC	standby liquid control

1.0 INTRODUCTION

Framatome Inc. has performed an equilibrium fuel cycle design for Browns Ferry. This design uses the ATRIUM 11 fuel assembly and the MELLLA+ operating domain. This analysis has been performed with the approved Framatome Inc. neutronic modeling methodology (Reference 1). The CASMO-4 lattice depletion code was used to generate nuclear data including cross sections and local power peaking factors. The MICROBURN-B2 three dimensional core simulator code, combined with the application of the ACE critical power correlation (Reference 2), was used to model the core. The MICROBURN-B2 pin power reconstruction (PPR) model was used to determine the thermal margins presented in this report. Design results including projected control rod patterns and evaluations of thermal and reactivity margins are also presented in this report. The following MICROBURN-B2 Version 2 modeling features were also used in the analyses supporting this document:

- Control Blade B-10 Depletion
- Explicit modeling treatment of spacer grids
- Explicit modeling of PLFR plenums
- Explicit modeling of the water rod flow

The following ATRIUM 11 fuel operating limits were assumed for the equilibrium cycle depletion:

[ ]

2.0 SUMMARY

The fresh batch size **[ ]** and batch average enrichment **[ ]** were determined to meet the energy requirements provided by Tennessee Valley Authority (Reference 3). The complete description of the fresh reload assemblies is provided with Reference 6. The loading of the fuel as described in this report results in a projected full power energy capability of 2,506±42 GWd (18,107±300 MWd/MTU). Beyond the full power capability, the cycle has been designed to achieve 180 GWd additional energy via FFTR and coastdown operation.

In order to obtain optimum operating flexibility, the projected control rod patterns were developed with acceptable margin to thermal limits in accordance with Reference 3. The cycle design calculations also demonstrate adequate hot excess reactivity and cold shutdown margin throughout the cycle. Key results from the design analysis are summarized in Table 2.1. Table 2.2 summarizes the assembly identification range by nuclear fuel type batch. Figures 2.1 and 2.2 provide a summary of the cycle design step-through projection.

Table 2.1 Browns Ferry Equilibrium Cycle Energy and Key Results Summary

Cycle Energy, GWd (Cycle Exposure, MWd/MTU)	
Cycle N-1	
• Nominal EOC	2,685 (19,405)
• Short window EOC	2,602 (18,804)
• Long window EOC	2,740 (19,804)
Cycle N	
• EOFP Energy	2,506±42 (18,107±300)
• FFTR and coastdown Energy	180 (1,298)
• EOC Energy	2,685±42 (19,405±300)

Key Results	
BOC CSDM, %Δk/k (based on short EOC N-1)	1.16
Minimum CSDM, %Δk/k (based on short EOC N-1)	1.16
Cycle Exposure of Minimum CSDM, MWd/MTU (short basis)	0
Moderator Temperature of Minimum CSDM, °F (short basis)	68
Cycle R Value, %Δk/k (short basis)	0.00
BOC CSDM, %Δk/k (based on nominal EOC N-1)	1.41
Minimum CSDM, %Δk/k (based on nominal EOC N-1)	1.41
Cycle Exposure of Minimum CSDM, MWd/MTU (nominal basis)	0
Moderator Temperature of Minimum CSDM, °F (nominal basis)	68
Cycle R Value, %Δk/k (nominal basis)	0.00
BOC CSDM, %Δk/k (based on long EOC N-1)	1.64
Minimum CSDM, %Δk/k (based on long EOC N-1)	1.64
Cycle Exposure of Minimum CSDM, MWd/MTU (long basis)	0
Moderator Temperature of Minimum CSDM, °F (long basis)	68
Cycle R Value, %Δk/k (long basis)	0.00

Key Results	
Minimum SLC SDM, %Δk/k (based on short EOC N-1)	1.57
Cycle Exposure of Minimum SLC SDM, MWd/MTU (short basis)	0
Minimum SLC SDM, %Δk/k (based on nominal EOC N-1)	1.86
Cycle Exposure of Minimum SLC SDM, MWd/MTU (nominal basis)	0
Minimum SLC SDM, %Δk/k (based on long EOC N-1)	2.07
Cycle Exposure of Minimum SLC SDM, MWd/MTU (long basis)	0
BOC HEXR, %Δk/k (based on short EOC N-1)	1.77
Maximum HEXR, %Δk/k (based on short EOC N-1)	2.44
Cycle Exposure of Maximum HEXR, MWd/MTU (short basis)	12,000
BOC HEXR, %Δk/k (based on nominal EOC N-1)	1.42
Maximum HEXR, %Δk/k (based on nominal EOC N-1)	1.99
Cycle Exposure of Maximum HEXR, MWd/MTU (nominal basis)	11,000
BOC HEXR, %Δk/k (based on long EOC N-1)	1.18
Maximum HEXR, %Δk/k (based on long EOC N-1)	1.80
Cycle Exposure of Maximum HEXR, MWd/MTU (long basis)	11,000
Minimum MAPLHGR Margin, %	11.2
Exposure of Minimum MAPLHGR Margin, MWd/MTU	6,900
Minimum LHGR Margin, %	12.1
Exposure of Minimum LHGR Margin, MWd/MTU	1,710
Minimum CPR Margin, %	7.5
Exposure of Minimum CPR Margin, MWd/MTU	17,451
Maximum Exposure Limit Ratio (Peak Rod)	0.97(Rod) 0.95(Bundle)
Exposure Limit Energy Basis, GWD (EOC N with long window step-out)	2,803.7
Reg. Guide 1.183 maximum rod average power (<6.3 kw/ft) for rods with burnup > 54 GWd/MTU	Met

Fuel Reliability Constraints and Core Loading Restrictions	
No peripheral fuel from previous cycle remaining in core	Met
No fresh fuel loaded with a corner on the periphery	Met
No startup sequence control rod cells that contain fuel from previous cycle which had a corner on the periphery	Met

Key Results	
No startup sequence control rod cells that contain fuel from the second row in from the periphery in the previous two cycles	Met
Do not load twice burnt assemblies in the central part of the core	Met
Satisfy C-lattice Channel Bow Requirements per SIL-320	Met
No same cell shuffles	Met
No cross quadrant shuffles with bundles going adjacent to an SRM	Met
Minimize cross quadrant shuffles	Met

Table 2.2 Browns Ferry Equilibrium Cycle Fuel Cycle Design Assembly ID Range by Nuclear Fuel Type

Nuclear Fuel Type	Number of Assemblies	Assembly ID Range
13	[ ]	[ ]
14	[ ]	[ ]
15	[ ]	[ ]
16	[ ]	[ ]
17	[ ]	[ ]
18	[ ]	[ ]
19	[ ]	[ ]
20	[ ]	[ ]
21	[ ]	[ ]

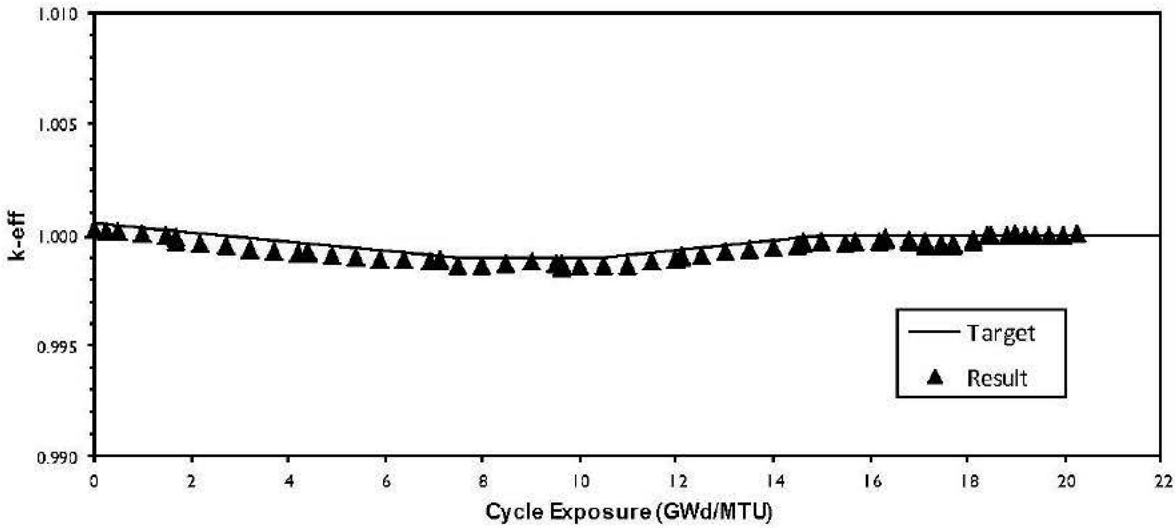

Figure 2.1 Browns Ferry Equilibrium Cycle Design Step-through k-eff versus Cycle Exposure

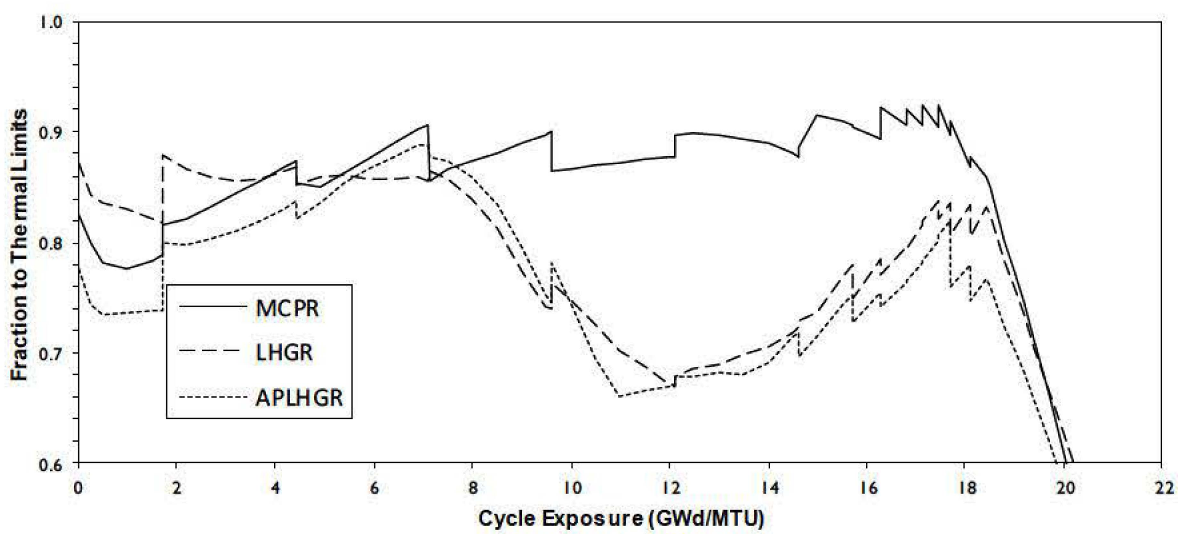

Figure 2.2 Browns Ferry Equilibrium Cycle Design Margin to Thermal Limits versus Cycle Exposure

3.0 EQUILIBRIUM CYCLE FUEL CYCLE DESIGN

3.1 *General Description*

The assembly design for the equilibrium cycle fresh reload fuel for Browns Ferry is described in detail in Reference 6. Elevation views of the fresh reload fuel design axial enrichment and gadolinia distributions are shown in Appendix B, Figures B.1 through B.3. The loading pattern maintains full core symmetry within a scatter load fuel management scheme. This loading in conjunction with the control rod patterns presented in Appendix A shows acceptable power peaking and associated margins to limits for projected equilibrium cycle operation. The analyses supporting this fuel cycle design were based on the core parameters shown in Table 3.1. Figures 3.1 through 3.5, along with Table 3.1 define the reference loading pattern used in the fuel cycle design. The specific core location of the fresh assemblies in the equilibrium cycle is provided in Appendix C. Key results for the cycle are summarized in Table 2.1.

3.2 *Control Rod Patterns and Thermal Limits*

Projected control rod patterns for the equilibrium cycle and resultant key operating parameters including thermal margins are shown in Appendix A. The thermal margins presented in this report were determined using the MICROBURN-B2 3D core simulator PPR model to provide adequate margin to thermal limits. A detailed summary of the core parameters resulting from the step-through projection analysis is provided in Tables A.1 and A.2. Limiting results from the step-through are summarized in Table 2.1 and in Figure 2.2. The hot operating target k-eff versus cycle exposure from Reference 4 which was determined to be appropriate for the equilibrium cycle is shown in Table 3.2. The k-eff and margin to limits results from the design cycle depletion are presented graphically in Figures 2.1 and 2.2. The k-eff values presented in Figure 2.1 and in Appendix A are not bias corrected. Selected exposure and radial power distributions from the design step-through are presented in Appendix D.

3.3 *Hot Excess Reactivity and Cold Shutdown Margin*

The equilibrium cycle design calculations demonstrate adequate hot excess reactivity, SLC shutdown margin, and cold shutdown margin throughout the equilibrium cycle. Key shutdown margin and R-Value results are presented in Table 2.1. The shutdown margin for the equilibrium cycle is in conformance with the Technical Specification limit of R + 0.38 %Δk/k at BOC. The cold target k-eff versus exposure from Reference 4 determined to be appropriate for calculation of cold shutdown margin for the equilibrium cycle is shown in Table 3.3. The core hot excess reactivity was calculated at full power with all rods out, 102.5 Mlb/hr core flow, with equilibrium xenon. Tables 3.4 through 3.6 summarize the equilibrium cycle reactivity margins versus cycle exposure, including the SLC shutdown margin for the cycle.

Table 3.1 Equilibrium Cycle Core Composition and Design Parameters

Fuel Description	Cycle Loaded	Nuclear Fuel Type	Number of Assemblies
ATRIUM 11 [ ]	N-2	13	[ ]
ATRIUM 11 [ ]	N-2	14	[ ]
ATRIUM 11 [ ]	N-2	15	[ ]
ATRIUM 11 [ ]	N-1	16	[ ]
ATRIUM 11 [ ]	N-1	17	[ ]
ATRIUM 11 [ ]	N-1	18	[ ]
ATRIUM 11 [ ]	N	19	[ ]
ATRIUM 11 [ ]	N	20	[ ]
ATRIUM 11 [ ]	N	21	[ ]

Number of Fuel Assemblies in Core	764
Total Number of Fresh Assemblies	[ ]
Total Core Mass, MTU	[ ]
Rated Thermal Power Level, MW_t	3,952
Rated Core Flow, Mlb/hr	102.5
Reference Pressure, psia	1,050*
Reference Inlet Subcooling, Btu/lbm	26.94†

* Value is representative of MICROBURN-B2 input for dome pressure at rated conditions and varies depending on core state point.

† Value is typically determined by MICROBURN-B2 using a heat balance method based on nominal feedwater temperature and other parameters identified in the cycle specific plant parameters document.

Table 3.2 Browns Ferry Equilibrium Cycle Hot Operating Target k-eff Versus Cycle Exposure

Cycle Exposure (MWd/MTU)	Hot Operating k-eff*
0.0	1.0005
7,500.0	0.9990
10,500.0	0.9990
15,000.0	1.0000
25,000.0	1.0000

Table 3.3 Browns Ferry Equilibrium Cycle Cold Critical Target k-eff Versus Cycle Exposure

Cycle Exposure (MWd/MTU)	Cold Critical k-eff*
0.0	0.9940
25,000.0	0.9940

* Values are linearly interpolated between cycle exposure points.

Table 3.4 Browns Ferry Equilibrium Cycle Reactivity Margin Summary (Short EOC N-1)

Cycle Exposure (MWd/MTU)	Cold Shutdown Margin* (% Δk/k)	SLC Cold Shutdown Margin† (% Δk/k)	Hot Excess Reactivity (% Δk/k)
0	1.16	1.57	1.77
250	1.20	1.92	1.64
1,000	1.48	2.29	1.50
2,200	1.71	2.52	1.56
3,200	1.85	2.64	1.63
4,200	2.04	2.72	1.73
5,400	2.31	2.74	1.87
6,400	2.56	2.72	2.01
7,500	2.72	2.70	2.17
8,500	2.72	2.76	2.28
10,000	2.68	2.96	2.39
11,000	2.57	3.16	2.43
12,000	2.43	3.46	2.44
13,000	2.32	3.83	2.42
14,000	**2.22**	4.22	2.32
15,130	**1.88**	4.62	2.05
16,400	**1.51**	5.03	1.47
17,143	**1.38**	5.34	0.92
18,220	**1.40**	5.99	--
18,530	**1.43**	6.20	--
19,405	**1.71**	6.93	--
20,262	**2.32**	7.91	--

* Values in **BOLD** are limiting values at elevated moderator temperatures.
† Calculated at 366.0 °F ARO conditions.

Table 3.5 Browns Ferry Equilibrium Cycle Reactivity Margin Summary (Nominal EOC N-1)

Cycle Exposure (MWd/MTU)	Cold Shutdown Margin* (% Δk/k)	SLC Cold Shutdown Margin† (% Δk/k)	Hot Excess Reactivity (% Δk/k)
0	1.41	1.86	1.42
250	1.50	2.25	1.27
1,000	1.85	2.58	1.12
2,200	2.16	2.77	1.20
3,200	2.42	2.90	1.27
4,200	2.67	2.97	1.37
5,400	2.99	3.00	1.52
6,400	3.06	2.94	1.65
7,500	3.06	2.92	1.80
8,500	2.98	2.96	1.89
10,000	2.93	3.21	1.96
11,000	2.83	3.47	1.99
12,000	2.79	3.80	1.99
13,000	**2.88**	4.23	1.96
14,000	**2.77**	4.68	1.87
15,000	**2.66**	5.04	1.69
16,200	**2.28**	5.32	1.26
17,143	**1.95**	5.60	0.69
18,107	**1.74**	5.97	-0.14
18,500	**1.72**	6.17	--
19,405	**1.79**	6.79	--
20,262	**2.25**	7.74	--

* Values in **BOLD** are limiting values at elevated moderator temperatures.
† Calculated at 366.0 °F ARO conditions.

Table 3.6 Browns Ferry Equilibrium Cycle Reactivity Margin Summary (Long EOC N-1)

Cycle Exposure (MWd/MTU)	Cold Shutdown Margin* (% Δk/k)	SLC Cold Shutdown Margin† (% Δk/k)	Hot Excess Reactivity (% Δk/k)
0	1.64	2.07	1.18
250	1.82	2.41	1.02
1,000	2.22	2.76	0.87
2,200	2.58	2.99	0.94
3,200	2.88	3.08	1.02
4,200	3.16	3.18	1.13
5,400	3.31	3.16	1.29
6,400	3.31	3.12	1.44
7,500	3.17	3.10	1.61
8,500	3.07	3.12	1.70
10,000	3.04	3.36	1.78
11,000	2.95	3.62	1.80
12,000	2.91	3.95	1.79
13,000	3.07	4.35	1.73
14,000	**2.98**	4.83	1.61
15,000	**2.80**	5.31	1.35
16,200	**2.38**	5.73	0.79
17,380	**2.01**	6.13	-0.11
18,300	**1.90**	6.53	--
19,405	**2.02**	7.30	--
20,262	**2.57**	8.32	--

* Values in **BOLD** are limiting values at elevated moderator temperatures.
† Calculated at 366.0 °F ARO conditions.

Figure 3.1 Browns Ferry Equilibrium Cycle Reference Loading Pattern

[ ]

Figure 3.2 Browns Ferry Equilibrium Cycle Upper Left Quarter Core Layout by Fuel Type

Figure 3.3 Browns Ferry Equilibrium Cycle Upper Right Quarter Core Layout by Fuel Type

[ ]

Figure 3.4 Browns Ferry Equilibrium Cycle Lower Left Quarter Core Layout by Fuel Type

Figure 3.5 Browns Ferry Equilibrium Cycle Lower Right Quarter Core Layout by Fuel Type

3.4 *Voiding in the Channel Bypass Region*

To demonstrate compliance with the NRC's requirement that there be less than 5% bypass voiding around the LPRMs (see Section 5.1.1.5.1 of Reference 5), the bypass void level has been evaluated throughout the equilibrium cycle. The maximum bypass void value applicable to the equilibrium cycle design **[**

]

Table 3.7 Maximum Bypass Voiding at LPRM Level D

Power (%), Flow (%) Condition	Cycle Exposure (GWd/MTU)	Bypass Void (%)
[		**]**

Note: There is no bypass voiding at LPRM levels A, B, or C.

[**]**
[**]**

4.0 REFERENCES

1. EMF-2158(P)(A) Revision 0, Siemens Power Corporation Methodology for Boiling Water Reactors: Evaluation and Validation of CASMO-4/MICROBURN-B2, Siemens Power Corporation, October, 1999.

2. ANP-10335P-A Revision 0, ACE/ATRIUM 11 Critical Power Correlation, Framatome Inc., May 2018.

3. FS1-0049790 Revision 1.0, TVA Reload Requirements Specification for ATRIUM 11 equilibrium cycle (TVA Document BFE-4494 Revision 0).

4. 47-9310936-000, Browns Ferry Unit 3 Cycle 21 FSDD Response - ATRIUM 11 Equilibrium Cycle Design.

5. NEDO-33006-A Revision 3, *General Electric Boiling Water Reactor Maximum Extended Load Line Limit Analysis Plus*, General Electric Hitachi Nuclear Energy America, LLC, June 2009. (ADAMS Accession Number ML091800530)

6. ANP-3850P Revision 1, Browns Ferry ATRIUM 11 Equilibrium Cycle Nuclear Fuel Design Report, Framatome Inc. April 2022.

Appendix A Browns Ferry Equilibrium Cycle Step-through Depletion Summary, Control Rod Patterns and Core Average Axial Power and Exposure Distributions

Table A.1 Browns Ferry Equilibrium Cycle Design Depletion Summary

Cycle Exposure (GWd/MT)	Calculated K-eff	Control Rod Density	Total Core Power MWt	Total Core Flow (Mlb/hr)	Ref. Pressure (psia)	Inlet Sub-Cooling (Btu/lb)	Void Fraction	Core Minimum CPR	Core Maximum LHGR (kW/ft)	Core Maximum APLHGR (kW/ft)
0.000	1.00029	4.41	3952.0	88.15	1050.04	31.69	0.524	1.710	11.86	8.92
0.250	1.00015	4.41	3952.0	93.17	1050.04	29.86	0.508	1.764	11.46	8.55
0.500	1.00015	4.41	3952.0	98.30	1050.04	28.19	0.496	1.806	11.35	8.44
1.000	1.00006	4.41	3952.0	99.63	1050.04	27.78	0.492	1.817	11.28	8.48
1.500	0.99995	4.41	3952.0	98.09	1050.04	28.25	0.493	1.799	11.17	8.48
1.709	0.99986	4.41	3952.0	97.07	1050.04	28.57	0.494	1.789	11.11	8.48
1.710	0.99970	4.14	3952.0	97.99	1050.04	28.28	0.503	1.728	11.95	9.19
2.200	0.99963	4.14	3952.0	96.76	1050.04	28.67	0.503	1.715	11.79	9.18
2.700	0.99956	4.14	3952.0	95.22	1050.04	29.17	0.504	1.695	11.70	9.23
3.200	0.99930	4.14	3952.0	92.76	1050.04	30.00	0.507	1.669	11.64	9.31
3.700	0.99925	4.14	3952.0	91.12	1050.04	30.58	0.509	1.648	11.67	9.41
4.200	0.99918	4.14	3952.0	89.18	1050.04	31.30	0.512	1.623	11.77	9.55
4.410	0.99922	4.14	3952.0	88.56	1050.04	31.53	0.513	1.615	11.81	9.62
4.410	0.99915	5.14	3952.0	100.76	1050.04	27.44	0.492	1.652	11.59	9.45
4.900	0.99908	5.14	3952.0	98.30	1050.04	28.19	0.496	1.657	11.68	9.62
5.400	0.99899	5.14	3952.0	95.84	1050.04	28.97	0.501	1.635	11.71	9.82
5.900	0.99893	5.14	3952.0	93.48	1050.04	29.75	0.505	1.611	11.66	9.97
6.400	0.99887	5.14	3952.0	91.02	1050.04	30.62	0.509	1.586	11.67	10.09
6.900	0.99884	5.14	3952.0	88.66	1050.04	31.49	0.513	1.562	11.69	10.21
7.111	0.99893	5.14	3952.0	88.15	1050.04	31.69	0.513	1.556	11.65	10.21
7.118	0.99882	5.59	3952.0	95.94	1050.04	28.93	0.505	1.648	11.76	10.10
7.500	0.99864	5.59	3952.0	93.68	1050.04	29.68	0.508	1.627	11.65	10.05
8.000	0.99865	5.59	3952.0	92.05	1050.04	30.25	0.508	1.613	11.42	9.89
8.500	0.99869	5.59	3952.0	90.92	1050.04	30.66	0.505	1.602	11.05	9.59
9.000	0.99879	5.59	3952.0	90.20	1050.04	30.92	0.500	1.587	10.53	9.16
9.500	0.99872	5.59	3952.0	88.97	1050.04	31.38	0.494	1.570	9.91	8.66
9.619	0.99875	5.59	3952.0	88.76	1050.04	31.45	0.493	1.565	9.78	8.56
9.620	0.99853	6.33	3952.0	93.28	1050.04	29.82	0.485	1.631	10.21	8.99
10.000	0.99865	6.33	3952.0	93.38	1050.04	29.79	0.478	1.628	9.65	8.55
10.500	0.99859	6.33	3952.0	92.56	1050.04	30.07	0.470	1.621	8.98	7.98
11.000	0.99863	6.33	3952.0	92.25	1050.04	30.18	0.461	1.616	8.83	7.56
11.500	0.99877	6.33	3952.0	92.25	1050.04	30.18	0.451	1.610	8.92	7.65
12.000	0.99888	6.33	3952.0	92.25	1050.04	30.18	0.441	1.608	9.00	7.71
12.127	0.99896	6.33	3952.0	92.25	1050.04	30.18	0.438	1.608	8.99	7.71
12.127	0.99906	5.95	3952.0	92.05	1050.04	30.25	0.443	1.572	9.12	7.79
12.500	0.99909	5.95	3952.0	92.25	1050.04	30.18	0.435	1.569	9.13	7.79
13.000	0.99922	5.95	3952.0	92.97	1050.04	29.93	0.423	1.571	9.11	7.84
13.500	0.99930	5.95	3952.0	93.79	1050.04	29.65	0.411	1.576	9.08	7.83
14.000	0.99948	5.95	3952.0	95.43	1050.04	29.10	0.398	1.586	9.17	7.95
14.500	0.99955	5.95	3952.0	97.38	1050.04	28.47	0.385	1.601	9.30	8.22
14.635	0.99964	5.95	3952.0	98.09	1050.04	28.25	0.382	1.608	9.31	8.27
14.636	0.99968	6.04	3952.0	94.30	1050.04	29.48	0.390	1.590	9.36	8.01
15.000	0.99970	6.04	3952.0	96.66	1050.04	28.70	0.379	1.606	9.53	8.21
15.500	0.99963	6.04	3952.0	100.45	1050.04	27.53	0.363	1.617	9.75	8.54
15.700	0.99967	6.04	3952.0	102.50	1050.04	26.94	0.357	1.620	9.81	8.66
15.701	0.99970	4.32	3952.0	93.17	1050.04	29.86	0.378	1.625	9.43	8.36
16.200	0.99974	4.32	3952.0	100.76	1050.04	27.44	0.357	1.643	9.67	8.62
16.300	0.99986	4.32	3952.0	102.50	1050.04	26.94	0.353	1.646	9.72	8.67
16.301	0.99980	3.78	3952.0	92.15	1050.04	30.22	0.361	1.595	9.55	8.54
16.800	0.99969	3.78	3952.0	100.86	1050.04	27.41	0.340	1.622	9.85	8.79
16.801	0.99979	3.60	3952.0	95.53	1050.04	29.07	0.344	1.598	9.83	8.79
17.143	0.99967	3.60	3952.0	102.91	1050.04	26.82	0.328	1.622	10.15	8.98
17.143	0.99953	2.66	3952.0	93.68	1050.04	29.68	0.345	1.591	10.22	9.02
17.450	0.99955	2.66	3952.0	102.09	1050.04	27.05	0.329	1.624	10.44	9.21
17.451	0.99963	1.71	3952.0	95.12	1050.04	29.20	0.342	1.590	10.23	9.28
17.700	0.99957	1.71	3952.0	102.50	1050.04	26.94	0.328	1.638	10.39	9.42
17.701	0.99961	0.00	3952.0	93.68	1050.04	29.68	0.348	1.618	9.66	8.73
18.107	0.99972	0.00	3952.0	107.62	1050.04	25.55	0.323	1.694	9.90	8.93
18.115	0.99978	0.00	3952.0	95.74	1044.36	36.06	0.321	1.674	9.45	8.54
18.420	1.00002	0.00	3952.0	107.62	1044.36	31.83	0.300	1.710	9.74	8.79

18.500	0.99998	0.00	3889.3	107.62	1043.08	31.25	0.297	1.729	9.63	8.69
18.804	1.00002	0.00	3597.1	107.62	1037.12	28.61	0.281	1.834	9.20	8.27
19.000	1.00003	0.00	3438.5	107.62	1033.88	27.18	0.273	1.898	8.93	8.04
19.200	1.00002	0.00	3277.4	107.62	1030.60	25.74	0.264	1.970	8.66	7.79
19.405	0.99997	0.00	3085.3	107.62	1026.68	24.01	0.254	2.068	8.33	7.47
19.691	1.00000	0.00	2840.1	107.62	1021.69	21.84	0.240	2.212	7.94	7.05
19.976	0.99996	0.00	2586.6	107.62	1016.52	19.60	0.225	2.391	7.50	6.60
20.262	1.00003	0.00	2330.1	107.62	1011.30	17.37	0.209	2.608	7.02	6.14

Table A.2 Browns Ferry Equilibrium Cycle Design Depletion Thermal Margin Summary

Cycle Exposure (GWd/MT)	Calculated K-eff	Control Rod Density	Core Limiting CPR	Fraction of Limiting CPR	Core Limiting LHGR (kW/ft)	Fraction of Limiting LHGR	Core Limiting APLHGR (kW/ft)	Fraction of Limiting APLHGR
0.000	1.00029	4.414	1.710	0.825	11.86	0.872	8.92	0.776
0.250	1.00015	4.414	1.764	0.799	11.46	0.843	8.55	0.744
0.500	1.00015	4.414	1.806	0.781	11.35	0.835	8.44	0.734
1.000	1.00006	4.414	1.817	0.776	11.28	0.830	8.48	0.737
1.500	0.99995	4.414	1.799	0.784	11.17	0.821	8.48	0.738
1.709	0.99986	4.414	1.789	0.788	11.11	0.817	8.48	0.738
1.710	0.99970	4.144	1.728	0.816	11.95	0.879	9.19	0.799
2.200	0.99963	4.144	1.715	0.822	11.79	0.867	9.18	0.798
2.700	0.99956	4.144	1.695	0.832	11.70	0.860	9.23	0.803
3.200	0.99930	4.144	1.669	0.845	11.64	0.856	9.31	0.810
3.700	0.99925	4.144	1.648	0.856	11.67	0.858	9.41	0.819
4.200	0.99918	4.144	1.623	0.869	11.77	0.865	9.55	0.831
4.410	0.99922	4.144	1.615	0.873	11.81	0.869	9.62	0.837
4.410	0.99915	5.135	1.652	0.854	11.59	0.852	9.45	0.822
4.900	0.99908	5.135	1.657	0.851	11.68	0.859	9.62	0.836
5.400	0.99899	5.135	1.635	0.862	11.71	0.861	9.82	0.854
5.900	0.99893	5.135	1.611	0.875	11.66	0.857	9.97	0.867
6.400	0.99887	5.135	1.586	0.889	11.67	0.858	10.09	0.877
6.900	0.99884	5.135	1.562	0.903	11.69	0.860	10.21	0.888
7.111	0.99893	5.135	1.556	0.906	11.65	0.856	10.21	0.888
7.118	0.99882	5.586	1.648	0.856	11.76	0.865	10.10	0.878
7.500	0.99864	5.586	1.627	0.866	11.65	0.857	10.05	0.874
8.000	0.99865	5.586	1.613	0.874	11.42	0.840	9.89	0.860
8.500	0.99869	5.586	1.602	0.880	11.05	0.812	9.59	0.834
9.000	0.99879	5.586	1.587	0.889	10.53	0.774	9.16	0.796
9.500	0.99872	5.586	1.570	0.898	7.21	0.742	8.66	0.753
9.619	0.99875	5.586	1.565	0.901	7.14	0.740	8.56	0.745
9.620	0.99853	6.329	1.631	0.865	7.22	0.764	8.99	0.782
10.000	0.99865	6.329	1.628	0.866	6.94	0.748	8.55	0.743
10.500	0.99859	6.329	1.621	0.870	6.57	0.725	7.98	0.695
11.000	0.99863	6.329	1.616	0.872	6.46	0.702	7.55	0.661
11.500	0.99877	6.329	1.610	0.876	6.22	0.688	7.65	0.665
12.000	0.99888	6.329	1.608	0.877	5.95	0.672	7.71	0.670
12.127	0.99896	6.329	1.608	0.877	8.99	0.671	7.71	0.670
12.127	0.99906	5.946	1.572	0.897	9.12	0.679	7.79	0.678
12.500	0.99909	5.946	1.569	0.899	9.13	0.686	7.79	0.678
13.000	0.99922	5.946	1.571	0.897	9.11	0.690	7.84	0.682
13.500	0.99930	5.946	1.576	0.894	6.94	0.698	7.83	0.681
14.000	0.99948	5.946	1.586	0.889	6.86	0.706	7.95	0.691
14.500	0.99955	5.946	1.601	0.881	7.51	0.719	8.22	0.714
14.635	0.99964	5.946	1.608	0.877	7.53	0.723	8.27	0.719
14.636	0.99968	6.036	1.590	0.887	6.98	0.729	8.01	0.696
15.000	0.99970	6.036	1.606	0.915	7.88	0.737	8.21	0.714
15.500	0.99963	6.036	1.617	0.909	8.12	0.768	8.54	0.743
15.700	0.99967	6.036	1.620	0.907	8.20	0.779	8.66	0.753
15.701	0.99970	4.324	1.625	0.905	7.89	0.749	8.36	0.727
16.200	0.99974	4.324	1.643	0.895	8.14	0.780	8.62	0.750
16.300	0.99986	4.324	1.646	0.893	8.17	0.785	8.67	0.754
16.301	0.99980	3.784	1.595	0.922	8.03	0.771	8.54	0.742
16.800	0.99969	3.784	1.622	0.907	8.20	0.796	8.79	0.764
16.801	0.99979	3.604	1.598	0.920	8.44	0.794	8.79	0.765
17.143	0.99967	3.604	1.622	0.906	8.60	0.815	8.98	0.781
17.143	0.99953	2.658	1.591	0.924	8.64	0.819	9.02	0.784
17.450	0.99955	2.658	1.624	0.905	8.77	0.837	9.21	0.801
17.451	0.99963	1.712	1.590	0.925	8.60	0.821	9.28	0.807
17.700	0.99957	1.712	1.638	0.897	8.71	0.836	9.42	0.820
17.701	0.99961	0.000	1.618	0.909	8.40	0.806	8.73	0.759
18.107	0.99972	0.000	1.694	0.868	8.35	0.834	8.90	0.779
18.115	0.99978	0.000	1.674	0.878	8.05	0.805	8.54	0.748
18.420	1.00002	0.000	1.710	0.860	8.20	0.832	8.73	0.767

18.500	0.99998	0.000	1.729	0.850	8.08	0.824	8.69	0.760
18.804	1.00002	0.000	1.834	0.801	7.55	0.783	8.24	0.723
19.000	1.00003	0.000	1.898	0.774	7.24	0.759	8.04	0.703
19.200	1.00002	0.000	1.970	0.746	6.89	0.734	7.74	0.683
19.405	0.99997	0.000	2.068	0.711	6.54	0.704	7.43	0.657
19.691	1.00000	0.000	2.212	0.665	6.97	0.668	7.02	0.623
19.976	0.99996	0.000	2.391	0.615	6.55	0.632	6.56	0.585
20.262	1.00003	0.000	2.608	0.564	6.17	0.593	6.13	0.545

```
Cycle:                              21
Exposure: MWd/MTU (GWd)            0.0 (    0.00 )
Delta E: MWd/MTU, (GWd)            0.0 (    0.00 )
Power: MWt                      3952.0 (100.00 %)
Core Pressure: psia             1050.0
Inlet Subcooling: Btu/lbm       -31.69
Flow: Mlb/hr                     88.15 ( 86.00 %)

    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58
59             -- -- -- -- -- -- --             59
55          -- -- -- -- -- -- -- -- --          55
51       -- -- -- -- -- -- -- -- -- -- --       51
47    -- -- -- -- 18 -- -- -- 18 -- -- -- --    47
43 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 43
39 -- -- -- 18 -- -- -- 10 -- -- -- 18 -- -- -- 39
35 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 35
31 -- -- -- -- -- 10 -- -- -- 10 -- -- -- -- -- 31
27 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 27
23 -- -- -- 18 -- -- -- 10 -- -- -- 18 -- -- -- 23
19 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 19
15    -- -- -- -- 18 -- -- -- 18 -- -- -- --    15
11       -- -- -- -- -- -- -- -- -- -- --       11
 7          -- -- -- -- -- -- -- -- --           7
 3             -- -- -- -- -- -- --              3
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58

Control Rod Density: %            4.41

k-effective:                   1.00029
Void Fraction:                   0.524
Core Delta-P: psia              20.212
Core Plate Delta-P: psia        15.657
Coolant Temp: Deg-F              548.5
In Channel Flow: Mlb/hr          77.07   Active Channel Flow: Mlb/hr        74.18
Total Bypass Flow (%):            12.6   (of total core flow)
Total Water Rod Flow (%):          3.3   (of total core flow)
Source Convergence             0.00010
```

Core Average Exposure: MWd/MTU   17775.7

N(PRA)	Axial Profile Power	Axial Profile Exposure
Top 25	0.143	3.779
24	0.397	10.166
23	0.503	13.001
22	0.571	14.871
21	0.620	16.109
20	0.661	17.079
19	0.686	17.710
18	0.718	18.375
17	0.755	18.951
16	0.805	19.078
15	0.870	19.081
14	0.914	19.683
13	0.963	20.224
12	1.027	20.909
11	1.090	21.197
10	1.239	20.341
9	1.356	20.877
8	1.462	21.283
7	1.583	21.737
6	1.701	22.045
5	1.791	22.060*
4	1.791*	21.385
3	1.681	19.757
2	1.322	15.244
Bottom 1	0.350	4.571

% AXIAL TILT	-36.405	-10.471
AVG BOT 8ft/12ft	1.2036	1.0598

Edit Zone	Radial Power Avg.	Radial Power Max.	IR	JR
13	0.487	0.696	7	16
14	0.397	0.694	27	4
15	0.483	0.746	33	58
16	1.127	1.269	37	24
17	1.114	1.267	35	22
18	1.010	1.277	29	48
19	1.152	1.314	35	24
20	1.253	1.313	37	22
21	1.106	1.219	31	54

Top Ten Thermal Limits Summary - Sorted by Margin

Power Value	FT	IR	JR	MCPR Value	Margin	FT	IR	JR	APLHGR Value	Margin	Exp.	FT	IR	JR	K	LHGR Value	Margin	Exp.	FT	IR	JR	K
1.314	19	35	24	1.710	0.825	20	37	40	8.92	0.776	0.0	21	31	54	4	11.86	0.872	0.0	20	29	50	5
1.313	20	37	22	1.711	0.824	20	21	38	8.77	0.763	0.0	21	7	32	4	11.84	0.871	0.0	21	31	54	4
1.311	20	21	24	1.711	0.824	20	29	46	8.75	0.761	0.0	21	35	54	4	11.78	0.866	0.0	20	29	46	5
1.311	19	37	26	1.713	0.823	21	31	54	8.73	0.759	0.0	20	31	50	5	11.74	0.864	0.0	19	33	54	4
1.302	20	31	46	1.723	0.819	20	45	30	8.70	0.757	0.0	19	25	38	4	11.74	0.863	0.0	19	35	50	4
1.296	20	15	30	1.731	0.815	21	7	32	8.70	0.756	0.0	19	33	54	4	11.72	0.862	0.0	20	11	32	5
1.291	20	35	42	1.746	0.807	20	29	50	8.68	0.755	0.0	19	23	36	4	11.71	0.861	0.0	20	37	40	5
1.287	19	33	26	1.749	0.806	19	35	24	8.66	0.753	0.0	21	37	54	4	11.70	0.860	0.0	20	39	38	5
1.287	20	33	30	1.753	0.804	19	37	26	8.63	0.750	0.0	20	29	46	5	11.70	0.860	0.0	20	45	30	5
1.287	20	19	22	1.754	0.804	20	39	20	8.63	0.750	0.0	21	7	36	4	11.68	0.859	0.0	19	25	38	4

* LHGR calculated with pin-power reconstruction
* CPR calculated with pin-power reconstruction & CPR limit TYPE 3

Figure A.1 Browns Ferry Equilibrium Cycle Control Rod Pattern and Axial Distributions at 0.0 MWd/MTU

```
Cycle:                            21                       Core Average Exposure: MWd/MTU    18024.1
Exposure: MWd/MTU (GWd)        250.0 (  34.59 )
Delta E: MWd/MTU, (GWd)        250.0 (  34.59 )               Axial Profile    Edit   Radial Power
Power: MWt                    3952.0 (100.00 %)           N(PRA) Power Exposure  Zone  Avg.  Max.  IR JR
Core Pressure: psia           1050.0                     Top 25  0.151   3.819    13  0.488 0.697   7 16
Inlet Subcooling: Btu/lbm     -29.86                         24  0.422  10.278    14  0.398 0.694  27  4
Flow: Mlb/hr                   93.17 ( 90.90 %)              23  0.534  13.143    15  0.485 0.747  33 58
                                                             22  0.605  15.033    16  1.129 1.270  37 24
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58              21  0.656  16.285    17  1.116 1.269  35 22
59             -- -- -- -- -- -- --             59           20  0.697  17.266    18  1.013 1.280  29 48
55          -- -- -- -- -- -- -- -- --          55           19  0.721  17.904    19  1.150 1.310  35 24
51       -- -- -- -- -- -- -- -- -- -- --       51           18  0.752  18.578    20  1.250 1.309  37 22
47    -- -- -- -- 18 -- -- -- 18 -- -- -- --    47           17  0.786  19.164    21  1.102 1.213  31 54
43 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 43           16  0.834  19.299
39 -- -- -- 18 -- -- -- 10 -- -- -- 18 -- -- -- 39           15  0.897  19.305
35 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 35           14  0.937  19.918
31 -- -- -- -- -- 10 -- -- -- 10 -- -- -- -- -- 31           13  0.982  20.470
27 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 27           12  1.042  21.171
23 -- -- -- 18 -- -- -- 10 -- -- -- 18 -- -- -- 23           11  1.100  21.475
19 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 19           10  1.245  20.624
15    -- -- -- -- 18 -- -- -- 18 -- -- -- --    15            9  1.356  21.183
11       -- -- -- -- -- -- -- -- -- -- --       11            8  1.454  21.612
 7          -- -- -- -- -- -- -- -- --           7            7  1.564  22.092
 3             -- -- -- -- -- -- --              3            6  1.667  22.425
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58               5  1.739* 22.458*
                                                              4  1.716  21.781
Control Rod Density: %          4.41                          3  1.584  20.126
                                                              2  1.232  15.533
k-effective:                 1.00015                  Bottom  1  0.326   4.656
Void Fraction:                 0.508
Core Delta-P: psia            21.816                % AXIAL TILT -33.443 -10.712
Core Plate Delta-P: psia      17.260            AVG BOT 8ft/12ft  1.1876  1.0609
Coolant Temp: Deg-F            548.5
In Channel Flow: Mlb/hr        81.60   Active Channel Flow: Mlb/hr        78.59
Total Bypass Flow (%):          12.4   (of total core flow)
Total Water Rod Flow (%):        3.2   (of total core flow)
Source Convergence           0.00008
```

Top Ten Thermal Limits Summary - Sorted by Margin

Power				MCPR					APLHGR							LHGR						
Value	FT	IR	JR	Value	Margin	FT	IR	JR	Value	Margin	Exp.	FT	IR	JR	K	Value	Margin	Exp.	FT	IR	JR	K
1.310	19	35	24	1.764	0.799	20	37	22	8.55	0.744	0.5	21	31	54	4	11.46	0.843	0.7	20	29	50	5
1.309	20	37	22	1.764	0.799	21	31	54	8.47	0.737	0.5	20	31	50	5	11.38	0.837	0.7	20	29	46	5
1.308	20	21	24	1.765	0.799	20	29	46	8.40	0.731	0.5	21	7	32	4	11.32	0.833	0.7	20	11	32	5
1.307	19	37	26	1.765	0.799	20	21	38	8.38	0.729	0.5	21	35	54	4	11.31	0.832	0.7	21	31	54	4
1.298	20	31	46	1.776	0.794	20	45	30	8.38	0.728	0.5	20	29	46	5	11.31	0.831	0.7	20	37	40	5
1.292	20	15	30	1.781	0.792	21	7	32	8.38	0.728	0.5	20	11	30	5	11.30	0.831	0.7	20	45	30	5
1.287	20	35	42	1.792	0.787	19	35	24	8.35	0.726	0.5	20	23	40	5	11.30	0.831	0.7	20	39	38	5
1.284	20	19	22	1.796	0.785	19	37	26	8.35	0.726	0.5	20	21	24	5	11.28	0.829	0.7	20	33	52	5
1.284	20	39	42	1.799	0.784	20	39	20	8.34	0.725	0.5	19	25	38	4	11.19	0.823	0.7	19	33	54	4
1.284	20	33	30	1.802	0.782	20	19	22	8.34	0.725	0.5	20	33	52	5	11.18	0.822	0.7	20	9	28	5

* LHGR calculated with pin-power reconstruction
* CPR calculated with pin-power reconstruction & CPR limit TYPE 3

Figure A.2 Browns Ferry Equilibrium Cycle Control Rod Pattern and Axial Distributions at 250.0 MWd/MTU

```
Cycle:                           21                 Core Average Exposure: MWd/MTU    18274.2
Exposure: MWd/MTU (GWd)       500.0 (  69.19 )
Delta E: MWd/MTU, (GWd)       250.0 (  34.59 )         Axial Profile    Edit   Radial Power
Power: MWt                   3952.0 (100.00 %)     N(PRA) Power Exposure  Zone  Avg.  Max.  IR JR
Core Pressure: psia          1050.0               Top 25  0.156   3.860    13  0.486 0.695   7 16
Inlet Subcooling: Btu/lbm    -28.19                   24  0.435  10.396    14  0.396 0.692  27  4
Flow: Mlb/hr                  98.30 ( 95.90 %)        23  0.550  13.292    15  0.482 0.746  33 58
                                                      22  0.623  15.202    16  1.131 1.272  37 24
   2  6 10 14 18 22 26 30 34 38 42 46 50 54 58        21  0.673  16.468    17  1.117 1.270  35 22
59          -- -- -- -- -- -- -- --           59      20  0.714  17.461    18  1.013 1.282  29 48
55       -- -- -- -- -- -- -- -- -- --        55      19  0.736  18.105    19  1.151 1.310  35 24
51    -- -- -- -- -- -- -- -- -- -- -- --     51      18  0.765  18.787    20  1.251 1.310  37 22
47  -- -- -- -- 18 -- -- -- 18 -- -- -- --    47      17  0.799  19.382    21  1.101 1.214  31 54
43 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 43    16  0.844  19.525
39 -- -- -- 18 -- -- -- 10 -- -- -- 18 -- -- -- 39    15  0.906  19.533
35 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 35    14  0.944  20.156
31 -- -- -- -- -- 10 -- -- -- 10 -- -- -- -- -- 31    13  0.987  20.719
27 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 27    12  1.047  21.435
23 -- -- -- 18 -- -- -- 10 -- -- -- 18 -- -- -- 23    11  1.104  21.754
19 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 19    10  1.247  20.908
15  -- -- -- -- 18 -- -- -- 18 -- -- -- --    15       9  1.358  21.489
11    -- -- -- -- -- -- -- -- -- -- -- --     11       8  1.453  21.940
 7       -- -- -- -- -- -- -- -- -- --         7       7  1.559  22.444
 3          -- -- -- -- -- -- -- --            3       6  1.657  22.800
   2  6 10 14 18 22 26 30 34 38 42 46 50 54 58         5  1.719* 22.849*
                                                       4  1.682  22.164
Control Rod Density: %         4.41                    3  1.538  20.479
                                                       2  1.188  15.806
k-effective:                1.00015           Bottom  1  0.316   4.736
Void Fraction:                0.496
Core Delta-P: psia           23.578            % AXIAL TILT -32.165 -10.917
Core Plate Delta-P: psia     19.020          AVG BOT 8ft/12ft  1.1803  1.0619
Coolant Temp: Deg-F           548.6
In Channel Flow: Mlb/hr       86.20  Active Channel Flow: Mlb/hr        83.07
Total Bypass Flow (%):         12.3  (of total core flow)
Total Water Rod Flow (%):       3.2  (of total core flow)
Source Convergence          0.00009
```

Top Ten Thermal Limits Summary - Sorted by Margin

Power				MCPR					APLHGR							LHGR						
Value	FT	IR	JR	Value	Margin	FT	IR	JR	Value	Margin	Exp.	FT	IR	JR	K	Value	Margin	Exp.	FT	IR	JR	K
1.310	19	35	24	1.806	0.781	21	31	54	8.44	0.734	1.1	21	31	54	4	11.35	0.835	1.5	20	29	50	5
1.310	20	37	22	1.810	0.779	20	37	22	8.44	0.734	1.1	20	31	50	5	11.27	0.828	1.5	20	29	46	5
1.308	20	21	24	1.811	0.779	20	29	46	8.33	0.725	1.1	20	29	46	5	11.21	0.824	1.5	20	11	32	5
1.307	19	37	26	1.812	0.778	20	21	38	8.33	0.725	1.1	20	11	30	5	11.18	0.822	1.4	20	45	30	5
1.299	20	31	46	1.822	0.774	20	45	30	8.30	0.722	1.1	20	23	40	5	11.18	0.822	1.5	20	37	40	5
1.294	20	15	30	1.823	0.774	21	7	32	8.30	0.722	1.1	20	21	24	5	11.17	0.821	1.5	20	39	38	5
1.288	20	35	42	1.838	0.767	19	35	24	8.30	0.721	1.1	20	33	52	5	11.16	0.821	1.5	20	33	52	5
1.285	20	19	22	1.842	0.765	19	37	26	8.29	0.721	1.1	20	15	30	5	11.13	0.819	1.5	21	31	54	4
1.285	20	39	42	1.845	0.764	20	39	20	8.28	0.720	1.1	21	7	32	4	11.06	0.813	1.4	20	9	28	5
1.284	20	19	26	1.848	0.763	20	29	50	8.27	0.719	1.1	21	35	54	4	11.02	0.810	1.4	19	35	50	5

* LHGR calculated with pin-power reconstruction
* CPR calculated with pin-power reconstruction & CPR limit TYPE 3

Figure A.3 Browns Ferry Equilibrium Cycle Control Rod Pattern and Axial Distributions at 500.0 MWd/MTU

```
Cycle:                            21
Exposure: MWd/MTU (GWd)       1000.0 ( 138.37 )
Delta E: MWd/MTU, (GWd)        500.0 (  69.19 )
Power: MWt                    3952.0 (100.00 %)
Core Pressure: psia           1050.0
Inlet Subcooling: Btu/lbm     -27.78
Flow: Mlb/hr                   99.63 ( 97.20 %)

    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58
59             -- -- -- -- -- -- --             59
55          -- -- -- -- -- -- -- -- --          55
51       -- -- -- -- -- -- -- -- -- -- --       51
47    -- -- -- -- 18 -- -- -- 18 -- -- -- --    47
43 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 43
39 -- -- -- 18 -- -- -- 10 -- -- -- 18 -- -- -- 39
35 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 35
31 -- -- -- -- -- 10 -- -- -- 10 -- -- -- -- -- 31
27 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 27
23 -- -- -- 18 -- -- -- 10 -- -- -- 18 -- -- -- 23
19 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 19
15    -- -- -- -- 18 -- -- -- 18 -- -- -- --    15
11       -- -- -- -- -- -- -- -- -- -- --       11
 7          -- -- -- -- -- -- -- -- --           7
 3             -- -- -- -- -- -- --              3
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58

Control Rod Density: %          4.41

k-effective:                 1.00006
Void Fraction:                 0.492
Core Delta-P: psia            24.048
Core Plate Delta-P: psia      19.490
Coolant Temp: Deg-F            548.6
In Channel Flow: Mlb/hr        87.40   Active Channel Flow: Mlb/hr        84.24
Total Bypass Flow (%):          12.3   (of total core flow)
Total Water Rod Flow (%):        3.2   (of total core flow)
Source Convergence           0.00008
```

```
Core Average Exposure: MWd/MTU    18774.1

         Axial Profile     Edit   Radial Power
  N(PRA) Power Exposure    Zone  Avg.   Max.   IR JR
 Top 25  0.159   3.946      13  0.481 0.690    7 16
     24  0.440  10.636      14  0.391 0.688   27  4
     23  0.556  13.595      15  0.477 0.741   33 58
     22  0.629  15.547      16  1.130 1.273   37 24
     21  0.679  16.841      17  1.116 1.271   35 22
     20  0.719  17.856      18  1.009 1.283   29 48
     19  0.741  18.513      19  1.155 1.317   35 24
     18  0.770  19.210      20  1.258 1.318   37 22
     17  0.802  19.824      21  1.101 1.217   31 54
     16  0.845  19.980
     15  0.906  19.992
     14  0.945  20.635
     13  0.988  21.220
     12  1.047  21.966
     11  1.105  22.313
     10  1.247  21.477
      9  1.357  22.102
      8  1.451  22.596
      7  1.557  23.148
      6  1.653  23.547
      5  1.712* 23.623*
      4  1.672  22.922
      3  1.525  21.171
      2  1.176  16.340
Bottom  1  0.317   4.894

    % AXIAL TILT -31.768 -11.287
AVG BOT 8ft/12ft  1.1777  1.0636
```

Top Ten Thermal Limits Summary - Sorted by Margin

Power				MCPR					APLHGR							LHGR						
Value	FT	IR	JR	Value	Margin	FT	IR	JR	Value	Margin	Exp.	FT	IR	JR	K	Value	Margin	Exp.	FT	IR	JR	K
1.318	20	37	22	1.817	0.776	20	37	22	8.48	0.737	2.1	20	31	50	5	11.28	0.830	2.9	20	29	50	5
1.317	19	35	24	1.819	0.775	21	31	54	8.43	0.733	2.1	21	31	54	4	11.20	0.823	2.9	20	29	46	5
1.316	20	21	24	1.819	0.775	20	21	38	8.37	0.728	2.1	20	29	46	5	11.14	0.819	2.9	20	11	32	5
1.314	19	37	26	1.820	0.775	20	29	46	8.37	0.728	2.1	20	11	30	5	11.12	0.817	2.9	20	45	30	5
1.308	20	31	46	1.831	0.770	20	45	30	8.34	0.725	2.1	20	23	40	5	11.10	0.816	2.9	20	37	40	5
1.301	20	15	30	1.836	0.768	21	7	32	8.33	0.725	2.1	20	21	24	5	11.09	0.816	2.9	20	39	38	5
1.296	20	35	42	1.844	0.765	19	35	24	8.33	0.725	2.1	20	33	52	5	11.09	0.816	2.9	20	33	52	5
1.292	20	19	22	1.848	0.763	19	37	26	8.33	0.724	2.1	20	15	30	5	11.04	0.812	2.9	21	31	54	4
1.292	20	39	42	1.853	0.761	20	39	20	8.29	0.721	2.1	19	25	38	5	10.99	0.808	2.9	20	9	28	5
1.292	20	19	26	1.856	0.760	20	19	22	8.28	0.720	2.1	21	7	32	4	10.95	0.805	2.8	19	35	50	5

* LHGR calculated with pin-power reconstruction
* CPR calculated with pin-power reconstruction & CPR limit TYPE 3

Figure A.4 Browns Ferry Equilibrium Cycle Control Rod Pattern and Axial Distributions at 1,000.0 MWd/MTU

```
Cycle:                          21                  Core Average Exposure: MWd/MTU    19274.0
Exposure: MWd/MTU (GWd)      1500.0 ( 207.56 )
Delta E: MWd/MTU, (GWd)       500.0 (  69.19 )         Axial Profile    Edit   Radial Power
Power: MWt                   3952.0 (100.00 %)     N(PRA) Power Exposure  Zone  Avg.  Max.  IR JR
Core Pressure: psia          1050.0               Top 25  0.162   4.033    13  0.477 0.686   7 16
Inlet Subcooling: Btu/lbm    -28.25                   24  0.444  10.878    14  0.387 0.684  27  4
Flow: Mlb/hr                  98.09 ( 95.70 %)        23  0.560  13.901    15  0.473 0.736  33 58
                                                      22  0.634  15.896    16  1.128 1.271  37 24
   2  6 10 14 18 22 26 30 34 38 42 46 50 54 58        21  0.685  17.218    17  1.114 1.269  35 22
59             -- -- -- -- -- -- --             59    20  0.725  18.255    18  1.005 1.281  29 48
55          -- -- -- -- -- -- -- -- --          55    19  0.747  18.923    19  1.161 1.324  35 24
51       -- -- -- -- -- -- -- -- -- -- --       51    18  0.775  19.636    20  1.265 1.326  37 22
47    -- -- -- -- 18 -- -- -- 18 -- -- -- --    47    17  0.807  20.268    21  1.102 1.220  31 54
43 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 43    16  0.849  20.437
39 -- -- -- 18 -- -- -- 10 -- -- -- 18 -- -- -- 39    15  0.910  20.453
35 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 35    14  0.947  21.114
31 -- -- -- -- -- 10 -- -- -- 10 -- -- -- -- -- 31    13  0.990  21.721
27 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 27    12  1.049  22.497
23 -- -- -- 18 -- -- -- 10 -- -- -- 18 -- -- -- 23    11  1.105  22.872
19 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 19    10  1.245  22.046
15    -- -- -- -- 18 -- -- -- 18 -- -- -- --    15     9  1.352  22.714
11       -- -- -- -- -- -- -- -- -- -- --       11     8  1.445  23.249
 7          -- -- -- -- -- -- -- -- --           7     7  1.549  23.849
 3             -- -- -- -- -- -- --              3     6  1.643  24.291
   2  6 10 14 18 22 26 30 34 38 42 46 50 54 58         5  1.702* 24.394*
                                                       4  1.664  23.675
Control Rod Density: %         4.41                    3  1.520  21.859
                                                       2  1.173  16.871
k-effective:                0.99995            Bottom  1  0.319   5.053
Void Fraction:                0.493
Core Delta-P: psia           23.481          % AXIAL TILT -31.317 -11.627
Core Plate Delta-P: psia     18.923      AVG BOT 8ft/12ft  1.1752  1.0651
Coolant Temp: Deg-F           548.5
In Channel Flow: Mlb/hr       86.03  Active Channel Flow: Mlb/hr        82.92
Total Bypass Flow (%):         12.3  (of total core flow)
Total Water Rod Flow (%):       3.2  (of total core flow)
Source Convergence          0.00009
```

Top Ten Thermal Limits Summary - Sorted by Margin

Power Value	FT	IR	JR	MCPR Value	Margin	FT	IR	JR	APLHGR Value	Margin	Exp.	FT	IR	JR	K	LHGR Value	Margin	Exp.	FT	IR	JR	K
1.326	20	37	22	1.799	0.784	20	37	22	8.48	0.738	3.2	20	31	50	5	11.17	0.821	4.3	20	29	50	5
1.324	20	21	24	1.801	0.783	20	21	38	8.42	0.732	3.2	21	31	54	4	11.08	0.815	4.3	20	29	46	5
1.324	19	35	24	1.808	0.780	20	29	46	8.38	0.729	3.2	20	29	46	5	11.02	0.811	4.3	20	11	32	5
1.320	19	37	26	1.811	0.778	21	31	54	8.38	0.729	3.2	20	11	30	5	11.00	0.809	4.3	20	45	30	5
1.315	20	31	46	1.819	0.775	20	45	30	8.34	0.725	3.2	20	33	52	5	10.98	0.808	4.3	20	37	40	5
1.309	20	15	30	1.821	0.774	19	35	24	8.34	0.725	3.2	20	23	40	5	10.98	0.807	4.3	20	33	52	5
1.303	20	35	42	1.825	0.772	19	37	26	8.34	0.725	3.2	20	21	24	5	10.97	0.807	4.3	20	39	38	5
1.300	20	19	22	1.828	0.771	21	7	32	8.33	0.725	3.2	20	15	30	5	10.93	0.804	4.3	21	31	54	4
1.299	20	39	42	1.836	0.768	20	39	20	8.28	0.720	3.1	19	25	38	5	10.87	0.800	4.3	20	9	28	5
1.299	20	19	26	1.836	0.768	19	35	28	8.26	0.719	3.1	20	33	48	5	10.84	0.797	4.2	19	35	50	5

* LHGR calculated with pin-power reconstruction
* CPR calculated with pin-power reconstruction & CPR limit TYPE 3

Figure A.5 Browns Ferry Equilibrium Cycle Control Rod Pattern and Axial Distributions at 1,500.0 MWd/MTU

```
Cycle:                            21                     Core Average Exposure: MWd/MTU    19482.8
Exposure: MWd/MTU (GWd)       1708.8 ( 236.45 )
Delta E: MWd/MTU, (GWd)        208.8 (  28.89 )              Axial Profile    Edit   Radial Power
Power: MWt                    3952.0 (100.00 %)        N(PRA) Power Exposure  Zone  Avg.  Max.  IR JR
Core Pressure: psia           1050.0                  Top 25  0.163   4.070    13  0.476 0.685   7 16
Inlet Subcooling: Btu/lbm     -28.57                      24  0.446  10.980    14  0.385 0.682  27  4
Flow: Mlb/hr                   97.07 ( 94.70 %)           23  0.562  14.029    15  0.471 0.734  33 58
                                                          22  0.636  16.042    16  1.127 1.270  37 24
   2  6 10 14 18 22 26 30 34 38 42 46 50 54 58            21  0.687  17.376    17  1.113 1.268  35 22
59             -- -- -- -- -- -- -- --           59       20  0.728  18.422    18  1.003 1.281  29 48
55          -- -- -- -- -- -- -- -- -- --        55       19  0.750  19.095    19  1.163 1.326  35 24
51       -- -- -- -- -- -- -- -- -- -- -- --     51       18  0.778  19.815    20  1.268 1.329  37 22
47    -- -- -- -- 18 -- -- -- 18 -- -- -- --     47       17  0.809  20.454    21  1.103 1.221  31 54
43 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 43       16  0.851  20.628
39 -- -- -- 18 -- -- -- 10 -- -- -- 18 -- -- -- 39       15  0.911  20.645
35 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 35       14  0.948  21.315
31 -- -- -- -- -- 10 -- -- -- 10 -- -- -- -- -- 31       13  0.990  21.930
27 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 27       12  1.049  22.719
23 -- -- -- 18 -- -- -- 10 -- -- -- 18 -- -- -- 23       11  1.104  23.105
19 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 19       10  1.243  22.283
15    -- -- -- -- 18 -- -- -- 18 -- -- -- --     15        9  1.349  22.968
11       -- -- -- -- -- -- -- -- -- -- -- --     11        8  1.441  23.522
 7          -- -- -- -- -- -- -- -- -- --         7        7  1.544  24.140
 3             -- -- -- -- -- -- -- --            3        6  1.638  24.600
   2  6 10 14 18 22 26 30 34 38 42 46 50 54 58             5  1.697* 24.714*
                                                           4  1.661  23.989
Control Rod Density: %          4.41                       3  1.519  22.146
                                                           2  1.173  17.092
k-effective:                 0.99986            Bottom  1  0.321   5.119
Void Fraction:                 0.494
Core Delta-P: psia            23.109               % AXIAL TILT -31.113 -11.760
Core Plate Delta-P: psia      18.552           AVG BOT 8ft/12ft  1.1741  1.0657
Coolant Temp: Deg-F            548.5
In Channel Flow: Mlb/hr        85.12  Active Channel Flow: Mlb/hr        82.04
Total Bypass Flow (%):          12.3  (of total core flow)
Total Water Rod Flow (%):        3.2  (of total core flow)
Source Convergence           0.00010
```

Top Ten Thermal Limits Summary - Sorted by Margin

Power				MCPR					APLHGR							LHGR						
Value	FT	IR	JR	Value	Margin	FT	IR	JR	Value	Margin	Exp.	FT	IR	JR	K	Value	Margin	Exp.	FT	IR	JR	K
1.329	20	37	22	1.789	0.788	20	37	22	8.48	0.738	3.7	20	31	50	5	11.11	0.817	4.9	20	29	50	5
1.327	20	21	24	1.790	0.788	20	21	38	8.41	0.732	3.7	21	31	54	4	11.03	0.811	4.9	20	29	46	5
1.326	19	35	24	1.800	0.783	20	29	46	8.38	0.729	3.6	20	29	46	5	10.97	0.807	4.9	20	11	32	5
1.323	19	37	26	1.806	0.781	21	31	54	8.38	0.729	3.6	20	11	30	5	10.95	0.805	4.9	20	45	30	5
1.318	20	31	46	1.808	0.780	19	35	24	8.34	0.725	3.6	20	33	52	5	10.93	0.804	4.9	20	37	40	5
1.312	20	15	30	1.812	0.778	20	45	30	8.34	0.725	3.6	20	23	40	5	10.92	0.803	4.9	20	33	52	5
1.306	20	35	42	1.812	0.778	19	37	26	8.34	0.725	3.6	20	21	24	5	10.92	0.803	4.9	20	39	38	5
1.303	20	19	22	1.822	0.774	21	7	32	8.33	0.725	3.6	20	15	30	5	10.88	0.800	4.8	21	31	54	4
1.302	20	19	26	1.823	0.773	19	35	28	8.28	0.720	3.6	19	25	38	5	10.82	0.796	4.8	20	9	28	5
1.302	20	39	42	1.825	0.773	19	27	36	8.26	0.719	3.6	20	33	48	5	10.79	0.793	4.8	19	35	50	5

* LHGR calculated with pin-power reconstruction
* CPR calculated with pin-power reconstruction & CPR limit TYPE 3

Figure A.6 Browns Ferry Equilibrium Cycle Control Rod Pattern and Axial Distributions at 1,708.8 MWd/MTU

```
Cycle:                          21                        Core Average Exposure: MWd/MTU    19483.9
Exposure: MWd/MTU (GWd)      1709.9 ( 236.60 )
Delta E: MWd/MTU, (GWd)         1.1 (   0.15 )               Axial Profile    Edit   Radial Power
Power: MWt                   3952.0 (100.00 %)          N(PRA) Power Exposure  Zone  Avg.  Max.  IR JR
Core Pressure: psia          1050.0                     Top 25  0.150   4.070    13  0.478 0.695  15  8
Inlet Subcooling: Btu/lbm    -28.28                         24  0.410  10.981    14  0.386 0.694  27  4
Flow: Mlb/hr                  97.99 ( 95.60 %)              23  0.516  14.030    15  0.472 0.746  33 58
                                                            22  0.581  16.043    16  1.103 1.281  29 44
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58             21  0.624  17.376    17  1.124 1.279  39 30
59             -- -- -- -- -- -- -- --             59       20  0.655  18.423    18  1.004 1.310  29 48
55          -- -- -- -- -- -- -- -- -- --          55       19  0.671  19.096    19  1.248 1.342  37 30
51       -- -- -- -- -- -- -- -- -- -- -- --       51       18  0.696  19.816    20  1.195 1.352  31 46
47    -- -- -- -- -- -- -- -- -- -- -- -- -- --    47       17  0.725  20.455    21  1.120 1.252  31 54
43 -- -- -- -- -- 10 -- -- -- 10 -- -- -- -- -- 43       16  0.777  20.629
39 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 39       15  0.862  20.646
35 -- -- -- 14 -- -- --  8 -- -- -- 14 -- -- -- 35       14  0.922  21.316
31 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 31       13  0.983  21.931
27 -- -- -- 14 -- -- --  8 -- -- -- 14 -- -- -- 27       12  1.056  22.720
23 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 23       11  1.125  23.107
19 -- -- -- -- -- 10 -- -- -- 10 -- -- -- -- -- 19       10  1.275  22.284
15    -- -- -- -- -- -- -- -- -- -- -- -- -- --    15        9  1.391  22.969
11       -- -- -- -- -- -- -- -- -- -- -- --       11        8  1.491  23.523
 7          -- -- -- -- -- -- -- -- -- --           7        7  1.603  24.142
 3             -- -- -- -- -- -- -- --              3        6  1.706  24.602
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58              5  1.777* 24.716*
                                                             4  1.756  23.990
Control Rod Density: %         4.14                          3  1.626  22.148
                                                             2  1.271  17.094
k-effective:                0.99970                  Bottom  1  0.350   5.120
Void Fraction:                0.503
Core Delta-P: psia           23.620              % AXIAL TILT -36.801 -11.761
Core Plate Delta-P: psia     19.063           AVG BOT 8ft/12ft  1.2055  1.0657
Coolant Temp: Deg-F           548.6
In Channel Flow: Mlb/hr       85.85  Active Channel Flow: Mlb/hr        82.70
Total Bypass Flow (%):         12.4  (of total core flow)
Total Water Rod Flow (%):       3.2  (of total core flow)
Source Convergence          0.00009


                           Top Ten Thermal Limits Summary - Sorted by Margin

     Power                  MCPR                           APLHGR                               LHGR
Value FT  IR JR     Value Margin FT  IR JR    Value Margin Exp. FT  IR JR  K    Value Margin Exp. FT  IR JR  K
1.352  20 31 46     1.728  0.816  20 29 46     9.19  0.799  3.5  19 35 50  4    11.95  0.879  4.7  19 37 52  4
1.342  19 37 30     1.744  0.808  21 31 54     9.14  0.795  3.3  19 39 50  4    11.95  0.878  4.5  19 21 50  4
1.338  20 33 48     1.759  0.802  20 27 48     9.11  0.792  3.5  19 37 52  4    11.94  0.878  4.8  19 35 50  4
1.335  19 39 28     1.764  0.799  20 29 50     9.08  0.789  3.7  20 31 50  5    11.84  0.871  4.9  20 29 50  5
1.335  20 31 50     1.774  0.795  19 35 50     9.01  0.783  3.6  20 27 48  5    11.81  0.869  4.9  20 29 46  5
1.327  19 37 26     1.777  0.793  20 29 42     8.99  0.782  3.6  20 29 46  5    11.80  0.867  4.9  20 33 52  5
1.325  20 29 42     1.782  0.791  20 33 52     8.96  0.779  2.3  19 37 48  4    11.72  0.862  1.8  19 37 14  4
1.322  19 35 50     1.787  0.789  21 35 54     8.95  0.778  3.7  21 31 54  4    11.71  0.861  4.7  21 43 12  4
1.313  20 27 44     1.789  0.788  19 37 30     8.95  0.778  3.6  20 33 52  5    11.70  0.860  4.7  21 41 52  4
1.310  18 29 48     1.789  0.788  21 17 50     8.91  0.774  3.6  21 35 54  4    11.66  0.857  4.7  20 27 48  5

  * LHGR calculated with pin-power reconstruction
  * CPR calculated with pin-power reconstruction & CPR limit TYPE 3
```

Figure A.7 Browns Ferry Equilibrium Cycle Control Rod Pattern and Axial Distributions at 1,709.9 MWd/MTU

```
Cycle:                            21                Core Average Exposure: MWd/MTU    19973.9
Exposure: MWd/MTU (GWd)       2200.0 ( 304.42 )
Delta E: MWd/MTU, (GWd)        490.1 (  67.82 )        Axial Profile    Edit   Radial Power
Power: MWt                    3952.0 (100.00 %)   N(PRA) Power Exposure  Zone  Avg.  Max.  IR JR
Core Pressure: psia           1050.0             Top 25  0.153   4.150    13  0.474 0.690  15  8
Inlet Subcooling: Btu/lbm     -28.67                 24  0.416  11.203    14  0.382 0.690  27  4
Flow: Mlb/hr                   96.76 ( 94.40 %)      23  0.523  14.309    15  0.468 0.741  33 58
                                                     22  0.589  16.359    16  1.101 1.279  29 44
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58      21  0.632  17.716    17  1.121 1.277  39 30
59             -- -- -- -- -- -- --            59    20  0.663  18.779    18  1.000 1.308  29 48
55          -- -- -- -- -- -- -- -- --         55    19  0.680  19.462    19  1.253 1.347  37 30
51       -- -- -- -- -- -- -- -- -- -- --      51    18  0.704  20.195    20  1.202 1.359  31 46
47    -- -- -- -- -- -- -- -- -- -- -- -- --   47    17  0.733  20.849    21  1.121 1.255  31 54
43 -- -- -- -- -- 10 -- -- -- 10 -- -- -- -- -- 43    16  0.784  21.042
39 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 39    15  0.868  21.076
35 -- -- -- 14 -- -- --  8 -- -- -- 14 -- -- -- 35    14  0.927  21.775
31 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 31    13  0.986  22.421
27 -- -- -- 14 -- -- --  8 -- -- -- 14 -- -- -- 27    12  1.059  23.246
23 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 23    11  1.125  23.665
19 -- -- -- -- -- 10 -- -- -- 10 -- -- -- -- -- 19    10  1.272  22.854
15    -- -- -- -- -- -- -- -- -- -- -- -- --   15     9  1.385  23.584
11       -- -- -- -- -- -- -- -- -- -- --      11     8  1.483  24.181
 7          -- -- -- -- -- -- -- -- --          7     7  1.592  24.848
 3             -- -- -- -- -- -- --             3     6  1.693  25.354
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58       5  1.763* 25.499*
                                                      4  1.744  24.765
Control Rod Density: %          4.14                  3  1.615  22.866
                                                      2  1.262  17.655
k-effective:                 0.99963          Bottom  1  0.350   5.291
Void Fraction:                 0.503
Core Delta-P: psia            23.158            % AXIAL TILT -36.110 -12.195
Core Plate Delta-P: psia      18.602        AVG BOT 8ft/12ft  1.2018  1.0678
Coolant Temp: Deg-F            548.6
In Channel Flow: Mlb/hr        84.76   Active Channel Flow: Mlb/hr        81.65
Total Bypass Flow (%):          12.4   (of total core flow)
Total Water Rod Flow (%):        3.2   (of total core flow)
Source Convergence           0.00008
```

Top Ten Thermal Limits Summary - Sorted by Margin

Power				MCPR					APLHGR							LHGR						
Value	FT	IR	JR	Value	Margin	FT	IR	JR	Value	Margin	Exp.	FT	IR	JR	K	Value	Margin	Exp.	FT	IR	JR	K
1.359	20	31	46	1.715	0.822	20	29	46	9.18	0.798	4.6	19	35	50	4	11.79	0.867	6.3	19	35	50	4
1.347	19	37	30	1.739	0.811	21	31	54	9.10	0.792	4.4	19	39	50	4	11.77	0.865	6.2	19	37	52	4
1.344	20	33	48	1.749	0.806	20	27	48	9.09	0.790	4.7	19	37	52	4	11.76	0.864	6.0	19	21	50	4
1.342	19	39	28	1.752	0.805	20	29	50	9.07	0.789	4.8	20	31	50	5	11.69	0.859	6.4	20	29	50	5
1.342	20	31	50	1.765	0.799	19	35	50	9.00	0.782	4.7	20	27	48	5	11.66	0.858	6.4	20	29	46	5
1.333	19	37	26	1.766	0.799	20	29	42	8.98	0.781	4.7	20	29	46	5	11.64	0.856	6.4	20	33	52	5
1.332	20	29	42	1.773	0.795	20	33	52	8.94	0.777	4.7	20	33	52	5	11.55	0.849	3.3	19	37	14	4
1.327	19	35	50	1.780	0.792	21	35	54	8.93	0.776	3.4	19	37	48	4	11.54	0.848	6.2	21	43	12	4
1.320	20	27	44	1.784	0.790	21	17	50	8.92	0.776	4.8	21	31	54	4	11.52	0.847	6.2	21	41	52	4
1.311	19	27	40	1.784	0.790	19	37	30	8.89	0.773	4.7	21	35	54	4	11.50	0.846	6.2	20	27	48	5

* LHGR calculated with pin-power reconstruction
* CPR calculated with pin-power reconstruction & CPR limit TYPE 3

Figure A.8 Browns Ferry Equilibrium Cycle Control Rod Pattern and Axial Distributions at 2,200.0 MWd/MTU

```
Cycle:                             21                           Core Average Exposure: MWd/MTU    20474.0
Exposure: MWd/MTU (GWd)        2700.0 ( 373.61 )
Delta E: MWd/MTU, (GWd)         500.0 (  69.19 )                    Axial Profile    Edit   Radial Power
Power: MWt                     3952.0 (100.00 %)             N(PRA) Power Exposure  Zone  Avg.  Max.  IR JR
Core Pressure: psia            1050.0                         Top 25  0.155   4.234    13  0.470 0.686  15  8
Inlet Subcooling: Btu/lbm      -29.17                             24  0.420  11.432    14  0.378 0.686  27  4
Flow: Mlb/hr                    95.22 ( 92.90 %)                  23  0.528  14.597    15  0.464 0.736  33 58
                                                                  22  0.595  16.686    16  1.099 1.277  29 44
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58                   21  0.638  18.066    17  1.119 1.274  39 30
59             -- -- -- -- -- -- -- --            59              20  0.670  19.147    18  0.996 1.307  29 48
55          -- -- -- -- -- -- -- -- -- --         55              19  0.687  19.839    19  1.259 1.353  37 30
51       -- -- -- -- -- -- -- -- -- -- -- --      51              18  0.711  20.585    20  1.209 1.367  31 46
47    -- -- -- -- -- -- -- -- -- -- -- -- -- --   47              17  0.739  21.255    21  1.123 1.258  31 54
43 -- -- -- -- -- -- 10 -- -- -- 10 -- -- -- -- -- 43             16  0.789  21.465
39 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 39             15  0.872  21.517
35 -- -- -- 14 -- -- --  8 -- -- -- 14 -- -- -- 35                14  0.929  22.245
31 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 31             13  0.988  22.921
27 -- -- -- 14 -- -- --  8 -- -- -- 14 -- -- -- 27                12  1.058  23.782
23 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 23             11  1.123  24.234
19 -- -- -- -- -- -- 10 -- -- -- 10 -- -- -- -- -- 19             10  1.267  23.433
15    -- -- -- -- -- -- -- -- -- -- -- -- -- --   15               9  1.377  24.207
11       -- -- -- -- -- -- -- -- -- -- -- --      11               8  1.473  24.848
 7          -- -- -- -- -- -- -- -- -- --          7               7  1.580  25.564
 3             -- -- -- -- -- -- -- --             3               6  1.682  26.116
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58                    5  1.753* 26.293*
                                                                   4  1.738  25.552
Control Rod Density: %           4.14                              3  1.614  23.595
                                                                   2  1.263  18.225
k-effective:                  0.99956                      Bottom  1  0.352   5.466
Void Fraction:                  0.504
Core Delta-P: psia             22.600                   % AXIAL TILT -35.597 -12.601
Core Plate Delta-P: psia       18.044               AVG BOT 8ft/12ft  1.1989  1.0697
Coolant Temp: Deg-F             548.5
In Channel Flow: Mlb/hr         83.40   Active Channel Flow: Mlb/hr        80.33
Total Bypass Flow (%):           12.4   (of total core flow)
Total Water Rod Flow (%):         3.2   (of total core flow)
Source Convergence            0.00008
```

Top Ten Thermal Limits Summary - Sorted by Margin

Power				MCPR					APLHGR							LHGR						
Value	FT	IR	JR	Value	Margin	FT	IR	JR	Value	Margin	Exp.	FT	IR	JR	K	Value	Margin	Exp.	FT	IR	JR	K
1.367	20	31	46	1.695	0.832	20	29	46	9.23	0.803	5.8	19	35	50	4	11.70	0.860	7.8	19	35	50	4
1.353	19	37	30	1.731	0.815	21	31	54	9.13	0.794	5.8	19	37	52	4	11.65	0.857	7.7	19	37	52	4
1.353	20	33	48	1.732	0.814	20	29	50	9.12	0.793	5.6	19	39	50	4	11.64	0.856	7.5	19	21	50	4
1.350	20	31	50	1.733	0.814	20	27	48	9.10	0.791	5.9	20	31	50	5	11.63	0.855	7.8	20	29	50	4
1.348	19	39	28	1.747	0.807	20	29	42	9.02	0.784	5.8	20	27	48	5	11.58	0.851	7.8	20	33	52	4
1.340	20	29	42	1.750	0.806	19	35	50	9.00	0.783	5.9	20	29	46	5	11.57	0.851	7.7	20	29	46	5
1.340	19	37	26	1.756	0.803	20	27	52	8.96	0.779	5.8	20	33	52	5	11.42	0.840	4.8	19	37	14	4
1.334	19	35	50	1.768	0.798	19	37	30	8.96	0.779	4.6	19	37	48	4	11.42	0.840	7.6	21	43	12	4
1.328	20	27	44	1.770	0.797	21	35	54	8.94	0.777	5.9	21	31	54	4	11.40	0.838	7.6	21	41	52	4
1.318	19	27	40	1.771	0.796	20	25	46	8.91	0.775	5.8	21	35	54	4	11.40	0.838	7.6	20	27	48	5

* LHGR calculated with pin-power reconstruction
* CPR calculated with pin-power reconstruction & CPR limit TYPE 3

Figure A.9 Browns Ferry Equilibrium Cycle Control Rod Pattern and Axial Distributions at 2,700.0 MWd/MTU

```
Cycle:                              21                   Core Average Exposure: MWd/MTU    20973.8
Exposure: MWd/MTU (GWd)         3200.0 ( 442.80 )
Delta E: MWd/MTU, (GWd)          500.0 (  69.19 )               Axial Profile    Edit   Radial Power
Power: MWt                      3952.0 (100.00 %)          N(PRA) Power Exposure  Zone  Avg.  Max.  IR JR
Core Pressure: psia             1050.0                    Top 25  0.157   4.319    13  0.467 0.683  15  8
Inlet Subcooling: Btu/lbm       -30.00                        24  0.423  11.663    14  0.375 0.682  27  4
Flow: Mlb/hr                     92.76 ( 90.50 %)             23  0.531  14.887    15  0.460 0.732  33 58
                                                              22  0.598  17.015    16  1.097 1.276  29 44
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58               21  0.642  18.419    17  1.116 1.271  39 30
59             -- -- -- -- -- -- -- --             59         20  0.674  19.517    18  0.991 1.305  29 48
55          -- -- -- -- -- -- -- -- -- --          55         19  0.691  20.219    19  1.264 1.358  37 30
51       -- -- -- -- -- -- -- -- -- -- -- --       51         18  0.715  20.978    20  1.215 1.376  31 46
47    -- -- -- -- -- -- -- -- -- -- -- -- -- --    47         17  0.742  21.663    21  1.124 1.262  31 54
43 -- -- -- -- -- 10 -- -- -- 10 -- -- -- -- -- 43         16  0.791  21.891
39 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 39         15  0.873  21.959
35 -- -- -- 14 -- -- --  8 -- -- -- 14 -- -- -- 35         14  0.929  22.716
31 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 31         13  0.986  23.421
27 -- -- -- 14 -- -- --  8 -- -- -- 14 -- -- -- 27         12  1.056  24.318
23 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 23         11  1.118  24.801
19 -- -- -- -- -- 10 -- -- -- 10 -- -- -- -- -- 19         10  1.259  24.009
15    -- -- -- -- -- -- -- -- -- -- -- -- -- --    15          9  1.367  24.826
11       -- -- -- -- -- -- -- -- -- -- -- --       11          8  1.462  25.511
 7          -- -- -- -- -- -- -- -- -- --           7          7  1.569  26.275
 3             -- -- -- -- -- -- -- --              3          6  1.673  26.873
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58                5  1.748* 27.083*
                                                               4  1.741  26.338
Control Rod Density: %            4.14                         3  1.625  24.327
                                                               2  1.274  18.798
k-effective:                   0.99930                 Bottom  1  0.358   5.643
Void Fraction:                   0.507
Core Delta-P: psia              21.738                 % AXIAL TILT -35.332 -12.979
Core Plate Delta-P: psia        17.183             AVG BOT 8ft/12ft  1.1972  1.0714
Coolant Temp: Deg-F              548.5
In Channel Flow: Mlb/hr          81.21   Active Channel Flow: Mlb/hr        78.21
Total Bypass Flow (%):            12.5   (of total core flow)
Total Water Rod Flow (%):          3.2   (of total core flow)
Source Convergence             0.00008
```

Top Ten Thermal Limits Summary - Sorted by Margin

Power				MCPR					APLHGR							LHGR						
Value	FT	IR	JR	Value	Margin	FT	IR	JR	Value	Margin	Exp.	FT	IR	JR	K	Value	Margin	Exp.	FT	IR	JR	K
1.376	20	31	46	1.669	0.845	20	29	46	9.31	0.810	6.9	19	35	50	4	11.64	0.856	9.1	19	35	50	4
1.361	20	33	48	1.705	0.827	20	29	50	9.20	0.800	7.0	19	37	52	4	11.61	0.854	9.3	20	29	50	4
1.358	19	37	30	1.705	0.827	20	27	48	9.17	0.798	6.7	19	39	50	4	11.58	0.851	9.1	20	27	52	4
1.358	20	31	50	1.716	0.822	21	31	54	9.14	0.795	7.1	20	31	50	5	11.57	0.851	9.2	19	37	52	4
1.355	19	39	28	1.721	0.819	20	29	42	9.05	0.787	6.9	20	27	48	5	11.54	0.849	9.0	19	21	50	4
1.348	20	29	42	1.723	0.818	19	35	50	9.04	0.786	7.0	20	29	46	5	11.52	0.847	9.2	20	29	46	5
1.346	19	37	26	1.728	0.816	20	27	52	9.03	0.786	6.8	20	33	52	4	11.34	0.834	8.9	20	27	48	4
1.341	19	35	50	1.737	0.812	19	37	30	9.02	0.784	5.7	19	37	48	4	11.34	0.834	9.0	21	43	12	4
1.336	20	27	44	1.745	0.808	20	25	46	8.99	0.782	7.0	21	31	54	4	11.33	0.833	6.2	19	37	14	4
1.324	19	27	40	1.751	0.805	19	39	28	8.98	0.781	6.9	21	35	54	4	11.33	0.833	9.1	21	41	52	4

* LHGR calculated with pin-power reconstruction
* CPR calculated with pin-power reconstruction & CPR limit TYPE 3

Figure A.10 Browns Ferry Equilibrium Cycle Control Rod Pattern and Axial Distributions at 3,200.0 MWd/MTU

Cycle:	21	
Exposure: MWd/MTU (GWd)	3700.0	(511.98)
Delta E: MWd/MTU, (GWd)	500.0	(69.19)
Power: MWt	3952.0	(100.00 %)
Core Pressure: psia	1050.0	
Inlet Subcooling: Btu/lbm	-30.58	
Flow: Mlb/hr	91.12	(88.90 %)

Core Average Exposure: MWd/MTU 21473.9

N(PRA)	Axial Profile Power	Axial Profile Exposure
Top 25	0.158	4.404
24	0.425	11.895
23	0.532	15.179
22	0.601	17.346
21	0.645	18.774
20	0.677	19.890
19	0.694	20.600
18	0.717	21.373
17	0.744	22.073
16	0.792	22.318
15	0.872	22.401
14	0.928	23.187
13	0.984	23.921
12	1.052	24.852
11	1.113	25.366
10	1.252	24.582
9	1.357	25.441
8	1.452	26.168
7	1.560	26.982
6	1.665	27.626
5	1.745	27.871*
4	1.747*	27.126
3	1.637	25.064
2	1.286	19.377
Bottom 1	0.363	5.823

Edit Zone	Radial Power Avg.	Radial Power Max.	IR	JR
13	0.463	0.678	15	8
14	0.371	0.678	27	4
15	0.456	0.727	33	58
16	1.095	1.274	29	44
17	1.114	1.268	21	32
18	0.987	1.303	29	48
19	1.270	1.364	23	32
20	1.222	1.385	31	46
21	1.126	1.266	31	54

	2	6	10	14	18	22	26	30	34	38	42	46	50	54	58	
59					--	--	--	--	--	--	--					59
55				--	--	--	--	--	--	--	--	--				55
51			--	--	--	--	--	--	--	--	--	--	--			51
47		--	--	--	--	--	--	--	--	--	--	--	--	--		47
43	--	--	--	--	--	10	--	--	--	10	--	--	--	--	--	43
39	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	39
35	--	--	--	14	--	--	--	8	--	--	--	14	--	--	--	35
31	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	31
27	--	--	--	14	--	--	--	8	--	--	--	14	--	--	--	27
23	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	23
19	--	--	--	--	--	10	--	--	--	10	--	--	--	--	--	19
15		--	--	--	--	--	--	--	--	--	--	--	--	--		15
11			--	--	--	--	--	--	--	--	--	--	--			11
7				--	--	--	--	--	--	--	--	--				7
3					--	--	--	--	--	--	--					3
	2	6	10	14	18	22	26	30	34	38	42	46	50	54	58	

Control Rod Density: % 4.14

k-effective:	0.99925	
Void Fraction:	0.509	
Core Delta-P: psia	21.175	% AXIAL TILT -35.165 -13.334
Core Plate Delta-P: psia	16.621	AVG BOT 8ft/12ft 1.1960 1.0731
Coolant Temp: Deg-F	548.4	
In Channel Flow: Mlb/hr	79.75	Active Channel Flow: Mlb/hr 76.79
Total Bypass Flow (%):	12.5	(of total core flow)
Total Water Rod Flow (%):	3.2	(of total core flow)
Source Convergence	0.00008	

Top Ten Thermal Limits Summary - Sorted by Margin

Power Value	FT	IR	JR	MCPR Value	Margin	FT	IR	JR	APLHGR Value	Margin	Exp.	FT	IR	JR	K	LHGR Value	Margin	Exp.	FT	IR	JR	K
1.385	20	31	46	1.648	0.856	20	29	46	9.41	0.819	8.1	19	35	50	4	11.67	0.858	10.6	19	35	50	4
1.370	20	33	48	1.683	0.838	20	29	50	9.29	0.808	8.1	19	37	52	4	11.66	0.858	10.6	20	29	50	4
1.367	20	31	50	1.683	0.838	20	27	48	9.26	0.805	8.0	20	31	50	4	11.62	0.855	10.6	20	27	52	4
1.364	19	23	32	1.700	0.829	20	29	42	9.25	0.804	7.9	19	39	50	4	11.53	0.848	10.4	19	21	50	4
1.361	19	39	28	1.702	0.828	19	35	50	9.19	0.799	8.0	20	33	52	4	11.53	0.847	10.5	19	23	52	4
1.356	20	29	42	1.706	0.826	21	31	54	9.13	0.794	7.9	20	33	48	4	11.52	0.847	10.4	20	29	46	4
1.353	19	37	26	1.707	0.826	20	27	52	9.11	0.792	8.1	20	29	46	5	11.36	0.835	10.2	20	27	48	4
1.349	19	35	50	1.714	0.823	19	37	30	9.10	0.791	6.8	19	37	48	4	11.30	0.831	10.1	20	25	46	4
1.345	20	27	44	1.725	0.817	20	25	46	9.06	0.788	8.1	21	31	54	4	11.29	0.830	10.5	21	35	54	4
1.331	19	27	40	1.727	0.816	19	39	28	9.06	0.788	8.1	21	35	54	4	11.28	0.829	10.5	21	43	12	4

* LHGR calculated with pin-power reconstruction
* CPR calculated with pin-power reconstruction & CPR limit TYPE 3

Figure A.11 Browns Ferry Equilibrium Cycle Control Rod Pattern and Axial Distributions at 3,700.0 MWd/MTU

```
Cycle:                           21                         Core Average Exposure: MWd/MTU    21973.9
Exposure: MWd/MTU (GWd)      4200.0 ( 581.17 )
Delta E: MWd/MTU, (GWd)       500.0 (  69.19 )                 Axial Profile    Edit   Radial Power
Power: MWt                   3952.0 (100.00 %)           N(PRA) Power Exposure  Zone  Avg.  Max.  IR JR
Core Pressure: psia          1050.0                     Top 25  0.159   4.491    13  0.459 0.674  15  8
Inlet Subcooling: Btu/lbm    -31.30                         24  0.425  12.128    14  0.367 0.674  27  4
Flow: Mlb/hr                  89.18 ( 87.00 %)              23  0.532  15.471    15  0.452 0.723  33 58
                                                            22  0.601  17.677    16  1.093 1.273  29 44
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58             21  0.645  19.130    17  1.111 1.265  21 32
59             -- -- -- -- -- -- -- --             59       20  0.678  20.263    18  0.982 1.302  29 48
55          -- -- -- -- -- -- -- -- -- --          55       19  0.695  20.983    19  1.276 1.370  23 32
51       -- -- -- -- -- -- -- -- -- -- -- --       51       18  0.718  21.769    20  1.229 1.395  31 46
47    -- -- -- -- -- -- -- -- -- -- -- -- -- --    47       17  0.745  22.484    21  1.128 1.271  31 54
43 -- -- -- -- -- 10 -- -- -- 10 -- -- -- -- -- 43          16  0.791  22.745
39 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 39          15  0.870  22.843
35 -- -- -- 14 -- -- --  8 -- -- -- 14 -- -- -- 35          14  0.924  23.656
31 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 31          13  0.980  24.418
27 -- -- -- 14 -- -- --  8 -- -- -- 14 -- -- -- 27          12  1.047  25.384
23 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 23          11  1.107  25.928
19 -- -- -- -- -- 10 -- -- -- 10 -- -- -- -- -- 19          10  1.243  25.151
15    -- -- -- -- -- -- -- -- -- -- -- -- -- --    15        9  1.346  26.052
11       -- -- -- -- -- -- -- -- -- -- -- --       11        8  1.441  26.821
 7          -- -- -- -- -- -- -- -- -- --           7        7  1.551  27.684
 3             -- -- -- -- -- -- -- --              3        6  1.660  28.377
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58              5  1.747  28.660*
                                                             4  1.759* 27.917
Control Rod Density: %         4.14                          3  1.658  25.808
                                                             2  1.306  19.963
k-effective:                0.99918               Bottom  1  0.370   6.005
Void Fraction:                0.512
Core Delta-P: psia           20.523            % AXIAL TILT -35.188 -13.671
Core Plate Delta-P: psia     15.969          AVG BOT 8ft/12ft  1.1957  1.0746
Coolant Temp: Deg-F           548.4
In Channel Flow: Mlb/hr       78.01   Active Channel Flow: Mlb/hr        75.11
Total Bypass Flow (%):         12.5   (of total core flow)
Total Water Rod Flow (%):       3.3   (of total core flow)
Source Convergence          0.00008
```

Top Ten Thermal Limits Summary - Sorted by Margin

Power Value	FT	IR	JR	MCPR Value	Margin	FT	IR	JR	APLHGR Value	Margin	Exp.	FT	IR	JR	K	LHGR Value	Margin	Exp.	FT	IR	JR	K
1.395	20	31	46	1.623	0.869	20	29	46	9.55	0.831	9.3	19	35	50	4	11.77	0.865	12.1	20	29	50	4
1.379	20	33	48	1.657	0.851	20	29	50	9.46	0.822	9.2	20	31	50	4	11.74	0.863	12.1	19	35	50	4
1.377	20	31	50	1.658	0.850	20	27	48	9.41	0.819	9.3	19	37	52	4	11.72	0.862	12.1	20	27	52	4
1.370	19	23	32	1.676	0.841	20	29	42	9.38	0.816	9.1	20	33	52	4	11.63	0.855	11.9	20	29	46	4
1.368	19	39	28	1.678	0.840	19	35	50	9.35	0.813	9.1	19	39	50	4	11.56	0.850	11.9	19	23	52	4
1.365	20	29	42	1.682	0.838	20	27	52	9.32	0.810	9.0	20	33	48	4	11.55	0.850	11.8	19	21	50	4
1.360	19	37	26	1.689	0.835	19	37	30	9.27	0.806	9.0	20	29	46	4	11.44	0.842	11.7	20	27	48	4
1.357	19	35	50	1.694	0.832	21	31	54	9.21	0.801	8.0	19	37	48	4	11.39	0.837	11.5	20	25	46	4
1.354	20	27	44	1.701	0.829	19	39	28	9.19	0.799	9.2	19	33	54	4	11.34	0.834	11.8	21	25	8	4
1.339	19	27	40	1.702	0.828	20	25	46	9.18	0.798	9.2	21	35	54	4	11.29	0.830	11.9	21	31	8	4

* LHGR calculated with pin-power reconstruction
* CPR calculated with pin-power reconstruction & CPR limit TYPE 3

Figure A.12 Browns Ferry Equilibrium Cycle Control Rod Pattern and Axial Distributions at 4,200.0 MWd/MTU

```
Cycle:                           21                          Core Average Exposure: MWd/MTU    22183.4
Exposure: MWd/MTU (GWd)      4409.7 ( 610.19 )
Delta E: MWd/MTU, (GWd)       209.7 (  29.02 )                  Axial Profile    Edit   Radial Power
Power: MWt                   3952.0 (100.00 %)            N(PRA) Power Exposure  Zone  Avg.  Max.  IR JR
Core Pressure: psia          1050.0                      Top 25  0.160   4.527    13  0.457 0.672  15  8
Inlet Subcooling: Btu/lbm    -31.53                          24  0.424  12.226    14  0.365 0.673  27  4
Flow: Mlb/hr                  88.56 ( 86.40 %)               23  0.532  15.593    15  0.450 0.721  33 58
                                                             22  0.601  17.816    16  1.092 1.272  29 44
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58              21  0.645  19.280    17  1.110 1.263  21 32
59             -- -- -- -- -- -- --             59           20  0.677  20.420    18  0.980 1.301  29 48
55          -- -- -- -- -- -- -- -- --          55           19  0.695  21.144    19  1.279 1.373  37 30
51       -- -- -- -- -- -- -- -- -- -- --       51           18  0.718  21.935    20  1.232 1.399  31 46
47    -- -- -- -- -- -- -- -- -- -- -- -- --    47           17  0.744  22.656    21  1.129 1.273  31 54
43 -- -- -- -- -- 10 -- -- -- 10 -- -- -- -- -- 43           16  0.790  22.924
39 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 39           15  0.869  23.028
35 -- -- -- 14 -- -- --  8 -- -- -- 14 -- -- -- 35           14  0.922  23.852
31 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 31           13  0.978  24.626
27 -- -- -- 14 -- -- --  8 -- -- -- 14 -- -- -- 27           12  1.044  25.607
23 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 23           11  1.104  26.163
19 -- -- -- -- -- 10 -- -- -- 10 -- -- -- -- -- 19           10  1.239  25.388
15    -- -- -- -- -- -- -- -- -- -- -- -- --    15            9  1.342  26.306
11       -- -- -- -- -- -- -- -- -- -- --       11            8  1.437  27.094
 7          -- -- -- -- -- -- -- -- --           7            7  1.548  27.978
 3             -- -- -- -- -- -- --              3            6  1.659  28.691
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58               5  1.748  28.990*
                                                              4  1.765* 28.251
Control Rod Density: %         4.14                           3  1.669  26.124
                                                              2  1.316  20.211
k-effective:                0.99922                   Bottom  1  0.374   6.083
Void Fraction:                0.513
Core Delta-P: psia           20.322                 % AXIAL TILT -35.248 -13.809
Core Plate Delta-P: psia     15.768             AVG BOT 8ft/12ft  1.1959  1.0753
Coolant Temp: Deg-F           548.4
In Channel Flow: Mlb/hr       77.46  Active Channel Flow: Mlb/hr        74.57
Total Bypass Flow (%):         12.5  (of total core flow)
Total Water Rod Flow (%):       3.3  (of total core flow)
Source Convergence          0.00008
```

Top Ten Thermal Limits Summary - Sorted by Margin

Power				MCPR					APLHGR							LHGR						
Value	FT	IR	JR	Value	Margin	FT	IR	JR	Value	Margin	Exp.	FT	IR	JR	K	Value	Margin	Exp.	FT	IR	JR	K
1.399	20	31	46	1.615	0.873	20	29	46	9.62	0.837	9.8	19	35	50	4	11.81	0.869	12.7	20	29	50	4
1.383	20	33	48	1.648	0.855	20	29	50	9.55	0.831	9.7	20	31	50	4	11.78	0.866	12.7	19	35	50	4
1.381	20	31	50	1.649	0.855	20	27	48	9.48	0.824	9.8	19	37	52	4	11.77	0.865	12.7	20	27	52	4
1.373	19	37	30	1.668	0.845	20	29	42	9.47	0.824	9.6	20	33	52	4	11.68	0.859	12.5	20	29	46	4
1.371	19	39	28	1.670	0.845	19	35	50	9.41	0.818	9.5	20	33	48	4	11.58	0.851	12.5	19	23	52	4
1.369	20	29	42	1.673	0.843	20	27	52	9.40	0.818	9.6	19	39	50	4	11.57	0.851	12.4	19	21	50	4
1.363	19	37	26	1.680	0.839	19	37	30	9.37	0.815	9.5	20	29	46	4	11.49	0.845	12.3	20	27	48	4
1.361	19	35	50	1.690	0.834	21	31	54	9.26	0.806	8.5	19	37	48	4	11.44	0.841	12.1	20	25	46	4
1.358	20	27	44	1.692	0.833	19	39	28	9.25	0.805	9.7	19	33	54	4	11.38	0.837	12.4	21	25	8	4
1.342	19	27	40	1.694	0.832	20	25	46	9.24	0.803	9.7	21	35	54	4	11.32	0.832	12.5	21	31	8	4

* LHGR calculated with pin-power reconstruction
* CPR calculated with pin-power reconstruction & CPR limit TYPE 3

Figure A.13 Browns Ferry Equilibrium Cycle Control Rod Pattern and Axial Distributions at 4,409.7 MWd/MTU

```
Cycle:                            21                    Core Average Exposure: MWd/MTU    22184.2
Exposure: MWd/MTU (GWd)       4410.4 ( 610.29 )
Delta E: MWd/MTU, (GWd)          0.7 (    0.10 )           Axial Profile    Edit   Radial Power
Power: MWt                    3952.0 (100.00 %)       N(PRA) Power Exposure  Zone  Avg.  Max.  IR JR
Core Pressure: psia           1050.0                 Top 25  0.166   4.527    13  0.462 0.676   7 16
Inlet Subcooling: Btu/lbm     -27.44                     24  0.444  12.226    14  0.369 0.676  27  4
Flow: Mlb/hr                  100.76 ( 98.30 %)          23  0.555  15.593    15  0.456 0.725  33 58
                                                         22  0.622  17.817    16  1.096 1.337  29 30
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58          21  0.660  19.280    17  1.104 1.321  31 26
59             -- -- -- -- -- -- -- --           59      20  0.681  20.421    18  0.981 1.235  29 48
55          -- -- -- -- -- -- -- -- -- --        55      19  0.696  21.145    19  1.301 1.430  33 26
51       -- -- -- -- -- -- -- -- -- -- -- --     51      18  0.718  21.936    20  1.192 1.452  33 30
47    -- -- -- -- -- -- -- -- -- -- -- -- -- --  47      17  0.743  22.657    21  1.152 1.275  31 54
43 -- -- -- -- 14 --  8 --  8 -- 14 -- -- -- -- 43      16  0.788  22.924
39 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 39      15  0.867  23.028
35 -- -- -- --  8 -- -- -- -- --  8 -- -- -- -- 35      14  0.921  23.853
31 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 31      13  0.977  24.627
27 -- -- -- --  8 -- -- -- -- --  8 -- -- -- -- 27      12  1.045  25.607
23 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 23      11  1.107  26.164
19 -- -- -- -- 14 --  8 --  8 -- 14 -- -- -- -- 19      10  1.244  25.389
15    -- -- -- -- -- -- -- -- -- -- -- -- -- --  15       9  1.351  26.307
11       -- -- -- -- -- -- -- -- -- -- -- --     11       8  1.448  27.095
 7          -- -- -- -- -- -- -- -- -- --         7       7  1.559  27.979
 3             -- -- -- -- -- -- -- --            3       6  1.667  28.693
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58           5  1.748* 28.992*
                                                          4  1.744  28.252
Control Rod Density: %          5.14                      3  1.625  26.125
                                                          2  1.267  20.212
k-effective:                 0.99915             Bottom  1  0.358   6.084
Void Fraction:                 0.492
Core Delta-P: psia            24.569            % AXIAL TILT -34.570 -13.809
Core Plate Delta-P: psia      20.007        AVG BOT 8ft/12ft  1.1908  1.0753
Coolant Temp: Deg-F            548.6
In Channel Flow: Mlb/hr        88.36  Active Channel Flow: Mlb/hr        85.17
Total Bypass Flow (%):          12.3  (of total core flow)
Total Water Rod Flow (%):        3.2  (of total core flow)
Source Convergence           0.00009
```

```
                          Top Ten Thermal Limits Summary - Sorted by Margin

     Power                  MCPR                          APLHGR                              LHGR
Value FT  IR JR    Value Margin FT  IR JR    Value Margin Exp. FT  IR JR  K    Value Margin Exp. FT  IR JR  K
1.452  20 33 30    1.652  0.854  20 31 28    9.45  0.822  9.8  19 37 52  4    11.59  0.852 12.7  19 35 50  4
1.451  20 31 28    1.674  0.842  20 27 32    9.44  0.821  9.8  19 35 50  4    11.57  0.851 12.7  20 27 52  4
1.430  19 33 26    1.698  0.831  19 27 36    9.39  0.816  9.6  20 33 52  4    11.57  0.851 12.7  20 29 50  4
1.430  19 35 28    1.699  0.830  19 35 28    9.30  0.809  9.6  19 39 50  4    11.55  0.850  6.9  20 31 28  5
1.386  19 31 24    1.803  0.782  21 31 54    9.27  0.806  9.7  20 31 50  4    11.48  0.844 12.5  19 23 52  4
1.383  19 23 32    1.810  0.779  19 23 32    9.27  0.806  9.2  19  9 24  4    11.46  0.843 12.4  19 21 50  4
1.354  19 35 24    1.810  0.779  20 29 50    9.25  0.805  9.7  19 33 54  4    11.39  0.838 11.6  19 27 36  4
1.350  19 37 26    1.811  0.779  19 31 24    9.24  0.804  9.7  21 35 54  4    11.38  0.837 11.4  19 11 36  4
1.345  20 31 50    1.814  0.777  20 27 52    9.21  0.801  9.8  21 31 54  4    11.35  0.835 11.6  19 35 28  4
1.340  19 35 50    1.823  0.774  19 35 50    9.20  0.800  9.2  19 25 34  4    11.35  0.835 11.5  20 27 32  5

  * LHGR calculated with pin-power reconstruction
  * CPR calculated with pin-power reconstruction & CPR limit TYPE 3
```

Figure A.14 Browns Ferry Equilibrium Cycle Control Rod Pattern and Axial Distributions at 4,410.4 MWd/MTU

```
Cycle:                          21                       Core Average Exposure: MWd/MTU    22673.7
Exposure: MWd/MTU (GWd)      4900.0 ( 678.03 )
Delta E: MWd/MTU, (GWd)       489.6 (  67.74 )                Axial Profile    Edit   Radial Power
Power: MWt                   3952.0 (100.00 %)          N(PRA) Power Exposure  Zone  Avg.  Max.  IR JR
Core Pressure: psia          1050.0                    Top 25  0.166   4.615    13  0.458 0.672   7 16
Inlet Subcooling: Btu/lbm    -28.19                        24  0.443  12.464    14  0.365 0.672  27  4
Flow: Mlb/hr                  98.30 ( 95.90 %)             23  0.554  15.891    15  0.452 0.721  33 58
                                                           22  0.621  18.152    16  1.094 1.328  29 30
   2  6 10 14 18 22 26 30 34 38 42 46 50 54 58             21  0.659  19.636    17  1.101 1.315  31 26
59             -- -- -- -- -- -- -- --             59      20  0.680  20.788    18  0.976 1.234  29 48
55          -- -- -- -- -- -- -- -- -- --          55      19  0.696  21.521    19  1.308 1.435  33 26
51       -- -- -- -- -- -- -- -- -- -- -- --       51      18  0.717  22.323    20  1.199 1.457  33 30
47    -- -- -- -- -- -- -- -- -- -- -- -- -- --    47      17  0.742  23.058    21  1.154 1.280  31 54
43 -- -- -- -- 14 --  8 --  8 -- 14 -- -- -- -- -- 43      16  0.785  23.339
39 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 39      15  0.862  23.457
35 -- -- -- --  8 -- -- -- -- --  8 -- -- -- -- -- 35      14  0.915  24.308
31 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 31      13  0.970  25.110
27 -- -- -- --  8 -- -- -- -- --  8 -- -- -- -- -- 27      12  1.038  26.124
23 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 23      11  1.098  26.710
19 -- -- -- -- 14 --  8 --  8 -- 14 -- -- -- -- -- 19      10  1.233  25.943
15    -- -- -- -- -- -- -- -- -- -- -- -- -- --    15       9  1.339  26.902
11       -- -- -- -- -- -- -- -- -- -- -- --       11       8  1.437  27.732
 7          -- -- -- -- -- -- -- -- -- --           7       7  1.551  28.666
 3             -- -- -- -- -- -- -- --              3       6  1.664  29.429
   2  6 10 14 18 22 26 30 34 38 42 46 50 54 58              5  1.752  29.765*
                                                            4  1.763* 29.028
Control Rod Density: %         5.14                         3  1.654  26.850
                                                            2  1.294  20.778
k-effective:                0.99908                 Bottom  1  0.367   6.261
Void Fraction:                0.496
Core Delta-P: psia           23.688                % AXIAL TILT -34.751 -14.108
Core Plate Delta-P: psia     19.128            AVG BOT 8ft/12ft  1.1913  1.0766
Coolant Temp: Deg-F           548.6
In Channel Flow: Mlb/hr       86.16   Active Channel Flow: Mlb/hr        83.02
Total Bypass Flow (%):         12.4   (of total core flow)
Total Water Rod Flow (%):       3.2   (of total core flow)
Source Convergence          0.00010
```

Top Ten Thermal Limits Summary - Sorted by Margin

Power				MCPR					APLHGR							LHGR						
Value	FT	IR	JR	Value	Margin	FT	IR	JR	Value	Margin	Exp.	FT	IR	JR	K	Value	Margin	Exp.	FT	IR	JR	K
1.457	20	33	30	1.657	0.851	20	31	28	9.62	0.836	10.8	20	33	52	4	11.68	0.859	14.2	20	29	50	4
1.453	20	31	28	1.658	0.851	20	27	32	9.61	0.836	11.0	19	35	50	4	11.67	0.858	14.1	20	27	52	4
1.435	19	33	26	1.680	0.839	19	35	28	9.60	0.835	11.0	19	37	52	4	11.67	0.858	14.1	19	35	50	4
1.435	19	35	28	1.681	0.839	19	27	36	9.50	0.826	10.9	20	31	50	4	11.52	0.847	14.0	19	23	52	4
1.391	19	31	24	1.783	0.791	20	29	50	9.44	0.821	10.7	19	39	50	4	11.50	0.846	13.8	19	21	50	4
1.389	19	23	32	1.787	0.789	20	27	52	9.42	0.820	10.8	19	33	54	4	11.48	0.844	8.4	20	31	28	5
1.360	19	35	24	1.787	0.789	19	23	32	9.40	0.817	10.8	21	35	54	4	11.44	0.841	13.8	21	25	8	4
1.357	19	37	26	1.788	0.789	19	31	24	9.39	0.817	10.4	19	9	24	4	11.42	0.840	12.8	19	11	36	4
1.356	20	31	50	1.789	0.788	21	31	54	9.35	0.813	10.9	21	31	54	4	11.40	0.839	13.0	19	27	36	4
1.349	19	35	50	1.797	0.785	19	35	50	9.32	0.811	9.8	19	11	26	4	11.36	0.835	13.0	19	35	28	4

* LHGR calculated with pin-power reconstruction
* CPR calculated with pin-power reconstruction & CPR limit TYPE 3

Figure A.15 Browns Ferry Equilibrium Cycle Control Rod Pattern and Axial Distributions at 4,900.0 MWd/MTU

```
Cycle:                              21                   Core Average Exposure: MWd/MTU    23173.7
Exposure: MWd/MTU (GWd)         5400.0 ( 747.22 )
Delta E: MWd/MTU, (GWd)          500.0 (  69.19 )            Axial Profile    Edit   Radial Power
Power: MWt                      3952.0 (100.00 %)       N(PRA) Power Exposure  Zone  Avg.  Max.  IR JR
Core Pressure: psia             1050.0                 Top 25  0.166   4.705    13  0.454 0.668   7 16
Inlet Subcooling: Btu/lbm       -28.97                     24  0.440  12.706    14  0.361 0.668  27  4
Flow: Mlb/hr                     95.84 ( 93.50 %)          23  0.550  16.193    15  0.448 0.716  33 58
                                                           22  0.617  18.494    16  1.091 1.323  29 30
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58            21  0.655  19.998    17  1.098 1.310  29 26
59             -- -- -- -- -- -- -- --            59       20  0.677  21.163    18  0.972 1.232  29 48
55          -- -- -- -- -- -- -- -- -- --         55       19  0.693  21.904    19  1.314 1.442  35 28
51       -- -- -- -- -- -- -- -- -- -- -- --      51       18  0.715  22.718    20  1.206 1.464  33 30
47    -- -- -- -- -- -- -- -- -- -- -- -- -- --   47       17  0.739  23.466    21  1.157 1.285  31 54
43 -- -- -- -- 14 --  8 --  8 -- 14 -- -- -- -- -- 43      16  0.781  23.761
39 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 39         15  0.856  23.893
35 -- -- -- --  8 -- -- -- -- --  8 -- -- -- -- 35         14  0.908  24.770
31 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 31         13  0.963  25.600
27 -- -- -- --  8 -- -- -- -- --  8 -- -- -- -- 27         12  1.030  26.648
23 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 23         11  1.090  27.264
19 -- -- -- -- 14 --  8 --  8 -- 14 -- -- -- -- 19         10  1.223  26.503
15    -- -- -- -- -- -- -- -- -- -- -- -- -- --   15        9  1.327  27.503
11       -- -- -- -- -- -- -- -- -- -- -- --      11        8  1.426  28.379
 7          -- -- -- -- -- -- -- -- -- --          7        7  1.543  29.365
 3             -- -- -- -- -- -- -- --             3        6  1.661  30.179
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58             5  1.759  30.558*
                                                            4  1.784* 29.829
Control Rod Density: %            5.14                      3  1.690  27.606
                                                            2  1.328  21.371
k-effective:                   0.99899              Bottom  1  0.378   6.447
Void Fraction:                   0.501
Core Delta-P: psia              22.831              % AXIAL TILT -35.129 -14.406
Core Plate Delta-P: psia        18.271          AVG BOT 8ft/12ft  1.1929  1.0779
Coolant Temp: Deg-F              548.5
In Channel Flow: Mlb/hr          83.95   Active Channel Flow: Mlb/hr        80.87
Total Bypass Flow (%):            12.4   (of total core flow)
Total Water Rod Flow (%):          3.2   (of total core flow)
Source Convergence             0.00007
```

Top Ten Thermal Limits Summary - Sorted by Margin

Power Value	FT	IR	JR	MCPR Value	Margin	FT	IR	JR	APLHGR Value	Margin	Exp.	FT	IR	JR	K	LHGR Value	Margin	Exp.	FT	IR	JR	K
1.464	20	33	30	1.635	0.862	20	27	32	9.82	0.854	12.0	20	33	52	4	11.71	0.861	15.6	20	29	50	4
1.460	20	31	28	1.636	0.862	20	31	28	9.76	0.848	12.2	19	35	50	4	11.71	0.861	15.6	20	27	52	4
1.442	19	35	28	1.658	0.850	19	35	28	9.75	0.848	12.2	19	37	52	4	11.68	0.859	15.6	19	35	50	4
1.442	19	33	26	1.659	0.850	19	27	36	9.70	0.843	12.1	20	31	50	4	11.51	0.847	15.4	19	23	52	4
1.398	19	31	24	1.758	0.802	20	29	50	9.58	0.833	12.0	19	33	54	4	11.51	0.846	15.2	21	25	8	4
1.396	19	23	32	1.761	0.801	20	27	52	9.56	0.832	11.9	19	39	50	4	11.50	0.846	15.3	19	21	50	4
1.367	19	35	24	1.762	0.800	19	23	32	9.55	0.831	11.6	19	9	24	4	11.50	0.846	14.3	19	11	36	4
1.364	20	31	50	1.763	0.800	19	31	24	9.54	0.830	12.0	21	35	54	4	11.50	0.845	9.3	20	31	28	4
1.364	19	37	26	1.772	0.796	19	35	50	9.49	0.825	11.0	19	11	26	4	11.45	0.842	14.2	20	9	28	4
1.357	19	35	50	1.776	0.794	21	31	54	9.48	0.824	12.1	21	31	54	4	11.44	0.841	14.4	19	27	36	4

* LHGR calculated with pin-power reconstruction
* CPR calculated with pin-power reconstruction & CPR limit TYPE 3

Figure A.16 Browns Ferry Equilibrium Cycle Control Rod Pattern and Axial Distributions at 5,400.0 MWd/MTU

```
Cycle:                            21                        Core Average Exposure: MWd/MTU    23673.7
Exposure: MWd/MTU (GWd)       5900.0 ( 816.41 )
Delta E: MWd/MTU, (GWd)        500.0 (  69.19 )                Axial Profile    Edit   Radial Power
Power: MWt                    3952.0 (100.00 %)           N(PRA) Power Exposure  Zone  Avg.  Max.  IR JR
Core Pressure: psia           1050.0                     Top 25  0.166   4.795    13  0.450 0.664   7 16
Inlet Subcooling: Btu/lbm     -29.75                         24  0.437  12.947    14  0.357 0.664  27  4
Flow: Mlb/hr                   93.48 ( 91.20 %)              23  0.547  16.494    15  0.443 0.711  33 58
                                                             22  0.614  18.833    16  1.088 1.318  29 30
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58              21  0.653  20.359    17  1.095 1.306  29 26
59             -- -- -- -- -- -- -- --            59         20  0.675  21.536    18  0.967 1.228  29 48
55          -- -- -- -- -- -- -- -- -- --         55         19  0.691  22.285    19  1.320 1.449  35 28
51       -- -- -- -- -- -- -- -- -- -- -- --      51         18  0.713  23.112    20  1.213 1.472  33 30
47    -- -- -- -- -- -- -- -- -- -- -- -- -- --   47         17  0.737  23.873    21  1.159 1.288  31 54
43 -- -- -- -- -- 14 --  8 --  8 -- 14 -- -- -- -- 43        16  0.778  24.182
39 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 39        15  0.852  24.326
35 -- -- -- --  8 -- -- -- -- -- --  8 -- -- -- -- 35        14  0.903  25.230
31 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 31        13  0.958  26.087
27 -- -- -- --  8 -- -- -- -- -- --  8 -- -- -- -- 27        12  1.024  27.169
23 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 23        11  1.083  27.814
19 -- -- -- -- 14 --  8 --  8 -- 14 -- -- -- -- 19           10  1.214  27.059
15    -- -- -- -- -- -- -- -- -- -- -- -- -- --   15          9  1.317  28.100
11       -- -- -- -- -- -- -- -- -- -- -- --      11          8  1.417  29.020
 7          -- -- -- -- -- -- -- -- -- --          7          7  1.535  30.059
 3             -- -- -- -- -- -- -- --             3          6  1.656  30.928
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58               5  1.761  31.352*
                                                              4  1.800* 30.639
Control Rod Density: %          5.14                          3  1.721  28.376
                                                              2  1.359  21.978
k-effective:                 0.99893                  Bottom  1  0.388   6.638
Void Fraction:                 0.505
Core Delta-P: psia            22.019               % AXIAL TILT -35.394 -14.699
Core Plate Delta-P: psia      17.461           AVG BOT 8ft/12ft  1.1939  1.0792
Coolant Temp: Deg-F            548.5
In Channel Flow: Mlb/hr        81.84   Active Channel Flow: Mlb/hr        78.82
Total Bypass Flow (%):          12.5   (of total core flow)
Total Water Rod Flow (%):        3.2   (of total core flow)
Source Convergence           0.00008
```

Top Ten Thermal Limits Summary - Sorted by Margin

Power				MCPR					APLHGR							LHGR						
Value	FT	IR	JR	Value	Margin	FT	IR	JR	Value	Margin	Exp.	FT	IR	JR	K	Value	Margin	Exp.	FT	IR	JR	K
1.472	20	33	30	1.611	0.875	20	33	30	9.97	0.867	13.3	20	33	52	4	11.66	0.857	16.9	20	31	50	4
1.467	20	31	28	1.612	0.875	20	31	28	9.86	0.858	13.5	19	35	50	4	11.65	0.856	16.5	20	33	52	4
1.449	19	35	28	1.635	0.862	19	35	28	9.85	0.857	13.4	19	37	52	4	11.57	0.851	17.0	19	35	50	4
1.449	19	33	26	1.636	0.862	19	27	36	9.84	0.855	13.3	20	31	50	4	11.55	0.849	10.8	20	31	28	4
1.405	19	31	24	1.734	0.813	20	29	50	9.69	0.842	13.2	19	33	54	4	11.52	0.847	16.7	21	25	8	4
1.403	19	23	32	1.736	0.812	19	23	32	9.68	0.842	12.8	19	9	24	4	11.52	0.847	15.7	19	11	36	4
1.374	19	35	24	1.737	0.812	19	31	24	9.65	0.839	13.1	19	39	50	4	11.47	0.844	15.7	20	9	28	4
1.371	20	31	50	1.737	0.812	20	27	52	9.65	0.839	12.2	20	9	28	4	11.46	0.842	16.5	19	23	10	4
1.371	19	37	26	1.749	0.806	19	35	50	9.63	0.838	12.2	19	11	26	4	11.44	0.842	15.4	20	33	30	4
1.363	19	35	50	1.762	0.800	21	31	54	9.63	0.837	13.2	21	35	54	4	11.44	0.841	15.5	20	11	32	4

* LHGR calculated with pin-power reconstruction
* CPR calculated with pin-power reconstruction & CPR limit TYPE 3

Figure A.17 Browns Ferry Equilibrium Cycle Control Rod Pattern and Axial Distributions at 5,900.0 MWd/MTU

```
Cycle:                           21                      Core Average Exposure: MWd/MTU    24173.7
Exposure: MWd/MTU (GWd)      6400.0 ( 885.59 )
Delta E: MWd/MTU, (GWd)       500.0 (  69.19 )              Axial Profile    Edit   Radial Power
Power: MWt                   3952.0 (100.00 %)        N(PRA) Power Exposure  Zone  Avg.  Max.  IR JR
Core Pressure: psia          1050.0                  Top 25  0.166   4.885    13  0.447 0.660   7 16
Inlet Subcooling: Btu/lbm    -30.62                      24  0.436  13.186    14  0.354 0.659  27  4
Flow: Mlb/hr                  91.02 ( 88.80 %)           23  0.545  16.793    15  0.440 0.706  33 58
                                                         22  0.612  19.171    16  1.086 1.314  29 30
   2  6 10 14 18 22 26 30 34 38 42 46 50 54 58           21  0.652  20.719    17  1.093 1.303  29 26
59             -- -- -- -- -- -- -- --           59      20  0.675  21.908    18  0.962 1.225  29 48
55          -- -- -- -- -- -- -- -- -- --        55      19  0.692  22.667    19  1.327 1.457  35 28
51       -- -- -- -- -- -- -- -- -- -- -- --     51      18  0.714  23.505    20  1.219 1.480  33 30
47    -- -- -- -- -- -- -- -- -- -- -- -- -- --  47      17  0.737  24.279    21  1.161 1.291  31 54
43 -- -- -- -- 14 --  8 --  8 -- 14 -- -- -- -- 43      16  0.777  24.601
39 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 39      15  0.850  24.757
35 -- -- -- --  8 -- -- -- -- --  8 -- -- -- -- 35      14  0.901  25.687
31 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 31      13  0.955  26.571
27 -- -- -- --  8 -- -- -- -- --  8 -- -- -- -- 27      12  1.020  27.687
23 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 23      11  1.079  28.362
19 -- -- -- -- 14 --  8 --  8 -- 14 -- -- -- -- 19      10  1.207  27.611
15    -- -- -- -- -- -- -- -- -- -- -- -- -- --  15       9  1.308  28.693
11       -- -- -- -- -- -- -- -- -- -- -- --     11       8  1.406  29.658
 7          -- -- -- -- -- -- -- -- -- --         7       7  1.525  30.750
 3             -- -- -- -- -- -- -- --            3       6  1.647  31.674
   2  6 10 14 18 22 26 30 34 38 42 46 50 54 58            5  1.758  32.147*
                                                          4  1.810* 31.454
Control Rod Density: %         5.14                       3  1.746  29.160
                                                          2  1.387  22.598
k-effective:                0.99887               Bottom  1  0.397   6.834
Void Fraction:                0.509
Core Delta-P: psia           21.180             % AXIAL TILT -35.490 -14.984
Core Plate Delta-P: psia     16.623         AVG BOT 8ft/12ft  1.1943  1.0805
Coolant Temp: Deg-F           548.4
In Channel Flow: Mlb/hr       79.64   Active Channel Flow: Mlb/hr        76.69
Total Bypass Flow (%):         12.5   (of total core flow)
Total Water Rod Flow (%):       3.2   (of total core flow)
Source Convergence          0.00009
```

Top Ten Thermal Limits Summary - Sorted by Margin

Power				MCPR					APLHGR							LHGR						
Value	FT	IR	JR	Value	Margin	FT	IR	JR	Value	Margin	Exp.	FT	IR	JR	K	Value	Margin	Exp.	FT	IR	JR	K
1.480	20	33	30	1.586	0.889	20	33	30	10.09	0.877	13.9	20	33	52	3	11.67	0.858	17.9	20	33	52	4
1.475	20	31	28	1.587	0.889	20	31	28	9.94	0.864	14.7	19	35	50	4	11.66	0.858	18.4	20	31	50	4
1.457	19	35	28	1.607	0.877	19	35	28	9.92	0.863	14.7	19	37	52	4	11.56	0.850	12.3	20	31	28	4
1.456	19	33	26	1.608	0.877	19	27	36	9.92	0.863	14.6	20	31	50	4	11.51	0.846	18.1	21	25	8	4
1.412	19	31	24	1.708	0.826	19	23	32	9.80	0.852	13.6	19	33	54	3	11.49	0.845	17.8	19	25	50	4
1.410	19	23	32	1.708	0.825	19	31	24	9.79	0.852	13.4	20	9	28	4	11.46	0.843	16.9	20	9	34	4
1.380	19	35	24	1.710	0.825	20	29	50	9.78	0.850	14.0	19	9	24	4	11.45	0.842	18.0	19	23	10	4
1.378	20	31	50	1.711	0.824	20	27	52	9.74	0.847	13.4	19	11	26	4	11.44	0.841	16.9	19	33	54	3
1.378	19	37	26	1.724	0.818	19	35	50	9.72	0.845	14.3	19	39	50	4	11.41	0.839	17.2	19	11	36	4
1.369	19	35	50	1.737	0.812	19	35	24	9.71	0.845	13.9	21	35	54	3	11.38	0.837	17.3	21	7	26	4

* LHGR calculated with pin-power reconstruction
* CPR calculated with pin-power reconstruction & CPR limit TYPE 3

Figure A.18 Browns Ferry Equilibrium Cycle Control Rod Pattern and Axial Distributions at 6,400.0 MWd/MTU

```
Cycle:                            21                    Core Average Exposure: MWd/MTU    24673.6
Exposure: MWd/MTU (GWd)       6900.0 ( 954.78 )
Delta E: MWd/MTU, (GWd)        500.0 (  69.19 )            Axial Profile    Edit   Radial Power
Power: MWt                    3952.0 (100.00 %)       N(PRA) Power Exposure  Zone  Avg.  Max.  IR JR
Core Pressure: psia           1050.0                 Top 25  0.166   4.976    13  0.443 0.657   7 16
Inlet Subcooling: Btu/lbm     -31.49                     24  0.435  13.425    14  0.351 0.655  27  4
Flow: Mlb/hr                   88.66 ( 86.50 %)          23  0.544  17.092    15  0.436 0.701  33 58
                                                         22  0.612  19.509    16  1.083 1.309  29 30
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58          21  0.653  21.079    17  1.090 1.300  29 26
59             -- -- -- -- -- -- -- --             59    20  0.677  22.281    18  0.958 1.221  29 48
55          -- -- -- -- -- -- -- -- -- --          55    19  0.694  23.049    19  1.332 1.463  35 28
51       -- -- -- -- -- -- -- -- -- -- -- --       51    18  0.716  23.900    20  1.226 1.488  33 30
47    -- -- -- -- -- -- -- -- -- -- -- -- -- --    47    17  0.739  24.686    21  1.163 1.293  31 54
43 -- -- -- -- -- 14 --  8 --  8 -- 14 -- -- -- -- -- 43    16  0.779  25.020
39 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 39    15  0.851  25.188
35 -- -- -- --  8 -- -- -- -- -- --  8 -- -- -- -- 35    14  0.901  26.143
31 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 31    13  0.954  27.055
27 -- -- -- --  8 -- -- -- -- -- --  8 -- -- -- -- 27    12  1.019  28.204
23 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 23    11  1.076  28.907
19 -- -- -- -- 14 --  8 --  8 -- 14 -- -- -- -- -- 19    10  1.201  28.161
15    -- -- -- -- -- -- -- -- -- -- -- -- -- --    15     9  1.299  29.282
11       -- -- -- -- -- -- -- -- -- -- -- --       11     8  1.395  30.290
 7          -- -- -- -- -- -- -- -- -- --           7     7  1.512  31.435
 3             -- -- -- -- -- -- -- --              3     6  1.636  32.415
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58           5  1.750  32.938*
                                                          4  1.813* 32.272
Control Rod Density: %          5.14                      3  1.763  29.953
                                                          2  1.409  23.230
k-effective:                 0.99884              Bottom  1  0.404   7.033
Void Fraction:                 0.513
Core Delta-P: psia            20.383            % AXIAL TILT -35.386 -15.257
Core Plate Delta-P: psia      15.827        AVG BOT 8ft/12ft  1.1937  1.0817
Coolant Temp: Deg-F            548.4
In Channel Flow: Mlb/hr        77.55  Active Channel Flow: Mlb/hr        74.65
Total Bypass Flow (%):          12.5  (of total core flow)
Total Water Rod Flow (%):        3.3  (of total core flow)
Source Convergence           0.00009
```

Top Ten Thermal Limits Summary - Sorted by Margin

Power				MCPR					APLHGR							LHGR						
Value	FT	IR	JR	Value	Margin	FT	IR	JR	Value	Margin	Exp.	FT	IR	JR	K	Value	Margin	Exp.	FT	IR	JR	K
1.488	20	33	30	1.562	0.903	20	31	28	10.21	0.888	15.2	20	33	52	3	11.69	0.860	18.5	20	33	52	3
1.483	20	31	28	1.563	0.902	20	33	30	10.04	0.873	15.0	19	37	52	3	11.57	0.851	18.9	20	31	50	3
1.463	19	35	28	1.577	0.894	19	35	28	9.98	0.868	15.1	20	31	50	3	11.53	0.848	18.8	21	25	8	3
1.463	19	33	26	1.577	0.894	19	27	36	9.97	0.867	15.0	19	35	50	3	11.49	0.845	18.3	19	33	54	3
1.419	19	31	24	1.680	0.839	19	29	24	9.93	0.864	14.8	19	33	54	3	11.49	0.845	13.8	20	31	28	4
1.417	19	23	32	1.680	0.839	19	23	32	9.89	0.860	14.7	20	9	28	4	11.49	0.845	18.3	20	9	34	4
1.387	19	35	24	1.688	0.835	20	29	50	9.87	0.858	14.2	19	9	24	3	11.49	0.845	18.7	19	23	10	3
1.384	19	37	26	1.688	0.835	20	27	52	9.82	0.854	15.1	21	35	54	3	11.44	0.841	18.3	19	25	50	3
1.382	20	31	50	1.701	0.829	19	35	50	9.82	0.854	14.6	19	11	26	4	11.38	0.837	18.2	21	29	54	3
1.373	19	35	50	1.705	0.827	19	35	24	9.74	0.847	15.6	19	39	50	4	11.38	0.837	17.8	21	7	26	3

* LHGR calculated with pin-power reconstruction
* CPR calculated with pin-power reconstruction & CPR limit TYPE 3

Figure A.19 Browns Ferry Equilibrium Cycle Control Rod Pattern and Axial Distributions at 6,900.0 MWd/MTU

```
Cycle:                            21                   Core Average Exposure: MWd/MTU    24884.3
Exposure: MWd/MTU (GWd)      7110.7 ( 983.93 )
Delta E: MWd/MTU, (GWd)       210.7 (  29.15 )               Axial Profile    Edit   Radial Power
Power: MWt                   3952.0 (100.00 %)          N(PRA) Power Exposure  Zone  Avg.  Max.  IR JR
Core Pressure: psia          1050.0                    Top 25  0.167   5.014    13  0.442 0.655   7 16
Inlet Subcooling: Btu/lbm    -31.69                        24  0.436  13.526    14  0.349 0.654  27  4
Flow: Mlb/hr                  88.15 ( 86.00 %)             23  0.545  17.217    15  0.435 0.699  33 58
                                                           22  0.614  19.652    16  1.082 1.308  29 30
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58            21  0.655  21.231    17  1.089 1.299  29 26
59             -- -- -- -- -- -- -- --             59      20  0.679  22.438    18  0.956 1.219  29 48
55          -- -- -- -- -- -- -- -- -- --          55      19  0.697  23.210    19  1.335 1.466  33 26
51       -- -- -- -- -- -- -- -- -- -- -- --       51      18  0.719  24.066    20  1.228 1.491  33 30
47    -- -- -- -- -- -- -- -- -- -- -- -- -- --    47      17  0.742  24.858    21  1.164 1.293  31 54
43 -- -- -- -- 14 --  8 --  8 -- 14 -- -- -- -- 43         16  0.781  25.197
39 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 39         15  0.853  25.370
35 -- -- -- --  8 -- -- -- -- --  8 -- -- -- -- 35         14  0.902  26.336
31 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 31         13  0.955  27.259
27 -- -- -- --  8 -- -- -- -- --  8 -- -- -- -- 27         12  1.020  28.421
23 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 23         11  1.076  29.137
19 -- -- -- -- 14 --  8 --  8 -- 14 -- -- -- -- 19         10  1.199  28.391
15    -- -- -- -- -- -- -- -- -- -- -- -- -- --    15       9  1.296  29.529
11       -- -- -- -- -- -- -- -- -- -- -- --       11       8  1.391  30.555
 7          -- -- -- -- -- -- -- -- -- --           7       7  1.507  31.723
 3             -- -- -- -- -- -- -- --              3       6  1.630  32.726
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58             5  1.745  33.271*
                                                            4  1.810* 32.617
Control Rod Density: %             5.14                     3  1.764  30.288
                                                            2  1.413  23.499
k-effective:                    0.99893             Bottom  1  0.405   7.118
Void Fraction:                    0.513
Core Delta-P: psia               20.208               % AXIAL TILT -35.207 -15.367
Core Plate Delta-P: psia         15.652           AVG BOT 8ft/12ft  1.1927  1.0822
Coolant Temp: Deg-F               548.4
In Channel Flow: Mlb/hr           77.09  Active Channel Flow: Mlb/hr        74.21
Total Bypass Flow (%):             12.5  (of total core flow)
Total Water Rod Flow (%):           3.3  (of total core flow)
Source Convergence              0.00009
```

```
                          Top Ten Thermal Limits Summary - Sorted by Margin

     Power                 MCPR                         APLHGR                            LHGR
Value FT  IR JR    Value Margin FT  IR JR   Value Margin Exp. FT  IR JR  K   Value Margin Exp. FT  IR JR  K
1.491  20 33 30    1.556  0.906  20 31 28   10.21  0.888 15.7  20 33 52  3   11.65  0.856 19.2  20 33 52  3
1.486  20 31 28    1.558  0.905  20 33 30   10.06  0.875 15.5  19 37 52  3   11.50  0.845 19.5  20 31 50  3
1.466  19 33 26    1.568  0.899  19 35 28    9.97  0.867 15.5  19 35 50  3   11.49  0.845 19.5  21 25  8  3
1.466  19 35 28    1.568  0.899  19 27 36    9.97  0.867 15.6  20 31 50  3   11.49  0.845 17.8  20  9 34  3
1.422  19 31 24    1.670  0.844  19 29 38    9.94  0.865 15.3  19 33 54  3   11.47  0.844 18.9  19 33  8  3
1.420  19 23 32    1.673  0.843  19 23 32    9.94  0.864 14.3  20  9 28  3   11.47  0.843 19.3  19 23 10  3
1.390  19 35 24    1.683  0.838  20 27 52    9.92  0.863 14.7  19  9 24  3   11.42  0.840 14.4  20 31 28  4
1.387  19 37 26    1.684  0.837  20 29 50    9.83  0.855 15.2  19 11 26  4   11.40  0.838 18.9  19 25 50  3
1.383  20 31 50    1.696  0.831  19 35 24    9.83  0.855 15.7  21 35 54  3   11.39  0.837 18.4  21  7 26  3
1.375  19 35 50    1.697  0.831  19 35 50    9.75  0.848 15.1  19 39 50  3   11.38  0.837 18.3  19  9 24  3

  * LHGR calculated with pin-power reconstruction
  * CPR calculated with pin-power reconstruction & CPR limit TYPE 3
```

Figure A.20 Browns Ferry Equilibrium Cycle Control Rod Pattern and Axial Distributions at 7,110.7 MWd/MTU

```
Cycle:                            21                  Core Average Exposure: MWd/MTU    24891.3
Exposure: MWd/MTU (GWd)       7117.7 ( 984.90 )
Delta E: MWd/MTU, (GWd)          7.0 (   0.97 )             Axial Profile    Edit   Radial Power
Power: MWt                    3952.0 (100.00 %)        N(PRA) Power Exposure  Zone  Avg.  Max.  IR JR
Core Pressure: psia           1050.0                  Top 25  0.154   5.015    13  0.441 0.665   7 16
Inlet Subcooling: Btu/lbm     -28.93                      24  0.405  13.529    14  0.343 0.629  27  4
Flow: Mlb/hr                   95.94 ( 93.60 %)           23  0.504  17.221    15  0.428 0.684  45  8
                                                          22  0.563  19.656    16  1.069 1.268  33 24
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58           21  0.591  21.236    17  1.098 1.289  31 22
59             -- -- -- -- -- -- -- --           59       20  0.616  22.443    18  0.957 1.236  43 18
55          -- -- -- -- -- -- -- -- -- --        55       19  0.638  23.216    19  1.327 1.457  31 24
51       -- -- -- -- -- -- -- -- -- -- -- --     51       18  0.670  24.072    20  1.251 1.410  29 42
47    -- -- -- -- -- --  6 --  6 -- -- -- -- --  47       17  0.709  24.864    21  1.152 1.300  43 12
43 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 43       16  0.760  25.203
39 -- -- -- -- --  8 -- -- -- -- --  8 -- -- -- -- -- 39  15  0.843  25.376
35 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 35       14  0.903  26.342
31 -- --  6 -- -- --  6 --  6 -- -- --  6 -- -- 31       13  0.964  27.266
27 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 27       12  1.037  28.429
23 -- -- -- -- --  8 -- -- -- -- --  8 -- -- -- -- -- 23  11  1.100  29.145
19 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 19       10  1.231  28.399
15    -- -- -- -- -- --  6 --  6 -- -- -- -- --  15        9  1.334  29.537
11       -- -- -- -- -- -- -- -- -- -- -- --     11        8  1.434  30.564
 7          -- -- -- -- -- -- -- -- -- --         7        7  1.554  31.732
 3             -- -- -- -- -- -- -- --            3        6  1.681  32.736
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58            5  1.796  33.282*
                                                           4  1.857* 32.628
Control Rod Density: %          5.59                       3  1.803  30.300
                                                           2  1.440  23.508
k-effective:                 0.99882               Bottom  1  0.413   7.121
Void Fraction:                 0.505
Core Delta-P: psia            23.008           % AXIAL TILT -38.787 -15.371
Core Plate Delta-P: psia      18.447       AVG BOT 8ft/12ft  1.2165  1.0822
Coolant Temp: Deg-F            548.6
In Channel Flow: Mlb/hr        83.97  Active Channel Flow: Mlb/hr        80.87
Total Bypass Flow (%):          12.5  (of total core flow)
Total Water Rod Flow (%):        3.2  (of total core flow)
Source Convergence           0.00009
```

Top Ten Thermal Limits Summary - Sorted by Margin

Power				MCPR					APLHGR							LHGR						
Value	FT	IR	JR	Value	Margin	FT	IR	JR	Value	Margin	Exp.	FT	IR	JR	K	Value	Margin	Exp.	FT	IR	JR	K
1.457	19	31	24	1.648	0.856	19	29	38	10.10	0.878	14.9	19	27	40	4	11.76	0.865	15.6	20	41	18	4
1.455	19	33	22	1.650	0.855	19	33	22	10.07	0.875	15.6	19	41	14	4	11.70	0.860	15.7	20	25	42	4
1.444	19	35	24	1.662	0.848	19	35	24	10.05	0.874	14.7	20	43	16	4	11.64	0.856	16.8	19	31	24	4
1.415	19	33	26	1.718	0.821	20	19	32	10.02	0.871	14.0	19	31	24	4	11.63	0.855	17.8	20	17	16	4
1.410	20	29	42	1.738	0.811	20	35	20	9.98	0.868	15.6	19	25	38	4	11.60	0.853	18.0	19	33	40	4
1.407	20	41	30	1.742	0.809	20	43	16	9.94	0.865	15.7	19	11	22	4	11.57	0.850	18.7	20	15	48	4
1.404	19	37	26	1.747	0.807	20	29	42	9.94	0.864	14.7	20	15	18	4	11.54	0.849	18.7	20	15	18	4
1.398	20	37	22	1.749	0.806	19	41	14	9.93	0.863	15.5	19	13	20	4	11.52	0.847	18.6	20	47	16	4
1.397	20	25	42	1.750	0.806	19	33	26	9.88	0.859	16.1	19	39	50	4	11.51	0.847	15.3	20	17	34	4
1.396	19	21	28	1.751	0.805	20	37	22	9.83	0.855	14.4	20	29	42	4	11.51	0.846	17.8	20	31	42	4

* LHGR calculated with pin-power reconstruction
* CPR calculated with pin-power reconstruction & CPR limit TYPE 3

Figure A.21 Browns Ferry Equilibrium Cycle Control Rod Pattern and Axial Distributions at 7,117.7 MWd/MTU

```
Cycle:                             21                            Core Average Exposure: MWd/MTU    25273.6
Exposure: MWd/MTU (GWd)        7500.0 (1037.80 )
Delta E: MWd/MTU, (GWd)         382.3 (  52.90 )                   Axial Profile    Edit   Radial Power
Power: MWt                     3952.0 (100.00 %)             N(PRA) Power Exposure  Zone  Avg.  Max.  IR JR
Core Pressure: psia            1050.0                       Top 25  0.155   5.079    13  0.439 0.663   7 16
Inlet Subcooling: Btu/lbm      -29.68                           24  0.407  13.699    14  0.341 0.627  27  4
Flow: Mlb/hr                    93.68 ( 91.40 %)                23  0.507  17.433    15  0.426 0.682  45  8
                                                                22  0.566  19.894    16  1.068 1.266  33 24
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58                 21  0.595  21.486    17  1.095 1.286  31 22
59             -- -- -- -- -- -- --             59              20  0.621  22.704    18  0.954 1.232  43 18
55          -- -- -- -- -- -- -- -- --          55              19  0.644  23.486    19  1.331 1.462  31 24
51       -- -- -- -- -- -- -- -- -- -- --       51              18  0.676  24.356    20  1.255 1.413  31 42
47    -- -- -- -- --  6 --  6 -- -- -- -- --    47              17  0.715  25.164    21  1.154 1.301  43 12
43 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 43              16  0.766  25.518
39 -- -- -- --  8 -- -- -- -- --  8 -- -- -- -- 39              15  0.848  25.704
35 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 35              14  0.907  26.693
31 -- --  6 -- -- --  6 --  6 -- -- --  6 -- -- 31              13  0.968  27.640
27 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 27              12  1.039  28.831
23 -- -- -- --  8 -- -- -- -- --  8 -- -- -- -- 23              11  1.100  29.570
19 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 19              10  1.228  28.828
15    -- -- -- -- --  6 --  6 -- -- -- -- --    15               9  1.328  29.996
11       -- -- -- -- -- -- -- -- -- -- --       11               8  1.425  31.057
 7          -- -- -- -- -- -- -- -- --           7               7  1.542  32.267
 3             -- -- -- -- -- -- --              3               6  1.667  33.314
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58                  5  1.782  33.900*
                                                                 4  1.847* 33.268
Control Rod Density: %           5.59                            3  1.804  30.923
                                                                 2  1.447  24.006
k-effective:                  0.99864                   Bottom  1  0.416   7.279
Void Fraction:                  0.508
Core Delta-P: psia             22.199                 % AXIAL TILT -38.364 -15.619
Core Plate Delta-P: psia       17.639             AVG BOT 8ft/12ft  1.2144  1.0834
Coolant Temp: Deg-F             548.5
In Channel Flow: Mlb/hr         81.97  Active Channel Flow: Mlb/hr        78.93
Total Bypass Flow (%):           12.5  (of total core flow)
Total Water Rod Flow (%):         3.2  (of total core flow)
Source Convergence            0.00008


                         Top Ten Thermal Limits Summary - Sorted by Margin

     Power                  MCPR                            APLHGR                                 LHGR
Value FT   IR JR     Value Margin FT   IR JR    Value Margin Exp. FT   IR JR   K     Value Margin Exp. FT   IR JR   K
1.462  19 31 24     1.627  0.866  19 29 38    10.05  0.874 15.8  19 27 40   4     11.65  0.857 16.8  20 41 18   4
1.458  19 33 22     1.632  0.864  19 33 22    10.02  0.871 15.5  19 41 14   3     11.58  0.852 16.8  20 25 42   4
1.448  19 35 24     1.644  0.858  19 35 24    10.00  0.870 15.7  20 43 16   4     11.55  0.849 17.9  19 31 24   4
1.419  19 33 26     1.697  0.831  20 19 32    10.00  0.869 15.0  19 31 24   4     11.50  0.845 18.9  20 17 16   4
1.413  20 31 42     1.716  0.822  20 35 20     9.93  0.863 16.5  19 25 38   4     11.47  0.844 19.1  19 33 40   4
1.412  20 41 30     1.723  0.818  20 43 16     9.92  0.863 15.6  19 11 22   3     11.44  0.841 19.8  20 15 48   4
1.408  19 37 26     1.727  0.817  19 33 26     9.89  0.860 15.7  20 15 18   4     11.43  0.840 16.4  20 17 34   4
1.402  20 37 22     1.727  0.816  20 29 42     9.89  0.860 16.4  19 13 20   4     11.41  0.839 19.8  20 15 18   4
1.400  20 25 42     1.731  0.815  19 41 14     9.81  0.853 15.0  20 19 30   4     11.40  0.838 19.7  20 47 16   4
1.400  19 21 28     1.732  0.814  20 37 22     9.81  0.853 16.1  19 39 12   3     11.38  0.836 18.9  20 31 42   4

  * LHGR calculated with pin-power reconstruction
  * CPR calculated with pin-power reconstruction & CPR limit TYPE 3
```

Figure A.22 Browns Ferry Equilibrium Cycle Control Rod Pattern and Axial Distributions at 7,500.0 MWd/MTU

```
Cycle:                              21          Core Average Exposure: MWd/MTU    25773.5
Exposure: MWd/MTU (GWd)         8000.0 (1106.99 )
Delta E: MWd/MTU, (GWd)          500.0 (  69.19 )     Axial Profile    Edit   Radial Power
Power: MWt                      3952.0 (100.00 %)  N(PRA) Power Exposure  Zone  Avg.  Max.  IR JR
Core Pressure: psia             1050.0             Top 25  0.159   5.165    13  0.437 0.661   7 16
Inlet Subcooling: Btu/lbm       -30.25                 24  0.414  13.924    14  0.339 0.623  27  4
Flow: Mlb/hr                     92.05 ( 89.80 %)      23  0.516  17.714    15  0.423 0.679  45  8
                                                       22  0.576  20.209    16  1.066 1.263  33 24
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58        21  0.607  21.817    17  1.093 1.282  31 22
59             -- -- -- -- -- -- -- --          59     20  0.633  23.050    18  0.951 1.229  43 18
55          -- -- -- -- -- -- -- -- -- --       55     19  0.657  23.845    19  1.334 1.467  31 24
51       -- -- -- -- -- -- -- -- -- -- -- --    51     18  0.690  24.732    20  1.260 1.418  41 30
47    -- -- -- -- --  6 --  6 -- -- -- -- --    47     17  0.729  25.562    21  1.156 1.303  43 50
43 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 43     16  0.779  25.934
39 -- -- -- --  8 -- -- -- -- --  8 -- -- -- -- 39     15  0.861  26.137
35 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 35     14  0.919  27.156
31 -- --  6 -- -- --  6 --  6 -- -- --  6 -- -- 31     13  0.978  28.134
27 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 27     12  1.047  29.360
23 -- -- -- --  8 -- -- -- -- --  8 -- -- -- -- 23     11  1.105  30.129
19 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 19     10  1.229  29.389
15    -- -- -- -- --  6 --  6 -- -- -- -- --    15      9  1.323  30.595
11       -- -- -- -- -- -- -- -- -- -- -- --    11      8  1.415  31.698
 7          -- -- -- -- -- -- -- -- -- --        7      7  1.527  32.959
 3             -- -- -- -- -- -- -- --           3      6  1.645  34.061
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58         5  1.754  34.698*
                                                        4  1.816* 34.096
Control Rod Density: %            5.59                  3  1.778  31.732
                                                        2  1.432  24.657
k-effective:                   0.99865          Bottom  1  0.412   7.486
Void Fraction:                   0.508
Core Delta-P: psia              21.591            % AXIAL TILT -37.238 -15.915
Core Plate Delta-P: psia        17.032          AVG BOT 8ft/12ft  1.2089  1.0848
Coolant Temp: Deg-F              548.5
In Channel Flow: Mlb/hr          80.53  Active Channel Flow: Mlb/hr        77.54
Total Bypass Flow (%):            12.5  (of total core flow)
Total Water Rod Flow (%):          3.3  (of total core flow)
Source Convergence             0.00008
```

Top Ten Thermal Limits Summary - Sorted by Margin

Power				MCPR					APLHGR							LHGR						
Value	FT	IR	JR	Value	Margin	FT	IR	JR	Value	Margin	Exp.	FT	IR	JR	K	Value	Margin	Exp.	FT	IR	JR	K
1.467	19	31	24	1.613	0.874	19	29	38	9.89	0.860	17.1	19	33	22	4	11.42	0.840	18.2	20	41	18	4
1.463	19	33	22	1.620	0.870	19	33	22	9.88	0.860	15.9	20	43	16	3	11.34	0.834	18.3	20	25	42	4
1.451	19	35	24	1.634	0.863	19	35	24	9.87	0.858	16.2	19	31	24	4	11.30	0.831	19.4	19	31	24	4
1.424	19	33	26	1.683	0.838	20	19	32	9.86	0.858	16.7	19	41	14	3	11.25	0.827	17.8	20	17	34	4
1.418	20	41	30	1.701	0.829	20	35	20	9.81	0.853	16.8	19	11	22	3	11.21	0.825	20.3	20	17	16	4
1.418	20	31	42	1.709	0.825	20	43	16	9.77	0.849	15.9	20	15	18	3	11.18	0.822	20.5	19	33	40	4
1.412	19	37	26	1.710	0.825	19	33	26	9.76	0.849	16.5	19	13	20	3	11.14	0.821	21.2	20	15	48	4
1.407	20	23	40	1.714	0.822	20	29	42	9.74	0.847	17.7	19	25	38	4	11.11	0.818	21.2	20	47	16	4
1.405	20	25	42	1.718	0.821	19	41	14	9.71	0.844	16.9	19	9	24	3	11.11	0.818	21.2	20	15	18	4
1.405	19	21	28	1.718	0.821	20	37	22	9.69	0.843	16.2	20	41	32	4	11.08	0.815	17.2	20	39	42	4

* LHGR calculated with pin-power reconstruction
* CPR calculated with pin-power reconstruction & CPR limit TYPE 3

Figure A.23 Browns Ferry Equilibrium Cycle Control Rod Pattern and Axial Distributions at 8,000.0 MWd/MTU

```
Cycle:                          21                 Core Average Exposure: MWd/MTU    26273.4
Exposure: MWd/MTU (GWd)       8500.0 (1176.18 )
Delta E: MWd/MTU, (GWd)        500.0 (  69.19 )          Axial Profile    Edit   Radial Power
Power: MWt                    3952.0 (100.00 %)      N(PRA) Power Exposure  Zone  Avg.  Max.  IR JR
Core Pressure: psia           1050.0                Top 25  0.163   5.252    13  0.435 0.660   7 16
Inlet Subcooling: Btu/lbm     -30.66                    24  0.424  14.153    14  0.337 0.621  27  4
Flow: Mlb/hr                   90.92 ( 88.70 %)         23  0.529  18.000    15  0.421 0.677  45  8
                                                        22  0.592  20.531    16  1.065 1.260  33 24
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58         21  0.624  22.157    17  1.091 1.279  31 22
59             -- -- -- -- -- -- --             59      20  0.652  23.404    18  0.948 1.227  43 18
55          -- -- -- -- -- -- -- -- --          55      19  0.677  24.213    19  1.337 1.472  31 24
51       -- -- -- -- -- -- -- -- -- -- --       51      18  0.711  25.119    20  1.264 1.422  41 30
47    -- -- -- -- --  6 --  6 -- -- -- -- --    47      17  0.750  25.970    21  1.157 1.304  43 50
43 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 43      16  0.799  26.359
39 -- -- -- --  8 -- -- -- -- --  8 -- -- -- -- 39      15  0.881  26.578
35 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 35      14  0.938  27.626
31 -- --  6 -- -- --  6 --  6 -- -- --  6 -- -- 31      13  0.996  28.634
27 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 27      12  1.063  29.894
23 -- -- -- --  8 -- -- -- -- --  8 -- -- -- -- 23      11  1.117  30.691
19 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 19      10  1.236  29.951
15    -- -- -- -- --  6 --  6 -- -- -- -- --    15       9  1.324  31.192
11       -- -- -- -- -- -- -- -- -- -- --       11       8  1.408  32.335
 7          -- -- -- -- -- -- -- -- --           7       7  1.511  33.645
 3             -- -- -- -- -- -- --              3       6  1.617  34.798
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58          5  1.712  35.480*
                                                         4  1.763* 34.904
Control Rod Density: %          5.59                     3  1.723  32.523
                                                         2  1.391  25.295
k-effective:                  0.99869            Bottom  1  0.400   7.688
Void Fraction:                  0.505
Core Delta-P: psia             21.144              % AXIAL TILT -35.504 -16.172
Core Plate Delta-P: psia       16.585          AVG BOT 8ft/12ft  1.2004  1.0860
Coolant Temp: Deg-F             548.4
In Channel Flow: Mlb/hr         79.56  Active Channel Flow: Mlb/hr        76.61
Total Bypass Flow (%):           12.5  (of total core flow)
Total Water Rod Flow (%):         3.2  (of total core flow)
Source Convergence            0.00008
```

Top Ten Thermal Limits Summary - Sorted by Margin

Power				MCPR					APLHGR							LHGR						
Value	FT	IR	JR	Value	Margin	FT	IR	JR	Value	Margin	Exp.	FT	IR	JR	K	Value	Margin	Exp.	FT	IR	JR	K
1.472	19	31	24	1.602	0.880	19	29	38	9.59	0.834	17.4	19	31	24	4	11.05	0.812	19.6	20	41	18	4
1.466	19	33	22	1.607	0.877	19	33	22	9.58	0.833	17.1	20	43	16	3	10.94	0.804	19.7	20	25	42	4
1.453	19	35	24	1.623	0.869	19	35	24	9.57	0.832	18.3	19	33	22	4	10.90	0.802	19.2	20	17	34	4
1.427	19	33	26	1.675	0.842	20	19	32	9.52	0.828	17.9	19	41	14	3	10.88	0.800	20.8	19	31	24	4
1.422	20	41	30	1.690	0.834	20	35	20	9.49	0.825	18.0	19	11	22	3	10.71	0.797	22.5	20	17	16	4
1.421	20	31	42	1.699	0.830	19	33	26	9.48	0.824	17.1	20	15	18	3	10.70	0.796	22.6	20	15	48	4
1.415	19	37	26	1.701	0.829	20	43	16	9.45	0.822	17.8	19	13	20	3	10.75	0.795	21.7	19	33	40	4
1.411	20	23	40	1.707	0.826	19	21	34	9.45	0.822	15.8	20	19	18	4	10.68	0.794	22.5	20	47	16	4
1.410	20	25	42	1.710	0.825	20	29	42	9.43	0.820	17.4	20	41	32	4	10.65	0.793	22.5	20	15	18	4
1.409	19	21	28	1.711	0.824	19	23	36	9.42	0.820	18.1	19	9	24	3	10.78	0.792	18.6	20	39	42	4

* LHGR calculated with pin-power reconstruction
* CPR calculated with pin-power reconstruction & CPR limit TYPE 3

Figure A.24 Browns Ferry Equilibrium Cycle Control Rod Pattern and Axial Distributions at 8,500.0 MWd/MTU

```
Cycle:                            21                     Core Average Exposure: MWd/MTU    26773.4
Exposure: MWd/MTU (GWd)       9000.0 (1245.36 )
Delta E: MWd/MTU, (GWd)        500.0 (  69.19 )                Axial Profile    Edit   Radial Power
Power: MWt                    3952.0 (100.00 %)          N(PRA) Power Exposure  Zone  Avg.  Max.  IR JR
Core Pressure: psia           1050.0                    Top 25  0.169   5.342    13  0.434 0.659   7 16
Inlet Subcooling: Btu/lbm     -30.92                        24  0.439  14.390    14  0.335 0.618  27  4
Flow: Mlb/hr                   90.20 ( 88.00 %)             23  0.548  18.295    15  0.419 0.676  45  8
                                                            22  0.614  20.864    16  1.064 1.257  33 24
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58             21  0.648  22.508    17  1.089 1.276  31 22
59             -- -- -- -- -- -- -- --          59          20  0.678  23.771    18  0.946 1.225  43 18
55          -- -- -- -- -- -- -- -- -- --       55          19  0.704  24.594    19  1.339 1.474  31 24
51       -- -- -- -- -- -- -- -- -- -- -- --    51          18  0.739  25.519    20  1.268 1.426  41 30
47    -- -- -- -- -- --  6 --  6 -- -- -- -- -- 47          17  0.778  26.391    21  1.159 1.304  43 50
43 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 43          16  0.827  26.798
39 -- -- -- -- --  8 -- -- -- -- --  8 -- -- -- -- -- 39    15  0.908  27.031
35 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 35          14  0.964  28.108
31 -- --  6 -- -- --  6 --  6 -- -- --  6 -- -- 31          13  1.020  29.145
27 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 27          12  1.084  30.439
23 -- -- -- -- --  8 -- -- -- -- --  8 -- -- -- -- -- 23    11  1.134  31.261
19 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 19          10  1.248  30.517
15    -- -- -- -- -- --  6 --  6 -- -- -- -- -- 15           9  1.329  31.791
11       -- -- -- -- -- -- -- -- -- -- -- --    11           8  1.403  32.970
 7          -- -- -- -- -- -- -- -- -- --        7           7  1.493  34.323
 3             -- -- -- -- -- -- -- --           3           6  1.582  35.520
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58              5  1.657  36.241*
                                                             4  1.688* 35.683
Control Rod Density: %          5.59                         3  1.639  33.283
                                                             2  1.323  25.908
k-effective:                 0.99879                 Bottom  1  0.380   7.883
Void Fraction:                 0.500
Core Delta-P: psia            20.816               % AXIAL TILT -33.126 -16.380
Core Plate Delta-P: psia      16.259           AVG BOT 8ft/12ft  1.1889  1.0870
Coolant Temp: Deg-F            548.3
In Channel Flow: Mlb/hr        78.97   Active Channel Flow: Mlb/hr        76.06
Total Bypass Flow (%):          12.4   (of total core flow)
Total Water Rod Flow (%):        3.2   (of total core flow)
Source Convergence           0.00009
```

```
                          Top Ten Thermal Limits Summary - Sorted by Margin

     Power                 MCPR                       APLHGR                              LHGR
Value FT  IR JR   Value Margin FT  IR JR   Value Margin Exp. FT  IR JR  K   Value Margin Exp. FT  IR JR  K
1.474  19 31 24   1.587  0.889  19 29 38    9.16  0.796 18.6  19 31 24  4   10.53  0.774 21.0  20 41 18  4
1.467  19 33 22   1.595  0.884  19 33 22    9.11  0.793 19.5  19 33 22  4   10.41  0.765 20.5  20 17 34  4
1.454  19 35 24   1.612  0.875  19 35 24    9.11  0.792 19.3  20 43 16  4   10.24  0.765 23.0  19 33 40  4
1.429  19 33 26   1.675  0.842  20 19 32    9.11  0.792 17.0  20 19 18  4   10.40  0.764 21.0  20 25 42  4
1.426  20 41 30   1.682  0.838  19 27 36    9.06  0.788 20.2  19 41 14  4   10.21  0.763 23.0  20 17 16  4
1.422  20 31 42   1.685  0.837  20 35 20    9.05  0.787 20.2  19 49 40  4   10.29  0.763 22.1  19 31 24  4
1.416  19 37 26   1.692  0.833  19 39 28    9.04  0.786 18.3  19 39 16  4   10.14  0.763 23.9  20 15 48  4
1.414  20 37 22   1.695  0.832  19 37 26    9.02  0.785 19.3  20 15 18  4   10.15  0.762 23.6  19 49 40  4
1.414  20 25 42   1.701  0.829  20 43 16    9.02  0.784 18.6  20 41 32  4    7.62  0.762 53.8  18 15 16  4
1.412  19 21 28   1.704  0.828  20 31 42    9.02  0.784 20.0  19 47 42  4   10.12  0.761 23.8  20 47 16  4

  * LHGR calculated with pin-power reconstruction
  * CPR calculated with pin-power reconstruction & CPR limit TYPE 3
```

Figure A.25 Browns Ferry Equilibrium Cycle Control Rod Pattern and Axial Distributions at 9,000.0 MWd/MTU

```
Cycle:                              21                        Core Average Exposure: MWd/MTU    27273.4
Exposure: MWd/MTU (GWd)         9500.0 (1314.55 )
Delta E: MWd/MTU, (GWd)          500.0 (  69.19 )                Axial Profile    Edit   Radial Power
Power: MWt                      3952.0 (100.00 %)          N(PRA) Power Exposure  Zone  Avg.  Max.  IR JR
Core Pressure: psia             1050.0                    Top 25  0.176   5.436    13  0.433 0.658   7 16
Inlet Subcooling: Btu/lbm       -31.38                        24  0.456  14.636    14  0.334 0.617  27  4
Flow: Mlb/hr                     88.97 ( 86.80 %)             23  0.571  18.602    15  0.419 0.675  45  8
                                                              22  0.640  21.210    16  1.063 1.254  33 24
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58               21  0.676  22.873    17  1.088 1.273  31 22
59             -- -- -- -- -- -- -- --            59          20  0.708  24.154    18  0.945 1.223  43 18
55          -- -- -- -- -- -- -- -- -- --         55          19  0.736  24.992    19  1.340 1.476  31 24
51       -- -- -- -- -- -- -- -- -- -- -- --      51          18  0.772  25.936    20  1.271 1.427  41 30
47    -- -- -- -- -- --  6 --  6 -- -- -- -- --   47          17  0.811  26.830    21  1.160 1.305  43 50
43 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 43            16  0.859  27.252
39 -- -- -- -- --  8 -- -- -- -- --  8 -- -- -- -- -- 39      15  0.941  27.500
35 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 35            14  0.995  28.605
31 -- --  6 -- -- --  6 --  6 -- -- --  6 -- -- 31            13  1.049  29.669
27 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 27            12  1.110  30.995
23 -- -- -- --  8 -- -- -- -- --  8 -- -- -- -- 23            11  1.156  31.841
19 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 19            10  1.263  31.090
15    -- -- -- -- --  6 --  6 -- -- -- -- --    15             9  1.335  32.392
11       -- -- -- -- -- -- -- -- -- -- -- --      11           8  1.398  33.602
 7          -- -- -- -- -- -- -- -- -- --          7           7  1.473  34.993
 3             -- -- -- -- -- -- -- --             3           6  1.541  36.225
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58                5  1.593  36.974*
                                                               4  1.600* 36.426
Control Rod Density: %            5.59                         3  1.540  34.001
                                                               2  1.242  26.488
k-effective:                   0.99872              Bottom  1  0.356   8.066
Void Fraction:                   0.494
Core Delta-P: psia              20.307            % AXIAL TILT -30.336 -16.531
Core Plate Delta-P: psia        15.750        AVG BOT 8ft/12ft  1.1755  1.0878
Coolant Temp: Deg-F              548.1
In Channel Flow: Mlb/hr          77.93   Active Channel Flow: Mlb/hr        75.07
Total Bypass Flow (%):            12.4   (of total core flow)
Total Water Rod Flow (%):          3.2   (of total core flow)
Source Convergence             0.00010
```

Top Ten Thermal Limits Summary - Sorted by Margin

Power				MCPR					APLHGR						LHGR						
Value	FT	IR	JR	Value	Margin	FT	IR	JR	Value	Margin	Exp.	FT	IR	JR	K	Value	Margin	Exp.	FT	IR	JR	K
1.476	19	31	24	1.570	0.898	19	29	38	8.66	0.753	18.1	20	19	18	4	7.21	0.742	55.0	18	15	16	5
1.467	19	33	40	1.577	0.894	19	33	22	8.64	0.752	19.7	19	31	24	4	7.13	0.738	55.2	18	43	48	5
1.455	19	25	38	1.594	0.884	19	35	24	8.62	0.749	20.4	20	43	16	4	7.14	0.737	55.1	18	47	18	5
1.430	19	33	26	1.657	0.851	20	19	32	8.58	0.747	21.3	19	49	40	4	9.91	0.736	22.2	20	41	18	4
1.427	20	41	30	1.658	0.850	19	27	36	8.59	0.747	20.6	19	33	22	4	9.63	0.730	24.9	19	49	40	4
1.423	20	31	42	1.664	0.847	19	39	28	8.57	0.746	21.3	19	41	14	4	9.65	0.729	24.3	19	33	40	4
1.417	19	37	26	1.669	0.845	19	23	36	8.56	0.746	21.4	19	9	24	4	9.59	0.729	25.1	19	47	42	4
1.417	20	35	42	1.680	0.839	20	37	22	8.57	0.745	19.4	19	21	16	4	9.66	0.726	23.8	19	39	16	4
1.416	20	23	40	1.682	0.838	20	35	20	8.57	0.745	17.8	20	43	34	4	9.57	0.726	24.9	19	41	48	4
1.414	19	21	28	1.687	0.836	20	29	42	8.56	0.745	19.5	19	47	24	4	9.81	0.726	21.8	20	17	34	4

* LHGR calculated with pin-power reconstruction
* CPR calculated with pin-power reconstruction & CPR limit TYPE 3

Figure A.26 Browns Ferry Equilibrium Cycle Control Rod Pattern and Axial Distributions at 9,500.0 MWd/MTU

```
Cycle:                            21                          Core Average Exposure: MWd/MTU    27392.2
Exposure: MWd/MTU (GWd)       9618.7 (1330.97 )
Delta E: MWd/MTU, (GWd)        118.7 (  16.42 )                  Axial Profile    Edit   Radial Power
Power: MWt                    3952.0 (100.00 %)            N(PRA) Power Exposure  Zone  Avg.  Max.  IR JR
Core Pressure: psia           1050.0                      Top 25  0.178   5.459    13  0.433 0.658   7 16
Inlet Subcooling: Btu/lbm     -31.45                          24  0.460  14.695    14  0.333 0.616  27  4
Flow: Mlb/hr                   88.76 ( 86.60 %)               23  0.576  18.677    15  0.418 0.675  45  8
                                                              22  0.646  21.294    16  1.062 1.254  33 24
   2  6 10 14 18 22 26 30 34 38 42 46 50 54 58                21  0.683  22.962    17  1.088 1.272  31 22
59             -- -- -- -- -- -- --             59            20  0.715  24.247    18  0.944 1.223  43 18
55          -- -- -- -- -- -- -- -- --          55            19  0.743  25.088    19  1.340 1.476  31 24
51       -- -- -- -- -- -- -- -- -- -- --       51            18  0.779  26.037    20  1.272 1.428  41 30
47    -- -- -- -- --  6 --  6 -- -- -- -- --    47            17  0.819  26.936    21  1.160 1.305  43 50
43 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 43            16  0.867  27.363
39 -- -- -- --  8 -- -- -- -- --  8 -- -- -- -- 39            15  0.948  27.614
35 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 35            14  1.002  28.725
31 -- --  6 -- -- --  6 --  6 -- -- --  6 -- -- 31            13  1.055  29.796
27 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 27            12  1.116  31.129
23 -- -- -- --  8 -- -- -- -- --  8 -- -- -- -- 23            11  1.160  31.980
19 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 19            10  1.266  31.227
15    -- -- -- -- --  6 --  6 -- -- -- -- --    15             9  1.337  32.536
11       -- -- -- -- -- -- -- -- -- -- --       11             8  1.397  33.752
 7          -- -- -- -- -- -- -- -- --           7             7  1.468  35.150
 3             -- -- -- -- -- -- --              3             6  1.532  36.390
   2  6 10 14 18 22 26 30 34 38 42 46 50 54 58                 5  1.579  37.144*
                                                               4  1.580* 36.596
Control Rod Density: %          5.59                           3  1.518  34.165
                                                               2  1.224  26.620
k-effective:                 0.99875                    Bottom  1  0.351   8.108
Void Fraction:                 0.493
Core Delta-P: psia            20.218               % AXIAL TILT -29.700 -16.558
Core Plate Delta-P: psia      15.661           AVG BOT 8ft/12ft  1.1724  1.0880
Coolant Temp: Deg-F            548.1
In Channel Flow: Mlb/hr        77.76   Active Channel Flow: Mlb/hr        74.91
Total Bypass Flow (%):          12.4   (of total core flow)
Total Water Rod Flow (%):        3.2   (of total core flow)
Source Convergence           0.00010
```

Top Ten Thermal Limits Summary - Sorted by Margin

Power Value	FT	IR	JR	MCPR Value	Margin	FT	IR	JR	APLHGR Value	Margin	Exp.	FT	IR	JR	K	LHGR Value	Margin	Exp.	FT	IR	JR	K
1.476	19	31	24	1.565	0.901	19	29	38	8.56	0.745	18.3	20	19	18	4	7.14	0.740	55.2	18	15	16	5
1.468	19	33	40	1.572	0.897	19	33	22	8.53	0.742	20.0	19	31	24	4	7.06	0.735	55.4	18	43	48	5
1.455	19	35	24	1.590	0.887	19	35	24	8.51	0.740	20.7	20	43	16	4	7.08	0.735	55.3	18	47	18	5
1.430	19	33	26	1.652	0.854	20	19	32	8.48	0.740	21.5	19	49	40	4	9.78	0.728	22.5	20	41	18	4
1.428	20	41	30	1.654	0.853	19	27	36	8.46	0.738	21.7	19	9	24	4	9.51	0.723	25.1	19	49	40	4
1.423	20	31	42	1.659	0.850	19	39	28	8.46	0.738	21.5	19	41	14	4	9.47	0.722	25.4	19	47	42	4
1.418	20	35	42	1.665	0.847	19	37	26	8.48	0.737	20.9	19	33	22	4	9.52	0.721	24.6	19	33	40	4
1.417	19	37	26	1.675	0.842	20	37	22	8.47	0.737	19.7	19	39	16	4	7.21	0.720	53.8	18	17	18	5
1.416	20	23	40	1.678	0.840	20	35	20	8.47	0.736	18.0	20	43	34	4	9.55	0.719	24.1	19	39	16	4
1.414	19	21	28	1.682	0.838	20	29	42	8.46	0.736	19.8	19	47	24	4	9.45	0.718	25.2	19	41	48	4

* LHGR calculated with pin-power reconstruction
* CPR calculated with pin-power reconstruction & CPR limit TYPE 3

Figure A.27 Browns Ferry Equilibrium Cycle Control Rod Pattern and Axial Distributions at 9,618.7 MWd/MTU

```
Cycle:                            21                    Core Average Exposure: MWd/MTU    27393.0
Exposure: MWd/MTU (GWd)       9619.6 (1331.10 )
Delta E: MWd/MTU, (GWd)          0.9 (    0.12 )              Axial Profile    Edit   Radial Power
Power: MWt                    3952.0 (100.00 %)          N(PRA) Power Exposure  Zone  Avg.  Max.  IR JR
Core Pressure: psia           1050.0                     Top 25  0.165   5.459    13  0.410 0.615   7 16
Inlet Subcooling: Btu/lbm     -29.82                         24  0.428  14.696    14  0.326 0.639  27  4
Flow: Mlb/hr                   93.28 ( 91.00 %)              23  0.538  18.677    15  0.406 0.684  33 58
                                                             22  0.609  21.295    16  1.068 1.227  33 42
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58              21  0.652  22.963    17  1.133 1.251  29 40
59             -- -- -- -- -- -- -- --             59        20  0.691  24.248    18  0.895 1.194  35 52
55          -- -- -- -- -- -- -- -- -- --          55        19  0.725  25.089    19  1.354 1.453  31 24
51       -- -- -- -- -- -- -- -- -- -- -- --       51        18  0.767  26.038    20  1.273 1.416  31 42
47    -- --  8 -- -- --  6 -- -- --  8 -- --    47           17  0.812  26.937    21  1.151 1.295  35 54
43 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 43           16  0.865  27.363
39 -- -- -- -- --  0 -- -- --  0 -- -- -- -- -- 39           15  0.952  27.615
35 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 35           14  1.010  28.726
31 -- -- --  6 -- -- --  6 -- -- --  6 -- -- -- 31           13  1.068  29.797
27 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 27           12  1.132  31.130
23 -- -- -- -- --  0 -- -- --  0 -- -- -- -- -- 23           11  1.179  31.982
19 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 19           10  1.287  31.228
15    -- --  8 -- -- --  6 -- -- --  8 -- --    15            9  1.359  32.537
11       -- -- -- -- -- -- -- -- -- -- -- --       11         8  1.419  33.753
 7          -- -- -- -- -- -- -- -- -- --           7         7  1.490  35.151
 3             -- -- -- -- -- -- -- --              3         6  1.552  36.391
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58               5  1.595* 37.146*
                                                              4  1.592  36.598
Control Rod Density: %          6.33                          3  1.527  34.167
                                                              2  1.231  26.621
k-effective:                 0.99853                  Bottom  1  0.354   8.108
Void Fraction:                 0.485
Core Delta-P: psia            21.797              % AXIAL TILT -31.347 -16.558
Core Plate Delta-P: psia      17.236          AVG BOT 8ft/12ft  1.1846  1.0880
Coolant Temp: Deg-F            548.2
In Channel Flow: Mlb/hr        81.76  Active Channel Flow: Mlb/hr        78.78
Total Bypass Flow (%):          12.3  (of total core flow)
Total Water Rod Flow (%):        3.2  (of total core flow)
Source Convergence           0.00009
```

Top Ten Thermal Limits Summary - Sorted by Margin

Power				MCPR					APLHGR							LHGR						
Value	FT	IR	JR	Value	Margin	FT	IR	JR	Value	Margin	Exp.	FT	IR	JR	K	Value	Margin	Exp.	FT	IR	JR	K
1.453	19	31	24	1.631	0.865	19	29	38	8.99	0.782	19.8	19	47	24	4	7.22	0.764	56.0	18	25	10	5
1.452	19	23	30	1.635	0.862	19	37	30	8.90	0.774	19.5	19	45	40	4	7.46	0.760	54.6	18	9	26	4
1.423	19	33	40	1.675	0.842	19	37	48	8.87	0.772	17.8	20	43	38	4	9.95	0.759	25.6	19	9	24	4
1.422	19	35	28	1.676	0.841	19	13	38	8.83	0.771	21.7	19	9	24	4	9.97	0.758	25.1	21	7	26	4
1.422	19	33	26	1.680	0.839	19	21	46	8.85	0.770	17.8	20	45	36	4	10.21	0.754	21.6	20	17	24	4
1.421	19	37	48	1.681	0.839	19	33	40	8.82	0.767	20.9	19	49	26	4	9.92	0.752	24.9	19	49	26	4
1.419	19	21	28	1.684	0.837	19	45	22	8.81	0.766	20.3	19	23	14	4	10.02	0.752	23.5	19	47	24	4
1.418	19	13	24	1.688	0.835	20	35	20	8.79	0.765	20.4	20	51	28	4	10.15	0.751	21.8	20	15	26	4
1.416	20	31	42	1.689	0.835	20	17	38	8.78	0.763	19.7	19	39	16	4	9.86	0.749	25.1	20	9	34	4
1.414	19	15	22	1.690	0.834	20	27	44	8.75	0.761	17.9	20	23	18	4	9.90	0.748	24.5	19	7	34	4

* LHGR calculated with pin-power reconstruction
* CPR calculated with pin-power reconstruction & CPR limit TYPE 3

Figure A.28 Browns Ferry Equilibrium Cycle Control Rod Pattern and Axial Distributions at 9,619.6 MWd/MTU

```
Cycle:                             21
Exposure: MWd/MTU (GWd)       10000.0 (1383.74 )
Delta E: MWd/MTU, (GWd)         380.4 (  52.64 )
Power: MWt                     3952.0 (100.00 %)
Core Pressure: psia            1050.0
Inlet Subcooling: Btu/lbm      -29.79
Flow: Mlb/hr                    93.38 ( 91.10 %)

    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58
59             -- -- -- -- -- -- --             59
55          -- -- -- -- -- -- -- -- --          55
51       -- -- -- -- -- -- -- -- -- -- --       51
47    -- --  8 -- -- --  6 -- -- --  8 -- --    47
43 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 43
39 -- -- -- -- --  0 -- -- --  0 -- -- -- -- -- 39
35 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 35
31 -- -- --  6 -- -- --  6 -- -- --  6 -- -- -- 31
27 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 27
23 -- -- -- -- --  0 -- -- --  0 -- -- -- -- -- 23
19 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 19
15    -- --  8 -- -- --  6 -- -- --  8 -- --    15
11       -- -- -- -- -- -- -- -- -- -- --       11
 7          -- -- -- -- -- -- -- -- --           7
 3             -- -- -- -- -- -- --              3
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58

Control Rod Density: %           6.33

k-effective:                  0.99865
Void Fraction:                  0.478
Core Delta-P: psia             21.740
Core Plate Delta-P: psia       17.179
Coolant Temp: Deg-F             548.1
In Channel Flow: Mlb/hr         81.90   Active Channel Flow: Mlb/hr        78.94
Total Bypass Flow (%):           12.3   (of total core flow)
Total Water Rod Flow (%):         3.2   (of total core flow)
Source Convergence            0.00007
```

```
Core Average Exposure: MWd/MTU    27773.4

           Axial Profile     Edit   Radial Power
   N(PRA) Power Exposure     Zone  Avg.  Max.   IR JR
  Top 25  0.171    5.528      13  0.409 0.615    7 16
      24  0.444   14.878      14  0.325 0.638   27  4
      23  0.558   18.906      15  0.406 0.682   33 58
      22  0.632   21.555      16  1.067 1.226   33 42
      21  0.678   23.242      17  1.132 1.249   29 40
      20  0.719   24.543      18  0.895 1.193   35 52
      19  0.754   25.400      19  1.354 1.454   31 24
      18  0.797   26.366      20  1.275 1.416   31 42
      17  0.843   27.284      21  1.152 1.295   35 54
      16  0.896   27.725
      15  0.982   27.988
      14  1.040   29.121
      13  1.095   30.214
      12  1.157   31.571
      11  1.200   32.440
      10  1.304   31.678
       9  1.368   33.005
       8  1.417   34.240
       7  1.473   35.660
       6  1.516   36.918
       5  1.536*  37.683*
       4  1.510   37.131
       3  1.431   34.675
       2  1.150   27.030
Bottom 1  0.330    8.238

      % AXIAL TILT -28.769 -16.644
  AVG BOT 8ft/12ft  1.1722  1.0885
```

Top Ten Thermal Limits Summary - Sorted by Margin

Power				MCPR					APLHGR							LHGR						
Value	FT	IR	JR	Value	Margin	FT	IR	JR	Value	Margin	Exp.	FT	IR	JR	K	Value	Margin	Exp.	FT	IR	JR	K
1.454	19	31	24	1.628	0.866	19	29	38	8.55	0.743	20.6	19	47	24	4	6.94	0.748	56.7	18	25	10	5
1.452	19	23	30	1.633	0.863	19	37	30	8.42	0.738	22.4	19	51	24	4	7.17	0.745	55.3	18	9	26	5
1.423	19	33	40	1.672	0.844	19	37	48	8.46	0.736	20.4	19	45	40	4	9.47	0.728	26.5	19	9	24	4
1.422	19	33	26	1.672	0.844	19	33	40	8.44	0.734	18.7	20	43	38	4	9.50	0.727	26.1	21	7	26	4
1.422	19	35	28	1.674	0.842	19	13	38	8.43	0.733	18.7	20	45	36	4	9.43	0.721	25.9	19	49	26	4
1.420	19	37	48	1.677	0.841	19	21	46	8.38	0.731	21.7	19	49	26	4	9.53	0.720	24.5	19	47	24	4
1.419	19	21	28	1.682	0.838	19	39	34	8.36	0.728	21.3	20	9	34	4	9.43	0.718	25.4	19	7	34	4
1.418	19	13	24	1.683	0.838	19	45	22	8.32	0.727	21.8	21	7	36	4	9.65	0.718	22.5	20	17	24	4
1.416	20	31	42	1.694	0.833	20	35	20	8.35	0.726	21.1	19	23	14	4	7.07	0.716	54.3	17	49	24	5
1.415	19	15	22	1.694	0.832	19	35	28	8.34	0.725	20.5	19	39	16	4	9.59	0.715	22.7	20	15	26	4

* LHGR calculated with pin-power reconstruction
* CPR calculated with pin-power reconstruction & CPR limit TYPE 3

Figure A.29 Browns Ferry Equilibrium Cycle Control Rod Pattern and Axial Distributions at 10,000.0 MWd/MTU

```
Cycle:                           21                        Core Average Exposure: MWd/MTU    28273.4
Exposure: MWd/MTU (GWd)     10500.0 (1452.92 )
Delta E: MWd/MTU, (GWd)       500.0 (  69.19 )                 Axial Profile    Edit   Radial Power
Power: MWt                   3952.0 (100.00 %)           N(PRA) Power Exposure  Zone  Avg.  Max.  IR JR
Core Pressure: psia         1050.0                      Top 25  0.180   5.624    13  0.410 0.616   7 16
Inlet Subcooling: Btu/lbm    -30.07                          24  0.465  15.127    14  0.324 0.637  27  4
Flow: Mlb/hr                  92.56 ( 90.30 %)               23  0.586  19.219    15  0.406 0.681  33 58
                                                             22  0.664  21.912    16  1.065 1.223  33 42
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58              21  0.712  23.625    17  1.130 1.245  29 40
59             -- -- -- -- -- -- -- --             59        20  0.756  24.950    18  0.896 1.192  35 52
55          -- -- -- -- -- -- -- -- -- --          55        19  0.794  25.827    19  1.354 1.453  31 24
51       -- -- -- -- -- -- -- -- -- -- -- --       51        18  0.838  26.817    20  1.276 1.415  31 42
47    -- --  8 -- -- --  6 -- -- --  8 -- --    47           17  0.884  27.761    21  1.154 1.296  35 54
43 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 43           16  0.936  28.218
39 -- -- -- -- -- --  0 -- -- --  0 -- -- -- -- -- 39        15  1.022  28.496
35 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 35           14  1.078  29.657
31 -- -- --  6 -- -- --  6 -- -- --  6 -- -- -- 31           13  1.131  30.778
27 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 27           12  1.190  32.166
23 -- -- -- -- -- --  0 -- -- --  0 -- -- -- -- -- 23        11  1.227  33.054
19 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 19           10  1.323  32.277
15    -- --  8 -- -- --  6 -- -- --  8 -- --    15            9  1.377  33.624
11       -- -- -- -- -- -- -- -- -- -- -- --       11         8  1.410  34.878
 7          -- -- -- -- -- -- -- -- -- --           7         7  1.446  36.319
 3             -- -- -- -- -- -- -- --              3         6  1.465* 37.591
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58               5  1.456  38.359*
                                                              4  1.403  37.789
Control Rod Density: %         6.33                           3  1.310  35.294
                                                              2  1.047  27.527
k-effective:                0.99859                 Bottom  1  0.300   8.395
Void Fraction:                0.470
Core Delta-P: psia           21.338              % AXIAL TILT -25.302 -16.699
Core Plate Delta-P: psia     16.778          AVG BOT 8ft/12ft  1.1556  1.0889
Coolant Temp: Deg-F           547.9
In Channel Flow: Mlb/hr       81.24  Active Channel Flow: Mlb/hr        78.32
Total Bypass Flow (%):         12.2  (of total core flow)
Total Water Rod Flow (%):       3.1  (of total core flow)
Source Convergence          0.00006
```

Top Ten Thermal Limits Summary - Sorted by Margin

Power				MCPR					APLHGR							LHGR						
Value	FT	IR	JR	Value	Margin	FT	IR	JR	Value	Margin	Exp.	FT	IR	JR	K	Value	Margin	Exp.	FT	IR	JR	K
1.453	19	31	24	1.621	0.870	19	29	38	7.98	0.695	21.2	19	47	24	5	6.57	0.725	57.6	18	25	10	5
1.451	19	23	30	1.627	0.867	19	37	30	7.87	0.694	23.4	19	51	24	4	6.82	0.725	56.2	18	9	26	5
1.422	19	33	40	1.655	0.852	19	33	40	7.86	0.687	22.1	19	49	26	5	6.72	0.696	55.2	17	49	24	5
1.421	19	33	26	1.661	0.849	19	37	48	7.90	0.687	21.0	19	15	22	5	6.59	0.686	55.4	17	23	50	5
1.420	19	25	28	1.663	0.848	19	13	38	7.86	0.685	21.6	19	37	14	5	8.84	0.686	27.7	19	9	24	4
1.420	19	37	48	1.664	0.847	19	39	34	7.83	0.685	22.0	20	9	34	5	8.87	0.686	27.2	21	7	26	4
1.418	19	13	24	1.666	0.847	19	21	46	7.80	0.685	22.8	21	7	36	4	6.55	0.684	55.5	17	9	32	5
1.418	19	21	28	1.672	0.844	19	45	22	7.87	0.684	19.9	20	45	36	5	6.38	0.681	56.4	17	41	50	5
1.415	20	31	42	1.681	0.839	19	35	28	7.87	0.684	19.9	20	17	24	5	6.26	0.681	57.1	16	33	50	5
1.415	19	15	22	1.684	0.838	19	27	36	7.83	0.681	21.1	19	39	16	5	6.33	0.681	56.6	17	11	20	5

* LHGR calculated with pin-power reconstruction
* CPR calculated with pin-power reconstruction & CPR limit TYPE 3

Figure A.30 Browns Ferry Equilibrium Cycle Control Rod Pattern and Axial Distributions at 10,500.0 MWd/MTU

```
Cycle:                           21                        Core Average Exposure: MWd/MTU    28773.2
Exposure: MWd/MTU (GWd)     11000.0 (1522.11 )
Delta E: MWd/MTU, (GWd)       500.0 (  69.19 )                 Axial Profile    Edit   Radial Power
Power: MWt                   3952.0 (100.00 %)            N(PRA) Power Exposure  Zone  Avg.  Max.  IR JR
Core Pressure: psia          1050.0                      Top 25  0.189   5.724    13  0.409 0.617   7 16
Inlet Subcooling: Btu/lbm    -30.18                          24  0.488  15.388    14  0.324 0.636  27  4
Flow: Mlb/hr                  92.25 ( 90.00 %)               23  0.614  19.548    15  0.405 0.680  33 58
                                                             22  0.697  22.288    16  1.064 1.221  33 42
   2  6 10 14 18 22 26 30 34 38 42 46 50 54 58               21  0.748  24.028    17  1.127 1.241  29 40
59             -- -- -- -- -- -- -- --             59        20  0.795  25.378    18  0.896 1.191  35 52
55          -- -- -- -- -- -- -- -- -- --          55        19  0.834  26.275    19  1.355 1.452  31 24
51       -- -- -- -- -- -- -- -- -- -- -- --       51        18  0.880  27.291    20  1.277 1.414  31 42
47    -- --  8 -- -- --  6 -- -- --  8 -- --    47           17  0.926  28.260    21  1.157 1.297  35 54
43 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 43           16  0.976  28.733
39 -- -- -- -- -- --  0 -- -- --  0 -- -- -- -- -- 39        15  1.062  29.024
35 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 35           14  1.116  30.213
31 -- -- --  6 -- -- --  6 -- -- --  6 -- -- -- 31           13  1.166  31.360
27 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 27           12  1.222  32.777
23 -- -- -- -- -- --  0 -- -- --  0 -- -- -- -- -- 23        11  1.253  33.682
19 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 19           10  1.341  32.885
15    -- --  8 -- -- --  6 -- -- --  8 -- --    15            9  1.384  34.247
11       -- -- -- -- -- -- -- -- -- -- -- --       11         8  1.402  35.513
 7          -- -- -- -- -- -- -- -- -- --           7         7  1.417* 36.965
 3             -- -- -- -- -- -- -- --              3         6  1.411  38.240
   2  6 10 14 18 22 26 30 34 38 42 46 50 54 58                5  1.375  38.998*
                                                              4  1.297  38.399
Control Rod Density: %         6.33                           3  1.190  35.859
                                                              2  0.946  27.977
k-effective:                0.99863                   Bottom  1  0.271   8.538
Void Fraction:                0.461
Core Delta-P: psia           21.116             % AXIAL TILT -21.752 -16.690
Core Plate Delta-P: psia     16.556         AVG BOT 8ft/12ft  1.1384  1.0890
Coolant Temp: Deg-F           547.7
In Channel Flow: Mlb/hr       81.03   Active Channel Flow: Mlb/hr        78.15
Total Bypass Flow (%):         12.2   (of total core flow)
Total Water Rod Flow (%):       3.1   (of total core flow)
Source Convergence          0.00007


                          Top Ten Thermal Limits Summary - Sorted by Margin

     Power                  MCPR                              APLHGR                               LHGR
Value FT  IR JR     Value Margin FT  IR JR    Value Margin Exp. FT  IR JR  K    Value Margin Exp. FT  IR JR  K
1.452  19 31 24     1.616  0.872  19 29 38    7.55  0.661 22.2  19 47 24  5     6.46  0.702 57.0  18  9 26  5
1.450  19 23 30     1.622  0.870  19 37 30    7.50  0.661 23.5  19  9 24  5     6.48  0.701 56.8  18 25 10  6
1.421  19 33 40     1.645  0.857  19 33 40    7.53  0.655 16.6  19 29 38 11     6.36  0.673 56.0  17 49 24  5
1.420  19 33 26     1.655  0.852  19 39 34    7.44  0.655 23.1  19 49 26  5     6.46  0.668 55.1  17 23 50  6
1.419  19 25 28     1.660  0.849  19 37 48    7.44  0.654 23.0  20  9 34  5     6.21  0.667 56.6  16 33 50  6
1.419  19 37 48     1.660  0.849  19 13 38    7.47  0.653 22.0  19 15 22  5     6.26  0.663 56.0  17 41 50  6
1.418  19 13 24     1.664  0.847  19 21 46    7.51  0.653 16.5  19 23 30 11     6.20  0.662 56.3  17  9 32  5
1.417  19 21 28     1.669  0.845  19 45 22    7.50  0.653 21.3  19 23 48  6     6.15  0.662 56.7  17 31 26  6
1.415  19 15 22     1.670  0.844  19 35 28    7.35  0.650 23.9  19 23 10  5     6.38  0.660 55.1  17 39 48  6
1.414  19 39 46     1.673  0.843  19 27 36    7.39  0.649 22.8  21  7 36  5     6.16  0.660 56.5  17 25 32  6

  * LHGR calculated with pin-power reconstruction
  * CPR calculated with pin-power reconstruction & CPR limit TYPE 3
```

Figure A.31 Browns Ferry Equilibrium Cycle Control Rod Pattern and Axial Distributions at 11,000.0 MWd/MTU

```
Cycle:                          21                     Core Average Exposure: MWd/MTU    29273.3
Exposure: MWd/MTU (GWd)      11500.0 (1591.30 )
Delta E: MWd/MTU, (GWd)        500.0 (  69.19 )           Axial Profile     Edit   Radial Power
Power: MWt                    3952.0 (100.00 %)       N(PRA) Power Exposure  Zone  Avg.  Max.  IR JR
Core Pressure: psia           1050.0                 Top 25  0.198   5.829    13  0.409 0.617   7 16
Inlet Subcooling: Btu/lbm     -30.18                     24  0.512  15.662    14  0.323 0.635  27  4
Flow: Mlb/hr                   92.25 ( 90.00 %)          23  0.646  19.894    15  0.404 0.679  33 58
                                                         22  0.733  22.682    16  1.063 1.218  33 42
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58          21  0.788  24.452    17  1.125 1.236  29 40
59             -- -- -- -- -- -- -- --             59    20  0.837  25.828    18  0.897 1.191  35 52
55          -- -- -- -- -- -- -- -- -- --          55    19  0.878  26.747    19  1.355 1.450  31 24
51       -- -- -- -- -- -- -- -- -- -- -- --       51    18  0.925  27.789    20  1.278 1.412  31 42
47    -- --  8 -- -- --  6 -- -- --  8 -- --    47       17  0.970  28.783    21  1.160 1.299  35 54
43 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 43       16  1.018  29.271
39 -- -- -- -- -- --  0 -- -- --  0 -- -- -- -- -- 39    15  1.104  29.573
35 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 35       14  1.154  30.789
31 -- -- --  6 -- -- --  6 -- -- --  6 -- -- -- 31       13  1.200  31.960
27 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 27       12  1.251  33.404
23 -- -- -- -- -- --  0 -- -- --  0 -- -- -- -- -- 23    11  1.276  34.323
19 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 19       10  1.356  33.500
15    -- --  8 -- -- --  6 -- -- --  8 -- --    15        9  1.387  34.873
11       -- -- -- -- -- -- -- -- -- -- -- --       11     8  1.388* 36.143
 7          -- -- -- -- -- -- -- -- -- --           7     7  1.383  37.597
 3             -- -- -- -- -- -- -- --              3     6  1.354  38.864
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58           5  1.291  39.599*
                                                          4  1.191  38.961
Control Rod Density: %          6.33                      3  1.072  36.370
                                                          2  0.847  28.382
k-effective:                 0.99877             Bottom  1  0.242   8.666
Void Fraction:                 0.451
Core Delta-P: psia            20.995           % AXIAL TILT -17.970 -16.616
Core Plate Delta-P: psia      16.436         AVG BOT 8ft/12ft  1.1198  1.0888
Coolant Temp: Deg-F            547.5
In Channel Flow: Mlb/hr        81.10   Active Channel Flow: Mlb/hr       78.25
Total Bypass Flow (%):          12.1   (of total core flow)
Total Water Rod Flow (%):        3.1   (of total core flow)
Source Convergence           0.00010
```

Top Ten Thermal Limits Summary - Sorted by Margin

Power				MCPR					APLHGR							LHGR						
Value	FT	IR	JR	Value	Margin	FT	IR	JR	Value	Margin	Exp.	FT	IR	JR	K	Value	Margin	Exp.	FT	IR	JR	K
1.450	19	31	24	1.610	0.876	19	29	38	7.65	0.665	17.6	19	29	38	11	6.22	0.688	57.6	18	25	10	6
1.448	19	23	30	1.615	0.873	19	37	30	7.63	0.663	17.5	19	23	30	11	6.37	0.682	56.5	18	9	26	6
1.419	19	37	48	1.637	0.861	19	33	40	7.53	0.655	18.0	19	33	40	11	8.89	0.660	22.1	19	31	24	11
1.419	19	33	40	1.647	0.856	19	39	34	7.53	0.655	16.8	19	37	48	11	6.94	0.659	49.9	17	31	40	11
1.419	19	13	24	1.650	0.855	19	37	48	7.49	0.652	18.2	19	33	26	11	6.28	0.659	55.7	17	49	24	6
1.418	19	33	26	1.656	0.852	19	13	38	7.49	0.652	17.8	20	31	42	11	8.85	0.656	21.9	19	23	32	11
1.417	19	25	28	1.659	0.850	19	21	46	7.49	0.651	18.2	19	25	34	11	6.21	0.655	55.9	17	23	50	6
1.415	19	15	22	1.663	0.848	19	15	22	7.49	0.651	17.8	19	21	28	11	6.90	0.655	49.9	17	39	32	11
1.415	19	21	28	1.665	0.847	19	35	28	7.46	0.648	16.6	19	39	46	11	8.79	0.655	22.6	19	33	40	11
1.415	19	39	46	1.667	0.846	19	27	36	7.44	0.647	16.2	20	35	46	11	5.94	0.652	57.4	16	33	50	6

* LHGR calculated with pin-power reconstruction
* CPR calculated with pin-power reconstruction & CPR limit TYPE 3

Figure A.32 Browns Ferry Equilibrium Cycle Control Rod Pattern and Axial Distributions at 11,500.0 MWd/MTU

```
Cycle:                           21                       Core Average Exposure: MWd/MTU    29773.2
Exposure: MWd/MTU (GWd)     12000.0 (1660.49 )
Delta E: MWd/MTU, (GWd)       500.0 (  69.19 )               Axial Profile    Edit   Radial Power
Power: MWt                   3952.0 (100.00 %)          N(PRA) Power Exposure  Zone  Avg.  Max.  IR JR
Core Pressure: psia          1050.0                    Top 25  0.209   5.939    13  0.409 0.617   7 16
Inlet Subcooling: Btu/lbm    -30.18                        24  0.538  15.950    14  0.322 0.634  27  4
Flow: Mlb/hr                  92.25 ( 90.00 %)             23  0.679  20.257    15  0.404 0.678   3 34
                                                           22  0.771  23.097    16  1.061 1.214  33 42
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58            21  0.830  24.898    17  1.123 1.230  31 40
59             -- -- -- -- -- -- -- --            59       20  0.881  26.301    18  0.898 1.192  35 52
55          -- -- -- -- -- -- -- -- -- --         55       19  0.923  27.244    19  1.355 1.446  31 24
51       -- -- -- -- -- -- -- -- -- -- -- --      51       18  0.971  28.312    20  1.279 1.409  31 42
47    -- --  8 -- -- --  6 -- -- --  8 -- --      47       17  1.016  29.331    21  1.164 1.303  35 54
43 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 43       16  1.061  29.831
39 -- -- -- -- -- --  0 -- -- --  0 -- -- -- -- -- 39    15  1.145  30.143
35 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 35       14  1.191  31.383
31 -- -- --  6 -- -- --  6 -- -- --  6 -- -- -- 31       13  1.233  32.576
27 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 27       12  1.278  34.045
23 -- -- -- -- -- --  0 -- -- --  0 -- -- -- -- -- 23    11  1.294  34.973
19 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 19       10  1.365  34.121
15    -- --  8 -- -- --  6 -- -- --  8 -- --      15        9  1.384* 35.498
11       -- -- -- -- -- -- -- -- -- -- -- --      11        8  1.368  36.765
 7          -- -- -- -- -- -- -- -- -- --          7        7  1.344  38.213
 3             -- -- -- -- -- -- -- --             3        6  1.293  39.462
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58             5  1.206  40.163*
                                                            4  1.087  39.475
Control Rod Density: %         6.33                         3  0.961  36.830
                                                            2  0.754  28.744
k-effective:                0.99888               Bottom  1  0.216   8.780
Void Fraction:                0.441
Core Delta-P: psia           20.876            % AXIAL TILT -14.041 -16.478
Core Plate Delta-P: psia     16.316        AVG BOT 8ft/12ft  1.1001  1.0883
Coolant Temp: Deg-F           547.3
In Channel Flow: Mlb/hr       81.17   Active Channel Flow: Mlb/hr        78.34
Total Bypass Flow (%):         12.0   (of total core flow)
Total Water Rod Flow (%):       3.1   (of total core flow)
Source Convergence          0.00009


                    Top Ten Thermal Limits Summary - Sorted by Margin

     Power               MCPR                        APLHGR                            LHGR
Value FT  IR JR    Value Margin FT  IR JR    Value Margin Exp. FT  IR JR  K    Value Margin Exp. FT  IR JR  K
1.446  19 31 24    1.608  0.877  19 29 38     7.71  0.670 18.6  19 31 24 11     5.95  0.672 58.4  18 25 10  6
1.444  19 23 30    1.613  0.874  19 37 30     7.70  0.669 18.5  19 23 32 11     9.00  0.670 22.7  19 31 24 12
1.419  19 37 48    1.627  0.867  19 33 40     7.65  0.665 17.8  19 37 48 11     6.11  0.668 57.2  18  9 26  6
1.419  19 13 24    1.636  0.862  19 39 34     7.59  0.660 19.0  19 27 40 11     6.96  0.667 50.8  17 31 40 11
1.416  19 33 40    1.640  0.860  19 37 48     7.58  0.659 17.5  19 39 46 11     8.96  0.666 22.4  19 23 32 12
1.415  19 15 22    1.645  0.857  19 13 38     7.57  0.658 17.3  19 13 24 11     8.91  0.666 23.1  19 33 40 12
1.414  19 33 26    1.650  0.855  19 21 46     7.56  0.657 18.8  19 21 28 11     6.93  0.664 50.7  17 39 32 11
1.414  19 39 46    1.653  0.853  19 15 22     7.56  0.657 18.7  20 31 42 11     8.85  0.660 22.8  19 39 34 12
1.414  19 25 28    1.660  0.850  19 33 26     7.55  0.657 18.5  19 35 50 11     8.86  0.656 21.9  19 23 48 11
1.411  19 21 28    1.660  0.849  19 25 34     7.55  0.656 17.2  20 35 46 11     8.82  0.655 22.2  20 31 42 12

  * LHGR calculated with pin-power reconstruction
  * CPR calculated with pin-power reconstruction & CPR limit TYPE 3
```

Figure A.33 Browns Ferry Equilibrium Cycle Control Rod Pattern and Axial Distributions at 12,000.0 MWd/MTU

```
Cycle:                            21              Core Average Exposure: MWd/MTU    29899.9
Exposure: MWd/MTU (GWd)      12126.7 (1678.02 )
Delta E: MWd/MTU, (GWd)        126.7 (  17.53 )            Axial Profile    Edit   Radial Power
Power: MWt                    3952.0 (100.00 %)       N(PRA) Power Exposure  Zone  Avg.  Max.  IR JR
Core Pressure: psia           1050.0                  Top 25  0.211   5.968    13  0.409 0.618   7 16
Inlet Subcooling: Btu/lbm     -30.18                      24  0.544  16.025    14  0.322 0.633  27  4
Flow: Mlb/hr                   92.25 ( 90.00 %)           23  0.687  20.352    15  0.404 0.678   3 34
                                                          22  0.781  23.205    16  1.060 1.212  33 42
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58           21  0.840  25.015    17  1.122 1.229  31 40
59             -- -- -- -- -- -- -- --          59        20  0.892  26.425    18  0.898 1.192  35 52
55          -- -- -- -- -- -- -- -- -- --       55        19  0.934  27.374    19  1.355 1.445  31 24
51       -- -- -- -- -- -- -- -- -- -- -- --    51        18  0.982  28.448    20  1.279 1.408  31 42
47    -- --  8 -- -- --  6 -- -- --  8 -- --    47        17  1.027  29.474    21  1.165 1.303  35 54
43 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 43        16  1.071  29.977
39 -- -- -- -- -- --  0 -- -- --  0 -- -- -- -- -- 39     15  1.154  30.290
35 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 35        14  1.199  31.537
31 -- -- --  6 -- -- --  6 -- -- --  6 -- -- -- 31        13  1.239  32.735
27 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 27        12  1.283  34.209
23 -- -- -- -- -- --  0 -- -- --  0 -- -- -- -- -- 23     11  1.297  35.140
19 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 19        10  1.366  34.279
15    -- --  8 -- -- --  6 -- -- --  8 -- --    15         9  1.381* 35.656
11       -- -- -- -- -- -- -- -- -- -- -- --    11         8  1.362  36.921
 7          -- -- -- -- -- -- -- -- -- --        7         7  1.334  38.366
 3             -- -- -- -- -- -- -- --           3         6  1.278  39.609
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58            5  1.188  40.300*
                                                           4  1.065  39.598
Control Rod Density: %          6.33                       3  0.939  36.938
                                                           2  0.735  28.829
k-effective:                 0.99896           Bottom  1  0.211   8.807
Void Fraction:                 0.438
Core Delta-P: psia            20.849             % AXIAL TILT -13.108 -16.433
Core Plate Delta-P: psia      16.289           AVG BOT 8ft/12ft  1.0953  1.0881
Coolant Temp: Deg-F            547.3
In Channel Flow: Mlb/hr        81.19   Active Channel Flow: Mlb/hr        78.36
Total Bypass Flow (%):          12.0   (of total core flow)
Total Water Rod Flow (%):        3.1   (of total core flow)
Source Convergence           0.00009
```

Top Ten Thermal Limits Summary - Sorted by Margin

Power				MCPR					APLHGR							LHGR						
Value	FT	IR	JR	Value	Margin	FT	IR	JR	Value	Margin	Exp.	FT	IR	JR	K	Value	Margin	Exp.	FT	IR	JR	K
1.445	19	31	24	1.608	0.877	19	29	38	7.71	0.670	18.8	19	31	24	11	8.99	0.671	22.9	19	31	24	12
1.443	19	23	30	1.613	0.874	19	37	30	7.70	0.669	18.7	19	23	32	11	5.89	0.668	58.6	18	25	10	6
1.419	19	37	48	1.625	0.868	19	33	40	7.67	0.667	18.0	19	37	48	11	6.95	0.668	51.0	17	31	40	11
1.419	19	13	24	1.635	0.862	19	39	34	7.60	0.660	17.8	19	39	46	11	8.95	0.667	22.7	19	23	32	12
1.415	19	33	40	1.638	0.861	19	37	48	7.59	0.660	19.2	19	27	40	11	8.90	0.667	23.3	19	33	40	12
1.415	19	15	22	1.643	0.858	19	13	38	7.59	0.660	17.5	19	13	24	11	6.05	0.665	57.4	18	9	26	6
1.414	19	39	46	1.648	0.856	19	21	46	7.57	0.658	18.7	19	35	50	11	6.92	0.664	51.0	17	39	32	11
1.414	19	33	26	1.651	0.854	19	15	22	7.56	0.658	17.4	20	35	46	11	8.85	0.661	23.1	19	39	34	12
1.413	19	25	28	1.658	0.850	19	33	26	7.56	0.657	17.5	19	15	22	11	8.86	0.657	22.1	19	23	48	11
1.411	19	21	28	1.659	0.850	19	25	34	7.56	0.657	19.0	19	21	28	11	8.82	0.656	22.5	20	31	42	12

* LHGR calculated with pin-power reconstruction
* CPR calculated with pin-power reconstruction & CPR limit TYPE 3

Figure A.34 Browns Ferry Equilibrium Cycle Control Rod Pattern and Axial Distributions at 12,126.7 MWd/MTU

```
Cycle:                          21                     Core Average Exposure: MWd/MTU    29900.4
Exposure: MWd/MTU (GWd)     12127.3 (1678.10 )
Delta E: MWd/MTU, (GWd)         0.6 (   0.08 )              Axial Profile    Edit   Radial Power
Power: MWt                   3952.0 (100.00 %)        N(PRA) Power Exposure  Zone  Avg.  Max.  IR JR
Core Pressure: psia          1050.0                  Top 25  0.206   5.968    13  0.431 0.662   7 16
Inlet Subcooling: Btu/lbm    -30.25                      24  0.530  16.025    14  0.328 0.585  27  4
Flow: Mlb/hr                  92.05 ( 89.80 %)           23  0.670  20.352    15  0.416 0.675  45  8
                                                         22  0.760  23.206    16  1.054 1.238  23 28
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58          21  0.817  25.015    17  1.073 1.251  21 32
59             -- -- -- -- -- -- --             59       20  0.875  26.426    18  0.948 1.212  45 16
55          -- -- -- -- -- -- -- -- --          55       19  0.922  27.375    19  1.344 1.472  23 30
51       -- -- -- -- --  6 -- -- -- -- --       51       18  0.973  28.449    20  1.274 1.424  19 32
47    -- -- -- -- -- -- -- -- -- -- -- -- --    47       17  1.021  29.474    21  1.181 1.327  11 18
43 -- -- -- -- --  0 -- -- --  0 -- -- -- -- -- 43       16  1.067  29.977
39 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 39       15  1.151  30.291
35 -- -- --  6 -- -- --  6 -- -- --  6 -- -- -- 35       14  1.198  31.537
31 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 31       13  1.239  32.736
27 -- -- --  6 -- -- --  6 -- -- --  6 -- -- -- 27       12  1.285  34.210
23 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 23       11  1.300  35.140
19 -- -- -- -- --  0 -- -- --  0 -- -- -- -- -- 19       10  1.370  34.279
15    -- -- -- -- -- -- -- -- -- -- -- -- --    15        9  1.387* 35.657
11       -- -- -- -- --  6 -- -- -- -- --       11        8  1.370  36.922
 7          -- -- -- -- -- -- -- -- --           7        7  1.345  38.367
 3             -- -- -- -- -- -- --              3        6  1.292  39.609
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58           5  1.205  40.301*
                                                          4  1.086  39.599
Control Rod Density: %         5.95                       3  0.961  36.939
                                                          2  0.754  28.829
k-effective:                0.99906              Bottom  1  0.216   8.807
Void Fraction:                0.443
Core Delta-P: psia           20.809           % AXIAL TILT -14.228 -16.433
Core Plate Delta-P: psia     16.251       AVG BOT 8ft/12ft  1.1027  1.0881
Coolant Temp: Deg-F           547.4
In Channel Flow: Mlb/hr       80.98   Active Channel Flow: Mlb/hr        78.16
Total Bypass Flow (%):         12.0   (of total core flow)
Total Water Rod Flow (%):       3.1   (of total core flow)
Source Convergence          0.00008
```

Top Ten Thermal Limits Summary - Sorted by Margin

Power				MCPR					APLHGR							LHGR						
Value	FT	IR	JR	Value	Margin	FT	IR	JR	Value	Margin	Exp.	FT	IR	JR	K	Value	Margin	Exp.	FT	IR	JR	K
1.472	19	23	30	1.572	0.897	19	37	30	7.79	0.678	18.7	19	23	30	11	9.12	0.679	22.7	19	23	32	12
1.462	19	21	28	1.575	0.895	19	39	34	7.77	0.675	19.0	19	21	28	11	9.04	0.676	23.1	19	39	34	12
1.448	19	23	26	1.599	0.882	19	23	26	7.72	0.671	19.2	19	23	26	11	7.01	0.673	51.0	17	39	32	11
1.425	19	25	28	1.634	0.863	19	25	34	7.62	0.663	19.0	20	31	42	11	6.87	0.670	52.5	16	37	28	11
1.424	20	19	32	1.650	0.854	20	21	38	7.61	0.662	17.4	20	21	24	11	8.91	0.668	23.4	19	23	26	12
1.421	20	21	24	1.661	0.849	19	25	24	7.56	0.657	18.6	20	19	32	11	9.03	0.667	21.6	20	39	24	12
1.420	20	19	26	1.661	0.849	20	29	42	7.54	0.656	17.4	20	19	26	11	6.86	0.666	52.1	17	39	26	11
1.417	20	31	42	1.666	0.846	20	41	26	7.54	0.655	19.4	19	25	34	11	8.83	0.662	23.4	19	25	34	12
1.409	19	35	24	1.668	0.845	19	33	40	7.53	0.655	19.3	19	25	38	11	6.16	0.660	56.5	18	15	16	6
1.403	19	33	40	1.668	0.845	20	41	22	7.52	0.654	17.8	20	15	18	11	8.93	0.659	21.6	20	41	26	12

* LHGR calculated with pin-power reconstruction
* CPR calculated with pin-power reconstruction & CPR limit TYPE 3

Figure A.35 Browns Ferry Equilibrium Cycle Control Rod Pattern and Axial Distributions at 12,127.3 MWd/MTU

```
Cycle:                            21                    Core Average Exposure: MWd/MTU    30273.2
Exposure: MWd/MTU (GWd)      12500.0 (1729.67 )
Delta E: MWd/MTU, (GWd)        372.7 (  51.57 )                Axial Profile    Edit   Radial Power
Power: MWt                    3952.0 (100.00 %)          N(PRA) Power Exposure  Zone  Avg.  Max.  IR JR
Core Pressure: psia           1050.0                    Top 25  0.214   6.053    13  0.431 0.662   7 16
Inlet Subcooling: Btu/lbm     -30.18                        24  0.551  16.246    14  0.327 0.585  27  4
Flow: Mlb/hr                   92.25 ( 90.00 %)             23  0.697  20.632    15  0.415 0.674  45  8
                                                            22  0.791  23.525    16  1.053 1.233  23 28
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58             21  0.850  25.358    17  1.072 1.246  21 30
59             -- -- -- -- -- -- -- --            59        20  0.910  26.793    18  0.948 1.210  45 16
55          -- -- -- -- -- -- -- -- -- --         55        19  0.959  27.761    19  1.345 1.470  23 30
51       -- -- -- -- -- --  6 -- -- -- -- -- --   51        18  1.010  28.857    20  1.274 1.422  19 32
47    -- -- -- -- -- -- -- -- -- -- -- -- -- --   47        17  1.057  29.902    21  1.184 1.328  11 18
43 -- -- -- -- -- --  0 -- -- -- --  0 -- -- -- -- -- -- 43 16  1.100  30.413
39 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 39 15  1.182  30.732
35 -- -- --  6 -- -- -- --  6 -- -- --  6 -- -- -- 35      14  1.225  31.995
31 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 31      13  1.262  33.208
27 -- -- --  6 -- -- -- --  6 -- -- --  6 -- -- -- 27      12  1.301  34.698
23 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 23      11  1.309  35.633
19 -- -- -- -- -- --  0 -- -- -- --  0 -- -- -- -- -- -- 19 10  1.373  34.746
15    -- -- -- -- -- -- -- -- -- -- -- -- -- --   15         9  1.380* 36.123
11       -- -- -- -- -- --  6 -- -- -- -- -- --   11         8  1.351  37.380
 7          -- -- -- -- -- -- -- -- -- --          7         7  1.312  38.814
 3             -- -- -- -- -- -- -- --             3         6  1.243  40.036
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58              5  1.141  40.696*
                                                             4  1.011  39.952
Control Rod Density: %          5.95                         3  0.883  37.249
                                                             2  0.690  29.073
k-effective:                 0.99909                 Bottom  1  0.198   8.884
Void Fraction:                 0.435
Core Delta-P: psia            20.788              % AXIAL TILT -11.140 -16.293
Core Plate Delta-P: psia      16.230          AVG BOT 8ft/12ft  1.0869  1.0876
Coolant Temp: Deg-F            547.2
In Channel Flow: Mlb/hr        81.22  Active Channel Flow: Mlb/hr        78.41
Total Bypass Flow (%):          12.0  (of total core flow)
Total Water Rod Flow (%):        3.0  (of total core flow)
Source Convergence           0.00010


                     Top Ten Thermal Limits Summary - Sorted by Margin

     Power                MCPR                           APLHGR                                LHGR
Value FT  IR JR     Value Margin FT  IR JR    Value Margin Exp. FT  IR JR  K    Value Margin Exp. FT  IR JR  K
1.470  19 23 30     1.569  0.899  19 23 32     7.79  0.678 19.4  19 23 32 11     9.13  0.686 23.6  19 23 32 12
1.459  19 21 28     1.571  0.897  19 39 34     7.77  0.676 19.7  19 21 28 11     9.05  0.681 23.9  19 39 34 12
1.445  19 23 26     1.596  0.883  19 23 26     7.72  0.672 19.0  19 23 26 12     7.10  0.680 50.8  17 39 32 12
1.423  19 25 28     1.628  0.866  19 25 34     7.63  0.664 18.1  20 21 24 11     6.96  0.677 52.3  16 37 28 12
1.422  20 19 32     1.651  0.854  20 39 24     7.63  0.663 18.7  20 31 42 12     9.06  0.674 22.4  20 39 24 12
1.418  20 19 26     1.655  0.852  19 25 24     7.58  0.659 18.5  20 15 18 11     8.92  0.673 24.3  19 23 26 12
1.418  20 21 24     1.658  0.850  20 41 26     7.58  0.659 18.1  20 19 26 11     6.94  0.672 51.8  17 39 26 12
1.414  20 31 42     1.663  0.848  19 33 40     7.57  0.659 19.4  20 19 32 11     8.85  0.668 24.2  19 25 34 12
1.407  19 25 24     1.666  0.846  20 29 42     7.56  0.657 19.1  19 25 34 12     8.97  0.667 22.4  20 41 26 12
1.401  19 33 40     1.668  0.846  20 41 22     7.54  0.656 17.9  20 17 20 11     8.89  0.664 23.0  20 41 32 12

  * LHGR calculated with pin-power reconstruction
  * CPR calculated with pin-power reconstruction & CPR limit TYPE 3
```

Figure A.36 Browns Ferry Equilibrium Cycle Control Rod Pattern and Axial Distributions at 12,500.0 MWd/MTU

```
Cycle:                              21                   Core Average Exposure: MWd/MTU    30773.2
Exposure: MWd/MTU (GWd)      13000.0 (1798.86 )
Delta E: MWd/MTU, (GWd)        500.0 (  69.19 )              Axial Profile    Edit   Radial Power
Power: MWt                    3952.0 (100.00 %)          N(PRA) Power Exposure  Zone  Avg.  Max.  IR JR
Core Pressure: psia           1050.0                     Top 25  0.226   6.173    13  0.430 0.662   7 16
Inlet Subcooling: Btu/lbm     -29.93                         24  0.581  16.557    14  0.326 0.585  27  4
Flow: Mlb/hr                   92.97 ( 90.70 %)              23  0.736  21.024    15  0.414 0.673  45  8
                                                             22  0.835  23.973    16  1.051 1.226  23 28
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58              21  0.898  25.840    17  1.070 1.239  21 30
59             -- -- -- -- -- -- -- --            59         20  0.960  27.309    18  0.948 1.209  45 16
55          -- -- -- -- -- -- -- -- -- --         55         19  1.010  28.304    19  1.345 1.464  23 30
51       -- -- -- -- -- --  6 -- -- -- -- -- --   51         18  1.062  29.428    20  1.274 1.418  19 32
47    -- -- -- -- -- -- -- -- -- -- -- -- -- --   47         17  1.106  30.498    21  1.189 1.332  11 18
43 -- -- -- -- -- --  0 -- -- -- --  0 -- -- -- -- -- -- 43  16  1.145  31.018
39 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 39           15  1.223  31.341
35 -- -- --  6 -- -- -- --  6 -- -- --  6 -- -- -- 35        14  1.260  32.625
31 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 31           13  1.289  33.855
27 -- -- --  6 -- -- -- --  6 -- -- --  6 -- -- -- 27        12  1.320  35.363
23 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 23           11  1.315  36.297
19 -- -- -- -- -- --  0 -- -- -- --  0 -- -- -- -- -- -- 19  10  1.369* 35.371
15    -- -- -- -- -- -- -- -- -- -- -- -- -- --   15          9  1.364  36.742
11       -- -- -- -- -- --  6 -- -- -- -- -- --   11          8  1.321  37.983
 7          -- -- -- -- -- -- -- -- -- --          7          7  1.264  39.396
 3             -- -- -- -- -- -- -- --             3          6  1.176  40.582
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58               5  1.056  41.191*
                                                              4  0.914  40.387
Control Rod Density: %          5.95                          3  0.785  37.626
                                                              2  0.610  29.366
k-effective:                 0.99922                  Bottom  1  0.175   8.977
Void Fraction:                 0.423
Core Delta-P: psia            20.908              % AXIAL TILT  -6.864 -16.049
Core Plate Delta-P: psia      16.350          AVG BOT 8ft/12ft  1.0648  1.0866
Coolant Temp: Deg-F            547.0
In Channel Flow: Mlb/hr        81.93   Active Channel Flow: Mlb/hr        79.13
Total Bypass Flow (%):          11.9   (of total core flow)
Total Water Rod Flow (%):        3.0   (of total core flow)
Source Convergence           0.00008
```

Top Ten Thermal Limits Summary - Sorted by Margin

Power Value	FT	IR	JR	MCPR Value	Margin	FT	IR	JR	APLHGR Value	Margin	Exp.	FT	IR	JR	K	LHGR Value	Margin	Exp.	FT	IR	JR	K
1.464	19	23	30	1.571	0.897	19	23	32	7.84	0.682	19.5	19	23	30	12	9.11	0.690	24.7	19	23	32	12
1.454	19	21	28	1.574	0.896	19	39	34	7.82	0.680	19.7	19	21	28	12	7.11	0.688	51.7	17	39	32	12
1.440	19	23	26	1.598	0.882	19	23	26	7.77	0.676	19.9	19	23	26	12	6.97	0.687	53.2	16	37	28	12
1.418	20	19	32	1.632	0.864	19	25	34	7.69	0.668	19.7	20	31	42	12	9.03	0.686	25.1	19	39	34	12
1.418	19	25	28	1.648	0.855	19	25	24	7.65	0.665	18.1	20	21	24	12	6.96	0.680	52.7	17	39	26	12
1.415	20	19	26	1.649	0.855	20	39	24	7.63	0.663	19.4	20	19	32	12	9.05	0.679	23.6	20	39	24	12
1.413	20	21	24	1.654	0.852	20	41	26	7.63	0.663	19.5	20	15	18	11	8.89	0.677	25.4	19	23	26	12
1.410	20	31	42	1.658	0.851	19	33	40	7.60	0.661	18.2	20	19	26	12	8.98	0.674	23.5	20	41	26	12
1.402	19	25	24	1.667	0.846	20	19	32	7.60	0.661	20.1	19	25	34	12	8.82	0.671	25.4	19	25	34	12
1.397	19	33	40	1.668	0.845	19	47	20	7.59	0.660	18.8	20	17	20	11	6.99	0.671	50.9	16	23	24	12

* LHGR calculated with pin-power reconstruction
* CPR calculated with pin-power reconstruction & CPR limit TYPE 3

Figure A.37 Browns Ferry Equilibrium Cycle Control Rod Pattern and Axial Distributions at 13,000.0 MWd/MTU

```
Cycle:                            21                      Core Average Exposure: MWd/MTU    31273.2
Exposure: MWd/MTU (GWd)      13500.0 (1868.05 )
Delta E: MWd/MTU, (GWd)        500.0 (  69.19 )              Axial Profile    Edit   Radial Power
Power: MWt                    3952.0 (100.00 %)          N(PRA) Power Exposure  Zone  Avg.  Max.  IR JR
Core Pressure: psia           1050.0                    Top 25  0.239   6.299    13  0.430 0.663   7 16
Inlet Subcooling: Btu/lbm     -29.65                        24  0.613  16.884    14  0.326 0.585  27  4
Flow: Mlb/hr                   93.79 ( 91.50 %)             23  0.777  21.439    15  0.414 0.674  45  8
                                                            22  0.882  24.447    16  1.049 1.218  23 28
   2  6 10 14 18 22 26 30 34 38 42 46 50 54 58              21  0.948  26.349    17  1.068 1.232  21 30
59             -- -- -- -- -- -- -- --             59       20  1.013  27.853    18  0.949 1.208  45 16
55          -- -- -- -- -- -- -- -- -- --          55       19  1.063  28.876    19  1.345 1.458  23 30
51       -- -- -- -- -- --  6 -- -- -- -- -- --       51    18  1.114  30.028    20  1.274 1.414  19 32
47    -- -- -- -- -- -- -- -- -- -- -- -- -- --    47       17  1.156  31.122    21  1.194 1.337  11 18
43 -- -- -- -- -- --  0 -- -- -- --  0 -- -- -- -- -- -- 43  16  1.189  31.646
39 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 39          15  1.262  31.971
35 -- -- --  6 -- -- -- --  6 -- -- -- --  6 -- -- -- 35    14  1.291  33.271
31 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 31          13  1.311  34.513
27 -- -- --  6 -- -- -- --  6 -- -- -- --  6 -- -- -- 27    12  1.332  36.035
23 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 23          11  1.314  36.963
19 -- -- -- -- -- --  0 -- -- -- --  0 -- -- -- -- -- -- 19  10  1.358* 35.994
15    -- -- -- -- -- -- -- -- -- -- -- -- -- --    15        9  1.341  37.353
11       -- -- -- -- -- --  6 -- -- -- -- -- --       11     8  1.284  38.571
 7          -- -- -- -- -- -- -- -- -- --           7        7  1.211  39.954
 3             -- -- -- -- -- -- -- --              3        6  1.106  41.097
   2  6 10 14 18 22 26 30 34 38 42 46 50 54 58               5  0.973  41.649*
                                                             4  0.825  40.779
Control Rod Density: %          5.95                         3  0.700  37.962
                                                             2  0.542  29.627
k-effective:                 0.99930                Bottom   1  0.156   9.059
Void Fraction:                 0.411
Core Delta-P: psia            21.065             % AXIAL TILT  -2.518 -15.743
Core Plate Delta-P: psia      16.507           AVG BOT 8ft/12ft  1.0417  1.0853
Coolant Temp: Deg-F            546.8
In Channel Flow: Mlb/hr        82.73   Active Channel Flow: Mlb/hr        79.94
Total Bypass Flow (%):          11.8   (of total core flow)
Total Water Rod Flow (%):        3.0   (of total core flow)
Source Convergence           0.00010


                          Top Ten Thermal Limits Summary - Sorted by Margin

     Power                  MCPR                         APLHGR                             LHGR
Value FT  IR JR     Value Margin FT  IR JR    Value Margin Exp. FT  IR JR  K    Value Margin Exp. FT  IR JR  K
1.458  19 23 30     1.576  0.894  19 37 30     7.83  0.681 20.5  19 23 32 12     6.94  0.698 54.1  16 37 28 12
1.448  19 21 28     1.577  0.894  19 39 34     7.81  0.679 20.7  19 21 28 12     7.08  0.691 52.6  17 39 32 12
1.434  19 23 26     1.597  0.883  19 23 26     7.75  0.674 20.9  19 23 26 12     9.02  0.689 25.9  19 23 32 12
1.414  20 19 32     1.635  0.862  19 25 34     7.69  0.669 19.4  20 15 18 12     6.94  0.689 53.5  17 39 26 12
1.412  19 25 28     1.645  0.857  19 25 24     7.68  0.668 20.7  20 31 42 12     8.94  0.685 26.2  19 39 34 12
1.411  20 19 26     1.651  0.854  20 39 24     7.68  0.668 19.1  20 21 24 12     8.98  0.680 24.7  20 39 24 12
1.408  20 21 24     1.654  0.852  19 33 40     7.64  0.665 19.2  20 19 26 12     6.67  0.679 54.5  16 33 24 12
1.405  20 31 42     1.655  0.852  20 41 26     7.64  0.664 20.3  20 19 32 12     8.85  0.676 25.8  19 23 26 12
1.397  20 45 18     1.661  0.849  19 47 42     7.64  0.664 18.8  20 17 20 12     8.93  0.676 24.6  20 41 26 12
1.397  19 25 24     1.671  0.844  20 19 32     7.61  0.662 19.5  20 43 16 12     6.97  0.675 51.8  16 23 24 12

  * LHGR calculated with pin-power reconstruction
  * CPR calculated with pin-power reconstruction & CPR limit TYPE 3
```

Figure A.38 Browns Ferry Equilibrium Cycle Control Rod Pattern and Axial Distributions at 13,500.0 MWd/MTU

```
Cycle:                             21                         Core Average Exposure: MWd/MTU    31773.1
Exposure: MWd/MTU (GWd)     14000.0 (1937.23 )
Delta E: MWd/MTU, (GWd)       500.0 (  69.19 )                   Axial Profile    Edit   Radial Power
Power: MWt                   3952.0 (100.00 %)             N(PRA) Power Exposure  Zone  Avg.  Max.  IR JR
Core Pressure: psia          1050.0                        Top 25  0.252   6.433    13  0.430 0.663   7 16
Inlet Subcooling: Btu/lbm    -29.10                            24  0.648  17.230    14  0.325 0.585  27  4
Flow: Mlb/hr                  95.43 ( 93.10 %)                 23  0.822  21.877    15  0.414 0.674  45  8
                                                               22  0.933  24.948    16  1.046 1.209  23 28
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58                21  1.001  26.886    17  1.065 1.222  21 30
59             -- -- -- -- -- -- --             59             20  1.069  28.427    18  0.950 1.208  45 16
55          -- -- -- -- -- -- -- -- --          55             19  1.119  29.477    19  1.345 1.450  23 32
51       -- -- -- -- --  6 -- -- -- -- --       51             18  1.169  30.658    20  1.274 1.408  41 30
47    -- -- -- -- -- -- -- -- -- -- -- -- --    47             17  1.207  31.774    21  1.201 1.343  11 18
43 -- -- -- -- --  0 -- -- --  0 -- -- -- -- -- 43             16  1.233  32.299
39 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 39             15  1.300  32.620
35 -- -- --  6 -- -- --  6 -- -- --  6 -- -- -- 35             14  1.320  33.933
31 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 31             13  1.329  35.182
27 -- -- --  6 -- -- --  6 -- -- --  6 -- -- -- 27             12  1.338  36.711
23 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 23             11  1.307  37.626
19 -- -- -- -- --  0 -- -- --  0 -- -- -- -- -- 19             10  1.340* 36.609
15    -- -- -- -- -- -- -- -- -- -- -- -- --    15              9  1.313  37.952
11       -- -- -- -- --  6 -- -- -- -- --       11              8  1.242  39.141
 7          -- -- -- -- -- -- -- -- --           7              7  1.154  40.488
 3             -- -- -- -- -- -- --              3              6  1.034  41.580
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58                 5  0.891  42.070*
                                                                4  0.741  41.133
Control Rod Density: %             5.95                         3  0.621  38.260
                                                                2  0.479  29.858
k-effective:                    0.99948                 Bottom  1  0.138   9.133
Void Fraction:                    0.398
Core Delta-P: psia               21.497             % AXIAL TILT   2.021 -15.375
Core Plate Delta-P: psia         16.939         AVG BOT 8ft/12ft  1.0170  1.0837
Coolant Temp: Deg-F               546.6
In Channel Flow: Mlb/hr           84.27  Active Channel Flow: Mlb/hr        81.46
Total Bypass Flow (%):             11.7  (of total core flow)
Total Water Rod Flow (%):           2.9  (of total core flow)
Source Convergence              0.00006


                          Top Ten Thermal Limits Summary - Sorted by Margin

     Power                 MCPR                         APLHGR                            LHGR
Value FT  IR JR      Value Margin FT  IR JR    Value Margin Exp. FT  IR JR  K    Value Margin Exp. FT  IR JR  K
1.450  19 23 32      1.586  0.889  19 39 34     7.95  0.691 17.5  19 23 30 17     6.86  0.706 55.0  16 37 28 12
1.441  19 21 28      1.588  0.888  19 23 32     7.87  0.685 17.7  19 21 28 17     7.38  0.699 49.7  17 39 32 16
1.426  19 23 26      1.605  0.878  19 23 26     7.85  0.682 17.8  19 23 26 17     6.88  0.698 54.4  17 39 26 12
1.408  20 41 30      1.644  0.858  19 25 34     7.77  0.676 18.0  19 25 28 17     9.12  0.689 24.4  19 23 32 14
1.406  20 19 26      1.653  0.853  19 25 24     7.74  0.673 20.4  20 15 18 12     6.60  0.686 55.4  16 33 24 12
1.404  19 25 28      1.661  0.849  19 33 40     7.68  0.668 19.8  20 17 20 12     9.05  0.685 24.7  19 39 34 14
1.401  20 21 24      1.662  0.848  20 39 24     7.67  0.667 20.5  19 13 20 12     6.77  0.685 54.3  16 29 44 12
1.399  20 45 18      1.662  0.848  19 47 42     7.67  0.667 20.4  20 43 16 12     7.31  0.683 48.3  17 25 32 16
1.399  20 31 42      1.664  0.847  20 41 26     7.67  0.667 17.8  20 31 42 16     6.98  0.682 52.7  17 15 42 12
1.392  19 13 20      1.674  0.842  20 19 32     7.66  0.666 17.7  19 25 24 17     6.84  0.681 53.6  16 23 24 12

  * LHGR calculated with pin-power reconstruction
  * CPR calculated with pin-power reconstruction & CPR limit TYPE 3
```

Figure A.39 Browns Ferry Equilibrium Cycle Control Rod Pattern and Axial Distributions at 14,000.0 MWd/MTU

```
Cycle:                            21
Exposure: MWd/MTU (GWd)      14500.0 (2006.42 )
Delta E: MWd/MTU, (GWd)        500.0 (  69.19 )
Power: MWt                    3952.0 (100.00 %)
Core Pressure: psia           1050.0
Inlet Subcooling: Btu/lbm     -28.47
Flow: Mlb/hr                   97.38 ( 95.00 %)

   2  6 10 14 18 22 26 30 34 38 42 46 50 54 58
59             -- -- -- -- -- -- --             59
55          -- -- -- -- -- -- -- -- --          55
51       -- -- -- -- --  6 -- -- -- -- --       51
47    -- -- -- -- -- -- -- -- -- -- -- -- --    47
43 -- -- -- -- --  0 -- -- --  0 -- -- -- -- -- 43
39 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 39
35 -- -- --  6 -- -- --  6 -- -- --  6 -- -- -- 35
31 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 31
27 -- -- --  6 -- -- --  6 -- -- --  6 -- -- -- 27
23 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 23
19 -- -- -- -- --  0 -- -- --  0 -- -- -- -- -- 19
15    -- -- -- -- -- -- -- -- -- -- -- -- --    15
11       -- -- -- -- --  6 -- -- -- -- --       11
 7          -- -- -- -- -- -- -- -- --           7
 3             -- -- -- -- -- -- --              3
   2  6 10 14 18 22 26 30 34 38 42 46 50 54 58

Control Rod Density: %          5.95

k-effective:                 0.99955
Void Fraction:                 0.385
Core Delta-P: psia            22.040
Core Plate Delta-P: psia      17.480
Coolant Temp: Deg-F            546.5
In Channel Flow: Mlb/hr        86.08   Active Channel Flow: Mlb/hr        83.25
Total Bypass Flow (%):          11.6   (of total core flow)
Total Water Rod Flow (%):        2.9   (of total core flow)
Source Convergence           0.00010
```

Core Average Exposure: MWd/MTU   32273.0

N(PRA)	Axial Profile Power	Axial Profile Exposure
Top 25	0.267	6.573
24	0.686	17.596
23	0.870	22.341
22	0.988	25.478
21	1.058	27.454
20	1.127	29.033
19	1.176	30.110
18	1.224	31.318
17	1.258	32.454
16	1.276	32.975
15	1.336	33.289
14	1.346*	34.609
13	1.342	35.859
12	1.338	37.389
11	1.292	38.284
10	1.316	37.215
9	1.279	38.537
8	1.195	39.691
7	1.093	40.995
6	0.962	42.031
5	0.811	42.454*
4	0.663	41.450
3	0.551	38.525
2	0.424	30.062
Bottom 1	0.122	9.197
% AXIAL TILT	6.623	-14.947
AVG BOT 8ft/12ft	0.9913	1.0818

Edit Zone	Radial Power Avg.	Radial Power Max.	IR	JR
13	0.430	0.665	7	16
14	0.324	0.586	27	4
15	0.413	0.675	45	8
16	1.042	1.197	23	28
17	1.062	1.211	21	30
18	0.951	1.209	45	16
19	1.345	1.439	23	32
20	1.273	1.401	41	30
21	1.208	1.349	11	18

Top Ten Thermal Limits Summary - Sorted by Margin

Power				MCPR					APLHGR							LHGR						
Value	FT	IR	JR	Value	Margin	FT	IR	JR	Value	Margin	Exp.	FT	IR	JR	K	Value	Margin	Exp.	FT	IR	JR	K
1.439	19	23	32	1.601	0.881	19	39	34	8.22	0.714	18.5	19	23	30	17	7.51	0.719	50.7	17	39	32	16
1.432	19	21	28	1.604	0.879	19	23	32	8.14	0.708	18.7	19	21	28	17	7.37	0.716	52.2	16	23	28	16
1.417	19	23	26	1.621	0.870	19	23	26	8.10	0.705	18.8	19	23	26	17	7.34	0.707	51.4	17	39	26	16
1.401	20	41	30	1.659	0.850	19	25	34	8.01	0.696	19.0	19	25	28	17	7.44	0.701	49.2	17	25	32	16
1.401	20	45	18	1.667	0.846	19	47	42	7.92	0.689	18.7	19	25	24	17	7.44	0.699	48.9	17	25	26	16
1.400	20	41	26	1.667	0.846	19	25	24	7.89	0.686	18.1	20	31	42	17	9.30	0.698	23.6	19	23	32	16
1.395	19	13	20	1.670	0.844	20	39	24	7.89	0.686	18.6	19	33	40	17	7.30	0.695	50.1	16	23	24	16
1.394	20	21	24	1.672	0.843	21	49	18	7.83	0.681	18.0	20	19	32	17	9.22	0.694	23.9	19	39	34	16
1.394	19	25	28	1.672	0.843	20	41	26	7.78	0.677	17.6	20	21	24	16	7.25	0.693	50.4	17	31	40	16
1.391	20	31	42	1.674	0.842	19	33	40	7.75	0.676	21.4	20	15	18	12	6.96	0.693	53.6	17	15	42	12

* LHGR calculated with pin-power reconstruction
* CPR calculated with pin-power reconstruction & CPR limit TYPE 3

Figure A.40 Browns Ferry Equilibrium Cycle Control Rod Pattern and Axial Distributions at 14,500.0 MWd/MTU

```
Cycle:                             21                  Core Average Exposure: MWd/MTU    32407.7
Exposure: MWd/MTU (GWd)     14634.7 (2025.06 )
Delta E: MWd/MTU, (GWd)       134.7 (  18.65 )             Axial Profile    Edit   Radial Power
Power: MWt                   3952.0 (100.00 %)         N(PRA) Power Exposure  Zone  Avg.  Max.  IR JR
Core Pressure: psia          1050.0                   Top 25  0.270   6.613    13  0.430 0.665   7 16
Inlet Subcooling: Btu/lbm    -28.25                       24  0.697  17.698    14  0.324 0.586  27  4
Flow: Mlb/hr                  98.09 ( 95.70 %)            23  0.884  22.471    15  0.413 0.676  45  8
                                                          22  1.003  25.626    16  1.041 1.194  23 28
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58           21  1.074  27.613    17  1.061 1.208  21 30
59             -- -- -- -- -- -- -- --           59       20  1.143  29.202    18  0.951 1.210  45 16
55          -- -- -- -- -- -- -- -- -- --        55       19  1.191  30.286    19  1.345 1.436  23 32
51       -- -- -- -- -- -- 6 -- -- -- -- -- --   51       18  1.238  31.501    20  1.273 1.401  45 18
47    -- -- -- -- -- -- -- -- -- -- -- -- -- --  47       17  1.270  32.642    21  1.210 1.351  11 18
43 -- -- -- -- -- -- 0 -- -- -- -- 0 -- -- -- -- -- 43    16  1.286  33.161
39 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 39    15  1.344  33.472
35 -- -- -- 6 -- -- -- 6 -- -- -- 6 -- -- -- 35          14  1.351* 34.793
31 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 31       13  1.344  36.043
27 -- -- -- 6 -- -- -- 6 -- -- -- 6 -- -- -- 27          12  1.336  37.572
23 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 23       11  1.287  38.460
19 -- -- -- -- -- -- 0 -- -- -- 0 -- -- -- -- -- 19      10  1.308  37.376
15    -- -- -- -- -- -- -- -- -- -- -- -- -- --  15        9  1.269  38.692
11       -- -- -- -- -- -- 6 -- -- -- -- -- --   11        8  1.182  39.835
 7          -- -- -- -- -- -- -- -- -- --         7        7  1.077  41.127
 3             -- -- -- -- -- -- -- --            3        6  0.943  42.146
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58            5  0.792  42.552*
                                                           4  0.645  41.530
Control Rod Density: %         5.95                        3  0.535  38.591
                                                           2  0.412  30.113
k-effective:                0.99964              Bottom  1  0.118   9.214
Void Fraction:                0.382
Core Delta-P: psia           22.255             % AXIAL TILT   7.802 -14.822
Core Plate Delta-P: psia     17.695          AVG BOT 8ft/12ft  0.9845  1.0812
Coolant Temp: Deg-F           546.4
In Channel Flow: Mlb/hr       86.74  Active Channel Flow: Mlb/hr        83.90
Total Bypass Flow (%):         11.6  (of total core flow)
Total Water Rod Flow (%):       2.9  (of total core flow)
Source Convergence          0.00009
```

```
                       Top Ten Thermal Limits Summary - Sorted by Margin

     Power                   MCPR                           APLHGR                              LHGR
Value FT  IR JR    Value Margin FT  IR JR   Value Margin Exp. FT  IR JR  K    Value Margin Exp. FT  IR JR  K
1.436  19 23 32    1.608  0.877  19 39 34    8.27  0.719 18.8  19 23 30 17     7.53  0.723 50.9  17 39 32 16
1.429  19 21 28    1.611  0.875  19 23 32    8.20  0.713 18.9  19 21 28 17     7.39  0.720 52.4  16 23 28 16
1.413  19 23 26    1.628  0.866  19 23 26    8.16  0.709 19.1  19 23 26 17     7.36  0.711 51.6  17 39 26 16
1.401  20 45 18    1.666  0.846  19 25 34    8.05  0.700 19.3  19 25 28 17     7.45  0.705 49.5  17 25 32 16
1.399  20 41 30    1.668  0.845  19 47 42    7.97  0.693 19.0  19 25 24 17     7.46  0.703 49.1  17 25 26 16
1.399  20 41 26    1.671  0.844  21 49 18    7.96  0.692 18.4  20 31 42 17     9.31  0.701 23.9  19 23 32 16
1.396  19 13 20    1.674  0.842  19 25 24    7.95  0.691 18.8  19 33 40 17     7.32  0.699 50.3  16 23 24 16
1.392  20 21 24    1.675  0.842  20 39 24    7.89  0.686 18.3  20 19 30 17     7.22  0.697 51.5  16 29 44 16
1.390  19 25 28    1.677  0.841  20 41 26    7.84  0.682 17.3  20 21 24 17     7.28  0.697 50.7  17 31 40 16
1.389  20 31 42    1.680  0.839  19 33 40    6.76  0.680 45.3  16 23 28 17     9.23  0.697 24.2  19 39 34 16

  * LHGR calculated with pin-power reconstruction
  * CPR calculated with pin-power reconstruction & CPR limit TYPE 3
```

Figure A.41 Browns Ferry Equilibrium Cycle Control Rod Pattern and Axial Distributions at 14,634.7 MWd/MTU

```
Cycle:                            21                     Core Average Exposure: MWd/MTU    32408.7
Exposure: MWd/MTU (GWd)     14635.7 (2025.20 )
Delta E: MWd/MTU, (GWd)         1.0 (   0.14 )               Axial Profile    Edit   Radial Power
Power: MWt                   3952.0 (100.00 %)         N(PRA) Power Exposure  Zone  Avg.  Max.  IR JR
Core Pressure: psia          1050.0                    Top 25  0.256   6.613    13  0.442 0.676   7 16
Inlet Subcooling: Btu/lbm    -29.48                        24  0.657  17.699    14  0.336 0.641  27  4
Flow: Mlb/hr                  94.30 ( 92.00 %)             23  0.839  22.472    15  0.428 0.690  45  8
                                                           22  0.968  25.627    16  0.994 1.204  11 28
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58            21  1.063  27.614    17  1.052 1.216  41 16
59             -- -- -- -- -- -- -- --             59      20  1.144  29.203    18  0.992 1.255  17 18
55          -- -- -- -- -- -- -- -- -- --          55      19  1.190  30.287    19  1.295 1.431  13 20
51       -- -- -- -- -- -- -- -- -- -- -- --       51      18  1.236  31.502    20  1.270 1.442  43 16
47    -- -- -- -- -- -- -- -- -- -- -- -- -- --    47      17  1.269  32.643    21  1.257 1.376  11 18
43 -- -- -- -- -- -- --  0 --  0 -- -- -- -- -- -- 43      16  1.287  33.163
39 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 39      15  1.347  33.473
35 -- -- -- --  0 -- 10 -- 10 --  0 -- -- -- -- -- 35      14  1.355* 34.794
31 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 31      13  1.348  36.044
27 -- -- -- --  0 -- 10 -- 10 --  0 -- -- -- -- -- 27      12  1.340  37.573
23 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 23      11  1.292  38.461
19 -- -- -- -- -- -- --  0 --  0 -- -- -- -- -- -- 19      10  1.312  37.377
15    -- -- -- -- -- -- -- -- -- -- -- -- -- --    15       9  1.269  38.693
11       -- -- -- -- -- -- -- -- -- -- -- --       11       8  1.181  39.837
 7          -- -- -- -- -- -- -- -- -- --           7       7  1.079  41.128
 3             -- -- -- -- -- -- -- --              3       6  0.953  42.147
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58             5  0.813  42.552*
                                                            4  0.673  41.530
Control Rod Density: %         6.04                         3  0.564  38.591
                                                            2  0.437  30.113
k-effective:                0.99968                 Bottom  1  0.126   9.214
Void Fraction:                0.390
Core Delta-P: psia           21.001              % AXIAL TILT   6.650 -14.821
Core Plate Delta-P: psia     16.442          AVG BOT 8ft/12ft  0.9927  1.0812
Coolant Temp: Deg-F           546.3
In Channel Flow: Mlb/hr       83.33  Active Channel Flow: Mlb/hr        80.58
Total Bypass Flow (%):         11.6  (of total core flow)
Total Water Rod Flow (%):       2.9  (of total core flow)
Source Convergence          0.00004


                          Top Ten Thermal Limits Summary - Sorted by Margin

     Power                  MCPR                         APLHGR                                LHGR
Value FT  IR JR     Value Margin FT  IR JR    Value Margin Exp. FT  IR JR  K    Value Margin Exp. FT  IR JR  K
1.442  20 43 16     1.590  0.887  19 41 48     8.01  0.696 16.7  20 31 50 16     6.98  0.729 55.5  16 33 50 12
1.442  20 45 18     1.594  0.884  19 47 42     7.97  0.695 21.6  20 43 16 12     7.09  0.720 54.4  17 41 46 12
1.441  20 41 18     1.599  0.882  19  9 24     7.97  0.695 21.6  20 15 18 12     7.14  0.714 53.8  17 15 42 12
1.438  20 43 20     1.604  0.879  19 23 10     7.98  0.694 17.3  20 41 18 16     7.67  0.713 47.7  18 17 18 17
1.431  19 13 20     1.605  0.878  21 49 18     7.96  0.692 17.5  20 43 20 16     7.00  0.708 54.2  16 11 28 12
1.431  19 41 48     1.606  0.878  21 17 50     7.96  0.692 17.9  19 35 50 16     7.65  0.703 46.7  18 31 48 17
1.427  19 11 26     1.607  0.878  19 39 50     7.94  0.691 18.0  19 41 48 16     9.27  0.703 24.9  20 31 50 13
1.427  20 11 30     1.608  0.877  19 39 16     7.90  0.690 21.8  19 13 20 12     7.05  0.703 53.7  17 39 14 12
1.423  20 31 50     1.612  0.875  19 49 40     7.92  0.690 21.3  19 11 26 12     7.17  0.700 52.6  17 31 10 12
1.422  19 39 46     1.613  0.874  20 29 50     7.92  0.689 20.2  20 11 30 12     7.05  0.699 53.4  17 13 22 12

  * LHGR calculated with pin-power reconstruction
  * CPR calculated with pin-power reconstruction & CPR limit TYPE 3
```

Figure A.42 Browns Ferry Equilibrium Cycle Control Rod Pattern and Axial Distributions at 14,635.7 MWd/MTU

```
Cycle:                           21                  Core Average Exposure: MWd/MTU    32772.9
Exposure: MWd/MTU (GWd)     15000.0 (2075.61 )
Delta E: MWd/MTU, (GWd)       364.3 (  50.41 )             Axial Profile    Edit   Radial Power
Power: MWt                   3952.0 (100.00 %)        N(PRA) Power Exposure  Zone  Avg.  Max.  IR JR
Core Pressure: psia          1050.0                  Top 25  0.267   6.717    13  0.441 0.676   7 16
Inlet Subcooling: Btu/lbm    -28.70                      24  0.687  17.967    14  0.335 0.639  27  4
Flow: Mlb/hr                  96.66 ( 94.30 %)           23  0.877  22.815    15  0.427 0.690  45  8
                                                         22  1.011  26.024    16  0.993 1.202  11 28
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58          21  1.109  28.050    17  1.051 1.213  41 16
59             -- -- -- -- -- -- -- --             59    20  1.191  29.672    18  0.991 1.252  17 18
55          -- -- -- -- -- -- -- -- -- --          55    19  1.235  30.775    19  1.297 1.431  13 20
51       -- -- -- -- -- -- -- -- -- -- -- --       51    18  1.278  32.007    20  1.269 1.442  43 16
47    -- -- -- -- -- -- -- -- -- -- -- -- -- --    47    17  1.307  33.161    21  1.261 1.379  11 18
43 -- -- -- -- -- -- --  0 --  0 -- -- -- -- -- -- 43    16  1.318  33.674
39 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 39    15  1.372* 33.975
35 -- -- -- --  0 -- 10 -- 10 --  0 -- -- -- -- -- 35    14  1.371  35.298
31 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 31    13  1.354  36.543
27 -- -- -- --  0 -- 10 -- 10 --  0 -- -- -- -- -- 27    12  1.336  38.067
23 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 23    11  1.277  38.935
19 -- -- -- -- -- -- --  0 --  0 -- -- -- -- -- -- 19    10  1.290  37.810
15    -- -- -- -- -- -- -- -- -- -- -- -- -- --    15     9  1.239  39.106
11       -- -- -- -- -- -- -- -- -- -- -- --       11     8  1.143  40.219
 7          -- -- -- -- -- -- -- -- -- --           7     7  1.032  41.475
 3             -- -- -- -- -- -- -- --              3     6  0.900  42.452
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58           5  0.756  42.810*
                                                          4  0.619  41.743
Control Rod Density: %         6.04                       3  0.516  38.769
                                                          2  0.399  30.251
k-effective:                0.99970            Bottom  1  0.115   9.257
Void Fraction:                0.379
Core Delta-P: psia           21.706           % AXIAL TILT  10.163 -14.474
Core Plate Delta-P: psia     17.147       AVG BOT 8ft/12ft  0.9726  1.0796
Coolant Temp: Deg-F           546.2
In Channel Flow: Mlb/hr       85.50   Active Channel Flow: Mlb/hr        82.70
Total Bypass Flow (%):         11.5   (of total core flow)
Total Water Rod Flow (%):       2.9   (of total core flow)
Source Convergence          0.00008
```

Top Ten Thermal Limits Summary - Sorted by Margin

Power Value	Power FT	Power IR	Power JR	MCPR Value	MCPR Margin	MCPR FT	MCPR IR	MCPR JR	APLHGR Value	APLHGR Margin	APLHGR Exp.	APLHGR FT	APLHGR IR	APLHGR JR	APLHGR K	LHGR Value	LHGR Margin	LHGR Exp.	LHGR FT	LHGR IR	LHGR JR	LHGR K
1.442	20	43	16	1.606	0.915	19	41	48	8.21	0.714	17.4	20	31	50	16	7.88	0.737	48.4	18	17	18	17
1.441	20	45	18	1.608	0.914	19	47	20	8.21	0.714	18.0	19	35	50	17	6.93	0.735	56.2	16	33	50	12
1.438	20	41	18	1.608	0.914	19	9	24	8.19	0.712	18.5	20	43	46	16	7.59	0.728	50.9	17	41	46	16
1.435	20	43	20	1.610	0.913	21	49	18	8.19	0.712	18.2	19	41	48	17	7.85	0.727	47.4	18	31	48	17
1.431	19	13	20	1.610	0.913	21	17	50	8.17	0.711	18.0	20	41	18	16	7.58	0.725	50.7	17	15	42	16
1.430	19	41	48	1.613	0.911	19	23	10	8.17	0.711	18.5	20	45	18	16	7.68	0.719	48.5	17	29	52	16
1.427	19	11	26	1.622	0.906	19	39	50	8.15	0.709	18.3	20	43	20	16	7.62	0.719	49.2	17	37	50	16
1.427	20	11	30	1.626	0.904	19	49	40	8.13	0.707	18.5	19	39	46	17	7.63	0.717	48.8	17	41	20	16
1.422	20	31	50	1.626	0.904	19	39	16	8.12	0.706	18.1	19	13	20	17	7.49	0.717	50.7	17	39	48	16
1.420	19	39	46	1.629	0.902	20	47	16	8.11	0.705	18.5	19	37	48	17	6.98	0.717	54.9	16	11	28	12

* LHGR calculated with pin-power reconstruction
* CPR calculated with pin-power reconstruction & CPR limit TYPE 3

Figure A.43 Browns Ferry Equilibrium Cycle Control Rod Pattern and Axial Distributions at 15,000.0 MWd/MTU

```
Cycle:                            21                     Core Average Exposure: MWd/MTU    33272.9
Exposure: MWd/MTU (GWd)      15500.0 (2144.79 )
Delta E: MWd/MTU, (GWd)        500.0 (  69.19 )             Axial Profile    Edit   Radial Power
Power: MWt                    3952.0 (100.00 %)        N(PRA) Power Exposure  Zone  Avg.  Max.  IR JR
Core Pressure: psia           1050.0                  Top 25  0.283   6.866    13  0.441 0.677   7 16
Inlet Subcooling: Btu/lbm     -27.53                      24  0.730  18.356    14  0.334 0.639  27  4
Flow: Mlb/hr                  100.45 ( 98.00 %)           23  0.932  23.311    15  0.426 0.691  45  8
                                                          22  1.073  26.599    16  0.990 1.202  11 28
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58           21  1.174  28.680    17  1.048 1.209  41 16
59             -- -- -- -- -- -- -- --             59     20  1.256  30.347    18  0.992 1.249  17 18
55          -- -- -- -- -- -- -- -- -- --          55     19  1.296  31.473    19  1.297 1.432  13 20
51       -- -- -- -- -- -- -- -- -- -- -- --       51     18  1.334  32.728    20  1.268 1.442  43 16
47    -- -- -- -- -- -- -- -- -- -- -- -- -- --    47     17  1.355  33.895    21  1.270 1.386  11 18
43 -- -- -- -- -- -- --  0 --  0 -- -- -- -- -- -- 43     16  1.356  34.395
39 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 39     15  1.402* 34.678
35 -- -- -- --  0 -- 10 -- 10 --  0 -- -- -- -- -- 35     14  1.388  35.997
31 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 31     13  1.356  37.230
27 -- -- -- --  0 -- 10 -- 10 --  0 -- -- -- -- -- 27     12  1.324  38.741
23 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 23     11  1.253  39.576
19 -- -- -- -- -- -- --  0 --  0 -- -- -- -- -- -- 19     10  1.256  38.390
15    -- -- -- -- -- -- -- -- -- -- -- -- -- --    15      9  1.197  39.656
11       -- -- -- -- -- -- -- -- -- -- -- --       11      8  1.090  40.723
 7          -- -- -- -- -- -- -- -- -- --           7      7  0.969  41.927
 3             -- -- -- -- -- -- -- --              3      6  0.830  42.842
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58             5  0.684  43.136*
                                                            4  0.552  42.007
Control Rod Density: %          6.04                        3  0.456  38.989
                                                            2  0.352  30.420
k-effective:                 0.99963               Bottom  1  0.102   9.311
Void Fraction:                 0.363
Core Delta-P: psia            22.889           % AXIAL TILT  14.858 -13.948
Core Plate Delta-P: psia      18.328       AVG BOT 8ft/12ft  0.9448  1.0771
Coolant Temp: Deg-F            546.2
In Channel Flow: Mlb/hr        88.97   Active Channel Flow: Mlb/hr        86.11
Total Bypass Flow (%):          11.4   (of total core flow)
Total Water Rod Flow (%):        2.8   (of total core flow)
Source Convergence           0.00007
```

Top Ten Thermal Limits Summary - Sorted by Margin

Power				MCPR					APLHGR							LHGR						
Value	FT	IR	JR	Value	Margin	FT	IR	JR	Value	Margin	Exp.	FT	IR	JR	K	Value	Margin	Exp.	FT	IR	JR	K
1.442	20	43	16	1.617	0.909	21	49	18	8.54	0.743	19.1	19	35	50	17	8.12	0.768	49.4	18	17	18	17
1.441	20	45	18	1.618	0.909	21	17	50	8.51	0.740	17.6	20	31	50	17	8.11	0.758	48.4	18	31	48	17
1.434	20	41	18	1.620	0.907	19	41	48	8.50	0.740	19.2	19	41	48	17	7.79	0.752	51.6	16	33	50	16
1.432	19	13	20	1.623	0.906	19	47	20	8.46	0.735	18.9	20	43	46	17	7.76	0.752	51.8	17	41	46	16
1.431	20	17	20	1.625	0.905	19	9	24	8.43	0.733	19.2	19	13	20	17	7.99	0.750	48.7	18	25	10	17
1.431	19	41	48	1.629	0.902	19	23	10	8.43	0.733	18.9	19	39	50	17	7.75	0.749	51.6	17	15	42	16
1.429	19	11	26	1.633	0.900	21	41	52	8.43	0.733	18.9	20	45	18	17	7.98	0.749	48.6	18	15	16	17
1.429	20	11	30	1.635	0.899	21	51	20	8.42	0.732	18.7	20	41	18	17	7.97	0.746	48.5	18	47	18	17
1.422	20	31	50	1.635	0.899	19	39	50	8.40	0.731	19.6	19	37	48	17	7.89	0.746	49.5	17	29	52	16
1.419	20	9	28	1.637	0.898	21	7	26	8.40	0.730	19.6	19	39	46	17	7.82	0.745	50.2	17	37	50	16

* LHGR calculated with pin-power reconstruction
* CPR calculated with pin-power reconstruction & CPR limit TYPE 3

Figure A.44 Browns Ferry Equilibrium Cycle Control Rod Pattern and Axial Distributions at 15,500.0 MWd/MTU

```
Cycle:                          21
Exposure: MWd/MTU (GWd)     15700.0 (2172.47 )
Delta E: MWd/MTU, (GWd)       200.0 (  27.67 )
Power: MWt                   3952.0 (100.00 %)
Core Pressure: psia          1050.0
Inlet Subcooling: Btu/lbm    -26.94
Flow: Mlb/hr                 102.50 (100.00 %)

    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58
59             -- -- -- -- -- -- --             59
55          -- -- -- -- -- -- -- -- --          55
51       -- -- -- -- -- -- -- -- -- -- --       51
47    -- -- -- -- -- -- -- -- -- -- -- -- --    47
43 -- -- -- -- -- --  0 --  0 -- -- -- -- -- -- 43
39 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 39
35 -- -- -- --  0 -- 10 -- 10 --  0 -- -- -- -- 35
31 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 31
27 -- -- -- --  0 -- 10 -- 10 --  0 -- -- -- -- 27
23 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 23
19 -- -- -- -- -- --  0 --  0 -- -- -- -- -- -- 19
15    -- -- -- -- -- -- -- -- -- -- -- -- --    15
11       -- -- -- -- -- -- -- -- -- -- --       11
 7          -- -- -- -- -- -- -- -- --           7
 3             -- -- -- -- -- -- --              3
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58

Control Rod Density: %         6.04

k-effective:                0.99967
Void Fraction:                0.357
Core Delta-P: psia           23.561
Core Plate Delta-P: psia     18.999
Coolant Temp: Deg-F           546.2
In Channel Flow: Mlb/hr       90.83  Active Channel Flow: Mlb/hr        87.94
Total Bypass Flow (%):         11.4  (of total core flow)
Total Water Rod Flow (%):       2.8  (of total core flow)
Source Convergence          0.00007
```

```
Core Average Exposure: MWd/MTU    33472.9

      Axial Profile    Edit   Radial Power
N(PRA) Power Exposure  Zone  Avg.  Max.  IR JR
Top 25  0.290   6.928    13  0.440 0.678  7 16
    24  0.749  18.518    14  0.333 0.639 27  4
    23  0.956  23.518    15  0.426 0.692 45  8
    22  1.099  26.839    16  0.988 1.202 11 28
    21  1.200  28.942    17  1.046 1.209 31 52
    20  1.282  30.627    18  0.993 1.247 17 18
    19  1.320  31.761    19  1.297 1.433 13 20
    18  1.354  33.024    20  1.267 1.442 43 16
    17  1.371  34.196    21  1.274 1.389 11 18
    16  1.369  34.689
    15  1.411* 34.963
    14  1.392  36.279
    13  1.355  37.505
    12  1.317  39.009
    11  1.242  39.828
    10  1.242  38.618
     9  1.179  39.870
     8  1.068  40.918
     7  0.944  42.100
     6  0.803  42.990
     5  0.658  43.257*
     4  0.528  42.105
     3  0.436  39.069
     2  0.336  30.483
Bottom 1  0.097   9.331

% AXIAL TILT  16.663 -13.722
AVG BOT 8ft/12ft  0.9336  1.0761
```

Top Ten Thermal Limits Summary - Sorted by Margin

Power				MCPR					APLHGR							LHGR						
Value	FT	IR	JR	Value	Margin	FT	IR	JR	Value	Margin	Exp.	FT	IR	JR	K	Value	Margin	Exp.	FT	IR	JR	K
1.442	20	43	16	1.620	0.907	21	49	18	8.66	0.753	19.5	19	35	50	17	8.20	0.779	49.8	18	17	18	17
1.441	20	45	18	1.621	0.907	21	17	50	8.64	0.751	18.1	20	31	50	17	8.19	0.770	48.8	18	31	48	17
1.433	19	13	20	1.629	0.902	19	41	48	8.61	0.749	19.6	19	41	48	17	8.10	0.764	49.1	18	25	10	17
1.433	20	41	18	1.632	0.901	19	47	20	8.56	0.744	19.3	20	43	16	17	7.85	0.761	52.0	16	33	50	16
1.431	19	41	48	1.634	0.900	19	9	24	8.55	0.744	19.4	19	39	50	17	8.08	0.761	49.1	18	15	16	17
1.431	19	11	26	1.636	0.899	19	23	10	8.54	0.743	19.6	19	13	20	17	7.81	0.760	52.2	17	41	46	16
1.431	20	11	30	1.636	0.899	21	7	26	8.54	0.742	19.3	20	45	18	17	8.07	0.759	48.9	18	47	18	17
1.430	20	17	20	1.637	0.898	21	41	52	8.52	0.741	18.4	20	33	52	17	7.80	0.757	52.0	17	15	42	16
1.423	20	9	28	1.638	0.897	21	51	20	8.51	0.740	19.1	20	41	18	17	8.09	0.757	48.4	18	17	48	17
1.422	20	31	50	1.641	0.896	21	25	8	8.50	0.739	20.0	19	37	48	17	7.96	0.756	49.9	17	29	52	16

* LHGR calculated with pin-power reconstruction
* CPR calculated with pin-power reconstruction & CPR limit TYPE 3

Figure A.45 Browns Ferry Equilibrium Cycle Control Rod Pattern and Axial Distributions at 15,700.0 MWd/MTU

```
Cycle:                             21                 Core Average Exposure: MWd/MTU    33473.9
Exposure: MWd/MTU (GWd)      15701.0 (2172.61 )
Delta E: MWd/MTU, (GWd)          1.0 (    0.14 )           Axial Profile    Edit   Radial Power
Power: MWt                    3952.0 (100.00 %)        N(PRA) Power Exposure  Zone  Avg.  Max.  IR JR
Core Pressure: psia           1050.0                   Top 25  0.269   6.929    13  0.428 0.658   7 16
Inlet Subcooling: Btu/lbm     -29.86                       24  0.689  18.519    14  0.324 0.621  27  4
Flow: Mlb/hr                   93.17 ( 90.90 %)            23  0.880  23.519    15  0.414 0.672  45  8
                                                           22  1.018  26.840    16  1.015 1.167  11 28
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58            21  1.123  28.943    17  1.059 1.175  41 16
59             -- -- -- -- -- -- --             59         20  1.215  30.629    18  0.963 1.214  17 18
55          -- -- -- -- -- -- -- -- --          55         19  1.276  31.763    19  1.340 1.390  13 20
51       -- -- -- -- -- -- -- -- -- -- --       51         18  1.328  33.026    20  1.271 1.407  29 28
47    -- -- -- -- -- -- -- -- -- -- -- -- --    47         17  1.358  34.197    21  1.233 1.345  11 18
43 -- -- -- -- -- --  0 --  0 -- -- -- -- -- -- 43         16  1.366  34.690
39 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 39         15  1.413* 34.965
35 -- -- -- --  0 -- -- -- -- --  0 -- -- -- -- 35         14  1.398  36.280
31 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 31         13  1.364  37.506
27 -- -- -- --  0 -- -- -- -- --  0 -- -- -- -- 27         12  1.328  39.010
23 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 23         11  1.256  39.830
19 -- -- -- -- -- --  0 --  0 -- -- -- -- -- -- 19         10  1.262  38.620
15    -- -- -- -- -- -- -- -- -- -- -- -- --    15          9  1.208  39.871
11       -- -- -- -- -- -- -- -- -- -- --       11          8  1.110  40.919
 7          -- -- -- -- -- -- -- -- --           7          7  0.998  42.101
 3             -- -- -- -- -- -- --              3          6  0.864  42.991
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58             5  0.719  43.258*
                                                            4  0.585  42.105
Control Rod Density: %          4.32                        3  0.487  39.070
                                                            2  0.378  30.483
k-effective:                 0.99970               Bottom  1  0.109   9.331
Void Fraction:                 0.378
Core Delta-P: psia            20.505              % AXIAL TILT  12.812 -13.721
Core Plate Delta-P: psia      15.951          AVG BOT 8ft/12ft  0.9610  1.0760
Coolant Temp: Deg-F            545.9
In Channel Flow: Mlb/hr        82.39   Active Channel Flow: Mlb/hr        79.69
Total Bypass Flow (%):          11.6   (of total core flow)
Total Water Rod Flow (%):        2.9   (of total core flow)
Source Convergence           0.00010
```

Top Ten Thermal Limits Summary - Sorted by Margin

Power				MCPR					APLHGR							LHGR						
Value	FT	IR	JR	Value	Margin	FT	IR	JR	Value	Margin	Exp.	FT	IR	JR	K	Value	Margin	Exp.	FT	IR	JR	K
1.407	20	29	28	1.625	0.905	19	41	48	8.36	0.727	18.5	20	31	28	17	7.89	0.749	49.8	18	17	18	17
1.401	20	41	18	1.626	0.904	21	49	18	8.31	0.723	19.5	19	35	50	17	7.88	0.740	48.8	18	31	48	17
1.399	20	43	16	1.627	0.904	21	17	50	8.29	0.721	18.1	20	31	50	17	7.53	0.733	52.2	17	41	46	16
1.399	20	15	18	1.627	0.903	19	47	20	8.27	0.719	19.7	20	27	30	17	7.55	0.732	52.0	16	33	50	16
1.398	20	17	20	1.633	0.900	19	9	24	8.27	0.719	19.6	19	41	48	17	7.76	0.731	49.1	18	25	10	17
1.391	20	33	30	1.636	0.898	19	23	10	8.24	0.717	20.4	19	27	26	17	7.61	0.731	51.0	17	31	26	16
1.390	19	13	20	1.641	0.896	19	39	50	8.23	0.715	19.1	20	41	18	17	7.53	0.730	52.0	17	15	42	16
1.389	20	11	30	1.641	0.896	21	41	52	8.23	0.715	19.3	20	43	16	17	7.74	0.729	49.1	18	15	16	17
1.388	19	41	48	1.642	0.895	19	39	16	8.21	0.714	20.7	19	25	28	17	7.39	0.727	53.2	16	33	28	16
1.388	19	11	26	1.642	0.895	21	51	20	8.20	0.713	19.6	19	13	20	17	7.73	0.727	48.9	18	47	18	17

* LHGR calculated with pin-power reconstruction
* CPR calculated with pin-power reconstruction & CPR limit TYPE 3

Figure A.46 Browns Ferry Equilibrium Cycle Control Rod Pattern and Axial Distributions at 15,701.0 MWd/MTU

```
Cycle:                            21                      Core Average Exposure: MWd/MTU    33972.8
Exposure: MWd/MTU (GWd)      16200.0 (2241.66 )
Delta E: MWd/MTU, (GWd)        499.0 (  69.05 )               Axial Profile    Edit   Radial Power
Power: MWt                    3952.0 (100.00 %)         N(PRA) Power Exposure  Zone  Avg.  Max.  IR JR
Core Pressure: psia           1050.0                   Top 25  0.288   7.079    13  0.428 0.661   7 16
Inlet Subcooling: Btu/lbm     -27.44                       24  0.741  18.910    14  0.323 0.623  27  4
Flow: Mlb/hr                  100.76 ( 98.30 %)            23  0.946  24.018    15  0.414 0.675  45  8
                                                           22  1.090  27.420    16  1.009 1.171  11 28
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58            21  1.196  29.581    17  1.055 1.176  31 52
59             -- -- -- -- -- -- -- --           59        20  1.286  31.317    18  0.968 1.214  17 18
55          -- -- -- -- -- -- -- -- -- --        55        19  1.340  32.483    19  1.337 1.395  13 20
51       -- -- -- -- -- -- -- -- -- -- -- --     51        18  1.383  33.772    20  1.267 1.404  43 16
47    -- -- -- -- -- -- -- -- -- -- -- -- -- --  47        17  1.402  34.957    21  1.247 1.357  11 18
43 -- -- -- -- -- -- --  0 --  0 -- -- -- -- -- -- 43     16  1.398  35.434
39 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 39        15  1.437* 35.685
35 -- -- -- --  0 -- -- -- -- -- --  0 -- -- -- -- 35     14  1.409  36.990
31 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 31        13  1.361  38.195
27 -- -- -- --  0 -- -- -- -- -- --  0 -- -- -- -- 27     12  1.313  39.678
23 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 23        11  1.230  40.458
19 -- -- -- -- -- -- --  0 --  0 -- -- -- -- -- -- 19     10  1.229  39.186
15    -- -- -- -- -- -- -- -- -- -- -- -- -- --  15         9  1.166  40.406
11       -- -- -- -- -- -- -- -- -- -- -- --     11         8  1.056  41.407
 7          -- -- -- -- -- -- -- -- -- --         7         7  0.931  42.535
 3             -- -- -- -- -- -- -- --            3         6  0.788  43.363
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58             5  0.643  43.564*
                                                            4  0.515  42.353
Control Rod Density: %          4.32                        3  0.426  39.276
                                                            2  0.330  30.642
k-effective:                 0.99974               Bottom  1  0.096   9.383
Void Fraction:                 0.357
Core Delta-P: psia            22.943          % AXIAL TILT  17.742 -13.177
Core Plate Delta-P: psia      18.387      AVG BOT 8ft/12ft  0.9304  1.0735
Coolant Temp: Deg-F            546.0
In Channel Flow: Mlb/hr        89.27  Active Channel Flow: Mlb/hr        86.41
Total Bypass Flow (%):          11.4  (of total core flow)
Total Water Rod Flow (%):        2.8  (of total core flow)
Source Convergence           0.00009
```

Top Ten Thermal Limits Summary - Sorted by Margin

Power Value	FT	IR	JR	MCPR Value	Margin	FT	IR	JR	APLHGR Value	Margin	Exp.	FT	IR	JR	K	LHGR Value	Margin	Exp.	FT	IR	JR	K
1.404	20	43	16	1.643	0.895	21	49	18	8.62	0.750	19.1	20	31	50	17	8.14	0.780	50.8	18	17	18	17
1.403	20	15	18	1.643	0.895	21	17	50	8.61	0.749	20.6	19	35	50	17	8.14	0.772	49.8	18	31	48	17
1.399	20	41	18	1.656	0.888	21	7	26	8.56	0.744	20.7	19	41	48	17	8.09	0.770	50.1	18	25	10	17
1.396	20	11	30	1.658	0.886	19	9	24	8.52	0.741	19.4	20	33	52	17	8.05	0.766	50.0	18	15	16	17
1.396	20	17	20	1.659	0.886	19	23	10	8.52	0.741	20.4	19	39	50	17	8.03	0.762	49.9	18	47	18	17
1.395	19	13	20	1.661	0.885	21	25	8	8.51	0.740	20.3	20	43	16	17	8.05	0.761	49.4	18	17	48	17
1.394	19	11	26	1.662	0.884	21	41	10	8.50	0.739	20.7	19	13	20	17	7.72	0.759	53.1	16	33	50	16
1.393	19	41	14	1.663	0.884	19	41	14	8.49	0.738	20.4	20	15	18	17	7.70	0.758	53.2	17	41	46	16
1.389	20	9	28	1.664	0.883	21	51	20	8.48	0.738	20.1	19	11	26	17	8.03	0.757	49.2	18	9	26	17
1.386	20	31	50	1.665	0.883	19	47	20	8.46	0.736	20.2	20	41	18	17	7.88	0.755	50.7	17	31	10	16

* LHGR calculated with pin-power reconstruction
* CPR calculated with pin-power reconstruction & CPR limit TYPE 3

Figure A.47 Browns Ferry Equilibrium Cycle Control Rod Pattern and Axial Distributions at 16,200.0 MWd/MTU

```
Cycle:                            21                  Core Average Exposure: MWd/MTU    34072.8
Exposure: MWd/MTU (GWd)      16300.0 (2255.49 )
Delta E: MWd/MTU, (GWd)        100.0 (  13.84 )          Axial Profile    Edit   Radial Power
Power: MWt                    3952.0 (100.00 %)     N(PRA) Power Exposure  Zone  Avg.  Max.  IR JR
Core Pressure: psia           1050.0               Top 25  0.291   7.111    13  0.428 0.662   7 16
Inlet Subcooling: Btu/lbm     -26.94                   24  0.751  18.992    14  0.323 0.623  27  4
Flow: Mlb/hr                  102.50 (100.00 %)        23  0.959  24.123    15  0.414 0.675  45  8
                                                       22  1.105  27.541    16  1.007 1.171  11 28
   2  6 10 14 18 22 26 30 34 38 42 46 50 54 58         21  1.210  29.714    17  1.054 1.177  31 52
59             -- -- -- -- -- -- -- --           59    20  1.300  31.460    18  0.969 1.214  17 18
55          -- -- -- -- -- -- -- -- -- --        55    19  1.352  32.632    19  1.336 1.396  13 20
51       -- -- -- -- -- -- -- -- -- -- -- --     51    18  1.393  33.925    20  1.267 1.404  43 16
47    -- -- -- -- -- -- -- -- -- -- -- -- -- --  47    17  1.409  35.112    21  1.250 1.360  11 18
43 -- -- -- -- -- -- --  0 --  0 -- -- -- -- -- -- 43  16  1.403  35.584
39 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 39     15  1.440* 35.831
35 -- -- -- --  0 -- -- -- -- -- --  0 -- -- -- -- 35  14  1.410  37.133
31 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 31     13  1.359  38.333
27 -- -- -- --  0 -- -- -- -- -- --  0 -- -- -- -- 27  12  1.309  39.811
23 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 23     11  1.225  40.582
19 -- -- -- -- -- -- --  0 --  0 -- -- -- -- -- -- 19  10  1.222  39.298
15    -- -- -- -- -- -- -- -- -- -- -- -- -- --  15     9  1.158  40.511
11       -- -- -- -- -- -- -- -- -- -- -- --     11     8  1.045  41.501
 7          -- -- -- -- -- -- -- -- -- --         7     7  0.919  42.619
 3             -- -- -- -- -- -- -- --            3     6  0.775  43.434
   2  6 10 14 18 22 26 30 34 38 42 46 50 54 58          5  0.629  43.622*
                                                        4  0.503  42.399
Control Rod Density: %          4.32                    3  0.416  39.314
                                                        2  0.322  30.672
k-effective:                 0.99986            Bottom  1  0.093   9.392
Void Fraction:                 0.353
Core Delta-P: psia            23.528           % AXIAL TILT  18.638 -13.061
Core Plate Delta-P: psia      18.972       AVG BOT 8ft/12ft  0.9246  1.0730
Coolant Temp: Deg-F            546.1
In Channel Flow: Mlb/hr        90.85   Active Channel Flow: Mlb/hr       87.96
Total Bypass Flow (%):          11.4   (of total core flow)
Total Water Rod Flow (%):        2.8   (of total core flow)
Source Convergence           0.00009
```

Top Ten Thermal Limits Summary - Sorted by Margin

Power				MCPR					APLHGR							LHGR						
Value	FT	IR	JR	Value	Margin	FT	IR	JR	Value	Margin	Exp.	FT	IR	JR	K	Value	Margin	Exp.	FT	IR	JR	K
1.404	20	43	16	1.646	0.893	21	17	50	8.67	0.754	19.4	20	31	50	17	8.17	0.785	51.0	18	17	18	17
1.404	20	15	18	1.647	0.893	21	49	18	8.66	0.753	20.8	19	35	50	17	8.17	0.777	50.0	18	31	48	17
1.398	20	41	18	1.660	0.886	21	7	26	8.60	0.748	20.9	19	41	48	17	8.14	0.777	50.3	18	25	10	17
1.397	20	11	30	1.664	0.883	21	25	8	8.58	0.746	19.6	20	33	52	17	8.10	0.772	50.2	18	15	16	17
1.396	19	13	20	1.665	0.883	21	41	10	8.56	0.745	20.6	19	39	50	17	8.07	0.768	50.1	18	47	18	17
1.395	19	11	26	1.665	0.883	19	23	10	8.55	0.744	20.6	20	43	16	17	8.09	0.766	49.6	18	17	48	17
1.395	20	17	20	1.666	0.883	19	9	24	8.54	0.743	20.9	19	13	20	17	7.74	0.765	53.3	16	33	50	16
1.394	19	41	14	1.668	0.881	21	9	42	8.53	0.742	20.3	19	11	26	17	7.72	0.763	53.4	17	41	46	16
1.391	20	9	28	1.671	0.879	19	41	14	8.53	0.742	20.6	20	15	18	17	8.08	0.763	49.4	18	9	26	17
1.387	20	31	50	1.672	0.879	21	7	32	8.50	0.739	19.8	19	37	52	17	7.92	0.759	50.9	17	31	10	16

* LHGR calculated with pin-power reconstruction
* CPR calculated with pin-power reconstruction & CPR limit TYPE 3

Figure A.48 Browns Ferry Equilibrium Cycle Control Rod Pattern and Axial Distributions at 16,300.0 MWd/MTU

```
Cycle:                            21                  Core Average Exposure: MWd/MTU    34073.7
Exposure: MWd/MTU (GWd)      16301.0 (2255.63 )
Delta E: MWd/MTU, (GWd)          1.0 (   0.14 )           Axial Profile    Edit   Radial Power
Power: MWt                    3952.0 (100.00 %)     N(PRA) Power Exposure  Zone  Avg.  Max.  IR JR
Core Pressure: psia           1050.0               Top 25  0.325   7.111    13  0.423 0.652   7 16
Inlet Subcooling: Btu/lbm     -30.22                   24  0.834  18.993    14  0.320 0.615  27  4
Flow: Mlb/hr                   92.15 ( 89.90 %)        23  1.055  24.124    15  0.409 0.665  45  8
                                                       22  1.194  27.542    16  1.024 1.164  11 28
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58        21  1.268  29.715    17  1.061 1.171  39 18
59             -- -- -- -- -- -- --             59     20  1.332  31.461    18  0.955 1.203  17 18
55          -- -- -- -- -- -- -- -- --          55     19  1.364  32.633    19  1.335 1.381  11 26
51       -- -- -- -- -- -- -- -- -- -- --       51     18  1.387  33.927    20  1.284 1.391  41 18
47    -- -- -- -- -- -- -- -- -- -- -- -- --    47     17  1.390  35.113    21  1.225 1.332  11 18
43 -- -- -- -- -- --  6 --  6 -- -- -- -- -- -- 43     16  1.375  35.586
39 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 39     15  1.402* 35.833
35 -- -- -- --  6 -- -- -- -- --  6 -- -- -- -- 35     14  1.367  37.134
31 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 31     13  1.314  38.334
27 -- -- -- --  6 -- -- -- -- --  6 -- -- -- -- 27     12  1.264  39.812
23 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 23     11  1.183  40.583
19 -- -- -- -- -- --  6 --  6 -- -- -- -- -- -- 19     10  1.182  39.299
15    -- -- -- -- -- -- -- -- -- -- -- -- --    15      9  1.123  40.512
11       -- -- -- -- -- -- -- -- -- -- --       11      8  1.019  41.502
 7          -- -- -- -- -- -- -- -- --           7      7  0.901  42.620
 3             -- -- -- -- -- -- --              3      6  0.764  43.434
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58         5  0.624  43.622*
                                                        4  0.501  42.400
Control Rod Density: %          3.78                    3  0.416  39.314
                                                        2  0.322  30.672
k-effective:                 0.99980            Bottom  1  0.093   9.392
Void Fraction:                 0.361
Core Delta-P: psia            19.976            % AXIAL TILT  20.680 -13.060
Core Plate Delta-P: psia      15.424        AVG BOT 8ft/12ft  0.9029  1.0730
Coolant Temp: Deg-F            545.5
In Channel Flow: Mlb/hr        81.59   Active Channel Flow: Mlb/hr        78.96
Total Bypass Flow (%):          11.5   (of total core flow)
Total Water Rod Flow (%):        2.9   (of total core flow)
Source Convergence           0.00009


                     Top Ten Thermal Limits Summary - Sorted by Margin

     Power                   MCPR                           APLHGR                              LHGR
Value FT  IR JR     Value Margin FT  IR JR    Value Margin Exp. FT  IR JR  K    Value Margin Exp. FT  IR JR  K
1.391  20 41 18     1.595  0.922  21 49 18     8.54  0.742 19.4  20 31 50 17     8.03  0.771 51.0  18 17 18 17
1.388  20 17 20     1.595  0.921  21 17 50     8.51  0.740 20.8  19 35 50 17     8.06  0.766 50.0  18 31 48 17
1.386  20 11 30     1.596  0.921  19 41 48     8.45  0.734 19.2  20 29 28 18     7.96  0.760 50.3  18 25 10 17
1.384  20 43 16     1.599  0.919  19  9 24     8.44  0.734 20.9  19 41 48 17     7.91  0.754 50.3  18 15 16 17
1.383  20 15 18     1.600  0.919  19 23 10     8.41  0.731 19.6  20 33 52 17     7.89  0.750 50.1  18 47 18 17
1.383  20 31 28     1.602  0.918  19 47 42     8.39  0.730 20.6  19 39 50 17     7.91  0.749 49.6  18 17 48 17
1.381  19 11 26     1.608  0.914  19 39 50     8.39  0.730 20.6  20 43 16 17     7.90  0.747 49.4  18  9 26 17
1.377  20 31 50     1.609  0.914  19 49 26     8.39  0.729 20.4  20 41 18 17     7.55  0.746 53.3  16 33 50 16
1.376  19 13 20     1.609  0.914  19 25 50     8.38  0.729 20.3  19 11 26 17     7.91  0.745 49.1  18 47 32 17
1.375  19 39 16     1.615  0.910  19 49 40     8.38  0.728 20.9  19 13 20 17     7.53  0.745 53.4  17 41 46 16

  * LHGR calculated with pin-power reconstruction
  * CPR calculated with pin-power reconstruction & CPR limit TYPE 3
```

Figure A.49 Browns Ferry Equilibrium Cycle Control Rod Pattern and Axial Distributions at 16,301.0 MWd/MTU

```
Cycle:                          21                          Core Average Exposure: MWd/MTU    34572.8
Exposure: MWd/MTU (GWd)     16800.0 (2324.68 )
Delta E: MWd/MTU, (GWd)       499.0 (  69.05 )                 Axial Profile    Edit   Radial Power
Power: MWt                   3952.0 (100.00 %)           N(PRA) Power Exposure  Zone  Avg.  Max.  IR JR
Core Pressure: psia          1050.0                     Top 25  0.346   7.293    13  0.423 0.654   7 16
Inlet Subcooling: Btu/lbm    -27.41                         24  0.892  19.465    14  0.318 0.617  27  4
Flow: Mlb/hr                 100.86 ( 98.40 %)              23  1.126  24.721    15  0.409 0.668  45  8
                                                            22  1.271  28.221    16  1.019 1.166  49 34
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58             21  1.341  30.433    17  1.057 1.168  31 52
59             -- -- -- -- -- -- --             59          20  1.399  32.213    18  0.959 1.202  17 18
55          -- -- -- -- -- -- -- -- --          55          19  1.420  33.399    19  1.332 1.386  11 26
51       -- -- -- -- -- -- -- -- -- -- --       51          18  1.432* 34.703    20  1.281 1.390  11 30
47    -- -- -- -- -- -- -- -- -- -- -- -- --    47          17  1.422  35.887    21  1.238 1.343  11 18
43 -- -- -- -- -- -- --  6 --  6 -- -- -- -- -- -- -- 43    16  1.396  36.331
39 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 39          15  1.417  36.546
35 -- -- -- --  6 -- -- -- -- -- --  6 -- -- -- -- 35       14  1.370  37.827
31 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 31          13  1.306  38.997
27 -- -- -- --  6 -- -- -- -- -- --  6 -- -- -- -- 27       12  1.246  40.447
23 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 23          11  1.158  41.175
19 -- -- -- -- -- -- --  6 --  6 -- -- -- -- -- -- -- 19    10  1.150  39.830
15    -- -- -- -- -- -- -- -- -- -- -- -- --    15           9  1.081  41.009
11       -- -- -- -- -- -- -- -- -- -- --       11           8  0.965  41.950
 7          -- -- -- -- -- -- -- -- --           7           7  0.836  43.011
 3             -- -- -- -- -- -- --              3           6  0.694  43.763
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58              5  0.557  43.888*
                                                             4  0.444  42.613
Control Rod Density: %         3.78                          3  0.366  39.490
                                                             2  0.283  30.809
k-effective:                0.99969                   Bottom 1  0.082   9.436
Void Fraction:                0.340
Core Delta-P: psia           22.773              % AXIAL TILT  25.191 -12.421
Core Plate Delta-P: psia     18.219          AVG BOT 8ft/12ft  0.8732  1.0697
Coolant Temp: Deg-F           545.7
In Channel Flow: Mlb/hr       89.48   Active Channel Flow: Mlb/hr        86.67
Total Bypass Flow (%):         11.3   (of total core flow)
Total Water Rod Flow (%):       2.8   (of total core flow)
Source Convergence          0.00005
```

Top Ten Thermal Limits Summary - Sorted by Margin

Power Value	FT	IR	JR	MCPR Value	Margin	FT	IR	JR	APLHGR Value	Margin	Exp.	FT	IR	JR	K	LHGR Value	Margin	Exp.	FT	IR	JR	K
1.390	20	11	30	1.622	0.907	21	17	50	8.79	0.764	19.4	20	31	50	18	8.20	0.796	52.0	18	17	18	17
1.387	20	41	18	1.622	0.906	21	49	18	8.72	0.762	21.9	19	35	50	17	8.23	0.793	51.3	18	25	10	17
1.386	20	43	16	1.633	0.900	21	7	26	8.64	0.755	22.0	19	41	14	17	8.24	0.792	51.0	18	31	48	17
1.386	20	15	18	1.634	0.900	19	23	10	8.68	0.754	19.5	20	33	52	18	8.15	0.785	51.2	18	15	16	17
1.386	19	11	26	1.634	0.900	21	25	8	8.62	0.752	21.7	19	39	50	17	8.12	0.780	51.1	18	47	18	17
1.383	20	17	20	1.635	0.899	21	31	8	8.60	0.750	21.4	19	11	26	17	8.16	0.779	50.4	18	9	26	17
1.382	20	31	50	1.637	0.898	19	9	24	8.57	0.750	21.9	19	13	20	17	8.14	0.779	50.6	18	17	48	17
1.379	20	9	28	1.637	0.898	21	7	32	8.58	0.749	21.6	20	43	16	17	7.68	0.777	54.3	16	33	50	16
1.379	19	13	20	1.637	0.898	21	41	10	8.59	0.747	20.8	19	37	52	17	7.63	0.773	54.3	17	41	46	16
1.378	19	41	14	1.641	0.896	21	9	42	8.56	0.747	21.6	20	15	18	17	8.10	0.771	50.1	18	47	32	17

* LHGR calculated with pin-power reconstruction
* CPR calculated with pin-power reconstruction & CPR limit TYPE 3

Figure A.50 Browns Ferry Equilibrium Cycle Control Rod Pattern and Axial Distributions at 16,800.0 MWd/MTU

```
Cycle:                            21                  Core Average Exposure: MWd/MTU    34573.8
Exposure: MWd/MTU (GWd)      16801.0 (2324.82 )
Delta E: MWd/MTU, (GWd)          1.0 (   0.14 )             Axial Profile    Edit   Radial Power
Power: MWt                    3952.0 (100.00 %)         N(PRA) Power Exposure  Zone  Avg.  Max.  IR JR
Core Pressure: psia           1050.0                   Top 25  0.352   7.293    13  0.420 0.649   7 16
Inlet Subcooling: Btu/lbm     -29.07                       24  0.904  19.466    14  0.316 0.613  27  4
Flow: Mlb/hr                   95.53 ( 93.20 %)            23  1.145  24.722    15  0.406 0.662  45  8
                                                           22  1.300  28.222    16  1.026 1.163  49 34
   2  6 10 14 18 22 26 30 34 38 42 46 50 54 58             21  1.386  30.435    17  1.061 1.168  39 18
59             -- -- -- -- -- -- -- --            59       20  1.426  32.214    18  0.953 1.197  17 18
55          -- -- -- -- -- -- -- -- -- --         55       19  1.433  33.401    19  1.332 1.379  11 26
51       -- -- -- -- -- -- -- -- -- -- -- --      51       18  1.435* 34.704    20  1.290 1.385  11 30
47    -- -- -- -- -- -- -- -- -- -- -- -- -- --   47       17  1.417  35.889    21  1.226 1.330  11 18
43 -- -- -- -- -- -- --  8 --  8 -- -- -- -- -- -- -- 43   16  1.386  36.333
39 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 39   15  1.401  36.547
35 -- -- -- --  8 -- -- -- -- -- --  8 -- -- -- -- -- 35   14  1.352  37.828
31 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 31   13  1.287  38.998
27 -- -- -- --  8 -- -- -- -- -- --  8 -- -- -- -- -- 27   12  1.227  40.448
23 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 23   11  1.140  41.176
19 -- -- -- -- -- -- --  8 --  8 -- -- -- -- -- -- -- 19   10  1.134  39.831
15    -- -- -- -- -- -- -- -- -- -- -- -- -- --   15        9  1.068  41.009
11       -- -- -- -- -- -- -- -- -- -- -- --      11        8  0.956  41.950
 7          -- -- -- -- -- -- -- -- -- --          7        7  0.830  43.012
 3             -- -- -- -- -- -- -- --             3        6  0.691  43.763
   2  6 10 14 18 22 26 30 34 38 42 46 50 54 58              5  0.556  43.889*
                                                            4  0.443  42.613
Control Rod Density: %          3.60                        3  0.366  39.491
                                                            2  0.284  30.809
k-effective:                 0.99979                Bottom  1  0.082   9.436
Void Fraction:                 0.344
Core Delta-P: psia            20.953            % AXIAL TILT  25.986 -12.420
Core Plate Delta-P: psia      16.401        AVG BOT 8ft/12ft  0.8643  1.0697
Coolant Temp: Deg-F            545.4
In Channel Flow: Mlb/hr        84.70  Active Channel Flow: Mlb/hr        82.02
Total Bypass Flow (%):          11.3  (of total core flow)
Total Water Rod Flow (%):        2.8  (of total core flow)
Source Convergence           0.00008
```

Top Ten Thermal Limits Summary - Sorted by Margin

Power Value	FT	IR	JR	MCPR Value	Margin	FT	IR	JR	APLHGR Value	Margin	Exp.	FT	IR	JR	K	LHGR Value	Margin	Exp.	FT	IR	JR	K
1.385	20	11	30	1.598	0.920	21	17	50	8.79	0.765	19.4	20	31	50	18	8.44	0.794	49.0	18	31	48	18
1.384	20	41	18	1.598	0.920	21	49	18	8.75	0.761	20.8	19	35	50	18	8.14	0.790	52.1	18	17	18	17
1.380	20	17	20	1.605	0.916	19	23	10	8.63	0.751	19.5	20	33	52	18	8.15	0.785	51.3	18	25	10	17
1.379	19	11	26	1.608	0.914	19	9	24	8.62	0.749	19.7	20	29	28	19	8.06	0.776	51.3	18	15	16	17
1.377	20	31	12	1.609	0.914	21	31	8	8.57	0.749	22.0	19	41	14	17	8.03	0.771	51.1	18	47	18	17
1.377	20	43	16	1.609	0.914	21	7	26	8.59	0.748	21.4	19	27	26	19	8.08	0.771	50.4	18	9	26	17
1.376	20	15	18	1.610	0.913	21	25	8	8.58	0.747	21.3	19	37	48	18	8.05	0.770	50.6	18	17	48	17
1.371	19	39	16	1.611	0.913	19	41	48	8.59	0.747	20.6	19	39	50	18	8.09	0.770	50.1	18	47	32	17
1.369	19	13	20	1.611	0.912	21	7	32	8.58	0.746	17.4	20	33	44	21	7.60	0.769	54.3	16	33	50	16
1.369	20	9	28	1.615	0.910	19	25	50	8.56	0.746	21.3	19	39	16	18	7.55	0.765	54.3	17	41	46	16

* LHGR calculated with pin-power reconstruction
* CPR calculated with pin-power reconstruction & CPR limit TYPE 3

Figure A.51 Browns Ferry Equilibrium Cycle Control Rod Pattern and Axial Distributions at 16,801.0 MWd/MTU

```
Cycle:                            21                      Core Average Exposure: MWd/MTU    34915.5
Exposure: MWd/MTU (GWd)      17142.8 (2372.11 )
Delta E: MWd/MTU, (GWd)        341.8 (  47.29 )              Axial Profile    Edit   Radial Power
Power: MWt                    3952.0 (100.00 %)        N(PRA) Power Exposure  Zone  Avg.  Max.  IR JR
Core Pressure: psia           1050.0                  Top 25  0.366   7.427    13  0.420 0.650   7 16
Inlet Subcooling: Btu/lbm     -26.82                      24  0.946  19.812    14  0.315 0.614  27  4
Flow: Mlb/hr                  102.91 (100.40 %)           23  1.196  25.160    15  0.406 0.664  45  8
                                                          22  1.355  28.723    16  1.023 1.164  49 34
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58           21  1.438  30.967    17  1.058 1.164  21 18
59              -- -- -- -- -- -- --              59      20  1.472* 32.761    18  0.955 1.195  17 18
55           -- -- -- -- -- -- -- -- --           55      19  1.469  33.948    19  1.330 1.382  11 26
51        -- -- -- -- -- -- -- -- -- -- --        51      18  1.461  35.250    20  1.288 1.388  49 32
47     -- -- -- -- -- -- -- -- -- -- -- -- --     47      17  1.435  36.427    21  1.235 1.338  11 18
43  -- -- -- -- -- -- 8 -- 8 -- -- -- -- -- --    43      16  1.396  36.845
39  -- -- -- -- -- -- -- -- -- -- -- -- -- -- --  39      15  1.408  37.034
35  -- -- -- --  8 -- -- -- -- --  8 -- -- -- --  35      14  1.352  38.296
31  -- -- -- -- -- -- -- -- -- -- -- -- -- -- --  31      13  1.279  39.443
27  -- -- -- --  8 -- -- -- -- --  8 -- -- -- --  27      12  1.213  40.871
23  -- -- -- -- -- -- -- -- -- -- -- -- -- -- --  23      11  1.122  41.567
19  -- -- -- -- -- -- 8 -- 8 -- -- -- -- -- --    19      10  1.109  40.181
15     -- -- -- -- -- -- -- -- -- -- -- -- --     15       9  1.037  41.334
11        -- -- -- -- -- -- -- -- -- -- --        11       8  0.918  42.239
 7           -- -- -- -- -- -- -- -- --            7       7  0.786  43.261
 3              -- -- -- -- -- -- --               3       6  0.646  43.969
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58            5  0.515  44.054*
                                                           4  0.408  42.745
Control Rod Density: %          3.60                       3  0.337  39.599
                                                           2  0.261  30.893
k-effective:                 0.99967              Bottom   1  0.076   9.463
Void Fraction:                 0.328
Core Delta-P: psia            23.387              % AXIAL TILT  28.951 -11.948
Core Plate Delta-P: psia      18.833          AVG BOT 8ft/12ft  0.8441  1.0672
Coolant Temp: Deg-F            545.6
In Channel Flow: Mlb/hr        91.38   Active Channel Flow: Mlb/hr        88.54
Total Bypass Flow (%):          11.2   (of total core flow)
Total Water Rod Flow (%):        2.8   (of total core flow)
Source Convergence           0.00008
```

Top Ten Thermal Limits Summary - Sorted by Margin

Power				MCPR					APLHGR							LHGR						
Value	FT	IR	JR	Value	Margin	FT	IR	JR	Value	Margin	Exp.	FT	IR	JR	K	Value	Margin	Exp.	FT	IR	JR	K
1.388	20	49	32	1.622	0.906	21	17	50	8.98	0.781	20.1	20	31	50	18	8.60	0.815	49.7	18	31	48	18
1.382	19	11	26	1.623	0.906	21	49	18	8.92	0.778	21.5	19	35	50	18	8.31	0.807	52.0	18	25	10	17
1.382	20	29	12	1.625	0.905	21	25	8	8.86	0.771	18.1	20	33	44	21	8.24	0.806	52.8	18	17	18	17
1.381	20	19	18	1.626	0.904	21	31	8	8.85	0.770	20.3	20	33	52	18	8.21	0.796	51.9	18	15	16	17
1.378	20	17	16	1.626	0.904	21	7	26	8.81	0.766	18.3	20	35	42	21	8.24	0.792	51.1	18	9	26	17
1.378	20	15	18	1.632	0.901	21	7	32	8.78	0.766	21.7	19	41	48	18	8.17	0.791	51.8	18	47	18	17
1.377	20	17	20	1.636	0.898	19	23	10	7.88	0.765	39.6	18	31	48	20	8.20	0.790	51.3	18	17	48	17
1.376	20	9	28	1.638	0.897	21	41	10	8.77	0.764	21.3	19	39	50	18	8.38	0.790	49.1	18	47	32	18
1.372	19	41	14	1.642	0.895	19	9	24	8.77	0.763	19.8	20	33	48	19	7.66	0.788	54.9	16	33	50	16
1.372	19	13	20	1.642	0.895	21	9	42	8.72	0.763	22.0	19	37	48	18	7.60	0.783	55.0	17	41	46	16

* LHGR calculated with pin-power reconstruction
* CPR calculated with pin-power reconstruction & CPR limit TYPE 3

Figure A.52 Browns Ferry Equilibrium Cycle Control Rod Pattern and Axial Distributions at 17,142.8 MWd/MTU

```
Cycle:                              21                  Core Average Exposure: MWd/MTU    34916.1
Exposure: MWd/MTU (GWd)      17143.4 (2372.20 )
Delta E: MWd/MTU, (GWd)          0.6 (   0.09 )             Axial Profile    Edit   Radial Power
Power: MWt                    3952.0 (100.00 %)        N(PRA) Power Exposure  Zone  Avg.  Max.  IR JR
Core Pressure: psia           1050.0                  Top 25  0.351   7.427    13  0.415 0.641   7 16
Inlet Subcooling: Btu/lbm     -29.68                      24  0.900  19.813    14  0.312 0.608  27  4
Flow: Mlb/hr                   93.68 ( 91.40 %)           23  1.138  25.161    15  0.401 0.654  45  8
                                                          22  1.296  28.724    16  1.030 1.174  27 12
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58           21  1.388  30.968    17  1.063 1.190  21 18
59             -- -- -- -- -- -- -- --          59        20  1.440  32.762    18  0.947 1.210  29 14
55          -- -- -- -- -- -- -- -- -- --       55        19  1.447* 33.949    19  1.288 1.392  21 16
51       -- -- -- -- -- -- -- -- -- -- -- --    51        18  1.445  35.251    20  1.337 1.398  29 12
47    -- -- -- -- -- -- -- -- -- -- -- -- -- -- 47        17  1.424  36.428    21  1.217 1.318  11 18
43 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 43        16  1.391  36.846
39 -- -- -- -- -- -- --  8 --  8 -- -- -- -- -- 39        15  1.404  37.035
35 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 35        14  1.350  38.297
31 -- -- -- -- 10 -- -- -- -- -- 10 -- -- -- -- 31        13  1.280  39.444
27 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 27        12  1.216  40.872
23 -- -- -- -- -- -- --  8 --  8 -- -- -- -- -- 23        11  1.127  41.568
19 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 19        10  1.120  40.182
15    -- -- -- -- -- -- -- -- -- -- -- -- -- -- 15         9  1.055  41.335
11       -- -- -- -- -- -- -- -- -- -- -- --    11         8  0.946  42.240
 7          -- -- -- -- -- -- -- -- -- --        7         7  0.825  43.262
 3             -- -- -- -- -- -- -- --           3         6  0.691  43.970
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58            5  0.561  44.054*
                                                           4  0.451  42.745
Control Rod Density: %          2.66                       3  0.375  39.600
                                                           2  0.293  30.893
k-effective:                 0.99953               Bottom  1  0.085   9.463
Void Fraction:                 0.345
Core Delta-P: psia            20.352             % AXIAL TILT  26.265 -11.947
Core Plate Delta-P: psia      15.802         AVG BOT 8ft/12ft  0.8624  1.0672
Coolant Temp: Deg-F            545.3
In Channel Flow: Mlb/hr        83.04  Active Channel Flow: Mlb/hr        80.41
Total Bypass Flow (%):          11.4  (of total core flow)
Total Water Rod Flow (%):        2.8  (of total core flow)
Source Convergence           0.00008
```

Top Ten Thermal Limits Summary - Sorted by Margin

Power				MCPR					APLHGR							LHGR						
Value	FT	IR	JR	Value	Margin	FT	IR	JR	Value	Margin	Exp.	FT	IR	JR	K	Value	Margin	Exp.	FT	IR	JR	K
1.398	20	29	12	1.591	0.924	19	25	50	9.02	0.784	19.5	20	19	32	21	8.64	0.819	49.7	18	31	48	18
1.395	20	27	14	1.594	0.922	19	39	16	8.93	0.777	20.1	20	31	50	18	8.14	0.796	52.8	18	17	18	17
1.392	20	47	34	1.596	0.921	21	31	8	8.85	0.772	21.5	19	35	50	18	8.17	0.793	52.0	18	25	10	17
1.392	19	21	16	1.597	0.920	20	31	50	8.87	0.771	20.8	20	33	14	18	7.69	0.791	54.9	16	33	50	16
1.392	20	19	18	1.597	0.920	21	49	18	7.76	0.770	43.1	18	29	14	18	8.33	0.785	49.1	18	47	32	18
1.389	20	17	20	1.598	0.920	21	25	8	8.75	0.765	21.9	19	37	14	18	7.65	0.785	54.8	16	25	48	16
1.389	19	15	22	1.598	0.920	19	37	14	8.77	0.763	20.8	20	29	16	18	7.48	0.779	55.4	16	23	16	16
1.389	20	45	26	1.598	0.920	21	17	50	8.69	0.761	22.1	19	39	16	18	8.48	0.778	46.4	16	17	32	21
1.388	20	23	18	1.599	0.920	19	49	26	8.72	0.758	20.8	20	35	16	18	7.59	0.778	54.8	16	33	16	16
1.387	19	47	24	1.600	0.919	19	47	24	7.71	0.758	41.7	16	17	32	21	8.09	0.778	51.1	18	9	26	17

* LHGR calculated with pin-power reconstruction
* CPR calculated with pin-power reconstruction & CPR limit TYPE 3

Figure A.53 Browns Ferry Equilibrium Cycle Control Rod Pattern and Axial Distributions at 17,143.4 MWd/MTU

```
Cycle:                          21                 Core Average Exposure: MWd/MTU    35222.8
Exposure: MWd/MTU (GWd)     17450.0 (2414.62 )
Delta E: MWd/MTU, (GWd)       306.6 (  42.42 )            Axial Profile    Edit   Radial Power
Power: MWt                   3952.0 (100.00 %)      N(PRA) Power Exposure  Zone  Avg.  Max.  IR JR
Core Pressure: psia          1050.0                Top 25  0.364   7.546    13  0.414 0.642   7 16
Inlet Subcooling: Btu/lbm    -27.05                    24  0.939  20.122    14  0.310 0.608  27  4
Flow: Mlb/hr                 102.09 ( 99.60 %)         23  1.186  25.552    15  0.400 0.655  45  8
                                                       22  1.349  29.171    16  1.026 1.176  27 12
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58        21  1.437  31.446    17  1.061 1.186  21 18
59             -- -- -- -- -- -- -- --           59    20  1.483* 33.256    18  0.949 1.208  29 14
55          -- -- -- -- -- -- -- -- -- --        55    19  1.480  34.444    19  1.288 1.390  21 16
51       -- -- -- -- -- -- -- -- -- -- -- --     51    18  1.469  35.744    20  1.335 1.400  29 12
47    -- -- -- -- -- -- -- -- -- -- -- -- -- --  47    17  1.440  36.912    21  1.226 1.326  11 18
43 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 43    16  1.401  37.308
39 -- -- -- -- -- -- --  8 --  8 -- -- -- -- -- -- 39 15  1.410  37.472
35 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 35    14  1.350  38.717
31 -- -- -- -- 10 -- -- -- -- -- 10 -- -- -- -- 31    13  1.274  39.841
27 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 27    12  1.205  41.248
23 -- -- -- -- -- -- --  8 --  8 -- -- -- -- -- -- 23 11  1.111  41.916
19 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 19    10  1.099  40.492
15    -- -- -- -- -- -- -- -- -- -- -- -- -- --  15     9  1.028  41.623
11       -- -- -- -- -- -- -- -- -- -- -- --     11     8  0.911  42.497
 7          -- -- -- -- -- -- -- -- -- --         7     7  0.784  43.484
 3             -- -- -- -- -- -- -- --            3     6  0.648  44.155
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58         5  0.521  44.204*
                                                        4  0.417  42.865
Control Rod Density: %         2.66                     3  0.346  39.700
                                                        2  0.270  30.971
k-effective:                0.99955             Bottom  1  0.079   9.488
Void Fraction:                0.329
Core Delta-P: psia           23.109              % AXIAL TILT  29.035 -11.530
Core Plate Delta-P: psia     18.557          AVG BOT 8ft/12ft  0.8435  1.0651
Coolant Temp: Deg-F           545.6
In Channel Flow: Mlb/hr       90.63  Active Channel Flow: Mlb/hr        87.82
Total Bypass Flow (%):         11.2  (of total core flow)
Total Water Rod Flow (%):       2.8  (of total core flow)
Source Convergence          0.00006
```

Top Ten Thermal Limits Summary - Sorted by Margin

Power				MCPR					APLHGR							LHGR						
Value	FT	IR	JR	Value	Margin	FT	IR	JR	Value	Margin	Exp.	FT	IR	JR	K	Value	Margin	Exp.	FT	IR	JR	K
1.400	20	29	12	1.624	0.905	21	25	8	9.21	0.801	20.2	20	19	32	21	8.77	0.837	50.4	18	31	48	18
1.393	20	27	14	1.625	0.904	21	31	8	9.10	0.791	20.7	20	31	12	18	8.23	0.814	53.4	18	17	18	17
1.391	20	47	34	1.629	0.902	21	7	26	9.01	0.788	22.1	19	35	12	18	8.32	0.813	52.7	18	25	10	17
1.390	19	21	16	1.631	0.901	21	17	50	9.00	0.784	21.5	20	33	14	18	7.74	0.808	55.5	16	33	50	16
1.389	20	49	32	1.631	0.901	21	49	18	7.87	0.783	43.7	18	29	14	18	8.47	0.803	49.7	18	47	32	18
1.389	20	19	18	1.636	0.898	21	7	32	8.88	0.779	22.6	19	37	14	18	8.67	0.800	47.1	16	17	32	21
1.387	19	47	24	1.642	0.895	19	23	10	7.88	0.777	42.3	16	17	32	21	7.68	0.800	55.4	16	25	48	16
1.386	19	49	26	1.642	0.895	19	25	50	8.91	0.775	20.5	20	29	16	19	8.24	0.797	51.7	18	9	26	17
1.386	19	15	22	1.642	0.895	20	31	50	8.81	0.773	22.7	19	21	16	18	8.15	0.795	52.6	18	15	16	17
1.386	19	23	14	1.647	0.893	19	39	16	8.87	0.772	21.0	20	33	52	18	7.51	0.794	56.0	16	23	16	16

* LHGR calculated with pin-power reconstruction
* CPR calculated with pin-power reconstruction & CPR limit TYPE 3

Figure A.54 Browns Ferry Equilibrium Cycle Control Rod Pattern and Axial Distributions at 17,450.0 MWd/MTU

```
Cycle:                              21                   Core Average Exposure: MWd/MTU    35223.8
Exposure: MWd/MTU (GWd)      17451.0 (2414.76 )
Delta E: MWd/MTU, (GWd)          1.0 (   0.14 )            Axial Profile    Edit   Radial Power
Power: MWt                    3952.0 (100.00 %)         N(PRA) Power Exposure  Zone  Avg.  Max.  IR JR
Core Pressure: psia           1050.0                    Top 25  0.352   7.546   13  0.407 0.631   7 16
Inlet Subcooling: Btu/lbm     -29.20                        24  0.903  20.123   14  0.305 0.596  27  4
Flow: Mlb/hr                   95.12 ( 92.80 %)             23  1.141  25.553   15  0.393 0.643  45  8
                                                            22  1.303  29.172   16  1.046 1.202  45 34
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58             21  1.399  31.447   17  1.063 1.199  43 26
59             -- -- -- -- -- -- --             59          20  1.461  33.258   18  0.935 1.227  47 32
55          -- -- -- -- -- -- -- -- --          55          19  1.464* 34.445   19  1.291 1.386  47 24
51       -- -- -- -- -- -- -- -- -- -- --       51          18  1.458  35.746   20  1.353 1.424  45 32
47    -- -- -- -- -- -- -- -- -- -- -- -- --    47          17  1.433  36.914   21  1.203 1.301   7 32
43 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 43          16  1.397  37.309
39 -- -- -- -- -- -- 10 -- 10 -- -- -- -- -- -- 39          15  1.407  37.473
35 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 35          14  1.349  38.718
31 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 31          13  1.274  39.842
27 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 27          12  1.206  41.249
23 -- -- -- -- -- -- 10 -- 10 -- -- -- -- -- -- 23          11  1.115  41.917
19 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 19          10  1.106  40.493
15    -- -- -- -- -- -- -- -- -- -- -- -- --    15           9  1.041  41.624
11       -- -- -- -- -- -- -- -- -- -- --       11           8  0.933  42.498
 7          -- -- -- -- -- -- -- -- --           7           7  0.814  43.485
 3             -- -- -- -- -- -- --              3           6  0.682  44.156
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58              5  0.556  44.204*
                                                             4  0.449  42.865
Control Rod Density: %            1.71                       3  0.376  39.700
                                                             2  0.294  30.971
k-effective:                   0.99963               Bottom  1  0.086   9.488
Void Fraction:                   0.342
Core Delta-P: psia              20.813            % AXIAL TILT  27.008 -11.529
Core Plate Delta-P: psia        16.265        AVG BOT 8ft/12ft  0.8572  1.0650
Coolant Temp: Deg-F              545.3
In Channel Flow: Mlb/hr          84.33   Active Channel Flow: Mlb/hr        81.67
Total Bypass Flow (%):            11.3   (of total core flow)
Total Water Rod Flow (%):          2.8   (of total core flow)
Source Convergence             0.00007
```

Top Ten Thermal Limits Summary - Sorted by Margin

Power				MCPR					APLHGR							LHGR						
Value	FT	IR	JR	Value	Margin	FT	IR	JR	Value	Margin	Exp.	FT	IR	JR	K	Value	Margin	Exp.	FT	IR	JR	K
1.424	20	45	32	1.590	0.925	20	15	32	9.28	0.807	20.6	19	27	22	21	8.60	0.821	50.4	18	31	48	18
1.424	20	47	34	1.592	0.923	20	47	34	9.17	0.797	20.8	19	25	24	21	8.65	0.815	49.1	16	33	24	21
1.422	20	43	28	1.595	0.922	20	15	26	7.76	0.775	44.2	16	27	24	21	8.39	0.810	51.5	18	47	32	17
1.421	20	45	36	1.597	0.920	20	17	34	8.90	0.774	20.7	20	31	12	18	8.75	0.809	47.1	17	25	40	21
1.402	20	49	32	1.608	0.914	20	49	32	8.83	0.770	21.5	20	33	14	18	8.05	0.797	53.4	18	17	18	17
1.395	20	17	24	1.613	0.911	19	49	26	8.80	0.770	22.1	19	35	12	18	8.10	0.791	52.7	18	25	10	17
1.392	20	41	26	1.614	0.911	19	47	24	7.72	0.769	43.7	18	29	14	18	7.55	0.789	55.5	16	33	50	16
1.386	19	47	24	1.619	0.908	21	7	26	8.81	0.767	21.3	20	13	28	17	7.42	0.788	56.2	16	15	24	16
1.385	19	49	26	1.619	0.908	20	17	24	8.82	0.767	20.5	20	29	16	19	7.81	0.784	54.0	16	47	26	16
1.381	19	15	22	1.622	0.907	21	7	32	8.77	0.766	21.9	20	45	30	17	7.51	0.783	55.4	16	25	48	16

* LHGR calculated with pin-power reconstruction
* CPR calculated with pin-power reconstruction & CPR limit TYPE 3

Figure A.55 Browns Ferry Equilibrium Cycle Control Rod Pattern and Axial Distributions at 17,451.0 MWd/MTU

```
Cycle:                              21
Exposure: MWd/MTU (GWd)      17700.0 (2449.22 )
Delta E: MWd/MTU, (GWd)        249.0 (  34.46 )
Power: MWt                    3952.0 (100.00 %)
Core Pressure: psia           1050.0
Inlet Subcooling: Btu/lbm     -26.94
Flow: Mlb/hr                  102.50 (100.00 %)

    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58
59             -- -- -- -- -- -- --             59
55          -- -- -- -- -- -- -- -- --          55
51       -- -- -- -- -- -- -- -- -- -- --       51
47    -- -- -- -- -- -- -- -- -- -- -- -- --    47
43 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 43
39 -- -- -- -- -- -- 10 -- 10 -- -- -- -- -- -- 39
35 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 35
31 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 31
27 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 27
23 -- -- -- -- -- -- 10 -- 10 -- -- -- -- -- -- 23
19 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 19
15    -- -- -- -- -- -- -- -- -- -- -- -- --    15
11       -- -- -- -- -- -- -- -- -- -- --       11
 7          -- -- -- -- -- -- -- -- --           7
 3             -- -- -- -- -- -- --              3
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58

Control Rod Density: %          1.71

k-effective:                 0.99957
Void Fraction:                 0.328
Core Delta-P: psia            23.257
Core Plate Delta-P: psia      18.708
Coolant Temp: Deg-F            545.6
In Channel Flow: Mlb/hr        91.00   Active Channel Flow: Mlb/hr        88.17
Total Bypass Flow (%):          11.2   (of total core flow)
Total Water Rod Flow (%):        2.8   (of total core flow)
Source Convergence           0.00009
```

Core Average Exposure: MWd/MTU 35472.6

N(PRA)	Axial Profile Power	Axial Profile Exposure	Edit Zone	Radial Power Avg.	Radial Power Max.	IR	JR
Top 25	0.363	7.643	13	0.407	0.632	7	16
24	0.935	20.374	14	0.304	0.597	27	4
23	1.181	25.870	15	0.392	0.644	45	8
22	1.345	29.536	16	1.043	1.197	45	34
21	1.438	31.837	17	1.061	1.192	43	26
20	1.494*	33.664	18	0.937	1.224	47	32
19	1.489	34.851	19	1.290	1.386	49	26
18	1.475	36.149	20	1.350	1.421	47	34
17	1.444	37.309	21	1.211	1.309	7	26
16	1.403	37.685					
15	1.411	37.829					
14	1.348	39.059					
13	1.269	40.163					
12	1.198	41.552					
11	1.104	42.197					
10	1.091	40.743					
9	1.021	41.856					
8	0.906	42.705					
7	0.782	43.664					
6	0.649	44.305					
5	0.524	44.326*					
4	0.422	42.963					
3	0.352	39.782					
2	0.275	31.035					
Bottom 1	0.081	9.509					
% AXIAL TILT	29.165	-11.192					
AVG BOT 8ft/12ft	0.8423	1.0633					

Top Ten Thermal Limits Summary - Sorted by Margin

Power Value	FT	IR	JR	MCPR Value	Margin	FT	IR	JR	APLHGR Value	Margin	Exp.	FT	IR	JR	K	LHGR Value	Margin	Exp.	FT	IR	JR	K
1.421	20	47	34	1.638	0.897	20	47	34	9.42	0.820	21.2	19	27	22	21	8.71	0.836	50.9	18	31	48	18
1.418	20	45	32	1.642	0.895	20	15	32	9.30	0.810	21.4	19	25	24	21	8.76	0.829	49.6	16	33	24	21
1.416	20	45	36	1.645	0.894	21	25	8	7.84	0.786	44.7	16	27	24	21	8.88	0.825	47.7	17	25	40	21
1.413	20	43	28	1.646	0.893	20	15	26	9.02	0.786	21.3	20	31	12	18	8.45	0.820	52.0	18	47	32	17
1.402	20	49	32	1.646	0.893	21	7	26	7.94	0.783	42.3	18	29	14	19	8.12	0.814	53.9	18	17	18	17
1.389	20	17	24	1.648	0.892	21	31	8	8.92	0.783	22.6	19	35	12	18	8.43	0.810	51.1	18	25	10	18
1.386	19	49	26	1.649	0.892	20	17	34	8.93	0.781	22.0	20	27	14	18	7.59	0.803	56.0	16	33	50	16
1.385	19	47	24	1.651	0.891	20	49	32	7.91	0.778	41.8	17	25	22	21	7.43	0.799	56.6	16	15	24	16
1.383	20	41	26	1.651	0.890	21	7	32	8.94	0.778	21.0	20	29	16	19	8.18	0.796	52.2	18	9	26	17
1.379	19	15	22	1.656	0.888	19	49	26	8.92	0.776	19.6	20	27	18	20	7.82	0.795	54.4	16	47	26	16

* LHGR calculated with pin-power reconstruction
* CPR calculated with pin-power reconstruction & CPR limit TYPE 3

Figure A.56 Browns Ferry Equilibrium Cycle Control Rod Pattern and Axial Distributions at 17,700.0 MWd/MTU

```
Cycle:                           21              Core Average Exposure: MWd/MTU    35473.7
Exposure: MWd/MTU (GWd)     17701.0 (2449.35 )
Delta E: MWd/MTU, (GWd)         1.0 (   0.14 )         Axial Profile    Edit   Radial Power
Power: MWt                   3952.0 (100.00 %)      N(PRA) Power Exposure  Zone  Avg.  Max.  IR JR
Core Pressure: psia          1050.0                Top 25  0.338   7.643    13  0.396 0.615   7 16
Inlet Subcooling: Btu/lbm    -29.68                    24  0.865  20.375    14  0.296 0.582  27  4
Flow: Mlb/hr                  93.68 ( 91.40 %)         23  1.094  25.871    15  0.382 0.628  45  8
                                                       22  1.251  29.537    16  1.063 1.175  33 20
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58        21  1.348  31.839    17  1.073 1.184  25 18
59            -- -- -- -- -- -- -- --           59     20  1.418  33.665    18  0.913 1.192  47 32
55         -- -- -- -- -- -- -- -- -- --        55     19  1.440  34.853    19  1.322 1.362  33 22
51      -- -- -- -- -- -- -- -- -- -- -- --     51     18  1.446* 36.150    20  1.357 1.398  25 20
47   -- -- -- -- -- -- -- -- -- -- -- -- -- --  47     17  1.429  37.311    21  1.176 1.270  11 18
43 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 43     16  1.401  37.687
39 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 39     15  1.415  37.830
35 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 35     14  1.357  39.060
31 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 31     13  1.283  40.164
27 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 27     12  1.214  41.554
23 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 23     11  1.123  42.198
19 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 19     10  1.117  40.744
15   -- -- -- -- -- -- -- -- -- -- -- -- -- --  15      9  1.055  41.857
11      -- -- -- -- -- -- -- -- -- -- -- --     11      8  0.952  42.706
 7         -- -- -- -- -- -- -- -- -- --         7      7  0.840  43.665
 3            -- -- -- -- -- -- -- --            3      6  0.714  44.306
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58         5  0.590  44.326*
                                                        4  0.483  42.964
Control Rod Density: %         0.00                     3  0.409  39.782
                                                        2  0.323  31.036
k-effective:                0.99961             Bottom  1  0.095   9.509
Void Fraction:                0.348
Core Delta-P: psia           20.412            % AXIAL TILT  24.820 -11.191
Core Plate Delta-P: psia     15.869        AVG BOT 8ft/12ft  0.8741  1.0633
Coolant Temp: Deg-F           545.3
In Channel Flow: Mlb/hr       83.00   Active Channel Flow: Mlb/hr        80.35
Total Bypass Flow (%):         11.4   (of total core flow)
Total Water Rod Flow (%):       2.8   (of total core flow)
Source Convergence          0.00006
```

Top Ten Thermal Limits Summary - Sorted by Margin

Power Value	FT	IR	JR	MCPR Value	Margin	FT	IR	JR	APLHGR Value	Margin	Exp.	FT	IR	JR	K	LHGR Value	Margin	Exp.	FT	IR	JR	K
1.398	20	25	20	1.618	0.909	20	33	18	8.73	0.759	21.0	20	27	18	18	8.40	0.806	50.9	18	31	48	18
1.396	20	23	18	1.618	0.908	20	23	18	8.68	0.759	22.0	20	29	16	18	7.87	0.788	53.9	18	17	18	17
1.395	20	43	28	1.620	0.908	20	25	42	8.66	0.757	22.0	20	33	14	18	8.12	0.788	52.0	18	47	32	17
1.394	20	27	18	1.627	0.903	20	39	42	8.69	0.757	21.3	20	31	12	18	7.48	0.787	55.8	16	33	16	16
1.392	20	21	20	1.628	0.903	20	17	34	7.58	0.757	44.2	18	29	14	18	7.18	0.787	57.3	16	33	24	16
1.388	20	45	32	1.632	0.901	20	31	16	8.59	0.754	22.7	19	35	12	18	7.28	0.785	56.8	16	29	18	16
1.387	20	45	36	1.632	0.901	20	15	32	8.67	0.754	21.0	20	25	20	18	7.44	0.785	55.9	16	25	48	16
1.386	20	41	26	1.634	0.900	20	15	26	8.60	0.752	22.0	20	25	16	18	7.30	0.782	56.5	16	23	16	16
1.385	20	47	34	1.635	0.899	20	47	34	8.63	0.751	21.1	20	23	18	18	7.39	0.782	56.0	16	33	50	16
1.377	20	29	16	1.636	0.899	20	23	40	8.49	0.748	23.4	19	27	22	18	7.91	0.779	53.2	18	25	10	17

* LHGR calculated with pin-power reconstruction
* CPR calculated with pin-power reconstruction & CPR limit TYPE 3

Figure A.57 Browns Ferry Equilibrium Cycle Control Rod Pattern and Axial Distributions at 17,701.0 MWd/MTU

```
Cycle:                           21                    Core Average Exposure: MWd/MTU    35880.1
Exposure: MWd/MTU (GWd)     18107.4 (2505.59 )
Delta E: MWd/MTU, (GWd)       406.4 (  56.23 )           Axial Profile    Edit   Radial Power
Power: MWt                   3952.0 (100.00 %)      N(PRA) Power Exposure  Zone  Avg.  Max.  IR JR
Core Pressure: psia          1050.0                Top 25  0.357   7.797    13  0.395 0.617   7 16
Inlet Subcooling: Btu/lbm    -25.55                    24  0.924  20.774    14  0.295 0.583  27  4
Flow: Mlb/hr                 107.62 (105.00 %)         23  1.164  26.374    15  0.381 0.630  45  8
                                                       22  1.326  30.115    16  1.057 1.167  45 34
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58        21  1.417  32.459    17  1.070 1.175  25 18
59            -- -- -- -- -- -- -- --            59    20  1.477  34.314    18  0.918 1.191  47 32
55         -- -- -- -- -- -- -- -- -- --         55    19  1.485* 35.508    19  1.320 1.356  21 16
51      -- -- -- -- -- -- -- -- -- -- -- --      51    18  1.478  36.806    20  1.352 1.389  23 18
47   -- -- -- -- -- -- -- -- -- -- -- -- -- --   47    17  1.450  37.956    21  1.190 1.284   7 26
43 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 43    16  1.412  38.303
39 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 39    15  1.422  38.415
35 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 35    14  1.357  39.619
31 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 31    13  1.275  40.691
27 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 27    12  1.201  42.051
23 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 23    11  1.106  42.657
19 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 19    10  1.093  41.153
15   -- -- -- -- -- -- -- -- -- -- -- -- -- --   15     9  1.022  42.238
11      -- -- -- -- -- -- -- -- -- -- -- --      11     8  0.907  43.047
 7         -- -- -- -- -- -- -- -- -- --          7     7  0.783  43.963
 3            -- -- -- -- -- -- -- --             3     6  0.652  44.557*
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58         5  0.530  44.532
                                                        4  0.430  43.131
Control Rod Density: %          0.00                    3  0.361  39.924
                                                        2  0.284  31.147
k-effective:                 0.99972            Bottom  1  0.084   9.545
Void Fraction:                 0.323
Core Delta-P: psia            25.109              % AXIAL TILT  28.733 -10.667
Core Plate Delta-P: psia      20.566          AVG BOT 8ft/12ft  0.8474  1.0605
Coolant Temp: Deg-F            545.8
In Channel Flow: Mlb/hr        95.59  Active Channel Flow: Mlb/hr        92.64
Total Bypass Flow (%):          11.2  (of total core flow)
Total Water Rod Flow (%):        2.7  (of total core flow)
Source Convergence           0.00007
```

Top Ten Thermal Limits Summary - Sorted by Margin

Power				MCPR					APLHGR							LHGR						
Value	FT	IR	JR	Value	Margin	FT	IR	JR	Value	Margin	Exp.	FT	IR	JR	K	Value	Margin	Exp.	FT	IR	JR	K
1.389	20	23	18	1.694	0.868	21	25	8	8.90	0.779	22.2	20	31	12	18	8.35	0.834	53.8	18	31	48	17
1.385	20	43	28	1.699	0.865	21	31	8	8.80	0.776	23.5	19	25	12	18	8.01	0.820	54.7	18	17	18	17
1.384	20	25	20	1.703	0.863	21	7	26	7.83	0.776	43.1	18	29	14	19	8.12	0.816	54.0	18	25	10	17
1.384	20	47	34	1.705	0.862	20	33	18	8.82	0.776	22.9	20	27	14	18	8.42	0.810	51.1	18	47	32	18
1.384	20	21	20	1.708	0.861	20	23	18	8.81	0.774	22.9	20	29	16	18	7.51	0.807	56.6	16	33	16	16
1.383	20	27	18	1.712	0.859	21	7	32	8.82	0.771	21.9	20	27	18	18	7.47	0.806	56.8	16	33	50	16
1.383	20	45	32	1.712	0.859	20	25	42	8.68	0.767	24.0	19	23	14	18	7.49	0.806	56.6	16	25	48	16
1.382	20	45	36	1.713	0.858	20	31	16	8.73	0.767	22.9	20	25	16	18	7.34	0.802	57.2	16	23	16	16
1.373	20	41	26	1.714	0.858	21	17	50	8.75	0.765	21.9	20	23	18	18	7.26	0.799	57.5	16	29	18	16
1.370	20	29	16	1.715	0.857	20	47	34	8.74	0.764	21.9	20	25	20	18	7.26	0.798	57.4	16	15	24	16

* LHGR calculated with pin-power reconstruction
* CPR calculated with pin-power reconstruction & CPR limit TYPE 3

Figure A.58 Browns Ferry Equilibrium Cycle Control Rod Pattern and Axial Distributions at 18,107.4 MWd/MTU

```
Cycle:                           21                 Core Average Exposure: MWd/MTU    35887.8
Exposure: MWd/MTU (GWd)     18115.0 (2506.64 )
Delta E: MWd/MTU, (GWd)         7.6 (   1.05 )             Axial Profile    Edit   Radial Power
Power: MWt                   3952.0 (100.00 %)         N(PRA) Power Exposure  Zone  Avg.  Max.  IR JR
Core Pressure: psia          1044.4                   Top 25  0.342   7.800    13  0.400 0.627   7 16
Inlet Subcooling: Btu/lbm    -36.06                       24  0.884  20.781    14  0.298 0.592  27  4
Flow: Mlb/hr                  95.74 ( 93.40 %)            23  1.114  26.384    15  0.386 0.640  45  8
                                                          22  1.271  30.126    16  1.056 1.162  45 34
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58           21  1.360  32.470    17  1.069 1.170  25 18
59             -- -- -- -- -- -- -- --           59       20  1.420  34.326    18  0.923 1.186  47 32
55          -- -- -- -- -- -- -- -- -- --        55       19  1.431* 35.521    19  1.315 1.350  21 16
51       -- -- -- -- -- -- -- -- -- -- -- --     51       18  1.428  36.818    20  1.346 1.381  23 18
47    -- -- -- -- -- -- -- -- -- -- -- -- -- --  47       17  1.407  37.968    21  1.194 1.284   7 26
43 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 43       16  1.378  38.314
39 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 39       15  1.396  38.425
35 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 35       14  1.344  39.630
31 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 31       13  1.275  40.701
27 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 27       12  1.216  42.061
23 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 23       11  1.137  42.665
19 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 19       10  1.143  41.161
15    -- -- -- -- -- -- -- -- -- -- -- -- -- --  15        9  1.087  42.245
11       -- -- -- -- -- -- -- -- -- -- -- --     11        8  0.975  43.053
 7          -- -- -- -- -- -- -- -- -- --         7        7  0.846  43.968
 3             -- -- -- -- -- -- -- --            3        6  0.706  44.561*
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58            5  0.575  44.536
                                                           4  0.468  43.134
Control Rod Density: %         0.00                        3  0.395  39.926
                                                           2  0.311  31.149
k-effective:                0.99978             Bottom  1  0.091   9.546
Void Fraction:                0.321
Core Delta-P: psia           20.701              % AXIAL TILT  24.541 -10.658
Core Plate Delta-P: psia     16.124          AVG BOT 8ft/12ft  0.8726  1.0605
Coolant Temp: Deg-F           542.6
In Channel Flow: Mlb/hr       85.01   Active Channel Flow: Mlb/hr        82.38
Total Bypass Flow (%):         11.2   (of total core flow)
Total Water Rod Flow (%):       2.8   (of total core flow)
Source Convergence          0.00009


                          Top Ten Thermal Limits Summary - Sorted by Margin

     Power                   MCPR                            APLHGR                              LHGR
Value FT  IR JR     Value Margin FT  IR JR    Value Margin Exp. FT  IR JR  K    Value Margin Exp. FT  IR JR  K
1.381  20 23 18     1.674  0.878  21 25  8     8.54  0.748 22.2  20 31 12 18     8.05  0.805 53.8  18 31 48 17
1.377  20 47 34     1.679  0.875  20 33 18     8.45  0.745 23.5  19 25 12 18     7.73  0.791 54.7  18 17 18 17
1.377  20 43 28     1.681  0.874  20 23 18     7.42  0.745 45.0  18 29 14 18     7.85  0.789 54.0  18 25 10 17
1.376  20 21 20     1.681  0.874  21 31  8     8.46  0.744 22.9  20 27 14 18     7.27  0.785 56.8  16 33 50 16
1.376  20 25 20     1.681  0.874  21  7 26     8.44  0.741 22.9  20 29 16 18     7.29  0.783 56.6  16 33 16 16
1.375  20 45 36     1.687  0.871  20 25 42     8.45  0.739 21.9  20 27 18 18     7.28  0.783 56.7  16 25 48 16
1.375  20 27 18     1.688  0.871  20 47 34     8.32  0.736 24.0  19 23 14 18     7.96  0.779 52.9  18 47 32 17
1.374  20 45 32     1.689  0.870  20 31 16     8.36  0.735 22.9  20 25 16 18     7.13  0.779 57.2  16 23 16 16
1.365  20 41 26     1.691  0.870  20 15 32     8.38  0.732 22.0  20 23 18 18     7.05  0.776 57.5  16 29 18 16
1.362  20 31 16     1.691  0.869  20 17 34     8.35  0.731 22.3  20 33 10 18     7.04  0.774 57.4  16 15 24 16

  * LHGR calculated with pin-power reconstruction
  * CPR calculated with pin-power reconstruction & CPR limit TYPE 3
```

Figure A.59 Browns Ferry Equilibrium Cycle Control Rod Pattern and Axial Distributions at 18,115.0 MWd/MTU

```
Cycle:                           21                    Core Average Exposure: MWd/MTU    36192.7
Exposure: MWd/MTU (GWd)     18420.0 (2548.84 )
Delta E: MWd/MTU, (GWd)       305.0 (  42.20 )             Axial Profile    Edit   Radial Power
Power: MWt                   3952.0 (100.00 %)        N(PRA) Power Exposure  Zone  Avg.  Max.  IR JR
Core Pressure: psia          1044.4                  Top 25  0.358   7.916    13  0.398 0.626   7 16
Inlet Subcooling: Btu/lbm    -31.83                      24  0.931  21.085    14  0.295 0.591  27  4
Flow: Mlb/hr                 107.62 (105.00 %)           23  1.171  26.766    15  0.384 0.640  45  8
                                                         22  1.331  30.564    16  1.052 1.159  45 34
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58          21  1.416  32.937    17  1.067 1.165  25 18
59             -- -- -- -- -- -- -- --             59    20  1.468  34.812    18  0.926 1.185  47 32
55          -- -- -- -- -- -- -- -- -- --          55    19  1.468* 36.008    19  1.315 1.350  49 36
51       -- -- -- -- -- -- -- -- -- -- -- --       51    18  1.457  37.303    20  1.344 1.377  23 18
47    -- -- -- -- -- -- -- -- -- -- -- -- -- --    47    17  1.428  38.445    21  1.204 1.295   7 26
43 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 43    16  1.393  38.770
39 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 39    15  1.409  38.859
35 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 35    14  1.351  40.046
31 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 31    13  1.276  41.095
27 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 27    12  1.213  42.436
23 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 23    11  1.126  43.015
19 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 19    10  1.124  41.477
15    -- -- -- -- -- -- -- -- -- -- -- -- -- --    15     9  1.055  42.540
11       -- -- -- -- -- -- -- -- -- -- -- --       11     8  0.929  43.315
 7          -- -- -- -- -- -- -- -- -- --           7     7  0.790  44.194
 3             -- -- -- -- -- -- -- --              3     6  0.648  44.748*
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58           5  0.522  44.687
                                                          4  0.422  43.257
Control Rod Density: %         0.00                       3  0.354  40.029
                                                          2  0.279  31.231
k-effective:                1.00002               Bottom  1  0.082   9.572
Void Fraction:                0.300
Core Delta-P: psia           24.684            % AXIAL TILT  27.970 -10.277
Core Plate Delta-P: psia     20.109        AVG BOT 8ft/12ft  0.8505  1.0585
Coolant Temp: Deg-F           543.2
In Channel Flow: Mlb/hr       95.76  Active Channel Flow: Mlb/hr        92.88
Total Bypass Flow (%):         11.0  (of total core flow)
Total Water Rod Flow (%):       2.7  (of total core flow)
Source Convergence          0.00009
```

```
                            Top Ten Thermal Limits Summary - Sorted by Margin

     Power                 MCPR                         APLHGR                              LHGR
Value FT  IR JR     Value Margin FT  IR JR    Value Margin Exp. FT  IR JR  K    Value Margin Exp. FT  IR JR  K
1.377  20 23 18     1.710  0.860  21 25  8     8.73  0.767 22.9  20 31 12 18     8.20  0.832 54.4  18 31 48 17
1.377  20 47 34     1.719  0.855  21 31  8     8.70  0.765 23.0  19 25 12 19     8.04  0.821 54.6  18 25 10 17
1.372  20 45 36     1.722  0.854  21  7 26     7.69  0.765 43.7  18 29 14 19     7.88  0.819 55.3  18 17 18 17
1.372  20 21 20     1.734  0.848  21  7 32     8.68  0.761 22.5  20 27 14 19     7.37  0.808 57.3  16 33 50 16
1.371  20 45 32     1.736  0.847  21 17 50     8.57  0.756 23.6  20 29 16 18     8.11  0.804 53.5  18 47 32 17
1.371  20 43 34     1.740  0.845  21 49 18     8.55  0.754 23.5  19 23 14 19     7.34  0.804 57.3  16 25 14 16
1.369  20 25 20     1.744  0.843  21 41 10     8.57  0.754 22.9  20 33 10 18     7.36  0.803 57.2  16 33 16 16
1.369  20 27 18     1.749  0.841  20 23 18     8.57  0.752 22.6  20 27 18 18     7.21  0.799 57.8  16 23 16 16
1.363  20 49 32     1.749  0.840  20 33 18     8.50  0.750 23.5  20 25 16 18     7.86  0.799 54.5  18 15 16 17
1.359  20 31 16     1.752  0.839  20 47 34     8.46  0.748 24.0  19 11 26 18     7.94  0.797 54.0  18  9 26 17

  * LHGR calculated with pin-power reconstruction
  * CPR calculated with pin-power reconstruction & CPR limit TYPE 3
```

Figure A.60 Browns Ferry Equilibrium Cycle Control Rod Pattern and Axial Distributions at 18,420.0 MWd/MTU

```
Cycle:                          21                    Core Average Exposure: MWd/MTU    36272.6
Exposure: MWd/MTU (GWd)     18500.0 (2559.91 )
Delta E: MWd/MTU, (GWd)        80.0 (  11.07 )            Axial Profile    Edit   Radial Power
Power: MWt                   3889.3 ( 98.41 %)       N(PRA) Power Exposure  Zone  Avg.  Max.  IR JR
Core Pressure: psia          1043.1                 Top 25  0.361   7.947    13  0.398 0.627   7 16
Inlet Subcooling: Btu/lbm    -31.25                     24  0.942  21.167    14  0.295 0.591  27  4
Flow: Mlb/hr                 107.62 (105.00 %)          23  1.184  26.869    15  0.384 0.640  45  8
                                                        22  1.345  30.682    16  1.051 1.158  45 34
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58         21  1.428  33.063    17  1.066 1.164  25 18
59             -- -- -- -- -- -- -- --            59    20  1.479* 34.942    18  0.927 1.185  47 32
55          -- -- -- -- -- -- -- -- -- --         55    19  1.476  36.138    19  1.315 1.351  49 36
51       -- -- -- -- -- -- -- -- -- -- -- --      51    18  1.462  37.432    20  1.343 1.376  47 34
47    -- -- -- -- -- -- -- -- -- -- -- -- -- --   47    17  1.431  38.571    21  1.206 1.297   7 26
43 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 43      16  1.394  38.890
39 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 39      15  1.409  38.973
35 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 35      14  1.350  40.156
31 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 31      13  1.274  41.199
27 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 27      12  1.209  42.534
23 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 23      11  1.121  43.106
19 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 19      10  1.117  41.558
15    -- -- -- -- -- -- -- -- -- -- -- -- -- --   15     9  1.046  42.616
11       -- -- -- -- -- -- -- -- -- -- -- --      11     8  0.919  43.382
 7          -- -- -- -- -- -- -- -- -- --          7     7  0.779  44.250
 3             -- -- -- -- -- -- -- --             3     6  0.639  44.794*
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58          5  0.514  44.724
                                                         4  0.415  43.287
Control Rod Density: %          0.00                     3  0.349  40.055
                                                         2  0.275  31.251
k-effective:                 0.99998             Bottom  1  0.081   9.579
Void Fraction:                 0.297
Core Delta-P: psia            24.620            % AXIAL TILT  28.645 -10.174
Core Plate Delta-P: psia      20.047        AVG BOT 8ft/12ft  0.8457  1.0580
Coolant Temp: Deg-F            543.1
In Channel Flow: Mlb/hr        95.80  Active Channel Flow: Mlb/hr        92.93
Total Bypass Flow (%):          11.0  (of total core flow)
Total Water Rod Flow (%):        2.7  (of total core flow)
Source Convergence           0.00010
```

Top Ten Thermal Limits Summary - Sorted by Margin

Power Value	FT	IR	JR	MCPR Value	Margin	FT	IR	JR	APLHGR Value	Margin	Exp.	FT	IR	JR	K	LHGR Value	Margin	Exp.	FT	IR	JR	K
1.376	20	47	34	1.729	0.850	21	25	8	8.69	0.760	21.9	20	31	12	19	8.08	0.824	54.6	18	31	48	17
1.376	20	23	18	1.739	0.845	21	31	8	8.62	0.758	23.1	19	25	12	19	7.94	0.814	54.8	18	25	10	17
1.371	20	45	36	1.742	0.844	21	7	26	7.60	0.757	43.9	18	29	14	19	7.77	0.811	55.5	18	17	18	17
1.370	20	21	20	1.755	0.837	21	7	32	8.58	0.753	22.7	20	27	14	19	7.26	0.799	57.5	16	33	50	16
1.370	20	45	32	1.757	0.836	21	17	50	8.51	0.748	22.8	20	29	16	19	8.00	0.796	53.6	18	47	32	17
1.369	20	43	34	1.761	0.835	21	49	18	8.46	0.747	23.7	19	23	14	19	7.23	0.794	57.4	16	25	14	16
1.368	20	25	20	1.764	0.833	21	41	10	8.48	0.746	23.1	20	33	10	18	7.24	0.793	57.3	16	33	16	16
1.368	20	27	18	1.774	0.829	20	23	18	8.45	0.742	22.8	20	27	18	18	7.76	0.792	54.6	18	15	16	17
1.364	20	49	32	1.774	0.828	21	9	42	8.44	0.741	22.7	20	25	16	19	7.84	0.790	54.1	18	9	26	17
1.358	20	31	16	1.775	0.828	20	33	18	7.37	0.740	45.1	16	27	12	19	7.09	0.790	57.9	16	23	16	16

* LHGR calculated with pin-power reconstruction
* CPR calculated with pin-power reconstruction & CPR limit TYPE 3

Figure A.61 Browns Ferry Equilibrium Cycle Control Rod Pattern and Axial Distributions at 18,500.0 MWd/MTU

```
Cycle:                            21                    Core Average Exposure: MWd/MTU    36577.0
Exposure: MWd/MTU (GWd)      18804.4 (2602.03 )
Delta E: MWd/MTU, (GWd)        304.4 (  42.12 )           Axial Profile    Edit   Radial Power
Power: MWt                    3597.1 ( 91.02 %)      N(PRA) Power Exposure  Zone  Avg.  Max.  IR JR
Core Pressure: psia           1037.1                Top 25  0.378   8.069    13  0.398 0.627   7 16
Inlet Subcooling: Btu/lbm     -28.61                    24  0.990  21.489    14  0.294 0.591  27  4
Flow: Mlb/hr                  107.62 (105.00 %)         23  1.242  27.274    15  0.383 0.641  45  8
                                                        22  1.406  31.144    16  1.048 1.155  45 34
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58         21  1.482  33.551    17  1.064 1.159  25 18
59             -- -- -- -- -- -- -- --            59    20  1.523* 35.446    18  0.929 1.184  47 32
55          -- -- -- -- -- -- -- -- -- --         55    19  1.508  36.639    19  1.314 1.354  49 36
51       -- -- -- -- -- -- -- -- -- -- -- --      51    18  1.484  37.927    20  1.340 1.376  47 34
47    -- -- -- -- -- -- -- -- -- -- -- -- -- --   47    17  1.445  39.054    21  1.215 1.307   7 26
43 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 43    16  1.400  39.348
39 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 39    15  1.411  39.408
35 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 35    14  1.345  40.571
31 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 31    13  1.263  41.590
27 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 27    12  1.194  42.905
23 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 23    11  1.099  43.448
19 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 19    10  1.088  41.865
15    -- -- -- -- -- -- -- -- -- -- -- -- -- --   15     9  1.009  42.898
11       -- -- -- -- -- -- -- -- -- -- -- --      11     8  0.875  43.629
 7          -- -- -- -- -- -- -- -- -- --          7     7  0.735  44.459
 3             -- -- -- -- -- -- -- --             3     6  0.598  44.964*
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58          5  0.480  44.861
                                                         4  0.388  43.398
Control Rod Density: %          0.00                     3  0.326  40.148
                                                         2  0.257  31.324
k-effective:                 1.00002             Bottom  1  0.076   9.602
Void Fraction:                 0.281
Core Delta-P: psia            24.330           % AXIAL TILT  31.556  -9.770
Core Plate Delta-P: psia      19.763       AVG BOT 8ft/12ft  0.8250  1.0558
Coolant Temp: Deg-F            542.8
In Channel Flow: Mlb/hr        95.98  Active Channel Flow: Mlb/hr        93.19
Total Bypass Flow (%):          10.8  (of total core flow)
Total Water Rod Flow (%):        2.6  (of total core flow)
Source Convergence           0.00007


                          Top Ten Thermal Limits Summary - Sorted by Margin

     Power                  MCPR                         APLHGR                            LHGR
Value FT  IR JR     Value Margin FT  IR JR    Value Margin Exp. FT  IR JR  K    Value Margin Exp. FT  IR JR  K
1.376  20 47 34     1.834  0.801  21 25  8     8.24  0.723 22.6  20 31 12 19     7.55  0.783 55.2  18 31 48 17
1.372  20 23 18     1.847  0.796  21 31  8     8.16  0.721 23.8  19 25 12 19     7.47  0.778 55.4  18 25 10 17
1.368  20 45 36     1.850  0.795  21  7 26     7.29  0.720 42.6  18 29 14 20     7.27  0.771 56.1  18 17 18 17
1.367  20 45 32     1.868  0.787  21  7 32     8.10  0.714 23.4  20 27 14 19     7.30  0.757 55.2  18 15 16 17
1.366  20 49 32     1.871  0.785  21 17 50     8.12  0.712 22.5  20 33 10 19     7.48  0.757 54.3  18 47 32 17
1.365  20 21 20     1.874  0.784  21 41 10     8.06  0.709 23.2  19 23 14 20     7.38  0.756 54.7  18  9 26 17
1.363  20 43 34     1.876  0.784  21 49 18     7.10  0.707 43.7  16 27 12 20     6.76  0.755 58.0  16 33 50 16
1.362  20 27 18     1.886  0.779  21  9 42     8.01  0.706 23.5  20 29 16 19     6.71  0.749 58.0  16 25 14 16
1.361  20 25 20     1.892  0.777  21 23  8     7.15  0.705 42.3  18 35 52 20     7.26  0.749 55.1  18 47 18 17
1.361  20 29 12     1.898  0.774  21 39  8     7.99  0.705 23.6  19 39 12 19     6.71  0.747 57.9  16 33 16 16

  * LHGR calculated with pin-power reconstruction
  * CPR calculated with pin-power reconstruction & CPR limit TYPE 3
```

Figure A.62 Browns Ferry Equilibrium Cycle Control Rod Pattern and Axial Distributions at 18,804.4 MWd/MTU

```
Cycle:                            21                     Core Average Exposure: MWd/MTU    36772.7
Exposure: MWd/MTU (GWd)      19000.0 (2629.10 )
Delta E: MWd/MTU, (GWd)        195.6 (  27.07 )                Axial Profile    Edit   Radial Power
Power: MWt                    3438.5 ( 87.01 %)          N(PRA) Power Exposure  Zone  Avg.  Max.  IR JR
Core Pressure: psia           1033.9                     Top 25  0.387   8.151    13  0.397 0.628   7 16
Inlet Subcooling: Btu/lbm     -27.18                         24  1.018  21.704    14  0.293 0.591  27  4
Flow: Mlb/hr                  107.62 (105.00 %)              23  1.275  27.544    15  0.382 0.641  45  8
                                                             22  1.440  31.451    16  1.046 1.152  45 34
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58              21  1.511  33.874    17  1.063 1.157  21 18
59             -- -- -- -- -- -- -- --             59        20  1.547* 35.778    18  0.931 1.183  47 32
55          -- -- -- -- -- -- -- -- -- --          55        19  1.525  36.967    19  1.313 1.356  49 36
51       -- -- -- -- -- -- -- -- -- -- -- --       51        18  1.494  38.248    20  1.338 1.375  47 34
47    -- -- -- -- -- -- -- -- -- -- -- -- -- --    47        17  1.450  39.366    21  1.221 1.314   7 26
43 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 43        16  1.401  39.644
39 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 39        15  1.410  39.688
35 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 35        14  1.341  40.838
31 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 31        13  1.257  41.840
27 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 27        12  1.183  43.140
23 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 23        11  1.085  43.664
19 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 19        10  1.070  42.057
15    -- -- -- -- -- -- -- -- -- -- -- -- -- --    15         9  0.988  43.074
11       -- -- -- -- -- -- -- -- -- -- -- --       11         8  0.852  43.781
 7          -- -- -- -- -- -- -- -- -- --           7         7  0.712  44.586
 3             -- -- -- -- -- -- -- --              3         6  0.578  45.068*
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58               5  0.464  44.944
                                                              4  0.375  43.465
Control Rod Density: %          0.00                          3  0.315  40.204
                                                              2  0.248  31.368
k-effective:                 1.00003               Bottom  1  0.073   9.617
Void Fraction:                 0.273
Core Delta-P: psia            24.176                 % AXIAL TILT  33.083  -9.502
Core Plate Delta-P: psia      19.613             AVG BOT 8ft/12ft  0.8138  1.0544
Coolant Temp: Deg-F            542.7
In Channel Flow: Mlb/hr        96.08   Active Channel Flow: Mlb/hr        93.32
Total Bypass Flow (%):          10.7   (of total core flow)
Total Water Rod Flow (%):        2.6   (of total core flow)
Source Convergence           0.00006
```

Top Ten Thermal Limits Summary - Sorted by Margin

Power Value	FT	IR	JR	MCPR Value	Margin	FT	IR	JR	APLHGR Value	Margin	Exp.	FT	IR	JR	K	LHGR Value	Margin	Exp.	FT	IR	JR	K
1.375	20	47	34	1.898	0.774	21	25	8	8.04	0.703	22.0	20	31	12	20	7.24	0.759	55.6	18	31	48	17
1.369	20	23	18	1.914	0.768	21	31	8	7.99	0.702	23.0	19	25	12	20	7.18	0.756	55.8	18	25	10	17
1.367	20	49	32	1.916	0.767	21	7	26	7.06	0.700	43.0	18	29	14	20	6.98	0.748	56.5	18	17	18	17
1.366	20	45	36	1.936	0.759	21	7	32	7.89	0.694	22.8	20	27	14	20	7.03	0.736	55.6	18	15	16	17
1.364	20	45	32	1.941	0.757	21	17	50	7.94	0.693	21.7	20	33	10	20	7.11	0.736	55.1	18	9	26	17
1.362	20	29	12	1.941	0.757	21	41	10	7.82	0.690	23.6	19	23	14	20	7.18	0.734	54.7	18	47	32	17
1.362	20	21	20	1.946	0.755	21	49	18	6.96	0.689	42.6	18	35	10	20	6.46	0.729	58.4	16	33	50	16
1.359	20	43	34	1.954	0.752	21	9	42	6.90	0.688	44.1	16	27	12	20	6.98	0.728	55.5	18	47	18	17
1.358	20	27	18	1.956	0.751	21	23	8	7.83	0.687	22.7	19	39	12	20	6.96	0.725	55.4	18	17	48	17
1.356	20	25	20	1.963	0.749	21	39	8	7.80	0.685	22.9	19	23	10	19	6.41	0.723	58.4	16	25	14	16

* LHGR calculated with pin-power reconstruction
* CPR calculated with pin-power reconstruction & CPR limit TYPE 3

Figure A.63 Browns Ferry Equilibrium Cycle Control Rod Pattern and Axial Distributions at 19,000.0 MWd/MTU

```
Cycle:                            21                  Core Average Exposure: MWd/MTU    36972.6
Exposure: MWd/MTU (GWd)      19200.0 (2656.78 )
Delta E: MWd/MTU, (GWd)        200.0 (  27.67 )          Axial Profile    Edit   Radial Power
Power: MWt                    3277.4 ( 82.93 %)     N(PRA) Power Exposure  Zone  Avg.  Max.  IR JR
Core Pressure: psia           1030.6               Top 25  0.397   8.236    13  0.397 0.628   7 16
Inlet Subcooling: Btu/lbm     -25.74                   24  1.048  21.931    14  0.293 0.590  27  4
Flow: Mlb/hr                  107.62 (105.00 %)        23  1.310  27.827    15  0.382 0.642  45  8
                                                       22  1.476  31.773    16  1.043 1.150  45 34
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58        21  1.542  34.211    17  1.061 1.154  21 18
59            -- -- -- -- -- -- -- --            59    20  1.571* 36.122    18  0.932 1.182  47 32
55         -- -- -- -- -- -- -- -- -- --         55    19  1.541  37.305    19  1.313 1.358  49 36
51      -- -- -- -- -- -- -- -- -- -- -- --      51    18  1.504  38.579    20  1.336 1.374  47 34
47   -- -- -- -- -- -- -- -- -- -- -- -- -- --   47    17  1.455  39.687    21  1.227 1.320   7 26
43 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 43    16  1.402  39.946
39 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 39    15  1.408  39.974
35 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 35    14  1.337  41.109
31 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 31    13  1.249  42.094
27 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 27    12  1.171  43.379
23 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 23    11  1.071  43.883
19 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 19    10  1.052  42.251
15   -- -- -- -- -- -- -- -- -- -- -- -- -- --   15     9  0.966  43.251
11      -- -- -- -- -- -- -- -- -- -- -- --      11     8  0.829  43.933
 7         -- -- -- -- -- -- -- -- -- --          7     7  0.689  44.713
 3            -- -- -- -- -- -- -- --             3     6  0.559  45.171*
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58         5  0.448  45.027
                                                        4  0.361  43.531
Control Rod Density: %          0.00                    3  0.304  40.260
                                                        2  0.240  31.412
k-effective:                 1.00002            Bottom  1  0.071   9.631
Void Fraction:                 0.264
Core Delta-P: psia            24.021              % AXIAL TILT  34.657  -9.223
Core Plate Delta-P: psia      19.461          AVG BOT 8ft/12ft  0.8021  1.0528
Coolant Temp: Deg-F            542.5
In Channel Flow: Mlb/hr        96.18   Active Channel Flow: Mlb/hr        93.46
Total Bypass Flow (%):          10.6   (of total core flow)
Total Water Rod Flow (%):        2.5   (of total core flow)
Source Convergence           0.00005
```

Top Ten Thermal Limits Summary - Sorted by Margin

Power Value	FT	IR	JR	MCPR Value	Margin	FT	IR	JR	APLHGR Value	Margin	Exp.	FT	IR	JR	K	LHGR Value	Margin	Exp.	FT	IR	JR	K
1.374	20	47	34	1.970	0.746	21	25	8	7.74	0.683	23.5	19	25	12	20	6.89	0.734	56.2	18	25	10	17
1.369	20	49	32	1.990	0.739	21	7	26	7.79	0.683	22.5	20	31	12	20	6.93	0.733	56.0	18	31	48	17
1.366	20	23	18	1.990	0.739	21	31	8	6.82	0.678	43.4	18	29	14	20	6.69	0.724	56.9	18	17	18	17
1.363	20	29	12	2.013	0.730	21	7	32	7.71	0.675	22.2	20	33	10	20	6.75	0.715	56.0	18	15	16	17
1.363	20	45	36	2.017	0.729	21	41	10	7.63	0.672	23.3	20	27	14	20	6.83	0.714	55.6	18	9	26	17
1.362	20	45	32	2.019	0.728	21	17	50	6.77	0.671	43.0	18	35	10	20	6.88	0.710	55.1	18	47	32	17
1.359	20	21	20	2.025	0.726	21	49	18	7.56	0.669	24.1	19	23	14	20	6.70	0.706	55.9	18	47	18	17
1.358	19	49	36	2.027	0.725	21	37	8	7.64	0.669	22.1	19	37	10	20	6.68	0.703	55.8	18	17	48	17
1.355	20	43	34	2.030	0.724	21	9	42	7.60	0.669	23.2	19	39	12	20	6.16	0.703	58.8	16	33	50	16
1.354	20	51	34	2.035	0.722	21	39	8	6.68	0.668	44.5	16	27	12	20	6.11	0.696	58.7	16	25	14	16

* LHGR calculated with pin-power reconstruction
* CPR calculated with pin-power reconstruction & CPR limit TYPE 3

Figure A.64 Browns Ferry Equilibrium Cycle Control Rod Pattern and Axial Distributions at 19,200.0 MWd/MTU

```
Cycle:                          21                    Core Average Exposure: MWd/MTU    37177.7
Exposure: MWd/MTU (GWd)    19405.1 (2685.16 )
Delta E: MWd/MTU, (GWd)      205.1 (  28.38 )            Axial Profile    Edit   Radial Power
Power: MWt                  3085.3 ( 78.07 %)        N(PRA) Power Exposure  Zone  Avg.  Max.  IR JR
Core Pressure: psia         1026.7                  Top 25  0.409   8.326    13  0.397 0.629   7 16
Inlet Subcooling: Btu/lbm   -24.01                      24  1.084  22.171    14  0.292 0.590  27  4
Flow: Mlb/hr                107.62 (105.00 %)           23  1.351  28.127    15  0.382 0.642  45  8
                                                        22  1.518  32.111    16  1.041 1.147  45 34
   2  6 10 14 18 22 26 30 34 38 42 46 50 54 58          21  1.578  34.564    17  1.060 1.152  21 18
59             -- -- -- -- -- -- -- --            59    20  1.599* 36.480    18  0.934 1.181  47 32
55          -- -- -- -- -- -- -- -- -- --         55    19  1.561  37.656    19  1.312 1.361  49 36
51       -- -- -- -- -- -- -- -- -- -- -- --      51    18  1.516  38.920    20  1.334 1.373  47 34
47    -- -- -- -- -- -- -- -- -- -- -- -- -- --   47    17  1.460  40.016    21  1.234 1.328  53 36
43 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 43    16  1.402  40.256
39 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 39    15  1.405  40.266
35 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 35    14  1.330  41.386
31 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 31    13  1.238  42.352
27 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 27    12  1.156  43.621
23 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 23    11  1.052  44.103
19 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 19    10  1.029  42.446
15    -- -- -- -- -- -- -- -- -- -- -- -- -- --   15     9  0.939  43.427
11       -- -- -- -- -- -- -- -- -- -- -- --      11     8  0.801  44.084
 7          -- -- -- -- -- -- -- -- -- --          7     7  0.664  44.838
 3             -- -- -- -- -- -- -- --             3     6  0.537  45.272*
   2  6 10 14 18 22 26 30 34 38 42 46 50 54 58           5  0.431  45.108
                                                         4  0.348  43.597
Control Rod Density: %        0.00                       3  0.293  40.316
                                                         2  0.231  31.456
k-effective:               0.99997              Bottom  1  0.068   9.646
Void Fraction:               0.254
Core Delta-P: psia          23.842            % AXIAL TILT  36.473  -8.929
Core Plate Delta-P: psia    19.286        AVG BOT 8ft/12ft  0.7883  1.0512
Coolant Temp: Deg-F          542.4
In Channel Flow: Mlb/hr      96.30  Active Channel Flow: Mlb/hr        93.62
Total Bypass Flow (%):        10.5  (of total core flow)
Total Water Rod Flow (%):      2.5  (of total core flow)
Source Convergence         0.00009
```

Top Ten Thermal Limits Summary - Sorted by Margin

Power				MCPR					APLHGR							LHGR						
Value	FT	IR	JR	Value	Margin	FT	IR	JR	Value	Margin	Exp.	FT	IR	JR	K	Value	Margin	Exp.	FT	IR	JR	K
1.373	20	47	34	2.068	0.711	21	25	8	7.43	0.657	24.0	19	25	12	20	6.54	0.704	56.7	18	25	10	17
1.370	20	49	32	2.088	0.704	21	7	26	7.47	0.657	23.0	20	29	12	20	7.36	0.702	50.4	18	31	48	20
1.365	20	29	12	2.092	0.703	21	31	8	7.42	0.652	22.7	20	33	10	20	6.33	0.693	57.3	18	17	18	17
1.363	20	23	18	2.115	0.695	21	7	32	6.53	0.651	43.9	18	29	14	20	6.49	0.686	56.0	18	9	26	17
1.361	20	45	36	2.118	0.694	21	41	10	6.52	0.648	43.5	18	25	10	20	6.41	0.686	56.5	18	15	16	17
1.361	19	49	36	2.122	0.693	21	37	8	7.37	0.646	22.5	19	23	10	20	6.51	0.680	55.5	18	47	32	17
1.359	20	51	34	2.124	0.692	21	17	50	7.31	0.645	23.8	20	27	14	20	6.36	0.677	56.3	18	47	18	17
1.359	20	45	32	2.130	0.690	21	49	18	7.31	0.645	23.6	19	21	12	20	7.10	0.675	50.0	18	17	48	20
1.355	20	21	20	2.131	0.690	21	9	42	6.41	0.643	44.9	16	27	12	20	7.07	0.671	49.8	17	31	10	20
1.354	20	27	10	2.133	0.689	21	39	8	7.25	0.643	24.5	19	23	14	20	5.81	0.669	59.1	16	33	12	16

* LHGR calculated with pin-power reconstruction
* CPR calculated with pin-power reconstruction & CPR limit TYPE 3

Figure A.65 Browns Ferry Equilibrium Cycle Control Rod Pattern and Axial Distributions at 19,405.1 MWd/MTU

```
Cycle:                           21                   Core Average Exposure: MWd/MTU    37463.4
Exposure: MWd/MTU (GWd)     19690.7 (2724.68 )
Delta E: MWd/MTU, (GWd)       285.6 (  39.52 )              Axial Profile    Edit   Radial Power
Power: MWt                   2840.1 ( 71.87 %)         N(PRA) Power Exposure  Zone  Avg.  Max.  IR JR
Core Pressure: psia          1021.7                    Top 25  0.425   8.455    13  0.396 0.629   7 16
Inlet Subcooling: Btu/lbm    -21.84                        24  1.133  22.518    14  0.291 0.590  27  4
Flow: Mlb/hr                 107.62 (105.00 %)             23  1.408  28.559    15  0.381 0.643  45  8
                                                           22  1.577  32.599    16  1.037 1.147  49 34
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58            21  1.627  35.069    17  1.057 1.148  21 18
59             -- -- -- -- -- -- -- --            59       20  1.637* 36.990    18  0.937 1.180  47 32
55          -- -- -- -- -- -- -- -- -- --         55       19  1.586  38.152    19  1.312 1.364  49 36
51       -- -- -- -- -- -- -- -- -- -- -- --      51       18  1.530  39.400    20  1.331 1.372  49 32
47    -- -- -- -- -- -- -- -- -- -- -- -- -- --   47       17  1.466  40.477    21  1.243 1.339  53 36
43 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 43      16  1.401  40.688
39 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 39      15  1.401  40.672
35 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 35      14  1.321  41.770
31 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 31      13  1.222  42.708
27 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 27      12  1.134  43.953
23 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 23      11  1.025  44.403
19 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 19      10  0.996  42.709
15    -- -- -- -- -- -- -- -- -- -- -- -- -- --   15        9  0.902  43.664
11       -- -- -- -- -- -- -- -- -- -- -- --      11        8  0.765  44.286
 7          -- -- -- -- -- -- -- -- -- --          7        7  0.631  45.005
 3             -- -- -- -- -- -- -- --             3        6  0.510  45.407*
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58             5  0.409  45.216
                                                            4  0.330  43.685
Control Rod Density: %         0.00                         3  0.278  40.389
                                                            2  0.220  31.514
k-effective:                1.00000                 Bottom  1  0.065   9.665
Void Fraction:                0.240
Core Delta-P: psia           23.614             % AXIAL TILT  38.892  -8.510
Core Plate Delta-P: psia     19.063         AVG BOT 8ft/12ft  0.7697  1.0489
Coolant Temp: Deg-F           542.2
In Channel Flow: Mlb/hr       96.45  Active Channel Flow: Mlb/hr        93.83
Total Bypass Flow (%):         10.4  (of total core flow)
Total Water Rod Flow (%):       2.4  (of total core flow)
Source Convergence          0.00009
```

Top Ten Thermal Limits Summary - Sorted by Margin

Power				MCPR					APLHGR							LHGR						
Value	FT	IR	JR	Value	Margin	FT	IR	JR	Value	Margin	Exp.	FT	IR	JR	K	Value	Margin	Exp.	FT	IR	JR	K
1.372	20	49	32	2.212	0.665	21	25	8	7.02	0.623	24.7	19	25	12	20	6.97	0.668	50.8	18	25	10	20
1.372	20	47	34	2.233	0.658	21	7	26	7.05	0.623	23.7	20	29	12	20	6.92	0.666	51.1	18	31	48	20
1.367	20	29	12	2.242	0.656	21	31	8	7.03	0.620	23.4	20	33	10	20	5.86	0.652	57.9	18	17	18	17
1.366	20	51	34	2.262	0.650	21	37	8	7.00	0.616	23.2	19	23	10	20	6.05	0.649	56.6	18	9	26	17
1.364	19	49	36	2.266	0.649	21	7	32	6.17	0.616	44.1	18	25	10	20	5.96	0.648	57.0	18	15	16	17
1.361	20	27	10	2.269	0.648	21	41	10	6.14	0.614	44.5	18	29	14	20	6.72	0.643	50.7	18	17	48	20
1.359	20	23	18	2.278	0.645	21	39	8	6.91	0.612	24.3	19	21	12	20	6.69	0.642	50.9	18	47	18	20
1.358	19	51	38	2.279	0.645	21	17	50	6.88	0.610	24.4	20	27	14	20	6.68	0.640	50.8	18	47	32	20
1.357	20	45	36	2.279	0.645	21	7	38	6.05	0.609	45.5	16	27	12	20	6.68	0.638	50.5	17	31	10	20
1.355	20	45	32	2.282	0.644	21	9	42	6.83	0.608	25.2	19	23	14	20	6.70	0.634	49.4	16	33	50	20

* LHGR calculated with pin-power reconstruction
* CPR calculated with pin-power reconstruction & CPR limit TYPE 3

Figure A.66 Browns Ferry Equilibrium Cycle Control Rod Pattern and Axial Distributions at 19,690.7 MWd/MTU

```
Cycle:                            21
Exposure: MWd/MTU (GWd)      19976.3 (2764.20 )
Delta E: MWd/MTU, (GWd)        285.6 (  39.52 )
Power: MWt                    2586.6 ( 65.45 %)
Core Pressure: psia           1016.5
Inlet Subcooling: Btu/lbm     -19.60
Flow: Mlb/hr                  107.62 (105.00 %)

    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58
59             -- -- -- -- -- -- --             59
55          -- -- -- -- -- -- -- -- --          55
51       -- -- -- -- -- -- -- -- -- -- --       51
47    -- -- -- -- -- -- -- -- -- -- -- -- --    47
43 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 43
39 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 39
35 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 35
31 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 31
27 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 27
23 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 23
19 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 19
15    -- -- -- -- -- -- -- -- -- -- -- -- --    15
11       -- -- -- -- -- -- -- -- -- -- --       11
 7          -- -- -- -- -- -- -- -- --           7
 3             -- -- -- -- -- -- --              3
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58

Control Rod Density: %          0.00

k-effective:                 0.99996
Void Fraction:                 0.225
Core Delta-P: psia            23.386
Core Plate Delta-P: psia      18.839
Coolant Temp: Deg-F            542.0
In Channel Flow: Mlb/hr        96.61   Active Channel Flow: Mlb/hr        94.04
Total Bypass Flow (%):          10.2   (of total core flow)
Total Water Rod Flow (%):        2.4   (of total core flow)
Source Convergence           0.00009
```

```
Core Average Exposure: MWd/MTU    37748.8

            Axial Profile     Edit   Radial Power
     N(PRA) Power Exposure    Zone  Avg.  Max.  IR JR
     Top 25  0.442   8.589     13  0.395 0.630   7 16
         24  1.187  22.881     14  0.290 0.590  27  4
         23  1.471  29.010     15  0.380 0.643  45  8
         22  1.640  33.106     16  1.033 1.149  49 34
         21  1.679* 35.590     17  1.055 1.149  31 10
         20  1.677  37.512     18  0.939 1.179  47 32
         19  1.611  38.655     19  1.311 1.367  49 36
         18  1.543  39.884     20  1.328 1.375  49 32
         17  1.470  40.940     21  1.252 1.350  53 36
         16  1.398  41.119
         15  1.394  41.077
         14  1.309  42.151
         13  1.202  43.059
         12  1.108  44.277
         11  0.994  44.695
         10  0.960  42.964
          9  0.864  43.892
          8  0.728  44.478
          7  0.599  45.164
          6  0.484  45.535*
          5  0.388  45.319
          4  0.314  43.768
          3  0.265  40.459
          2  0.209  31.570
  Bottom  1  0.062   9.683

   % AXIAL TILT  41.361  -8.078
AVG BOT 8ft/12ft  0.7501  1.0465
```

Top Ten Thermal Limits Summary - Sorted by Margin

Power				MCPR					APLHGR							LHGR						
Value	FT	IR	JR	Value	Margin	FT	IR	JR	Value	Margin	Exp.	FT	IR	JR	K	Value	Margin	Exp.	FT	IR	JR	K
1.375	20	49	32	2.391	0.615	21	25	8	6.56	0.585	25.4	19	25	12	20	6.55	0.632	51.5	18	25	10	20
1.373	20	51	34	2.412	0.609	21	7	26	6.59	0.584	24.4	20	29	12	20	6.45	0.625	51.8	18	31	48	20
1.371	20	47	34	2.427	0.606	21	31	8	6.60	0.584	24.1	20	27	10	20	6.39	0.614	51.0	18	9	26	20
1.369	20	29	12	2.436	0.603	21	37	8	6.58	0.582	23.9	19	23	10	20	6.29	0.611	52.1	18	15	16	20
1.368	20	27	10	2.452	0.599	21	7	32	5.79	0.580	44.7	18	25	10	20	6.30	0.607	51.4	18	17	48	20
1.367	19	49	36	2.453	0.599	21	7	38	6.48	0.576	25.0	19	21	12	20	5.56	0.607	57.2	18	17	18	18
1.367	19	51	38	2.456	0.599	21	41	10	5.71	0.574	45.1	18	29	14	20	6.27	0.606	51.6	18	47	18	20
1.363	19	23	10	2.456	0.599	21	39	8	6.53	0.574	22.8	21	25	8	20	6.25	0.601	51.2	17	31	10	20
1.358	19	25	12	2.468	0.596	21	9	42	6.52	0.573	23.1	21	31	8	20	6.23	0.601	51.5	18	47	32	20
1.354	20	23	18	2.470	0.595	21	17	50	5.64	0.571	46.1	16	27	12	20	6.27	0.597	50.1	16	33	50	20

* LHGR calculated with pin-power reconstruction
* CPR calculated with pin-power reconstruction & CPR limit TYPE 3

Figure A.67 Browns Ferry Equilibrium Cycle Control Rod Pattern and Axial Distributions at 19,976.3 MWd/MTU

```
Cycle:                            21                  Core Average Exposure: MWd/MTU    38034.6
Exposure: MWd/MTU (GWd)      20261.9 (2803.72 )
Delta E: MWd/MTU, (GWd)        285.6 (  39.52 )             Axial Profile    Edit   Radial Power
Power: MWt                    2330.1 ( 58.96 %)        N(PRA) Power Exposure  Zone  Avg.  Max.  IR JR
Core Pressure: psia           1011.3                   Top 25  0.461   8.729    13  0.394 0.630   7 16
Inlet Subcooling: Btu/lbm     -17.37                       24  1.247  23.262    14  0.288 0.589  27  4
Flow: Mlb/hr                  107.62 (105.00 %)            23  1.541  29.481    15  0.379 0.643  45  8
                                                           22  1.709  33.633    16  1.029 1.151  49 34
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58            21  1.735* 36.128    17  1.053 1.153  31 10
59             -- -- -- -- -- -- -- --            59       20  1.719  38.047    18  0.942 1.184  51 26
55          -- -- -- -- -- -- -- -- -- --         55       19  1.637  39.167    19  1.311 1.377  51 38
51       -- -- -- -- -- -- -- -- -- -- -- --      51       18  1.557  40.373    20  1.325 1.381  51 34
47    -- -- -- -- -- -- -- -- -- -- -- -- -- --   47       17  1.473  41.404    21  1.263 1.363  53 36
43 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 43       16  1.395  41.549
39 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 39       15  1.386  41.479
35 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 35       14  1.293  42.528
31 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 31       13  1.179  43.404
27 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 27       12  1.078  44.594
23 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 23       11  0.960  44.978
19 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 19       10  0.921  43.209
15    -- -- -- -- -- -- -- -- -- -- -- -- -- --   15        9  0.823  44.110
11       -- -- -- -- -- -- -- -- -- -- -- --      11        8  0.690  44.661
 7          -- -- -- -- -- -- -- -- -- --          7        7  0.566  45.314
 3             -- -- -- -- -- -- -- --             3        6  0.457  45.657*
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58             5  0.367  45.417
                                                            4  0.297  43.847
Control Rod Density: %          0.00                        3  0.251  40.526
                                                            2  0.199  31.622
k-effective:                 1.00003            Bottom  1  0.059   9.700
Void Fraction:                 0.209
Core Delta-P: psia            23.157               % AXIAL TILT  44.010  -7.634
Core Plate Delta-P: psia      18.616           AVG BOT 8ft/12ft  0.7287  1.0439
Coolant Temp: Deg-F            541.8
In Channel Flow: Mlb/hr        96.77  Active Channel Flow: Mlb/hr        94.26
Total Bypass Flow (%):          10.1  (of total core flow)
Total Water Rod Flow (%):        2.3  (of total core flow)
Source Convergence           0.00009
```

Top Ten Thermal Limits Summary - Sorted by Margin

Power				MCPR					APLHGR							LHGR						
Value	FT	IR	JR	Value	Margin	FT	IR	JR	Value	Margin	Exp.	FT	IR	JR	K	Value	Margin	Exp.	FT	IR	JR	K
1.381	20	51	34	2.608	0.564	21	25	8	6.13	0.545	24.8	20	27	10	20	6.17	0.593	51.0	18	25	10	20
1.378	20	49	32	2.631	0.559	21	7	26	6.08	0.544	26.1	19	25	12	20	5.95	0.581	52.5	18	31	48	20
1.377	19	51	38	2.650	0.555	21	37	8	6.13	0.544	24.7	19	23	10	20	5.96	0.576	51.7	18	9	26	20
1.375	20	27	10	2.654	0.554	21	31	8	6.10	0.543	25.1	20	29	12	20	5.85	0.572	52.8	18	15	16	20
1.372	19	23	10	2.667	0.551	21	53	38	5.38	0.541	45.4	18	25	10	20	5.85	0.568	52.1	18	17	48	20
1.371	19	49	36	2.674	0.550	21	39	8	6.10	0.538	23.5	21	25	8	20	5.83	0.567	52.3	18	47	18	20
1.371	20	29	12	2.677	0.549	21	53	30	6.01	0.537	25.7	19	21	12	20	5.64	0.566	53.9	18	17	18	20
1.370	20	47	34	2.684	0.548	21	41	10	6.07	0.536	23.8	21	31	8	20	5.87	0.562	50.7	17	31	10	20
1.363	21	53	36	2.690	0.546	21	7	40	6.03	0.531	23.4	19	33	8	20	5.76	0.560	52.2	18	47	32	20
1.361	19	25	12	2.696	0.545	21	9	42	5.26	0.531	45.7	18	29	14	20	5.36	0.556	55.3	16	25	14	20

* LHGR calculated with pin-power reconstruction
* CPR calculated with pin-power reconstruction & CPR limit TYPE 3

Figure A.68 Browns Ferry Equilibrium Cycle Control Rod Pattern and Axial Distributions at 20,261.9 MWd/MTU

Appendix B Elevation Views of the Browns Ferry Equilibrium Cycle Fresh Reload Batch Fuel Assemblies

[ ]

Figure B.1 Elevation View for the Browns Ferry Equilibrium Cycle Fresh Fuel Reload Batch BFE ATRIUM 11 [ ] Fuel Assembly Design

[ ]

Figure B.2 Elevation View for the Browns Ferry Equilibrium Cycle Fresh Fuel Reload Batch BFE ATRIUM 11 [ ] Fuel Assembly Design

[ ]

Figure B.3 Elevation View for the Browns Ferry Equilibrium Cycle Fresh Fuel Reload Batch BFE ATRIUM 11 [ ] Fuel Assembly Design

Appendix C Browns Ferry Equilibrium Cycle Fresh Fuel Locations

Table C.1 Browns Ferry Equilibrium Cycle Reload Fuel Identification and Locations

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Table C.2 Browns Ferry Equilibrium Cycle Reload Fuel Identification and Locations (*Continued*)

Table C.3 Browns Ferry Equilibrium Cycle Reload Fuel Identification and Locations (*Continued*)

Appendix D Browns Ferry Equilibrium Cycle Radial Exposure and Power Distributions

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Appendix E Browns Ferry Cycle N-1 EOC Projection Control Rod Patterns and Core Average Axial Power and Exposure Distributions

```
Cycle:                           20                  Core Average Exposure: MWd/MTU    36577.8
Exposure: MWd/MTU (GWd)     18804.4 (2602.03 )
Delta E: MWd/MTU, (GWd)       304.4 (  42.12 )              Axial Profile    Edit   Radial Power
Power: MWt                   3607.7 ( 91.29 %)          N(PRA) Power Exposure  Zone  Avg.  Max.  IR JR
Core Pressure: psia          1037.3                    Top 25  0.377   8.067    10  0.398 0.627   7 16
Inlet Subcooling: Btu/lbm    -28.70                        24  0.988  21.485    11  0.294 0.591  27  4
Flow: Mlb/hr                 107.62 (105.00 %)             23  1.239  27.268    12  0.383 0.640  45  8
                                                           22  1.403  31.136    13  1.048 1.155  45 34
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58            21  1.479  33.540    14  1.064 1.160  21 18
59             -- -- -- -- -- -- -- --            59       20  1.521* 35.433    15  0.929 1.185  47 32
55          -- -- -- -- -- -- -- -- -- --         55       19  1.507  36.624    16  1.314 1.354  49 26
51       -- -- -- -- -- -- -- -- -- -- -- --      51       18  1.484  37.909    17  1.341 1.376  47 34
47    -- -- -- -- -- -- -- -- -- -- -- -- -- --   47       17  1.445  39.036    18  1.214 1.306  53 26
43 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 43       16  1.402  39.332
39 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 39       15  1.413  39.394
35 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 35       14  1.347  40.560
31 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 31       13  1.266  41.581
27 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 27       12  1.196  42.900
23 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 23       11  1.101  43.447
19 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 19       10  1.090  41.867
15    -- -- -- -- -- -- -- -- -- -- -- -- -- --   15        9  1.010  42.903
11       -- -- -- -- -- -- -- -- -- -- -- --      11        8  0.877  43.636
 7          -- -- -- -- -- -- -- -- -- --          7        7  0.735  44.468
 3             -- -- -- -- -- -- -- --             3        6  0.598  44.976*
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58             5  0.480  44.876
                                                            4  0.387  43.419
Control Rod Density: %         0.00                         3  0.325  40.177
                                                            2  0.255  31.355
k-effective:                0.99998                 Bottom  1  0.075   9.613
Void Fraction:                0.282
Core Delta-P: psia           24.341               % AXIAL TILT  31.495  -9.803
Core Plate Delta-P: psia     19.773           AVG BOT 8ft/12ft  0.8259  1.0559
Coolant Temp: Deg-F           542.8
In Channel Flow: Mlb/hr       95.98   Active Channel Flow: Mlb/hr        93.18
Total Bypass Flow (%):         10.8   (of total core flow)
Total Water Rod Flow (%):       2.6   (of total core flow)
Source Convergence          0.00009
```

Top Ten Thermal Limits Summary - Sorted by Margin

Power Value	FT	IR	JR	MCPR Value	Margin	FT	IR	JR	APLHGR Value	Margin	Exp.	FT	IR	JR	K	LHGR Value	Margin	Exp.	FT	IR	JR	K
1.376	17	47	34	1.830	0.803	18	25	8	8.26	0.725	22.6	17	31	12	19	7.58	0.784	55.1	15	31	48	17
1.373	17	23	18	1.843	0.798	18	31	8	8.19	0.723	23.8	16	25	12	19	7.49	0.780	55.4	15	25	10	17
1.369	17	45	36	1.847	0.796	18	7	26	7.30	0.722	42.6	15	29	14	20	7.30	0.773	56.0	15	17	18	17
1.368	17	45	32	1.864	0.789	18	7	32	8.12	0.716	23.3	17	27	14	19	7.32	0.759	55.2	15	15	16	17
1.367	17	21	20	1.869	0.787	18	17	50	8.14	0.714	22.5	17	33	10	19	7.51	0.758	54.2	15	47	32	17
1.366	17	49	32	1.870	0.786	18	41	10	8.07	0.710	23.1	16	37	14	20	7.40	0.757	54.7	15	9	26	17
1.365	17	43	28	1.872	0.785	18	49	18	8.04	0.708	23.4	17	29	16	19	6.78	0.756	58.0	13	33	50	16
1.363	17	27	18	1.883	0.781	18	9	42	7.11	0.708	43.7	13	33	12	20	6.74	0.752	58.0	13	25	14	16
1.363	17	25	20	1.888	0.779	18	23	8	8.01	0.706	23.5	16	39	12	19	7.28	0.751	55.0	15	47	18	17
1.361	17	29	12	1.894	0.776	18	39	8	8.06	0.706	22.5	16	37	10	19	6.74	0.750	57.9	13	33	16	16

* LHGR calculated with pin-power reconstruction
* CPR calculated with pin-power reconstruction & CPR limit TYPE 3

Figure E.1 Browns Ferry Cycle N-1 Control Rod Pattern and Axial Distributions at 18,804.4 MWd/MTU (Short Window)

```
Cycle:                             20                        Core Average Exposure: MWd/MTU    37178.5
Exposure: MWd/MTU (GWd)      19405.1 (2685.16 )
Delta E: MWd/MTU, (GWd)        205.1 (  28.38 )                  Axial Profile    Edit   Radial Power
Power: MWt                    3090.8 ( 78.21 %)            N(PRA) Power Exposure  Zone  Avg.  Max.  IR JR
Core Pressure: psia           1026.8                       Top 25  0.408   8.323   10  0.397 0.629   7 16
Inlet Subcooling: Btu/lbm    -24.07                            24  1.082  22.165   11  0.292 0.590  27  4
Flow: Mlb/hr                  107.62 (105.00 %)                23  1.350  28.119   12  0.381 0.642  45  8
                                                               22  1.517  32.102   13  1.041 1.148  45 34
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58                21  1.577  34.552   14  1.060 1.153  21 18
59             -- -- -- -- -- -- -- --            59           20  1.599* 36.466   15  0.934 1.182  47 32
55          -- -- -- -- -- -- -- -- -- --         55           19  1.561  37.640   16  1.313 1.361  49 36
51       -- -- -- -- -- -- -- -- -- -- -- --      51           18  1.517  38.904   17  1.335 1.374  47 34
47    -- -- -- -- -- -- -- -- -- -- -- -- -- --   47           17  1.462  40.000   18  1.233 1.327  53 26
43 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 43          16  1.405  40.241
39 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 39          15  1.408  40.253
35 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 35          14  1.333  41.376
31 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 31          13  1.241  42.345
27 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 27          12  1.158  43.618
23 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 23          11  1.053  44.103
19 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 19          10  1.030  42.449
15    -- -- -- -- -- -- -- -- -- -- -- -- -- --   15            9  0.939  43.433
11       -- -- -- -- -- -- -- -- -- -- -- --      11            8  0.801  44.092
 7          -- -- -- -- -- -- -- -- -- --          7            7  0.663  44.847
 3             -- -- -- -- -- -- -- --             3            6  0.536  45.284*
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58                 5  0.429  45.123
                                                                4  0.346  43.618
Control Rod Density: %          0.00                            3  0.291  40.344
                                                                2  0.229  31.487
k-effective:                 1.00000                    Bottom  1  0.068   9.656
Void Fraction:                 0.254
Core Delta-P: psia            23.846              % AXIAL TILT  36.514  -8.962
Core Plate Delta-P: psia      19.290          AVG BOT 8ft/12ft  0.7886  1.0514
Coolant Temp: Deg-F            542.4
In Channel Flow: Mlb/hr        96.30   Active Channel Flow: Mlb/hr        93.62
Total Bypass Flow (%):          10.5   (of total core flow)
Total Water Rod Flow (%):        2.5   (of total core flow)
Source Convergence           0.00008
```

Top Ten Thermal Limits Summary - Sorted by Margin

Power				MCPR					APLHGR							LHGR						
Value	FT	IR	JR	Value	Margin	FT	IR	JR	Value	Margin	Exp.	FT	IR	JR	K	Value	Margin	Exp.	FT	IR	JR	K
1.374	17	47	34	2.065	0.712	18	25	8	7.45	0.659	24.0	16	25	12	20	6.56	0.706	56.6	15	25	10	17
1.371	17	49	32	2.086	0.705	18	7	26	7.49	0.658	23.0	17	31	12	20	7.36	0.703	50.4	15	31	48	20
1.366	17	29	12	2.088	0.704	18	31	8	7.44	0.653	22.7	17	33	10	20	6.35	0.694	57.2	15	17	18	17
1.365	17	23	18	2.113	0.696	18	7	32	6.54	0.652	43.8	15	29	14	20	6.43	0.687	56.4	15	15	16	17
1.362	17	45	36	2.115	0.695	18	41	10	6.53	0.649	43.4	15	35	10	20	6.51	0.687	55.9	15	9	26	17
1.361	16	49	36	2.119	0.694	18	37	8	7.38	0.648	22.5	16	37	10	20	6.53	0.681	55.4	15	47	32	17
1.360	17	45	32	2.123	0.693	18	17	50	7.32	0.647	23.7	17	27	14	20	6.38	0.679	56.3	15	47	18	17
1.359	17	51	34	2.126	0.691	18	49	18	7.32	0.646	23.6	16	39	12	20	6.35	0.675	56.2	15	17	48	17
1.357	17	21	20	2.130	0.690	18	9	42	6.42	0.644	44.9	13	27	12	20	7.08	0.672	49.8	14	31	10	20
1.354	17	27	10	2.130	0.690	18	39	8	7.26	0.644	24.5	16	23	14	20	5.84	0.671	59.0	13	33	12	16

* LHGR calculated with pin-power reconstruction
* CPR calculated with pin-power reconstruction & CPR limit TYPE 3

Figure E.2 Browns Ferry Cycle N-1 Control Rod Pattern and Axial Distributions at 19,405.1 MWd/MTU (Nominal Window)

```
Cycle:                            20                    Core Average Exposure: MWd/MTU    37577.2
Exposure: MWd/MTU (GWd)      19803.9 (2740.34 )
Delta E: MWd/MTU, (GWd)        113.2 (  15.66 )            Axial Profile    Edit   Radial Power
Power: MWt                    2747.6 ( 69.52 %)      N(PRA) Power Exposure  Zone  Avg.  Max.  IR JR
Core Pressure: psia           1019.8                Top 25  0.431   8.505    10  0.396 0.629   7 16
Inlet Subcooling: Btu/lbm     -21.03                    24  1.151  22.653    11  0.290 0.590  27  4
Flow: Mlb/hr                  107.62 (105.00 %)         23  1.430  28.726    12  0.380 0.643  45  8
                                                        22  1.598  32.787    13  1.036 1.148  49 34
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58         21  1.645  35.261    14  1.057 1.148  21 18
59             -- -- -- -- -- -- --             59      20  1.652* 37.181    15  0.937 1.180  47 32
55          -- -- -- -- -- -- -- -- --          55      19  1.596  38.334    16  1.312 1.365  49 36
51       -- -- -- -- -- -- -- -- -- -- --       51      18  1.537  39.575    17  1.331 1.374  49 32
47    -- -- -- -- -- -- -- -- -- -- -- -- --    47      17  1.470  40.645    18  1.245 1.342  53 36
43 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 43      16  1.403  40.844
39 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 39      15  1.402  40.821
35 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 35      14  1.320  41.912
31 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 31      13  1.218  42.842
27 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 27      12  1.127  44.080
23 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 23      11  1.015  44.521
19 -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- 19      10  0.983  42.815
15    -- -- -- -- -- -- -- -- -- -- -- -- --    15       9  0.888  43.762
11       -- -- -- -- -- -- -- -- -- -- --       11       8  0.750  44.371
 7          -- -- -- -- -- -- -- -- --           7       7  0.617  45.078
 3             -- -- -- -- -- -- --              3       6  0.498  45.470*
    2  6 10 14 18 22 26 30 34 38 42 46 50 54 58          5  0.399  45.272
                                                         4  0.322  43.738
Control Rod Density: %          0.00                     3  0.271  40.446
                                                         2  0.214  31.567
k-effective:                 1.00002             Bottom  1  0.063   9.682
Void Fraction:                 0.234
Core Delta-P: psia            23.529            % AXIAL TILT  39.896  -8.372
Core Plate Delta-P: psia      18.980        AVG BOT 8ft/12ft  0.7625  1.0481
Coolant Temp: Deg-F            542.1
In Channel Flow: Mlb/hr        96.51   Active Channel Flow: Mlb/hr        93.91
Total Bypass Flow (%):          10.3   (of total core flow)
Total Water Rod Flow (%):        2.4   (of total core flow)
Source Convergence           0.00009


                          Top Ten Thermal Limits Summary - Sorted by Margin

     Power                  MCPR                        APLHGR                             LHGR
Value FT  IR JR     Value Margin FT  IR JR    Value Margin Exp. FT  IR JR  K    Value Margin Exp. FT  IR JR  K
1.374  17 49 32     2.273  0.647  18 25  8     6.86  0.610 24.9  16 25 12 20     6.82  0.656 51.1  15 25 10 20
1.372  17 47 34     2.295  0.640  18  7 26     6.89  0.609 23.9  17 29 12 20     6.75  0.651 51.3  15 31 48 20
1.368  17 29 12     2.305  0.638  18 31  8     6.89  0.608 23.6  17 33 10 20     6.65  0.636 50.6  15  9 26 20
1.368  17 51 34     2.322  0.633  18 37  8     6.86  0.604 23.5  16 23 10 20     5.69  0.636 58.1  15 17 18 17
1.365  16 49 36     2.331  0.631  18  7 32     6.04  0.604 44.3  15 25 10 20     6.56  0.634 51.6  15 15 16 20
1.363  17 27 10     2.333  0.630  18 41 10     5.99  0.600 44.7  15 29 14 20     6.57  0.630 50.9  15 17 48 20
1.360  16 51 38     2.338  0.629  18 39  8     6.76  0.600 24.5  16 21 12 20     6.54  0.630 51.2  15 47 18 20
1.358  17 23 18     2.339  0.628  18 53 24     6.79  0.596 22.6  18 31  8 20     6.51  0.626 51.0  15 47 32 20
1.357  17 45 36     2.346  0.627  18 17 50     6.71  0.596 24.7  17 27 14 20     6.53  0.626 50.8  14 31 10 20
1.357  16 23 10     2.347  0.626  18  9 42     5.91  0.596 45.7  13 27 12 20     6.55  0.620 49.7  13 33 50 20

  * LHGR calculated with pin-power reconstruction
  * CPR calculated with pin-power reconstruction & CPR limit TYPE 3
```

Figure E.3 Browns Ferry Cycle N-1 Control Rod Pattern and Axial Distributions at 19,803.9 MWd/MTU (Long Window)

ATTACHMENT 7a

ANP-3850P Revision 1

(Proprietary)

Browns Ferry ATRIUM 11 Equilibrium Cycle Nuclear Fuel Design Report

ATTACHMENT 7b

ANP-3850NP Revision 1

(Non Proprietary)

Browns Ferry ATRIUM 11 Equilibrium Cycle Nuclear Fuel Design Report

Browns Ferry ATRIUM 11 Equilibrium Cycle

ANP-3850NP
Revision 1

Nuclear Fuel Design Report

April 2022

Nature of Changes

Item	Section(s) or Page(s)	Description and Justification
1	Page 2	Minor change to trademark statement
2	Pages 2-1, 2-3, and 2-4	Changes to proprietary redaction markings only, no modification of technical content

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Nomenclature

Acronym	**Definition**
[ ]	the information contained within brackets is proprietary to Framatome Inc.
BOL	beginning of life
BWR	boiling water reactor
EVC	plenum region in a fuel pin modeled as an evacuated section
kg/MTU	kilograms per metric ton of initial uranium
LHGR	linear heat generation rate
LPF	local peaking factor
MCPR	minimum critical power ratio
MWd/MTU	megawatt days per metric ton of initial uranium
NRC	(United States) Nuclear Regulatory Commission
PLFR	part-length fuel rod
SLC	standby liquid boron control

1.0 INTRODUCTION

This report provides results of the neutronic design analyses performed by Framatome Inc. for the Browns Ferry ATRIUM 11 equilibrium cycle design. The mechanical design parameters for the fuel are from Reference 1 and are shown in Table 2.1.

Applicable neutronic design criteria are provided in the approved topical report ANF-89-98(P)(A) Revision 1 and Supplement 1 (Reference 2). Neutronic design analysis methodology used to determine conformance to design criteria has been reviewed and approved by the NRC in the topical report EMF-2158(P)(A) (Reference 3).

The fuel design includes advanced fuel channels that use beta quenched Zircaloy-4 (Z4B) material.

The neutronic design for the equilibrium cycle includes axially-varying enrichment and gadolinia designs with natural UO_2 blankets at the top and bottom of the assembly. Pertinent fuel and reactor core design information associated with this equilibrium cycle batch is given in Section 2.0 and in Appendices A through D.

2.0 NEUTRONIC DESIGN

The results of the Browns Ferry equilibrium cycle neutronic design analyses are presented in this section. The fuel was designed to meet applicable design criteria, as well as reactivity and control requirements. Reactor core loading patterns and the number of assemblies to be loaded will depend upon final cycle energy requirements as specified by the utility. Applicable neutronic design criteria outlined in Reference 2 are summarized below:

- **Power Distribution.** The local power distribution in the fuel assembly combined with the core power distribution shall result in Linear Heat Generation Rate (LHGR) and Minimum Critical Power Ratio (MCPR) values that are within the limits established for each fuel design.
- **Kinetics Parameters.** The moderator void reactivity coefficient due to boiling in the active channels and the Doppler fuel temperature reactivity coefficient shall be negative. The negative void and Doppler reactivity coefficients ensure a negative power coefficient during reactor operation. Additional calculations were performed to show that the assembly average Doppler and void reactivity coefficients remain negative for the life of the assembly. These results demonstrate that the Reference 2 kinetics criteria are met on a bundle average basis.
- **Control Blade Reactivity.** The design of the fuel assembly and the reactor core loading shall be such that the technical specification shutdown margin requirement is met for all reactor conditions.

2.1 *Neutronic Design Description*

The neutronic design parameters for equilibrium cycle ATRIUM 11 assemblies are presented in Table 2.1. The key nuclear design characteristics are summarized below:

- The fuel assembly contains 92 full-length fuel rods, 20 part-length fuel rods and one central water channel that occupies the positions of 9 fuel rods.
- Each fuel assembly has top and bottom natural uranium blankets.
- The plenum region above the PLFRs will be explicitly modeled.
- The enrichments are designed to yield a local power distribution which results in a balanced design relative to MCPR, LHGR, and other reactor operating requirements, e.g., power peaking.
- Gadolinia (Gd_2O_3 blended with UO_2) rods are designed to control assembly reactivity in order to meet reactivity control requirements in the reactor, e.g. cold shutdown margin.
- The equilibrium cycle reload batch consists of 3 assembly designs which vary axially in enrichment and/or gadolinia. The axial distributions of the lattices in the assemblies are shown in Figures 2.1, 2.2, and 2.3. The fuel rod distribution and axial descriptions are presented in Figures 2.4 through 2.7. The enrichment and gadolinia distribution maps for each of the reload assembly lattices are displayed in Appendix D.

- The fuel assembly incorporates an advanced fuel channel which improves uranium utilization. For D-lattice plants, the fuel assembly is offset **[ ]** toward the control blade.

2.2 *Lattice Control Blade Worths and Kinetics Parameters*

Beginning of life (BOL) lattice reactivities (k_∞) have been calculated for moderator and fuel conditions ranging from cold to hot operating conditions. From these reactivities, BOL control blade worths and kinetics parameters have been determined based on ABB/Westinghouse Main Body, and ABB/Westinghouse Hafnium Tip control blades. Kinetics parameters are calculated for fuel temperature (Doppler), moderator void, and moderator temperature. The Doppler reactivity was calculated over a fuel temperature range from hot standby to hot operating. The moderator void reactivity was evaluated between the 0% and 40% voided hot operating cases, and the moderator temperature reactivity was calculated from the cold to hot standby condition. The calculations neglect the spacer material and assume zero void in the coolant outside the fuel assembly channel as well as inside the internal water channel. The results of these calculations are presented in Tables 2.2 through 2.70.

2.3 *Enriched Lattice Uncontrolled Reactivities and Isotopic Data*

The enriched lattice exposure-dependent uncontrolled reactivities calculated at three void fractions are presented graphically in Appendix A, and in tabular format in Appendix B. The enriched lattice exposure-dependent isotopic data calculated at three void fractions are presented in Appendix C.

Table 2.1 Neutronic Design Parameters

Parameter	Design Value
Fuel Rod	
Active fuel length, inch	
Full-length	150.00
Cladding material	Zircaloy-2

Table 2.1 Neutronic Design Parameters (Continued)

Parameter	Design Value
Fuel Assembly	
Water Rod Description	1 (square water channel that displaces 9 fuel rod locations)
Water channel material	Z4B
[ ]	
Number of fuel rods Short Part-Length Long Part-Length Full-Length	 12 8 92

[ ]

Table 2.1 Neutronic Design Parameters (Continued)

Table 2.1 Neutronic Design Parameters (Continued)

Parameter	Design Value
Core Data*	
Number of fuel assemblies in the core	764
Rated thermal power level, MWt	3952.0
Rated core flow, Mlbm/hr	102.5
Inlet subcooling, Btu/lbm	27.00
Dome pressure, psia	1050
Boron concentration, PPM	720.0
Intermediate temperature, °F	200.00
Warm temperature, °F	360.00

* Some values are representative of rated conditions and may vary depending on the core statepoint.

Table 2.2 Lattice [ ] Control Blade Worths at BOL for Control Blade Type ABB/Westinghouse Main Body

Blade Worth = $\frac{k_{Controlled} - k_{Uncontrolled}}{k_{Uncontrolled}}$		$k_{Controlled}$	$k_{Uncontrolled}$	Blade Worth (Δk/k)
Cold	$T_{Moderator}$=68° F T_{Fuel}=68° F 0% Void, No xenon	0.65148	0.81379	-0.1994
Intermediate	$T_{Moderator}$=200° F T_{Fuel}=200° F 0% Void, No xenon	0.64214	0.82016	-0.2171
Hot Standby	$T_{Moderator}$=550° F T_{Fuel}=550° F 0% Void, No xenon	0.60679	0.85460	-0.2900
Hot Operating$_{NoXe}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 0% Void, No xenon	0.60314	0.85002	-0.2904
Hot Operating$_{0}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 0% Void	0.60319	0.85002	-0.2904
Hot Operating$_{40}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 40% Void	0.57283	0.87265	-0.3436
Hot Operating$_{80}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 80% Void	0.51464	0.88861	-0.4209

Table 2.3 Lattice [ ] Control Blade Worths at BOL for Control Blade Type ABB/Westinghouse Hafnium Tip

Blade Worth = $\frac{k_{Controlled} - k_{Uncontrolled}}{k_{Uncontrolled}}$		$k_{Controlled}$	$k_{Uncontrolled}$	Blade Worth (Δk/k)
Cold	$T_{Moderator}$=68° F T_{Fuel}=68° F 0% Void, No xenon	0.66756	0.81379	-0.1797
Intermediate	$T_{Moderator}$=200° F T_{Fuel}=200° F 0% Void, No xenon	0.65955	0.82016	-0.1958
Hot Standby	$T_{Moderator}$=550° F T_{Fuel}=550° F 0% Void, No xenon	0.63193	0.85460	-0.2606
Hot Operating_{NoXe}	$T_{Moderator}$=550° F T_{Fuel}=1013° F 0% Void, No xenon	0.62813	0.85002	-0.2610
Hot Operating_{0}	$T_{Moderator}$=550° F T_{Fuel}=1013° F 0% Void	0.62813	0.85002	-0.2610
Hot Operating_{40}	$T_{Moderator}$=550° F T_{Fuel}=1013° F 40% Void	0.60448	0.87265	-0.3073
Hot Operating_{80}	$T_{Moderator}$=550° F T_{Fuel}=1013° F 80% Void	0.55512	0.88861	-0.3753

Table 2.4 Lattice [ ] Kinetics Parameters at BOL

Kinetics Parameter = $\frac{k_\alpha - k_\beta}{k_\beta}$	k_α	k_β	Kinetics Parameter (Δk/k)
Doppler = $\frac{k_{HotOperatingNoXe} - k_{HotStandby}}{k_{HotStandby}}$	0.85002	0.85460	-0.0054
$\text{Moderator}_{Void} = \frac{k_{HotOperating40} - k_{HotOperating0}}{k_{HotOperating0}}$	0.87265	0.85002	0.0266
$\text{Moderator}_{Temperature} = \frac{k_{HotStandby} - k_{Cold}}{k_{Cold}}$	0.85460	0.81379	0.0502

Table 2.5 Lattice [ ] Control Blade Worths at BOL for Control Blade Type ABB/Westinghouse Main Body

Blade Worth = $\frac{k_{Controlled} - k_{Uncontrolled}}{k_{Uncontrolled}}$		$k_{Controlled}$	$k_{Uncontrolled}$	Blade Worth ($\Delta k/k$)
Cold	$T_{Moderator}$=68° F T_{Fuel}=68° F 0% Void, No xenon	0.68961	0.84780	-0.1866
Intermediate	$T_{Moderator}$=200° F T_{Fuel}=200° F 0% Void, No xenon	0.67994	0.85239	-0.2023
Hot Standby	$T_{Moderator}$=550° F T_{Fuel}=550° F 0% Void, No xenon	0.64098	0.87595	-0.2682
Hot $Operating_{NoXe}$	$T_{Moderator}$=550° F T_{Fuel}=929° F 0% Void, No xenon	0.63747	0.87164	-0.2686
Hot $Operating_{0}$	$T_{Moderator}$=550° F T_{Fuel}=929° F 0% Void	0.63752	0.87164	-0.2686
Hot $Operating_{40}$	$T_{Moderator}$=550° F T_{Fuel}=929° F 40% Void	0.60343	0.88510	-0.3182
Hot $Operating_{80}$	$T_{Moderator}$=550° F T_{Fuel}=929° F 80% Void	0.54273	0.89039	-0.3905

Table 2.6 Lattice [ ] Control Blade Worths at BOL for Control Blade Type ABB/Westinghouse Hafnium Tip

Blade Worth = $\frac{k_{Controlled} - k_{Uncontrolled}}{k_{Uncontrolled}}$		$k_{Controlled}$	$k_{Uncontrolled}$	Blade Worth (Δk/k)
Cold	$T_{Moderator}$=68° F T_{Fuel}=68° F 0% Void, No xenon	0.70586	0.84780	-0.1674
Intermediate	$T_{Moderator}$=200° F T_{Fuel}=200° F 0% Void, No xenon	0.69739	0.85239	-0.1818
Hot Standby	$T_{Moderator}$=550° F T_{Fuel}=550° F 0% Void, No xenon	0.66561	0.87595	-0.2401
Hot $Operating_{NoXe}$	$T_{Moderator}$=550° F T_{Fuel}=929° F 0% Void, No xenon	0.66197	0.87164	-0.2406
Hot $Operating_{0}$	$T_{Moderator}$=550° F T_{Fuel}=929° F 0% Void	0.66197	0.87164	-0.2406
Hot $Operating_{40}$	$T_{Moderator}$=550° F T_{Fuel}=929° F 40% Void	0.63418	0.88510	-0.2835
Hot $Operating_{80}$	$T_{Moderator}$=550° F T_{Fuel}=929° F 80% Void	0.58171	0.89039	-0.3467

Table 2.7 Lattice [ ] Kinetics Parameters at BOL

Kinetics Parameter = $\frac{k_\alpha - k_\beta}{k_\beta}$	k_α	k_β	Kinetics Parameter (Δk/k)
Doppler = $\frac{k_{HotOperatingNoXe} - k_{HotStandby}}{k_{HotStandby}}$	0.87164	0.87595	-0.0049
$Moderator_{Void} = \frac{k_{HotOperating40} - k_{HotOperating0}}{k_{HotOperating0}}$	0.88510	0.87164	0.0154
$Moderator_{Temperature} = \frac{k_{HotStandby} - k_{Cold}}{k_{Cold}}$	0.87595	0.84780	0.0332

Table 2.8 Lattice [ ] Control Blade Worths at BOL for Control Blade Type ABB/Westinghouse Main Body

Blade Worth = $\frac{k_{Controlled} - k_{Uncontrolled}}{k_{Uncontrolled}}$		$k_{Controlled}$	$k_{Uncontrolled}$	Blade Worth ($\Delta k/k$)
Cold	$T_{Moderator}$=68° F T_{Fuel}=68° F 0% Void, No xenon	0.93681	1.10097	-0.1491
Intermediate	$T_{Moderator}$=200° F T_{Fuel}=200° F 0% Void, No xenon	0.92285	1.09165	-0.1546
Hot Standby	$T_{Moderator}$=550° F T_{Fuel}=550° F 0% Void, No xenon	0.86547	1.05847	-0.1823
Hot Operating$_{NoXe}$	$T_{Moderator}$=550° F T_{Fuel}=929° F 0% Void, No xenon	0.86146	1.05361	-0.1824
Hot Operating$_{0}$	$T_{Moderator}$=550° F T_{Fuel}=929° F 0% Void	0.86153	1.05361	-0.1823
Hot Operating$_{40}$	$T_{Moderator}$=550° F T_{Fuel}=929° F 40% Void	0.81409	1.03109	-0.2105
Hot Operating$_{80}$	$T_{Moderator}$=550° F T_{Fuel}=929° F 80% Void	0.75780	1.00588	-0.2466

Table 2.9 Lattice [ ] Control Blade Worths at BOL for Control Blade Type ABB/Westinghouse Hafnium Tip

Blade Worth = $\frac{k_{Controlled} - k_{Uncontrolled}}{k_{Uncontrolled}}$		$k_{Controlled}$	$k_{Uncontrolled}$	Blade Worth ($\Delta k/k$)
Cold	$T_{Moderator}$=68° F T_{Fuel}=68° F 0% Void, No xenon	0.95733	1.10097	-0.1305
Intermediate	$T_{Moderator}$=200° F T_{Fuel}=200° F 0% Void, No xenon	0.94400	1.09165	-0.1353
Hot Standby	$T_{Moderator}$=550° F T_{Fuel}=550° F 0% Void, No xenon	0.89169	1.05847	-0.1576
Hot $Operating_{NoXe}$	$T_{Moderator}$=550° F T_{Fuel}=929° F 0% Void, No xenon	0.88752	1.05361	-0.1576
Hot $Operating_{0}$	$T_{Moderator}$=550° F T_{Fuel}=929° F 0% Void	0.88752	1.05361	-0.1576
Hot $Operating_{40}$	$T_{Moderator}$=550° F T_{Fuel}=929° F 40% Void	0.84533	1.03109	-0.1802
Hot $Operating_{80}$	$T_{Moderator}$=550° F T_{Fuel}=929° F 80% Void	0.79596	1.00588	-0.2087

Table 2.10 Lattice [ ] Kinetics Parameters at BOL

Kinetics Parameter = $\frac{k_\alpha - k_\beta}{k_\beta}$	k_α	k_β	Kinetics Parameter ($\Delta k/k$)
Doppler = $\frac{k_{HotOperatingNoXe} - k_{HotStandby}}{k_{HotStandby}}$	1.05361	1.05847	-0.0046
$Moderator_{Void}$ = $\frac{k_{HotOperating40} - k_{HotOperating0}}{k_{HotOperating0}}$	1.03109	1.05361	-0.0214
$Moderator_{Temperature}$ = $\frac{k_{HotStandby} - k_{Cold}}{k_{Cold}}$	1.05847	1.10097	-0.0386

Table 2.11 Lattice [ ] Control Blade Worths at BOL for Control Blade Type ABB/Westinghouse Main Body

Blade Worth = $\frac{k_{Controlled} - k_{Uncontrolled}}{k_{Uncontrolled}}$		$k_{Controlled}$	$k_{Uncontrolled}$	Blade Worth (Δk/k)
Cold	$T_{Moderator}$=68° F T_{Fuel}=68° F 0% Void, No xenon	0.97473	1.14688	-0.1501
Intermediate	$T_{Moderator}$=200° F T_{Fuel}=200° F 0% Void, No xenon	0.96108	1.13874	-0.1560
Hot Standby	$T_{Moderator}$=550° F T_{Fuel}=550° F 0% Void, No xenon	0.90203	1.10639	-0.1847
Hot $Operating_{NoXe}$	$T_{Moderator}$=550° F T_{Fuel}=929° F 0% Void, No xenon	0.89784	1.10131	-0.1847
Hot $Operating_{0}$	$T_{Moderator}$=550° F T_{Fuel}=929° F 0% Void	0.89793	1.10131	-0.1847
Hot $Operating_{40}$	$T_{Moderator}$=550° F T_{Fuel}=929° F 40% Void	0.84657	1.07685	-0.2139
Hot $Operating_{80}$	$T_{Moderator}$=550° F T_{Fuel}=929° F 80% Void	0.78385	1.04868	-0.2525

Table 2.12 Lattice [ ] Control Blade Worths at BOL for Control Blade Type ABB/Westinghouse Hafnium Tip

Blade Worth = $\frac{k_{Controlled} - k_{Uncontrolled}}{k_{Uncontrolled}}$		$k_{Controlled}$	$k_{Uncontrolled}$	Blade Worth (Δk/k)
Cold	$T_{Moderator}$=68° F T_{Fuel}=68° F 0% Void, No xenon	0.99702	1.14688	-0.1307
Intermediate	$T_{Moderator}$=200° F T_{Fuel}=200° F 0% Void, No xenon	0.98406	1.13874	-0.1358
Hot Standby	$T_{Moderator}$=550° F T_{Fuel}=550° F 0% Void, No xenon	0.93030	1.10639	-0.1592
Hot $Operating_{NoXe}$	$T_{Moderator}$=550° F T_{Fuel}=929° F 0% Void, No xenon	0.92593	1.10131	-0.1593
Hot $Operating_{0}$	$T_{Moderator}$=550° F T_{Fuel}=929° F 0% Void	0.92593	1.10131	-0.1593
Hot $Operating_{40}$	$T_{Moderator}$=550° F T_{Fuel}=929° F 40% Void	0.88000	1.07685	-0.1828
Hot $Operating_{80}$	$T_{Moderator}$=550° F T_{Fuel}=929° F 80% Void	0.82428	1.04868	-0.2140

Table 2.13 Lattice [ ] Kinetics Parameters at BOL

Kinetics Parameter = $\frac{k_\alpha - k_\beta}{k_\beta}$	k_α	k_β	Kinetics Parameter (Δk/k)
Doppler = $\frac{k_{HotOperatingNoXe} - k_{HotStandby}}{k_{HotStandby}}$	1.10131	1.10639	-0.0046
$Moderator_{Void}$ = $\frac{k_{HotOperating40} - k_{HotOperating0}}{k_{HotOperating0}}$	1.07685	1.10131	-0.0222
$Moderator_{Temperature}$ = $\frac{k_{HotStandby} - k_{Cold}}{k_{Cold}}$	1.10639	1.14688	-0.0353

Table 2.14 Lattice [ ] Control Blade Worths at BOL for Control Blade Type ABB/Westinghouse Main Body

Blade Worth = $\frac{k_{Controlled} - k_{Uncontrolled}}{k_{Uncontrolled}}$		**$k_{Controlled}$**	**$k_{Uncontrolled}$**	**Blade Worth (Δk/k)**
Cold	$T_{Moderator}$=68° F T_{Fuel}=68° F 0% Void, No xenon	0.93739	1.10674	-0.1530
Intermediate	$T_{Moderator}$=200° F T_{Fuel}=200° F 0% Void, No xenon	0.92526	1.10044	-0.1592
Hot Standby	$T_{Moderator}$=550° F T_{Fuel}=550° F 0% Void, No xenon	0.87321	1.07634	-0.1887
Hot $Operating_{NoXe}$	$T_{Moderator}$=550° F T_{Fuel}=975° F 0% Void, No xenon	0.86906	1.07128	-0.1888
Hot $Operating_{0}$	$T_{Moderator}$=550° F T_{Fuel}=975° F 0% Void	0.86914	1.07128	-0.1887
Hot $Operating_{40}$	$T_{Moderator}$=550° F T_{Fuel}=975° F 40% Void	0.82099	1.05132	-0.2191
Hot $Operating_{80}$	$T_{Moderator}$=550° F T_{Fuel}=975° F 80% Void	0.75953	1.02705	-0.2605

Table 2.15 Lattice [ ] Control Blade Worths at BOL for Control Blade Type ABB/Westinghouse Hafnium Tip

Blade Worth = $\frac{k_{Controlled} - k_{Uncontrolled}}{k_{Uncontrolled}}$		$k_{Controlled}$	$k_{Uncontrolled}$	Blade Worth (Δk/k)
Cold	$T_{Moderator}$=68° F T_{Fuel}=68° F 0% Void, No xenon	0.95872	1.10674	-0.1337
Intermediate	$T_{Moderator}$=200° F T_{Fuel}=200° F 0% Void, No xenon	0.94736	1.10044	-0.1391
Hot Standby	$T_{Moderator}$=550° F T_{Fuel}=550° F 0% Void, No xenon	0.90076	1.07634	-0.1631
Hot Operating$_{NoXe}$	$T_{Moderator}$=550° F T_{Fuel}=975° F 0% Void, No xenon	0.89644	1.07128	-0.1632
Hot Operating$_{0}$	$T_{Moderator}$=550° F T_{Fuel}=975° F 0% Void	0.89644	1.07128	-0.1632
Hot Operating$_{40}$	$T_{Moderator}$=550° F T_{Fuel}=975° F 40% Void	0.85394	1.05132	-0.1877
Hot Operating$_{80}$	$T_{Moderator}$=550° F T_{Fuel}=975° F 80% Void	0.80003	1.02705	-0.2210

Table 2.16 Lattice [ ] Kinetics Parameters at BOL

Kinetics Parameter = $\frac{k_\alpha - k_\beta}{k_\beta}$	k_α	k_β	Kinetics Parameter (Δk/k)
Doppler = $\frac{k_{HotOperatingNoXe} - k_{HotStandby}}{k_{HotStandby}}$	1.07128	1.07634	-0.0047
$Moderator_{Void} = \frac{k_{HotOperating40} - k_{HotOperating0}}{k_{HotOperating0}}$	1.05132	1.07128	-0.0186
$Moderator_{Temperature} = \frac{k_{HotStandby} - k_{Cold}}{k_{Cold}}$	1.07634	1.10674	-0.0275

Table 2.17 Lattice [ ] Control Blade Worths at BOL for Control Blade Type ABB/Westinghouse Main Body

Blade Worth = $\frac{k_{Controlled} - k_{Uncontrolled}}{k_{Uncontrolled}}$		$k_{Controlled}$	$k_{Uncontrolled}$	Blade Worth (Δk/k)
Cold	$T_{Moderator}$=68° F T_{Fuel}=68° F 0% Void, No xenon	0.93950	1.10614	-0.1507
Intermediate	$T_{Moderator}$=200° F T_{Fuel}=200° F 0% Void, No xenon	0.92701	1.09953	-0.1569
Hot Standby	$T_{Moderator}$=550° F T_{Fuel}=550° F 0% Void, No xenon	0.87429	1.07496	-0.1867
Hot Operating$_{NoXe}$	$T_{Moderator}$=550° F T_{Fuel}=975° F 0% Void, No xenon	0.87019	1.06997	-0.1867
Hot Operating$_{0}$	$T_{Moderator}$=550° F T_{Fuel}=975° F 0% Void	0.87027	1.06997	-0.1866
Hot Operating$_{40}$	$T_{Moderator}$=550° F T_{Fuel}=975° F 40% Void	0.82158	1.04983	-0.2174
Hot Operating$_{80}$	$T_{Moderator}$=550° F T_{Fuel}=975° F 80% Void	0.75870	1.02478	-0.2596

Table 2.18 Lattice [ ] Control Blade Worths at BOL for Control Blade Type ABB/Westinghouse Hafnium Tip

Blade Worth = $\frac{k_{Controlled} - k_{Uncontrolled}}{k_{Uncontrolled}}$		$k_{Controlled}$	$k_{Uncontrolled}$	Blade Worth (Δk/k)
Cold	$T_{Moderator}$=68° F T_{Fuel}=68° F 0% Void, No xenon	0.96028	1.10614	-0.1319
Intermediate	$T_{Moderator}$=200° F T_{Fuel}=200° F 0% Void, No xenon	0.94855	1.09953	-0.1373
Hot Standby	$T_{Moderator}$=550° F T_{Fuel}=550° F 0% Void, No xenon	0.90129	1.07496	-0.1616
Hot $Operating_{NoXe}$	$T_{Moderator}$=550° F T_{Fuel}=975° F 0% Void, No xenon	0.89702	1.06997	-0.1616
Hot $Operating_{0}$	$T_{Moderator}$=550° F T_{Fuel}=975° F 0% Void	0.89702	1.06997	-0.1616
Hot $Operating_{40}$	$T_{Moderator}$=550° F T_{Fuel}=975° F 40% Void	0.85406	1.04983	-0.1865
Hot $Operating_{80}$	$T_{Moderator}$=550° F T_{Fuel}=975° F 80% Void	0.79887	1.02478	-0.2205

Table 2.19 Lattice [ ] Kinetics Parameters at BOL

Kinetics Parameter = $\frac{k_\alpha - k_\beta}{k_\beta}$	k_α	k_β	Kinetics Parameter (Δk/k)
Doppler = $\frac{k_{HotOperatingNoXe} - k_{HotStandby}}{k_{HotStandby}}$	1.06997	1.07496	-0.0046
$Moderator_{Void}$ = $\frac{k_{HotOperating40} - k_{HotOperating0}}{k_{HotOperating0}}$	1.04983	1.06997	-0.0188
$Moderator_{Temperature}$ = $\frac{k_{HotStandby} - k_{Cold}}{k_{Cold}}$	1.07496	1.10614	-0.0282

Table 2.20 Lattice [ ] Control Blade Worths at BOL for Control Blade Type ABB/Westinghouse Main Body

Blade Worth = $\frac{k_{Controlled} - k_{Uncontrolled}}{k_{Uncontrolled}}$		$k_{Controlled}$	$k_{Uncontrolled}$	Blade Worth ($\Delta k/k$)
Cold	$T_{Moderator}$=68° F T_{Fuel}=68° F 0% Void, No xenon	0.91296	1.08139	-0.1557
Intermediate	$T_{Moderator}$=200° F T_{Fuel}=200° F 0% Void, No xenon	0.90022	1.07450	-0.1622
Hot Standby	$T_{Moderator}$=550° F T_{Fuel}=550° F 0% Void, No xenon	0.84810	1.05038	-0.1926
Hot $Operating_{NoXe}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 0% Void, No xenon	0.84398	1.04533	-0.1926
Hot $Operating_{0}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 0% Void	0.84406	1.04533	-0.1925
Hot $Operating_{40}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 40% Void	0.79704	1.02698	-0.2239
Hot $Operating_{80}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 80% Void	0.73449	1.00264	-0.2674

Table 2.21 Lattice [ ] Control Blade Worths at BOL for Control Blade Type ABB/Westinghouse Hafnium Tip

Blade Worth = $\frac{k_{Controlled} - k_{Uncontrolled}}{k_{Uncontrolled}}$		$k_{Controlled}$	$k_{Uncontrolled}$	Blade Worth ($\Delta k/k$)
Cold	$T_{Moderator}$=68° F T_{Fuel}=68° F 0% Void, No xenon	0.93359	1.08139	-0.1367
Intermediate	$T_{Moderator}$=200° F T_{Fuel}=200° F 0% Void, No xenon	0.92162	1.07450	-0.1423
Hot Standby	$T_{Moderator}$=550° F T_{Fuel}=550° F 0% Void, No xenon	0.87496	1.05038	-0.1670
Hot $Operating_{NoXe}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 0% Void, No xenon	0.87068	1.04533	-0.1671
Hot $Operating_{0}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 0% Void	0.87068	1.04533	-0.1671
Hot $Operating_{40}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 40% Void	0.82940	1.02698	-0.1924
Hot $Operating_{80}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 80% Void	0.77463	1.00264	-0.2274

Table 2.22 Lattice [ ] Kinetics Parameters at BOL

Kinetics Parameter = $\frac{k_\alpha - k_\beta}{k_\beta}$	k_α	k_β	Kinetics Parameter ($\Delta k/k$)
Doppler = $\frac{k_{HotOperatingNoXe} - k_{HotStandby}}{k_{HotStandby}}$	1.04533	1.05038	-0.0048
$Moderator_{Void}$ = $\frac{k_{HotOperating40} - k_{HotOperating0}}{k_{HotOperating0}}$	1.02698	1.04533	-0.0175
$Moderator_{Temperature}$ = $\frac{k_{HotStandby} - k_{Cold}}{k_{Cold}}$	1.05038	1.08139	-0.0287

Table 2.23 Lattice [ ] Control Blade Worths at BOL for Control Blade Type ABB/Westinghouse Main Body

Blade Worth = $\frac{k_{Controlled} - k_{Uncontrolled}}{k_{Uncontrolled}}$		$k_{Controlled}$	$k_{Uncontrolled}$	Blade Worth ($\Delta k/k$)
Cold	$T_{Moderator}$=68° F T_{Fuel}=68° F 0% Void, No xenon	0.91380	1.07462	-0.1497
Intermediate	$T_{Moderator}$=200° F T_{Fuel}=200° F 0% Void, No xenon	0.90091	1.06772	-0.1562
Hot Standby	$T_{Moderator}$=550° F T_{Fuel}=550° F 0% Void, No xenon	0.84941	1.04524	-0.1873
Hot Operating$_{NoXe}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 0% Void, No xenon	0.84539	1.04034	-0.1874
Hot Operating$_{0}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 0% Void	0.84546	1.04034	-0.1873
Hot Operating$_{40}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 40% Void	0.79804	1.02300	-0.2199
Hot Operating $_{80}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 80% Void	0.73301	0.99873	-0.2661

Table 2.24 Lattice [ ] Control Blade Worths at BOL for Control Blade Type ABB/Westinghouse Hafnium Tip

Blade Worth = $\frac{k_{Controlled} - k_{Uncontrolled}}{k_{Uncontrolled}}$		$k_{Controlled}$	$k_{Uncontrolled}$	Blade Worth ($\Delta k/k$)
Cold	$T_{Moderator}$=68° F T_{Fuel}=68° F 0% Void, No xenon	0.93328	1.07462	-0.1315
Intermediate	$T_{Moderator}$=200° F T_{Fuel}=200° F 0% Void, No xenon	0.92114	1.06772	-0.1373
Hot Standby	$T_{Moderator}$=550° F T_{Fuel}=550° F 0% Void, No xenon	0.87515	1.04524	-0.1627
Hot $Operating_{NoXe}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 0% Void, No xenon	0.87097	1.04034	-0.1628
Hot $Operating_{0}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 0% Void	0.87097	1.04034	-0.1628
Hot $Operating_{40}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 40% Void	0.82955	1.02300	-0.1891
Hot $Operating_{80}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 80% Void	0.77282	0.99873	-0.2262

Table 2.25 Lattice [ ] Kinetics Parameters at BOL

Kinetics Parameter = $\frac{k_\alpha - k_\beta}{k_\beta}$	k_α	k_β	Kinetics Parameter ($\Delta k/k$)
Doppler = $\frac{k_{HotOperatingNoXe} - k_{HotStandby}}{k_{HotStandby}}$	1.04034	1.04524	-0.0047
$Moderator_{Void}$ = $\frac{k_{HotOperating40} - k_{HotOperating0}}{k_{HotOperating0}}$	1.02300	1.04034	-0.0167
$Moderator_{Temperature}$ = $\frac{k_{HotStandby} - k_{Cold}}{k_{Cold}}$	1.04524	1.07462	-0.0273

Table 2.26 Lattice [ ] Control Blade Worths at BOL for Control Blade Type ABB/Westinghouse Main Body

Blade Worth = $\frac{k_{Controlled} - k_{Uncontrolled}}{k_{Uncontrolled}}$		$k_{Controlled}$	$k_{Uncontrolled}$	Blade Worth (Δk/k)
Cold	$T_{Moderator}$=68° F T_{Fuel}=68° F 0% Void, No xenon	0.95980	1.13294	-0.1528
Intermediate	$T_{Moderator}$=200° F T_{Fuel}=200° F 0% Void, No xenon	0.94835	1.12905	-0.1600
Hot Standby	$T_{Moderator}$=550° F T_{Fuel}=550° F 0% Void, No xenon	0.90006	1.11494	-0.1927
Hot Operating$_{NoXe}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 0% Void, No xenon	0.89587	1.10981	-0.1928
Hot Operating$_{0}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 0% Void	0.89595	1.10981	-0.1927
Hot Operating$_{40}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 40% Void	0.84890	1.09611	-0.2255
Hot Operating $_{80}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 80% Void	0.78207	1.07487	-0.2724

Table 2.27 Lattice [ ] Control Blade Worths at BOL for Control Blade Type ABB/Westinghouse Hafnium Tip

Blade Worth = $\frac{k_{Controlled} - k_{Uncontrolled}}{k_{Uncontrolled}}$		$k_{Controlled}$	$k_{Uncontrolled}$	Blade Worth (Δk/k)
Cold	$T_{Moderator}$=68° F T_{Fuel}=68° F 0% Void, No xenon	0.98113	1.13294	-0.1340
Intermediate	$T_{Moderator}$=200° F T_{Fuel}=200° F 0% Void, No xenon	0.97060	1.12905	-0.1403
Hot Standby	$T_{Moderator}$=550° F T_{Fuel}=550° F 0% Void, No xenon	0.92851	1.11494	-0.1672
Hot $Operating_{NoXe}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 0% Void, No xenon	0.92414	1.10981	-0.1673
Hot $Operating_{0}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 0% Void	0.92414	1.10981	-0.1673
Hot $Operating_{40}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 40% Void	0.88364	1.09611	-0.1938
Hot $Operating_{80}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 80% Void	0.82593	1.07487	-0.2316

Table 2.28 Lattice [ ] Kinetics Parameters at BOL

Kinetics Parameter = $\frac{k_\alpha - k_\beta}{k_\beta}$	k_α	k_β	Kinetics Parameter (Δk/k)
Doppler = $\frac{k_{HotOperatingNoXe} - k_{HotStandby}}{k_{HotStandby}}$	1.10981	1.11494	-0.0046
$Moderator_{Void}$ = $\frac{k_{HotOperating40} - k_{HotOperating0}}{k_{HotOperating0}}$	1.09611	1.10981	-0.0123
$Moderator_{Temperature}$ = $\frac{k_{HotStandby} - k_{Cold}}{k_{Cold}}$	1.11494	1.13294	-0.0159

Table 2.29 Lattice [ ] Control Blade Worths at BOL for Control Blade Type ABB/Westinghouse Main Body

Blade Worth = $\frac{k_{Controlled} - k_{Uncontrolled}}{k_{Uncontrolled}}$		$k_{Controlled}$	$k_{Uncontrolled}$	Blade Worth ($\Delta k/k$)
Cold	$T_{Moderator}$=68° F T_{Fuel}=68° F 0% Void, No xenon	0.65223	0.79845	-0.1831
Intermediate	$T_{Moderator}$=200° F T_{Fuel}=200° F 0% Void, No xenon	0.64455	0.80597	-0.2003
Hot Standby	$T_{Moderator}$=550° F T_{Fuel}=550° F 0% Void, No xenon	0.61712	0.84779	-0.2721
Hot Operating$_{NoXe}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 0% Void, No xenon	0.61365	0.84353	-0.2725
Hot Operating$_{0}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 0% Void	0.61370	0.84353	-0.2725
Hot Operating$_{40}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 40% Void	0.58746	0.87408	-0.3279
Hot Operating $_{80}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 80% Void	0.52737	0.89620	-0.4116

Table 2.30 Lattice [ ] Control Blade Worths at BOL for Control Blade Type ABB/Westinghouse Hafnium Tip

Blade Worth = $\frac{k_{Controlled} - k_{Uncontrolled}}{k_{Uncontrolled}}$		$k_{Controlled}$	$k_{Uncontrolled}$	Blade Worth (Δk/k)
Cold	$T_{Moderator}$=68° F T_{Fuel}=68° F 0% Void, No xenon	0.66635	0.79845	-0.1655
Intermediate	$T_{Moderator}$=200° F T_{Fuel}=200° F 0% Void, No xenon	0.65992	0.80597	-0.1812
Hot Standby	$T_{Moderator}$=550° F T_{Fuel}=550° F 0% Void, No xenon	0.64008	0.84779	-0.2450
Hot $Operating_{NoXe}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 0% Void, No xenon	0.63649	0.84353	-0.2454
Hot $Operating_{0}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 0% Void	0.63649	0.84353	-0.2454
Hot $Operating_{40}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 40% Void	0.61746	0.87408	-0.2936
Hot $Operating_{80}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 80% Void	0.56741	0.89620	-0.3669

Table 2.31 Lattice [ ] Kinetics Parameters at BOL

Kinetics Parameter = $\frac{k_\alpha - k_\beta}{k_\beta}$	k_α	k_β	Kinetics Parameter (Δk/k)
Doppler = $\frac{k_{HotOperatingNoXe} - k_{HotStandby}}{k_{HotStandby}}$	0.84353	0.84779	-0.0050
$Moderator_{Void}$ = $\frac{k_{HotOperating40} - k_{HotOperating0}}{k_{HotOperating0}}$	0.87408	0.84353	0.0362
$Moderator_{Temperature}$ = $\frac{k_{HotStandby} - k_{Cold}}{k_{Cold}}$	0.84779	0.79845	0.0618

Table 2.32 Lattice [ ] Control Blade Worths at BOL for Control Blade Type ABB/Westinghouse Main Body

Blade Worth = $\frac{k_{Controlled} - k_{Uncontrolled}}{k_{Uncontrolled}}$		$k_{Controlled}$	$k_{Uncontrolled}$	Blade Worth (Δk/k)
Cold	$T_{Moderator}$=68° F T_{Fuel}=68° F 0% Void, No xenon	0.93194	1.09494	-0.1489
Intermediate	$T_{Moderator}$=200° F T_{Fuel}=200° F 0% Void, No xenon	0.91786	1.08549	-0.1544
Hot Standby	$T_{Moderator}$=550° F T_{Fuel}=550° F 0% Void, No xenon	0.86032	1.05222	-0.1824
Hot Operating$_{NoXe}$	$T_{Moderator}$=550° F T_{Fuel}=929° F 0% Void, No xenon	0.85633	1.04737	-0.1824
Hot Operating$_{0}$	$T_{Moderator}$=550° F T_{Fuel}=929° F 0% Void	0.85640	1.04737	-0.1823
Hot Operating$_{40}$	$T_{Moderator}$=550° F T_{Fuel}=929° F 40% Void	0.80894	1.02488	-0.2107
Hot Operating$_{80}$	$T_{Moderator}$=550° F T_{Fuel}=929° F 80% Void	0.75262	0.99969	-0.2472

Table 2.33 Lattice [ ] Control Blade Worths at BOL for Control Blade Type ABB/Westinghouse Hafnium Tip

Blade Worth = $\frac{k_{Controlled} - k_{Uncontrolled}}{k_{Uncontrolled}}$		$k_{Controlled}$	$k_{Uncontrolled}$	Blade Worth (Δk/k)
Cold	$T_{Moderator}$=68° F T_{Fuel}=68° F 0% Void, No xenon	0.95224	1.09494	-0.1303
Intermediate	$T_{Moderator}$=200° F T_{Fuel}=200° F 0% Void, No xenon	0.93880	1.08549	-0.1351
Hot Standby	$T_{Moderator}$=550° F T_{Fuel}=550° F 0% Void, No xenon	0.88633	1.05222	-0.1577
Hot $Operating_{NoXe}$	$T_{Moderator}$=550° F T_{Fuel}=929° F 0% Void, No xenon	0.88217	1.04737	-0.1577
Hot $Operating_{0}$	$T_{Moderator}$=550° F T_{Fuel}=929° F 0% Void	0.88217	1.04737	-0.1577
Hot $Operating_{40}$	$T_{Moderator}$=550° F T_{Fuel}=929° F 40% Void	0.83997	1.02488	-0.1804
Hot $Operating_{80}$	$T_{Moderator}$=550° F T_{Fuel}=929° F 80% Void	0.79055	0.99969	-0.2092

Table 2.34 Lattice [ ] Kinetics Parameters at BOL

Kinetics Parameter = $\frac{k_\alpha - k_\beta}{k_\beta}$	k_α	k_β	Kinetics Parameter (Δk/k)
Doppler = $\frac{k_{HotOperatingNoXe} - k_{HotStandby}}{k_{HotStandby}}$	1.04737	1.05222	-0.0046
$Moderator_{Void}$ = $\frac{k_{HotOperating40} - k_{HotOperating0}}{k_{HotOperating0}}$	1.02488	1.04737	-0.0215
$Moderator_{Temperature}$ = $\frac{k_{HotStandby} - k_{Cold}}{k_{Cold}}$	1.05222	1.09494	-0.0390

Table 2.35 Lattice [ ] Control Blade Worths at BOL for Control Blade Type ABB/Westinghouse Main Body

Blade Worth = $\frac{k_{Controlled} - k_{Uncontrolled}}{k_{Uncontrolled}}$		$k_{Controlled}$	$k_{Uncontrolled}$	Blade Worth (Δk/k)
Cold	$T_{Moderator}$=68° F T_{Fuel}=68° F 0% Void, No xenon	0.97102	1.14202	-0.1497
Intermediate	$T_{Moderator}$=200° F T_{Fuel}=200° F 0% Void, No xenon	0.95730	1.13382	-0.1557
Hot Standby	$T_{Moderator}$=550° F T_{Fuel}=550° F 0% Void, No xenon	0.89820	1.10151	-0.1846
Hot Operating$_{NoXe}$	$T_{Moderator}$=550° F T_{Fuel}=929° F 0% Void, No xenon	0.89402	1.09645	-0.1846
Hot Operating$_{0}$	$T_{Moderator}$=550° F T_{Fuel}=929° F 0% Void	0.89410	1.09645	-0.1845
Hot Operating$_{40}$	$T_{Moderator}$=550° F T_{Fuel}=929° F 40% Void	0.84274	1.07204	-0.2139
Hot Operating $_{80}$	$T_{Moderator}$=550° F T_{Fuel}=929° F 80% Void	0.78000	1.04396	-0.2528

Table 2.36 Lattice [ ] Control Blade Worths at BOL for Control Blade Type ABB/Westinghouse Hafnium Tip

Blade Worth = $\frac{k_{Controlled} - k_{Uncontrolled}}{k_{Uncontrolled}}$		$k_{Controlled}$	$k_{Uncontrolled}$	Blade Worth ($\Delta k/k$)
Cold	$T_{Moderator}$=68° F T_{Fuel}=68° F 0% Void, No xenon	0.99312	1.14202	-0.1304
Intermediate	$T_{Moderator}$=200° F T_{Fuel}=200° F 0% Void, No xenon	0.98010	1.13382	-0.1356
Hot Standby	$T_{Moderator}$=550° F T_{Fuel}=550° F 0% Void, No xenon	0.92629	1.10151	-0.1591
Hot $Operating_{NoXe}$	$T_{Moderator}$=550° F T_{Fuel}=929° F 0% Void, No xenon	0.92193	1.09645	-0.1592
Hot $Operating_{0}$	$T_{Moderator}$=550° F T_{Fuel}=929° F 0% Void	0.92193	1.09645	-0.1592
Hot $Operating_{40}$	$T_{Moderator}$=550° F T_{Fuel}=929° F 40% Void	0.87599	1.07204	-0.1829
Hot $Operating_{80}$	$T_{Moderator}$=550° F T_{Fuel}=929° F 80% Void	0.82026	1.04396	-0.2143

Table 2.37 Lattice [ ] Kinetics Parameters at BOL

Kinetics Parameter = $\frac{k_\alpha - k_\beta}{k_\beta}$	k_α	k_β	Kinetics Parameter ($\Delta k/k$)
Doppler = $\frac{k_{HotOperatingNoXe} - k_{HotStandby}}{k_{HotStandby}}$	1.09645	1.10151	-0.0046
$Moderator_{Void}$ = $\frac{k_{HotOperating40} - k_{HotOperating0}}{k_{HotOperating0}}$	1.07204	1.09645	-0.0223
$Moderator_{Temperature}$ = $\frac{k_{HotStandby} - k_{Cold}}{k_{Cold}}$	1.10151	1.14202	-0.0355

Table 2.38 Lattice [ ] Control Blade Worths at BOL for Control Blade Type ABB/Westinghouse Main Body

Blade Worth = $\frac{k_{Controlled} - k_{Uncontrolled}}{k_{Uncontrolled}}$		$k_{Controlled}$	$k_{Uncontrolled}$	**Blade Worth ($\Delta k/k$)**
Cold	$T_{Moderator}$=68° F T_{Fuel}=68° F 0% Void, No xenon	0.93295	1.10093	-0.1526
Intermediate	$T_{Moderator}$=200° F T_{Fuel}=200° F 0% Void, No xenon	0.92079	1.09459	-0.1588
Hot Standby	$T_{Moderator}$=550° F T_{Fuel}=550° F 0% Void, No xenon	0.86871	1.07059	-0.1886
Hot Operating$_{NoXe}$	$T_{Moderator}$=550° F T_{Fuel}=975° F 0% Void, No xenon	0.86458	1.06555	-0.1886
Hot Operating$_{0}$	$T_{Moderator}$=550° F T_{Fuel}=975° F 0% Void	0.86466	1.06555	-0.1885
Hot Operating$_{40}$	$T_{Moderator}$=550° F T_{Fuel}=975° F 40% Void	0.81653	1.04568	-0.2191
Hot Operating $_{80}$	$T_{Moderator}$=550° F T_{Fuel}=975° F 80% Void	0.75513	1.02157	-0.2608

Table 2.39 Lattice [ ] Control Blade Worths at BOL for Control Blade Type ABB/Westinghouse Hafnium Tip

Blade Worth = $\frac{k_{Controlled} - k_{Uncontrolled}}{k_{Uncontrolled}}$		$k_{Controlled}$	$k_{Uncontrolled}$	Blade Worth ($\Delta k/k$)
Cold	$T_{Moderator}$=68° F T_{Fuel}=68° F 0% Void, No xenon	0.95406	1.10093	-0.1334
Intermediate	$T_{Moderator}$=200° F T_{Fuel}=200° F 0% Void, No xenon	0.94265	1.09459	-0.1388
Hot Standby	$T_{Moderator}$=550° F T_{Fuel}=550° F 0% Void, No xenon	0.89605	1.07059	-0.1630
Hot Operating$_{NoXe}$	$T_{Moderator}$=550° F T_{Fuel}=975° F 0% Void, No xenon	0.89175	1.06555	-0.1631
Hot Operating$_{0}$	$T_{Moderator}$=550° F T_{Fuel}=975° F 0% Void	0.89175	1.06555	-0.1631
Hot Operating$_{40}$	$T_{Moderator}$=550° F T_{Fuel}=975° F 40% Void	0.84927	1.04568	-0.1878
Hot Operating $_{80}$	$T_{Moderator}$=550° F T_{Fuel}=975° F 80% Void	0.79541	1.02157	-0.2214

Table 2.40 Lattice [ ] Kinetics Parameters at BOL

Kinetics Parameter = $\frac{k_\alpha - k_\beta}{k_\beta}$	k_α	k_β	Kinetics Parameter ($\Delta k/k$)
Doppler = $\frac{k_{HotOperatingNoXe} - k_{HotStandby}}{k_{HotStandby}}$	1.06555	1.07059	-0.0047
$Moderator_{Void} = \frac{k_{HotOperating40} - k_{HotOperating0}}{k_{HotOperating0}}$	1.04568	1.06555	-0.0186
$Moderator_{Temperature} = \frac{k_{HotStandby} - k_{Cold}}{k_{Cold}}$	1.07059	1.10093	-0.0276

Table 2.41 Lattice [ ] Control Blade Worths at BOL for Control Blade Type ABB/Westinghouse Main Body

Blade Worth = $\frac{k_{Controlled} - k_{Uncontrolled}}{k_{Uncontrolled}}$		$k_{Controlled}$	$k_{Uncontrolled}$	Blade Worth (Δk/k)
Cold	$T_{Moderator}$=68° F T_{Fuel}=68° F 0% Void, No xenon	0.93571	1.10089	-0.1500
Intermediate	$T_{Moderator}$=200° F T_{Fuel}=200° F 0% Void, No xenon	0.92323	1.09430	-0.1563
Hot Standby	$T_{Moderator}$=550° F T_{Fuel}=550° F 0% Void, No xenon	0.87073	1.07008	-0.1863
Hot Operating$_{NoXe}$	$T_{Moderator}$=550° F T_{Fuel}=975° F 0% Void, No xenon	0.86665	1.06511	-0.1863
Hot Operating$_{0}$	$T_{Moderator}$=550° F T_{Fuel}=975° F 0% Void	0.86673	1.06511	-0.1862
Hot Operating$_{40}$	$T_{Moderator}$=550° F T_{Fuel}=975° F 40% Void	0.81821	1.04520	-0.2172
Hot Operating$_{80}$	$T_{Moderator}$=550° F T_{Fuel}=975° F 80% Void	0.75561	1.02052	-0.2596

Table 2.42 Lattice [ ] Control Blade Worths at BOL for Control Blade Type ABB/Westinghouse Hafnium Tip

Blade Worth = $\frac{k_{Controlled} - k_{Uncontrolled}}{k_{Uncontrolled}}$		**$k_{Controlled}$**	**$k_{Uncontrolled}$**	**Blade Worth (Δk/k)**
Cold	$T_{Moderator}$=68° F T_{Fuel}=68° F 0% Void, No xenon	0.95627	1.10089	-0.1314
Intermediate	$T_{Moderator}$=200° F T_{Fuel}=200° F 0% Void, No xenon	0.94455	1.09430	-0.1368
Hot Standby	$T_{Moderator}$=550° F T_{Fuel}=550° F 0% Void, No xenon	0.89752	1.07008	-0.1613
Hot Operating$_{NoXe}$	$T_{Moderator}$=550° F T_{Fuel}=975° F 0% Void, No xenon	0.89326	1.06511	-0.1613
Hot Operating$_{0}$	$T_{Moderator}$=550° F T_{Fuel}=975° F 0% Void	0.89326	1.06511	-0.1613
Hot Operating$_{40}$	$T_{Moderator}$=550° F T_{Fuel}=975° F 40% Void	0.85048	1.04520	-0.1863
Hot Operating $_{80}$	$T_{Moderator}$=550° F T_{Fuel}=975° F 80% Void	0.79559	1.02052	-0.2204

Table 2.43 Lattice [ ] Kinetics Parameters at BOL

Kinetics Parameter = $\frac{k_\alpha - k_\beta}{k_\beta}$	k_α	k_β	Kinetics Parameter (Δk/k)
Doppler = $\frac{k_{HotOperatingNoXe} - k_{HotStandby}}{k_{HotStandby}}$	1.06511	1.07008	-0.0046
$Moderator_{Void}$ = $\frac{k_{HotOperating40} - k_{HotOperating0}}{k_{HotOperating0}}$	1.04520	1.06511	-0.0187
$Moderator_{Temperature}$ = $\frac{k_{HotStandby} - k_{Cold}}{k_{Cold}}$	1.07008	1.10089	-0.0280

Table 2.44 Lattice [ ] Control Blade Worths at BOL for Control Blade Type ABB/Westinghouse Main Body

Blade Worth = $\frac{k_{Controlled} - k_{Uncontrolled}}{k_{Uncontrolled}}$		$k_{Controlled}$	$k_{Uncontrolled}$	Blade Worth (Δk/k)
Cold	$T_{Moderator}$=68° F T_{Fuel}=68° F 0% Void, No xenon	0.90904	1.07596	-0.1551
Intermediate	$T_{Moderator}$=200° F T_{Fuel}=200° F 0% Void, No xenon	0.89630	1.06906	-0.1616
Hot Standby	$T_{Moderator}$=550° F T_{Fuel}=550° F 0% Void, No xenon	0.84437	1.04526	-0.1922
Hot Operating$_{NoXe}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 0% Void, No xenon	0.84027	1.04024	-0.1922
Hot Operating$_{0}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 0% Void	0.84035	1.04024	-0.1922
Hot Operating$_{40}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 40% Void	0.79348	1.02209	-0.2237
Hot Operating $_{80}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 80% Void	0.73120	0.99807	-0.2674

Table 2.45 Lattice [ ] Control Blade Worths at BOL for Control Blade Type ABB/Westinghouse Hafnium Tip

Blade Worth = $\frac{k_{Controlled} - k_{Uncontrolled}}{k_{Uncontrolled}}$		$k_{Controlled}$	$k_{Uncontrolled}$	**Blade Worth (Δk/k)**
Cold	$T_{Moderator}$=68° F T_{Fuel}=68° F 0% Void, No xenon	0.92944	1.07596	-0.1362
Intermediate	$T_{Moderator}$=200° F T_{Fuel}=200° F 0% Void, No xenon	0.91745	1.06906	-0.1418
Hot Standby	$T_{Moderator}$=550° F T_{Fuel}=550° F 0% Void, No xenon	0.87101	1.04526	-0.1667
Hot $Operating_{NoXe}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 0% Void, No xenon	0.86674	1.04024	-0.1668
Hot $Operating_{0}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 0% Void	0.86674	1.04024	-0.1668
Hot $Operating_{40}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 40% Void	0.82562	1.02209	-0.1922
Hot $Operating_{80}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 80% Void	0.77114	0.99807	-0.2274

Table 2.46 Lattice [ ] Kinetics Parameters at BOL

Kinetics Parameter = $\frac{k_\alpha - k_\beta}{k_\beta}$	k_α	k_β	Kinetics Parameter (Δk/k)
Doppler = $\frac{k_{HotOperatingNoXe} - k_{HotStandby}}{k_{HotStandby}}$	1.04024	1.04526	-0.0048
$Moderator_{Void}$ = $\frac{k_{HotOperating40} - k_{HotOperating0}}{k_{HotOperating0}}$	1.02209	1.04024	-0.0175
$Moderator_{Temperature}$ = $\frac{k_{HotStandby} - k_{Cold}}{k_{Cold}}$	1.04526	1.07596	-0.0285

Table 2.47 Lattice [ ] Control Blade Worths at BOL for Control Blade Type ABB/Westinghouse Main Body

Blade Worth = $\frac{k_{Controlled} - k_{Uncontrolled}}{k_{Uncontrolled}}$		$k_{Controlled}$	$k_{Uncontrolled}$	Blade Worth (Δk/k)
Cold	$T_{Moderator}$=68° F T_{Fuel}=68° F 0% Void, No xenon	0.90275	1.05904	-0.1476
Intermediate	$T_{Moderator}$=200° F T_{Fuel}=200° F 0% Void, No xenon	0.88963	1.05185	-0.1542
Hot Standby	$T_{Moderator}$=550° F T_{Fuel}=550° F 0% Void, No xenon	0.83773	1.02936	-0.1862
Hot Operating$_{NoXe}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 0% Void, No xenon	0.83375	1.02450	-0.1862
Hot Operating$_{0}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 0% Void	0.83382	1.02450	-0.1861
Hot Operating$_{40}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 40% Void	0.78654	1.00750	-0.2193
Hot Operating $_{80}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 80% Void	0.72189	0.98364	-0.2661

Table 2.48 Lattice [ ] Control Blade Worths at BOL for Control Blade Type ABB/Westinghouse Hafnium Tip

Blade Worth = $\frac{k_{Controlled} - k_{Uncontrolled}}{k_{Uncontrolled}}$		$k_{Controlled}$	$k_{Uncontrolled}$	Blade Worth (Δk/k)
Cold	$T_{Moderator}$=68° F T_{Fuel}=68° F 0% Void, No xenon	0.92155	1.05904	-0.1298
Intermediate	$T_{Moderator}$=200° F T_{Fuel}=200° F 0% Void, No xenon	0.90917	1.05185	-0.1356
Hot Standby	$T_{Moderator}$=550° F T_{Fuel}=550° F 0% Void, No xenon	0.86277	1.02936	-0.1618
Hot Operating$_{NoXe}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 0% Void, No xenon	0.85863	1.02450	-0.1619
Hot Operating$_{0}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 0% Void	0.85863	1.02450	-0.1619
Hot Operating$_{40}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 40% Void	0.81734	1.00750	-0.1887
Hot Operating$_{80}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 80% Void	0.76100	0.98364	-0.2263

Table 2.49 Lattice [ ] Kinetics Parameters at BOL

Kinetics Parameter = $\frac{k_\alpha - k_\beta}{k_\beta}$	k_α	k_β	Kinetics Parameter (Δk/k)
Doppler = $\frac{k_{HotOperatingNoXe} - k_{HotStandby}}{k_{HotStandby}}$	1.02450	1.02936	-0.0047
$Moderator_{Void}$ = $\frac{k_{HotOperating40} - k_{HotOperating0}}{k_{HotOperating0}}$	1.00750	1.02450	-0.0166
$Moderator_{Temperature}$ = $\frac{k_{HotStandby} - k_{Cold}}{k_{Cold}}$	1.02936	1.05904	-0.0280

Table 2.50 Lattice [ ] Control Blade Worths at BOL for Control Blade Type ABB/Westinghouse Main Body

Blade Worth = $\frac{k_{Controlled} - k_{Uncontrolled}}{k_{Uncontrolled}}$		$k_{Controlled}$	$k_{Uncontrolled}$	Blade Worth (Δk/k)
Cold	$T_{Moderator}$=68° F T_{Fuel}=68° F 0% Void, No xenon	0.94835	1.11773	-0.1515
Intermediate	$T_{Moderator}$=200° F T_{Fuel}=200° F 0% Void, No xenon	0.93655	1.11347	-0.1589
Hot Standby	$T_{Moderator}$=550° F T_{Fuel}=550° F 0% Void, No xenon	0.88756	1.09908	-0.1925
Hot Operating$_{NoXe}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 0% Void, No xenon	0.88340	1.09399	-0.1925
Hot Operating$_0$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 0% Void	0.88347	1.09399	-0.1924
Hot Operating$_{40}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 40% Void	0.83647	1.08054	-0.2259
Hot Operating $_{80}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 80% Void	0.76979	1.05953	-0.2735

Table 2.51 Lattice [ ] Control Blade Worths at BOL for Control Blade Type ABB/Westinghouse Hafnium Tip

Blade Worth = $\frac{k_{Controlled} - k_{Uncontrolled}}{k_{Uncontrolled}}$		$k_{Controlled}$	$k_{Uncontrolled}$	Blade Worth (Δk/k)
Cold	$T_{Moderator}$=68° F T_{Fuel}=68° F 0% Void, No xenon	0.96906	1.11773	-0.1330
Intermediate	$T_{Moderator}$=200° F T_{Fuel}=200° F 0% Void, No xenon	0.95817	1.11347	-0.1395
Hot Standby	$T_{Moderator}$=550° F T_{Fuel}=550° F 0% Void, No xenon	0.91536	1.09908	-0.1672
Hot Operating$_{NoXe}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 0% Void, No xenon	0.91103	1.09399	-0.1672
Hot Operating$_{0}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 0% Void	0.91103	1.09399	-0.1672
Hot Operating$_{40}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 40% Void	0.87057	1.08054	-0.1943
Hot Operating $_{80}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 80% Void	0.81300	1.05953	-0.2327

Table 2.52 Lattice [ ] Kinetics Parameters at BOL

Kinetics Parameter = $\frac{k_{\alpha} - k_{\beta}}{k_{\beta}}$	k_{α}	k_{β}	Kinetics Parameter (Δk/k)
Doppler = $\frac{k_{HotOperatingNoXe} - k_{HotStandby}}{k_{HotStandby}}$	1.09399	1.09908	-0.0046
Moderator$_{Void}$ = $\frac{k_{HotOperating40} - k_{HotOperating0}}{k_{HotOperating0}}$	1.08054	1.09399	-0.0123
Moderator$_{Temperature}$ = $\frac{k_{HotStandby} - k_{Cold}}{k_{Cold}}$	1.09908	1.11773	-0.0167

Table 2.53 Lattice [ ] Control Blade Worths at BOL for Control Blade Type ABB/Westinghouse Main Body

Blade Worth = $\frac{k_{Controlled} - k_{Uncontrolled}}{k_{Uncontrolled}}$		$k_{Controlled}$	$k_{Uncontrolled}$	Blade Worth ($\Delta k/k$)
Cold	$T_{Moderator}$=68° F T_{Fuel}=68° F 0% Void, No xenon	0.97625	1.16879	-0.1647
Intermediate	$T_{Moderator}$=200° F T_{Fuel}=200° F 0% Void, No xenon	0.96239	1.16166	-0.1715
Hot Standby	$T_{Moderator}$=550° F T_{Fuel}=550° F 0% Void, No xenon	0.90349	1.13045	-0.2008
Hot $Operating_{NoXe}$	$T_{Moderator}$=550° F T_{Fuel}=929° F 0% Void, No xenon	0.89931	1.12530	-0.2008
Hot $Operating_{0}$	$T_{Moderator}$=550° F T_{Fuel}=929° F 0% Void	0.89940	1.12530	-0.2008
Hot $Operating_{40}$	$T_{Moderator}$=550° F T_{Fuel}=929° F 40% Void	0.85110	1.10304	-0.2284
Hot $Operating_{80}$	$T_{Moderator}$=550° F T_{Fuel}=929° F 80% Void	0.79195	1.07734	-0.2649

Table 2.54 Lattice [ ] Control Blade Worths at BOL for Control Blade Type ABB/Westinghouse Hafnium Tip

Blade Worth = $\frac{k_{Controlled} - k_{Uncontrolled}}{k_{Uncontrolled}}$		$k_{Controlled}$	$k_{Uncontrolled}$	Blade Worth ($\Delta k/k$)
Cold	$T_{Moderator}$=68° F T_{Fuel}=68° F 0% Void, No xenon	1.00123	1.16879	-0.1434
Intermediate	$T_{Moderator}$=200° F T_{Fuel}=200° F 0% Void, No xenon	0.98819	1.16166	-0.1493
Hot Standby	$T_{Moderator}$=550° F T_{Fuel}=550° F 0% Void, No xenon	0.93465	1.13045	-0.1732
Hot Operating$_{NoXe}$	$T_{Moderator}$=550° F T_{Fuel}=929° F 0% Void, No xenon	0.93028	1.12530	-0.1733
Hot Operating$_0$	$T_{Moderator}$=550° F T_{Fuel}=929° F 0% Void	0.93028	1.12530	-0.1733
Hot Operating$_{40}$	$T_{Moderator}$=550° F T_{Fuel}=929° F 40% Void	0.88716	1.10304	-0.1957
Hot Operating $_{80}$	$T_{Moderator}$=550° F T_{Fuel}=929° F 80% Void	0.83468	1.07734	-0.2252

Table 2.55 Lattice [ ] Kinetics Parameters at BOL

Kinetics Parameter = $\frac{k_\alpha - k_\beta}{k_\beta}$	k_α	k_β	Kinetics Parameter ($\Delta k/k$)
Doppler = $\frac{k_{HotOperatingNoXe} - k_{HotStandby}}{k_{HotStandby}}$	1.12530	1.13045	-0.0046
$Moderator_{Void}$ = $\frac{k_{HotOperating40} - k_{HotOperating0}}{k_{HotOperating0}}$	1.10304	1.12530	-0.0198
$Moderator_{Temperature}$ = $\frac{k_{HotStandby} - k_{Cold}}{k_{Cold}}$	1.13045	1.16879	-0.0328

Table 2.56 Lattice [ ] Control Blade Worths at BOL for Control Blade Type ABB/Westinghouse Main Body

Blade Worth = $\frac{k_{Controlled} - k_{Uncontrolled}}{k_{Uncontrolled}}$		$k_{Controlled}$	$k_{Uncontrolled}$	Blade Worth (Δk/k)
Cold	$T_{Moderator}$=68° F T_{Fuel}=68° F 0% Void, No xenon	0.93573	1.12679	-0.1696
Intermediate	$T_{Moderator}$=200° F T_{Fuel}=200° F 0% Void, No xenon	0.92333	1.12158	-0.1768
Hot Standby	$T_{Moderator}$=550° F T_{Fuel}=550° F 0% Void, No xenon	0.87146	1.09890	-0.2070
Hot Operating$_{NoXe}$	$T_{Moderator}$=550° F T_{Fuel}=975° F 0% Void, No xenon	0.86734	1.09380	-0.2070
Hot Operating$_0$	$T_{Moderator}$=550° F T_{Fuel}=975° F 0% Void	0.86743	1.09380	-0.2070
Hot Operating$_{40}$	$T_{Moderator}$=550° F T_{Fuel}=975° F 40% Void	0.82246	1.07608	-0.2357
Hot Operating $_{80}$	$T_{Moderator}$=550° F T_{Fuel}=975° F 80% Void	0.76481	1.05438	-0.2746

Table 2.57 Lattice [ ] Control Blade Worths at BOL for Control Blade Type ABB/Westinghouse Hafnium Tip

Blade Worth = $\frac{k_{Controlled} - k_{Uncontrolled}}{k_{Uncontrolled}}$		$k_{Controlled}$	$k_{Uncontrolled}$	Blade Worth (Δk/k)
Cold	$T_{Moderator}$=68° F T_{Fuel}=68° F 0% Void, No xenon	0.95986	1.12679	-0.1482
Intermediate	$T_{Moderator}$=200° F T_{Fuel}=200° F 0% Void, No xenon	0.94834	1.12158	-0.1545
Hot Standby	$T_{Moderator}$=550° F T_{Fuel}=550° F 0% Void, No xenon	0.90205	1.09890	-0.1791
Hot Operating$_{NoXe}$	$T_{Moderator}$=550° F T_{Fuel}=975° F 0% Void, No xenon	0.89774	1.09380	-0.1792
Hot Operating$_{0}$	$T_{Moderator}$=550° F T_{Fuel}=975° F 0% Void	0.89774	1.09380	-0.1792
Hot Operating$_{40}$	$T_{Moderator}$=550° F T_{Fuel}=975° F 40% Void	0.85817	1.07608	-0.2025
Hot Operating$_{80}$	$T_{Moderator}$=550° F T_{Fuel}=975° F 80% Void	0.80770	1.05438	-0.2340

Table 2.58 Lattice [ ] Kinetics Parameters at BOL

Kinetics Parameter = $\frac{k_\alpha - k_\beta}{k_\beta}$	k_α	k_β	Kinetics Parameter (Δk/k)
Doppler = $\frac{k_{HotOperatingNoXe} - k_{HotStandby}}{k_{HotStandby}}$	1.09380	1.09890	-0.0046
$Moderator_{Void} = \frac{k_{HotOperating40} - k_{HotOperating0}}{k_{HotOperating0}}$	1.07608	1.09380	-0.0162
$Moderator_{Temperature} = \frac{k_{HotStandby} - k_{Cold}}{k_{Cold}}$	1.09890	1.12679	-0.0248

Table 2.59 Lattice [ ] Control Blade Worths at BOL for Control Blade Type ABB/Westinghouse Main Body

Blade Worth = $\frac{k_{Controlled} - k_{Uncontrolled}}{k_{Uncontrolled}}$		$k_{Controlled}$	$k_{Uncontrolled}$	Blade Worth ($\Delta k/k$)
Cold	$T_{Moderator}$=68° F T_{Fuel}=68° F 0% Void, No xenon	0.93918	1.12804	-0.1674
Intermediate	$T_{Moderator}$=200° F T_{Fuel}=200° F 0% Void, No xenon	0.92656	1.12276	-0.1747
Hot Standby	$T_{Moderator}$=550° F T_{Fuel}=550° F 0% Void, No xenon	0.87466	1.10056	-0.2053
Hot Operating$_{NoXe}$	$T_{Moderator}$=550° F T_{Fuel}=975° F 0% Void, No xenon	0.87059	1.09552	-0.2053
Hot Operating$_{0}$	$T_{Moderator}$=550° F T_{Fuel}=975° F 0% Void	0.87068	1.09552	-0.2052
Hot Operating$_{40}$	$T_{Moderator}$=550° F T_{Fuel}=975° F 40% Void	0.82539	1.07796	-0.2343
Hot Operating $_{80}$	$T_{Moderator}$=550° F T_{Fuel}=975° F 80% Void	0.76642	1.05572	-0.2740

Table 2.60 Lattice [ ] Control Blade Worths at BOL for Control Blade Type ABB/Westinghouse Hafnium Tip

Blade Worth = $\frac{k_{Controlled} - k_{Uncontrolled}}{k_{Uncontrolled}}$		**$k_{Controlled}$**	**$k_{Uncontrolled}$**	**Blade Worth (Δk/k)**
Cold	$T_{Moderator}$=68° F T_{Fuel}=68° F 0% Void, No xenon	0.96284	1.12804	-0.1464
Intermediate	$T_{Moderator}$=200° F T_{Fuel}=200° F 0% Void, No xenon	0.95110	1.12276	-0.1529
Hot Standby	$T_{Moderator}$=550° F T_{Fuel}=550° F 0% Void, No xenon	0.90483	1.10056	-0.1779
Hot Operating$_{NoXe}$	$T_{Moderator}$=550° F T_{Fuel}=975° F 0% Void, No xenon	0.90057	1.09552	-0.1779
Hot Operating$_{0}$	$T_{Moderator}$=550° F T_{Fuel}=975° F 0% Void	0.90057	1.09552	-0.1779
Hot Operating$_{40}$	$T_{Moderator}$=550° F T_{Fuel}=975° F 40% Void	0.86079	1.07796	-0.2015
Hot Operating $_{80}$	$T_{Moderator}$=550° F T_{Fuel}=975° F 80% Void	0.80919	1.05572	-0.2335

Table 2.61 Lattice [ ] Kinetics Parameters at BOL

Kinetics Parameter = $\frac{k_\alpha - k_\beta}{k_\beta}$	k_α	k_β	Kinetics Parameter (Δk/k)
Doppler = $\frac{k_{HotOperatingNoXe} - k_{HotStandby}}{k_{HotStandby}}$	1.09552	1.10056	-0.0046
$Moderator_{Void}$ = $\frac{k_{HotOperating40} - k_{HotOperating0}}{k_{HotOperating0}}$	1.07796	1.09552	-0.0160
$Moderator_{Temperature}$ = $\frac{k_{HotStandby} - k_{Cold}}{k_{Cold}}$	1.10056	1.12804	-0.0244

Table 2.62 Lattice [ ] Control Blade Worths at BOL for Control Blade Type ABB/Westinghouse Main Body

Blade Worth = $\frac{k_{Controlled} - k_{Uncontrolled}}{k_{Uncontrolled}}$		$k_{Controlled}$	$k_{Uncontrolled}$	Blade Worth (Δk/k)
Cold	$T_{Moderator}$=68° F T_{Fuel}=68° F 0% Void, No xenon	0.91120	1.10227	-0.1733
Intermediate	$T_{Moderator}$=200° F T_{Fuel}=200° F 0% Void, No xenon	0.89829	1.09667	-0.1809
Hot Standby	$T_{Moderator}$=550° F T_{Fuel}=550° F 0% Void, No xenon	0.84702	1.07491	-0.2120
Hot Operating$_{NoXe}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 0% Void, No xenon	0.84294	1.06981	-0.2121
Hot Operating$_{0}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 0% Void	0.84303	1.06981	-0.2120
Hot Operating$_{40}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 40% Void	0.79971	1.05429	-0.2415
Hot Operating $_{80}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 80% Void	0.74154	1.03330	-0.2824

Table 2.63 Lattice [ ] Control Blade Worths at BOL for Control Blade Type ABB/Westinghouse Hafnium Tip

Blade Worth = $\frac{k_{Controlled} - k_{Uncontrolled}}{k_{Uncontrolled}}$		$k_{Controlled}$	$k_{Uncontrolled}$	Blade Worth (Δk/k)
Cold	$T_{Moderator}$=68° F T_{Fuel}=68° F 0% Void, No xenon	0.93473	1.10227	-0.1520
Intermediate	$T_{Moderator}$=200° F T_{Fuel}=200° F 0% Void, No xenon	0.92271	1.09667	-0.1586
Hot Standby	$T_{Moderator}$=550° F T_{Fuel}=550° F 0% Void, No xenon	0.87707	1.07491	-0.1840
Hot Operating$_{NoXe}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 0% Void, No xenon	0.87280	1.06981	-0.1842
Hot Operating$_{0}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 0% Void	0.87280	1.06981	-0.1842
Hot Operating$_{40}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 40% Void	0.83499	1.05429	-0.2080
Hot Operating $_{80}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 80% Void	0.78428	1.03330	-0.2410

Table 2.64 Lattice [ ] Kinetics Parameters at BOL

Kinetics Parameter = $\frac{k_{\alpha} - k_{\beta}}{k_{\beta}}$	k_{α}	k_{β}	Kinetics Parameter (Δk/k)
Doppler = $\frac{k_{HotOperatingNoXe} - k_{HotStandby}}{k_{HotStandby}}$	1.06981	1.07491	-0.0047
$Moderator_{Void}$ = $\frac{k_{HotOperating40} - k_{HotOperating0}}{k_{HotOperating0}}$	1.05429	1.06981	-0.0145
$Moderator_{Temperature}$ = $\frac{k_{HotStandby} - k_{Cold}}{k_{Cold}}$	1.07491	1.10227	-0.0248

Table 2.65 Lattice [ ] Control Blade Worths at BOL for Control Blade Type ABB/Westinghouse Main Body

Blade Worth = $\frac{k_{Controlled} - k_{Uncontrolled}}{k_{Uncontrolled}}$		$k_{Controlled}$	$k_{Uncontrolled}$	Blade Worth (Δk/k)
Cold	$T_{Moderator}$=68° F T_{Fuel}=68° F 0% Void, No xenon	0.88374	1.05858	-0.1652
Intermediate	$T_{Moderator}$=200° F T_{Fuel}=200° F 0% Void, No xenon	0.87002	1.05100	-0.1722
Hot Standby	$T_{Moderator}$=550° F T_{Fuel}=550° F 0% Void, No xenon	0.82066	1.02791	-0.2016
Hot Operating$_{NoXe}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 0% Void, No xenon	0.81684	1.02318	-0.2017
Hot Operating$_{0}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 0% Void	0.81692	1.02318	-0.2016
Hot Operating$_{40}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 40% Void	0.77505	1.00840	-0.2314
Hot Operating $_{80}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 80% Void	0.71792	0.98904	-0.2741

Table 2.66 Lattice [ ] Control Blade Worths at BOL for Control Blade Type ABB/Westinghouse Hafnium Tip

Blade Worth = $\frac{k_{Controlled} - k_{Uncontrolled}}{k_{Uncontrolled}}$		$k_{Controlled}$	$k_{Uncontrolled}$	Blade Worth (Δk/k)
Cold	$T_{Moderator}$=68° F T_{Fuel}=68° F 0% Void, No xenon	0.90488	1.05858	-0.1452
Intermediate	$T_{Moderator}$=200° F T_{Fuel}=200° F 0% Void, No xenon	0.89193	1.05100	-0.1514
Hot Standby	$T_{Moderator}$=550° F T_{Fuel}=550° F 0% Void, No xenon	0.84776	1.02791	-0.1753
Hot Operating$_{NoXe}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 0% Void, No xenon	0.84378	1.02318	-0.1753
Hot Operating$_{0}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 0% Void	0.84378	1.02318	-0.1753
Hot Operating$_{40}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 40% Void	0.80740	1.00840	-0.1993
Hot Operating $_{80}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 80% Void	0.75801	0.98904	-0.2336

Table 2.67 Lattice [ ] Kinetics Parameters at BOL

Kinetics Parameter = $\frac{k_\alpha - k_\beta}{k_\beta}$	k_α	k_β	Kinetics Parameter (Δk/k)
Doppler = $\frac{k_{HotOperatingNoXe} - k_{HotStandby}}{k_{HotStandby}}$	1.02318	1.02791	-0.0046
$Moderator_{Void}$ = $\frac{k_{HotOperating40} - k_{HotOperating0}}{k_{HotOperating0}}$	1.00840	1.02318	-0.0144
$Moderator_{Temperature}$ = $\frac{k_{HotStandby} - k_{Cold}}{k_{Cold}}$	1.02791	1.05858	-0.0290

Table 2.68 Lattice [ ] Control Blade Worths at BOL for Control Blade Type ABB/Westinghouse Main Body

Blade Worth = $\frac{k_{Controlled} - k_{Uncontrolled}}{k_{Uncontrolled}}$		$k_{Controlled}$	$k_{Uncontrolled}$	Blade Worth (Δk/k)
Cold	$T_{Moderator}$=68° F T_{Fuel}=68° F 0% Void, No xenon	0.91821	1.10607	-0.1698
Intermediate	$T_{Moderator}$=200° F T_{Fuel}=200° F 0% Void, No xenon	0.90568	1.10121	-0.1776
Hot Standby	$T_{Moderator}$=550° F T_{Fuel}=550° F 0% Void, No xenon	0.85917	1.08560	-0.2086
Hot Operating$_{NoXe}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 0% Void, No xenon	0.85521	1.08066	-0.2086
Hot Operating$_{0}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 0% Void	0.85529	1.08066	-0.2086
Hot Operating$_{40}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 40% Void	0.81366	1.06894	-0.2388
Hot Operating $_{80}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 80% Void	0.75500	1.05221	-0.2825

Table 2.69 Lattice [ ] Control Blade Worths at BOL for Control Blade Type ABB/Westinghouse Hafnium Tip

Blade Worth = $\frac{k_{Controlled} - k_{Uncontrolled}}{k_{Uncontrolled}}$		$k_{Controlled}$	$k_{Uncontrolled}$	**Blade Worth (Δk/k)**
Cold	$T_{Moderator}$=68° F T_{Fuel}=68° F 0% Void, No xenon	0.94122	1.10607	-0.1490
Intermediate	$T_{Moderator}$=200° F T_{Fuel}=200° F 0% Void, No xenon	0.92963	1.10121	-0.1558
Hot Standby	$T_{Moderator}$=550° F T_{Fuel}=550° F 0% Void, No xenon	0.88892	1.08560	-0.1812
Hot $Operating_{NoXe}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 0% Void, No xenon	0.88477	1.08066	-0.1813
Hot $Operating_{0}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 0% Void	0.88477	1.08066	-0.1813
Hot $Operating_{40}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 40% Void	0.84906	1.06894	-0.2057
Hot $Operating_{80}$	$T_{Moderator}$=550° F T_{Fuel}=1013° F 80% Void	0.79877	1.05221	-0.2409

Table 2.70 Lattice [ ] Kinetics Parameters at BOL

Kinetics Parameter = $\frac{k_\alpha - k_\beta}{k_\beta}$	k_α	k_β	Kinetics Parameter (Δk/k)
Doppler = $\frac{k_{HotOperatingNoXe} - k_{HotStandby}}{k_{HotStandby}}$	1.08066	1.08560	-0.0046
$Moderator_{Void}$ = $\frac{k_{HotOperating40} - k_{HotOperating0}}{k_{HotOperating0}}$	1.06894	1.08066	-0.0109
$Moderator_{Temperature}$ = $\frac{k_{HotStandby} - k_{Cold}}{k_{Cold}}$	1.08560	1.10607	-0.0185

[ ]

Figure 2.1 Assembly Type [ ]

[ ]

Figure 2.2 Assembly Type [ ]

[ ]

Figure 2.3 Assembly Type [ ]

1	2	3	4	5	6	6	5	5	3	1
2	7	5	8	9	8	10	11	9	12	3
3	5	13	8	14	15	14	14	13	10	5
4	8	8	15	16	13	10	15	14	11	8
5	9	14	16				11	14	14	14
6	8	15	13		Water Channel		13	15	14	14
6	10	14	10				11	14	14	14
5	11	14	15	11	13	11	15	14	14	14
5	9	13	14	14	15	14	14	13	14	8
3	12	10	11	14	14	14	14	14	11	6
1	3	5	8	14	14	14	14	8	6	1

Fuel Rod Type	Quantity	Fuel Rod Type	Quantity
1	4	9	4
2	2	10	6
3	6	11	9
4	2	12	2
5	10	13	8
6	6	14	32
7	1	15	8
8	10	16	2

Figure 2.4 [ ] Fuel Rod Distribution

1	2	17	17	5	6	5	5	5	2	1
2	7	18	9	9	8	9	19	5	12	17
17	18	13	8	20	15	20	20	13	9	5
17	9	8	15	21	13	20	15	14	19	8
5	9	20	21				19	14	14	20
6	8	15	13		Water Channel		13	15	14	14
5	9	20	20				19	14	14	14
5	19	20	15	19	13	19	15	14	14	14
5	5	13	14	14	15	14	14	13	14	8
2	12	9	19	14	14	14	14	14	19	6
1	17	5	8	20	14	14	14	8	6	1

Fuel Rod Type	Quantity
1	4
2	4
5	12
6	4
7	1
8	8
9	8
12	2

Fuel Rod Type	Quantity
13	8
14	24
15	8
17	6
18	2
19	9
20	10
21	2

Figure 2.5 [ ] Fuel Rod Distribution

22	23	4	6	6	6	6	6	6	23	22
23	7	6	8	8	14	14	24	8	25	23
4	6	26	14	14	27	14	14	26	14	8
6	8	14	27	28	26	29	27	14	24	28
6	8	14	28				30	14	14	29
6	14	27	26		Water Channel		26	27	14	29
6	14	14	29				30	14	14	29
6	24	14	27	30	26	30	27	14	24	29
6	8	26	14	14	27	14	14	26	14	29
23	25	14	24	14	14	14	24	14	30	8
22	23	8	28	29	29	29	29	29	8	22

Fuel Rod Type	Quantity	Fuel Rod Type	Quantity
4	2	24	6
6	14	25	2
7	1	26	8
8	10	27	8
14	30	28	4
22	4	29	12
23	6	30	5

Figure 2.6 [ ] Fuel Rod Distribution

[ ]

Figure 2.7 Fuel Rod Axial Description

[ ]

Figure 2.7 Fuel Rod Axial Description *(continued)*

Figure 2.7 Fuel Rod Axial Description *(continued)*

3.0 REFERENCES

1. FS1-0048891 Revision 1.0, Browns Ferry LAR Equilibrium Cycle Specific ATRIUM 11 Fuel Assembly Mechanical Data for Core Engineering, April 2020.

2. ANF-89-98(P)(A) Revision 1 and Supplement 1, *Generic Mechanical Design Criteria for BWR Fuel Designs*, Advanced Nuclear Fuels Corporation, May 1995.

3. EMF-2158(P)(A), Revision 0, *Siemens Power Corporation Methodology for Boiling Water Reactors: Evaluation and Validation of CASMO-4/MICROBURN-B2*, Siemens Power Corporation, October 1999.

Appendix A Enriched Lattice Hot Uncontrolled Reactivity and LPF Plots

The results in this appendix are based on hot operating and equilibrium xenon conditions.

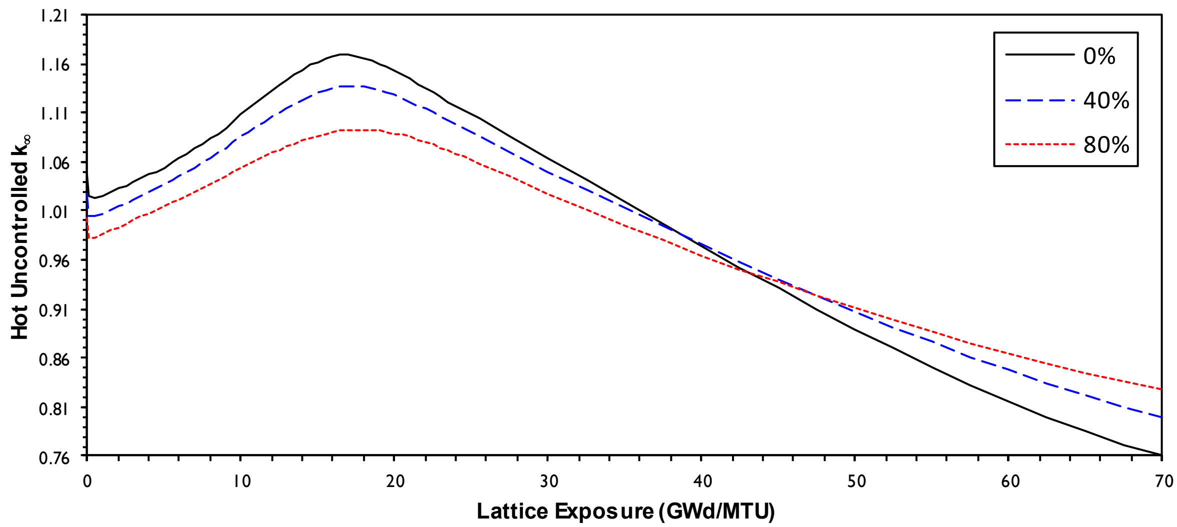

Figure A.1 [ ] Hot Uncontrolled k∞

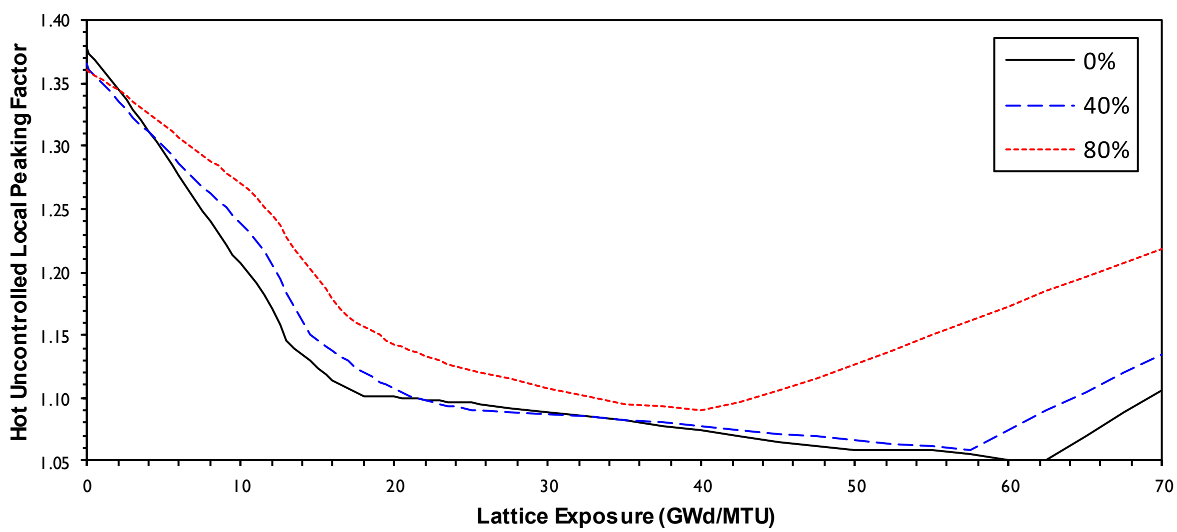

Figure A.2 [ ] Hot Uncontrolled LPF

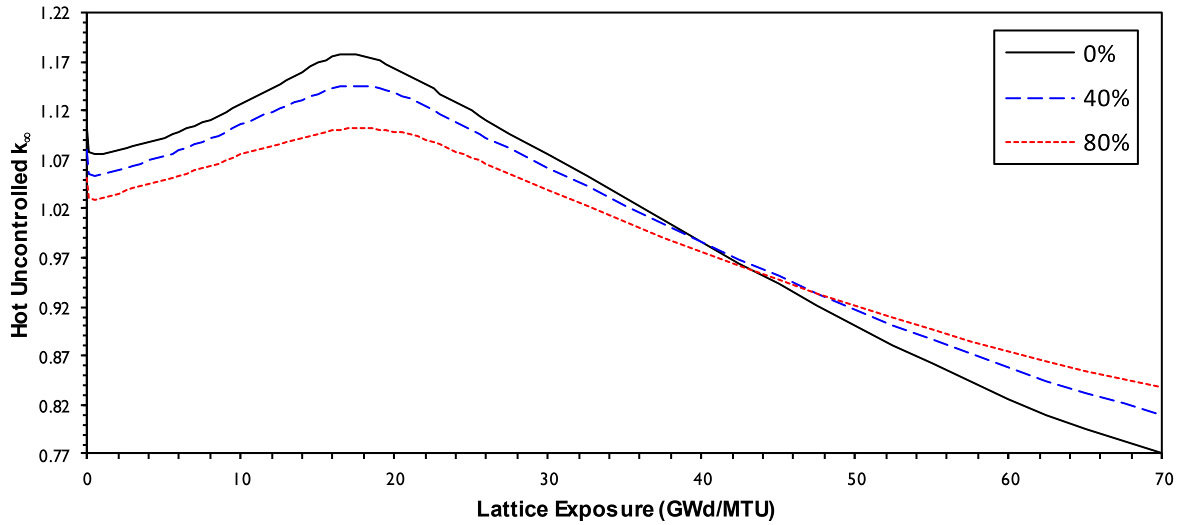

Figure A.3 [ ] Hot Uncontrolled k∞

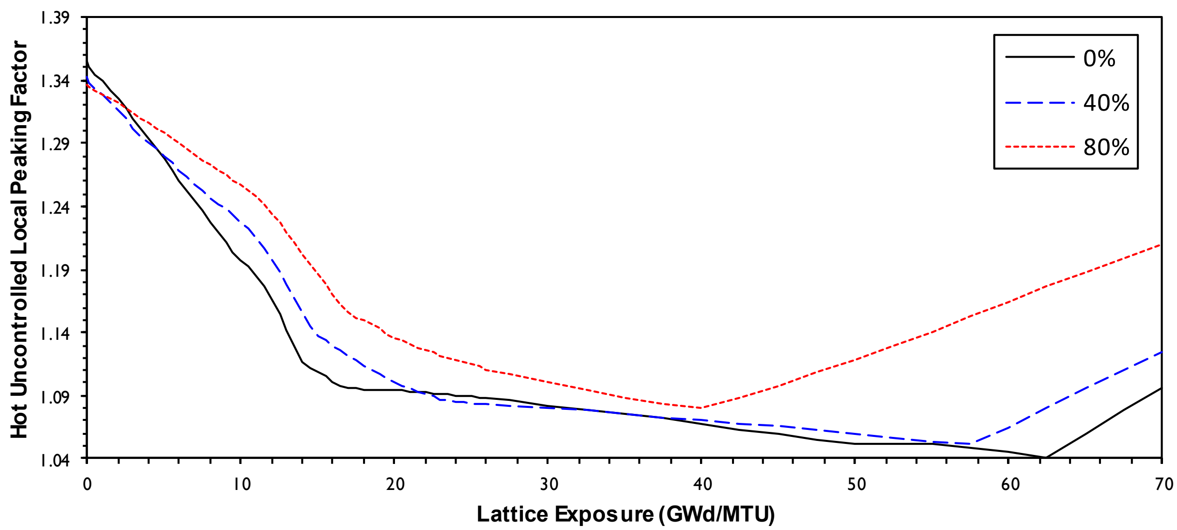

Figure A.4 [ ] Hot Uncontrolled LPF

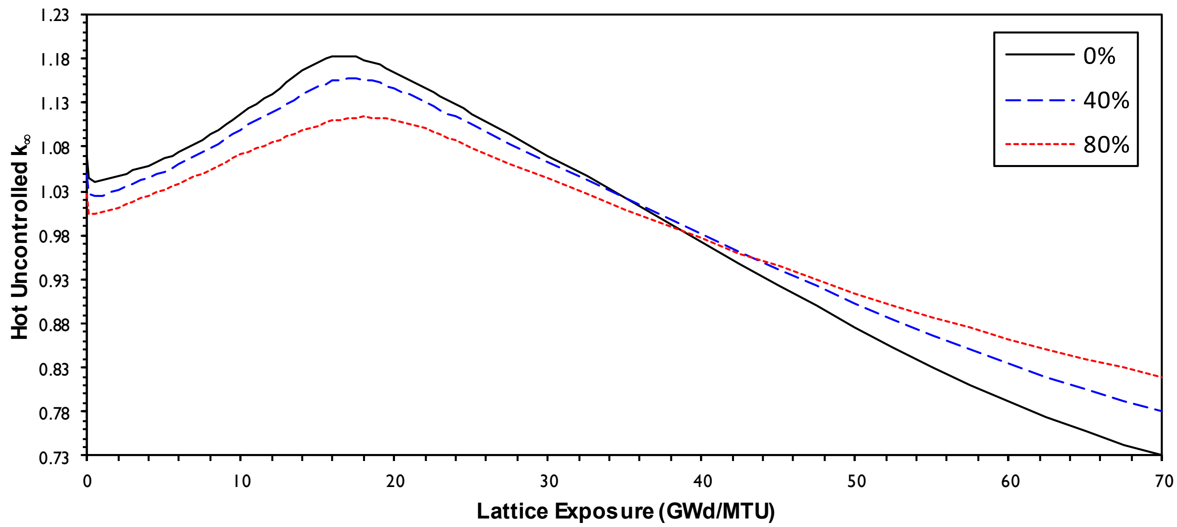

Figure A.5 [ ] Hot Uncontrolled k∞

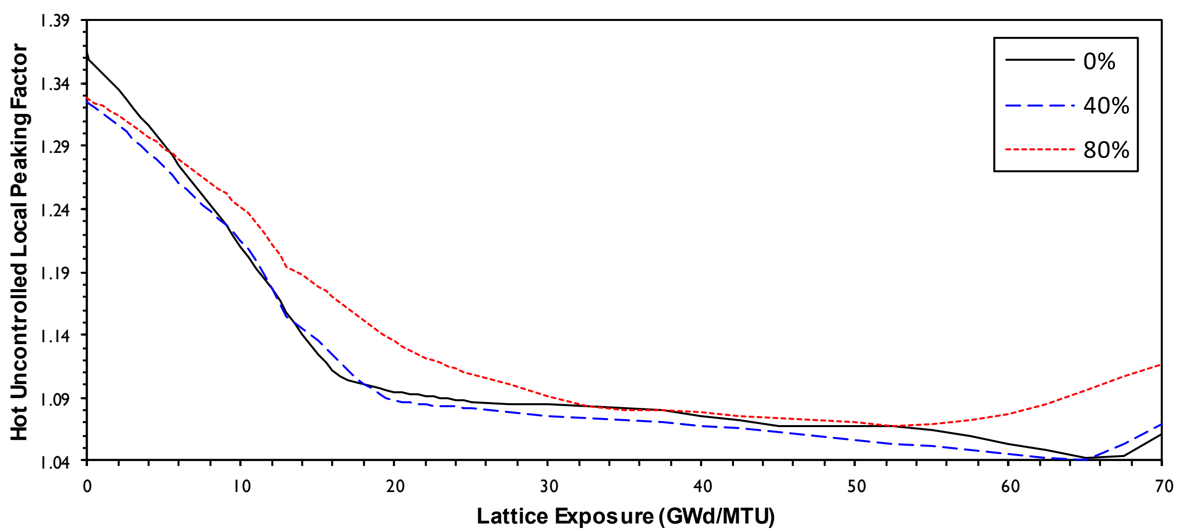

Figure A.6 [ ] Hot Uncontrolled LPF

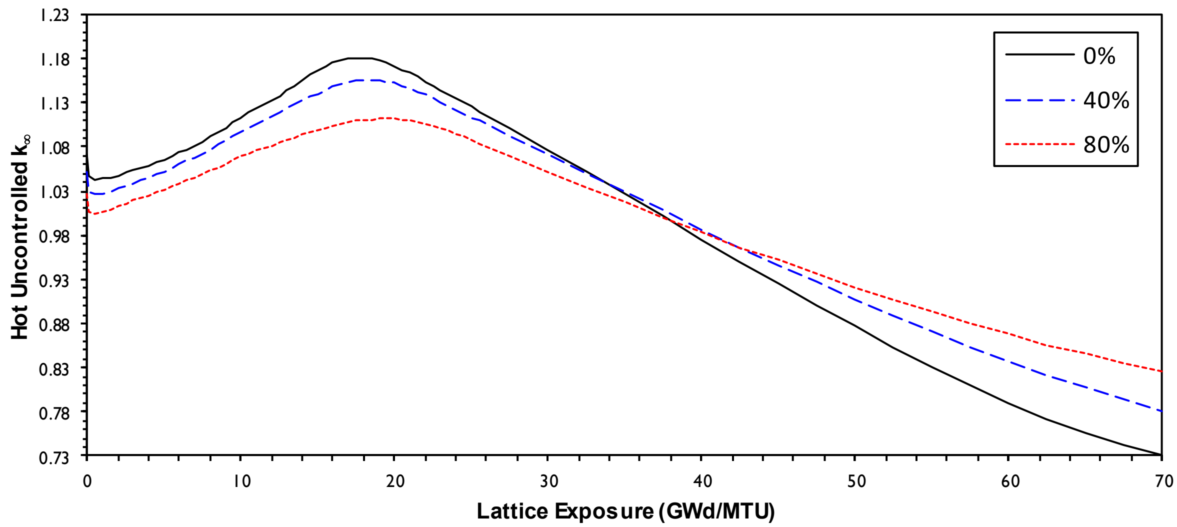

Figure A.7 [ ] Hot Uncontrolled k∞

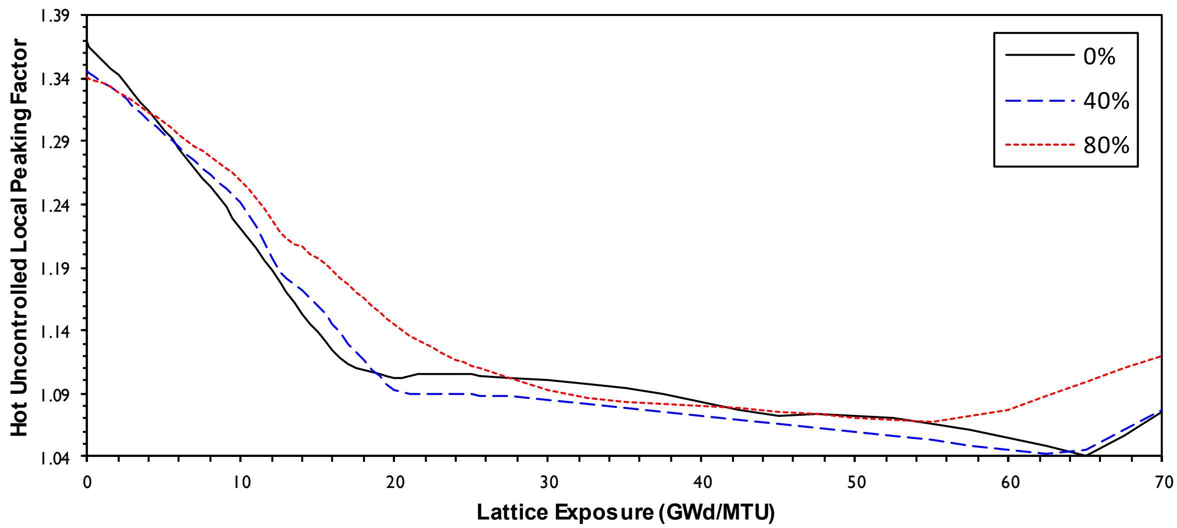

Figure A.8 [ ] Hot Uncontrolled LPF

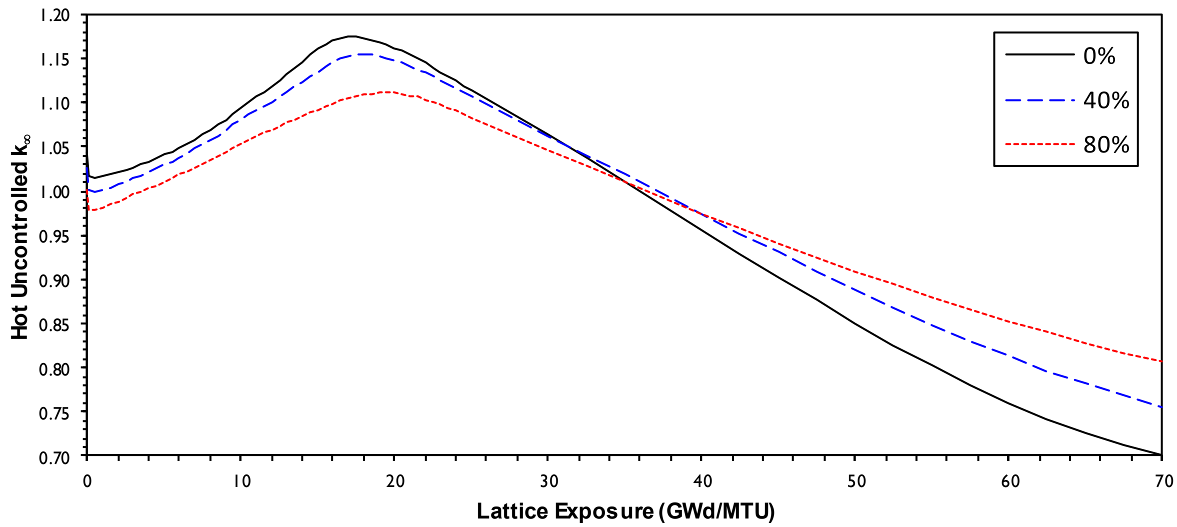

Figure A.9 [ ] Hot Uncontrolled k∞

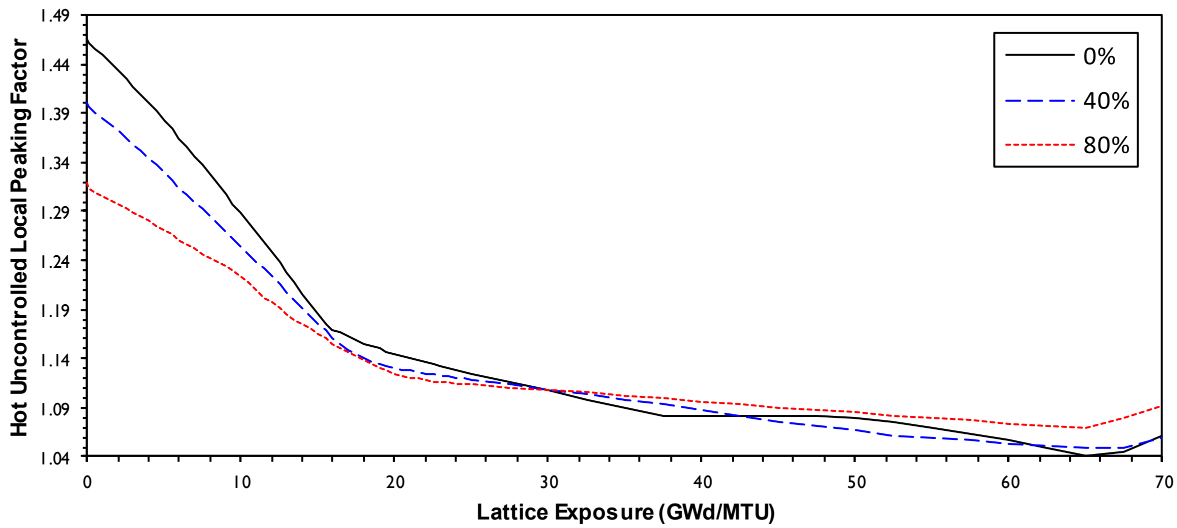

Figure A.10 [ ] Hot Uncontrolled LPF

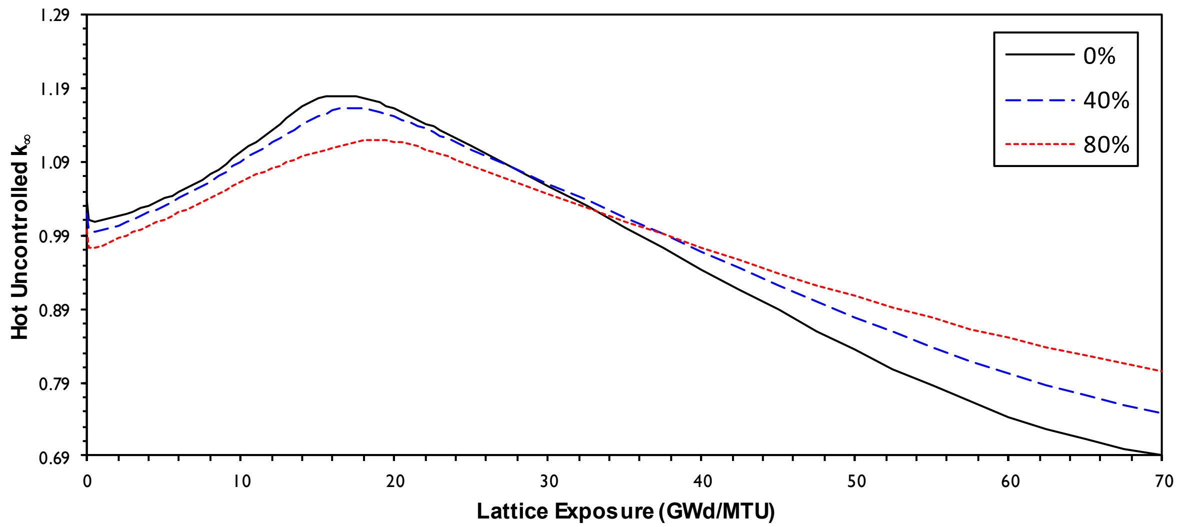

Figure A.11 [ ] Hot Uncontrolled k∞

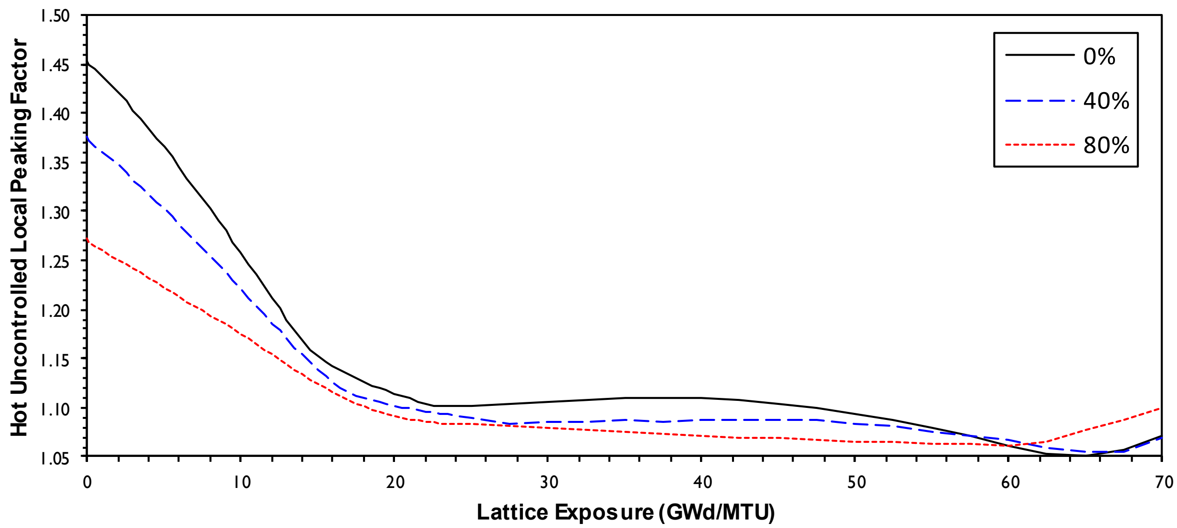

Figure A.12 [ ] Hot Uncontrolled LPF

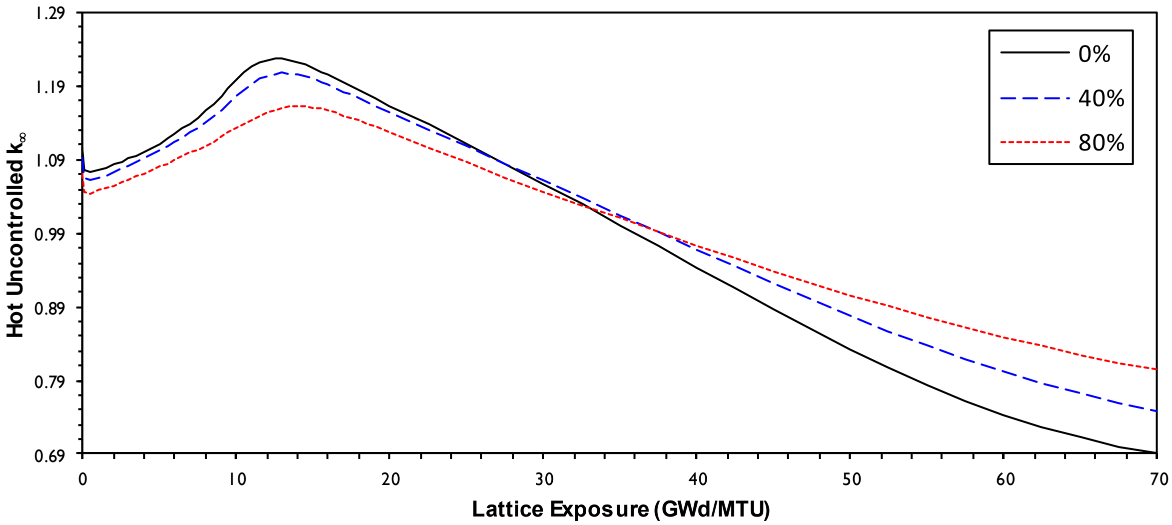

Figure A.13 [ ] Hot Uncontrolled k_∞

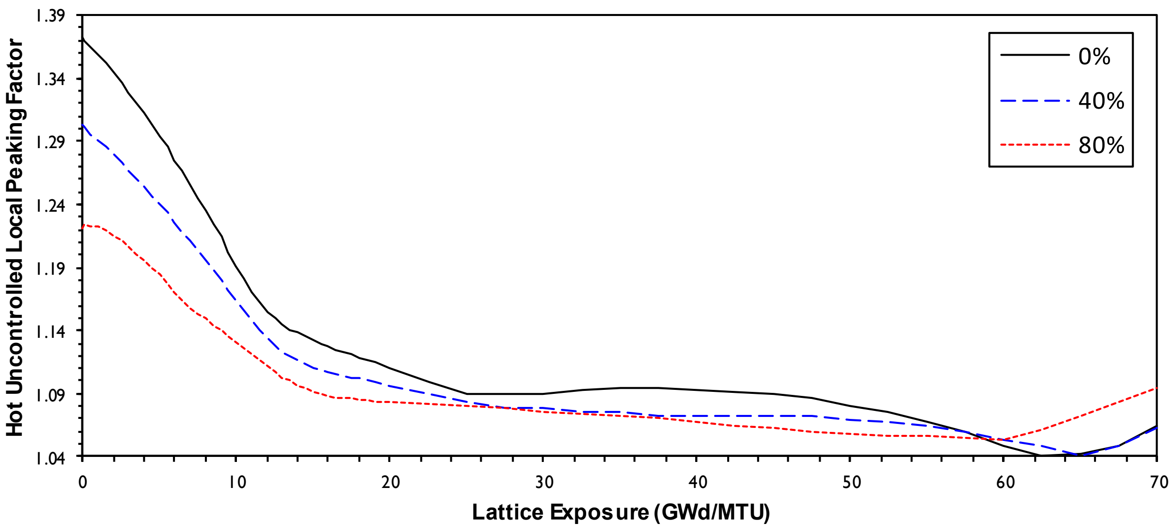

Figure A.14 [ ] Hot Uncontrolled LPF

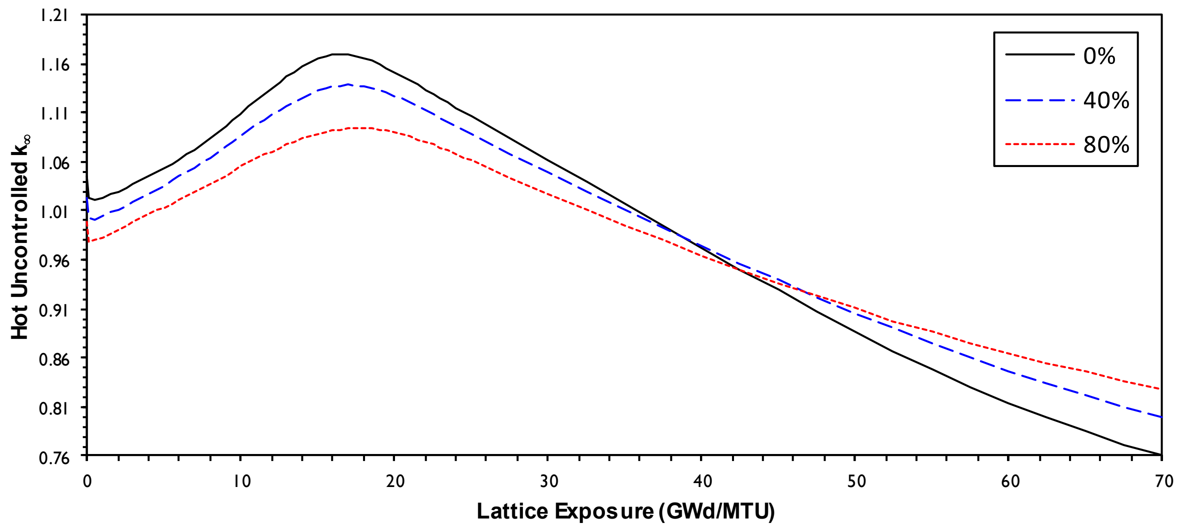

Figure A.15 [ ] Hot Uncontrolled k∞

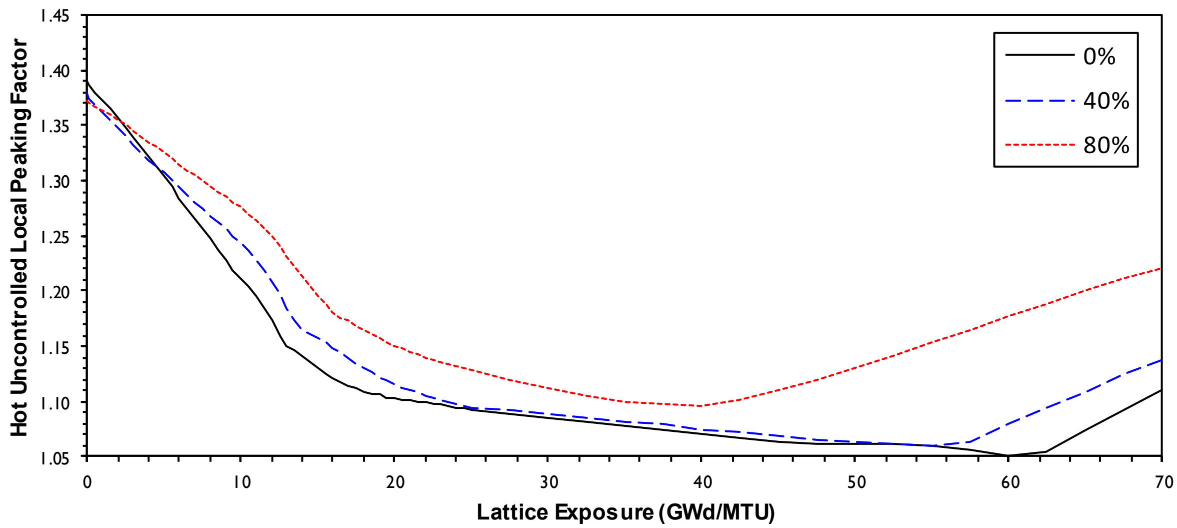

Figure A.16 [ ] Hot Uncontrolled LPF

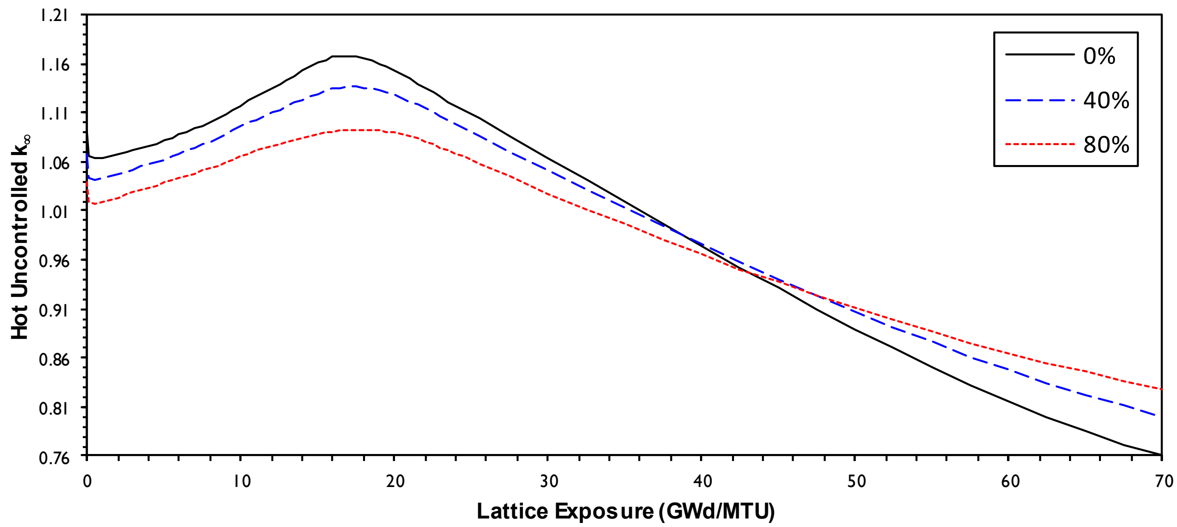

Figure A.17 [ ] Hot Uncontrolled k_∞

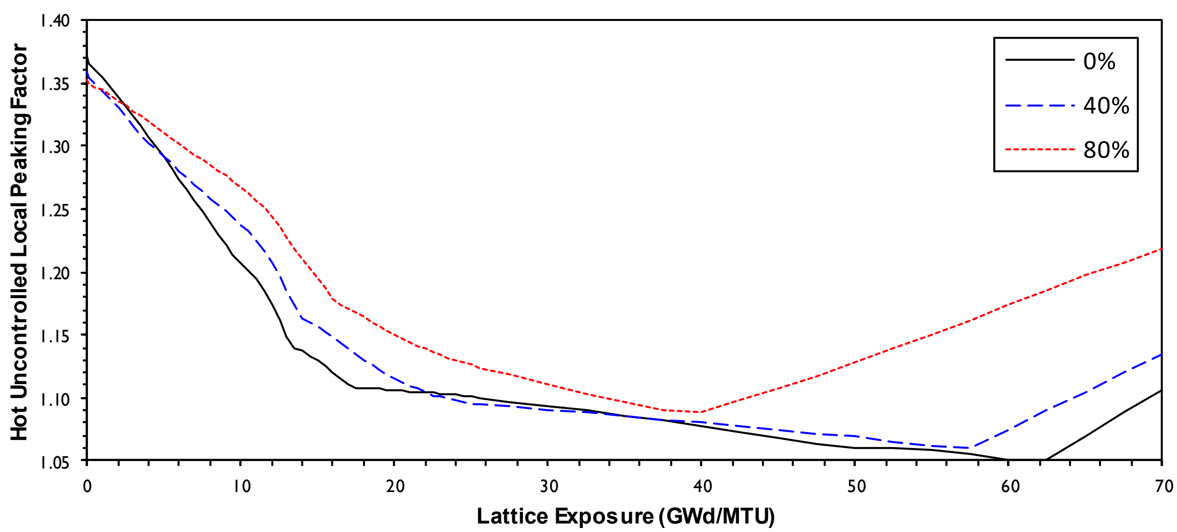

Figure A.18 [ ] Hot Uncontrolled LPF

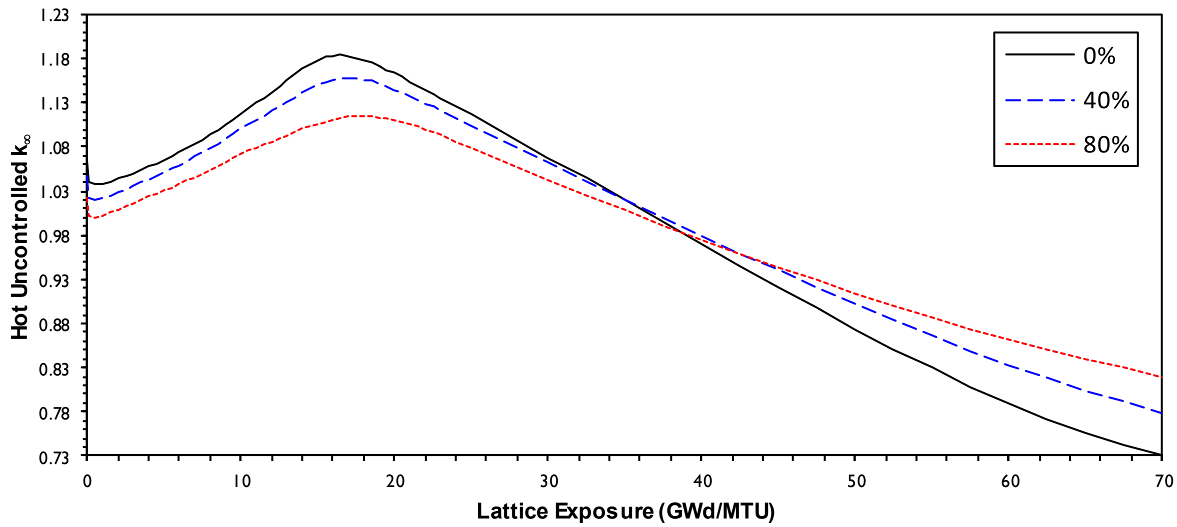

Figure A.19 [ ] Hot Uncontrolled k∞

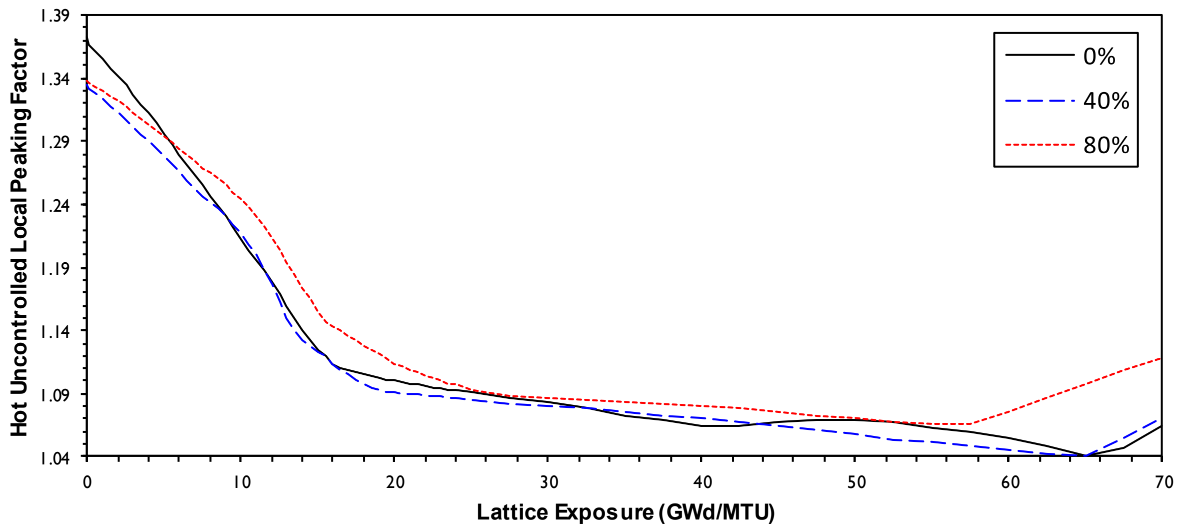

Figure A.20 [ ] Hot Uncontrolled LPF

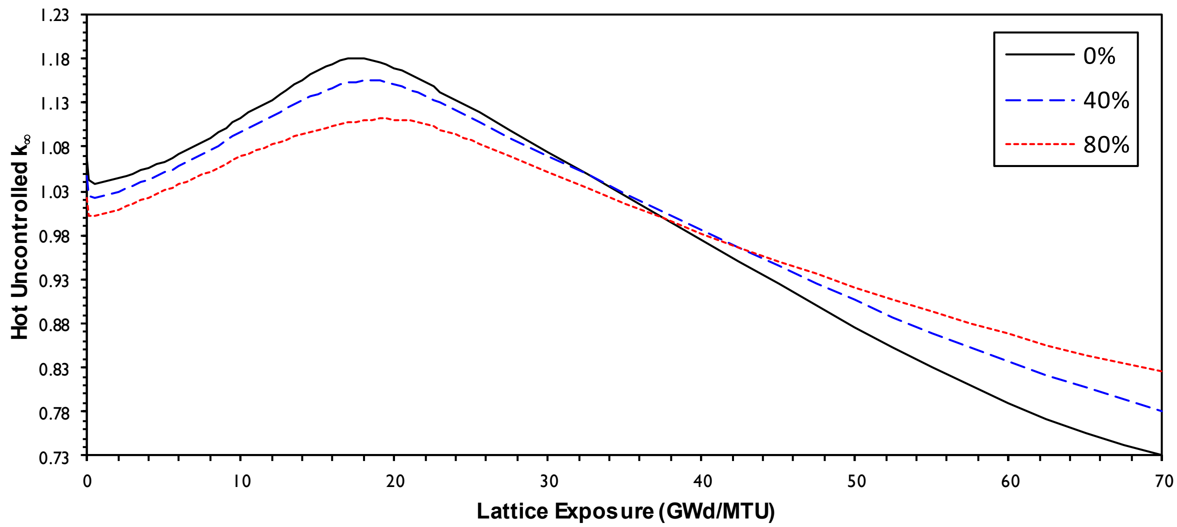

Figure A.21 [ ] Hot Uncontrolled k∞

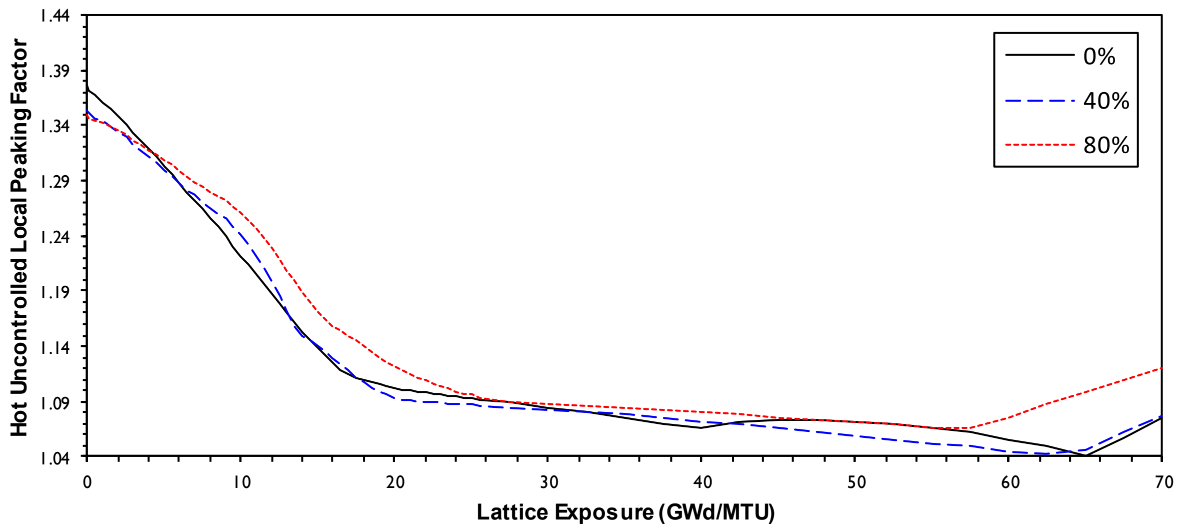

Figure A.22 [ ] Hot Uncontrolled LPF

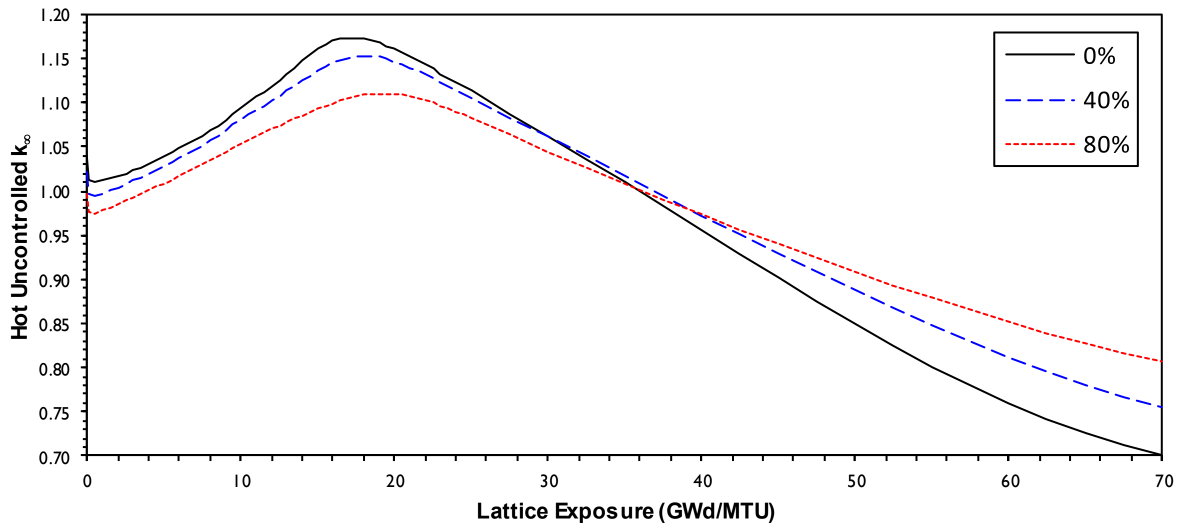

Figure A.23 [ ] Hot Uncontrolled k∞

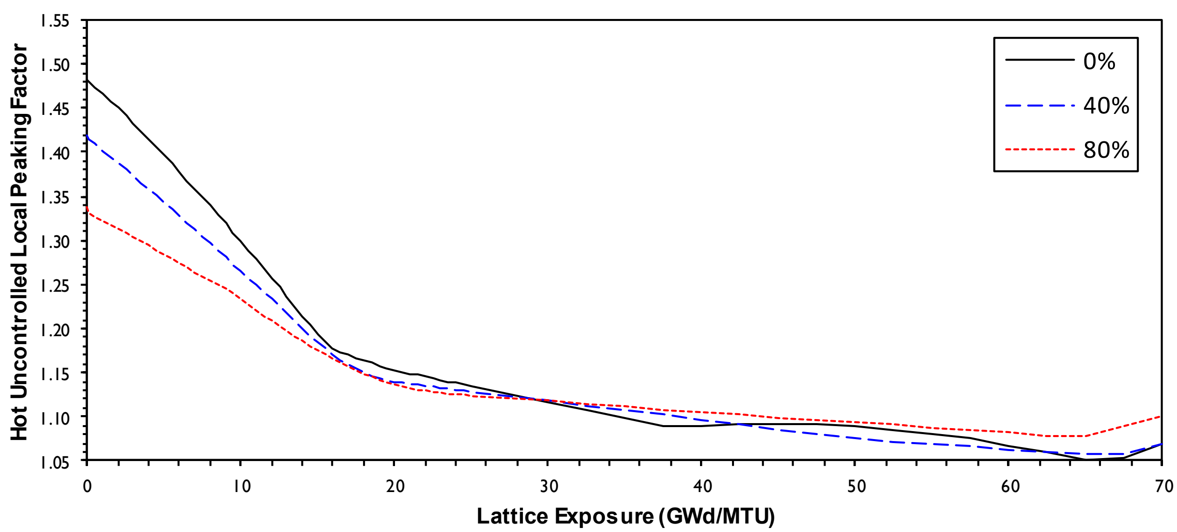

Figure A.24 [ ] Hot Uncontrolled LPF

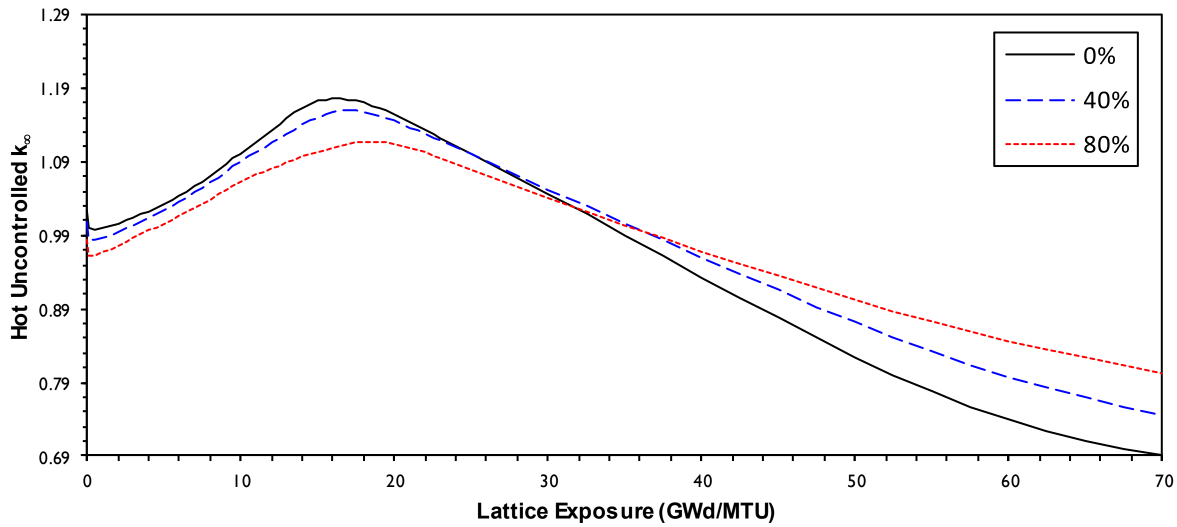

Figure A.25 [ ] Hot Uncontrolled k∞

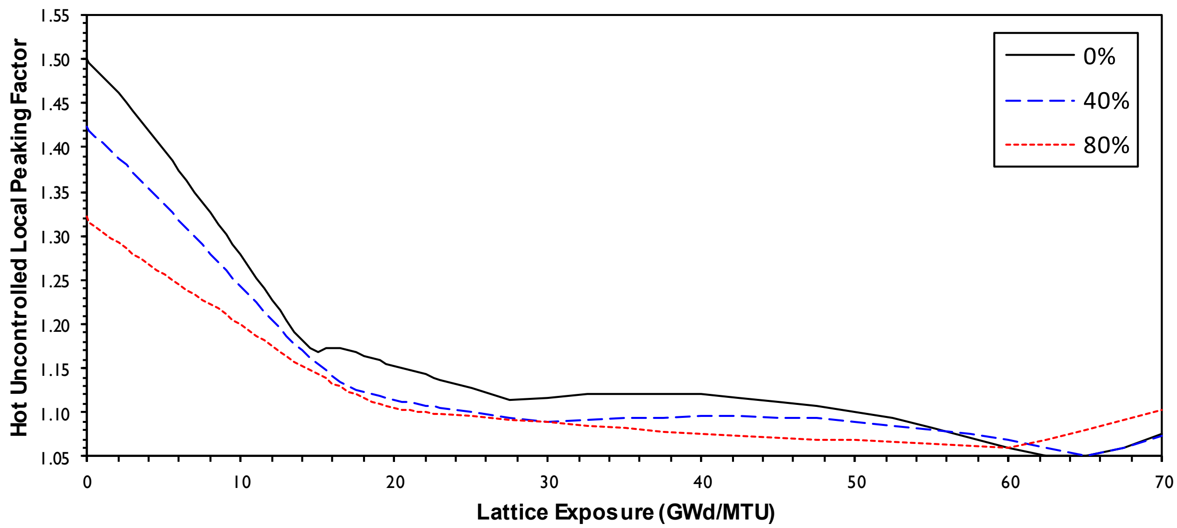

Figure A.26 [ ] Hot Uncontrolled LPF

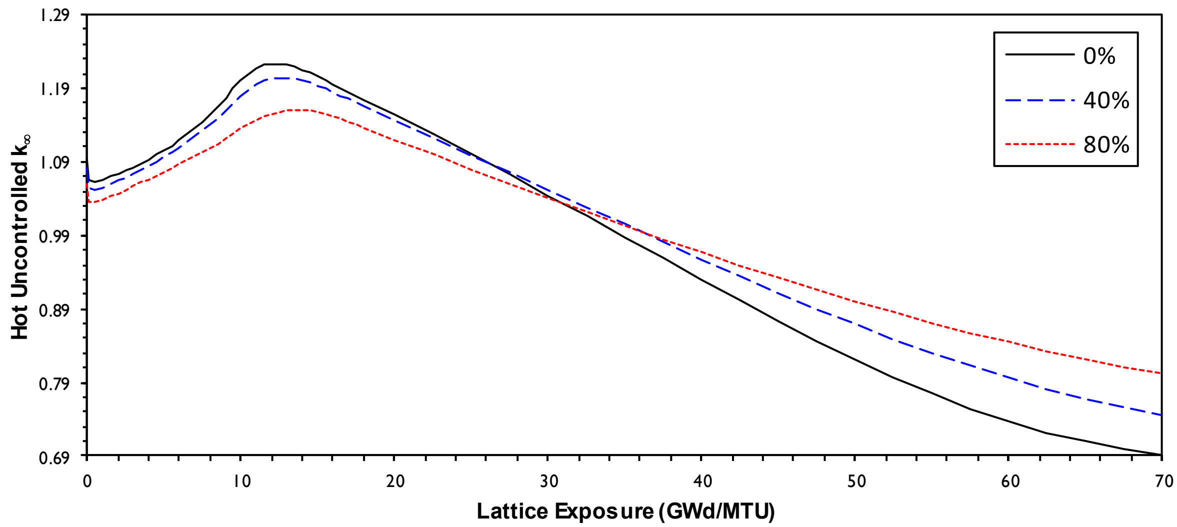

Figure A.27 [ ] Hot Uncontrolled k∞

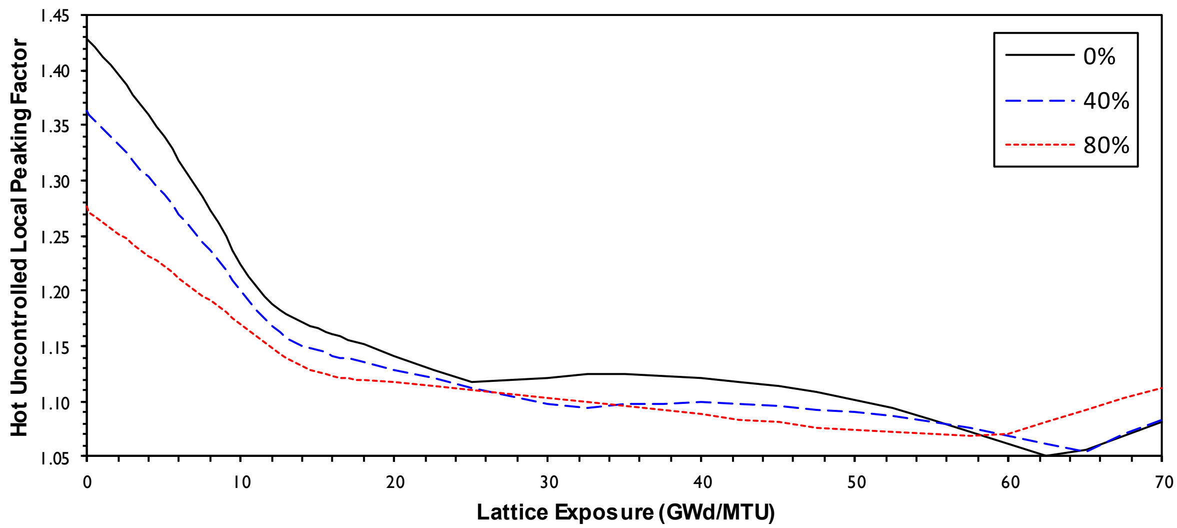

Figure A.28 [ ] Hot Uncontrolled LPF

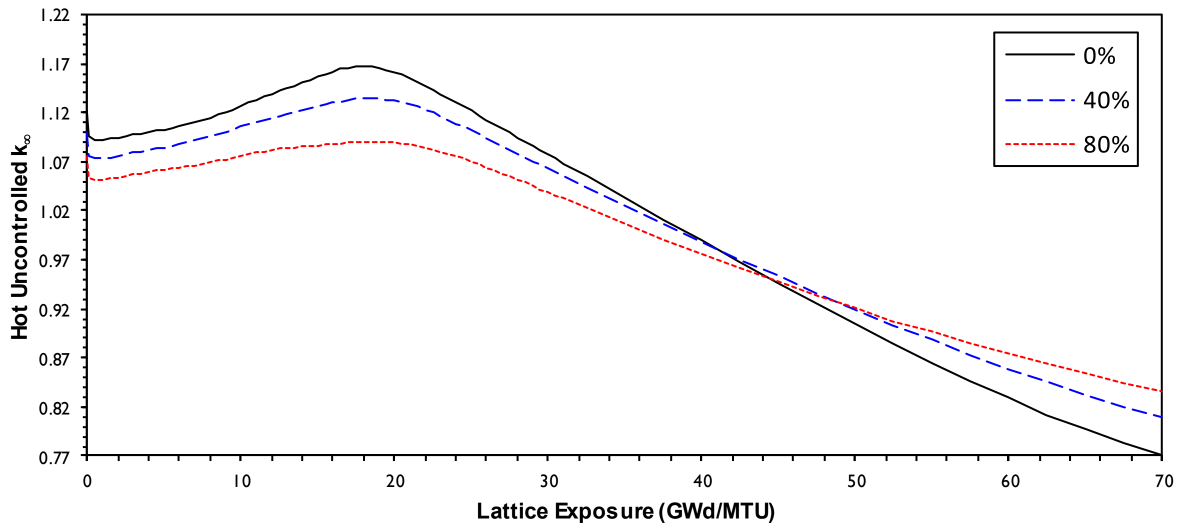

Figure A.29 [ ] Hot Uncontrolled k∞

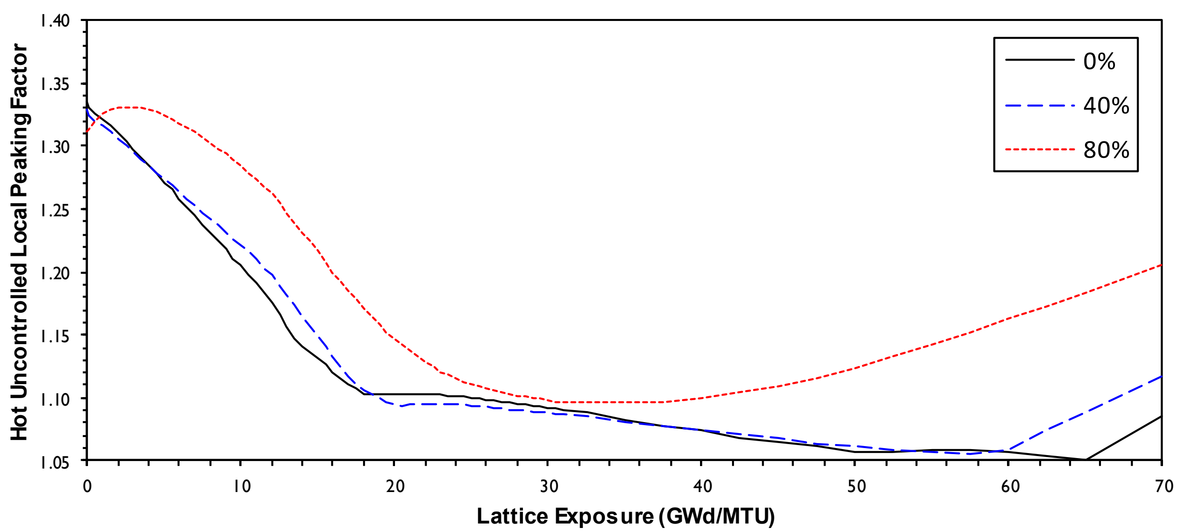

Figure A.30 [ ] Hot Uncontrolled LPF

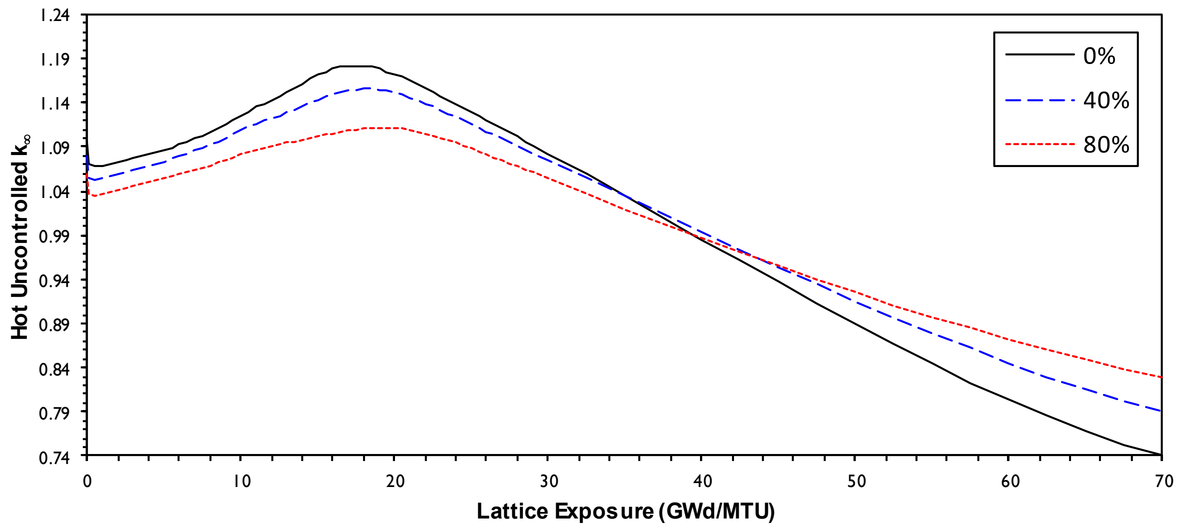

Figure A.31 [ ] Hot Uncontrolled k∞

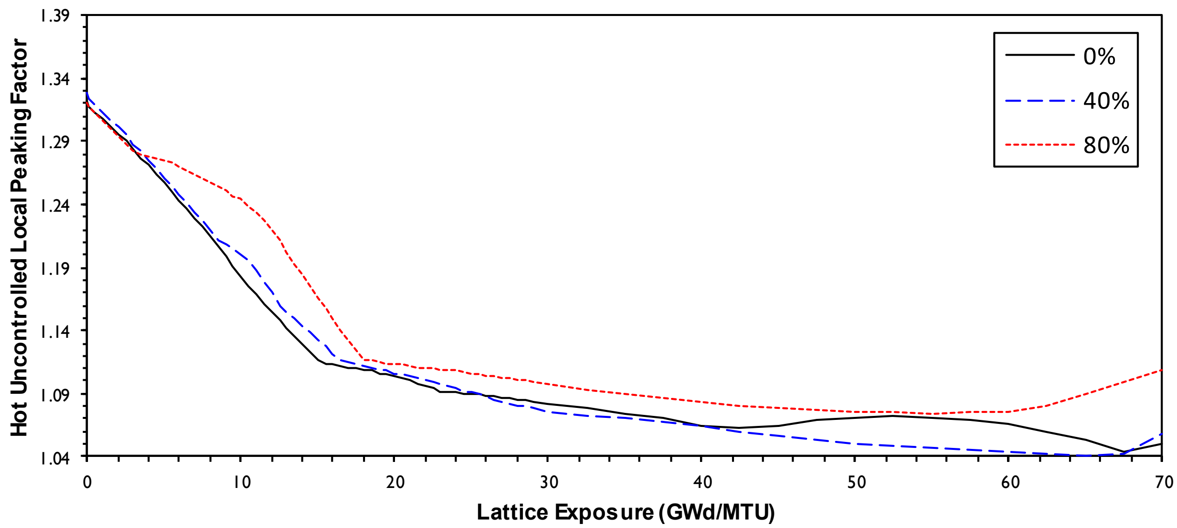

Figure A.32 [ ] Hot Uncontrolled LPF

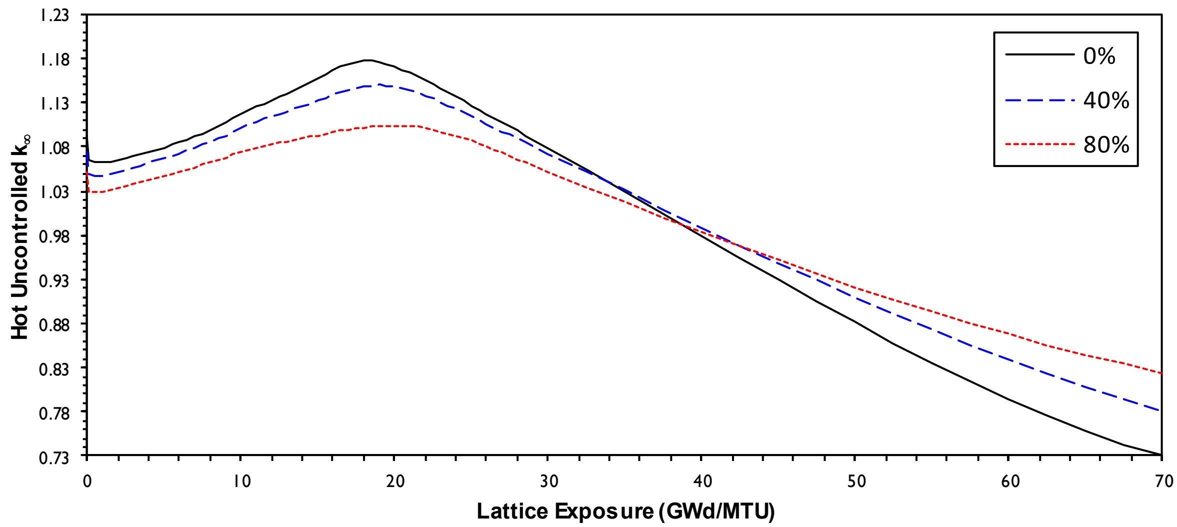

Figure A.33 [ ] Hot Uncontrolled k∞

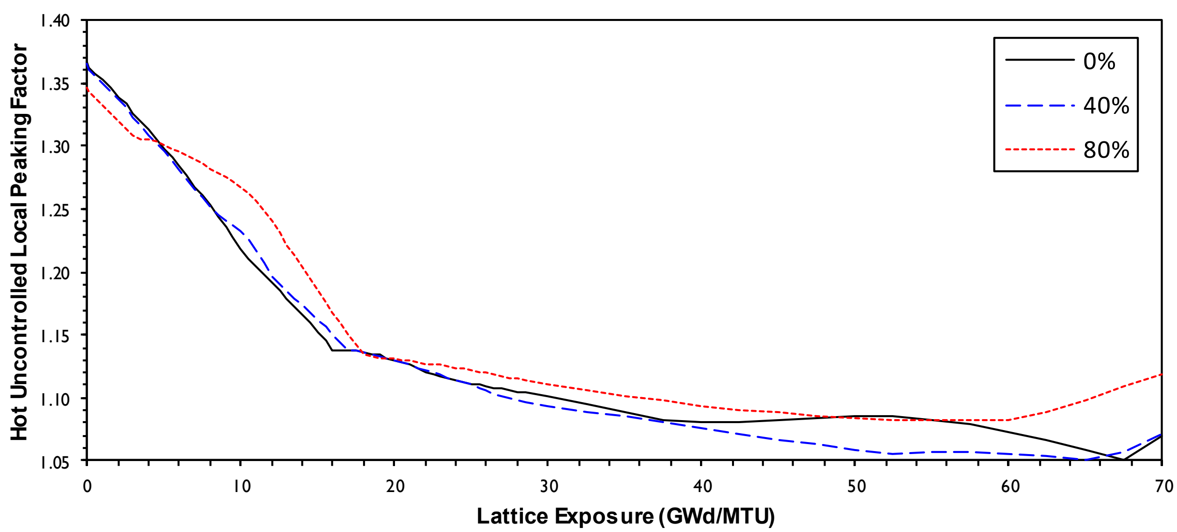

Figure A.34 [ ] Hot Uncontrolled LPF

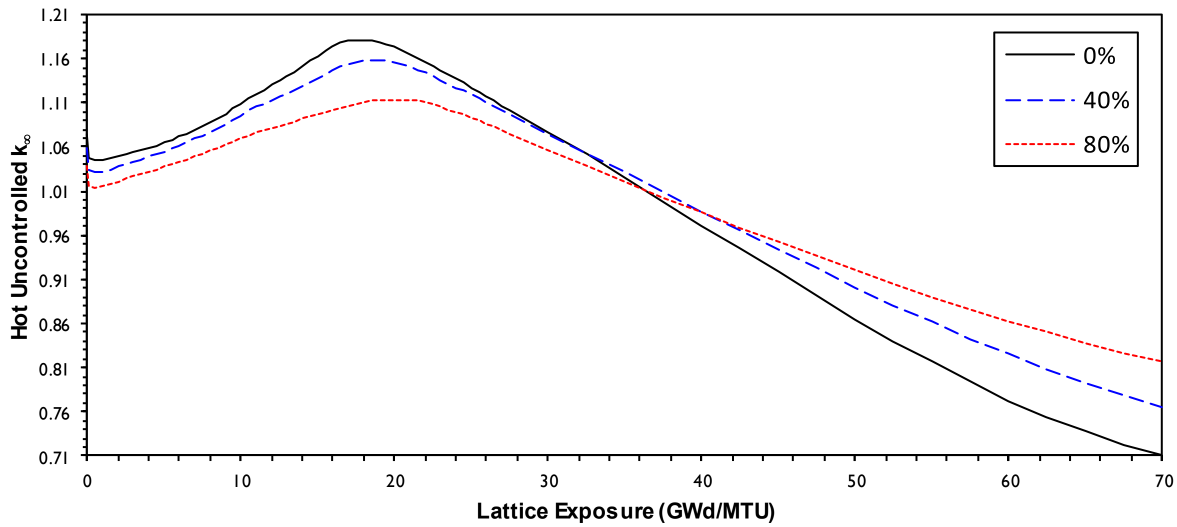

Figure A.35 [ ] Hot Uncontrolled k∞

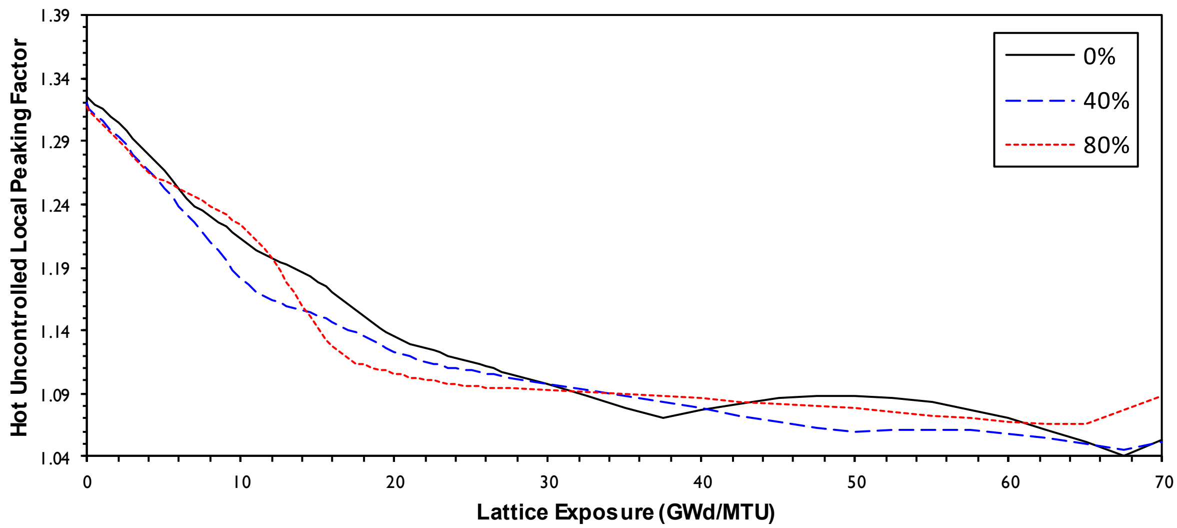

Figure A.36 [ ] Hot Uncontrolled LPF

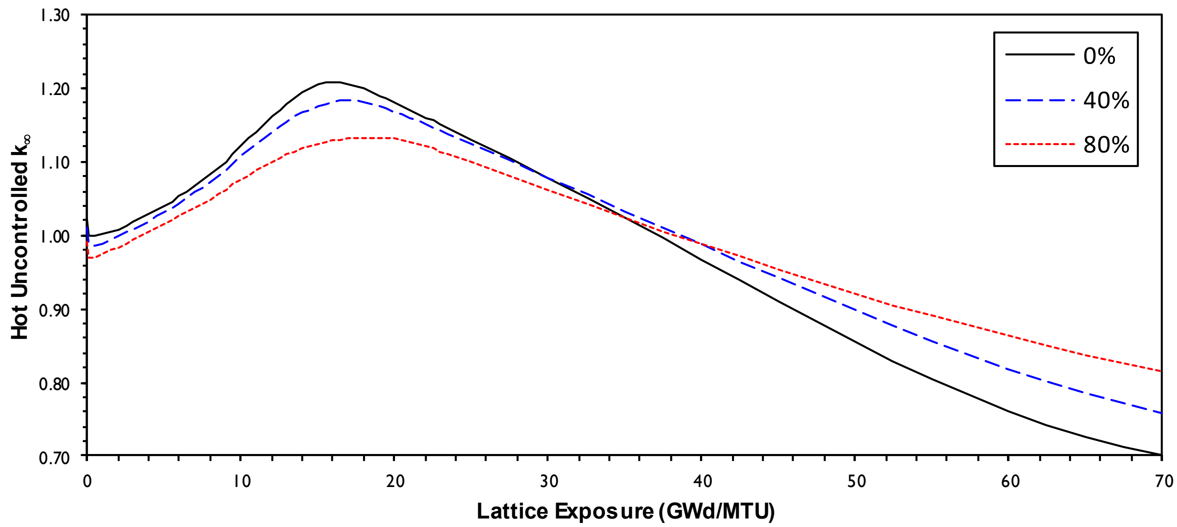

Figure A.37 [ ] Hot Uncontrolled k_∞

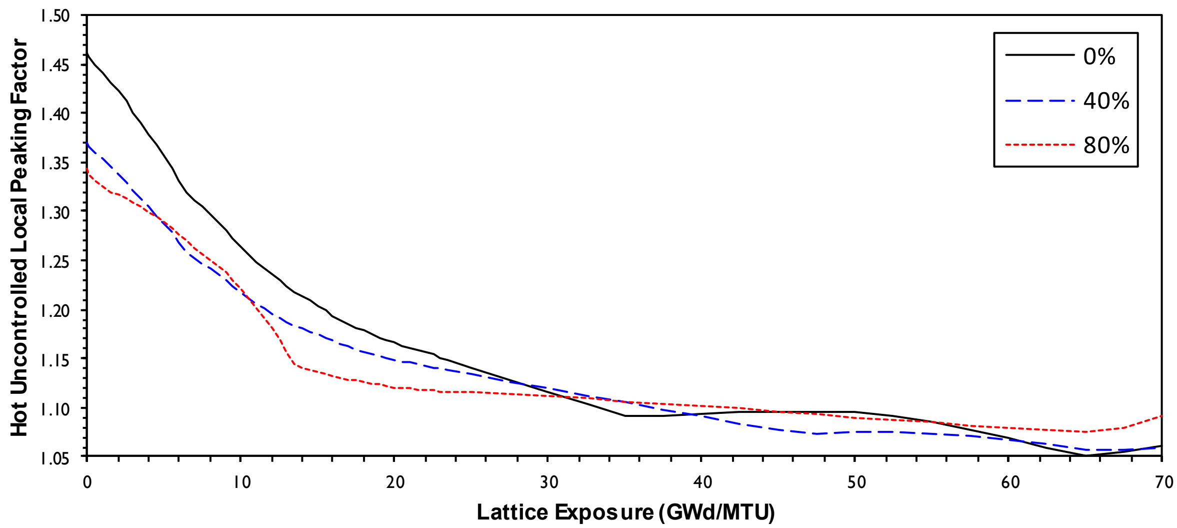

Figure A.38 [ ] Hot Uncontrolled LPF

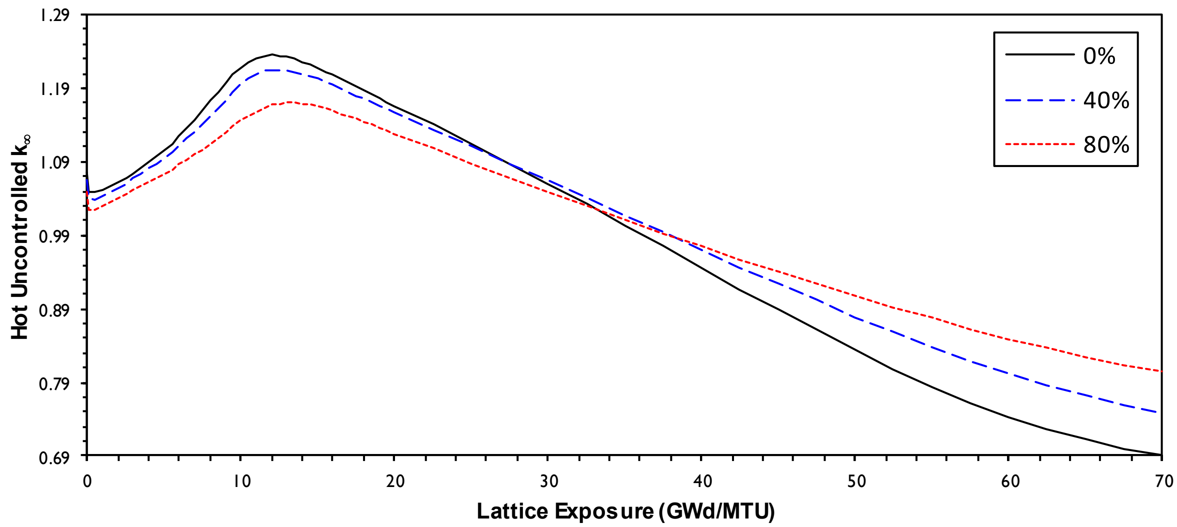

Figure A.39 [ ] Hot Uncontrolled k_∞

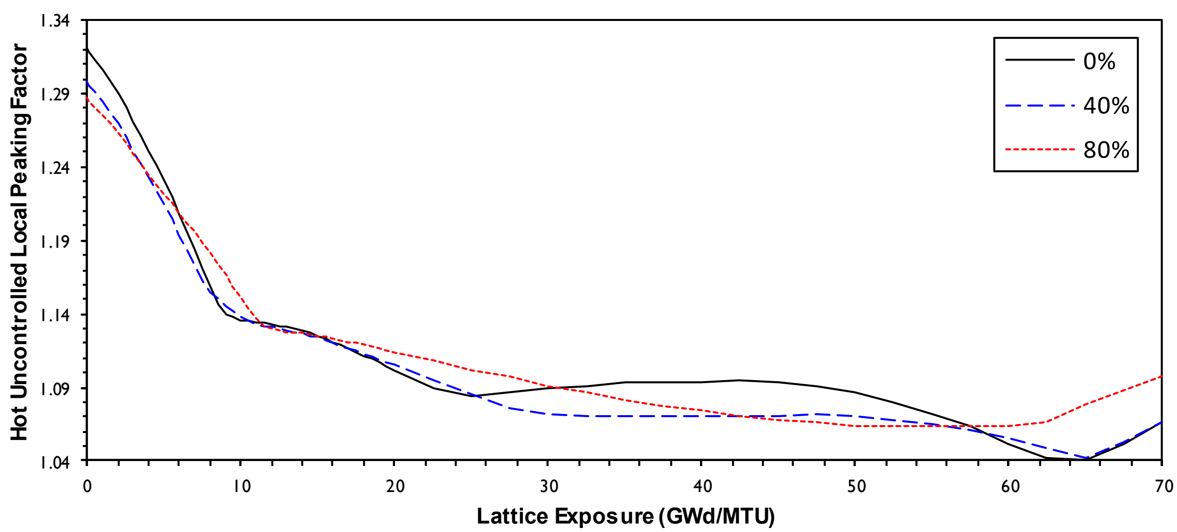

Figure A.40 [ ] Hot Uncontrolled LPF

Appendix B Enriched Lattice Hot Uncontrolled Reactivity and LPF Tables

The results in this appendix are based on hot operating and equilibrium xenon conditions.

Table B.1 [ ] Hot Uncontrolled k_∞

Exposure MWd/MTU	0.00 Void History	0.40 Void History	0.80 Void History
0.	1.05361	1.03109	1.00588
100.	1.02989	1.00933	0.98671
500.	1.02809	1.00849	0.98690
1000.	1.02994	1.01105	0.99002
1500.	1.03300	1.01461	0.99379
2000.	1.03638	1.01837	0.99763
2500.	1.03981	1.02213	1.00135
3000.	1.04330	1.02584	1.00494
3500.	1.04688	1.02956	1.00843
4000.	1.05060	1.03332	1.01187
4500.	1.05451	1.03719	1.01532
5000.	1.05863	1.04120	1.01879
5500.	1.06295	1.04533	1.02232
6000.	1.06747	1.04960	1.02592
6500.	1.07216	1.05400	1.02959
7000.	1.07706	1.05854	1.03333
7500.	1.08217	1.06322	1.03715
8000.	1.08754	1.06806	1.04108
8500.	1.09319	1.07310	1.04512
9000.	1.09915	1.07835	1.04928
9500.	1.10543	1.08378	1.05352
10000.	1.11195	1.08929	1.05775
10500.	1.11853	1.09475	1.06186
11000.	1.12499	1.10008	1.06581
11500.	1.13115	1.10516	1.06956
12000.	1.13693	1.10994	1.07310
12500.	1.14243	1.11448	1.07644
13000.	1.14776	1.11887	1.07962
13500.	1.15291	1.12311	1.08265
14000.	1.15782	1.12711	1.08553
14500.	1.16237	1.13078	1.08818
15000.	1.16637	1.13402	1.09055
15500.	1.16959	1.13674	1.09259
16000.	1.17181	1.13884	1.09425
16500.	1.17295	1.14026	1.09549
17000.	1.17303	1.14097	1.09631
17500.	1.17208	1.14099	1.09674
18000.	1.17022	1.14034	1.09678
18500.	1.16760	1.13905	1.09645
19000.	1.16440	1.13718	1.09573
19500.	1.16076	1.13480	1.09464
20000.	1.15680	1.13198	1.09319
20500.	1.15262	1.12880	1.09141
21000.	1.14830	1.12534	1.08933
21500.	1.14376	1.12168	1.08698
22000.	1.13923	1.11788	1.08439
22500.	1.13469	1.11398	1.08160
23000.	1.13019	1.10996	1.07864
23500.	1.12568	1.10594	1.07553
24000.	1.12118	1.10192	1.07231
24500.	1.11667	1.09790	1.06902
25000.	1.11217	1.09388	1.06567
25500.	1.10769	1.08992	1.06229
27500.	1.08977	1.07410	1.04858
30000.	1.06741	1.05460	1.03182
32500.	1.04510	1.03542	1.01547
35000.	1.02284	1.01654	0.99959
37500.	1.00066	0.99798	0.98417
40000.	0.97863	0.97976	0.96924
42500.	0.95681	0.96193	0.95479
45000.	0.93530	0.94451	0.94086
47500.	0.91422	0.92755	0.92746
50000.	0.89369	0.91111	0.91459
52500.	0.87384	0.89525	0.90228
55000.	0.85481	0.88001	0.89054
57500.	0.83672	0.86546	0.87936
60000.	0.81971	0.85163	0.86876
62500.	0.80387	0.83856	0.85874
65000.	0.78929	0.82629	0.84929
67500.	0.77601	0.81484	0.84041
70000.	0.76405	0.80422	0.83207

Table B.2 [ ] Hot Uncontrolled LPF

Exposure MWd/MTU	0.00 Void History	0.40 Void History	0.80 Void History
0.	1.375	1.363	1.358
100.	1.370	1.358	1.356
500.	1.365	1.353	1.353
1000.	1.358	1.347	1.349
1500.	1.350	1.340	1.345
2000.	1.342	1.333	1.341
2500.	1.334	1.326	1.337
3000.	1.326	1.320	1.332
3500.	1.318	1.314	1.327
4000.	1.309	1.308	1.323
4500.	1.300	1.302	1.318
5000.	1.291	1.296	1.313
5500.	1.282	1.290	1.309
6000.	1.273	1.284	1.304
6500.	1.264	1.277	1.299
7000.	1.255	1.271	1.295
7500.	1.246	1.265	1.290
8000.	1.237	1.259	1.285
8500.	1.228	1.253	1.281
9000.	1.219	1.248	1.276
9500.	1.211	1.242	1.272
10000.	1.204	1.236	1.267
10500.	1.197	1.229	1.262
11000.	1.189	1.222	1.256
11500.	1.179	1.213	1.249
12000.	1.168	1.202	1.242
12500.	1.155	1.192	1.234
13000.	1.142	1.180	1.225
13500.	1.136	1.169	1.216
14000.	1.131	1.158	1.208
14500.	1.126	1.147	1.199
15000.	1.120	1.142	1.191
15500.	1.116	1.138	1.183
16000.	1.111	1.134	1.175
16500.	1.107	1.130	1.168
17000.	1.104	1.126	1.161
17500.	1.101	1.121	1.157
18000.	1.099	1.118	1.153
18500.	1.099	1.114	1.150
19000.	1.098	1.110	1.147
19500.	1.098	1.107	1.143
20000.	1.098	1.104	1.140
20500.	1.097	1.102	1.138
21000.	1.097	1.099	1.135
21500.	1.096	1.097	1.133
22000.	1.096	1.095	1.130
22500.	1.095	1.093	1.128
23000.	1.095	1.092	1.126
23500.	1.094	1.091	1.124
24000.	1.094	1.090	1.122
24500.	1.093	1.089	1.121
25000.	1.093	1.088	1.119
25500.	1.092	1.088	1.117
27500.	1.089	1.086	1.112
30000.	1.086	1.084	1.105
32500.	1.083	1.082	1.098
35000.	1.079	1.080	1.092
37500.	1.075	1.077	1.090
40000.	1.071	1.075	1.088
42500.	1.067	1.072	1.094
45000.	1.062	1.069	1.103
47500.	1.058	1.067	1.113
50000.	1.056	1.064	1.124
52500.	1.056	1.061	1.135
55000.	1.055	1.058	1.147
57500.	1.052	1.055	1.158
60000.	1.047	1.071	1.170
62500.	1.047	1.087	1.182
65000.	1.067	1.102	1.193
67500.	1.085	1.117	1.204
70000.	1.103	1.131	1.215

Table B.3 [ ] Hot Uncontrolled k_∞

Exposure MWd/MTU	0.00 Void History	0.40 Void History	0.80 Void History
0.	1.10131	1.07685	1.04868
100.	1.07540	1.05292	1.02741
500.	1.07233	1.05077	1.02625
1000.	1.07275	1.05187	1.02790
1500.	1.07439	1.05399	1.03027
2000.	1.07632	1.05632	1.03274
2500.	1.07833	1.05866	1.03512
3000.	1.08038	1.06097	1.03741
3500.	1.08251	1.06329	1.03962
4000.	1.08474	1.06564	1.04180
4500.	1.08709	1.06807	1.04397
5000.	1.08959	1.07059	1.04618
5500.	1.09224	1.07321	1.04842
6000.	1.09504	1.07592	1.05072
6500.	1.09798	1.07875	1.05307
7000.	1.10106	1.08169	1.05549
7500.	1.10430	1.08474	1.05799
8000.	1.10772	1.08792	1.06058
8500.	1.11134	1.09124	1.06327
9000.	1.11518	1.09472	1.06605
9500.	1.11926	1.09834	1.06889
10000.	1.12353	1.10203	1.07171
10500.	1.12783	1.10563	1.07440
11000.	1.13205	1.10909	1.07690
11500.	1.13614	1.11235	1.07921
12000.	1.14008	1.11544	1.08132
12500.	1.14401	1.11846	1.08331
13000.	1.14808	1.12153	1.08524
13500.	1.15236	1.12470	1.08719
14000.	1.15681	1.12797	1.08914
14500.	1.16123	1.13119	1.09108
15000.	1.16537	1.13424	1.09291
15500.	1.16895	1.13698	1.09457
16000.	1.17171	1.13926	1.09601
16500.	1.17347	1.14096	1.09717
17000.	1.17416	1.14199	1.09799
17500.	1.17378	1.14236	1.09846
18000.	1.17242	1.14204	1.09859
18500.	1.17023	1.14108	1.09836
19000.	1.16738	1.13952	1.09778
19500.	1.16402	1.13741	1.09684
20000.	1.16028	1.13483	1.09555
20500.	1.15627	1.13186	1.09391
21000.	1.15206	1.12857	1.09197
21500.	1.14773	1.12504	1.08976
22000.	1.14321	1.12133	1.08729
22500.	1.13869	1.11750	1.08461
23000.	1.13419	1.11360	1.08173
23500.	1.12968	1.10958	1.07870
24000.	1.12518	1.10556	1.07555
24500.	1.12067	1.10153	1.07230
25000.	1.11617	1.09751	1.06899
25500.	1.11170	1.09355	1.06563
26000.	1.10723	1.08960	1.06224
27500.	1.09382	1.07773	1.05195
30000.	1.07151	1.05825	1.03516
32500.	1.04924	1.03906	1.01877
35000.	1.02702	1.02018	1.00284
37500.	1.00488	1.00161	0.98738
40000.	0.98286	0.98337	0.97239
42500.	0.96105	0.96550	0.95788
45000.	0.93953	0.94804	0.94388
47500.	0.91841	0.93104	0.93040
50000.	0.89781	0.91453	0.91745
52500.	0.87786	0.89859	0.90506
55000.	0.85869	0.88326	0.89323
57500.	0.84045	0.86860	0.88197
60000.	0.82325	0.85465	0.87127
62500.	0.80720	0.84145	0.86115
65000.	0.79238	0.82905	0.85161
67500.	0.77887	0.81746	0.84263
70000.	0.76666	0.80669	0.83420

Table B.4 [ ] Hot Uncontrolled LPF

Exposure MWd/MTU	0.00 Void History	0.40 Void History	0.80 Void History
0.	1.357	1.345	1.339
100.	1.352	1.340	1.337
500.	1.347	1.335	1.334
1000.	1.341	1.330	1.331
1500.	1.334	1.324	1.328
2000.	1.327	1.317	1.324
2500.	1.319	1.311	1.320
3000.	1.311	1.304	1.316
3500.	1.304	1.297	1.312
4000.	1.296	1.292	1.308
4500.	1.288	1.287	1.304
5000.	1.280	1.281	1.300
5500.	1.271	1.276	1.296
6000.	1.263	1.271	1.292
6500.	1.255	1.265	1.288
7000.	1.246	1.260	1.283
7500.	1.238	1.255	1.279
8000.	1.229	1.249	1.275
8500.	1.221	1.244	1.271
9000.	1.213	1.240	1.267
9500.	1.205	1.235	1.263
10000.	1.200	1.230	1.259
10500.	1.194	1.224	1.255
11000.	1.187	1.217	1.250
11500.	1.178	1.209	1.243
12000.	1.168	1.200	1.236
12500.	1.156	1.190	1.229
13000.	1.144	1.180	1.221
13500.	1.131	1.169	1.213
14000.	1.118	1.158	1.204
14500.	1.114	1.147	1.196
15000.	1.111	1.139	1.188
15500.	1.107	1.136	1.180
16000.	1.103	1.132	1.172
16500.	1.100	1.128	1.165
17000.	1.098	1.124	1.158
17500.	1.098	1.120	1.154
18000.	1.097	1.116	1.151
18500.	1.097	1.113	1.148
19000.	1.096	1.109	1.145
19500.	1.096	1.106	1.141
20000.	1.096	1.103	1.138
20500.	1.096	1.100	1.136
21000.	1.095	1.098	1.133
21500.	1.095	1.095	1.130
22000.	1.095	1.093	1.128
22500.	1.094	1.091	1.126
23000.	1.093	1.089	1.124
23500.	1.093	1.088	1.122
24000.	1.092	1.087	1.120
24500.	1.092	1.087	1.118
25000.	1.091	1.086	1.117
25500.	1.090	1.086	1.115
26000.	1.090	1.085	1.113
27500.	1.088	1.084	1.109
30000.	1.084	1.082	1.102
32500.	1.081	1.080	1.096
35000.	1.077	1.077	1.090
37500.	1.074	1.075	1.085
40000.	1.069	1.073	1.082
42500.	1.065	1.070	1.090
45000.	1.061	1.068	1.100
47500.	1.057	1.065	1.110
50000.	1.053	1.062	1.120
52500.	1.054	1.059	1.131
55000.	1.053	1.056	1.143
57500.	1.051	1.054	1.155
60000.	1.047	1.067	1.166
62500.	1.042	1.082	1.178
65000.	1.062	1.098	1.190
67500.	1.081	1.113	1.201
70000.	1.098	1.127	1.212

Table B.5 [ ] Hot Uncontrolled k_∞

Exposure MWd/MTU	0.00 Void History	0.40 Void History	0.80 Void History
0.	1.07128	1.05132	1.02705
100.	1.04540	1.02725	1.00552
500.	1.04260	1.02537	1.00464
1000.	1.04347	1.02697	1.00684
1500.	1.04573	1.02979	1.00996
2000.	1.04841	1.03294	1.01329
2500.	1.05125	1.03619	1.01661
3000.	1.05425	1.03950	1.01989
3500.	1.05740	1.04290	1.02315
4000.	1.06075	1.04641	1.02642
4500.	1.06431	1.05007	1.02975
5000.	1.06810	1.05388	1.03315
5500.	1.07210	1.05785	1.03662
6000.	1.07629	1.06198	1.04017
6500.	1.08068	1.06625	1.04380
7000.	1.08528	1.07069	1.04755
7500.	1.09012	1.07530	1.05141
8000.	1.09523	1.08011	1.05541
8500.	1.10065	1.08514	1.05954
9000.	1.10640	1.09039	1.06379
9500.	1.11243	1.09577	1.06805
10000.	1.11853	1.10106	1.07217
10500.	1.12457	1.10617	1.07607
11000.	1.13043	1.11103	1.07972
11500.	1.13614	1.11567	1.08312
12000.	1.14189	1.12028	1.08638
12500.	1.14789	1.12502	1.08962
13000.	1.15423	1.12999	1.09290
13500.	1.16078	1.13509	1.09624
14000.	1.16719	1.14014	1.09955
14500.	1.17310	1.14498	1.10274
15000.	1.17808	1.14936	1.10573
15500.	1.18177	1.15304	1.10842
16000.	1.18402	1.15581	1.11071
16500.	1.18484	1.15764	1.11254
17000.	1.18439	1.15855	1.11391
17500.	1.18288	1.15853	1.11481
18000.	1.18055	1.15764	1.11522
18500.	1.17761	1.15595	1.11512
19000.	1.17419	1.15362	1.11450
19500.	1.17039	1.15076	1.11339
20000.	1.16628	1.14750	1.11182
20500.	1.16195	1.14393	1.10983
21000.	1.15746	1.14014	1.10748
21500.	1.15272	1.13618	1.10480
22000.	1.14797	1.13211	1.10186
22500.	1.14323	1.12790	1.09870
23000.	1.13849	1.12365	1.09538
23500.	1.13375	1.11940	1.09194
24000.	1.12900	1.11516	1.08841
24500.	1.12426	1.11091	1.08484
25000.	1.11952	1.10666	1.08118
27500.	1.09576	1.08570	1.06296
30000.	1.07179	1.06486	1.04513
32500.	1.04763	1.04414	1.02765
35000.	1.02327	1.02355	1.01053
37500.	0.99877	1.00310	0.99378
40000.	0.97418	0.98284	0.97741
42500.	0.94960	0.96281	0.96145
45000.	0.92518	0.94307	0.94593
47500.	0.90107	0.92369	0.93088
50000.	0.87747	0.90476	0.91633
52500.	0.85459	0.88639	0.90233
55000.	0.83265	0.86866	0.88888
57500.	0.81188	0.85169	0.87602
60000.	0.79247	0.83555	0.86377
62500.	0.77462	0.82034	0.85215
65000.	0.75843	0.80613	0.84117
67500.	0.74399	0.79296	0.83085
70000.	0.73127	0.78087	0.82117

Table B.6 [ ] Hot Uncontrolled LPF

Exposure MWd/MTU	0.00 Void History	0.40 Void History	0.80 Void History
0.	1.364	1.326	1.329
100.	1.359	1.324	1.327
500.	1.354	1.320	1.324
1000.	1.348	1.316	1.322
1500.	1.341	1.311	1.318
2000.	1.334	1.306	1.314
2500.	1.327	1.301	1.310
3000.	1.320	1.295	1.306
3500.	1.313	1.290	1.302
4000.	1.306	1.284	1.297
4500.	1.298	1.279	1.293
5000.	1.291	1.273	1.288
5500.	1.283	1.267	1.284
6000.	1.275	1.261	1.279
6500.	1.267	1.255	1.274
7000.	1.259	1.249	1.270
7500.	1.251	1.243	1.265
8000.	1.243	1.238	1.261
8500.	1.235	1.232	1.256
9000.	1.227	1.227	1.252
9500.	1.219	1.222	1.247
10000.	1.210	1.215	1.242
10500.	1.202	1.208	1.236
11000.	1.193	1.199	1.229
11500.	1.185	1.188	1.221
12000.	1.176	1.176	1.212
12500.	1.167	1.164	1.203
13000.	1.158	1.154	1.194
13500.	1.149	1.150	1.191
14000.	1.140	1.145	1.187
14500.	1.132	1.141	1.183
15000.	1.124	1.135	1.179
15500.	1.118	1.130	1.175
16000.	1.112	1.124	1.170
16500.	1.107	1.118	1.165
17000.	1.104	1.112	1.161
17500.	1.102	1.106	1.156
18000.	1.101	1.101	1.151
18500.	1.099	1.097	1.146
19000.	1.098	1.093	1.142
19500.	1.096	1.089	1.138
20000.	1.095	1.088	1.135
20500.	1.094	1.087	1.131
21000.	1.093	1.086	1.128
21500.	1.092	1.085	1.125
22000.	1.092	1.085	1.122
22500.	1.091	1.084	1.120
23000.	1.090	1.084	1.118
23500.	1.089	1.083	1.115
24000.	1.089	1.083	1.113
24500.	1.088	1.082	1.111
25000.	1.087	1.082	1.109
27500.	1.085	1.079	1.100
30000.	1.085	1.076	1.092
32500.	1.084	1.074	1.084
35000.	1.082	1.072	1.081
37500.	1.080	1.070	1.080
40000.	1.076	1.068	1.078
42500.	1.072	1.066	1.076
45000.	1.067	1.063	1.074
47500.	1.068	1.060	1.072
50000.	1.068	1.057	1.070
52500.	1.067	1.054	1.068
55000.	1.064	1.051	1.069
57500.	1.059	1.048	1.073
60000.	1.054	1.045	1.077
62500.	1.049	1.042	1.085
65000.	1.042	1.040	1.096
67500.	1.044	1.054	1.107
70000.	1.062	1.069	1.117

Table B.7 [ ] Hot Uncontrolled k_∞

Exposure MWd/MTU	0.00 Void History	0.40 Void History	0.80 Void History
0.	1.06997	1.04983	1.02478
100.	1.04391	1.02557	1.00310
500.	1.04089	1.02351	1.00209
1000.	1.04148	1.02491	1.00414
1500.	1.04345	1.02752	1.00711
2000.	1.04583	1.03046	1.01028
2500.	1.04837	1.03351	1.01346
3000.	1.05108	1.03663	1.01662
3500.	1.05397	1.03985	1.01978
4000.	1.05707	1.04321	1.02298
4500.	1.06033	1.04669	1.02622
5000.	1.06377	1.05027	1.02951
5500.	1.06738	1.05397	1.03283
6000.	1.07120	1.05780	1.03620
6500.	1.07523	1.06180	1.03965
7000.	1.07949	1.06597	1.04320
7500.	1.08403	1.07036	1.04688
8000.	1.08888	1.07499	1.05072
8500.	1.09407	1.07989	1.05471
9000.	1.09961	1.08500	1.05883
9500.	1.10528	1.09008	1.06290
10000.	1.11086	1.09497	1.06675
10500.	1.11619	1.09957	1.07034
11000.	1.12118	1.10384	1.07363
11500.	1.12599	1.10794	1.07669
12000.	1.13091	1.11207	1.07963
12500.	1.13614	1.11636	1.08256
13000.	1.14172	1.12083	1.08555
13500.	1.14750	1.12534	1.08857
14000.	1.15332	1.12980	1.09154
14500.	1.15903	1.13414	1.09437
15000.	1.16436	1.13822	1.09704
15500.	1.16908	1.14196	1.09952
16000.	1.17299	1.14535	1.10176
16500.	1.17599	1.14829	1.10374
17000.	1.17803	1.15070	1.10547
17500.	1.17900	1.15249	1.10694
18000.	1.17879	1.15361	1.10816
18500.	1.17748	1.15394	1.10910
19000.	1.17529	1.15341	1.10970
19500.	1.17243	1.15204	1.10989
20000.	1.16904	1.14993	1.10962
20500.	1.16523	1.14723	1.10887
21000.	1.16107	1.14407	1.10764
21500.	1.15666	1.14054	1.10597
22000.	1.15189	1.13675	1.10390
22500.	1.14711	1.13276	1.10146
23000.	1.14225	1.12865	1.09871
23500.	1.13739	1.12432	1.09569
24000.	1.13253	1.11999	1.09246
24500.	1.12767	1.11566	1.08907
25000.	1.12281	1.11133	1.08558
25500.	1.11794	1.10705	1.08202
27500.	1.09845	1.08993	1.06733
30000.	1.07387	1.06866	1.04929
32500.	1.04907	1.04750	1.03160
35000.	1.02405	1.02646	1.01426
37500.	0.99887	1.00554	0.99730
40000.	0.97360	0.98481	0.98072
42500.	0.94836	0.96430	0.96456
45000.	0.92328	0.94408	0.94884
47500.	0.89857	0.92425	0.93360
50000.	0.87442	0.90489	0.91888
52500.	0.85107	0.88611	0.90470
55000.	0.82876	0.86802	0.89109
57500.	0.80774	0.85072	0.87807
60000.	0.78820	0.83432	0.86568
62500.	0.77034	0.81891	0.85393
65000.	0.75426	0.80455	0.84285
67500.	0.74003	0.79129	0.83243
70000.	0.72760	0.77918	0.82268

Table B.8 [ ] Hot Uncontrolled LPF

Exposure MWd/MTU	0.00 Void History	0.40 Void History	0.80 Void History
0.	1.370	1.347	1.342
100.	1.366	1.345	1.341
500.	1.361	1.342	1.339
1000.	1.355	1.338	1.337
1500.	1.349	1.334	1.334
2000.	1.343	1.329	1.330
2500.	1.336	1.324	1.327
3000.	1.329	1.319	1.323
3500.	1.322	1.314	1.319
4000.	1.315	1.308	1.314
4500.	1.308	1.303	1.310
5000.	1.300	1.297	1.305
5500.	1.293	1.292	1.301
6000.	1.285	1.286	1.296
6500.	1.278	1.280	1.292
7000.	1.270	1.275	1.287
7500.	1.262	1.269	1.283
8000.	1.255	1.264	1.279
8500.	1.247	1.259	1.274
9000.	1.239	1.254	1.270
9500.	1.230	1.249	1.266
10000.	1.222	1.242	1.260
10500.	1.214	1.233	1.254
11000.	1.206	1.223	1.246
11500.	1.197	1.211	1.238
12000.	1.189	1.199	1.229
12500.	1.180	1.187	1.219
13000.	1.172	1.183	1.214
13500.	1.163	1.178	1.210
14000.	1.154	1.173	1.207
14500.	1.146	1.167	1.202
15000.	1.139	1.161	1.198
15500.	1.132	1.154	1.193
16000.	1.125	1.146	1.188
16500.	1.119	1.139	1.183
17000.	1.114	1.131	1.177
17500.	1.112	1.124	1.172
18000.	1.110	1.117	1.166
18500.	1.108	1.110	1.161
19000.	1.106	1.105	1.155
19500.	1.105	1.099	1.150
20000.	1.103	1.094	1.146
20500.	1.104	1.092	1.141
21000.	1.105	1.091	1.137
21500.	1.106	1.091	1.133
22000.	1.106	1.091	1.130
22500.	1.106	1.091	1.127
23000.	1.106	1.091	1.124
23500.	1.106	1.091	1.121
24000.	1.106	1.090	1.118
24500.	1.106	1.090	1.116
25000.	1.106	1.090	1.113
25500.	1.106	1.090	1.111
27500.	1.104	1.089	1.103
30000.	1.102	1.086	1.094
32500.	1.099	1.083	1.087
35000.	1.095	1.080	1.085
37500.	1.090	1.076	1.083
40000.	1.084	1.073	1.081
42500.	1.078	1.070	1.079
45000.	1.074	1.067	1.077
47500.	1.075	1.064	1.075
50000.	1.074	1.060	1.072
52500.	1.071	1.057	1.070
55000.	1.067	1.054	1.069
57500.	1.063	1.050	1.073
60000.	1.056	1.047	1.078
62500.	1.049	1.044	1.089
65000.	1.041	1.047	1.100
67500.	1.058	1.063	1.111
70000.	1.076	1.078	1.121

Table B.9 [ ] Hot Uncontrolled k_∞

Exposure MWd/MTU	0.00 Void History	0.40 Void History	0.80 Void History
0.	1.04533	1.02698	1.00264
100.	1.01948	1.00284	0.98102
500.	1.01663	1.00097	0.98027
1000.	1.01744	1.00266	0.98273
1500.	1.01968	1.00561	0.98615
2000.	1.02235	1.00892	0.98980
2500.	1.02519	1.01234	0.99347
3000.	1.02822	1.01584	0.99711
3500.	1.03145	1.01947	1.00077
4000.	1.03491	1.02326	1.00448
4500.	1.03856	1.02718	1.00824
5000.	1.04242	1.03123	1.01205
5500.	1.04649	1.03543	1.01590
6000.	1.05079	1.03978	1.01982
6500.	1.05532	1.04431	1.02383
7000.	1.06010	1.04904	1.02795
7500.	1.06517	1.05399	1.03221
8000.	1.07055	1.05919	1.03663
8500.	1.07628	1.06467	1.04122
9000.	1.08239	1.07041	1.04597
9500.	1.08881	1.07627	1.05073
10000.	1.09529	1.08203	1.05532
10500.	1.10169	1.08758	1.05967
11000.	1.10787	1.09286	1.06375
11500.	1.11384	1.09790	1.06757
12000.	1.11986	1.10292	1.07125
12500.	1.12621	1.10810	1.07492
13000.	1.13308	1.11355	1.07866
13500.	1.14048	1.11928	1.08248
14000.	1.14816	1.12516	1.08631
14500.	1.15565	1.13108	1.09007
15000.	1.16249	1.13687	1.09373
15500.	1.16821	1.14226	1.09724
16000.	1.17238	1.14693	1.10055
16500.	1.17486	1.15069	1.10359
17000.	1.17586	1.15344	1.10629
17500.	1.17570	1.15516	1.10859
18000.	1.17464	1.15579	1.11047
18500.	1.17282	1.15535	1.11185
19000.	1.17035	1.15398	1.11268
19500.	1.16734	1.15186	1.11290
20000.	1.16386	1.14920	1.11248
20500.	1.15995	1.14609	1.11143
21000.	1.15568	1.14263	1.10979
21500.	1.15113	1.13887	1.10766
22000.	1.14620	1.13489	1.10511
22500.	1.14127	1.13073	1.10222
23000.	1.13623	1.12628	1.09906
23500.	1.13119	1.12183	1.09570
24000.	1.12616	1.11738	1.09219
24500.	1.12112	1.11293	1.08857
25000.	1.11608	1.10848	1.08488
27500.	1.09072	1.08636	1.06591
30000.	1.06497	1.06421	1.04731
32500.	1.03884	1.04205	1.02899
35000.	1.01233	1.01989	1.01098
37500.	0.98551	0.99775	0.99328
40000.	0.95848	0.97568	0.97591
42500.	0.93138	0.95376	0.95891
45000.	0.90441	0.93206	0.94232
47500.	0.87783	0.91072	0.92617
50000.	0.85190	0.88986	0.91053
52500.	0.82696	0.86962	0.89542
55000.	0.80330	0.85015	0.88090
57500.	0.78125	0.83160	0.86700
60000.	0.76106	0.81412	0.85376
62500.	0.74293	0.79781	0.84122
65000.	0.72695	0.78277	0.82941
67500.	0.71311	0.76906	0.81833
70000.	0.70132	0.75671	0.80801

Table B.10 [ ] Hot Uncontrolled LPF

Exposure MWd/MTU	0.00 Void History	0.40 Void History	0.80 Void History
0.	1.469	1.405	1.323
100.	1.465	1.401	1.317
500.	1.460	1.395	1.313
1000.	1.453	1.389	1.309
1500.	1.445	1.383	1.305
2000.	1.438	1.376	1.302
2500.	1.430	1.369	1.297
3000.	1.421	1.362	1.293
3500.	1.413	1.355	1.289
4000.	1.404	1.348	1.284
4500.	1.396	1.341	1.279
5000.	1.387	1.333	1.275
5500.	1.378	1.326	1.270
6000.	1.369	1.318	1.265
6500.	1.360	1.311	1.260
7000.	1.350	1.304	1.256
7500.	1.341	1.296	1.251
8000.	1.332	1.289	1.246
8500.	1.322	1.281	1.242
9000.	1.312	1.273	1.237
9500.	1.302	1.266	1.233
10000.	1.293	1.258	1.227
10500.	1.283	1.250	1.221
11000.	1.273	1.243	1.214
11500.	1.262	1.235	1.206
12000.	1.252	1.227	1.201
12500.	1.242	1.219	1.195
13000.	1.231	1.211	1.190
13500.	1.221	1.203	1.184
14000.	1.210	1.195	1.179
14500.	1.199	1.187	1.174
15000.	1.189	1.179	1.169
15500.	1.180	1.172	1.164
16000.	1.173	1.165	1.159
16500.	1.170	1.159	1.154
17000.	1.166	1.153	1.150
17500.	1.163	1.148	1.146
18000.	1.159	1.144	1.142
18500.	1.156	1.140	1.138
19000.	1.154	1.138	1.135
19500.	1.151	1.136	1.132
20000.	1.148	1.135	1.129
20500.	1.146	1.133	1.127
21000.	1.144	1.132	1.125
21500.	1.142	1.130	1.124
22000.	1.140	1.129	1.122
22500.	1.138	1.128	1.121
23000.	1.136	1.127	1.120
23500.	1.134	1.126	1.120
24000.	1.133	1.125	1.119
24500.	1.131	1.124	1.118
25000.	1.129	1.123	1.118
27500.	1.120	1.118	1.115
30000.	1.111	1.112	1.112
32500.	1.102	1.107	1.109
35000.	1.093	1.102	1.106
37500.	1.086	1.097	1.103
40000.	1.085	1.091	1.099
42500.	1.086	1.086	1.097
45000.	1.086	1.080	1.094
47500.	1.086	1.075	1.092
50000.	1.083	1.071	1.089
52500.	1.079	1.066	1.086
55000.	1.074	1.064	1.083
57500.	1.068	1.061	1.081
60000.	1.061	1.057	1.078
62500.	1.053	1.055	1.075
65000.	1.044	1.053	1.073
67500.	1.048	1.053	1.084
70000.	1.065	1.063	1.096

Table B.11 [ ] Hot Uncontrolled k∞

Exposure MWd/MTU	0.00 Void History	0.40 Void History	0.80 Void History
0.	1.04034	1.02300	0.99873
100.	1.01434	0.99869	0.97700
500.	1.01163	0.99705	0.97659
1000.	1.01281	0.99921	0.97965
1500.	1.01547	1.00268	0.98368
2000.	1.01855	1.00651	0.98793
2500.	1.02185	1.01048	0.99221
3000.	1.02540	1.01459	0.99648
3500.	1.02921	1.01888	1.00079
4000.	1.03327	1.02335	1.00517
4500.	1.03755	1.02796	1.00960
5000.	1.04208	1.03272	1.01407
5500.	1.04686	1.03767	1.01861
6000.	1.05193	1.04283	1.02323
6500.	1.05730	1.04824	1.02799
7000.	1.06301	1.05391	1.03291
7500.	1.06909	1.05987	1.03802
8000.	1.07558	1.06614	1.04332
8500.	1.08247	1.07272	1.04878
9000.	1.08978	1.07952	1.05431
9500.	1.09736	1.08635	1.05975
10000.	1.10501	1.09305	1.06498
10500.	1.11259	1.09954	1.06995
11000.	1.12004	1.10578	1.07464
11500.	1.12753	1.11192	1.07912
12000.	1.13530	1.11809	1.08347
12500.	1.14337	1.12429	1.08767
13000.	1.15159	1.13049	1.09171
13500.	1.15959	1.13664	1.09556
14000.	1.16683	1.14264	1.09922
14500.	1.17294	1.14833	1.10270
15000.	1.17760	1.15358	1.10602
15500.	1.18063	1.15811	1.10923
16000.	1.18217	1.16170	1.11228
16500.	1.18258	1.16421	1.11509
17000.	1.18209	1.16555	1.11755
17500.	1.18077	1.16569	1.11958
18000.	1.17868	1.16473	1.12107
18500.	1.17595	1.16288	1.12191
19000.	1.17269	1.16038	1.12202
19500.	1.16894	1.15737	1.12139
20000.	1.16475	1.15396	1.12008
20500.	1.16018	1.15020	1.11816
21000.	1.15536	1.14616	1.11573
21500.	1.15013	1.14190	1.11289
22000.	1.14491	1.13733	1.10972
22500.	1.13968	1.13276	1.10631
23000.	1.13441	1.12814	1.10272
23500.	1.12914	1.12351	1.09900
24000.	1.12386	1.11889	1.09521
25000.	1.11332	1.10964	1.08736
27500.	1.08665	1.08659	1.06795
30000.	1.05952	1.06351	1.04892
32500.	1.03193	1.04037	1.03020
35000.	1.00392	1.01720	1.01178
37500.	0.97558	0.99404	0.99369
40000.	0.94706	0.97097	0.97596
42500.	0.91857	0.94807	0.95863
45000.	0.89038	0.92547	0.94173
47500.	0.86280	0.90331	0.92533
50000.	0.83619	0.88176	0.90947
52500.	0.81093	0.86100	0.89420
55000.	0.78737	0.84119	0.87956
57500.	0.76584	0.82251	0.86560
60000.	0.74656	0.80510	0.85236
62500.	0.72965	0.78907	0.83988
65000.	0.71512	0.77451	0.82818
67500.	0.70284	0.76144	0.81727
70000.	0.69263	0.74985	0.80716

Table B.12 [ ] Hot Uncontrolled LPF

Exposure MWd/MTU	0.00 Void History	0.40 Void History	0.80 Void History
0.	1.453	1.375	1.272
100.	1.449	1.371	1.267
500.	1.444	1.365	1.263
1000.	1.436	1.359	1.259
1500.	1.428	1.353	1.254
2000.	1.420	1.346	1.250
2500.	1.411	1.339	1.245
3000.	1.402	1.331	1.240
3500.	1.393	1.324	1.236
4000.	1.383	1.316	1.231
4500.	1.374	1.309	1.226
5000.	1.364	1.301	1.221
5500.	1.354	1.293	1.217
6000.	1.344	1.285	1.212
6500.	1.333	1.277	1.207
7000.	1.323	1.269	1.203
7500.	1.312	1.261	1.198
8000.	1.301	1.253	1.193
8500.	1.290	1.245	1.189
9000.	1.279	1.237	1.184
9500.	1.268	1.228	1.179
10000.	1.257	1.220	1.174
10500.	1.246	1.211	1.169
11000.	1.234	1.203	1.164
11500.	1.223	1.194	1.158
12000.	1.211	1.185	1.153
12500.	1.200	1.177	1.148
13000.	1.188	1.169	1.143
13500.	1.177	1.160	1.138
14000.	1.167	1.153	1.133
14500.	1.157	1.145	1.128
15000.	1.151	1.138	1.124
15500.	1.146	1.131	1.120
16000.	1.142	1.125	1.115
16500.	1.137	1.119	1.111
17000.	1.133	1.114	1.107
17500.	1.129	1.111	1.103
18000.	1.125	1.109	1.100
18500.	1.122	1.106	1.097
19000.	1.119	1.104	1.094
19500.	1.116	1.102	1.092
20000.	1.113	1.101	1.090
20500.	1.111	1.099	1.088
21000.	1.108	1.098	1.087
21500.	1.106	1.096	1.086
22000.	1.103	1.095	1.085
22500.	1.101	1.094	1.084
23000.	1.101	1.093	1.083
23500.	1.101	1.092	1.083
24000.	1.101	1.090	1.083
25000.	1.101	1.088	1.082
27500.	1.103	1.083	1.080
30000.	1.104	1.085	1.078
32500.	1.107	1.085	1.076
35000.	1.108	1.086	1.074
37500.	1.109	1.085	1.072
40000.	1.108	1.086	1.070
42500.	1.106	1.087	1.069
45000.	1.103	1.087	1.068
47500.	1.098	1.086	1.066
50000.	1.093	1.083	1.065
52500.	1.086	1.080	1.064
55000.	1.079	1.075	1.063
57500.	1.070	1.071	1.062
60000.	1.061	1.066	1.061
62500.	1.051	1.059	1.064
65000.	1.049	1.053	1.076
67500.	1.056	1.053	1.087
70000.	1.070	1.068	1.099

Table B.13 [ ] Hot Uncontrolled k_∞

Exposure MWd/MTU	0.00 Void History	0.40 Void History	0.80 Void History
0.	1.10981	1.09611	1.07487
100.	1.08126	1.06908	1.05031
500.	1.07857	1.06722	1.04936
1000.	1.08030	1.06961	1.05216
1500.	1.08368	1.07349	1.05608
2000.	1.08752	1.07772	1.06021
2500.	1.09158	1.08209	1.06430
3000.	1.09588	1.08658	1.06835
3500.	1.10048	1.09124	1.07240
4000.	1.10544	1.09612	1.07649
4500.	1.11080	1.10128	1.08068
5000.	1.11658	1.10673	1.08500
5500.	1.12278	1.11247	1.08947
6000.	1.12939	1.11848	1.09410
6500.	1.13646	1.12480	1.09887
7000.	1.14405	1.13146	1.10381
7500.	1.15224	1.13851	1.10895
8000.	1.16111	1.14598	1.11431
8500.	1.17074	1.15395	1.11994
9000.	1.18115	1.16244	1.12583
9500.	1.19213	1.17143	1.13191
10000.	1.20313	1.18062	1.13799
10500.	1.21318	1.18952	1.14388
11000.	1.22149	1.19750	1.14941
11500.	1.22745	1.20396	1.15438
12000.	1.23086	1.20864	1.15862
12500.	1.23203	1.21147	1.16205
13000.	1.23145	1.21249	1.16463
13500.	1.22956	1.21196	1.16628
14000.	1.22671	1.21019	1.16696
14500.	1.22313	1.20752	1.16670
15000.	1.21900	1.20418	1.16557
15500.	1.21449	1.20036	1.16367
16000.	1.20973	1.19622	1.16113
16500.	1.20460	1.19186	1.15808
17000.	1.19947	1.18736	1.15467
17500.	1.19434	1.18269	1.15099
18000.	1.18917	1.17798	1.14713
18500.	1.18401	1.17328	1.14317
19000.	1.17884	1.16857	1.13914
20000.	1.16851	1.15916	1.13088
22500.	1.14252	1.13591	1.11053
25000.	1.11612	1.11268	1.09062
27500.	1.08925	1.08941	1.07106
30000.	1.06190	1.06610	1.05183
32500.	1.03407	1.04273	1.03290
35000.	1.00582	1.01933	1.01428
37500.	0.97726	0.99595	0.99600
40000.	0.94853	0.97266	0.97808
42500.	0.91985	0.94957	0.96056
45000.	0.89150	0.92680	0.94351
47500.	0.86381	0.90450	0.92696
50000.	0.83715	0.88284	0.91098
52500.	0.81188	0.86201	0.89561
55000.	0.78838	0.84218	0.88090
57500.	0.76695	0.82352	0.86689
60000.	0.74781	0.80616	0.85363
62500.	0.73107	0.79023	0.84115
65000.	0.71672	0.77578	0.82948
67500.	0.70462	0.76285	0.81861
70000.	0.69457	0.75141	0.80856

Table B.14 [ ] Hot Uncontrolled LPF

Exposure MWd/MTU	0.00 Void History	0.40 Void History	0.80 Void History
0.	1.376	1.307	1.225
100.	1.374	1.305	1.228
500.	1.369	1.300	1.227
1000.	1.363	1.295	1.226
1500.	1.356	1.289	1.223
2000.	1.348	1.283	1.219
2500.	1.340	1.277	1.215
3000.	1.332	1.271	1.210
3500.	1.324	1.264	1.205
4000.	1.316	1.258	1.200
4500.	1.307	1.251	1.194
5000.	1.298	1.244	1.188
5500.	1.289	1.237	1.181
6000.	1.279	1.230	1.175
6500.	1.270	1.222	1.168
7000.	1.260	1.215	1.161
7500.	1.249	1.208	1.157
8000.	1.239	1.200	1.153
8500.	1.228	1.192	1.148
9000.	1.218	1.184	1.144
9500.	1.206	1.176	1.139
10000.	1.195	1.168	1.135
10500.	1.185	1.160	1.130
11000.	1.175	1.152	1.125
11500.	1.166	1.145	1.121
12000.	1.158	1.138	1.116
12500.	1.153	1.132	1.111
13000.	1.149	1.127	1.107
13500.	1.145	1.123	1.104
14000.	1.142	1.120	1.100
14500.	1.139	1.117	1.098
15000.	1.136	1.115	1.095
15500.	1.134	1.113	1.094
16000.	1.131	1.111	1.092
16500.	1.129	1.110	1.091
17000.	1.127	1.108	1.090
17500.	1.125	1.107	1.090
18000.	1.123	1.106	1.089
18500.	1.121	1.104	1.089
19000.	1.118	1.103	1.088
20000.	1.114	1.100	1.088
22500.	1.103	1.093	1.086
25000.	1.093	1.087	1.084
27500.	1.093	1.083	1.082
30000.	1.094	1.082	1.080
32500.	1.097	1.080	1.078
35000.	1.098	1.079	1.076
37500.	1.098	1.077	1.074
40000.	1.097	1.076	1.071
42500.	1.095	1.077	1.069
45000.	1.093	1.077	1.067
47500.	1.090	1.076	1.064
50000.	1.085	1.073	1.062
52500.	1.079	1.071	1.061
55000.	1.071	1.068	1.060
57500.	1.063	1.063	1.059
60000.	1.053	1.058	1.058
62500.	1.044	1.052	1.065
65000.	1.046	1.045	1.076
67500.	1.053	1.053	1.087
70000.	1.068	1.067	1.098

Table B.15 [ ] Hot Uncontrolled k_∞

Exposure MWd/MTU	0.00 Void History	0.40 Void History	0.80 Void History
0.	1.04737	1.02488	0.99969
100.	1.02376	1.00321	0.98060
500.	1.02210	1.00254	0.98099
1000.	1.02416	1.00535	0.98438
1500.	1.02743	1.00913	0.98842
2000.	1.03100	1.01311	0.99249
2500.	1.03461	1.01707	0.99644
3000.	1.03828	1.02098	1.00024
3500.	1.04206	1.02490	1.00394
4000.	1.04598	1.02888	1.00759
4500.	1.05010	1.03297	1.01125
5000.	1.05443	1.03719	1.01494
5500.	1.05897	1.04155	1.01868
6000.	1.06371	1.04604	1.02249
6500.	1.06863	1.05067	1.02637
7000.	1.07376	1.05544	1.03033
7500.	1.07912	1.06036	1.03437
8000.	1.08475	1.06545	1.03852
8500.	1.09067	1.07075	1.04278
9000.	1.09691	1.07625	1.04715
9500.	1.10348	1.08194	1.05160
10000.	1.11028	1.08770	1.05603
10500.	1.11712	1.09338	1.06032
11000.	1.12380	1.09893	1.06444
11500.	1.13014	1.10419	1.06835
12000.	1.13611	1.10915	1.07205
12500.	1.14183	1.11388	1.07554
13000.	1.14736	1.11845	1.07886
13500.	1.15264	1.12279	1.08201
14000.	1.15758	1.12681	1.08495
14500.	1.16205	1.13041	1.08760
15000.	1.16580	1.13349	1.08991
15500.	1.16860	1.13595	1.09185
16000.	1.17033	1.13774	1.09335
16500.	1.17098	1.13883	1.09441
17000.	1.17057	1.13924	1.09505
17500.	1.16919	1.13894	1.09531
18000.	1.16695	1.13799	1.09518
18500.	1.16403	1.13643	1.09467
19000.	1.16057	1.13430	1.09377
19500.	1.15672	1.13170	1.09250
20000.	1.15260	1.12868	1.09088
20500.	1.14830	1.12532	1.08893
21000.	1.14375	1.12173	1.08671
21500.	1.13920	1.11795	1.08422
22000.	1.13464	1.11407	1.08151
22500.	1.13009	1.11005	1.07860
23000.	1.12556	1.10601	1.07554
23500.	1.12104	1.10197	1.07235
24000.	1.11651	1.09794	1.06906
24500.	1.11199	1.09390	1.06572
25000.	1.10746	1.08986	1.06233
27500.	1.08492	1.06999	1.04518
30000.	1.06243	1.05043	1.02838
32500.	1.03999	1.03120	1.01203
35000.	1.01762	1.01228	0.99615
37500.	0.99535	0.99369	0.98076
40000.	0.97326	0.97547	0.96586
42500.	0.95141	0.95764	0.95146
45000.	0.92991	0.94025	0.93760
47500.	0.90889	0.92335	0.92427
50000.	0.88845	0.90699	0.91149
52500.	0.86876	0.89124	0.89928
55000.	0.84993	0.87613	0.88764
57500.	0.83209	0.86173	0.87659
60000.	0.81538	0.84808	0.86611
62500.	0.79988	0.83521	0.85622
65000.	0.78567	0.82316	0.84691
67500.	0.77277	0.81194	0.83817
70000.	0.76120	0.80156	0.82999

Table B.16 [ ] Hot Uncontrolled LPF

Exposure MWd/MTU	0.00 Void History	0.40 Void History	0.80 Void History
0.	1.389	1.377	1.371
100.	1.384	1.372	1.369
500.	1.378	1.367	1.365
1000.	1.371	1.360	1.362
1500.	1.363	1.353	1.357
2000.	1.354	1.346	1.353
2500.	1.346	1.338	1.348
3000.	1.337	1.330	1.343
3500.	1.328	1.324	1.338
4000.	1.319	1.317	1.333
4500.	1.310	1.311	1.328
5000.	1.301	1.305	1.323
5500.	1.292	1.298	1.318
6000.	1.282	1.292	1.313
6500.	1.273	1.285	1.308
7000.	1.264	1.279	1.303
7500.	1.254	1.272	1.298
8000.	1.245	1.266	1.293
8500.	1.235	1.260	1.288
9000.	1.226	1.254	1.284
9500.	1.216	1.248	1.279
10000.	1.210	1.242	1.274
10500.	1.202	1.235	1.268
11000.	1.193	1.226	1.262
11500.	1.183	1.217	1.255
12000.	1.171	1.206	1.247
12500.	1.158	1.195	1.238
13000.	1.149	1.183	1.229
13500.	1.144	1.172	1.220
14000.	1.139	1.163	1.211
14500.	1.133	1.159	1.203
15000.	1.128	1.155	1.194
15500.	1.123	1.151	1.186
16000.	1.119	1.146	1.179
16500.	1.116	1.142	1.174
17000.	1.112	1.137	1.171
17500.	1.110	1.132	1.167
18000.	1.107	1.128	1.163
18500.	1.105	1.124	1.159
19000.	1.104	1.120	1.156
19500.	1.102	1.117	1.152
20000.	1.101	1.114	1.149
20500.	1.100	1.111	1.146
21000.	1.099	1.108	1.143
21500.	1.098	1.106	1.141
22000.	1.097	1.103	1.138
22500.	1.096	1.101	1.136
23000.	1.095	1.099	1.134
23500.	1.094	1.098	1.132
24000.	1.093	1.096	1.130
24500.	1.092	1.095	1.128
25000.	1.091	1.093	1.126
27500.	1.086	1.090	1.118
30000.	1.083	1.087	1.110
32500.	1.079	1.083	1.103
35000.	1.076	1.080	1.098
37500.	1.072	1.077	1.096
40000.	1.069	1.073	1.094
42500.	1.065	1.070	1.099
45000.	1.061	1.066	1.108
47500.	1.059	1.064	1.118
50000.	1.060	1.061	1.129
52500.	1.060	1.059	1.140
55000.	1.057	1.057	1.151
57500.	1.054	1.061	1.163
60000.	1.048	1.077	1.175
62500.	1.053	1.092	1.186
65000.	1.073	1.107	1.198
67500.	1.091	1.122	1.209
70000.	1.108	1.136	1.219

Table B.17 [ ] Hot Uncontrolled k_∞

Exposure MWd/MTU	0.00 Void History	0.40 Void History	0.80 Void History
0.	1.09645	1.07204	1.04396
100.	1.07061	1.04817	1.02275
500.	1.06765	1.04615	1.02174
1000.	1.06823	1.04743	1.02358
1500.	1.07001	1.04972	1.02614
2000.	1.07209	1.05220	1.02878
2500.	1.07423	1.05469	1.03133
3000.	1.07642	1.05716	1.03377
3500.	1.07868	1.05962	1.03614
4000.	1.08105	1.06213	1.03846
4500.	1.08355	1.06471	1.04080
5000.	1.08621	1.06738	1.04316
5500.	1.08901	1.07016	1.04556
6000.	1.09196	1.07304	1.04801
6500.	1.09506	1.07603	1.05051
7000.	1.09831	1.07913	1.05308
7500.	1.10172	1.08235	1.05574
8000.	1.10531	1.08570	1.05849
8500.	1.10910	1.08920	1.06133
9000.	1.11314	1.09285	1.06427
9500.	1.11742	1.09666	1.06726
10000.	1.12188	1.10051	1.07021
10500.	1.12636	1.10427	1.07302
11000.	1.13077	1.10790	1.07565
11500.	1.13506	1.11133	1.07808
12000.	1.13923	1.11461	1.08032
12500.	1.14341	1.11784	1.08246
13000.	1.14778	1.12113	1.08455
13500.	1.15233	1.12451	1.08664
14000.	1.15693	1.12788	1.08871
14500.	1.16138	1.13114	1.09071
15000.	1.16542	1.13414	1.09254
15500.	1.16874	1.13673	1.09417
16000.	1.17110	1.13878	1.09553
16500.	1.17243	1.14022	1.09656
17000.	1.17269	1.14098	1.09723
17500.	1.17193	1.14108	1.09756
18000.	1.17025	1.14052	1.09755
18500.	1.16779	1.13932	1.09719
19000.	1.16472	1.13755	1.09647
19500.	1.16117	1.13526	1.09539
20000.	1.15728	1.13252	1.09396
20500.	1.15315	1.12940	1.09221
21000.	1.14885	1.12599	1.09015
21500.	1.14432	1.12236	1.08783
22000.	1.13980	1.11857	1.08527
22500.	1.13527	1.11469	1.08249
23000.	1.13076	1.11067	1.07954
23500.	1.12625	1.10665	1.07644
24000.	1.12173	1.10263	1.07323
24500.	1.11722	1.09861	1.06994
25000.	1.11271	1.09459	1.06659
25500.	1.10822	1.09063	1.06321
27500.	1.09028	1.07477	1.04949
30000.	1.06790	1.05525	1.03269
32500.	1.04556	1.03603	1.01631
35000.	1.02328	1.01713	1.00040
37500.	1.00110	0.99856	0.98496
40000.	0.97907	0.98033	0.97000
42500.	0.95725	0.96249	0.95553
45000.	0.93576	0.94506	0.94159
47500.	0.91470	0.92811	0.92817
50000.	0.89418	0.91167	0.91530
52500.	0.87435	0.89582	0.90298
55000.	0.85534	0.88059	0.89124
57500.	0.83729	0.86605	0.88006
60000.	0.82030	0.85223	0.86946
62500.	0.80449	0.83918	0.85944
65000.	0.78993	0.82693	0.84999
67500.	0.77667	0.81550	0.84112
70000.	0.76473	0.80490	0.83279

Table B.18 [ ] Hot Uncontrolled LPF

Exposure MWd/MTU	0.00 Void History	0.40 Void History	0.80 Void History
0.	1.367	1.355	1.349
100.	1.362	1.350	1.346
500.	1.356	1.345	1.343
1000.	1.350	1.339	1.340
1500.	1.343	1.333	1.336
2000.	1.335	1.326	1.332
2500.	1.327	1.319	1.328
3000.	1.320	1.312	1.324
3500.	1.312	1.305	1.320
4000.	1.303	1.298	1.315
4500.	1.295	1.293	1.311
5000.	1.287	1.287	1.306
5500.	1.278	1.282	1.302
6000.	1.270	1.276	1.298
6500.	1.261	1.271	1.293
7000.	1.252	1.265	1.289
7500.	1.244	1.260	1.285
8000.	1.235	1.254	1.280
8500.	1.226	1.249	1.276
9000.	1.218	1.244	1.272
9500.	1.209	1.239	1.268
10000.	1.204	1.234	1.264
10500.	1.197	1.228	1.259
11000.	1.190	1.221	1.253
11500.	1.181	1.212	1.247
12000.	1.170	1.203	1.240
12500.	1.158	1.192	1.232
13000.	1.145	1.181	1.224
13500.	1.136	1.170	1.215
14000.	1.133	1.159	1.207
14500.	1.129	1.156	1.198
15000.	1.125	1.152	1.190
15500.	1.121	1.148	1.182
16000.	1.116	1.144	1.174
16500.	1.111	1.140	1.170
17000.	1.107	1.135	1.167
17500.	1.104	1.130	1.163
18000.	1.103	1.126	1.160
18500.	1.103	1.122	1.156
19000.	1.103	1.118	1.153
19500.	1.102	1.115	1.149
20000.	1.102	1.111	1.146
20500.	1.102	1.108	1.143
21000.	1.101	1.105	1.140
21500.	1.101	1.103	1.137
22000.	1.100	1.100	1.135
22500.	1.100	1.098	1.132
23000.	1.099	1.097	1.130
23500.	1.099	1.095	1.128
24000.	1.098	1.094	1.126
24500.	1.098	1.092	1.124
25000.	1.097	1.091	1.122
25500.	1.096	1.091	1.120
27500.	1.093	1.089	1.114
30000.	1.090	1.087	1.106
32500.	1.086	1.084	1.099
35000.	1.082	1.082	1.093
37500.	1.078	1.079	1.087
40000.	1.073	1.077	1.085
42500.	1.069	1.074	1.094
45000.	1.064	1.071	1.103
47500.	1.060	1.068	1.113
50000.	1.056	1.065	1.124
52500.	1.056	1.061	1.135
55000.	1.054	1.058	1.146
57500.	1.051	1.056	1.158
60000.	1.047	1.071	1.170
62500.	1.046	1.086	1.181
65000.	1.066	1.101	1.193
67500.	1.085	1.116	1.204
70000.	1.102	1.130	1.214

Table B.19 [ ] Hot Uncontrolled k_{∞}

Exposure MWd/MTU	0.00 Void History	0.40 Void History	0.80 Void History
0.	1.06555	1.04568	1.02157
100.	1.03978	1.02170	1.00012
500.	1.03710	1.01996	0.99940
1000.	1.03814	1.02176	1.00182
1500.	1.04058	1.02478	1.00516
2000.	1.04343	1.02811	1.00869
2500.	1.04643	1.03155	1.01221
3000.	1.04959	1.03504	1.01569
3500.	1.05292	1.03863	1.01913
4000.	1.05645	1.04233	1.02260
4500.	1.06020	1.04618	1.02612
5000.	1.06418	1.05020	1.02971
5500.	1.06837	1.05437	1.03337
6000.	1.07276	1.05870	1.03712
6500.	1.07736	1.06319	1.04096
7000.	1.08217	1.06784	1.04489
7500.	1.08724	1.07267	1.04896
8000.	1.09258	1.07771	1.05316
8500.	1.09824	1.08298	1.05750
9000.	1.10424	1.08847	1.06195
9500.	1.11052	1.09407	1.06640
10000.	1.11686	1.09957	1.07068
10500.	1.12314	1.10489	1.07474
11000.	1.12925	1.10997	1.07855
11500.	1.13525	1.11487	1.08213
12000.	1.14135	1.11977	1.08559
12500.	1.14775	1.12483	1.08904
13000.	1.15445	1.13007	1.09253
13500.	1.16122	1.13533	1.09603
14000.	1.16767	1.14045	1.09942
14500.	1.17341	1.14521	1.10263
15000.	1.17796	1.14936	1.10556
15500.	1.18111	1.15267	1.10813
16000.	1.18282	1.15506	1.11024
16500.	1.18314	1.15656	1.11189
17000.	1.18224	1.15712	1.11308
17500.	1.18035	1.15677	1.11379
18000.	1.17770	1.15556	1.11401
18500.	1.17450	1.15359	1.11370
19000.	1.17084	1.15101	1.11288
19500.	1.16684	1.14794	1.11157
20000.	1.16257	1.14451	1.10982
20500.	1.15811	1.14080	1.10766
21000.	1.15335	1.13688	1.10515
21500.	1.14859	1.13283	1.10234
22000.	1.14384	1.12858	1.09928
22500.	1.13908	1.12433	1.09602
23000.	1.13433	1.12008	1.09261
23500.	1.12958	1.11583	1.08911
24000.	1.12482	1.11157	1.08553
25000.	1.11532	1.10307	1.07817
27500.	1.09142	1.08203	1.05997
30000.	1.06734	1.06113	1.04211
32500.	1.04306	1.04036	1.02462
35000.	1.01860	1.01972	1.00750
37500.	0.99402	0.99925	0.99076
40000.	0.96937	0.97897	0.97441
42500.	0.94477	0.95894	0.95848
45000.	0.92037	0.93922	0.94300
47500.	0.89632	0.91989	0.92801
50000.	0.87283	0.90104	0.91354
52500.	0.85012	0.88277	0.89961
55000.	0.82840	0.86517	0.88626
57500.	0.80791	0.84836	0.87350
60000.	0.78882	0.83241	0.86136
62500.	0.77133	0.81740	0.84986
65000.	0.75553	0.80341	0.83902
67500.	0.74146	0.79048	0.82882
70000.	0.72913	0.77863	0.81928

Table B.20 [ ] Hot Uncontrolled LPF

Exposure MWd/MTU	0.00 Void History	0.40 Void History	0.80 Void History
0.	1.374	1.336	1.340
100.	1.369	1.334	1.338
500.	1.364	1.330	1.335
1000.	1.357	1.325	1.332
1500.	1.350	1.320	1.328
2000.	1.343	1.315	1.324
2500.	1.336	1.309	1.319
3000.	1.329	1.303	1.315
3500.	1.321	1.298	1.310
4000.	1.314	1.292	1.305
4500.	1.306	1.286	1.301
5000.	1.298	1.280	1.296
5500.	1.290	1.274	1.291
6000.	1.282	1.268	1.286
6500.	1.274	1.261	1.281
7000.	1.266	1.255	1.276
7500.	1.258	1.249	1.271
8000.	1.249	1.243	1.267
8500.	1.241	1.238	1.262
9000.	1.232	1.232	1.257
9500.	1.224	1.226	1.252
10000.	1.215	1.220	1.247
10500.	1.206	1.211	1.240
11000.	1.198	1.202	1.233
11500.	1.189	1.190	1.224
12000.	1.180	1.178	1.215
12500.	1.170	1.165	1.205
13000.	1.161	1.152	1.196
13500.	1.152	1.142	1.186
14000.	1.143	1.135	1.176
14500.	1.135	1.130	1.167
15000.	1.127	1.125	1.157
15500.	1.121	1.121	1.149
16000.	1.116	1.116	1.146
16500.	1.113	1.111	1.142
17000.	1.111	1.107	1.138
17500.	1.109	1.102	1.134
18000.	1.107	1.099	1.130
18500.	1.106	1.097	1.126
19000.	1.104	1.095	1.123
19500.	1.103	1.094	1.120
20000.	1.102	1.093	1.116
20500.	1.101	1.092	1.114
21000.	1.100	1.091	1.111
21500.	1.099	1.091	1.109
22000.	1.098	1.090	1.106
22500.	1.097	1.090	1.104
23000.	1.096	1.089	1.102
23500.	1.095	1.089	1.100
24000.	1.095	1.088	1.099
25000.	1.093	1.087	1.095
27500.	1.089	1.084	1.090
30000.	1.085	1.082	1.089
32500.	1.080	1.080	1.087
35000.	1.075	1.078	1.086
37500.	1.071	1.075	1.084
40000.	1.066	1.073	1.082
42500.	1.067	1.070	1.080
45000.	1.070	1.067	1.078
47500.	1.071	1.063	1.075
50000.	1.071	1.060	1.073
52500.	1.069	1.056	1.070
55000.	1.065	1.053	1.068
57500.	1.061	1.050	1.068
60000.	1.057	1.047	1.078
62500.	1.051	1.044	1.089
65000.	1.043	1.042	1.099
67500.	1.049	1.057	1.110
70000.	1.066	1.072	1.120

Table B.21 [ ] Hot Uncontrolled k∞

Exposure MWd/MTU	0.00 Void History	0.40 Void History	0.80 Void History
0.	1.06511	1.04520	1.02052
100.	1.03919	1.02108	0.99897
500.	1.03633	1.01918	0.99813
1000.	1.03714	1.02081	1.00041
1500.	1.03932	1.02365	1.00360
2000.	1.04192	1.02681	1.00699
2500.	1.04467	1.03007	1.01037
3000.	1.04759	1.03339	1.01373
3500.	1.05071	1.03683	1.01709
4000.	1.05402	1.04041	1.02048
4500.	1.05750	1.04409	1.02392
5000.	1.06115	1.04788	1.02739
5500.	1.06497	1.05178	1.03089
6000.	1.06900	1.05581	1.03444
6500.	1.07323	1.06001	1.03806
7000.	1.07771	1.06438	1.04179
7500.	1.08246	1.06897	1.04564
8000.	1.08752	1.07381	1.04965
8500.	1.09294	1.07891	1.05382
9000.	1.09868	1.08420	1.05809
9500.	1.10454	1.08946	1.06228
10000.	1.11028	1.09451	1.06626
10500.	1.11577	1.09926	1.06997
11000.	1.12092	1.10368	1.07338
11500.	1.12591	1.10794	1.07656
12000.	1.13104	1.11225	1.07962
12500.	1.13645	1.11670	1.08268
13000.	1.14207	1.12122	1.08577
13500.	1.14775	1.12567	1.08883
14000.	1.15334	1.13000	1.09175
14500.	1.15867	1.13409	1.09451
15000.	1.16353	1.13787	1.09707
15500.	1.16790	1.14132	1.09939
16000.	1.17159	1.14446	1.10146
16500.	1.17446	1.14722	1.10329
17000.	1.17645	1.14950	1.10488
17500.	1.17739	1.15119	1.10623
18000.	1.17717	1.15221	1.10734
18500.	1.17583	1.15245	1.10819
19000.	1.17358	1.15186	1.10870
19500.	1.17066	1.15044	1.10881
20000.	1.16721	1.14832	1.10846
20500.	1.16333	1.14561	1.10764
21000.	1.15913	1.14242	1.10636
21500.	1.15468	1.13887	1.10465
22000.	1.14989	1.13506	1.10255
22500.	1.14510	1.13106	1.10009
23000.	1.14024	1.12693	1.09732
23500.	1.13537	1.12260	1.09429
24000.	1.13051	1.11827	1.09106
24500.	1.12564	1.11394	1.08767
25000.	1.12078	1.10961	1.08418
25500.	1.11591	1.10533	1.08062
27500.	1.09643	1.08822	1.06595
30000.	1.07185	1.06696	1.04794
32500.	1.04706	1.04581	1.03027
35000.	1.02207	1.02479	1.01296
37500.	0.99692	1.00391	0.99603
40000.	0.97170	0.98322	0.97949
42500.	0.94652	0.96276	0.96337
45000.	0.92152	0.94261	0.94769
47500.	0.89690	0.92284	0.93250
50000.	0.87286	0.90356	0.91782
52500.	0.84964	0.88487	0.90370
55000.	0.82746	0.86687	0.89014
57500.	0.80657	0.84967	0.87719
60000.	0.78718	0.83337	0.86486
62500.	0.76946	0.81805	0.85318
65000.	0.75352	0.80379	0.84215
67500.	0.73941	0.79063	0.83179
70000.	0.72710	0.77861	0.82210

Table B.22 [ ] Hot Uncontrolled LPF

Exposure MWd/MTU	0.00 Void History	0.40 Void History	0.80 Void History
0.	1.379	1.355	1.351
100.	1.374	1.353	1.349
500.	1.369	1.349	1.347
1000.	1.363	1.346	1.344
1500.	1.357	1.341	1.341
2000.	1.350	1.336	1.337
2500.	1.343	1.331	1.333
3000.	1.336	1.325	1.329
3500.	1.328	1.320	1.324
4000.	1.321	1.314	1.320
4500.	1.313	1.308	1.315
5000.	1.305	1.302	1.310
5500.	1.298	1.296	1.306
6000.	1.290	1.290	1.301
6500.	1.282	1.284	1.296
7000.	1.274	1.279	1.291
7500.	1.266	1.273	1.287
8000.	1.258	1.267	1.282
8500.	1.250	1.262	1.278
9000.	1.241	1.257	1.274
9500.	1.233	1.251	1.269
10000.	1.224	1.244	1.263
10500.	1.216	1.235	1.256
11000.	1.207	1.224	1.249
11500.	1.199	1.212	1.240
12000.	1.190	1.200	1.230
12500.	1.181	1.187	1.220
13000.	1.172	1.174	1.211
13500.	1.164	1.161	1.201
14000.	1.155	1.152	1.191
14500.	1.147	1.148	1.182
15000.	1.140	1.143	1.173
15500.	1.133	1.137	1.166
16000.	1.127	1.131	1.161
16500.	1.121	1.126	1.156
17000.	1.116	1.120	1.151
17500.	1.113	1.114	1.147
18000.	1.111	1.109	1.142
18500.	1.109	1.104	1.137
19000.	1.107	1.101	1.132
19500.	1.106	1.098	1.128
20000.	1.104	1.096	1.124
20500.	1.103	1.094	1.120
21000.	1.102	1.093	1.117
21500.	1.101	1.092	1.114
22000.	1.100	1.092	1.111
22500.	1.099	1.091	1.108
23000.	1.098	1.091	1.106
23500.	1.097	1.090	1.104
24000.	1.097	1.090	1.101
24500.	1.096	1.089	1.099
25000.	1.095	1.089	1.098
25500.	1.094	1.089	1.096
27500.	1.091	1.087	1.091
30000.	1.086	1.084	1.090
32500.	1.082	1.082	1.088
35000.	1.077	1.080	1.087
37500.	1.072	1.077	1.085
40000.	1.069	1.074	1.083
42500.	1.073	1.071	1.080
45000.	1.075	1.068	1.078
47500.	1.075	1.065	1.076
50000.	1.073	1.061	1.073
52500.	1.072	1.057	1.071
55000.	1.069	1.054	1.068
57500.	1.064	1.051	1.068
60000.	1.058	1.047	1.078
62500.	1.051	1.044	1.089
65000.	1.042	1.048	1.100
67500.	1.059	1.064	1.111
70000.	1.077	1.079	1.122

Table B.23 [ ] Hot Uncontrolled k_{∞}

Exposure MWd/MTU	0.00 Void History	0.40 Void History	0.80 Void History
0.	1.04024	1.02209	0.99807
100.	1.01454	0.99810	0.97659
500.	1.01185	0.99640	0.97602
1000.	1.01290	0.99833	0.97873
1500.	1.01537	1.00152	0.98239
2000.	1.01827	1.00506	0.98627
2500.	1.02133	1.00870	0.99016
3000.	1.02458	1.01243	0.99401
3500.	1.02805	1.01629	0.99788
4000.	1.03174	1.02031	1.00180
4500.	1.03562	1.02446	1.00577
5000.	1.03971	1.02873	1.00978
5500.	1.04400	1.03314	1.01383
6000.	1.04852	1.03770	1.01794
6500.	1.05327	1.04245	1.02214
7000.	1.05827	1.04739	1.02644
7500.	1.06356	1.05255	1.03089
8000.	1.06916	1.05797	1.03550
8500.	1.07512	1.06366	1.04028
9000.	1.08144	1.06960	1.04520
9500.	1.08805	1.07564	1.05011
10000.	1.09470	1.08155	1.05483
10500.	1.10126	1.08726	1.05931
11000.	1.10758	1.09268	1.06351
11500.	1.11370	1.09789	1.06746
12000.	1.11987	1.10306	1.07128
12500.	1.12639	1.10841	1.07508
13000.	1.13339	1.11399	1.07894
13500.	1.14077	1.11972	1.08282
14000.	1.14829	1.12549	1.08664
14500.	1.15551	1.13122	1.09033
15000.	1.16202	1.13673	1.09388
15500.	1.16736	1.14176	1.09723
16000.	1.17125	1.14610	1.10035
16500.	1.17365	1.14961	1.10318
17000.	1.17463	1.15221	1.10569
17500.	1.17444	1.15385	1.10783
18000.	1.17329	1.15443	1.10957
18500.	1.17134	1.15395	1.11084
19000.	1.16873	1.15253	1.11158
19500.	1.16560	1.15036	1.11171
20000.	1.16202	1.14763	1.11120
20500.	1.15803	1.14447	1.11009
21000.	1.15370	1.14095	1.10841
21500.	1.14911	1.13714	1.10625
22000.	1.14416	1.13312	1.10367
22500.	1.13921	1.12894	1.10076
23000.	1.13416	1.12448	1.09759
23500.	1.12912	1.12002	1.09421
24000.	1.12407	1.11557	1.09068
24500.	1.11903	1.11111	1.08706
25000.	1.11398	1.10665	1.08337
27500.	1.08860	1.08451	1.06440
30000.	1.06283	1.06236	1.04581
32500.	1.03668	1.04020	1.02751
35000.	1.01017	1.01805	1.00952
37500.	0.98336	0.99592	0.99185
40000.	0.95635	0.97389	0.97451
42500.	0.92929	0.95200	0.95754
45000.	0.90239	0.93036	0.94099
47500.	0.87589	0.90909	0.92489
50000.	0.85008	0.88830	0.90930
52500.	0.82526	0.86815	0.89426
55000.	0.80176	0.84879	0.87980
57500.	0.77988	0.83035	0.86597
60000.	0.75986	0.81299	0.85280
62500.	0.74191	0.79680	0.84033
65000.	0.72609	0.78188	0.82859
67500.	0.71242	0.76830	0.81759
70000.	0.70077	0.75606	0.80734

Table B.24 [ ] Hot Uncontrolled LPF

Exposure MWd/MTU	0.00 Void History	0.40 Void History	0.80 Void History
0.	1.479	1.415	1.333
100.	1.475	1.410	1.328
500.	1.469	1.405	1.323
1000.	1.462	1.398	1.317
1500.	1.454	1.391	1.313
2000.	1.446	1.384	1.309
2500.	1.437	1.377	1.304
3000.	1.429	1.370	1.300
3500.	1.420	1.362	1.295
4000.	1.411	1.355	1.290
4500.	1.402	1.347	1.285
5000.	1.393	1.339	1.280
5500.	1.383	1.332	1.275
6000.	1.374	1.324	1.270
6500.	1.364	1.316	1.265
7000.	1.355	1.308	1.260
7500.	1.345	1.301	1.255
8000.	1.335	1.293	1.250
8500.	1.325	1.285	1.245
9000.	1.315	1.277	1.241
9500.	1.305	1.269	1.236
10000.	1.295	1.261	1.230
10500.	1.285	1.253	1.224
11000.	1.274	1.245	1.216
11500.	1.264	1.237	1.209
12000.	1.253	1.229	1.204
12500.	1.243	1.221	1.198
13000.	1.232	1.213	1.193
13500.	1.221	1.204	1.187
14000.	1.210	1.196	1.182
14500.	1.200	1.188	1.176
15000.	1.190	1.181	1.171
15500.	1.181	1.174	1.166
16000.	1.174	1.167	1.162
16500.	1.170	1.161	1.157
17000.	1.167	1.155	1.153
17500.	1.163	1.150	1.149
18000.	1.160	1.146	1.145
18500.	1.157	1.142	1.141
19000.	1.154	1.139	1.138
19500.	1.152	1.138	1.135
20000.	1.149	1.136	1.132
20500.	1.147	1.135	1.130
21000.	1.145	1.133	1.128
21500.	1.143	1.132	1.126
22000.	1.141	1.131	1.125
22500.	1.139	1.130	1.124
23000.	1.137	1.129	1.123
23500.	1.136	1.128	1.122
24000.	1.134	1.126	1.121
24500.	1.133	1.125	1.121
25000.	1.131	1.124	1.120
27500.	1.122	1.119	1.117
30000.	1.113	1.114	1.114
32500.	1.104	1.109	1.111
35000.	1.094	1.103	1.108
37500.	1.085	1.098	1.104
40000.	1.086	1.092	1.101
42500.	1.088	1.087	1.098
45000.	1.088	1.081	1.095
47500.	1.088	1.076	1.092
50000.	1.085	1.071	1.089
52500.	1.081	1.067	1.087
55000.	1.077	1.065	1.084
57500.	1.071	1.062	1.081
60000.	1.063	1.058	1.078
62500.	1.055	1.055	1.075
65000.	1.046	1.053	1.074
67500.	1.049	1.053	1.085
70000.	1.066	1.064	1.097

Table B.25 [ ] Hot Uncontrolled k_∞

Exposure MWd/MTU	0.00 Void History	0.40 Void History	0.80 Void History
0.	1.02450	1.00750	0.98364
100.	0.99896	0.98361	0.96229
500.	0.99663	0.98240	0.96239
1000.	0.99838	0.98520	0.96617
1500.	1.00157	0.98929	0.97088
2000.	1.00518	0.99370	0.97578
2500.	1.00900	0.99824	0.98067
3000.	1.01308	1.00293	0.98555
3500.	1.01745	1.00782	0.99048
4000.	1.02206	1.01288	0.99545
4500.	1.02691	1.01807	1.00046
5000.	1.03200	1.02344	1.00552
5500.	1.03738	1.02900	1.01064
6000.	1.04306	1.03480	1.01586
6500.	1.04908	1.04087	1.02124
7000.	1.05548	1.04723	1.02680
7500.	1.06229	1.05392	1.03255
8000.	1.06953	1.06094	1.03849
8500.	1.07719	1.06821	1.04452
9000.	1.08516	1.07551	1.05045
9500.	1.09317	1.08264	1.05614
10000.	1.10104	1.08948	1.06151
10500.	1.10864	1.09599	1.06656
11000.	1.11619	1.10235	1.07135
11500.	1.12396	1.10871	1.07600
12000.	1.13195	1.11503	1.08048
12500.	1.14010	1.12129	1.08476
13000.	1.14813	1.12744	1.08882
13500.	1.15564	1.13340	1.09263
14000.	1.16228	1.13914	1.09623
14500.	1.16775	1.14458	1.09965
15000.	1.17176	1.14948	1.10294
15500.	1.17422	1.15357	1.10609
16000.	1.17530	1.15663	1.10902
16500.	1.17521	1.15857	1.11163
17000.	1.17409	1.15924	1.11384
17500.	1.17209	1.15868	1.11552
18000.	1.16938	1.15708	1.11655
18500.	1.16611	1.15469	1.11685
19000.	1.16234	1.15174	1.11640
19500.	1.15812	1.14833	1.11524
20000.	1.15351	1.14455	1.11345
20500.	1.14863	1.14047	1.11111
21000.	1.14332	1.13617	1.10833
21500.	1.13801	1.13152	1.10518
22000.	1.13269	1.12686	1.10176
22500.	1.12738	1.12221	1.09815
23000.	1.12204	1.11754	1.09441
25000.	1.10066	1.09885	1.07867
27500.	1.07356	1.07555	1.05926
30000.	1.04603	1.05223	1.04016
32500.	1.01808	1.02890	1.02141
35000.	0.98979	1.00560	1.00300
37500.	0.96129	0.98237	0.98496
40000.	0.93273	0.95930	0.96732
42500.	0.90437	0.93651	0.95011
45000.	0.87650	0.91411	0.93339
47500.	0.84945	0.89227	0.91721
50000.	0.82358	0.87116	0.90162
52500.	0.79926	0.85093	0.88666
55000.	0.77682	0.83177	0.87237
57500.	0.75653	0.81383	0.85880
60000.	0.73856	0.79722	0.84598
62500.	0.72296	0.78204	0.83395
65000.	0.70966	0.76834	0.82271
67500.	0.69851	0.75612	0.81227
70000.	0.68929	0.74535	0.80262

Table B.26 [ ] Hot Uncontrolled LPF

Exposure MWd/MTU	0.00 Void History	0.40 Void History	0.80 Void History
0.	1.504	1.427	1.324
100.	1.499	1.422	1.318
500.	1.492	1.416	1.313
1000.	1.484	1.408	1.307
1500.	1.474	1.400	1.301
2000.	1.464	1.391	1.295
2500.	1.454	1.383	1.289
3000.	1.444	1.374	1.283
3500.	1.433	1.365	1.277
4000.	1.422	1.356	1.271
4500.	1.411	1.347	1.265
5000.	1.400	1.338	1.259
5500.	1.388	1.329	1.253
6000.	1.377	1.320	1.248
6500.	1.365	1.311	1.242
7000.	1.353	1.302	1.236
7500.	1.341	1.293	1.231
8000.	1.329	1.283	1.225
8500.	1.317	1.274	1.220
9000.	1.305	1.265	1.214
9500.	1.293	1.255	1.208
10000.	1.281	1.246	1.202
10500.	1.268	1.236	1.196
11000.	1.256	1.227	1.190
11500.	1.243	1.217	1.184
12000.	1.231	1.208	1.178
12500.	1.218	1.198	1.172
13000.	1.207	1.190	1.166
13500.	1.195	1.181	1.161
14000.	1.185	1.173	1.156
14500.	1.175	1.165	1.151
15000.	1.172	1.157	1.146
15500.	1.176	1.150	1.141
16000.	1.177	1.144	1.136
16500.	1.176	1.138	1.132
17000.	1.174	1.133	1.127
17500.	1.172	1.128	1.123
18000.	1.168	1.126	1.119
18500.	1.165	1.123	1.116
19000.	1.162	1.121	1.113
19500.	1.159	1.119	1.111
20000.	1.156	1.118	1.108
20500.	1.153	1.116	1.107
21000.	1.151	1.114	1.105
21500.	1.148	1.113	1.104
22000.	1.145	1.111	1.103
22500.	1.143	1.110	1.102
23000.	1.141	1.109	1.101
25000.	1.131	1.103	1.099
27500.	1.118	1.097	1.095
30000.	1.120	1.092	1.092
32500.	1.123	1.094	1.088
35000.	1.124	1.096	1.085
37500.	1.124	1.098	1.082
40000.	1.123	1.099	1.079
42500.	1.120	1.100	1.077
45000.	1.115	1.098	1.075
47500.	1.110	1.096	1.073
50000.	1.104	1.092	1.071
52500.	1.096	1.088	1.069
55000.	1.086	1.083	1.067
57500.	1.075	1.078	1.065
60000.	1.064	1.071	1.064
62500.	1.053	1.064	1.073
65000.	1.053	1.055	1.084
67500.	1.064	1.062	1.095
70000.	1.078	1.077	1.106

Table B.27 [ ] Hot Uncontrolled k∞

Exposure MWd/MTU	0.00 Void History	0.40 Void History	0.80 Void History
0.	1.09399	1.08054	1.05953
100.	1.06584	1.05387	1.03528
500.	1.06348	1.05241	1.03482
1000.	1.06574	1.05541	1.03833
1500.	1.06960	1.05985	1.04291
2000.	1.07387	1.06460	1.04763
2500.	1.07838	1.06948	1.05228
3000.	1.08314	1.07449	1.05689
3500.	1.08823	1.07968	1.06150
4000.	1.09373	1.08514	1.06618
4500.	1.09967	1.09090	1.07095
5000.	1.10605	1.09697	1.07588
5500.	1.11286	1.10334	1.08097
6000.	1.12013	1.11002	1.08622
6500.	1.12790	1.11703	1.09162
7000.	1.13628	1.12444	1.09722
7500.	1.14532	1.13229	1.10305
8000.	1.15513	1.14064	1.10915
8500.	1.16579	1.14956	1.11554
9000.	1.17726	1.15903	1.12215
9500.	1.18911	1.16881	1.12877
10000.	1.20037	1.17840	1.13518
10500.	1.21003	1.18717	1.14120
11000.	1.21731	1.19445	1.14661
11500.	1.22178	1.19991	1.15127
12000.	1.22364	1.20343	1.15512
12500.	1.22343	1.20504	1.15808
13000.	1.22171	1.20490	1.16006
13500.	1.21890	1.20335	1.16100
14000.	1.21527	1.20075	1.16093
14500.	1.21104	1.19740	1.15992
15000.	1.20640	1.19351	1.15808
15500.	1.20150	1.18926	1.15555
16000.	1.19623	1.18478	1.15247
16500.	1.19096	1.18017	1.14899
17000.	1.18568	1.17536	1.14524
17500.	1.18041	1.17055	1.14130
18000.	1.17513	1.16577	1.13726
20000.	1.15401	1.14663	1.12055
22500.	1.12737	1.12295	1.10006
25000.	1.10032	1.09930	1.07997
27500.	1.07283	1.07566	1.06026
30000.	1.04488	1.05199	1.04090
32500.	1.01653	1.02832	1.02189
35000.	0.98786	1.00468	1.00324
37500.	0.95901	0.98115	0.98497
40000.	0.93017	0.95782	0.96712
42500.	0.90160	0.93479	0.94974
45000.	0.87362	0.91223	0.93288
47500.	0.84658	0.89030	0.91659
50000.	0.82085	0.86916	0.90093
52500.	0.79680	0.84900	0.88593
55000.	0.77475	0.82998	0.87165
57500.	0.75493	0.81225	0.85812
60000.	0.73750	0.79593	0.84539
62500.	0.72246	0.78109	0.83347
65000.	0.70972	0.76777	0.82238
67500.	0.69908	0.75594	0.81211
70000.	0.69031	0.74557	0.80266

Table B.28 [ ] Hot Uncontrolled LPF

Exposure MWd/MTU	0.00 Void History	0.40 Void History	0.80 Void History
0.	1.424	1.358	1.272
100.	1.422	1.354	1.267
500.	1.416	1.349	1.263
1000.	1.408	1.342	1.258
1500.	1.400	1.335	1.252
2000.	1.391	1.328	1.247
2500.	1.382	1.320	1.242
3000.	1.373	1.313	1.237
3500.	1.364	1.305	1.232
4000.	1.354	1.298	1.227
4500.	1.344	1.290	1.222
5000.	1.334	1.282	1.217
5500.	1.324	1.274	1.212
6000.	1.313	1.265	1.207
6500.	1.302	1.257	1.201
7000.	1.291	1.249	1.196
7500.	1.280	1.240	1.191
8000.	1.268	1.231	1.186
8500.	1.257	1.223	1.181
9000.	1.244	1.214	1.176
9500.	1.232	1.205	1.171
10000.	1.220	1.196	1.165
10500.	1.209	1.187	1.160
11000.	1.199	1.178	1.154
11500.	1.190	1.170	1.149
12000.	1.183	1.164	1.143
12500.	1.178	1.158	1.138
13000.	1.174	1.153	1.134
13500.	1.170	1.149	1.130
14000.	1.167	1.146	1.127
14500.	1.164	1.143	1.124
15000.	1.161	1.141	1.122
15500.	1.158	1.139	1.120
16000.	1.156	1.137	1.118
16500.	1.154	1.135	1.117
17000.	1.151	1.133	1.116
17500.	1.149	1.132	1.115
18000.	1.146	1.130	1.115
20000.	1.136	1.124	1.112
22500.	1.124	1.116	1.109
25000.	1.112	1.107	1.105
27500.	1.115	1.100	1.102
30000.	1.117	1.093	1.098
32500.	1.119	1.090	1.094
35000.	1.119	1.092	1.091
37500.	1.118	1.093	1.087
40000.	1.116	1.094	1.083
42500.	1.113	1.093	1.079
45000.	1.109	1.091	1.076
47500.	1.104	1.088	1.072
50000.	1.097	1.085	1.070
52500.	1.089	1.082	1.067
55000.	1.079	1.077	1.066
57500.	1.068	1.071	1.064
60000.	1.056	1.063	1.065
62500.	1.045	1.056	1.076
65000.	1.052	1.050	1.087
67500.	1.064	1.065	1.098
70000.	1.077	1.078	1.108

Table B.29 [ ] Hot Uncontrolled k_∞

Exposure MWd/MTU	0.00 Void History	0.40 Void History	0.80 Void History
0.	1.12530	1.10304	1.07734
100.	1.09853	1.07818	1.05507
500.	1.09489	1.07534	1.05306
1000.	1.09465	1.07563	1.05373
1500.	1.09558	1.07691	1.05513
2000.	1.09680	1.07839	1.05661
2500.	1.09807	1.07987	1.05801
3000.	1.09936	1.08129	1.05929
3500.	1.10068	1.08268	1.06049
4000.	1.10207	1.08408	1.06163
4500.	1.10355	1.08552	1.06276
5000.	1.10516	1.08704	1.06389
5500.	1.10688	1.08863	1.06506
6000.	1.10874	1.09031	1.06626
6500.	1.11072	1.09208	1.06751
7000.	1.11284	1.09395	1.06883
7500.	1.11509	1.09593	1.07021
8000.	1.11749	1.09800	1.07167
8500.	1.12003	1.10017	1.07322
9000.	1.12276	1.10248	1.07484
9500.	1.12568	1.10492	1.07653
10000.	1.12881	1.10749	1.07827
10500.	1.13207	1.11008	1.07997
11000.	1.13532	1.11258	1.08155
11500.	1.13847	1.11492	1.08295
12000.	1.14145	1.11707	1.08415
12500.	1.14425	1.11900	1.08517
13000.	1.14698	1.12082	1.08602
13500.	1.14976	1.12261	1.08679
14000.	1.15265	1.12444	1.08752
14500.	1.15565	1.12633	1.08824
15000.	1.15869	1.12824	1.08896
15500.	1.16163	1.13013	1.08967
16000.	1.16434	1.13195	1.09034
16500.	1.16662	1.13360	1.09095
17000.	1.16835	1.13501	1.09149
17500.	1.16937	1.13606	1.09193
18000.	1.16965	1.13671	1.09224
18500.	1.16917	1.13688	1.09238
19000.	1.16794	1.13657	1.09232
19500.	1.16602	1.13576	1.09202
20000.	1.16352	1.13447	1.09147
20500.	1.16055	1.13270	1.09066
21000.	1.15720	1.13051	1.08958
21500.	1.15357	1.12793	1.08825
22000.	1.14970	1.12505	1.08666
22500.	1.14565	1.12191	1.08482
23000.	1.14146	1.11858	1.08275
23500.	1.13718	1.11508	1.08047
24000.	1.13272	1.11146	1.07799
24500.	1.12825	1.10774	1.07533
25000.	1.12379	1.10395	1.07254
25500.	1.11936	1.10012	1.06963
26000.	1.11493	1.09625	1.06662
26500.	1.11049	1.09230	1.06353
27000.	1.10606	1.08834	1.06038
27500.	1.10163	1.08439	1.05718
28000.	1.09722	1.08052	1.05395
28500.	1.09280	1.07665	1.05069
29000.	1.08839	1.07277	1.04742
29500.	1.08397	1.06890	1.04414
30000.	1.07956	1.06503	1.04086
30500.	1.07515	1.06122	1.03758
31000.	1.07074	1.05740	1.03430
32500.	1.05752	1.04596	1.02447
35000.	1.03551	1.02716	1.00856
37500.	1.01356	1.00866	0.99307
40000.	0.99170	0.99047	0.97804
42500.	0.97001	0.97262	0.96348
45000.	0.94856	0.95516	0.94940
47500.	0.92744	0.93811	0.93582
50000.	0.90677	0.92153	0.92276
52500.	0.88667	0.90547	0.91024
55000.	0.86727	0.88999	0.89826
57500.	0.84871	0.87513	0.88683
60000.	0.83110	0.86095	0.87596
62500.	0.81457	0.84749	0.86565
65000.	0.79921	0.83478	0.85590
67500.	0.78509	0.82285	0.84670
70000.	0.77225	0.81173	0.83805

Table B.30 [ ] Hot Uncontrolled LPF

Exposure MWd/MTU	0.00 Void History	0.40 Void History	0.80 Void History
0.	1.337	1.330	1.313
100.	1.332	1.325	1.314
500.	1.327	1.321	1.320
1000.	1.322	1.317	1.326
1500.	1.317	1.312	1.330
2000.	1.311	1.307	1.332
2500.	1.304	1.302	1.332
3000.	1.298	1.296	1.332
3500.	1.292	1.291	1.331
4000.	1.285	1.286	1.330
4500.	1.279	1.280	1.328
5000.	1.272	1.275	1.325
5500.	1.266	1.270	1.322
6000.	1.259	1.265	1.319
6500.	1.252	1.259	1.316
7000.	1.246	1.254	1.312
7500.	1.239	1.248	1.308
8000.	1.232	1.243	1.303
8500.	1.225	1.238	1.299
9000.	1.219	1.232	1.295
9500.	1.212	1.227	1.290
10000.	1.206	1.222	1.285
10500.	1.199	1.217	1.280
11000.	1.192	1.211	1.275
11500.	1.185	1.204	1.269
12000.	1.176	1.198	1.263
12500.	1.167	1.190	1.256
13000.	1.158	1.183	1.248
13500.	1.148	1.175	1.240
14000.	1.142	1.166	1.232
14500.	1.137	1.158	1.225
15000.	1.132	1.150	1.217
15500.	1.127	1.142	1.209
16000.	1.122	1.134	1.201
16500.	1.117	1.126	1.194
17000.	1.112	1.118	1.186
17500.	1.108	1.111	1.179
18000.	1.104	1.107	1.172
18500.	1.104	1.104	1.166
19000.	1.104	1.101	1.159
19500.	1.104	1.098	1.153
20000.	1.104	1.096	1.148
20500.	1.104	1.095	1.143
21000.	1.104	1.096	1.138
21500.	1.104	1.096	1.134
22000.	1.104	1.096	1.129
22500.	1.104	1.096	1.126
23000.	1.104	1.096	1.122
23500.	1.103	1.096	1.119
24000.	1.102	1.096	1.117
24500.	1.102	1.096	1.114
25000.	1.101	1.095	1.112
25500.	1.100	1.095	1.110
26000.	1.099	1.094	1.108
26500.	1.099	1.093	1.107
27000.	1.098	1.093	1.105
27500.	1.097	1.092	1.104
28000.	1.096	1.091	1.103
28500.	1.095	1.091	1.102
29000.	1.095	1.090	1.101
29500.	1.094	1.090	1.100
30000.	1.093	1.089	1.099
30500.	1.092	1.088	1.098
31000.	1.091	1.088	1.098
32500.	1.089	1.086	1.097
35000.	1.084	1.082	1.097
37500.	1.079	1.079	1.098
40000.	1.075	1.076	1.100
42500.	1.069	1.072	1.105
45000.	1.066	1.069	1.110
47500.	1.062	1.065	1.117
50000.	1.058	1.063	1.125
52500.	1.058	1.060	1.134
55000.	1.059	1.058	1.143
57500.	1.059	1.056	1.153
60000.	1.058	1.060	1.164
62500.	1.055	1.075	1.174
65000.	1.051	1.089	1.185
67500.	1.069	1.104	1.196
70000.	1.087	1.118	1.206

Table B.31 [ ] Hot Uncontrolled k_{∞}

Exposure MWd/MTU	0.00 Void History	0.40 Void History	0.80 Void History
0.	1.09380	1.07608	1.05438
100.	1.06707	1.05109	1.03187
500.	1.06378	1.04862	1.03027
1000.	1.06406	1.04952	1.03162
1500.	1.06567	1.05157	1.03385
2000.	1.06766	1.05391	1.03626
2500.	1.06977	1.05632	1.03863
3000.	1.07197	1.05873	1.04092
3500.	1.07428	1.06118	1.04315
4000.	1.07672	1.06369	1.04535
4500.	1.07934	1.06630	1.04759
5000.	1.08214	1.06904	1.04986
5500.	1.08512	1.07190	1.05217
6000.	1.08828	1.07489	1.05455
6500.	1.09161	1.07801	1.05700
7000.	1.09513	1.08128	1.05953
7500.	1.09884	1.08468	1.06217
8000.	1.10278	1.08824	1.06492
8500.	1.10695	1.09198	1.06778
9000.	1.11141	1.09591	1.07074
9500.	1.11614	1.10001	1.07378
10000.	1.12103	1.10411	1.07675
10500.	1.12587	1.10807	1.07954
11000.	1.13056	1.11179	1.08208
11500.	1.13498	1.11521	1.08434
12000.	1.13921	1.11841	1.08635
12500.	1.14349	1.12154	1.08820
13000.	1.14796	1.12476	1.09000
13500.	1.15266	1.12812	1.09181
14000.	1.15754	1.13161	1.09367
14500.	1.16237	1.13518	1.09556
15000.	1.16693	1.13872	1.09747
15500.	1.17098	1.14206	1.09934
16000.	1.17423	1.14508	1.10114
16500.	1.17655	1.14765	1.10282
17000.	1.17780	1.14960	1.10434
17500.	1.17802	1.15083	1.10561
18000.	1.17732	1.15134	1.10659
18500.	1.17584	1.15112	1.10722
19000.	1.17373	1.15023	1.10746
19500.	1.17109	1.14873	1.10731
20000.	1.16802	1.14668	1.10676
20500.	1.16461	1.14419	1.10582
21000.	1.16091	1.14134	1.10451
21500.	1.15695	1.13820	1.10286
22000.	1.15277	1.13483	1.10087
22500.	1.14842	1.13127	1.09859
23000.	1.14395	1.12754	1.09606
23500.	1.13923	1.12369	1.09331
24000.	1.13452	1.11974	1.09038
24500.	1.12980	1.11571	1.08732
25000.	1.12508	1.11163	1.08414
25500.	1.12038	1.10744	1.08086
26000.	1.11568	1.10324	1.07751
26500.	1.11097	1.09905	1.07411
27000.	1.10627	1.09485	1.07066
27500.	1.10157	1.09066	1.06717
28000.	1.09684	1.08653	1.06367
28500.	1.09211	1.08240	1.06016
29000.	1.08737	1.07828	1.05664
30000.	1.07791	1.07002	1.04949
32500.	1.05404	1.04948	1.03204
35000.	1.02997	1.02905	1.01497
37500.	1.00573	1.00875	0.99826
40000.	0.98139	0.98861	0.98191
42500.	0.95702	0.96868	0.96595
45000.	0.93274	0.94901	0.95042
47500.	0.90871	0.92967	0.93533
50000.	0.88510	0.91074	0.92074
52500.	0.86211	0.89232	0.90666
55000.	0.83997	0.87449	0.89312
57500.	0.81888	0.85736	0.88015
60000.	0.79906	0.84103	0.86777
62500.	0.78070	0.82556	0.85600
65000.	0.76394	0.81105	0.84485
67500.	0.74887	0.79755	0.83435
70000.	0.73553	0.78509	0.82448

Table B.32 [ ] Hot Uncontrolled LPF

Exposure MWd/MTU	0.00 Void History	0.40 Void History	0.80 Void History
0.	1.326	1.332	1.325
100.	1.322	1.328	1.321
500.	1.317	1.323	1.316
1000.	1.312	1.317	1.310
1500.	1.306	1.311	1.304
2000.	1.300	1.305	1.298
2500.	1.294	1.299	1.292
3000.	1.288	1.292	1.286
3500.	1.281	1.286	1.284
4000.	1.275	1.279	1.282
4500.	1.268	1.272	1.281
5000.	1.261	1.265	1.279
5500.	1.254	1.258	1.277
6000.	1.247	1.252	1.274
6500.	1.240	1.245	1.271
7000.	1.233	1.238	1.268
7500.	1.226	1.231	1.265
8000.	1.218	1.223	1.262
8500.	1.210	1.216	1.258
9000.	1.203	1.212	1.255
9500.	1.195	1.209	1.251
10000.	1.187	1.204	1.248
10500.	1.179	1.199	1.243
11000.	1.172	1.192	1.237
11500.	1.165	1.183	1.231
12000.	1.159	1.174	1.223
12500.	1.152	1.164	1.215
13000.	1.146	1.159	1.206
13500.	1.140	1.153	1.197
14000.	1.133	1.148	1.188
14500.	1.127	1.142	1.179
15000.	1.121	1.137	1.170
15500.	1.118	1.131	1.161
16000.	1.117	1.126	1.153
16500.	1.116	1.121	1.144
17000.	1.115	1.119	1.136
17500.	1.114	1.118	1.129
18000.	1.113	1.116	1.121
18500.	1.112	1.115	1.120
19000.	1.110	1.113	1.119
19500.	1.109	1.112	1.118
20000.	1.108	1.110	1.117
20500.	1.106	1.109	1.117
21000.	1.104	1.108	1.116
21500.	1.102	1.106	1.115
22000.	1.100	1.105	1.114
22500.	1.098	1.103	1.114
23000.	1.096	1.101	1.113
23500.	1.095	1.100	1.112
24000.	1.095	1.098	1.112
24500.	1.094	1.096	1.111
25000.	1.094	1.095	1.110
25500.	1.093	1.093	1.109
26000.	1.092	1.091	1.108
26500.	1.092	1.090	1.108
27000.	1.091	1.088	1.107
27500.	1.090	1.086	1.106
28000.	1.089	1.085	1.105
28500.	1.088	1.084	1.104
29000.	1.088	1.082	1.103
30000.	1.086	1.080	1.102
32500.	1.082	1.077	1.097
35000.	1.078	1.074	1.094
37500.	1.074	1.071	1.090
40000.	1.069	1.068	1.087
42500.	1.067	1.064	1.085
45000.	1.069	1.061	1.083
47500.	1.073	1.058	1.081
50000.	1.075	1.054	1.080
52500.	1.076	1.052	1.079
55000.	1.075	1.051	1.078
57500.	1.073	1.050	1.079
60000.	1.070	1.048	1.079
62500.	1.064	1.046	1.084
65000.	1.057	1.044	1.093
67500.	1.048	1.047	1.103
70000.	1.054	1.062	1.113

Table B.33 [ ] Hot Uncontrolled k_∞

Exposure MWd/MTU	0.00 Void History	0.40 Void History	0.80 Void History
0.	1.09552	1.07796	1.05572
100.	1.06856	1.05274	1.03303
500.	1.06516	1.05018	1.03136
1000.	1.06534	1.05101	1.03267
1500.	1.06685	1.05301	1.03487
2000.	1.06874	1.05530	1.03724
2500.	1.07074	1.05766	1.03959
3000.	1.07281	1.06000	1.04184
3500.	1.07500	1.06237	1.04405
4000.	1.07732	1.06482	1.04623
4500.	1.07976	1.06734	1.04842
5000.	1.08234	1.06994	1.05063
5500.	1.08510	1.07266	1.05287
6000.	1.08808	1.07552	1.05517
6500.	1.09129	1.07855	1.05756
7000.	1.09472	1.08176	1.06004
7500.	1.09836	1.08513	1.06264
8000.	1.10221	1.08867	1.06536
8500.	1.10633	1.09240	1.06821
9000.	1.11076	1.09635	1.07116
9500.	1.11544	1.10042	1.07417
10000.	1.12012	1.10439	1.07705
10500.	1.12461	1.10812	1.07971
11000.	1.12873	1.11150	1.08209
11500.	1.13245	1.11451	1.08416
12000.	1.13599	1.11732	1.08598
12500.	1.13961	1.12011	1.08766
13000.	1.14345	1.12300	1.08930
13500.	1.14756	1.12603	1.09096
14000.	1.15190	1.12918	1.09266
14500.	1.15641	1.13241	1.09440
15000.	1.16105	1.13566	1.09614
15500.	1.16568	1.13892	1.09784
16000.	1.17004	1.14211	1.09949
16500.	1.17386	1.14513	1.10108
17000.	1.17695	1.14782	1.10258
17500.	1.17910	1.15004	1.10397
18000.	1.18018	1.15175	1.10519
18500.	1.18014	1.15283	1.10619
19000.	1.17900	1.15320	1.10691
19500.	1.17691	1.15281	1.10736
20000.	1.17408	1.15168	1.10749
20500.	1.17071	1.14988	1.10729
21000.	1.16692	1.14749	1.10672
21500.	1.16282	1.14461	1.10576
22000.	1.15849	1.14135	1.10440
22500.	1.15399	1.13780	1.10266
23000.	1.14919	1.13403	1.10059
23500.	1.14439	1.13010	1.09821
24000.	1.13959	1.12606	1.09557
24500.	1.13479	1.12194	1.09270
25000.	1.12999	1.11769	1.08965
25500.	1.12520	1.11342	1.08645
26000.	1.12040	1.10916	1.08313
26500.	1.11561	1.10489	1.07973
27000.	1.11081	1.10063	1.07626
27500.	1.10602	1.09636	1.07275
28000.	1.10118	1.09215	1.06922
28500.	1.09634	1.08794	1.06567
30000.	1.08182	1.07532	1.05483
32500.	1.05739	1.05438	1.03720
35000.	1.03274	1.03355	1.01994
37500.	1.00791	1.01282	1.00302
40000.	0.98295	0.99224	0.98648
42500.	0.95796	0.97187	0.97032
45000.	0.93307	0.95175	0.95458
47500.	0.90844	0.93197	0.93930
50000.	0.88427	0.91261	0.92451
52500.	0.86077	0.89377	0.91024
55000.	0.83816	0.87555	0.89652
57500.	0.81670	0.85805	0.88337
60000.	0.79660	0.84138	0.87082
62500.	0.77806	0.82563	0.85889
65000.	0.76122	0.81088	0.84759
67500.	0.74617	0.79719	0.83695
70000.	0.73292	0.78460	0.82696

Table B.34 [ ] Hot Uncontrolled LPF

Exposure MWd/MTU	0.00 Void History	0.40 Void History	0.80 Void History
0.	1.364	1.362	1.344
100.	1.359	1.358	1.340
500.	1.354	1.353	1.335
1000.	1.349	1.347	1.329
1500.	1.343	1.340	1.323
2000.	1.336	1.334	1.316
2500.	1.330	1.327	1.310
3000.	1.323	1.320	1.305
3500.	1.316	1.313	1.303
4000.	1.310	1.306	1.302
4500.	1.302	1.299	1.300
5000.	1.295	1.292	1.298
5500.	1.288	1.285	1.295
6000.	1.281	1.278	1.292
6500.	1.273	1.271	1.289
7000.	1.265	1.263	1.286
7500.	1.258	1.256	1.283
8000.	1.250	1.248	1.279
8500.	1.241	1.242	1.276
9000.	1.233	1.238	1.272
9500.	1.225	1.234	1.269
10000.	1.216	1.229	1.264
10500.	1.208	1.223	1.259
11000.	1.201	1.214	1.253
11500.	1.195	1.204	1.245
12000.	1.188	1.193	1.237
12500.	1.182	1.187	1.228
13000.	1.176	1.182	1.219
13500.	1.170	1.176	1.210
14000.	1.163	1.171	1.201
14500.	1.156	1.165	1.192
15000.	1.149	1.159	1.182
15500.	1.142	1.153	1.173
16000.	1.135	1.147	1.165
16500.	1.134	1.141	1.156
17000.	1.134	1.135	1.147
17500.	1.134	1.134	1.139
18000.	1.133	1.133	1.132
18500.	1.132	1.131	1.130
19000.	1.131	1.130	1.129
19500.	1.129	1.128	1.128
20000.	1.127	1.126	1.128
20500.	1.125	1.125	1.127
21000.	1.123	1.123	1.126
21500.	1.120	1.121	1.125
22000.	1.118	1.119	1.124
22500.	1.115	1.117	1.124
23000.	1.114	1.115	1.123
23500.	1.112	1.113	1.122
24000.	1.111	1.111	1.121
24500.	1.109	1.109	1.120
25000.	1.108	1.107	1.119
25500.	1.107	1.105	1.118
26000.	1.106	1.103	1.117
26500.	1.105	1.100	1.115
27000.	1.104	1.098	1.114
27500.	1.103	1.096	1.113
28000.	1.102	1.095	1.112
28500.	1.101	1.094	1.111
30000.	1.098	1.090	1.108
32500.	1.092	1.086	1.103
35000.	1.086	1.082	1.099
37500.	1.080	1.077	1.095
40000.	1.077	1.073	1.091
42500.	1.078	1.069	1.088
45000.	1.079	1.064	1.085
47500.	1.081	1.060	1.083
50000.	1.082	1.056	1.081
52500.	1.082	1.053	1.080
55000.	1.080	1.054	1.079
57500.	1.076	1.054	1.079
60000.	1.070	1.053	1.080
62500.	1.063	1.051	1.085
65000.	1.055	1.048	1.095
67500.	1.047	1.054	1.106
70000.	1.066	1.069	1.116

Table B.35 [ ] Hot Uncontrolled k_∞

Exposure MWd/MTU	0.00 Void History	0.40 Void History	0.80 Void History
0.	1.06981	1.05429	1.03330
100.	1.04304	1.02915	1.01061
500.	1.03984	1.02682	1.00922
1000.	1.04029	1.02799	1.01098
1500.	1.04213	1.03038	1.01367
2000.	1.04436	1.03309	1.01654
2500.	1.04671	1.03586	1.01939
3000.	1.04917	1.03865	1.02216
3500.	1.05177	1.04149	1.02487
4000.	1.05451	1.04442	1.02758
4500.	1.05741	1.04744	1.03031
5000.	1.06048	1.05056	1.03306
5500.	1.06376	1.05382	1.03585
6000.	1.06728	1.05725	1.03871
6500.	1.07106	1.06088	1.04166
7000.	1.07508	1.06470	1.04473
7500.	1.07933	1.06870	1.04792
8000.	1.08382	1.07288	1.05125
8500.	1.08858	1.07726	1.05471
9000.	1.09366	1.08188	1.05829
9500.	1.09908	1.08671	1.06197
10000.	1.10469	1.09157	1.06558
10500.	1.11027	1.09628	1.06900
11000.	1.11566	1.10074	1.07217
11500.	1.12073	1.10485	1.07503
12000.	1.12558	1.10872	1.07762
12500.	1.13050	1.11253	1.08005
13000.	1.13568	1.11645	1.08243
13500.	1.14123	1.12056	1.08485
14000.	1.14709	1.12485	1.08732
14500.	1.15306	1.12927	1.08984
15000.	1.15896	1.13375	1.09237
15500.	1.16451	1.13818	1.09489
16000.	1.16930	1.14242	1.09738
16500.	1.17301	1.14629	1.09980
17000.	1.17551	1.14956	1.10211
17500.	1.17681	1.15204	1.10425
18000.	1.17694	1.15366	1.10610
18500.	1.17603	1.15440	1.10763
19000.	1.17421	1.15426	1.10877
19500.	1.17169	1.15325	1.10948
20000.	1.16859	1.15146	1.10972
20500.	1.16504	1.14905	1.10947
21000.	1.16110	1.14614	1.10871
21500.	1.15685	1.14287	1.10746
22000.	1.15237	1.13931	1.10576
22500.	1.14771	1.13551	1.10364
23000.	1.14272	1.13154	1.10117
23500.	1.13774	1.12742	1.09840
24000.	1.13275	1.12321	1.09540
24500.	1.12777	1.11879	1.09222
25000.	1.12278	1.11438	1.08889
25500.	1.11778	1.10997	1.08545
26000.	1.11279	1.10556	1.08193
26500.	1.10779	1.10115	1.07834
27000.	1.10280	1.09674	1.07471
27500.	1.09780	1.09233	1.07105
30000.	1.07243	1.07042	1.05242
32500.	1.04667	1.04849	1.03421
35000.	1.02053	1.02654	1.01627
37500.	0.99405	1.00460	0.99862
40000.	0.96733	0.98271	0.98129
42500.	0.94048	0.96093	0.96431
45000.	0.91368	0.93935	0.94771
47500.	0.88715	0.91807	0.93154
50000.	0.86116	0.89720	0.91584
52500.	0.83600	0.87688	0.90066
55000.	0.81198	0.85727	0.88604
57500.	0.78942	0.83849	0.87201
60000.	0.76858	0.82071	0.85862
62500.	0.74970	0.80403	0.84590
65000.	0.73290	0.78856	0.83388
67500.	0.71823	0.77437	0.82258
70000.	0.70563	0.76152	0.81202

Table B.36 [ ] Hot Uncontrolled LPF

Exposure MWd/MTU	0.00 Void History	0.40 Void History	0.80 Void History
0.	1.329	1.323	1.320
100.	1.326	1.319	1.317
500.	1.322	1.314	1.312
1000.	1.318	1.309	1.306
1500.	1.312	1.302	1.300
2000.	1.307	1.296	1.294
2500.	1.301	1.290	1.287
3000.	1.295	1.283	1.281
3500.	1.289	1.276	1.274
4000.	1.282	1.270	1.268
4500.	1.276	1.263	1.264
5000.	1.269	1.256	1.262
5500.	1.262	1.249	1.259
6000.	1.255	1.242	1.256
6500.	1.248	1.235	1.253
7000.	1.242	1.228	1.249
7500.	1.238	1.220	1.246
8000.	1.234	1.213	1.242
8500.	1.229	1.206	1.238
9000.	1.225	1.198	1.235
9500.	1.221	1.191	1.231
10000.	1.216	1.185	1.227
10500.	1.211	1.180	1.221
11000.	1.207	1.173	1.215
11500.	1.204	1.170	1.208
12000.	1.200	1.167	1.200
12500.	1.197	1.165	1.191
13000.	1.195	1.163	1.182
13500.	1.192	1.161	1.173
14000.	1.189	1.159	1.163
14500.	1.186	1.157	1.154
15000.	1.182	1.155	1.145
15500.	1.178	1.153	1.135
16000.	1.174	1.150	1.130
16500.	1.169	1.147	1.126
17000.	1.164	1.144	1.121
17500.	1.159	1.141	1.117
18000.	1.154	1.138	1.116
18500.	1.149	1.135	1.114
19000.	1.145	1.132	1.112
19500.	1.142	1.129	1.111
20000.	1.139	1.126	1.109
20500.	1.136	1.124	1.108
21000.	1.133	1.122	1.106
21500.	1.131	1.120	1.105
22000.	1.129	1.118	1.104
22500.	1.127	1.117	1.103
23000.	1.125	1.116	1.102
23500.	1.123	1.114	1.101
24000.	1.122	1.113	1.100
24500.	1.120	1.112	1.099
25000.	1.118	1.111	1.099
25500.	1.116	1.110	1.099
26000.	1.114	1.109	1.098
26500.	1.113	1.108	1.098
27000.	1.111	1.107	1.098
27500.	1.109	1.106	1.097
30000.	1.100	1.101	1.096
32500.	1.091	1.096	1.094
35000.	1.082	1.091	1.093
37500.	1.074	1.086	1.091
40000.	1.080	1.081	1.089
42500.	1.085	1.076	1.087
45000.	1.089	1.071	1.085
47500.	1.091	1.066	1.083
50000.	1.091	1.063	1.081
52500.	1.090	1.064	1.078
55000.	1.086	1.065	1.076
57500.	1.080	1.064	1.074
60000.	1.073	1.061	1.071
62500.	1.064	1.058	1.069
65000.	1.054	1.053	1.069
67500.	1.043	1.048	1.080
70000.	1.057	1.055	1.091

Table B.37 [ ] Hot Uncontrolled k_∞

Exposure MWd/MTU	0.00 Void History	0.40 Void History	0.80 Void History
0.	1.02318	1.00840	0.98904
100.	0.99852	0.98543	0.96855
500.	0.99669	0.98461	0.96882
1000.	0.99889	0.98769	0.97258
1500.	1.00261	0.99210	0.97732
2000.	1.00677	0.99688	0.98228
2500.	1.01115	1.00180	0.98725
3000.	1.01582	1.00689	0.99222
3500.	1.02080	1.01219	0.99724
4000.	1.02610	1.01772	1.00235
4500.	1.03171	1.02346	1.00755
5000.	1.03766	1.02943	1.01283
5500.	1.04395	1.03565	1.01822
6000.	1.05058	1.04212	1.02373
6500.	1.05756	1.04886	1.02938
7000.	1.06491	1.05587	1.03520
7500.	1.07269	1.06319	1.04120
8000.	1.08093	1.07086	1.04740
8500.	1.08969	1.07891	1.05380
9000.	1.09897	1.08733	1.06039
9500.	1.10874	1.09602	1.06706
10000.	1.11881	1.10478	1.07367
10500.	1.12901	1.11349	1.08012
11000.	1.13915	1.12201	1.08635
11500.	1.14910	1.13022	1.09229
12000.	1.15888	1.13811	1.09791
12500.	1.16837	1.14561	1.10314
13000.	1.17741	1.15264	1.10795
13500.	1.18566	1.15905	1.11231
14000.	1.19272	1.16472	1.11617
14500.	1.19839	1.16962	1.11949
15000.	1.20246	1.17375	1.12229
15500.	1.20490	1.17713	1.12465
16000.	1.20577	1.17969	1.12665
16500.	1.20513	1.18128	1.12835
17000.	1.20321	1.18183	1.12974
17500.	1.20035	1.18134	1.13077
18000.	1.19684	1.17985	1.13141
18500.	1.19286	1.17748	1.13160
19000.	1.18852	1.17440	1.13129
19500.	1.18392	1.17079	1.13045
20000.	1.17901	1.16683	1.12908
20500.	1.17393	1.16263	1.12720
21000.	1.16885	1.15810	1.12486
21500.	1.16376	1.15357	1.12212
22000.	1.15868	1.14904	1.11903
22500.	1.15360	1.14451	1.11569
23000.	1.14850	1.14000	1.11216
23500.	1.14341	1.13549	1.10851
25000.	1.12812	1.12195	1.09695
27500.	1.10219	1.09938	1.07785
30000.	1.07576	1.07675	1.05902
32500.	1.04883	1.05404	1.04046
35000.	1.02142	1.03125	1.02218
37500.	0.99358	1.00840	1.00417
40000.	0.96543	0.98555	0.98647
42500.	0.93712	0.96278	0.96911
45000.	0.90887	0.94018	0.95214
47500.	0.88097	0.91789	0.93559
50000.	0.85374	0.89605	0.91953
52500.	0.82755	0.87482	0.90399
55000.	0.80277	0.85440	0.88903
57500.	0.77976	0.83494	0.87469
60000.	0.75881	0.81661	0.86101
62500.	0.74014	0.79957	0.84804
65000.	0.72385	0.78390	0.83581
67500.	0.70990	0.76969	0.82434
70000.	0.69817	0.75696	0.81365

Table B.38 [ ] Hot Uncontrolled LPF

Exposure MWd/MTU	0.00 Void History	0.40 Void History	0.80 Void History
0.	1.460	1.368	1.341
100.	1.455	1.363	1.336
500.	1.448	1.357	1.330
1000.	1.439	1.351	1.324
1500.	1.430	1.343	1.318
2000.	1.420	1.335	1.315
2500.	1.410	1.327	1.311
3000.	1.399	1.319	1.307
3500.	1.388	1.311	1.302
4000.	1.377	1.302	1.297
4500.	1.365	1.293	1.292
5000.	1.354	1.284	1.286
5500.	1.342	1.276	1.280
6000.	1.330	1.267	1.274
6500.	1.318	1.257	1.268
7000.	1.309	1.250	1.261
7500.	1.302	1.245	1.255
8000.	1.294	1.239	1.248
8500.	1.287	1.233	1.241
9000.	1.279	1.227	1.235
9500.	1.271	1.221	1.227
10000.	1.262	1.215	1.219
10500.	1.255	1.210	1.210
11000.	1.247	1.204	1.200
11500.	1.240	1.199	1.189
12000.	1.233	1.194	1.178
12500.	1.227	1.190	1.166
13000.	1.221	1.185	1.154
13500.	1.216	1.181	1.143
14000.	1.211	1.178	1.138
14500.	1.207	1.175	1.136
15000.	1.202	1.172	1.134
15500.	1.197	1.169	1.132
16000.	1.192	1.166	1.130
16500.	1.187	1.163	1.129
17000.	1.183	1.160	1.127
17500.	1.179	1.157	1.126
18000.	1.176	1.155	1.124
18500.	1.172	1.152	1.123
19000.	1.169	1.150	1.122
19500.	1.167	1.148	1.120
20000.	1.164	1.146	1.119
20500.	1.162	1.145	1.118
21000.	1.159	1.143	1.117
21500.	1.157	1.142	1.116
22000.	1.154	1.141	1.116
22500.	1.152	1.139	1.115
23000.	1.149	1.138	1.114
23500.	1.147	1.136	1.114
25000.	1.139	1.132	1.113
27500.	1.127	1.124	1.111
30000.	1.114	1.117	1.109
32500.	1.102	1.110	1.107
35000.	1.089	1.103	1.104
37500.	1.089	1.096	1.102
40000.	1.092	1.089	1.099
42500.	1.093	1.082	1.097
45000.	1.094	1.076	1.094
47500.	1.094	1.072	1.091
50000.	1.093	1.073	1.088
52500.	1.089	1.073	1.086
55000.	1.084	1.072	1.083
57500.	1.076	1.069	1.080
60000.	1.068	1.066	1.078
62500.	1.058	1.061	1.075
65000.	1.048	1.055	1.073
67500.	1.053	1.055	1.078
70000.	1.059	1.057	1.089

Table B.39 [ ] Hot Uncontrolled k_∞

Exposure MWd/MTU	0.00 Void History	0.40 Void History	0.80 Void History
0.	1.08066	1.06894	1.05221
100.	1.05371	1.04350	1.02913
500.	1.05228	1.04291	1.02928
1000.	1.05563	1.04689	1.03340
1500.	1.06067	1.05238	1.03864
2000.	1.06623	1.05826	1.04409
2500.	1.07214	1.06434	1.04952
3000.	1.07845	1.07065	1.05495
3500.	1.08526	1.07726	1.06045
4000.	1.09265	1.08424	1.06608
4500.	1.10062	1.09163	1.07187
5000.	1.10918	1.09941	1.07786
5500.	1.11836	1.10760	1.08402
6000.	1.12827	1.11622	1.09038
6500.	1.13900	1.12536	1.09695
7000.	1.15064	1.13507	1.10377
7500.	1.16313	1.14536	1.11089
8000.	1.17617	1.15618	1.11829
8500.	1.18924	1.16737	1.12597
9000.	1.20166	1.17857	1.13386
9500.	1.21271	1.18928	1.14180
10000.	1.22195	1.19891	1.14944
10500.	1.22910	1.20691	1.15640
11000.	1.23416	1.21300	1.16241
11500.	1.23726	1.21703	1.16723
12000.	1.23849	1.21905	1.17075
12500.	1.23802	1.21933	1.17297
13000.	1.23620	1.21826	1.17402
13500.	1.23335	1.21619	1.17400
14000.	1.22975	1.21339	1.17307
14500.	1.22562	1.21003	1.17137
15000.	1.22112	1.20625	1.16905
15500.	1.21638	1.20217	1.16626
16000.	1.21150	1.19787	1.16310
16500.	1.20634	1.19343	1.15966
17000.	1.20118	1.18890	1.15602
17500.	1.19602	1.18422	1.15222
18000.	1.19086	1.17952	1.14831
18500.	1.18570	1.17482	1.14433
19000.	1.18055	1.17012	1.14031
19500.	1.17539	1.16542	1.13626
20000.	1.17023	1.16072	1.13220
22500.	1.14431	1.13752	1.11177
25000.	1.11795	1.11433	1.09187
27500.	1.09111	1.09109	1.07230
30000.	1.06375	1.06776	1.05305
32500.	1.03587	1.04436	1.03408
35000.	1.00753	1.02089	1.01542
37500.	0.97883	0.99741	0.99707
40000.	0.94993	0.97400	0.97907
42500.	0.92103	0.95074	0.96147
45000.	0.89244	0.92779	0.94430
47500.	0.86447	0.90528	0.92763
50000.	0.83752	0.88339	0.91151
52500.	0.81198	0.86233	0.89600
55000.	0.78823	0.84227	0.88115
57500.	0.76659	0.82338	0.86700
60000.	0.74730	0.80584	0.85360
62500.	0.73047	0.78974	0.84099
65000.	0.71607	0.77517	0.82920
67500.	0.70397	0.76215	0.81823
70000.	0.69395	0.75066	0.80809

Table B.40 [ ] Hot Uncontrolled LPF

Exposure MWd/MTU	0.00 Void History	0.40 Void History	0.80 Void History
0.	1.323	1.300	1.289
100.	1.321	1.298	1.287
500.	1.315	1.293	1.282
1000.	1.308	1.286	1.277
1500.	1.300	1.279	1.271
2000.	1.292	1.271	1.265
2500.	1.283	1.262	1.258
3000.	1.273	1.253	1.251
3500.	1.264	1.244	1.244
4000.	1.253	1.235	1.237
4500.	1.243	1.226	1.230
5000.	1.232	1.216	1.223
5500.	1.221	1.206	1.217
6000.	1.210	1.196	1.211
6500.	1.198	1.186	1.204
7000.	1.186	1.175	1.198
7500.	1.173	1.165	1.190
8000.	1.161	1.156	1.183
8500.	1.148	1.152	1.176
9000.	1.142	1.147	1.168
9500.	1.140	1.144	1.161
10000.	1.138	1.140	1.154
10500.	1.137	1.137	1.146
11000.	1.136	1.135	1.139
11500.	1.136	1.134	1.134
12000.	1.135	1.133	1.132
12500.	1.134	1.132	1.131
13000.	1.133	1.131	1.130
13500.	1.132	1.130	1.129
14000.	1.131	1.129	1.129
14500.	1.129	1.127	1.128
15000.	1.127	1.126	1.127
15500.	1.125	1.124	1.126
16000.	1.123	1.122	1.125
16500.	1.121	1.120	1.124
17000.	1.118	1.118	1.123
17500.	1.116	1.117	1.122
18000.	1.114	1.115	1.121
18500.	1.111	1.113	1.120
19000.	1.109	1.111	1.119
19500.	1.106	1.109	1.117
20000.	1.104	1.107	1.116
22500.	1.092	1.097	1.110
25000.	1.086	1.087	1.104
27500.	1.088	1.078	1.099
30000.	1.091	1.074	1.093
32500.	1.093	1.073	1.088
35000.	1.095	1.072	1.083
37500.	1.096	1.072	1.079
40000.	1.096	1.072	1.076
42500.	1.097	1.072	1.073
45000.	1.096	1.073	1.070
47500.	1.093	1.074	1.068
50000.	1.089	1.073	1.066
52500.	1.082	1.070	1.065
55000.	1.074	1.067	1.065
57500.	1.065	1.063	1.065
60000.	1.054	1.057	1.066
62500.	1.044	1.051	1.069
65000.	1.042	1.044	1.080
67500.	1.054	1.055	1.090
70000.	1.068	1.069	1.100

Appendix C Enriched Lattice Isotopic Data Tables

The results in this appendix are based on hot operating and equilibrium xenon conditions.

Table C.1 [ ] Exposure-Dependent 0% Void Isotopics (kg/MTU Initial)

Exposure MWd/MTU	U-234	U-235	U-236	U-238	NP-237	PU-238	PU-239	PU-240	PU-241	PU-242
0.0	0.327	43.320	0.000	956.353	0.000	0.000	0.000	0.000	0.000	0.000
100.0	0.327	43.200	0.023	956.298	0.000	0.000	0.020	0.000	0.000	0.000
500.0	0.325	42.723	0.113	956.075	0.002	0.000	0.199	0.002	0.000	0.000
1000.0	0.323	42.135	0.225	955.796	0.004	0.000	0.430	0.007	0.000	0.000
1500.0	0.321	41.556	0.334	955.518	0.006	0.000	0.651	0.016	0.001	0.000
2000.0	0.319	40.985	0.442	955.239	0.008	0.000	0.861	0.027	0.003	0.000
2500.0	0.318	40.422	0.548	954.961	0.011	0.000	1.062	0.042	0.005	0.000
3000.0	0.316	39.867	0.652	954.682	0.014	0.000	1.252	0.059	0.008	0.000
3500.0	0.314	39.320	0.754	954.404	0.017	0.001	1.434	0.077	0.012	0.000
4000.0	0.312	38.779	0.855	954.126	0.020	0.001	1.607	0.098	0.017	0.000
4500.0	0.310	38.245	0.954	953.848	0.024	0.001	1.772	0.120	0.024	0.001
5000.0	0.308	37.717	1.052	953.571	0.027	0.001	1.930	0.143	0.031	0.001
5500.0	0.306	37.196	1.149	953.293	0.031	0.001	2.080	0.167	0.039	0.001
6000.0	0.305	36.681	1.243	953.016	0.035	0.002	2.223	0.193	0.049	0.002
6500.0	0.303	36.171	1.337	952.739	0.039	0.002	2.359	0.220	0.059	0.003
7000.0	0.301	35.667	1.429	952.463	0.043	0.003	2.488	0.247	0.070	0.003
7500.0	0.299	35.169	1.520	952.187	0.047	0.003	2.611	0.275	0.082	0.004
8000.0	0.298	34.676	1.610	951.911	0.052	0.003	2.728	0.304	0.094	0.005
8500.0	0.296	34.188	1.698	951.636	0.056	0.004	2.840	0.333	0.108	0.006
9000.0	0.294	33.705	1.785	951.361	0.061	0.005	2.945	0.363	0.122	0.008
9500.0	0.292	33.227	1.871	951.086	0.065	0.005	3.045	0.393	0.136	0.009
10000.0	0.291	32.753	1.956	950.812	0.070	0.006	3.140	0.424	0.151	0.011
10500.0	0.289	32.284	2.040	950.539	0.075	0.007	3.230	0.455	0.167	0.013
11000.0	0.287	31.819	2.122	950.266	0.080	0.007	3.315	0.487	0.183	0.015
11500.0	0.286	31.359	2.203	949.993	0.085	0.008	3.395	0.519	0.199	0.017
12000.0	0.284	30.903	2.284	949.721	0.091	0.009	3.472	0.551	0.216	0.019
12500.0	0.282	30.451	2.363	949.449	0.096	0.010	3.543	0.583	0.232	0.022
13000.0	0.281	30.003	2.441	949.177	0.101	0.011	3.611	0.616	0.250	0.024
13500.0	0.279	29.559	2.518	948.906	0.107	0.012	3.675	0.648	0.267	0.027
14000.0	0.277	29.119	2.595	948.634	0.112	0.013	3.736	0.681	0.284	0.030
14500.0	0.276	28.682	2.670	948.363	0.118	0.014	3.792	0.714	0.302	0.034
15000.0	0.274	28.250	2.744	948.092	0.123	0.015	3.846	0.747	0.320	0.037
15500.0	0.273	27.820	2.818	947.821	0.129	0.016	3.896	0.780	0.338	0.041
16000.0	0.271	27.395	2.890	947.550	0.135	0.017	3.944	0.813	0.356	0.045
16500.0	0.269	26.972	2.962	947.279	0.141	0.019	3.989	0.846	0.374	0.049
17000.0	0.268	26.554	3.033	947.007	0.147	0.020	4.031	0.879	0.392	0.053
17500.0	0.266	26.139	3.103	946.734	0.153	0.021	4.071	0.911	0.410	0.058
18000.0	0.265	25.727	3.172	946.460	0.159	0.023	4.109	0.944	0.428	0.063
18500.0	0.263	25.319	3.240	946.186	0.165	0.024	4.144	0.977	0.446	0.068
19000.0	0.262	24.915	3.307	945.910	0.171	0.026	4.178	1.010	0.464	0.073
19500.0	0.260	24.514	3.374	945.633	0.177	0.028	4.210	1.042	0.482	0.078
20000.0	0.258	24.116	3.439	945.355	0.183	0.029	4.240	1.074	0.501	0.084
20500.0	0.257	23.723	3.504	945.076	0.190	0.031	4.268	1.106	0.519	0.090
21000.0	0.255	23.333	3.568	944.795	0.196	0.033	4.295	1.139	0.537	0.096
22500.0	0.251	22.183	3.756	943.945	0.216	0.039	4.367	1.234	0.591	0.115
25000.0	0.243	20.338	4.051	942.498	0.249	0.050	4.460	1.388	0.681	0.153
27500.0	0.235	18.581	4.327	941.013	0.284	0.063	4.522	1.537	0.766	0.196
30000.0	0.227	16.911	4.582	939.488	0.320	0.078	4.558	1.679	0.846	0.245
32500.0	0.220	15.329	4.817	937.922	0.356	0.095	4.573	1.816	0.920	0.299
35000.0	0.212	13.833	5.033	936.313	0.393	0.114	4.568	1.945	0.987	0.359
37500.0	0.205	12.424	5.228	934.657	0.430	0.134	4.548	2.066	1.048	0.425
40000.0	0.197	11.102	5.405	932.953	0.466	0.157	4.515	2.180	1.101	0.495
42500.0	0.190	9.868	5.561	931.200	0.503	0.180	4.471	2.284	1.147	0.571
45000.0	0.182	8.721	5.699	929.394	0.538	0.206	4.420	2.380	1.186	0.651
47500.0	0.175	7.662	5.817	927.535	0.573	0.232	4.363	2.467	1.218	0.735
50000.0	0.168	6.689	5.916	925.620	0.606	0.259	4.303	2.545	1.244	0.822
52500.0	0.161	5.803	5.997	923.650	0.638	0.286	4.241	2.614	1.264	0.913
55000.0	0.154	5.001	6.060	921.623	0.669	0.314	4.178	2.674	1.279	1.007
57500.0	0.147	4.281	6.106	919.539	0.697	0.341	4.117	2.726	1.289	1.103
60000.0	0.141	3.641	6.135	917.400	0.724	0.368	4.057	2.770	1.296	1.201
62500.0	0.134	3.076	6.148	915.206	0.748	0.394	4.001	2.806	1.298	1.300
65000.0	0.128	2.583	6.148	912.962	0.770	0.419	3.948	2.835	1.298	1.399
67500.0	0.122	2.157	6.133	910.669	0.790	0.442	3.900	2.858	1.296	1.499
70000.0	0.116	1.791	6.107	908.331	0.807	0.464	3.855	2.875	1.293	1.598

Table C.2 [ ] Exposure-Dependent 40% Void Isotopics (kg/MTU Initial)

Exposure MWd/MTU	U-234	U-235	U-236	U-238	NP-237	PU-238	PU-239	PU-240	PU-241	PU-242
0.0	0.327	43.320	0.000	956.353	0.000	0.000	0.000	0.000	0.000	0.000
100.0	0.327	43.200	0.024	956.290	0.000	0.000	0.022	0.000	0.000	0.000
500.0	0.325	42.725	0.118	956.037	0.002	0.000	0.225	0.002	0.000	0.000
1000.0	0.323	42.141	0.233	955.719	0.004	0.000	0.487	0.008	0.000	0.000
1500.0	0.321	41.566	0.347	955.402	0.007	0.000	0.736	0.018	0.001	0.000
2000.0	0.318	41.001	0.458	955.086	0.010	0.000	0.973	0.031	0.003	0.000
2500.0	0.316	40.445	0.567	954.770	0.013	0.000	1.199	0.047	0.006	0.000
3000.0	0.314	39.898	0.674	954.454	0.016	0.001	1.414	0.065	0.010	0.000
3500.0	0.312	39.358	0.779	954.138	0.020	0.001	1.619	0.086	0.016	0.000
4000.0	0.310	38.827	0.883	953.823	0.024	0.001	1.815	0.108	0.022	0.001
4500.0	0.308	38.302	0.985	953.508	0.028	0.001	2.001	0.132	0.030	0.001
5000.0	0.306	37.785	1.085	953.193	0.032	0.002	2.179	0.157	0.039	0.001
5500.0	0.304	37.275	1.183	952.879	0.037	0.002	2.349	0.183	0.049	0.002
6000.0	0.302	36.771	1.280	952.565	0.041	0.002	2.511	0.210	0.061	0.002
6500.0	0.300	36.273	1.375	952.252	0.046	0.003	2.666	0.239	0.073	0.003
7000.0	0.298	35.782	1.469	951.939	0.051	0.003	2.813	0.268	0.086	0.004
7500.0	0.296	35.296	1.561	951.627	0.056	0.004	2.954	0.298	0.101	0.005
8000.0	0.294	34.816	1.652	951.315	0.061	0.005	3.088	0.328	0.116	0.006
8500.0	0.292	34.342	1.741	951.003	0.067	0.005	3.216	0.359	0.132	0.008
9000.0	0.290	33.873	1.829	950.692	0.072	0.006	3.337	0.391	0.148	0.009
9500.0	0.288	33.410	1.915	950.382	0.078	0.007	3.453	0.423	0.165	0.011
10000.0	0.287	32.951	2.001	950.072	0.083	0.008	3.563	0.456	0.183	0.013
10500.0	0.285	32.497	2.085	949.763	0.089	0.009	3.667	0.488	0.201	0.015
11000.0	0.283	32.048	2.168	949.455	0.095	0.010	3.767	0.522	0.220	0.017
11500.0	0.281	31.604	2.249	949.147	0.101	0.011	3.861	0.555	0.239	0.020
12000.0	0.279	31.164	2.330	948.839	0.108	0.012	3.951	0.589	0.258	0.022
12500.0	0.277	30.728	2.409	948.532	0.114	0.013	4.036	0.623	0.278	0.025
13000.0	0.276	30.297	2.487	948.225	0.120	0.014	4.117	0.657	0.298	0.028
13500.0	0.274	29.870	2.564	947.918	0.127	0.015	4.194	0.692	0.318	0.032
14000.0	0.272	29.447	2.640	947.612	0.133	0.017	4.266	0.726	0.338	0.035
14500.0	0.270	29.028	2.715	947.306	0.140	0.018	4.336	0.761	0.358	0.039
15000.0	0.269	28.612	2.789	947.000	0.146	0.020	4.401	0.795	0.379	0.043
15500.0	0.267	28.201	2.862	946.694	0.153	0.021	4.463	0.830	0.399	0.047
16000.0	0.265	27.793	2.934	946.389	0.159	0.023	4.522	0.865	0.420	0.051
16500.0	0.263	27.390	3.005	946.082	0.166	0.024	4.578	0.899	0.440	0.055
17000.0	0.262	26.989	3.075	945.776	0.173	0.026	4.631	0.934	0.461	0.060
17500.0	0.260	26.593	3.144	945.469	0.180	0.028	4.681	0.969	0.482	0.065
18000.0	0.258	26.200	3.212	945.162	0.187	0.030	4.729	1.003	0.502	0.070
18500.0	0.257	25.811	3.280	944.854	0.194	0.032	4.775	1.038	0.523	0.076
19000.0	0.255	25.425	3.346	944.545	0.201	0.034	4.818	1.072	0.544	0.081
19500.0	0.253	25.043	3.412	944.236	0.208	0.036	4.860	1.106	0.564	0.087
20000.0	0.252	24.664	3.476	943.925	0.215	0.038	4.899	1.140	0.585	0.093
20500.0	0.250	24.289	3.540	943.613	0.222	0.041	4.937	1.174	0.606	0.099
21000.0	0.248	23.918	3.603	943.300	0.229	0.043	4.972	1.208	0.626	0.105
21500.0	0.247	23.550	3.665	942.986	0.237	0.045	5.007	1.242	0.647	0.112
22000.0	0.245	23.186	3.726	942.670	0.244	0.048	5.039	1.275	0.667	0.119
22500.0	0.243	22.825	3.787	942.354	0.252	0.050	5.070	1.308	0.688	0.126
25000.0	0.235	21.075	4.076	940.749	0.290	0.065	5.204	1.471	0.789	0.164
27500.0	0.227	19.411	4.343	939.110	0.329	0.081	5.306	1.628	0.887	0.208
30000.0	0.219	17.832	4.591	937.435	0.369	0.100	5.379	1.780	0.979	0.257
32500.0	0.212	16.337	4.818	935.724	0.409	0.120	5.429	1.925	1.066	0.311
35000.0	0.204	14.925	5.026	933.976	0.449	0.143	5.458	2.063	1.146	0.369
37500.0	0.197	13.593	5.214	932.188	0.489	0.168	5.468	2.193	1.219	0.433
40000.0	0.189	12.341	5.384	930.362	0.529	0.195	5.464	2.316	1.286	0.500
42500.0	0.182	11.168	5.536	928.496	0.568	0.224	5.448	2.432	1.346	0.571
45000.0	0.175	10.072	5.669	926.588	0.606	0.254	5.420	2.539	1.399	0.645
47500.0	0.168	9.051	5.786	924.640	0.642	0.285	5.385	2.638	1.445	0.723
50000.0	0.162	8.105	5.885	922.650	0.678	0.318	5.343	2.728	1.485	0.803
52500.0	0.155	7.231	5.968	920.618	0.712	0.351	5.297	2.811	1.520	0.886
55000.0	0.149	6.428	6.034	918.545	0.744	0.384	5.247	2.885	1.548	0.971
57500.0	0.143	5.693	6.086	916.430	0.774	0.418	5.195	2.952	1.572	1.057
60000.0	0.137	5.023	6.123	914.276	0.803	0.452	5.142	3.011	1.591	1.145
62500.0	0.131	4.416	6.146	912.082	0.830	0.485	5.090	3.063	1.605	1.234
65000.0	0.126	3.869	6.157	909.851	0.854	0.517	5.038	3.109	1.616	1.324
67500.0	0.120	3.378	6.155	907.584	0.877	0.548	4.988	3.148	1.624	1.413
70000.0	0.115	2.940	6.142	905.282	0.897	0.579	4.940	3.181	1.629	1.503

Table C.3 [ ] Exposure-Dependent 80% Void Isotopics (kg/MTU Initial)

Exposure MWd/MTU	U-234	U-235	U-236	U-238	NP-237	PU-238	PU-239	PU-240	PU-241	PU-242
0.0	0.327	43.320	0.000	956.353	0.000	0.000	0.000	0.000	0.000	0.000
100.0	0.327	43.201	0.025	956.280	0.000	0.000	0.025	0.000	0.000	0.000
500.0	0.325	42.729	0.124	955.987	0.002	0.000	0.257	0.002	0.000	0.000
1000.0	0.322	42.151	0.245	955.621	0.005	0.000	0.556	0.009	0.001	0.000
1500.0	0.320	41.583	0.363	955.256	0.008	0.000	0.840	0.020	0.002	0.000
2000.0	0.317	41.026	0.479	954.891	0.012	0.000	1.111	0.034	0.004	0.000
2500.0	0.315	40.479	0.592	954.526	0.016	0.000	1.370	0.052	0.008	0.000
3000.0	0.312	39.941	0.704	954.162	0.020	0.001	1.616	0.072	0.014	0.000
3500.0	0.310	39.412	0.813	953.799	0.024	0.001	1.852	0.093	0.020	0.000
4000.0	0.308	38.891	0.920	953.436	0.029	0.001	2.078	0.117	0.029	0.001
4500.0	0.305	38.379	1.025	953.073	0.034	0.002	2.293	0.142	0.038	0.001
5000.0	0.303	37.874	1.128	952.711	0.039	0.002	2.499	0.169	0.050	0.002
5500.0	0.301	37.376	1.230	952.350	0.045	0.003	2.697	0.196	0.062	0.002
6000.0	0.298	36.885	1.329	951.988	0.050	0.003	2.886	0.225	0.075	0.003
6500.0	0.296	36.401	1.427	951.628	0.056	0.004	3.067	0.255	0.090	0.004
7000.0	0.294	35.924	1.523	951.267	0.062	0.005	3.241	0.286	0.106	0.005
7500.0	0.292	35.453	1.617	950.908	0.068	0.006	3.407	0.317	0.123	0.006
8000.0	0.289	34.988	1.710	950.549	0.075	0.006	3.566	0.349	0.140	0.007
8500.0	0.287	34.529	1.801	950.190	0.081	0.007	3.718	0.382	0.159	0.009
9000.0	0.285	34.076	1.891	949.832	0.088	0.009	3.864	0.415	0.178	0.011
9500.0	0.283	33.629	1.979	949.475	0.095	0.010	4.004	0.449	0.197	0.013
10000.0	0.281	33.186	2.066	949.118	0.102	0.011	4.137	0.483	0.217	0.015
10500.0	0.279	32.749	2.152	948.762	0.109	0.012	4.265	0.518	0.238	0.017
11000.0	0.277	32.317	2.236	948.407	0.116	0.013	4.387	0.553	0.259	0.019
11500.0	0.275	31.890	2.319	948.052	0.123	0.015	4.505	0.588	0.281	0.022
12000.0	0.273	31.468	2.400	947.697	0.131	0.016	4.617	0.624	0.303	0.025
12500.0	0.271	31.051	2.480	947.343	0.138	0.018	4.724	0.660	0.325	0.028
13000.0	0.269	30.638	2.559	946.990	0.146	0.020	4.827	0.696	0.347	0.031
13500.0	0.267	30.229	2.637	946.636	0.153	0.022	4.925	0.733	0.370	0.035
14000.0	0.265	29.825	2.714	946.283	0.161	0.023	5.019	0.770	0.393	0.038
14500.0	0.263	29.425	2.789	945.930	0.168	0.025	5.109	0.807	0.415	0.042
15000.0	0.261	29.029	2.863	945.578	0.176	0.027	5.195	0.844	0.438	0.046
15500.0	0.259	28.637	2.937	945.225	0.184	0.030	5.277	0.881	0.461	0.050
16000.0	0.257	28.250	3.009	944.873	0.192	0.032	5.356	0.918	0.485	0.055
16500.0	0.255	27.866	3.080	944.520	0.200	0.034	5.432	0.955	0.508	0.059
17000.0	0.254	27.486	3.150	944.167	0.208	0.037	5.504	0.993	0.531	0.064
17500.0	0.252	27.110	3.219	943.814	0.216	0.039	5.574	1.030	0.554	0.069
18000.0	0.250	26.737	3.287	943.461	0.224	0.042	5.641	1.067	0.577	0.074
18500.0	0.248	26.369	3.354	943.107	0.232	0.044	5.705	1.105	0.600	0.080
19000.0	0.246	26.004	3.420	942.753	0.241	0.047	5.766	1.142	0.624	0.085
19500.0	0.244	25.642	3.485	942.398	0.249	0.050	5.825	1.179	0.647	0.091
20000.0	0.243	25.285	3.549	942.043	0.257	0.053	5.882	1.216	0.670	0.097
20500.0	0.241	24.931	3.612	941.687	0.265	0.056	5.936	1.253	0.693	0.103
21000.0	0.239	24.580	3.675	941.330	0.274	0.059	5.989	1.290	0.716	0.110
21500.0	0.237	24.233	3.736	940.972	0.282	0.062	6.040	1.327	0.739	0.116
22000.0	0.236	23.890	3.797	940.613	0.291	0.066	6.088	1.364	0.762	0.123
22500.0	0.234	23.549	3.856	940.253	0.299	0.069	6.135	1.400	0.784	0.130
23000.0	0.232	23.213	3.915	939.892	0.307	0.073	6.181	1.437	0.807	0.137
23500.0	0.230	22.880	3.973	939.529	0.316	0.076	6.224	1.473	0.830	0.144
24000.0	0.229	22.551	4.030	939.166	0.324	0.080	6.266	1.509	0.852	0.151
24500.0	0.227	22.225	4.086	938.802	0.333	0.084	6.307	1.545	0.875	0.159
25000.0	0.225	21.902	4.141	938.436	0.342	0.088	6.346	1.581	0.897	0.167
25500.0	0.224	21.583	4.196	938.069	0.350	0.092	6.384	1.616	0.919	0.175
27500.0	0.217	20.339	4.405	936.588	0.385	0.109	6.522	1.756	1.007	0.208
30000.0	0.209	18.859	4.648	934.709	0.428	0.133	6.668	1.926	1.114	0.254
32500.0	0.201	17.459	4.870	932.797	0.471	0.160	6.787	2.090	1.216	0.303
35000.0	0.193	16.136	5.074	930.853	0.514	0.189	6.883	2.249	1.312	0.357
37500.0	0.186	14.890	5.258	928.878	0.557	0.220	6.958	2.401	1.404	0.413
40000.0	0.179	13.716	5.424	926.870	0.599	0.253	7.015	2.546	1.489	0.473
42500.0	0.172	12.614	5.572	924.831	0.640	0.289	7.057	2.685	1.568	0.536
45000.0	0.165	11.580	5.703	922.760	0.680	0.326	7.085	2.816	1.642	0.602
47500.0	0.158	10.613	5.818	920.658	0.718	0.365	7.102	2.941	1.710	0.669
50000.0	0.152	9.710	5.916	918.526	0.756	0.405	7.109	3.058	1.772	0.739
52500.0	0.146	8.869	6.000	916.363	0.791	0.446	7.108	3.168	1.829	0.811
55000.0	0.140	8.088	6.069	914.172	0.825	0.489	7.100	3.271	1.881	0.885
57500.0	0.135	7.363	6.125	911.952	0.858	0.531	7.086	3.367	1.928	0.961
60000.0	0.130	6.693	6.167	909.705	0.888	0.574	7.068	3.456	1.971	1.037
62500.0	0.125	6.074	6.197	907.431	0.917	0.617	7.047	3.539	2.009	1.115
65000.0	0.120	5.504	6.216	905.132	0.943	0.660	7.023	3.615	2.043	1.195
67500.0	0.116	4.981	6.224	902.810	0.967	0.702	6.996	3.686	2.073	1.275
70000.0	0.111	4.502	6.222	900.465	0.990	0.743	6.969	3.750	2.100	1.356

Table C.4 [ ] Exposure-Dependent 0% Void Isotopics (kg/MTU Initial)

Exposure MWd/MTU	U-234	U-235	U-236	U-238	NP-237	PU-238	PU-239	PU-240	PU-241	PU-242
0.0	0.330	43.785	0.000	955.885	0.000	0.000	0.000	0.000	0.000	0.000
100.0	0.330	43.665	0.023	955.831	0.000	0.000	0.019	0.000	0.000	0.000
500.0	0.328	43.187	0.113	955.615	0.002	0.000	0.193	0.001	0.000	0.000
1000.0	0.326	42.598	0.224	955.345	0.003	0.000	0.418	0.007	0.000	0.000
1500.0	0.325	42.018	0.333	955.074	0.006	0.000	0.633	0.015	0.001	0.000
2000.0	0.323	41.446	0.440	954.803	0.008	0.000	0.837	0.026	0.002	0.000
2500.0	0.321	40.882	0.546	954.532	0.011	0.000	1.033	0.040	0.004	0.000
3000.0	0.319	40.325	0.650	954.260	0.013	0.000	1.219	0.056	0.008	0.000
3500.0	0.317	39.775	0.752	953.989	0.016	0.001	1.398	0.075	0.011	0.000
4000.0	0.315	39.231	0.853	953.717	0.019	0.001	1.568	0.094	0.016	0.000
4500.0	0.313	38.695	0.953	953.446	0.023	0.001	1.730	0.116	0.022	0.001
5000.0	0.312	38.165	1.050	953.174	0.026	0.001	1.885	0.138	0.029	0.001
5500.0	0.310	37.640	1.147	952.902	0.030	0.001	2.033	0.162	0.037	0.001
6000.0	0.308	37.122	1.242	952.631	0.034	0.002	2.174	0.187	0.046	0.002
6500.0	0.306	36.610	1.336	952.359	0.038	0.002	2.309	0.213	0.056	0.002
7000.0	0.305	36.103	1.429	952.087	0.042	0.002	2.438	0.240	0.066	0.003
7500.0	0.303	35.601	1.520	951.815	0.046	0.003	2.560	0.267	0.078	0.004
8000.0	0.301	35.105	1.610	951.543	0.050	0.003	2.677	0.295	0.090	0.005
8500.0	0.299	34.614	1.699	951.272	0.055	0.004	2.789	0.324	0.103	0.006
9000.0	0.298	34.127	1.786	951.000	0.059	0.004	2.895	0.354	0.116	0.007
9500.0	0.296	33.646	1.873	950.728	0.064	0.005	2.996	0.383	0.130	0.009
10000.0	0.294	33.169	1.958	950.457	0.069	0.006	3.092	0.414	0.145	0.010
10500.0	0.292	32.697	2.042	950.185	0.074	0.006	3.183	0.444	0.160	0.012
11000.0	0.291	32.230	2.125	949.914	0.079	0.007	3.269	0.475	0.176	0.014
11500.0	0.289	31.766	2.207	949.643	0.084	0.008	3.351	0.507	0.192	0.016
12000.0	0.287	31.307	2.288	949.372	0.089	0.009	3.429	0.538	0.209	0.018
12500.0	0.286	30.853	2.368	949.101	0.094	0.009	3.503	0.570	0.225	0.021
13000.0	0.284	30.402	2.447	948.830	0.100	0.010	3.573	0.602	0.242	0.023
13500.0	0.282	29.955	2.525	948.559	0.105	0.011	3.639	0.634	0.260	0.026
14000.0	0.281	29.512	2.601	948.288	0.111	0.012	3.702	0.667	0.277	0.029
14500.0	0.279	29.073	2.677	948.017	0.116	0.013	3.761	0.699	0.295	0.032
15000.0	0.277	28.638	2.752	947.747	0.122	0.015	3.816	0.732	0.312	0.036
15500.0	0.276	28.206	2.826	947.476	0.128	0.016	3.869	0.765	0.330	0.039
16000.0	0.274	27.778	2.899	947.205	0.134	0.017	3.918	0.797	0.348	0.043
16500.0	0.273	27.353	2.971	946.934	0.140	0.018	3.965	0.830	0.366	0.047
17000.0	0.271	26.932	3.043	946.663	0.145	0.020	4.008	0.863	0.384	0.051
17500.0	0.269	26.515	3.113	946.391	0.151	0.021	4.050	0.895	0.402	0.056
18000.0	0.268	26.101	3.183	946.118	0.157	0.022	4.089	0.928	0.420	0.061
18500.0	0.266	25.690	3.252	945.845	0.164	0.024	4.126	0.961	0.438	0.065
19000.0	0.265	25.283	3.320	945.570	0.170	0.025	4.161	0.993	0.456	0.070
19500.0	0.263	24.880	3.387	945.294	0.176	0.027	4.194	1.025	0.474	0.076
20000.0	0.262	24.480	3.453	945.017	0.182	0.029	4.226	1.058	0.492	0.081
20500.0	0.260	24.083	3.518	944.739	0.189	0.031	4.255	1.090	0.511	0.087
21000.0	0.258	23.691	3.583	944.460	0.195	0.032	4.283	1.122	0.529	0.093
21500.0	0.257	23.301	3.647	944.179	0.201	0.034	4.310	1.153	0.547	0.099
22500.0	0.254	22.533	3.772	943.613	0.215	0.038	4.358	1.217	0.583	0.112
25000.0	0.246	20.675	4.070	942.173	0.248	0.049	4.455	1.371	0.672	0.149
27500.0	0.238	18.904	4.348	940.695	0.283	0.062	4.522	1.520	0.758	0.191
30000.0	0.230	17.221	4.606	939.178	0.319	0.077	4.562	1.663	0.838	0.239
32500.0	0.223	15.624	4.844	937.620	0.356	0.094	4.579	1.799	0.913	0.293
35000.0	0.215	14.114	5.063	936.019	0.392	0.113	4.577	1.929	0.981	0.352
37500.0	0.207	12.690	5.261	934.373	0.430	0.133	4.559	2.051	1.042	0.417
40000.0	0.200	11.353	5.440	932.679	0.466	0.156	4.528	2.165	1.096	0.486
42500.0	0.192	10.103	5.600	930.936	0.503	0.179	4.486	2.271	1.143	0.561
45000.0	0.185	8.941	5.740	929.141	0.539	0.204	4.436	2.368	1.183	0.640
47500.0	0.178	7.865	5.862	927.292	0.574	0.231	4.380	2.456	1.216	0.723
50000.0	0.171	6.877	5.964	925.389	0.608	0.258	4.320	2.535	1.243	0.810
52500.0	0.164	5.974	6.048	923.430	0.640	0.285	4.258	2.606	1.264	0.900
55000.0	0.157	5.156	6.113	921.415	0.670	0.313	4.195	2.667	1.279	0.993
57500.0	0.150	4.421	6.162	919.344	0.699	0.340	4.133	2.720	1.290	1.089
60000.0	0.143	3.765	6.194	917.216	0.726	0.368	4.073	2.765	1.297	1.186
62500.0	0.137	3.186	6.209	915.035	0.751	0.394	4.016	2.802	1.300	1.285
65000.0	0.130	2.680	6.211	912.801	0.773	0.419	3.962	2.832	1.301	1.384
67500.0	0.124	2.240	6.198	910.519	0.794	0.443	3.913	2.856	1.299	1.484
70000.0	0.118	1.862	6.174	908.191	0.812	0.465	3.867	2.874	1.295	1.583

Table C.5 [ ] Exposure-Dependent 40% Void Isotopics (kg/MTU Initial)

Exposure MWd/MTU	U-234	U-235	U-236	U-238	NP-237	PU-238	PU-239	PU-240	PU-241	PU-242
0.0	0.330	43.785	0.000	955.885	0.000	0.000	0.000	0.000	0.000	0.000
100.0	0.330	43.665	0.024	955.824	0.000	0.000	0.021	0.000	0.000	0.000
500.0	0.328	43.190	0.117	955.578	0.002	0.000	0.218	0.002	0.000	0.000
1000.0	0.326	42.604	0.232	955.270	0.004	0.000	0.472	0.008	0.000	0.000
1500.0	0.324	42.028	0.345	954.962	0.007	0.000	0.715	0.017	0.001	0.000
2000.0	0.322	41.462	0.456	954.654	0.009	0.000	0.946	0.030	0.003	0.000
2500.0	0.320	40.904	0.565	954.346	0.013	0.000	1.166	0.045	0.006	0.000
3000.0	0.318	40.354	0.672	954.038	0.016	0.000	1.376	0.063	0.010	0.000
3500.0	0.316	39.812	0.777	953.730	0.019	0.001	1.577	0.083	0.015	0.000
4000.0	0.313	39.278	0.881	953.422	0.023	0.001	1.769	0.104	0.021	0.001
4500.0	0.311	38.751	0.982	953.114	0.027	0.001	1.953	0.128	0.028	0.001
5000.0	0.309	38.231	1.083	952.806	0.031	0.001	2.128	0.152	0.037	0.001
5500.0	0.307	37.717	1.181	952.498	0.036	0.002	2.296	0.178	0.047	0.002
6000.0	0.305	37.210	1.278	952.190	0.040	0.002	2.456	0.204	0.058	0.002
6500.0	0.303	36.709	1.374	951.883	0.045	0.003	2.609	0.232	0.069	0.003
7000.0	0.302	36.214	1.468	951.575	0.050	0.003	2.755	0.260	0.082	0.004
7500.0	0.300	35.726	1.560	951.268	0.055	0.004	2.895	0.290	0.096	0.005
8000.0	0.298	35.242	1.652	950.960	0.060	0.004	3.029	0.320	0.111	0.006
8500.0	0.296	34.764	1.741	950.653	0.065	0.005	3.156	0.350	0.126	0.007
9000.0	0.294	34.292	1.830	950.346	0.070	0.006	3.278	0.381	0.142	0.009
9500.0	0.292	33.825	1.917	950.039	0.076	0.007	3.394	0.413	0.159	0.010
10000.0	0.290	33.363	2.003	949.732	0.082	0.007	3.505	0.445	0.176	0.012
10500.0	0.288	32.905	2.087	949.426	0.088	0.008	3.611	0.477	0.194	0.014
11000.0	0.286	32.453	2.171	949.120	0.094	0.009	3.711	0.510	0.212	0.016
11500.0	0.284	32.005	2.253	948.814	0.100	0.010	3.807	0.543	0.231	0.019
12000.0	0.283	31.562	2.334	948.508	0.106	0.011	3.899	0.576	0.250	0.021
12500.0	0.281	31.123	2.414	948.202	0.112	0.012	3.986	0.609	0.269	0.024
13000.0	0.279	30.689	2.493	947.896	0.118	0.014	4.069	0.643	0.289	0.027
13500.0	0.277	30.259	2.570	947.590	0.125	0.015	4.148	0.677	0.309	0.030
14000.0	0.275	29.833	2.647	947.285	0.131	0.016	4.223	0.711	0.329	0.034
14500.0	0.274	29.411	2.723	946.979	0.138	0.018	4.294	0.745	0.349	0.037
15000.0	0.272	28.993	2.797	946.674	0.145	0.019	4.362	0.780	0.369	0.041
15500.0	0.270	28.579	2.871	946.369	0.151	0.021	4.426	0.814	0.390	0.045
16000.0	0.268	28.168	2.943	946.063	0.158	0.022	4.487	0.848	0.410	0.049
16500.0	0.267	27.762	3.015	945.758	0.165	0.024	4.545	0.883	0.431	0.053
17000.0	0.265	27.359	3.086	945.452	0.172	0.026	4.600	0.917	0.452	0.058
17500.0	0.263	26.960	3.156	945.146	0.178	0.027	4.652	0.952	0.472	0.063
18000.0	0.262	26.564	3.224	944.839	0.185	0.029	4.702	0.986	0.493	0.068
18500.0	0.260	26.172	3.292	944.532	0.192	0.031	4.749	1.020	0.513	0.073
19000.0	0.258	25.784	3.359	944.224	0.199	0.033	4.794	1.054	0.534	0.078
19500.0	0.257	25.399	3.426	943.915	0.206	0.035	4.837	1.089	0.555	0.084
20000.0	0.255	25.018	3.491	943.606	0.214	0.038	4.878	1.122	0.575	0.090
20500.0	0.253	24.640	3.555	943.295	0.221	0.040	4.917	1.156	0.596	0.096
21000.0	0.252	24.266	3.619	942.983	0.228	0.042	4.954	1.190	0.616	0.102
21500.0	0.250	23.896	3.681	942.670	0.236	0.045	4.989	1.224	0.637	0.109
22000.0	0.248	23.529	3.743	942.356	0.243	0.047	5.023	1.257	0.657	0.116
22500.0	0.247	23.165	3.804	942.040	0.250	0.050	5.055	1.290	0.678	0.122
23000.0	0.245	22.806	3.864	941.723	0.258	0.052	5.086	1.323	0.698	0.130
25000.0	0.238	21.401	4.096	940.442	0.289	0.064	5.194	1.453	0.779	0.160
27500.0	0.230	19.723	4.367	938.810	0.328	0.080	5.301	1.610	0.876	0.203
30000.0	0.222	18.131	4.617	937.142	0.368	0.098	5.378	1.762	0.969	0.251
32500.0	0.215	16.623	4.847	935.438	0.408	0.119	5.432	1.907	1.057	0.304
35000.0	0.207	15.196	5.057	933.697	0.449	0.142	5.463	2.046	1.137	0.362
37500.0	0.199	13.851	5.249	931.917	0.489	0.167	5.477	2.177	1.212	0.425
40000.0	0.192	12.585	5.421	930.099	0.529	0.194	5.475	2.301	1.279	0.491
42500.0	0.185	11.398	5.576	928.241	0.568	0.222	5.460	2.417	1.340	0.561
45000.0	0.178	10.288	5.712	926.342	0.606	0.252	5.435	2.525	1.394	0.635
47500.0	0.171	9.253	5.831	924.402	0.643	0.284	5.401	2.625	1.441	0.712
50000.0	0.164	8.293	5.933	922.421	0.679	0.316	5.360	2.717	1.482	0.792
52500.0	0.157	7.406	6.018	920.398	0.713	0.350	5.314	2.801	1.517	0.874
55000.0	0.151	6.589	6.087	918.334	0.746	0.383	5.264	2.877	1.547	0.958
57500.0	0.145	5.841	6.141	916.229	0.777	0.417	5.213	2.945	1.571	1.045
60000.0	0.139	5.159	6.180	914.083	0.806	0.451	5.160	3.005	1.591	1.132
62500.0	0.133	4.539	6.206	911.899	0.833	0.485	5.107	3.058	1.606	1.221
65000.0	0.128	3.981	6.218	909.676	0.858	0.517	5.055	3.104	1.618	1.310
67500.0	0.122	3.479	6.218	907.417	0.881	0.549	5.004	3.144	1.626	1.400
70000.0	0.117	3.030	6.206	905.124	0.902	0.579	4.955	3.178	1.631	1.489

Table C.6 [ ] Exposure-Dependent 80% Void Isotopics (kg/MTU Initial)

Exposure MWd/MTU	U-234	U-235	U-236	U-238	NP-237	PU-238	PU-239	PU-240	PU-241	PU-242
0.0	0.330	43.785	0.000	955.885	0.000	0.000	0.000	0.000	0.000	0.000
100.0	0.330	43.666	0.025	955.814	0.000	0.000	0.024	0.000	0.000	0.000
500.0	0.328	43.194	0.123	955.530	0.002	0.000	0.249	0.002	0.000	0.000
1000.0	0.325	42.614	0.243	955.174	0.005	0.000	0.539	0.009	0.001	0.000
1500.0	0.323	42.045	0.361	954.819	0.008	0.000	0.816	0.019	0.002	0.000
2000.0	0.320	41.487	0.477	954.463	0.012	0.000	1.080	0.033	0.004	0.000
2500.0	0.318	40.937	0.590	954.108	0.015	0.000	1.333	0.050	0.008	0.000
3000.0	0.316	40.397	0.701	953.753	0.019	0.001	1.574	0.069	0.013	0.000
3500.0	0.313	39.866	0.810	953.398	0.024	0.001	1.804	0.091	0.019	0.000
4000.0	0.311	39.342	0.917	953.043	0.028	0.001	2.025	0.114	0.027	0.001
4500.0	0.309	38.827	1.022	952.688	0.033	0.002	2.237	0.138	0.036	0.001
5000.0	0.306	38.319	1.125	952.334	0.038	0.002	2.440	0.164	0.047	0.001
5500.0	0.304	37.818	1.227	951.979	0.043	0.003	2.635	0.191	0.059	0.002
6000.0	0.302	37.324	1.327	951.625	0.049	0.003	2.821	0.219	0.072	0.003
6500.0	0.300	36.837	1.425	951.270	0.055	0.004	3.000	0.248	0.086	0.004
7000.0	0.297	36.356	1.521	950.916	0.061	0.005	3.172	0.278	0.101	0.005
7500.0	0.295	35.882	1.616	950.562	0.067	0.005	3.337	0.309	0.117	0.006
8000.0	0.293	35.413	1.709	950.209	0.073	0.006	3.495	0.341	0.134	0.007
8500.0	0.291	34.951	1.801	949.855	0.080	0.007	3.647	0.373	0.152	0.008
9000.0	0.289	34.494	1.891	949.502	0.086	0.008	3.792	0.405	0.171	0.010
9500.0	0.287	34.042	1.980	949.149	0.093	0.009	3.932	0.439	0.190	0.012
10000.0	0.285	33.597	2.067	948.796	0.100	0.010	4.066	0.472	0.210	0.014
10500.0	0.282	33.156	2.153	948.443	0.107	0.012	4.194	0.506	0.230	0.016
11000.0	0.280	32.720	2.238	948.091	0.114	0.013	4.318	0.541	0.251	0.018
11500.0	0.278	32.289	2.322	947.739	0.121	0.014	4.436	0.576	0.272	0.021
12000.0	0.276	31.864	2.404	947.387	0.129	0.016	4.549	0.611	0.293	0.024
12500.0	0.274	31.442	2.485	947.035	0.136	0.018	4.658	0.647	0.315	0.027
13000.0	0.272	31.026	2.565	946.683	0.143	0.019	4.763	0.682	0.337	0.030
13500.0	0.270	30.614	2.643	946.331	0.151	0.021	4.863	0.718	0.360	0.033
14000.0	0.268	30.206	2.720	945.979	0.159	0.023	4.959	0.755	0.382	0.037
14500.0	0.266	29.803	2.797	945.628	0.166	0.025	5.051	0.791	0.405	0.041
15000.0	0.264	29.404	2.872	945.276	0.174	0.027	5.139	0.828	0.428	0.044
15500.0	0.263	29.009	2.945	944.924	0.182	0.029	5.224	0.864	0.451	0.049
16000.0	0.261	28.618	3.018	944.573	0.190	0.031	5.305	0.901	0.474	0.053
16500.0	0.259	28.231	3.090	944.221	0.198	0.033	5.383	0.938	0.497	0.057
17000.0	0.257	27.848	3.161	943.869	0.206	0.036	5.457	0.975	0.520	0.062
17500.0	0.255	27.469	3.230	943.517	0.214	0.038	5.529	1.012	0.543	0.067
18000.0	0.253	27.094	3.299	943.165	0.222	0.041	5.598	1.049	0.566	0.072
18500.0	0.251	26.722	3.367	942.812	0.231	0.043	5.664	1.086	0.589	0.077
19000.0	0.250	26.355	3.434	942.458	0.239	0.046	5.727	1.123	0.612	0.083
19500.0	0.248	25.990	3.499	942.104	0.247	0.049	5.788	1.160	0.635	0.088
20000.0	0.246	25.630	3.564	941.750	0.255	0.052	5.846	1.197	0.658	0.094
20500.0	0.244	25.273	3.628	941.395	0.264	0.055	5.902	1.234	0.681	0.100
21000.0	0.242	24.919	3.691	941.039	0.272	0.058	5.956	1.271	0.704	0.107
21500.0	0.241	24.570	3.753	940.682	0.281	0.061	6.009	1.307	0.727	0.113
22000.0	0.239	24.223	3.814	940.324	0.289	0.065	6.059	1.344	0.750	0.119
22500.0	0.237	23.881	3.874	939.965	0.298	0.068	6.107	1.380	0.773	0.126
23000.0	0.235	23.541	3.934	939.605	0.306	0.072	6.154	1.417	0.795	0.133
23500.0	0.234	23.205	3.992	939.244	0.315	0.075	6.199	1.453	0.818	0.140
24000.0	0.232	22.873	4.050	938.882	0.323	0.079	6.242	1.489	0.840	0.148
24500.0	0.230	22.544	4.106	938.518	0.332	0.083	6.284	1.525	0.863	0.155
25000.0	0.228	22.219	4.162	938.154	0.340	0.087	6.324	1.560	0.885	0.163
25500.0	0.227	21.897	4.217	937.788	0.349	0.091	6.363	1.596	0.907	0.171
26000.0	0.225	21.578	4.271	937.421	0.358	0.095	6.401	1.631	0.929	0.179
27500.0	0.220	20.642	4.429	936.313	0.383	0.108	6.506	1.736	0.995	0.204
30000.0	0.212	19.148	4.675	934.439	0.427	0.132	6.656	1.906	1.102	0.249
32500.0	0.204	17.734	4.900	932.534	0.471	0.158	6.780	2.071	1.204	0.298
35000.0	0.196	16.399	5.106	930.597	0.514	0.187	6.879	2.229	1.301	0.350
37500.0	0.188	15.139	5.294	928.629	0.557	0.218	6.958	2.382	1.393	0.406
40000.0	0.181	13.952	5.462	926.628	0.599	0.251	7.018	2.528	1.479	0.466
42500.0	0.174	12.837	5.613	924.596	0.640	0.287	7.062	2.667	1.559	0.528
45000.0	0.167	11.790	5.747	922.532	0.681	0.324	7.093	2.800	1.633	0.593
47500.0	0.161	10.811	5.864	920.437	0.720	0.363	7.112	2.925	1.702	0.660
50000.0	0.154	9.896	5.965	918.311	0.757	0.403	7.120	3.043	1.765	0.730
52500.0	0.148	9.043	6.050	916.156	0.793	0.445	7.121	3.155	1.823	0.801
55000.0	0.143	8.250	6.122	913.971	0.828	0.487	7.114	3.259	1.876	0.875
57500.0	0.137	7.514	6.179	911.757	0.861	0.530	7.101	3.356	1.923	0.950
60000.0	0.132	6.833	6.224	909.517	0.891	0.573	7.083	3.446	1.967	1.026
62500.0	0.127	6.204	6.256	907.250	0.920	0.616	7.062	3.530	2.005	1.104
65000.0	0.122	5.625	6.276	904.957	0.947	0.659	7.038	3.607	2.040	1.183
67500.0	0.117	5.092	6.285	902.641	0.972	0.702	7.012	3.679	2.071	1.263
70000.0	0.113	4.604	6.285	900.302	0.995	0.744	6.985	3.744	2.098	1.343

Table C.7 [ ] Exposure-Dependent 0% Void Isotopics (kg/MTU Initial)

Exposure MWd/MTU	U-234	U-235	U-236	U-238	NP-237	PU-238	PU-239	PU-240	PU-241	PU-242
0.0	0.336	44.488	0.000	955.176	0.000	0.000	0.000	0.000	0.000	0.000
100.0	0.335	44.368	0.022	955.126	0.000	0.000	0.016	0.000	0.000	0.000
500.0	0.334	43.889	0.111	954.924	0.002	0.000	0.176	0.001	0.000	0.000
1000.0	0.332	43.298	0.221	954.671	0.003	0.000	0.387	0.006	0.000	0.000
1500.0	0.330	42.715	0.330	954.418	0.005	0.000	0.589	0.013	0.001	0.000
2000.0	0.328	42.139	0.436	954.165	0.007	0.000	0.781	0.024	0.002	0.000
2500.0	0.327	41.571	0.541	953.912	0.010	0.000	0.965	0.037	0.004	0.000
3000.0	0.325	41.009	0.644	953.659	0.012	0.000	1.141	0.051	0.006	0.000
3500.0	0.323	40.454	0.746	953.405	0.015	0.000	1.308	0.068	0.010	0.000
4000.0	0.321	39.905	0.847	953.152	0.018	0.001	1.468	0.087	0.014	0.000
4500.0	0.320	39.362	0.946	952.899	0.021	0.001	1.621	0.107	0.019	0.001
5000.0	0.318	38.825	1.044	952.646	0.024	0.001	1.767	0.128	0.025	0.001
5500.0	0.316	38.293	1.140	952.393	0.028	0.001	1.906	0.150	0.032	0.001
6000.0	0.314	37.767	1.235	952.140	0.031	0.002	2.039	0.174	0.040	0.002
6500.0	0.313	37.247	1.329	951.887	0.035	0.002	2.165	0.198	0.048	0.002
7000.0	0.311	36.732	1.422	951.635	0.039	0.002	2.286	0.223	0.058	0.003
7500.0	0.309	36.221	1.513	951.382	0.043	0.003	2.401	0.249	0.068	0.003
8000.0	0.308	35.716	1.604	951.130	0.046	0.003	2.510	0.276	0.079	0.004
8500.0	0.306	35.215	1.693	950.878	0.051	0.003	2.614	0.303	0.090	0.005
9000.0	0.304	34.719	1.781	950.627	0.055	0.004	2.712	0.331	0.102	0.006
9500.0	0.303	34.228	1.868	950.375	0.059	0.004	2.806	0.360	0.115	0.007
10000.0	0.301	33.741	1.954	950.124	0.063	0.005	2.895	0.389	0.128	0.009
10500.0	0.299	33.258	2.038	949.873	0.068	0.005	2.979	0.418	0.142	0.010
11000.0	0.298	32.779	2.122	949.623	0.073	0.006	3.059	0.448	0.156	0.012
11500.0	0.296	32.305	2.205	949.373	0.077	0.007	3.134	0.478	0.170	0.014
12000.0	0.295	31.834	2.286	949.123	0.082	0.007	3.205	0.508	0.185	0.016
12500.0	0.293	31.368	2.367	948.873	0.087	0.008	3.273	0.539	0.200	0.018
13000.0	0.291	30.905	2.447	948.623	0.092	0.009	3.336	0.570	0.215	0.020
13500.0	0.290	30.445	2.526	948.374	0.097	0.010	3.396	0.601	0.231	0.023
14000.0	0.288	29.989	2.603	948.125	0.102	0.011	3.452	0.632	0.246	0.025
14500.0	0.287	29.537	2.680	947.876	0.107	0.012	3.505	0.663	0.262	0.028
15000.0	0.285	29.088	2.756	947.628	0.112	0.013	3.555	0.694	0.278	0.031
15500.0	0.284	28.643	2.832	947.379	0.117	0.014	3.601	0.726	0.294	0.034
16000.0	0.282	28.201	2.906	947.130	0.123	0.015	3.645	0.757	0.310	0.038
16500.0	0.280	27.762	2.979	946.881	0.128	0.016	3.687	0.789	0.327	0.041
17000.0	0.279	27.327	3.052	946.631	0.133	0.017	3.726	0.820	0.343	0.045
17500.0	0.277	26.895	3.124	946.380	0.139	0.018	3.762	0.852	0.359	0.049
18000.0	0.276	26.467	3.195	946.129	0.144	0.019	3.797	0.883	0.376	0.053
18500.0	0.274	26.042	3.265	945.876	0.150	0.021	3.830	0.915	0.393	0.058
19000.0	0.273	25.620	3.335	945.622	0.156	0.022	3.861	0.946	0.409	0.062
19500.0	0.271	25.202	3.403	945.367	0.161	0.023	3.890	0.977	0.426	0.067
20000.0	0.270	24.787	3.471	945.111	0.167	0.025	3.917	1.009	0.443	0.072
20500.0	0.268	24.375	3.538	944.854	0.173	0.026	3.943	1.040	0.459	0.077
21000.0	0.267	23.968	3.605	944.595	0.179	0.028	3.967	1.071	0.476	0.083
22500.0	0.262	22.765	3.799	943.810	0.197	0.033	4.031	1.163	0.526	0.101
25000.0	0.254	20.828	4.107	942.472	0.229	0.043	4.112	1.313	0.609	0.134
27500.0	0.247	18.978	4.395	941.096	0.261	0.054	4.163	1.458	0.688	0.174
30000.0	0.239	17.215	4.664	939.679	0.295	0.067	4.188	1.599	0.762	0.220
32500.0	0.231	15.539	4.912	938.219	0.329	0.081	4.192	1.733	0.831	0.272
35000.0	0.223	13.951	5.141	936.712	0.364	0.098	4.177	1.861	0.893	0.329
37500.0	0.216	12.453	5.350	935.156	0.399	0.116	4.148	1.981	0.948	0.392
40000.0	0.208	11.046	5.539	933.548	0.435	0.135	4.106	2.093	0.996	0.461
42500.0	0.200	9.732	5.708	931.883	0.470	0.156	4.055	2.197	1.038	0.536
45000.0	0.193	8.511	5.857	930.160	0.504	0.179	3.996	2.292	1.072	0.615
47500.0	0.185	7.387	5.985	928.374	0.538	0.202	3.933	2.377	1.100	0.700
50000.0	0.177	6.358	6.092	926.524	0.570	0.226	3.868	2.454	1.122	0.789
52500.0	0.170	5.426	6.180	924.608	0.601	0.251	3.801	2.521	1.138	0.883
55000.0	0.162	4.590	6.247	922.624	0.631	0.275	3.736	2.578	1.149	0.979
57500.0	0.155	3.848	6.296	920.572	0.659	0.300	3.672	2.627	1.155	1.079
60000.0	0.147	3.197	6.326	918.452	0.684	0.324	3.613	2.667	1.158	1.182
62500.0	0.140	2.633	6.338	916.267	0.708	0.347	3.557	2.699	1.157	1.286
65000.0	0.133	2.150	6.334	914.021	0.729	0.369	3.507	2.724	1.155	1.391
67500.0	0.126	1.743	6.316	911.717	0.748	0.389	3.461	2.742	1.150	1.496
70000.0	0.120	1.403	6.284	909.360	0.764	0.408	3.421	2.755	1.145	1.601

Table C.8 [ ] Exposure-Dependent 40% Void Isotopics (kg/MTU Initial)

Exposure MWd/MTU	U-234	U-235	U-236	U-238	NP-237	PU-238	PU-239	PU-240	PU-241	PU-242
0.0	0.336	44.488	0.000	955.176	0.000	0.000	0.000	0.000	0.000	0.000
100.0	0.335	44.368	0.023	955.119	0.000	0.000	0.019	0.000	0.000	0.000
500.0	0.334	43.891	0.116	954.888	0.002	0.000	0.200	0.001	0.000	0.000
1000.0	0.332	43.303	0.230	954.598	0.004	0.000	0.440	0.007	0.000	0.000
1500.0	0.330	42.724	0.342	954.309	0.006	0.000	0.669	0.015	0.001	0.000
2000.0	0.328	42.154	0.452	954.019	0.009	0.000	0.887	0.027	0.003	0.000
2500.0	0.326	41.591	0.560	953.730	0.012	0.000	1.096	0.041	0.005	0.000
3000.0	0.324	41.036	0.667	953.441	0.015	0.000	1.295	0.058	0.008	0.000
3500.0	0.322	40.488	0.772	953.152	0.018	0.001	1.485	0.076	0.013	0.000
4000.0	0.320	39.948	0.875	952.864	0.022	0.001	1.666	0.097	0.018	0.000
4500.0	0.318	39.414	0.976	952.575	0.025	0.001	1.839	0.118	0.025	0.001
5000.0	0.316	38.886	1.076	952.287	0.029	0.001	2.005	0.142	0.032	0.001
5500.0	0.314	38.365	1.175	951.999	0.033	0.002	2.163	0.166	0.041	0.001
6000.0	0.312	37.850	1.272	951.712	0.037	0.002	2.314	0.191	0.051	0.002
6500.0	0.310	37.341	1.367	951.424	0.042	0.002	2.457	0.217	0.061	0.003
7000.0	0.308	36.838	1.461	951.137	0.046	0.003	2.595	0.245	0.073	0.003
7500.0	0.306	36.340	1.554	950.850	0.051	0.003	2.726	0.272	0.085	0.004
8000.0	0.304	35.847	1.646	950.564	0.055	0.004	2.850	0.301	0.099	0.005
8500.0	0.302	35.360	1.736	950.278	0.060	0.004	2.969	0.330	0.112	0.006
9000.0	0.301	34.877	1.825	949.992	0.065	0.005	3.083	0.360	0.127	0.008
9500.0	0.299	34.400	1.912	949.707	0.071	0.006	3.190	0.390	0.142	0.009
10000.0	0.297	33.927	1.999	949.422	0.076	0.007	3.293	0.421	0.158	0.011
10500.0	0.295	33.459	2.084	949.138	0.081	0.007	3.390	0.452	0.174	0.012
11000.0	0.293	32.995	2.168	948.854	0.087	0.008	3.482	0.483	0.191	0.014
11500.0	0.292	32.536	2.251	948.570	0.092	0.009	3.570	0.515	0.208	0.016
12000.0	0.290	32.081	2.332	948.287	0.098	0.010	3.654	0.547	0.225	0.019
12500.0	0.288	31.631	2.413	948.004	0.104	0.011	3.733	0.580	0.243	0.021
13000.0	0.286	31.184	2.493	947.721	0.110	0.012	3.808	0.612	0.261	0.024
13500.0	0.285	30.741	2.571	947.438	0.116	0.013	3.879	0.645	0.279	0.027
14000.0	0.283	30.303	2.649	947.156	0.122	0.014	3.946	0.678	0.298	0.030
14500.0	0.281	29.868	2.725	946.874	0.128	0.015	4.009	0.711	0.316	0.033
15000.0	0.280	29.436	2.801	946.593	0.134	0.017	4.069	0.744	0.335	0.036
15500.0	0.278	29.009	2.876	946.311	0.140	0.018	4.126	0.777	0.354	0.040
16000.0	0.276	28.585	2.949	946.029	0.146	0.019	4.180	0.811	0.373	0.044
16500.0	0.275	28.164	3.022	945.748	0.152	0.021	4.230	0.844	0.392	0.048
17000.0	0.273	27.747	3.094	945.466	0.159	0.022	4.278	0.877	0.410	0.052
17500.0	0.271	27.334	3.165	945.183	0.165	0.024	4.323	0.910	0.429	0.056
18000.0	0.270	26.924	3.236	944.900	0.171	0.025	4.366	0.943	0.449	0.061
18500.0	0.268	26.517	3.305	944.616	0.178	0.027	4.407	0.977	0.468	0.066
19000.0	0.266	26.114	3.373	944.332	0.184	0.029	4.446	1.010	0.487	0.071
19500.0	0.265	25.715	3.441	944.046	0.191	0.031	4.483	1.043	0.506	0.076
20000.0	0.263	25.319	3.508	943.759	0.198	0.033	4.518	1.075	0.525	0.082
20500.0	0.261	24.926	3.574	943.471	0.204	0.035	4.551	1.108	0.544	0.087
21000.0	0.260	24.537	3.639	943.182	0.211	0.037	4.582	1.141	0.563	0.093
21500.0	0.258	24.151	3.703	942.892	0.218	0.039	4.612	1.173	0.582	0.099
22000.0	0.257	23.769	3.767	942.600	0.225	0.041	4.640	1.206	0.601	0.106
22500.0	0.255	23.391	3.829	942.307	0.232	0.043	4.667	1.238	0.620	0.112
25000.0	0.247	21.549	4.130	940.821	0.268	0.055	4.781	1.395	0.714	0.148
27500.0	0.239	19.794	4.410	939.300	0.305	0.069	4.863	1.548	0.805	0.189
30000.0	0.231	18.124	4.670	937.742	0.343	0.086	4.917	1.696	0.891	0.236
32500.0	0.223	16.538	4.910	936.147	0.381	0.104	4.947	1.837	0.971	0.288
35000.0	0.215	15.036	5.130	934.511	0.420	0.124	4.958	1.971	1.045	0.345
37500.0	0.208	13.617	5.331	932.834	0.458	0.146	4.950	2.099	1.112	0.407
40000.0	0.200	12.281	5.513	931.114	0.497	0.170	4.929	2.219	1.172	0.473
42500.0	0.193	11.029	5.676	929.349	0.534	0.195	4.895	2.331	1.225	0.544
45000.0	0.185	9.858	5.820	927.538	0.571	0.222	4.852	2.434	1.271	0.619
47500.0	0.178	8.770	5.946	925.680	0.607	0.250	4.802	2.529	1.311	0.698
50000.0	0.171	7.763	6.053	923.773	0.641	0.279	4.746	2.615	1.344	0.781
52500.0	0.164	6.836	6.143	921.817	0.675	0.308	4.687	2.693	1.371	0.866
55000.0	0.157	5.988	6.215	919.811	0.706	0.339	4.625	2.762	1.392	0.955
57500.0	0.150	5.218	6.271	917.755	0.736	0.369	4.563	2.823	1.409	1.045
60000.0	0.144	4.522	6.310	915.650	0.764	0.398	4.501	2.876	1.420	1.137
62500.0	0.137	3.898	6.334	913.496	0.790	0.428	4.441	2.920	1.428	1.231
65000.0	0.131	3.343	6.344	911.295	0.814	0.456	4.384	2.958	1.432	1.326
67500.0	0.125	2.853	6.340	909.050	0.836	0.483	4.329	2.989	1.434	1.421
70000.0	0.120	2.422	6.323	906.762	0.855	0.509	4.278	3.014	1.433	1.516

Table C.9 [ ] Exposure-Dependent 80% Void Isotopics (kg/MTU Initial)

Exposure MWd/MTU	U-234	U-235	U-236	U-238	NP-237	PU-238	PU-239	PU-240	PU-241	PU-242
0.0	0.336	44.488	0.000	955.176	0.000	0.000	0.000	0.000	0.000	0.000
100.0	0.335	44.369	0.024	955.109	0.000	0.000	0.021	0.000	0.000	0.000
500.0	0.333	43.895	0.122	954.839	0.002	0.000	0.231	0.002	0.000	0.000
1000.0	0.331	43.312	0.242	954.502	0.005	0.000	0.508	0.008	0.000	0.000
1500.0	0.329	42.740	0.359	954.164	0.008	0.000	0.772	0.018	0.002	0.000
2000.0	0.326	42.176	0.474	953.827	0.011	0.000	1.024	0.031	0.004	0.000
2500.0	0.324	41.622	0.587	953.490	0.014	0.000	1.264	0.047	0.007	0.000
3000.0	0.322	41.076	0.697	953.154	0.018	0.001	1.494	0.065	0.011	0.000
3500.0	0.319	40.539	0.806	952.818	0.022	0.001	1.714	0.085	0.017	0.000
4000.0	0.317	40.009	0.913	952.482	0.027	0.001	1.925	0.107	0.024	0.001
4500.0	0.315	39.486	1.018	952.146	0.031	0.002	2.126	0.130	0.033	0.001
5000.0	0.313	38.971	1.122	951.811	0.036	0.002	2.319	0.155	0.042	0.001
5500.0	0.310	38.463	1.223	951.476	0.041	0.002	2.504	0.181	0.053	0.002
6000.0	0.308	37.961	1.323	951.142	0.046	0.003	2.680	0.208	0.065	0.002
6500.0	0.306	37.466	1.421	950.808	0.052	0.003	2.849	0.236	0.078	0.003
7000.0	0.304	36.977	1.518	950.474	0.057	0.004	3.011	0.265	0.093	0.004
7500.0	0.302	36.493	1.613	950.141	0.063	0.005	3.166	0.294	0.108	0.005
8000.0	0.300	36.016	1.707	949.808	0.069	0.006	3.315	0.324	0.123	0.006
8500.0	0.297	35.544	1.799	949.476	0.075	0.006	3.457	0.355	0.140	0.008
9000.0	0.295	35.078	1.889	949.144	0.081	0.007	3.593	0.387	0.157	0.009
9500.0	0.293	34.617	1.979	948.813	0.088	0.008	3.723	0.419	0.175	0.011
10000.0	0.291	34.161	2.067	948.482	0.094	0.009	3.847	0.452	0.194	0.012
10500.0	0.289	33.710	2.153	948.152	0.101	0.010	3.966	0.485	0.213	0.014
11000.0	0.287	33.264	2.239	947.822	0.107	0.012	4.079	0.518	0.232	0.017
11500.0	0.285	32.823	2.323	947.492	0.114	0.013	4.188	0.552	0.252	0.019
12000.0	0.283	32.387	2.406	947.163	0.121	0.014	4.291	0.586	0.273	0.022
12500.0	0.281	31.954	2.487	946.834	0.128	0.016	4.391	0.620	0.293	0.024
13000.0	0.279	31.527	2.568	946.505	0.135	0.017	4.485	0.655	0.314	0.027
13500.0	0.277	31.103	2.647	946.177	0.142	0.019	4.576	0.690	0.335	0.030
14000.0	0.276	30.684	2.725	945.849	0.149	0.020	4.662	0.725	0.356	0.034
14500.0	0.274	30.269	2.802	945.521	0.157	0.022	4.745	0.761	0.378	0.037
15000.0	0.272	29.858	2.878	945.193	0.164	0.024	4.823	0.796	0.399	0.041
15500.0	0.270	29.451	2.953	944.865	0.171	0.026	4.898	0.832	0.421	0.045
16000.0	0.268	29.048	3.027	944.538	0.179	0.028	4.970	0.868	0.443	0.049
16500.0	0.266	28.649	3.100	944.210	0.187	0.030	5.038	0.903	0.464	0.053
17000.0	0.264	28.253	3.172	943.883	0.194	0.032	5.103	0.939	0.486	0.057
17500.0	0.263	27.861	3.243	943.555	0.202	0.034	5.165	0.975	0.508	0.062
18000.0	0.261	27.473	3.312	943.227	0.209	0.036	5.225	1.011	0.530	0.067
18500.0	0.259	27.088	3.381	942.899	0.217	0.039	5.281	1.047	0.552	0.072
19000.0	0.257	26.707	3.449	942.570	0.225	0.041	5.336	1.083	0.573	0.077
19500.0	0.255	26.330	3.516	942.240	0.233	0.044	5.387	1.119	0.595	0.083
20000.0	0.254	25.956	3.582	941.910	0.241	0.046	5.437	1.155	0.617	0.088
20500.0	0.252	25.585	3.648	941.579	0.249	0.049	5.485	1.190	0.639	0.094
21000.0	0.250	25.218	3.712	941.247	0.257	0.052	5.530	1.226	0.660	0.100
21500.0	0.248	24.855	3.775	940.914	0.265	0.054	5.574	1.261	0.682	0.106
22000.0	0.247	24.495	3.838	940.580	0.273	0.057	5.616	1.297	0.704	0.112
22500.0	0.245	24.138	3.900	940.245	0.281	0.060	5.656	1.332	0.725	0.119
23000.0	0.243	23.785	3.960	939.909	0.289	0.064	5.695	1.367	0.747	0.126
23500.0	0.241	23.436	4.020	939.571	0.297	0.067	5.732	1.402	0.768	0.133
24000.0	0.240	23.090	4.079	939.233	0.305	0.070	5.768	1.437	0.789	0.140
24500.0	0.238	22.747	4.138	938.893	0.313	0.074	5.802	1.472	0.810	0.147
25000.0	0.236	22.408	4.195	938.552	0.321	0.077	5.835	1.506	0.832	0.154
27500.0	0.228	20.762	4.469	936.826	0.363	0.096	5.979	1.675	0.936	0.194
30000.0	0.220	19.199	4.723	935.068	0.405	0.117	6.093	1.839	1.037	0.239
32500.0	0.212	17.716	4.957	933.277	0.447	0.141	6.181	1.998	1.133	0.288
35000.0	0.204	16.314	5.171	931.452	0.489	0.167	6.246	2.151	1.223	0.341
37500.0	0.196	14.988	5.366	929.593	0.531	0.195	6.290	2.297	1.307	0.398
40000.0	0.189	13.739	5.542	927.700	0.572	0.225	6.317	2.436	1.386	0.458
42500.0	0.181	12.565	5.700	925.772	0.612	0.257	6.329	2.568	1.458	0.522
45000.0	0.174	11.463	5.840	923.808	0.652	0.291	6.329	2.693	1.524	0.589
47500.0	0.168	10.432	5.962	921.810	0.690	0.327	6.317	2.811	1.584	0.659
50000.0	0.161	9.470	6.068	919.776	0.728	0.363	6.297	2.920	1.638	0.731
52500.0	0.154	8.575	6.158	917.708	0.763	0.401	6.269	3.022	1.686	0.806
55000.0	0.148	7.745	6.232	915.605	0.797	0.439	6.235	3.117	1.729	0.883
57500.0	0.142	6.978	6.292	913.469	0.829	0.478	6.197	3.203	1.766	0.962
60000.0	0.136	6.272	6.337	911.299	0.860	0.517	6.156	3.283	1.799	1.042
62500.0	0.131	5.623	6.369	909.098	0.888	0.556	6.113	3.355	1.827	1.124
65000.0	0.126	5.029	6.389	906.865	0.914	0.595	6.068	3.420	1.851	1.208
67500.0	0.121	4.488	6.396	904.603	0.938	0.632	6.023	3.478	1.872	1.292
70000.0	0.116	3.996	6.393	902.312	0.960	0.669	5.978	3.531	1.888	1.377

Table C.10 [ ] Exposure-Dependent 0% Void Isotopics (kg/MTU Initial)

Exposure MWd/MTU	U-234	U-235	U-236	U-238	NP-237	PU-238	PU-239	PU-240	PU-241	PU-242
0.0	0.333	44.167	0.000	955.500	0.000	0.000	0.000	0.000	0.000	0.000
100.0	0.333	44.047	0.022	955.450	0.000	0.000	0.016	0.000	0.000	0.000
500.0	0.331	43.569	0.111	955.251	0.001	0.000	0.174	0.001	0.000	0.000
1000.0	0.330	42.978	0.220	955.002	0.003	0.000	0.382	0.006	0.000	0.000
1500.0	0.328	42.395	0.328	954.752	0.005	0.000	0.581	0.013	0.001	0.000
2000.0	0.326	41.819	0.434	954.502	0.007	0.000	0.771	0.024	0.002	0.000
2500.0	0.324	41.250	0.538	954.252	0.010	0.000	0.952	0.036	0.004	0.000
3000.0	0.323	40.688	0.641	954.001	0.012	0.000	1.125	0.051	0.006	0.000
3500.0	0.321	40.132	0.743	953.751	0.015	0.000	1.291	0.068	0.010	0.000
4000.0	0.319	39.583	0.843	953.501	0.018	0.001	1.449	0.086	0.014	0.000
4500.0	0.317	39.040	0.942	953.251	0.021	0.001	1.600	0.106	0.019	0.001
5000.0	0.316	38.503	1.039	953.000	0.024	0.001	1.744	0.127	0.025	0.001
5500.0	0.314	37.971	1.135	952.750	0.027	0.001	1.881	0.149	0.031	0.001
6000.0	0.312	37.445	1.230	952.500	0.031	0.001	2.012	0.172	0.039	0.001
6500.0	0.310	36.924	1.323	952.250	0.034	0.002	2.137	0.196	0.047	0.002
7000.0	0.309	36.408	1.416	952.000	0.038	0.002	2.256	0.222	0.057	0.003
7500.0	0.307	35.898	1.507	951.749	0.042	0.002	2.370	0.248	0.067	0.003
8000.0	0.305	35.392	1.597	951.500	0.046	0.003	2.477	0.274	0.077	0.004
8500.0	0.304	34.891	1.686	951.250	0.050	0.003	2.580	0.301	0.088	0.005
9000.0	0.302	34.395	1.773	951.000	0.054	0.004	2.677	0.329	0.100	0.006
9500.0	0.301	33.903	1.860	950.751	0.058	0.004	2.770	0.358	0.113	0.007
10000.0	0.299	33.416	1.946	950.502	0.063	0.005	2.857	0.386	0.126	0.009
10500.0	0.297	32.933	2.030	950.253	0.067	0.005	2.941	0.416	0.139	0.010
11000.0	0.296	32.454	2.113	950.004	0.072	0.006	3.019	0.445	0.153	0.012
11500.0	0.294	31.979	2.196	949.755	0.076	0.007	3.094	0.475	0.167	0.014
12000.0	0.292	31.509	2.277	949.507	0.081	0.007	3.164	0.506	0.182	0.016
12500.0	0.291	31.042	2.358	949.258	0.086	0.008	3.231	0.536	0.197	0.018
13000.0	0.289	30.579	2.437	949.010	0.091	0.009	3.294	0.567	0.212	0.020
13500.0	0.288	30.120	2.516	948.761	0.096	0.010	3.353	0.598	0.227	0.023
14000.0	0.286	29.664	2.593	948.513	0.101	0.011	3.408	0.629	0.243	0.025
14500.0	0.285	29.213	2.670	948.265	0.106	0.011	3.460	0.660	0.259	0.028
15000.0	0.283	28.764	2.746	948.017	0.111	0.012	3.509	0.692	0.274	0.031
15500.0	0.282	28.319	2.820	947.769	0.116	0.013	3.555	0.723	0.290	0.035
16000.0	0.280	27.877	2.895	947.521	0.121	0.014	3.598	0.755	0.306	0.038
16500.0	0.278	27.439	2.968	947.273	0.127	0.015	3.638	0.787	0.322	0.042
17000.0	0.277	27.004	3.040	947.025	0.132	0.017	3.676	0.818	0.339	0.045
17500.0	0.275	26.573	3.112	946.776	0.137	0.018	3.711	0.850	0.355	0.050
18000.0	0.274	26.144	3.183	946.526	0.143	0.019	3.744	0.882	0.371	0.054
18500.0	0.272	25.719	3.253	946.276	0.148	0.020	3.775	0.913	0.387	0.058
19000.0	0.271	25.298	3.322	946.024	0.154	0.022	3.804	0.945	0.403	0.063
19500.0	0.269	24.880	3.390	945.772	0.160	0.023	3.832	0.976	0.420	0.068
20000.0	0.268	24.465	3.458	945.518	0.165	0.024	3.857	1.007	0.436	0.073
20500.0	0.266	24.054	3.525	945.263	0.171	0.026	3.881	1.039	0.452	0.078
21000.0	0.265	23.646	3.591	945.007	0.177	0.027	3.903	1.070	0.469	0.083
21500.0	0.263	23.241	3.656	944.750	0.183	0.029	3.924	1.101	0.485	0.089
22500.0	0.260	22.442	3.784	944.230	0.195	0.032	3.962	1.162	0.517	0.101
25000.0	0.253	20.505	4.091	942.906	0.225	0.042	4.034	1.312	0.598	0.135
27500.0	0.245	18.654	4.378	941.541	0.257	0.053	4.078	1.458	0.675	0.175
30000.0	0.237	16.890	4.646	940.135	0.290	0.065	4.097	1.598	0.747	0.221
32500.0	0.230	15.214	4.894	938.684	0.324	0.080	4.096	1.732	0.814	0.273
35000.0	0.222	13.628	5.122	937.185	0.358	0.096	4.077	1.858	0.874	0.331
37500.0	0.214	12.132	5.330	935.634	0.393	0.113	4.043	1.978	0.927	0.395
40000.0	0.207	10.729	5.518	934.030	0.427	0.132	3.998	2.089	0.974	0.465
42500.0	0.199	9.420	5.685	932.367	0.462	0.153	3.945	2.192	1.013	0.540
45000.0	0.191	8.208	5.832	930.643	0.495	0.175	3.885	2.285	1.046	0.621
47500.0	0.183	7.092	5.958	928.854	0.528	0.197	3.820	2.369	1.072	0.707
50000.0	0.176	6.076	6.064	926.999	0.560	0.221	3.754	2.444	1.092	0.797
52500.0	0.168	5.158	6.149	925.074	0.590	0.245	3.688	2.509	1.106	0.892
55000.0	0.161	4.338	6.214	923.079	0.619	0.268	3.623	2.565	1.116	0.990
57500.0	0.153	3.614	6.259	921.014	0.646	0.292	3.561	2.612	1.121	1.092
60000.0	0.146	2.983	6.286	918.880	0.671	0.315	3.502	2.650	1.123	1.195
62500.0	0.138	2.439	6.296	916.678	0.694	0.337	3.449	2.680	1.122	1.301
65000.0	0.131	1.978	6.289	914.414	0.714	0.358	3.400	2.704	1.119	1.407
67500.0	0.125	1.591	6.268	912.092	0.732	0.377	3.357	2.720	1.114	1.514
70000.0	0.118	1.271	6.234	909.717	0.748	0.394	3.319	2.732	1.109	1.620

Table C.11 [ ] Exposure-Dependent 40% Void Isotopics (kg/MTU Initial)

Exposure MWd/MTU	U-234	U-235	U-236	U-238	NP-237	PU-238	PU-239	PU-240	PU-241	PU-242
0.0	0.333	44.167	0.000	955.500	0.000	0.000	0.000	0.000	0.000	0.000
100.0	0.333	44.047	0.023	955.443	0.000	0.000	0.018	0.000	0.000	0.000
500.0	0.331	43.570	0.115	955.214	0.002	0.000	0.198	0.001	0.000	0.000
1000.0	0.329	42.983	0.229	954.927	0.004	0.000	0.435	0.007	0.000	0.000
1500.0	0.327	42.404	0.340	954.640	0.006	0.000	0.662	0.015	0.001	0.000
2000.0	0.325	41.833	0.450	954.354	0.009	0.000	0.878	0.027	0.003	0.000
2500.0	0.323	41.271	0.558	954.067	0.012	0.000	1.085	0.041	0.005	0.000
3000.0	0.321	40.716	0.664	953.781	0.015	0.000	1.282	0.058	0.008	0.000
3500.0	0.319	40.168	0.768	953.494	0.018	0.001	1.470	0.076	0.013	0.000
4000.0	0.317	39.628	0.871	953.208	0.021	0.001	1.650	0.096	0.018	0.000
4500.0	0.315	39.094	0.972	952.922	0.025	0.001	1.821	0.118	0.024	0.001
5000.0	0.313	38.566	1.071	952.636	0.029	0.001	1.985	0.141	0.032	0.001
5500.0	0.311	38.045	1.169	952.350	0.033	0.002	2.142	0.165	0.041	0.001
6000.0	0.310	37.530	1.266	952.064	0.037	0.002	2.291	0.190	0.050	0.002
6500.0	0.308	37.021	1.361	951.779	0.041	0.002	2.433	0.216	0.061	0.003
7000.0	0.306	36.517	1.455	951.494	0.046	0.003	2.569	0.243	0.072	0.003
7500.0	0.304	36.019	1.547	951.209	0.050	0.003	2.699	0.271	0.084	0.004
8000.0	0.302	35.527	1.639	950.924	0.055	0.004	2.822	0.300	0.097	0.005
8500.0	0.300	35.039	1.728	950.640	0.060	0.004	2.940	0.329	0.111	0.006
9000.0	0.298	34.557	1.817	950.356	0.065	0.005	3.052	0.358	0.126	0.008
9500.0	0.297	34.079	1.904	950.073	0.070	0.006	3.159	0.389	0.141	0.009
10000.0	0.295	33.607	1.990	949.789	0.075	0.006	3.260	0.419	0.156	0.011
10500.0	0.293	33.139	2.075	949.507	0.081	0.007	3.356	0.450	0.172	0.012
11000.0	0.291	32.675	2.159	949.224	0.086	0.008	3.448	0.482	0.189	0.014
11500.0	0.290	32.216	2.241	948.941	0.092	0.009	3.535	0.513	0.206	0.016
12000.0	0.288	31.762	2.323	948.659	0.097	0.010	3.617	0.546	0.223	0.019
12500.0	0.286	31.312	2.403	948.377	0.103	0.011	3.696	0.578	0.241	0.021
13000.0	0.284	30.865	2.482	948.095	0.109	0.012	3.770	0.610	0.259	0.024
13500.0	0.283	30.423	2.560	947.813	0.115	0.013	3.840	0.643	0.277	0.027
14000.0	0.281	29.985	2.638	947.532	0.121	0.014	3.906	0.676	0.295	0.030
14500.0	0.279	29.550	2.714	947.250	0.127	0.015	3.969	0.709	0.314	0.033
15000.0	0.278	29.120	2.789	946.969	0.133	0.017	4.028	0.742	0.332	0.037
15500.0	0.276	28.693	2.864	946.688	0.139	0.018	4.084	0.775	0.351	0.040
16000.0	0.274	28.270	2.937	946.407	0.145	0.019	4.137	0.809	0.370	0.044
16500.0	0.273	27.850	3.010	946.126	0.151	0.021	4.187	0.842	0.389	0.048
17000.0	0.271	27.434	3.081	945.844	0.158	0.022	4.233	0.875	0.407	0.053
17500.0	0.269	27.021	3.152	945.563	0.164	0.024	4.278	0.909	0.426	0.057
18000.0	0.268	26.612	3.222	945.281	0.170	0.025	4.319	0.942	0.445	0.062
18500.0	0.266	26.206	3.291	944.999	0.177	0.027	4.358	0.975	0.464	0.067
19000.0	0.264	25.804	3.359	944.716	0.183	0.029	4.395	1.009	0.483	0.072
19500.0	0.263	25.405	3.426	944.432	0.190	0.030	4.430	1.042	0.501	0.077
20000.0	0.261	25.009	3.493	944.147	0.196	0.032	4.462	1.075	0.520	0.082
20500.0	0.260	24.617	3.558	943.862	0.203	0.034	4.493	1.107	0.539	0.088
21000.0	0.258	24.228	3.623	943.575	0.209	0.036	4.523	1.140	0.558	0.094
21500.0	0.256	23.843	3.687	943.288	0.216	0.038	4.550	1.173	0.576	0.100
22000.0	0.255	23.461	3.750	942.998	0.223	0.040	4.576	1.205	0.595	0.107
22500.0	0.253	23.083	3.812	942.708	0.230	0.043	4.601	1.237	0.613	0.113
23000.0	0.251	22.708	3.874	942.417	0.237	0.045	4.624	1.270	0.632	0.120
25000.0	0.245	21.243	4.112	941.236	0.265	0.055	4.704	1.396	0.705	0.149
27500.0	0.237	19.488	4.390	939.727	0.301	0.069	4.776	1.548	0.794	0.191
30000.0	0.229	17.819	4.649	938.181	0.339	0.084	4.822	1.695	0.878	0.238
32500.0	0.222	16.234	4.888	936.596	0.377	0.102	4.845	1.835	0.956	0.290
35000.0	0.214	14.734	5.107	934.970	0.414	0.122	4.849	1.969	1.028	0.348
37500.0	0.206	13.318	5.307	933.302	0.452	0.143	4.836	2.095	1.093	0.411
40000.0	0.199	11.985	5.487	931.589	0.490	0.167	4.809	2.213	1.151	0.478
42500.0	0.191	10.737	5.649	929.830	0.527	0.192	4.771	2.324	1.201	0.550
45000.0	0.184	9.571	5.792	928.024	0.563	0.218	4.725	2.425	1.245	0.626
47500.0	0.177	8.489	5.916	926.169	0.598	0.245	4.671	2.518	1.283	0.706
50000.0	0.170	7.490	6.022	924.263	0.632	0.273	4.613	2.603	1.314	0.790
52500.0	0.163	6.572	6.110	922.306	0.665	0.302	4.551	2.678	1.338	0.876
55000.0	0.156	5.735	6.180	920.298	0.696	0.331	4.488	2.745	1.358	0.966
57500.0	0.149	4.976	6.234	918.238	0.725	0.360	4.425	2.803	1.372	1.057
60000.0	0.142	4.293	6.271	916.127	0.753	0.389	4.363	2.854	1.382	1.151
62500.0	0.136	3.683	6.293	913.967	0.778	0.417	4.303	2.896	1.388	1.246
65000.0	0.130	3.143	6.300	911.758	0.801	0.444	4.246	2.931	1.391	1.341
67500.0	0.124	2.668	6.293	909.503	0.822	0.470	4.192	2.960	1.391	1.438
70000.0	0.118	2.253	6.275	907.204	0.841	0.495	4.142	2.983	1.389	1.534

Table C.12 [ ] Exposure-Dependent 80% Void Isotopics (kg/MTU Initial)

Exposure MWd/MTU	U-234	U-235	U-236	U-238	NP-237	PU-238	PU-239	PU-240	PU-241	PU-242
0.0	0.333	44.167	0.000	955.500	0.000	0.000	0.000	0.000	0.000	0.000
100.0	0.333	44.048	0.024	955.433	0.000	0.000	0.021	0.000	0.000	0.000
500.0	0.331	43.575	0.121	955.164	0.002	0.000	0.230	0.002	0.000	0.000
1000.0	0.328	42.992	0.241	954.827	0.005	0.000	0.506	0.008	0.000	0.000
1500.0	0.326	42.420	0.357	954.490	0.008	0.000	0.769	0.018	0.002	0.000
2000.0	0.324	41.857	0.472	954.154	0.011	0.000	1.020	0.031	0.004	0.000
2500.0	0.321	41.304	0.585	953.818	0.015	0.000	1.260	0.046	0.007	0.000
3000.0	0.319	40.758	0.695	953.482	0.018	0.001	1.490	0.065	0.011	0.000
3500.0	0.317	40.221	0.803	953.146	0.022	0.001	1.709	0.085	0.017	0.000
4000.0	0.315	39.692	0.910	952.811	0.027	0.001	1.919	0.107	0.024	0.001
4500.0	0.312	39.170	1.015	952.476	0.031	0.002	2.119	0.130	0.033	0.001
5000.0	0.310	38.655	1.118	952.141	0.036	0.002	2.311	0.155	0.042	0.001
5500.0	0.308	38.147	1.219	951.807	0.041	0.002	2.495	0.181	0.053	0.002
6000.0	0.306	37.646	1.318	951.473	0.046	0.003	2.671	0.208	0.065	0.002
6500.0	0.304	37.152	1.416	951.139	0.052	0.003	2.840	0.236	0.078	0.003
7000.0	0.301	36.663	1.513	950.806	0.057	0.004	3.002	0.265	0.092	0.004
7500.0	0.299	36.181	1.607	950.473	0.063	0.005	3.156	0.294	0.107	0.005
8000.0	0.297	35.704	1.700	950.140	0.069	0.006	3.304	0.324	0.123	0.006
8500.0	0.295	35.233	1.792	949.808	0.075	0.006	3.445	0.355	0.140	0.008
9000.0	0.293	34.767	1.883	949.476	0.081	0.007	3.581	0.387	0.157	0.009
9500.0	0.291	34.307	1.971	949.145	0.088	0.008	3.710	0.419	0.175	0.011
10000.0	0.289	33.852	2.059	948.814	0.094	0.009	3.834	0.452	0.194	0.013
10500.0	0.287	33.402	2.145	948.484	0.101	0.011	3.952	0.485	0.213	0.015
11000.0	0.285	32.957	2.230	948.153	0.108	0.012	4.065	0.518	0.232	0.017
11500.0	0.283	32.517	2.314	947.823	0.114	0.013	4.174	0.552	0.252	0.019
12000.0	0.281	32.082	2.397	947.494	0.121	0.014	4.277	0.586	0.273	0.022
12500.0	0.279	31.651	2.478	947.164	0.128	0.016	4.376	0.620	0.293	0.025
13000.0	0.277	31.224	2.558	946.835	0.135	0.017	4.470	0.655	0.314	0.028
13500.0	0.275	30.802	2.637	946.506	0.142	0.019	4.561	0.690	0.335	0.031
14000.0	0.273	30.384	2.715	946.177	0.150	0.020	4.647	0.725	0.357	0.034
14500.0	0.271	29.970	2.791	945.848	0.157	0.022	4.729	0.761	0.378	0.038
15000.0	0.270	29.561	2.867	945.519	0.164	0.024	4.807	0.796	0.400	0.041
15500.0	0.268	29.155	2.942	945.191	0.172	0.026	4.882	0.832	0.422	0.045
16000.0	0.266	28.754	3.015	944.862	0.179	0.028	4.953	0.868	0.443	0.049
16500.0	0.264	28.356	3.087	944.534	0.187	0.030	5.021	0.904	0.465	0.054
17000.0	0.262	27.962	3.159	944.205	0.194	0.032	5.085	0.940	0.487	0.058
17500.0	0.260	27.572	3.229	943.877	0.202	0.034	5.147	0.976	0.509	0.063
18000.0	0.259	27.185	3.299	943.548	0.210	0.036	5.205	1.012	0.531	0.068
18500.0	0.257	26.802	3.367	943.219	0.217	0.039	5.261	1.048	0.553	0.073
19000.0	0.255	26.423	3.434	942.890	0.225	0.041	5.314	1.084	0.574	0.078
19500.0	0.253	26.047	3.501	942.560	0.233	0.044	5.365	1.120	0.596	0.084
20000.0	0.251	25.675	3.567	942.230	0.241	0.046	5.413	1.156	0.618	0.089
20500.0	0.250	25.306	3.631	941.899	0.249	0.049	5.459	1.192	0.639	0.095
21000.0	0.248	24.941	3.695	941.568	0.257	0.052	5.503	1.227	0.661	0.101
21500.0	0.246	24.579	3.758	941.236	0.265	0.055	5.545	1.263	0.682	0.107
22000.0	0.245	24.221	3.820	940.903	0.272	0.058	5.584	1.299	0.704	0.114
22500.0	0.243	23.866	3.882	940.569	0.280	0.061	5.623	1.334	0.725	0.121
23000.0	0.241	23.514	3.942	940.234	0.288	0.064	5.659	1.369	0.746	0.127
23500.0	0.239	23.166	4.001	939.898	0.297	0.067	5.694	1.404	0.768	0.134
24000.0	0.238	22.821	4.060	939.561	0.305	0.070	5.727	1.439	0.789	0.142
24500.0	0.236	22.480	4.118	939.222	0.313	0.074	5.759	1.474	0.810	0.149
25000.0	0.234	22.142	4.175	938.883	0.321	0.077	5.790	1.509	0.830	0.156
25500.0	0.233	21.807	4.231	938.542	0.329	0.081	5.819	1.543	0.851	0.164
27500.0	0.226	20.502	4.447	937.166	0.362	0.096	5.923	1.679	0.933	0.197
30000.0	0.218	18.944	4.699	935.415	0.403	0.117	6.028	1.842	1.033	0.242
32500.0	0.210	17.468	4.931	933.631	0.445	0.141	6.107	2.000	1.127	0.292
35000.0	0.202	16.070	5.144	931.813	0.487	0.166	6.163	2.152	1.216	0.345
37500.0	0.195	14.751	5.337	929.960	0.528	0.194	6.201	2.297	1.299	0.403
40000.0	0.187	13.507	5.511	928.073	0.569	0.224	6.221	2.435	1.376	0.464
42500.0	0.180	12.338	5.667	926.150	0.609	0.256	6.227	2.565	1.446	0.528
45000.0	0.173	11.243	5.806	924.191	0.648	0.289	6.221	2.688	1.510	0.596
47500.0	0.166	10.218	5.927	922.197	0.686	0.324	6.205	2.804	1.569	0.667
50000.0	0.160	9.262	6.031	920.167	0.723	0.360	6.180	2.911	1.621	0.740
52500.0	0.153	8.374	6.119	918.101	0.758	0.397	6.148	3.011	1.667	0.815
55000.0	0.147	7.552	6.192	916.001	0.791	0.435	6.111	3.103	1.708	0.893
57500.0	0.141	6.792	6.250	913.866	0.823	0.473	6.070	3.187	1.744	0.973
60000.0	0.135	6.093	6.294	911.698	0.853	0.512	6.026	3.264	1.774	1.054
62500.0	0.130	5.452	6.325	909.497	0.881	0.550	5.981	3.334	1.801	1.137
65000.0	0.124	4.867	6.343	907.264	0.907	0.587	5.934	3.396	1.823	1.221
67500.0	0.119	4.333	6.349	905.001	0.930	0.624	5.887	3.452	1.841	1.306
70000.0	0.114	3.850	6.344	902.710	0.952	0.660	5.841	3.502	1.857	1.392

Table C.13 [ ] Exposure-Dependent 0% Void Isotopics (kg/MTU Initial)

Exposure MWd/MTU	U-234	U-235	U-236	U-238	NP-237	PU-238	PU-239	PU-240	PU-241	PU-242
0.0	0.331	43.917	0.000	955.752	0.000	0.000	0.000	0.000	0.000	0.000
100.0	0.331	43.797	0.022	955.704	0.000	0.000	0.015	0.000	0.000	0.000
500.0	0.330	43.318	0.110	955.510	0.001	0.000	0.166	0.001	0.000	0.000
1000.0	0.328	42.726	0.219	955.268	0.003	0.000	0.368	0.006	0.000	0.000
1500.0	0.326	42.142	0.325	955.025	0.005	0.000	0.562	0.013	0.001	0.000
2000.0	0.325	41.565	0.431	954.782	0.007	0.000	0.747	0.023	0.002	0.000
2500.0	0.323	40.994	0.534	954.539	0.009	0.000	0.924	0.035	0.003	0.000
3000.0	0.321	40.431	0.637	954.296	0.012	0.000	1.093	0.050	0.006	0.000
3500.0	0.319	39.874	0.738	954.053	0.014	0.000	1.254	0.066	0.009	0.000
4000.0	0.318	39.323	0.837	953.811	0.017	0.001	1.408	0.084	0.013	0.000
4500.0	0.316	38.777	0.935	953.568	0.020	0.001	1.554	0.103	0.018	0.000
5000.0	0.314	38.238	1.032	953.325	0.023	0.001	1.694	0.124	0.023	0.001
5500.0	0.313	37.704	1.128	953.082	0.026	0.001	1.828	0.146	0.030	0.001
6000.0	0.311	37.176	1.222	952.839	0.030	0.001	1.955	0.169	0.037	0.001
6500.0	0.309	36.652	1.315	952.597	0.033	0.002	2.076	0.193	0.045	0.002
7000.0	0.308	36.134	1.407	952.354	0.036	0.002	2.191	0.217	0.054	0.002
7500.0	0.306	35.621	1.498	952.112	0.040	0.002	2.301	0.243	0.063	0.003
8000.0	0.305	35.112	1.588	951.870	0.044	0.003	2.405	0.269	0.073	0.004
8500.0	0.303	34.609	1.676	951.628	0.048	0.003	2.504	0.296	0.084	0.005
9000.0	0.301	34.110	1.763	951.386	0.052	0.004	2.597	0.324	0.096	0.006
9500.0	0.300	33.615	1.850	951.145	0.056	0.004	2.686	0.352	0.108	0.007
10000.0	0.298	33.124	1.935	950.903	0.060	0.004	2.770	0.380	0.120	0.008
10500.0	0.297	32.638	2.019	950.663	0.064	0.005	2.850	0.409	0.133	0.010
11000.0	0.295	32.156	2.103	950.422	0.068	0.006	2.925	0.439	0.146	0.011
11500.0	0.293	31.677	2.185	950.182	0.073	0.006	2.996	0.468	0.160	0.013
12000.0	0.292	31.203	2.266	949.941	0.077	0.007	3.063	0.498	0.174	0.015
12500.0	0.290	30.733	2.346	949.701	0.082	0.008	3.126	0.529	0.188	0.017
13000.0	0.289	30.266	2.426	949.462	0.086	0.008	3.185	0.559	0.203	0.019
13500.0	0.287	29.803	2.504	949.222	0.091	0.009	3.241	0.590	0.217	0.022
14000.0	0.286	29.343	2.582	948.983	0.096	0.010	3.293	0.621	0.232	0.024
14500.0	0.284	28.887	2.658	948.744	0.101	0.011	3.341	0.652	0.247	0.027
15000.0	0.283	28.434	2.734	948.505	0.106	0.012	3.387	0.683	0.263	0.030
15500.0	0.281	27.985	2.809	948.267	0.111	0.012	3.429	0.714	0.278	0.033
16000.0	0.280	27.538	2.883	948.028	0.116	0.013	3.468	0.746	0.293	0.037
16500.0	0.278	27.095	2.957	947.790	0.121	0.014	3.505	0.777	0.308	0.040
17000.0	0.277	26.656	3.029	947.550	0.126	0.015	3.540	0.808	0.324	0.044
17500.0	0.275	26.219	3.101	947.310	0.131	0.016	3.572	0.839	0.339	0.048
18000.0	0.274	25.786	3.172	947.070	0.136	0.018	3.602	0.871	0.355	0.052
18500.0	0.272	25.357	3.242	946.828	0.141	0.019	3.630	0.902	0.371	0.056
19000.0	0.271	24.930	3.311	946.585	0.146	0.020	3.657	0.933	0.386	0.061
19500.0	0.269	24.507	3.380	946.341	0.152	0.021	3.681	0.964	0.402	0.065
20000.0	0.268	24.088	3.448	946.096	0.157	0.023	3.704	0.995	0.418	0.070
20500.0	0.266	23.671	3.515	945.850	0.163	0.024	3.726	1.026	0.433	0.075
21000.0	0.265	23.258	3.581	945.603	0.168	0.025	3.745	1.057	0.449	0.081
21500.0	0.263	22.848	3.647	945.354	0.174	0.027	3.764	1.088	0.465	0.086
22500.0	0.260	22.039	3.776	944.851	0.185	0.030	3.797	1.148	0.496	0.098
25000.0	0.253	20.076	4.085	943.568	0.214	0.039	3.859	1.297	0.574	0.132
27500.0	0.245	18.200	4.374	942.244	0.245	0.049	3.893	1.441	0.648	0.171
30000.0	0.238	16.411	4.643	940.877	0.277	0.061	3.903	1.579	0.717	0.217
32500.0	0.230	14.712	4.893	939.462	0.309	0.074	3.894	1.712	0.780	0.269
35000.0	0.223	13.104	5.123	937.996	0.342	0.089	3.868	1.837	0.838	0.328
37500.0	0.215	11.590	5.333	936.476	0.376	0.105	3.829	1.955	0.888	0.392
40000.0	0.207	10.172	5.522	934.897	0.409	0.123	3.779	2.064	0.931	0.463
42500.0	0.199	8.852	5.689	933.255	0.443	0.142	3.722	2.164	0.967	0.540
45000.0	0.191	7.635	5.836	931.545	0.475	0.163	3.659	2.255	0.997	0.622
47500.0	0.184	6.521	5.961	929.765	0.507	0.184	3.594	2.337	1.020	0.710
50000.0	0.176	5.513	6.064	927.910	0.538	0.206	3.527	2.409	1.037	0.803
52500.0	0.168	4.611	6.146	925.978	0.568	0.228	3.462	2.471	1.048	0.901
55000.0	0.160	3.815	6.206	923.968	0.596	0.250	3.399	2.523	1.055	1.003
57500.0	0.152	3.121	6.246	921.880	0.621	0.272	3.340	2.566	1.059	1.108
60000.0	0.144	2.526	6.266	919.716	0.645	0.294	3.286	2.600	1.059	1.216
62500.0	0.137	2.024	6.269	917.480	0.667	0.314	3.237	2.626	1.056	1.325
65000.0	0.130	1.606	6.255	915.178	0.686	0.332	3.194	2.646	1.052	1.435
67500.0	0.122	1.264	6.226	912.815	0.703	0.350	3.157	2.659	1.048	1.545
70000.0	0.116	0.987	6.186	910.400	0.717	0.365	3.125	2.668	1.042	1.654

Table C.14 [ ] Exposure-Dependent 40% Void Isotopics (kg/MTU Initial)

Exposure MWd/MTU	U-234	U-235	U-236	U-238	NP-237	PU-238	PU-239	PU-240	PU-241	PU-242
0.0	0.331	43.917	0.000	955.752	0.000	0.000	0.000	0.000	0.000	0.000
100.0	0.331	43.797	0.023	955.696	0.000	0.000	0.017	0.000	0.000	0.000
500.0	0.329	43.319	0.114	955.473	0.002	0.000	0.190	0.001	0.000	0.000
1000.0	0.327	42.730	0.227	955.194	0.004	0.000	0.422	0.006	0.000	0.000
1500.0	0.326	42.150	0.338	954.914	0.006	0.000	0.644	0.015	0.001	0.000
2000.0	0.324	41.578	0.447	954.635	0.008	0.000	0.855	0.026	0.002	0.000
2500.0	0.322	41.014	0.554	954.356	0.011	0.000	1.057	0.040	0.005	0.000
3000.0	0.320	40.458	0.659	954.077	0.014	0.000	1.249	0.056	0.008	0.000
3500.0	0.318	39.908	0.763	953.798	0.017	0.001	1.433	0.074	0.012	0.000
4000.0	0.316	39.365	0.865	953.519	0.021	0.001	1.608	0.094	0.017	0.000
4500.0	0.314	38.829	0.965	953.241	0.024	0.001	1.775	0.116	0.023	0.001
5000.0	0.312	38.300	1.064	952.963	0.028	0.001	1.935	0.138	0.031	0.001
5500.0	0.310	37.776	1.162	952.685	0.031	0.002	2.087	0.162	0.039	0.001
6000.0	0.308	37.259	1.258	952.407	0.035	0.002	2.232	0.187	0.048	0.002
6500.0	0.307	36.747	1.352	952.130	0.040	0.002	2.370	0.213	0.058	0.002
7000.0	0.305	36.241	1.446	951.852	0.044	0.003	2.502	0.240	0.069	0.003
7500.0	0.303	35.740	1.538	951.576	0.048	0.003	2.627	0.267	0.081	0.004
8000.0	0.301	35.245	1.629	951.299	0.053	0.004	2.747	0.296	0.094	0.005
8500.0	0.299	34.755	1.718	951.023	0.057	0.004	2.860	0.325	0.107	0.006
9000.0	0.298	34.269	1.806	950.748	0.062	0.005	2.968	0.354	0.121	0.007
9500.0	0.296	33.789	1.893	950.473	0.067	0.005	3.070	0.384	0.135	0.009
10000.0	0.294	33.313	1.979	950.198	0.072	0.006	3.167	0.414	0.151	0.010
10500.0	0.292	32.842	2.063	949.924	0.077	0.007	3.260	0.445	0.166	0.012
11000.0	0.291	32.375	2.147	949.650	0.082	0.008	3.347	0.476	0.182	0.014
11500.0	0.289	31.913	2.229	949.376	0.088	0.008	3.429	0.508	0.199	0.016
12000.0	0.287	31.455	2.310	949.103	0.093	0.009	3.508	0.540	0.215	0.018
12500.0	0.286	31.001	2.390	948.830	0.099	0.010	3.582	0.572	0.233	0.021
13000.0	0.284	30.551	2.469	948.557	0.104	0.011	3.652	0.604	0.250	0.023
13500.0	0.282	30.105	2.547	948.285	0.110	0.012	3.718	0.636	0.268	0.026
14000.0	0.281	29.663	2.625	948.013	0.116	0.013	3.780	0.669	0.285	0.029
14500.0	0.279	29.225	2.701	947.742	0.121	0.014	3.838	0.702	0.303	0.032
15000.0	0.277	28.790	2.776	947.470	0.127	0.015	3.893	0.735	0.321	0.036
15500.0	0.276	28.359	2.850	947.199	0.133	0.017	3.944	0.768	0.339	0.039
16000.0	0.274	27.931	2.924	946.928	0.139	0.018	3.992	0.801	0.357	0.043
16500.0	0.272	27.507	2.996	946.658	0.145	0.019	4.037	0.834	0.375	0.047
17000.0	0.271	27.086	3.068	946.387	0.151	0.021	4.080	0.867	0.394	0.051
17500.0	0.269	26.669	3.138	946.116	0.157	0.022	4.119	0.900	0.412	0.056
18000.0	0.268	26.255	3.208	945.844	0.163	0.023	4.157	0.933	0.430	0.060
18500.0	0.266	25.844	3.277	945.572	0.169	0.025	4.192	0.966	0.448	0.065
19000.0	0.265	25.437	3.346	945.300	0.175	0.027	4.225	0.999	0.466	0.070
19500.0	0.263	25.033	3.413	945.026	0.181	0.028	4.256	1.032	0.484	0.075
20000.0	0.261	24.632	3.480	944.751	0.187	0.030	4.285	1.064	0.502	0.081
20500.0	0.260	24.235	3.546	944.475	0.194	0.032	4.312	1.097	0.521	0.086
21000.0	0.258	23.842	3.610	944.198	0.200	0.034	4.338	1.129	0.539	0.092
21500.0	0.257	23.452	3.675	943.920	0.206	0.035	4.362	1.161	0.557	0.098
22000.0	0.255	23.065	3.738	943.641	0.213	0.037	4.385	1.193	0.575	0.104
22500.0	0.253	22.682	3.800	943.360	0.219	0.039	4.406	1.225	0.593	0.111
25000.0	0.246	20.816	4.101	941.934	0.253	0.051	4.494	1.381	0.682	0.147
27500.0	0.238	19.037	4.381	940.472	0.288	0.063	4.552	1.531	0.767	0.188
30000.0	0.230	17.343	4.641	938.970	0.324	0.078	4.584	1.675	0.848	0.236
32500.0	0.222	15.735	4.881	937.428	0.361	0.095	4.595	1.813	0.922	0.289
35000.0	0.215	14.212	5.102	935.844	0.398	0.113	4.587	1.944	0.990	0.347
37500.0	0.207	12.776	5.303	934.214	0.434	0.133	4.564	2.067	1.051	0.411
40000.0	0.200	11.426	5.485	932.536	0.471	0.155	4.528	2.182	1.105	0.479
42500.0	0.192	10.163	5.647	930.809	0.507	0.178	4.482	2.288	1.151	0.553
45000.0	0.185	8.988	5.790	929.030	0.542	0.203	4.428	2.386	1.191	0.631
47500.0	0.177	7.900	5.914	927.197	0.577	0.228	4.368	2.475	1.224	0.714
50000.0	0.170	6.899	6.018	925.309	0.610	0.255	4.305	2.554	1.250	0.800
52500.0	0.163	5.986	6.104	923.363	0.641	0.282	4.240	2.625	1.270	0.890
55000.0	0.156	5.158	6.171	921.361	0.671	0.309	4.175	2.686	1.285	0.982
57500.0	0.149	4.415	6.221	919.300	0.700	0.336	4.110	2.739	1.295	1.078
60000.0	0.142	3.753	6.254	917.183	0.726	0.362	4.048	2.783	1.301	1.175
62500.0	0.135	3.168	6.270	915.010	0.750	0.388	3.989	2.820	1.303	1.273
65000.0	0.129	2.657	6.272	912.783	0.772	0.413	3.934	2.849	1.303	1.373
67500.0	0.123	2.215	6.259	910.506	0.792	0.436	3.883	2.872	1.300	1.472
70000.0	0.116	1.836	6.234	908.183	0.809	0.458	3.837	2.889	1.296	1.572

Table C.15 [ ] Exposure-Dependent 80% Void Isotopics (kg/MTU Initial)

Exposure MWd/MTU	U-234	U-235	U-236	U-238	NP-237	PU-238	PU-239	PU-240	PU-241	PU-242
0.0	0.331	43.917	0.000	955.752	0.000	0.000	0.000	0.000	0.000	0.000
100.0	0.331	43.797	0.024	955.686	0.000	0.000	0.020	0.000	0.000	0.000
500.0	0.329	43.323	0.121	955.422	0.002	0.000	0.222	0.002	0.000	0.000
1000.0	0.327	42.739	0.239	955.092	0.005	0.000	0.493	0.008	0.000	0.000
1500.0	0.324	42.165	0.355	954.762	0.007	0.000	0.752	0.017	0.001	0.000
2000.0	0.322	41.601	0.469	954.433	0.011	0.000	0.999	0.030	0.003	0.000
2500.0	0.320	41.045	0.581	954.103	0.014	0.000	1.235	0.046	0.007	0.000
3000.0	0.318	40.498	0.691	953.775	0.018	0.001	1.460	0.064	0.011	0.000
3500.0	0.315	39.959	0.799	953.446	0.022	0.001	1.675	0.084	0.017	0.000
4000.0	0.313	39.428	0.905	953.118	0.026	0.001	1.880	0.106	0.024	0.001
4500.0	0.311	38.904	1.009	952.791	0.030	0.001	2.076	0.129	0.032	0.001
5000.0	0.309	38.387	1.111	952.464	0.035	0.002	2.264	0.154	0.041	0.001
5500.0	0.307	37.877	1.212	952.137	0.039	0.002	2.443	0.179	0.052	0.002
6000.0	0.305	37.374	1.311	951.811	0.045	0.003	2.615	0.206	0.064	0.002
6500.0	0.303	36.877	1.408	951.485	0.050	0.003	2.779	0.234	0.076	0.003
7000.0	0.300	36.386	1.504	951.159	0.055	0.004	2.936	0.263	0.090	0.004
7500.0	0.298	35.901	1.598	950.834	0.061	0.005	3.086	0.292	0.105	0.005
8000.0	0.296	35.422	1.691	950.510	0.067	0.005	3.229	0.323	0.121	0.006
8500.0	0.294	34.949	1.782	950.186	0.073	0.006	3.365	0.353	0.137	0.007
9000.0	0.292	34.481	1.872	949.863	0.079	0.007	3.496	0.385	0.154	0.009
9500.0	0.290	34.018	1.961	949.540	0.085	0.008	3.620	0.417	0.172	0.011
10000.0	0.288	33.561	2.048	949.218	0.091	0.009	3.739	0.449	0.190	0.012
10500.0	0.286	33.108	2.134	948.896	0.097	0.010	3.852	0.482	0.209	0.014
11000.0	0.284	32.660	2.218	948.575	0.104	0.011	3.960	0.516	0.228	0.017
11500.0	0.282	32.217	2.302	948.254	0.110	0.012	4.063	0.549	0.248	0.019
12000.0	0.281	31.779	2.384	947.933	0.117	0.013	4.161	0.583	0.268	0.022
12500.0	0.279	31.345	2.465	947.613	0.124	0.015	4.255	0.617	0.288	0.024
13000.0	0.277	30.916	2.545	947.293	0.130	0.016	4.344	0.652	0.309	0.027
13500.0	0.275	30.491	2.623	946.973	0.137	0.018	4.428	0.687	0.330	0.030
14000.0	0.273	30.070	2.701	946.654	0.144	0.019	4.509	0.722	0.351	0.034
14500.0	0.271	29.653	2.777	946.335	0.151	0.021	4.585	0.757	0.372	0.037
15000.0	0.269	29.241	2.853	946.016	0.158	0.023	4.658	0.792	0.393	0.041
15500.0	0.267	28.832	2.927	945.698	0.165	0.024	4.727	0.828	0.415	0.045
16000.0	0.266	28.427	3.000	945.380	0.173	0.026	4.792	0.863	0.436	0.049
16500.0	0.264	28.026	3.072	945.062	0.180	0.028	4.854	0.899	0.457	0.053
17000.0	0.262	27.628	3.143	944.744	0.187	0.030	4.913	0.935	0.479	0.058
17500.0	0.260	27.234	3.214	944.426	0.195	0.032	4.969	0.970	0.500	0.063
18000.0	0.259	26.844	3.283	944.108	0.202	0.034	5.022	1.006	0.522	0.068
18500.0	0.257	26.458	3.351	943.790	0.210	0.036	5.071	1.042	0.543	0.073
19000.0	0.255	26.075	3.419	943.472	0.217	0.039	5.119	1.078	0.564	0.078
19500.0	0.253	25.695	3.485	943.153	0.225	0.041	5.164	1.113	0.585	0.084
20000.0	0.252	25.319	3.550	942.834	0.232	0.043	5.206	1.149	0.607	0.089
20500.0	0.250	24.946	3.615	942.514	0.240	0.046	5.247	1.184	0.628	0.095
21000.0	0.248	24.576	3.679	942.194	0.247	0.048	5.285	1.219	0.649	0.101
21500.0	0.247	24.211	3.742	941.872	0.255	0.051	5.322	1.255	0.670	0.108
22000.0	0.245	23.848	3.804	941.550	0.263	0.054	5.357	1.290	0.691	0.114
22500.0	0.243	23.489	3.865	941.227	0.270	0.057	5.390	1.325	0.711	0.121
23000.0	0.242	23.133	3.925	940.902	0.278	0.060	5.421	1.359	0.732	0.128
23500.0	0.240	22.781	3.985	940.576	0.286	0.063	5.451	1.394	0.753	0.135
24000.0	0.238	22.432	4.044	940.249	0.294	0.066	5.480	1.428	0.773	0.142
24500.0	0.237	22.087	4.102	939.921	0.302	0.069	5.507	1.462	0.794	0.149
25000.0	0.235	21.744	4.159	939.592	0.309	0.072	5.533	1.496	0.814	0.157
27500.0	0.227	20.084	4.431	937.924	0.349	0.090	5.645	1.662	0.915	0.198
30000.0	0.219	18.507	4.684	936.223	0.390	0.110	5.729	1.822	1.011	0.244
32500.0	0.211	17.011	4.916	934.487	0.430	0.132	5.788	1.976	1.102	0.295
35000.0	0.203	15.596	5.129	932.715	0.471	0.156	5.825	2.123	1.187	0.350
37500.0	0.195	14.259	5.322	930.908	0.511	0.182	5.845	2.263	1.266	0.409
40000.0	0.188	13.000	5.497	929.063	0.551	0.210	5.848	2.395	1.338	0.472
42500.0	0.181	11.818	5.653	927.181	0.591	0.240	5.838	2.520	1.404	0.539
45000.0	0.174	10.711	5.790	925.261	0.629	0.272	5.817	2.637	1.463	0.609
47500.0	0.167	9.677	5.911	923.303	0.667	0.304	5.787	2.746	1.515	0.682
50000.0	0.160	8.716	6.014	921.306	0.703	0.338	5.750	2.847	1.562	0.758
52500.0	0.153	7.824	6.101	919.270	0.737	0.373	5.706	2.939	1.602	0.837
55000.0	0.147	7.002	6.172	917.196	0.770	0.409	5.659	3.023	1.637	0.918
57500.0	0.141	6.245	6.227	915.084	0.801	0.444	5.608	3.100	1.666	1.001
60000.0	0.135	5.552	6.268	912.935	0.830	0.480	5.556	3.168	1.690	1.085
62500.0	0.129	4.920	6.296	910.750	0.857	0.516	5.503	3.230	1.710	1.171
65000.0	0.124	4.347	6.310	908.529	0.882	0.550	5.451	3.283	1.726	1.258
67500.0	0.119	3.829	6.312	906.275	0.905	0.584	5.399	3.331	1.739	1.346
70000.0	0.113	3.363	6.303	903.988	0.926	0.617	5.349	3.371	1.748	1.435

Table C.16 [ ] Exposure-Dependent 0% Void Isotopics (kg/MTU Initial)

Exposure MWd/MTU	U-234	U-235	U-236	U-238	NP-237	PU-238	PU-239	PU-240	PU-241	PU-242
0.0	0.321	42.545	0.000	957.134	0.000	0.000	0.000	0.000	0.000	0.000
100.0	0.321	42.425	0.022	957.086	0.000	0.000	0.015	0.000	0.000	0.000
500.0	0.319	41.947	0.109	956.895	0.001	0.000	0.164	0.001	0.000	0.000
1000.0	0.318	41.356	0.216	956.655	0.003	0.000	0.364	0.006	0.000	0.000
1500.0	0.316	40.773	0.322	956.414	0.005	0.000	0.556	0.013	0.001	0.000
2000.0	0.314	40.197	0.426	956.174	0.007	0.000	0.738	0.023	0.002	0.000
2500.0	0.313	39.628	0.528	955.933	0.009	0.000	0.912	0.036	0.003	0.000
3000.0	0.311	39.066	0.629	955.693	0.012	0.000	1.078	0.050	0.006	0.000
3500.0	0.310	38.511	0.729	955.452	0.014	0.000	1.236	0.067	0.009	0.000
4000.0	0.308	37.962	0.827	955.212	0.017	0.001	1.386	0.085	0.013	0.000
4500.0	0.306	37.418	0.924	954.972	0.020	0.001	1.529	0.105	0.018	0.001
5000.0	0.305	36.881	1.020	954.732	0.023	0.001	1.665	0.126	0.023	0.001
5500.0	0.303	36.349	1.114	954.492	0.026	0.001	1.795	0.148	0.030	0.001
6000.0	0.302	35.822	1.207	954.252	0.029	0.001	1.918	0.172	0.037	0.001
6500.0	0.300	35.301	1.299	954.012	0.032	0.002	2.036	0.196	0.045	0.002
7000.0	0.298	34.785	1.390	953.772	0.036	0.002	2.147	0.221	0.054	0.003
7500.0	0.297	34.273	1.479	953.533	0.039	0.002	2.252	0.247	0.063	0.003
8000.0	0.295	33.767	1.567	953.294	0.043	0.003	2.353	0.274	0.073	0.004
8500.0	0.294	33.265	1.655	953.055	0.047	0.003	2.447	0.301	0.084	0.005
9000.0	0.292	32.768	1.741	952.817	0.051	0.003	2.537	0.329	0.095	0.006
9500.0	0.291	32.275	1.826	952.578	0.054	0.004	2.621	0.358	0.107	0.007
10000.0	0.289	31.787	1.910	952.341	0.058	0.004	2.701	0.387	0.119	0.009
10500.0	0.288	31.303	1.993	952.103	0.063	0.005	2.776	0.416	0.132	0.010
11000.0	0.286	30.822	2.075	951.866	0.067	0.005	2.847	0.446	0.145	0.012
11500.0	0.285	30.346	2.156	951.630	0.071	0.006	2.914	0.476	0.158	0.014
12000.0	0.283	29.874	2.236	951.393	0.075	0.007	2.976	0.506	0.172	0.016
12500.0	0.282	29.405	2.315	951.157	0.080	0.007	3.035	0.537	0.186	0.018
13000.0	0.280	28.940	2.394	950.921	0.084	0.008	3.090	0.568	0.200	0.020
13500.0	0.279	28.478	2.471	950.686	0.089	0.009	3.141	0.599	0.214	0.022
14000.0	0.277	28.020	2.547	950.451	0.093	0.010	3.189	0.630	0.229	0.025
14500.0	0.276	27.566	2.623	950.216	0.098	0.010	3.233	0.661	0.243	0.028
15000.0	0.274	27.114	2.698	949.981	0.102	0.011	3.275	0.693	0.258	0.031
15500.0	0.273	26.666	2.772	949.745	0.107	0.012	3.314	0.724	0.273	0.034
16000.0	0.271	26.222	2.845	949.509	0.112	0.013	3.350	0.756	0.288	0.038
16500.0	0.270	25.781	2.917	949.273	0.117	0.014	3.384	0.787	0.303	0.041
17000.0	0.268	25.343	2.988	949.036	0.122	0.015	3.416	0.819	0.318	0.045
17500.0	0.267	24.909	3.059	948.798	0.127	0.016	3.445	0.850	0.333	0.049
18000.0	0.265	24.478	3.129	948.559	0.132	0.017	3.473	0.882	0.348	0.053
18500.0	0.264	24.050	3.198	948.318	0.137	0.018	3.499	0.913	0.363	0.058
19000.0	0.263	23.626	3.267	948.077	0.142	0.019	3.523	0.944	0.379	0.062
19500.0	0.261	23.205	3.334	947.834	0.147	0.021	3.545	0.976	0.394	0.067
20000.0	0.260	22.788	3.401	947.590	0.152	0.022	3.566	1.007	0.409	0.072
20500.0	0.258	22.374	3.467	947.345	0.158	0.023	3.585	1.038	0.425	0.078
21000.0	0.257	21.964	3.533	947.098	0.163	0.025	3.603	1.069	0.440	0.083
22500.0	0.252	20.754	3.724	946.348	0.179	0.029	3.649	1.160	0.486	0.101
25000.0	0.245	18.808	4.027	945.065	0.208	0.038	3.701	1.309	0.561	0.136
27500.0	0.238	16.952	4.310	943.737	0.238	0.047	3.726	1.454	0.632	0.177
30000.0	0.230	15.187	4.574	942.363	0.269	0.059	3.729	1.592	0.698	0.225
32500.0	0.223	13.516	4.817	940.937	0.300	0.072	3.713	1.724	0.758	0.279
35000.0	0.215	11.940	5.039	939.456	0.332	0.086	3.681	1.849	0.811	0.340
37500.0	0.207	10.463	5.241	937.915	0.365	0.102	3.637	1.965	0.858	0.407
40000.0	0.200	9.088	5.421	936.309	0.397	0.120	3.585	2.073	0.897	0.481
42500.0	0.192	7.818	5.579	934.633	0.429	0.138	3.525	2.171	0.930	0.561
45000.0	0.184	6.656	5.715	932.884	0.460	0.158	3.462	2.259	0.956	0.648
47500.0	0.176	5.605	5.829	931.056	0.491	0.179	3.398	2.337	0.975	0.740
50000.0	0.168	4.665	5.920	929.148	0.520	0.199	3.334	2.405	0.989	0.837
52500.0	0.160	3.836	5.989	927.156	0.548	0.221	3.272	2.463	0.999	0.939
55000.0	0.152	3.116	6.037	925.082	0.574	0.241	3.214	2.511	1.004	1.045
57500.0	0.145	2.502	6.064	922.926	0.598	0.262	3.161	2.549	1.005	1.155
60000.0	0.137	1.986	6.072	920.693	0.620	0.281	3.114	2.579	1.004	1.266
62500.0	0.129	1.560	6.063	918.389	0.639	0.299	3.072	2.602	1.002	1.379
65000.0	0.122	1.214	6.038	916.022	0.656	0.316	3.037	2.618	0.998	1.491
67500.0	0.115	0.938	6.001	913.599	0.671	0.331	3.006	2.629	0.994	1.604
70000.0	0.108	0.720	5.954	911.129	0.683	0.344	2.980	2.635	0.989	1.715

Table C.17 [ ] Exposure-Dependent 40% Void Isotopics (kg/MTU Initial)

Exposure MWd/MTU	U-234	U-235	U-236	U-238	NP-237	PU-238	PU-239	PU-240	PU-241	PU-242
0.0	0.321	42.545	0.000	957.134	0.000	0.000	0.000	0.000	0.000	0.000
100.0	0.321	42.425	0.023	957.079	0.000	0.000	0.017	0.000	0.000	0.000
500.0	0.319	41.949	0.113	956.857	0.002	0.000	0.189	0.001	0.000	0.000
1000.0	0.317	41.361	0.224	956.578	0.004	0.000	0.419	0.007	0.000	0.000
1500.0	0.315	40.783	0.334	956.300	0.006	0.000	0.639	0.015	0.001	0.000
2000.0	0.314	40.212	0.441	956.022	0.008	0.000	0.848	0.027	0.002	0.000
2500.0	0.312	39.650	0.547	955.745	0.011	0.000	1.048	0.041	0.005	0.000
3000.0	0.310	39.096	0.651	955.467	0.014	0.000	1.237	0.058	0.008	0.000
3500.0	0.308	38.549	0.753	955.190	0.017	0.001	1.418	0.076	0.012	0.000
4000.0	0.306	38.008	0.854	954.913	0.020	0.001	1.590	0.096	0.017	0.000
4500.0	0.304	37.475	0.953	954.636	0.024	0.001	1.754	0.118	0.024	0.001
5000.0	0.303	36.948	1.050	954.360	0.027	0.001	1.910	0.142	0.031	0.001
5500.0	0.301	36.427	1.146	954.084	0.031	0.002	2.058	0.166	0.039	0.001
6000.0	0.299	35.912	1.241	953.809	0.035	0.002	2.199	0.191	0.048	0.002
6500.0	0.297	35.403	1.334	953.533	0.039	0.002	2.333	0.218	0.059	0.003
7000.0	0.295	34.900	1.426	953.259	0.043	0.003	2.461	0.245	0.070	0.003
7500.0	0.294	34.402	1.517	952.985	0.048	0.003	2.582	0.273	0.082	0.004
8000.0	0.292	33.910	1.606	952.711	0.052	0.004	2.697	0.302	0.094	0.005
8500.0	0.290	33.423	1.694	952.437	0.057	0.004	2.806	0.331	0.107	0.006
9000.0	0.288	32.940	1.781	952.165	0.061	0.005	2.909	0.361	0.121	0.008
9500.0	0.287	32.463	1.866	951.893	0.066	0.005	3.007	0.392	0.136	0.009
10000.0	0.285	31.990	1.950	951.621	0.071	0.006	3.099	0.423	0.151	0.011
10500.0	0.283	31.521	2.034	951.350	0.076	0.007	3.186	0.454	0.166	0.013
11000.0	0.282	31.058	2.116	951.079	0.081	0.007	3.269	0.486	0.182	0.014
11500.0	0.280	30.598	2.196	950.809	0.086	0.008	3.346	0.518	0.198	0.017
12000.0	0.278	30.143	2.276	950.539	0.091	0.009	3.420	0.550	0.215	0.019
12500.0	0.277	29.692	2.355	950.270	0.097	0.010	3.489	0.582	0.232	0.022
13000.0	0.275	29.244	2.433	950.001	0.102	0.011	3.554	0.615	0.249	0.024
13500.0	0.274	28.801	2.509	949.732	0.107	0.012	3.615	0.648	0.266	0.027
14000.0	0.272	28.361	2.585	949.464	0.113	0.013	3.672	0.681	0.283	0.030
14500.0	0.270	27.926	2.660	949.195	0.118	0.014	3.726	0.714	0.301	0.034
15000.0	0.269	27.493	2.734	948.927	0.124	0.015	3.776	0.747	0.318	0.037
15500.0	0.267	27.065	2.807	948.660	0.130	0.016	3.824	0.780	0.336	0.041
16000.0	0.266	26.639	2.879	948.392	0.135	0.017	3.868	0.814	0.354	0.045
16500.0	0.264	26.218	2.950	948.124	0.141	0.019	3.909	0.847	0.371	0.049
17000.0	0.263	25.800	3.021	947.856	0.147	0.020	3.948	0.880	0.389	0.053
17500.0	0.261	25.385	3.090	947.587	0.153	0.021	3.984	0.913	0.407	0.058
18000.0	0.259	24.973	3.159	947.317	0.158	0.023	4.018	0.946	0.425	0.062
18500.0	0.258	24.566	3.227	947.047	0.164	0.024	4.050	0.979	0.443	0.067
19000.0	0.256	24.162	3.294	946.775	0.170	0.026	4.080	1.012	0.460	0.073
19500.0	0.255	23.761	3.360	946.503	0.176	0.028	4.108	1.045	0.478	0.078
20000.0	0.253	23.363	3.425	946.229	0.182	0.029	4.135	1.078	0.496	0.084
20500.0	0.252	22.970	3.490	945.954	0.189	0.031	4.159	1.110	0.514	0.089
21000.0	0.250	22.580	3.554	945.678	0.195	0.033	4.183	1.142	0.531	0.095
21500.0	0.249	22.193	3.617	945.401	0.201	0.035	4.204	1.175	0.549	0.102
22500.0	0.246	21.430	3.740	944.841	0.214	0.038	4.244	1.238	0.584	0.115
25000.0	0.238	19.584	4.034	943.416	0.247	0.049	4.320	1.394	0.671	0.152
27500.0	0.230	17.827	4.308	941.952	0.281	0.062	4.367	1.543	0.754	0.196
30000.0	0.223	16.158	4.561	940.446	0.316	0.076	4.390	1.687	0.831	0.245
32500.0	0.215	14.577	4.794	938.897	0.352	0.093	4.391	1.823	0.902	0.300
35000.0	0.208	13.085	5.007	937.302	0.388	0.111	4.375	1.952	0.965	0.360
37500.0	0.200	11.682	5.201	935.658	0.423	0.130	4.345	2.073	1.022	0.427
40000.0	0.193	10.370	5.374	933.964	0.459	0.151	4.303	2.186	1.071	0.498
42500.0	0.185	9.148	5.528	932.215	0.494	0.174	4.253	2.289	1.114	0.575
45000.0	0.178	8.017	5.662	930.411	0.528	0.198	4.195	2.383	1.149	0.656
47500.0	0.171	6.977	5.776	928.548	0.561	0.222	4.134	2.468	1.177	0.742
50000.0	0.163	6.029	5.870	926.626	0.593	0.248	4.070	2.543	1.199	0.832
52500.0	0.156	5.171	5.946	924.642	0.623	0.273	4.005	2.608	1.216	0.925
55000.0	0.149	4.402	6.003	922.598	0.651	0.299	3.942	2.665	1.227	1.021
57500.0	0.142	3.719	6.042	920.492	0.678	0.324	3.880	2.712	1.234	1.120
60000.0	0.135	3.118	6.064	918.327	0.703	0.349	3.822	2.752	1.237	1.220
62500.0	0.129	2.595	6.071	916.104	0.725	0.373	3.768	2.783	1.238	1.321
65000.0	0.122	2.146	6.062	913.828	0.745	0.395	3.718	2.808	1.236	1.423
67500.0	0.116	1.762	6.041	911.502	0.763	0.416	3.673	2.827	1.232	1.525
70000.0	0.110	1.440	6.008	909.130	0.778	0.436	3.633	2.840	1.227	1.626

Table C.18 [ ] Exposure-Dependent 80% Void Isotopics (kg/MTU Initial)

Exposure MWd/MTU	U-234	U-235	U-236	U-238	NP-237	PU-238	PU-239	PU-240	PU-241	PU-242
0.0	0.321	42.545	0.000	957.134	0.000	0.000	0.000	0.000	0.000	0.000
100.0	0.321	42.426	0.024	957.068	0.000	0.000	0.020	0.000	0.000	0.000
500.0	0.319	41.953	0.120	956.802	0.002	0.000	0.223	0.002	0.000	0.000
1000.0	0.317	41.371	0.237	956.470	0.005	0.000	0.495	0.008	0.000	0.000
1500.0	0.314	40.799	0.352	956.138	0.008	0.000	0.754	0.018	0.002	0.000
2000.0	0.312	40.238	0.464	955.807	0.011	0.000	1.001	0.031	0.004	0.000
2500.0	0.310	39.685	0.575	955.477	0.014	0.000	1.236	0.047	0.007	0.000
3000.0	0.308	39.142	0.683	955.146	0.018	0.001	1.459	0.066	0.011	0.000
3500.0	0.306	38.606	0.789	954.817	0.022	0.001	1.673	0.087	0.017	0.000
4000.0	0.303	38.079	0.894	954.488	0.026	0.001	1.876	0.109	0.024	0.001
4500.0	0.301	37.559	0.996	954.159	0.030	0.001	2.070	0.133	0.033	0.001
5000.0	0.299	37.046	1.097	953.831	0.035	0.002	2.255	0.158	0.043	0.001
5500.0	0.297	36.540	1.196	953.503	0.040	0.002	2.432	0.185	0.054	0.002
6000.0	0.295	36.041	1.294	953.176	0.045	0.003	2.600	0.213	0.066	0.003
6500.0	0.293	35.549	1.390	952.850	0.050	0.003	2.761	0.241	0.079	0.003
7000.0	0.291	35.063	1.484	952.524	0.055	0.004	2.914	0.271	0.093	0.004
7500.0	0.289	34.583	1.576	952.199	0.061	0.005	3.060	0.301	0.108	0.005
8000.0	0.287	34.108	1.667	951.875	0.067	0.005	3.199	0.332	0.124	0.007
8500.0	0.285	33.639	1.757	951.551	0.072	0.006	3.332	0.363	0.140	0.008
9000.0	0.283	33.176	1.845	951.228	0.078	0.007	3.458	0.396	0.158	0.010
9500.0	0.281	32.719	1.932	950.906	0.085	0.008	3.578	0.428	0.176	0.011
10000.0	0.279	32.266	2.017	950.584	0.091	0.009	3.692	0.461	0.194	0.013
10500.0	0.277	31.818	2.102	950.263	0.097	0.010	3.801	0.495	0.213	0.015
11000.0	0.275	31.375	2.184	949.942	0.103	0.011	3.904	0.529	0.232	0.018
11500.0	0.273	30.937	2.266	949.622	0.110	0.012	4.002	0.563	0.252	0.020
12000.0	0.272	30.504	2.347	949.303	0.116	0.014	4.096	0.598	0.272	0.023
12500.0	0.270	30.075	2.426	948.984	0.123	0.015	4.184	0.632	0.292	0.026
13000.0	0.268	29.650	2.504	948.665	0.130	0.016	4.269	0.668	0.313	0.029
13500.0	0.266	29.230	2.581	948.346	0.136	0.018	4.349	0.703	0.334	0.032
14000.0	0.264	28.814	2.657	948.028	0.143	0.019	4.425	0.738	0.355	0.036
14500.0	0.262	28.402	2.732	947.710	0.150	0.021	4.497	0.774	0.376	0.039
15000.0	0.261	27.994	2.805	947.392	0.157	0.023	4.565	0.810	0.397	0.043
15500.0	0.259	27.590	2.878	947.075	0.164	0.024	4.630	0.845	0.418	0.047
16000.0	0.257	27.190	2.949	946.757	0.171	0.026	4.691	0.881	0.439	0.052
16500.0	0.255	26.793	3.020	946.440	0.178	0.028	4.749	0.917	0.461	0.056
17000.0	0.254	26.401	3.090	946.122	0.185	0.030	4.804	0.953	0.482	0.061
17500.0	0.252	26.012	3.158	945.805	0.193	0.032	4.856	0.989	0.503	0.066
18000.0	0.250	25.626	3.226	945.487	0.200	0.034	4.905	1.025	0.524	0.071
18500.0	0.249	25.245	3.293	945.170	0.207	0.036	4.951	1.061	0.545	0.076
19000.0	0.247	24.866	3.358	944.851	0.215	0.038	4.995	1.097	0.566	0.082
19500.0	0.245	24.492	3.423	944.533	0.222	0.041	5.037	1.133	0.587	0.088
20000.0	0.244	24.120	3.487	944.213	0.229	0.043	5.076	1.168	0.608	0.094
20500.0	0.242	23.753	3.550	943.893	0.237	0.046	5.113	1.204	0.629	0.100
21000.0	0.240	23.388	3.613	943.572	0.244	0.048	5.149	1.239	0.650	0.106
21500.0	0.239	23.028	3.674	943.250	0.252	0.051	5.183	1.274	0.671	0.113
22000.0	0.237	22.671	3.735	942.926	0.259	0.054	5.215	1.309	0.691	0.119
22500.0	0.235	22.317	3.794	942.602	0.267	0.056	5.245	1.344	0.712	0.126
23000.0	0.234	21.967	3.853	942.276	0.275	0.059	5.274	1.379	0.733	0.134
23500.0	0.232	21.620	3.911	941.949	0.282	0.062	5.302	1.413	0.753	0.141
24000.0	0.230	21.277	3.968	941.621	0.290	0.065	5.328	1.447	0.773	0.149
25000.0	0.227	20.601	4.080	940.960	0.306	0.072	5.377	1.515	0.813	0.164
27500.0	0.219	18.970	4.344	939.284	0.345	0.089	5.477	1.680	0.912	0.207
30000.0	0.211	17.424	4.589	937.572	0.385	0.109	5.550	1.838	1.006	0.255
32500.0	0.204	15.962	4.813	935.824	0.425	0.131	5.599	1.990	1.095	0.308
35000.0	0.196	14.581	5.017	934.040	0.465	0.155	5.627	2.135	1.177	0.365
37500.0	0.189	13.280	5.202	932.218	0.504	0.180	5.638	2.272	1.252	0.426
40000.0	0.181	12.058	5.368	930.358	0.543	0.208	5.634	2.402	1.321	0.492
42500.0	0.174	10.914	5.516	928.458	0.582	0.238	5.618	2.523	1.382	0.561
45000.0	0.167	9.847	5.645	926.520	0.619	0.269	5.591	2.636	1.438	0.633
47500.0	0.160	8.854	5.757	924.541	0.656	0.301	5.556	2.741	1.486	0.709
50000.0	0.154	7.934	5.852	922.522	0.690	0.334	5.515	2.837	1.528	0.788
52500.0	0.147	7.085	5.930	920.464	0.724	0.368	5.469	2.925	1.565	0.868
55000.0	0.141	6.304	5.993	918.365	0.755	0.402	5.420	3.004	1.595	0.952
57500.0	0.135	5.591	6.041	916.228	0.785	0.436	5.368	3.075	1.621	1.037
60000.0	0.129	4.941	6.074	914.053	0.813	0.471	5.316	3.139	1.642	1.123
62500.0	0.124	4.352	6.094	911.841	0.839	0.504	5.264	3.194	1.659	1.211
65000.0	0.118	3.820	6.101	909.593	0.862	0.537	5.212	3.243	1.672	1.300
67500.0	0.113	3.343	6.097	907.311	0.884	0.569	5.162	3.285	1.681	1.390
70000.0	0.108	2.917	6.081	904.998	0.903	0.600	5.114	3.321	1.688	1.480

Table C.19 [ ] Exposure-Dependent 0% Void Isotopics (kg/MTU Initial)

Exposure MWd/MTU	U-234	U-235	U-236	U-238	NP-237	PU-238	PU-239	PU-240	PU-241	PU-242
0.0	0.321	42.598	0.000	957.080	0.000	0.000	0.000	0.000	0.000	0.000
100.0	0.321	42.478	0.022	957.035	0.000	0.000	0.014	0.000	0.000	0.000
500.0	0.320	42.000	0.108	956.849	0.001	0.000	0.159	0.001	0.000	0.000
1000.0	0.318	41.408	0.215	956.617	0.003	0.000	0.352	0.005	0.000	0.000
1500.0	0.316	40.824	0.320	956.385	0.005	0.000	0.537	0.013	0.001	0.000
2000.0	0.315	40.247	0.423	956.153	0.007	0.000	0.713	0.023	0.002	0.000
2500.0	0.313	39.677	0.525	955.921	0.009	0.000	0.881	0.035	0.003	0.000
3000.0	0.312	39.114	0.626	955.689	0.011	0.000	1.041	0.049	0.005	0.000
3500.0	0.310	38.556	0.725	955.457	0.013	0.000	1.193	0.065	0.008	0.000
4000.0	0.308	38.005	0.823	955.226	0.016	0.001	1.338	0.083	0.012	0.000
4500.0	0.307	37.459	0.920	954.994	0.019	0.001	1.476	0.102	0.016	0.000
5000.0	0.305	36.919	1.015	954.763	0.021	0.001	1.607	0.123	0.022	0.001
5500.0	0.304	36.384	1.109	954.532	0.024	0.001	1.732	0.145	0.028	0.001
6000.0	0.302	35.855	1.202	954.301	0.027	0.001	1.851	0.167	0.034	0.001
6500.0	0.301	35.330	1.293	954.070	0.031	0.002	1.963	0.191	0.042	0.002
7000.0	0.299	34.811	1.384	953.840	0.034	0.002	2.070	0.216	0.050	0.002
7500.0	0.298	34.296	1.473	953.610	0.037	0.002	2.171	0.241	0.059	0.003
8000.0	0.296	33.785	1.562	953.381	0.041	0.002	2.267	0.267	0.068	0.004
8500.0	0.295	33.279	1.649	953.152	0.044	0.003	2.357	0.294	0.078	0.005
9000.0	0.293	32.778	1.735	952.924	0.048	0.003	2.443	0.321	0.089	0.006
9500.0	0.292	32.280	1.821	952.696	0.051	0.004	2.524	0.349	0.100	0.007
10000.0	0.290	31.786	1.905	952.469	0.055	0.004	2.600	0.377	0.111	0.008
10500.0	0.289	31.296	1.988	952.242	0.059	0.004	2.671	0.406	0.123	0.009
11000.0	0.287	30.810	2.070	952.016	0.063	0.005	2.739	0.435	0.135	0.011
11500.0	0.286	30.328	2.152	951.790	0.067	0.006	2.802	0.464	0.147	0.012
12000.0	0.284	29.849	2.232	951.564	0.071	0.006	2.862	0.494	0.160	0.014
12500.0	0.283	29.374	2.312	951.338	0.075	0.007	2.919	0.524	0.173	0.016
13000.0	0.281	28.903	2.390	951.111	0.079	0.007	2.973	0.554	0.186	0.018
13500.0	0.280	28.435	2.468	950.883	0.084	0.008	3.024	0.584	0.200	0.021
14000.0	0.278	27.972	2.545	950.654	0.088	0.009	3.072	0.614	0.214	0.023
14500.0	0.277	27.511	2.621	950.424	0.093	0.009	3.118	0.644	0.228	0.026
15000.0	0.276	27.055	2.697	950.192	0.097	0.010	3.162	0.675	0.242	0.029
15500.0	0.274	26.602	2.771	949.960	0.102	0.011	3.203	0.705	0.257	0.032
16000.0	0.273	26.153	2.845	949.726	0.107	0.012	3.242	0.736	0.272	0.035
17500.0	0.268	24.828	3.061	949.017	0.121	0.015	3.348	0.828	0.317	0.046
20000.0	0.261	22.692	3.405	947.807	0.147	0.021	3.487	0.982	0.395	0.068
22500.0	0.254	20.647	3.729	946.559	0.175	0.028	3.586	1.133	0.472	0.096
25000.0	0.246	18.694	4.033	945.270	0.204	0.036	3.650	1.282	0.548	0.131
27500.0	0.239	16.832	4.317	943.937	0.234	0.046	3.685	1.428	0.619	0.171
30000.0	0.231	15.064	4.580	942.557	0.265	0.057	3.695	1.567	0.685	0.218
32500.0	0.223	13.391	4.823	941.125	0.297	0.070	3.685	1.701	0.746	0.272
35000.0	0.216	11.816	5.045	939.637	0.329	0.085	3.658	1.828	0.800	0.333
37500.0	0.208	10.341	5.246	938.088	0.362	0.101	3.618	1.946	0.847	0.400
40000.0	0.200	8.970	5.425	936.474	0.395	0.118	3.568	2.056	0.888	0.474
42500.0	0.192	7.705	5.582	934.789	0.427	0.137	3.511	2.156	0.921	0.554
45000.0	0.184	6.550	5.717	933.030	0.459	0.157	3.449	2.246	0.948	0.640
47500.0	0.176	5.506	5.828	931.192	0.490	0.177	3.386	2.326	0.968	0.733
50000.0	0.168	4.575	5.918	929.273	0.519	0.198	3.323	2.396	0.983	0.830
52500.0	0.160	3.756	5.985	927.271	0.547	0.220	3.263	2.455	0.993	0.933
55000.0	0.152	3.046	6.030	925.185	0.573	0.241	3.206	2.504	0.998	1.039
57500.0	0.145	2.441	6.055	923.018	0.598	0.261	3.154	2.543	1.001	1.149
60000.0	0.137	1.935	6.062	920.775	0.619	0.280	3.108	2.574	1.000	1.260
62500.0	0.129	1.518	6.051	918.462	0.639	0.299	3.068	2.598	0.998	1.373
65000.0	0.122	1.180	6.025	916.085	0.656	0.315	3.033	2.614	0.995	1.486
67500.0	0.115	0.911	5.987	913.654	0.670	0.331	3.003	2.626	0.991	1.599
70000.0	0.108	0.699	5.938	911.178	0.683	0.344	2.978	2.633	0.987	1.710

Table C.20 [ ] Exposure-Dependent 40% Void Isotopics (kg/MTU Initial)

Exposure MWd/MTU	U-234	U-235	U-236	U-238	NP-237	PU-238	PU-239	PU-240	PU-241	PU-242
0.0	0.321	42.598	0.000	957.080	0.000	0.000	0.000	0.000	0.000	0.000
100.0	0.321	42.478	0.023	957.027	0.000	0.000	0.016	0.000	0.000	0.000
500.0	0.319	42.001	0.112	956.814	0.002	0.000	0.182	0.001	0.000	0.000
1000.0	0.318	41.413	0.223	956.546	0.004	0.000	0.404	0.006	0.000	0.000
1500.0	0.316	40.834	0.331	956.279	0.006	0.000	0.615	0.015	0.001	0.000
2000.0	0.314	40.262	0.438	956.012	0.008	0.000	0.816	0.026	0.002	0.000
2500.0	0.312	39.698	0.543	955.745	0.011	0.000	1.007	0.040	0.004	0.000
3000.0	0.310	39.142	0.646	955.478	0.013	0.000	1.189	0.056	0.007	0.000
3500.0	0.309	38.592	0.748	955.211	0.016	0.001	1.363	0.074	0.011	0.000
4000.0	0.307	38.050	0.848	954.945	0.019	0.001	1.528	0.094	0.016	0.000
4500.0	0.305	37.514	0.947	954.680	0.023	0.001	1.685	0.115	0.022	0.001
5000.0	0.303	36.984	1.044	954.414	0.026	0.001	1.834	0.138	0.029	0.001
5500.0	0.301	36.460	1.140	954.149	0.030	0.001	1.977	0.162	0.037	0.001
6000.0	0.300	35.942	1.234	953.884	0.033	0.002	2.112	0.187	0.045	0.002
6500.0	0.298	35.429	1.327	953.620	0.037	0.002	2.240	0.212	0.055	0.002
7000.0	0.296	34.922	1.419	953.356	0.041	0.002	2.362	0.239	0.065	0.003
7500.0	0.295	34.420	1.509	953.093	0.045	0.003	2.478	0.267	0.076	0.004
8000.0	0.293	33.923	1.598	952.830	0.049	0.003	2.588	0.295	0.088	0.005
8500.0	0.291	33.431	1.686	952.568	0.054	0.004	2.692	0.324	0.100	0.006
9000.0	0.290	32.944	1.773	952.307	0.058	0.004	2.790	0.353	0.113	0.007
9500.0	0.288	32.462	1.858	952.046	0.062	0.005	2.883	0.383	0.127	0.008
10000.0	0.286	31.983	1.943	951.786	0.067	0.005	2.971	0.413	0.141	0.010
10500.0	0.285	31.509	2.026	951.527	0.072	0.006	3.054	0.444	0.155	0.012
11000.0	0.283	31.039	2.108	951.268	0.076	0.007	3.133	0.474	0.170	0.013
11500.0	0.282	30.573	2.189	951.010	0.081	0.007	3.207	0.506	0.185	0.015
12000.0	0.280	30.112	2.269	950.752	0.086	0.008	3.277	0.537	0.201	0.018
12500.0	0.278	29.654	2.349	950.494	0.091	0.009	3.343	0.569	0.216	0.020
13000.0	0.277	29.200	2.427	950.236	0.097	0.010	3.406	0.601	0.232	0.022
13500.0	0.275	28.749	2.504	949.977	0.102	0.011	3.465	0.632	0.249	0.025
14000.0	0.274	28.303	2.580	949.717	0.107	0.012	3.522	0.664	0.265	0.028
14500.0	0.272	27.861	2.656	949.456	0.112	0.013	3.576	0.697	0.282	0.031
15000.0	0.270	27.422	2.730	949.195	0.118	0.014	3.628	0.729	0.299	0.034
15500.0	0.269	26.988	2.804	948.932	0.123	0.015	3.677	0.761	0.316	0.038
16000.0	0.267	26.557	2.876	948.668	0.129	0.016	3.723	0.793	0.334	0.042
16500.0	0.266	26.130	2.948	948.403	0.135	0.017	3.768	0.826	0.351	0.046
17000.0	0.264	25.707	3.019	948.137	0.140	0.019	3.810	0.858	0.369	0.050
17500.0	0.263	25.287	3.089	947.869	0.146	0.020	3.850	0.890	0.386	0.054
20000.0	0.255	23.247	3.427	946.510	0.176	0.027	4.022	1.050	0.477	0.079
22500.0	0.247	21.299	3.744	945.116	0.208	0.037	4.151	1.208	0.567	0.110
25000.0	0.239	19.444	4.039	943.684	0.242	0.047	4.243	1.363	0.654	0.146
27500.0	0.232	17.680	4.313	942.213	0.276	0.060	4.303	1.513	0.737	0.189
30000.0	0.224	16.006	4.567	940.701	0.312	0.074	4.336	1.657	0.814	0.238
32500.0	0.216	14.422	4.800	939.145	0.348	0.090	4.345	1.795	0.885	0.292
35000.0	0.209	12.930	5.013	937.542	0.384	0.108	4.336	1.926	0.950	0.353
37500.0	0.201	11.528	5.205	935.890	0.420	0.128	4.311	2.049	1.007	0.419
40000.0	0.193	10.219	5.378	934.187	0.456	0.149	4.273	2.164	1.057	0.490
42500.0	0.186	9.001	5.530	932.429	0.491	0.172	4.226	2.269	1.100	0.567
45000.0	0.178	7.876	5.662	930.614	0.526	0.196	4.172	2.365	1.136	0.648
47500.0	0.171	6.844	5.774	928.741	0.559	0.220	4.112	2.452	1.165	0.734
50000.0	0.164	5.904	5.867	926.807	0.591	0.246	4.050	2.529	1.188	0.824
52500.0	0.156	5.055	5.940	924.813	0.622	0.272	3.988	2.596	1.205	0.917
55000.0	0.149	4.296	5.995	922.756	0.650	0.298	3.926	2.654	1.218	1.014
57500.0	0.142	3.623	6.032	920.639	0.677	0.323	3.866	2.703	1.225	1.113
60000.0	0.136	3.032	6.052	918.462	0.701	0.348	3.809	2.743	1.229	1.213
62500.0	0.129	2.520	6.057	916.228	0.724	0.372	3.757	2.776	1.230	1.315
65000.0	0.122	2.080	6.047	913.940	0.744	0.394	3.708	2.801	1.229	1.417
67500.0	0.116	1.706	6.023	911.604	0.762	0.415	3.664	2.821	1.226	1.519
70000.0	0.110	1.392	5.989	909.222	0.777	0.435	3.625	2.835	1.222	1.621

Table C.21 [ ] Exposure-Dependent 80% Void Isotopics (kg/MTU Initial)

Exposure MWd/MTU	U-234	U-235	U-236	U-238	NP-237	PU-238	PU-239	PU-240	PU-241	PU-242
0.0	0.321	42.598	0.000	957.080	0.000	0.000	0.000	0.000	0.000	0.000
100.0	0.321	42.479	0.024	957.017	0.000	0.000	0.019	0.000	0.000	0.000
500.0	0.319	42.006	0.118	956.763	0.002	0.000	0.214	0.002	0.000	0.000
1000.0	0.317	41.423	0.234	956.445	0.004	0.000	0.474	0.008	0.000	0.000
1500.0	0.315	40.850	0.348	956.127	0.007	0.000	0.722	0.017	0.001	0.000
2000.0	0.313	40.287	0.460	955.810	0.010	0.000	0.957	0.030	0.003	0.000
2500.0	0.310	39.732	0.569	955.493	0.013	0.000	1.182	0.046	0.006	0.000
3000.0	0.308	39.187	0.677	955.177	0.017	0.001	1.396	0.064	0.011	0.000
3500.0	0.306	38.649	0.782	954.861	0.021	0.001	1.600	0.084	0.016	0.000
4000.0	0.304	38.118	0.886	954.545	0.025	0.001	1.794	0.106	0.023	0.001
4500.0	0.302	37.596	0.988	954.230	0.029	0.001	1.979	0.130	0.031	0.001
5000.0	0.300	37.080	1.088	953.915	0.033	0.002	2.156	0.155	0.040	0.001
5500.0	0.298	36.571	1.187	953.601	0.038	0.002	2.324	0.181	0.050	0.002
6000.0	0.296	36.068	1.284	953.287	0.042	0.003	2.485	0.208	0.061	0.002
6500.0	0.294	35.572	1.379	952.973	0.047	0.003	2.639	0.236	0.074	0.003
7000.0	0.292	35.081	1.473	952.661	0.052	0.004	2.785	0.265	0.087	0.004
7500.0	0.290	34.597	1.566	952.348	0.058	0.004	2.924	0.294	0.101	0.005
8000.0	0.288	34.118	1.656	952.036	0.063	0.005	3.057	0.325	0.116	0.006
8500.0	0.286	33.645	1.746	951.725	0.069	0.006	3.183	0.356	0.132	0.007
9000.0	0.284	33.177	1.834	951.415	0.075	0.006	3.304	0.387	0.148	0.009
9500.0	0.282	32.714	1.921	951.105	0.080	0.007	3.418	0.419	0.165	0.011
10000.0	0.281	32.256	2.006	950.796	0.086	0.008	3.527	0.452	0.183	0.012
10500.0	0.279	31.802	2.091	950.487	0.092	0.009	3.630	0.485	0.200	0.014
11000.0	0.277	31.354	2.174	950.180	0.098	0.010	3.729	0.518	0.219	0.017
11500.0	0.275	30.910	2.255	949.872	0.104	0.011	3.822	0.552	0.237	0.019
12000.0	0.273	30.470	2.336	949.565	0.111	0.012	3.911	0.586	0.256	0.021
12500.0	0.271	30.035	2.416	949.258	0.117	0.014	3.996	0.620	0.275	0.024
13000.0	0.270	29.604	2.494	948.952	0.123	0.015	4.077	0.654	0.295	0.027
13500.0	0.268	29.177	2.571	948.645	0.130	0.016	4.154	0.689	0.314	0.030
14000.0	0.266	28.753	2.648	948.338	0.136	0.018	4.227	0.723	0.334	0.034
14500.0	0.264	28.335	2.723	948.030	0.143	0.019	4.297	0.758	0.354	0.037
15000.0	0.263	27.920	2.797	947.722	0.150	0.021	4.364	0.793	0.374	0.041
15500.0	0.261	27.509	2.870	947.414	0.157	0.022	4.428	0.828	0.395	0.045
16000.0	0.259	27.102	2.942	947.104	0.163	0.024	4.490	0.862	0.415	0.049
16500.0	0.257	26.699	3.014	946.794	0.170	0.026	4.549	0.897	0.436	0.053
17000.0	0.256	26.300	3.084	946.482	0.177	0.028	4.605	0.932	0.457	0.058
17500.0	0.254	25.905	3.153	946.169	0.185	0.030	4.660	0.967	0.478	0.062
18000.0	0.252	25.514	3.221	945.855	0.192	0.032	4.712	1.002	0.498	0.067
18500.0	0.251	25.127	3.289	945.540	0.199	0.034	4.761	1.037	0.519	0.072
19000.0	0.249	24.744	3.355	945.223	0.207	0.036	4.809	1.072	0.540	0.078
20000.0	0.245	23.988	3.485	944.586	0.221	0.040	4.899	1.141	0.582	0.089
22500.0	0.237	22.166	3.795	942.971	0.260	0.053	5.092	1.312	0.688	0.121
25000.0	0.229	20.436	4.082	941.322	0.299	0.069	5.245	1.480	0.791	0.158
27500.0	0.221	18.796	4.348	939.638	0.339	0.086	5.362	1.644	0.890	0.201
30000.0	0.213	17.243	4.592	937.919	0.379	0.105	5.450	1.802	0.984	0.248
32500.0	0.205	15.775	4.817	936.163	0.420	0.127	5.511	1.955	1.073	0.301
35000.0	0.197	14.392	5.021	934.371	0.460	0.151	5.549	2.101	1.155	0.358
37500.0	0.190	13.090	5.205	932.540	0.500	0.177	5.568	2.240	1.231	0.419
40000.0	0.182	11.870	5.370	930.670	0.540	0.205	5.571	2.371	1.300	0.484
42500.0	0.175	10.729	5.517	928.762	0.578	0.234	5.561	2.494	1.362	0.553
45000.0	0.168	9.665	5.644	926.813	0.616	0.265	5.539	2.609	1.418	0.625
47500.0	0.161	8.678	5.755	924.823	0.653	0.298	5.508	2.715	1.467	0.701
50000.0	0.154	7.764	5.848	922.794	0.688	0.331	5.471	2.813	1.510	0.780
52500.0	0.148	6.923	5.924	920.724	0.721	0.365	5.428	2.903	1.547	0.861
55000.0	0.142	6.151	5.985	918.614	0.753	0.399	5.381	2.984	1.578	0.944
57500.0	0.136	5.446	6.030	916.465	0.783	0.434	5.333	3.056	1.605	1.029
60000.0	0.130	4.805	6.061	914.278	0.811	0.468	5.283	3.121	1.626	1.116
62500.0	0.124	4.226	6.079	912.054	0.836	0.502	5.233	3.178	1.644	1.204
65000.0	0.119	3.704	6.084	909.795	0.860	0.535	5.183	3.228	1.657	1.293
67500.0	0.113	3.237	6.077	907.502	0.881	0.567	5.136	3.272	1.668	1.383
70000.0	0.108	2.820	6.059	905.177	0.901	0.598	5.089	3.309	1.675	1.474

Table C.22 [ ] Exposure-Dependent 0% Void Isotopics (kg/MTU Initial)

Exposure MWd/MTU	U-234	U-235	U-236	U-238	NP-237	PU-238	PU-239	PU-240	PU-241	PU-242
0.0	0.322	42.668	0.000	957.009	0.000	0.000	0.000	0.000	0.000	0.000
100.0	0.322	42.549	0.023	956.954	0.000	0.000	0.020	0.000	0.000	0.000
500.0	0.320	42.072	0.113	956.729	0.002	0.000	0.201	0.002	0.000	0.000
1000.0	0.318	41.485	0.224	956.448	0.004	0.000	0.434	0.007	0.000	0.000
1500.0	0.316	40.906	0.333	956.167	0.006	0.000	0.656	0.016	0.001	0.000
2000.0	0.315	40.337	0.441	955.886	0.008	0.000	0.868	0.028	0.003	0.000
2500.0	0.313	39.775	0.546	955.605	0.011	0.000	1.069	0.043	0.005	0.000
3000.0	0.311	39.222	0.650	955.325	0.014	0.000	1.261	0.060	0.008	0.000
3500.0	0.309	38.675	0.752	955.044	0.017	0.001	1.443	0.079	0.013	0.000
4000.0	0.307	38.136	0.852	954.764	0.020	0.001	1.617	0.100	0.018	0.000
4500.0	0.305	37.604	0.951	954.484	0.024	0.001	1.782	0.122	0.024	0.001
5000.0	0.303	37.078	1.048	954.205	0.027	0.001	1.940	0.146	0.032	0.001
5500.0	0.302	36.558	1.144	953.925	0.031	0.002	2.090	0.171	0.040	0.002
6000.0	0.300	36.045	1.239	953.646	0.035	0.002	2.233	0.197	0.050	0.002
6500.0	0.298	35.538	1.332	953.367	0.039	0.002	2.369	0.224	0.060	0.003
7000.0	0.296	35.036	1.423	953.089	0.043	0.003	2.498	0.251	0.071	0.003
7500.0	0.295	34.540	1.514	952.811	0.047	0.003	2.621	0.280	0.083	0.004
8000.0	0.293	34.049	1.603	952.533	0.052	0.004	2.737	0.309	0.096	0.005
8500.0	0.291	33.563	1.691	952.256	0.056	0.004	2.848	0.339	0.110	0.007
9000.0	0.289	33.083	1.777	951.979	0.061	0.005	2.953	0.369	0.124	0.008
9500.0	0.288	32.607	1.863	951.703	0.066	0.005	3.052	0.400	0.139	0.010
10000.0	0.286	32.136	1.947	951.427	0.070	0.006	3.146	0.431	0.154	0.011
10500.0	0.284	31.669	2.030	951.152	0.075	0.007	3.235	0.463	0.170	0.013
11000.0	0.283	31.207	2.112	950.878	0.080	0.007	3.320	0.495	0.186	0.015
11500.0	0.281	30.749	2.192	950.603	0.086	0.008	3.399	0.527	0.202	0.017
12000.0	0.279	30.296	2.272	950.330	0.091	0.009	3.474	0.559	0.219	0.020
12500.0	0.278	29.846	2.351	950.056	0.096	0.010	3.545	0.592	0.236	0.022
13000.0	0.276	29.401	2.428	949.783	0.101	0.011	3.612	0.625	0.253	0.025
13500.0	0.274	28.960	2.505	949.510	0.107	0.012	3.675	0.658	0.271	0.028
14000.0	0.273	28.522	2.580	949.237	0.112	0.013	3.734	0.691	0.288	0.031
14500.0	0.271	28.088	2.655	948.965	0.118	0.014	3.790	0.724	0.306	0.035
15000.0	0.270	27.658	2.729	948.692	0.124	0.015	3.843	0.757	0.324	0.038
15500.0	0.268	27.232	2.801	948.420	0.129	0.016	3.892	0.790	0.342	0.042
16000.0	0.267	26.809	2.873	948.147	0.135	0.018	3.939	0.824	0.360	0.046
16500.0	0.265	26.389	2.944	947.873	0.141	0.019	3.983	0.857	0.378	0.051
17000.0	0.263	25.973	3.014	947.599	0.147	0.020	4.024	0.890	0.396	0.055
17500.0	0.262	25.561	3.084	947.325	0.153	0.022	4.063	0.923	0.414	0.060
18000.0	0.260	25.153	3.152	947.049	0.159	0.023	4.100	0.956	0.433	0.065
18500.0	0.259	24.748	3.219	946.772	0.165	0.025	4.135	0.989	0.451	0.070
19000.0	0.257	24.346	3.286	946.495	0.171	0.026	4.168	1.022	0.469	0.075
19500.0	0.256	23.949	3.352	946.216	0.177	0.028	4.200	1.054	0.487	0.080
20000.0	0.254	23.554	3.417	945.935	0.183	0.030	4.229	1.087	0.506	0.086
20500.0	0.252	23.164	3.481	945.654	0.190	0.031	4.257	1.119	0.524	0.092
22500.0	0.246	21.638	3.730	944.513	0.215	0.039	4.353	1.247	0.597	0.119
25000.0	0.239	19.811	4.021	943.053	0.249	0.051	4.443	1.402	0.686	0.157
27500.0	0.231	18.072	4.293	941.555	0.284	0.064	4.503	1.551	0.771	0.201
30000.0	0.223	16.422	4.544	940.017	0.319	0.079	4.536	1.694	0.851	0.251
32500.0	0.216	14.860	4.775	938.436	0.356	0.096	4.548	1.830	0.924	0.306
35000.0	0.208	13.386	4.986	936.810	0.392	0.115	4.541	1.959	0.991	0.368
37500.0	0.201	12.000	5.178	935.138	0.429	0.135	4.519	2.080	1.050	0.434
40000.0	0.193	10.702	5.349	933.417	0.465	0.158	4.485	2.193	1.102	0.506
42500.0	0.186	9.492	5.501	931.646	0.501	0.181	4.441	2.297	1.147	0.583
45000.0	0.179	8.370	5.634	929.821	0.536	0.206	4.389	2.392	1.185	0.664
47500.0	0.172	7.336	5.747	927.942	0.571	0.233	4.332	2.478	1.217	0.749
50000.0	0.164	6.389	5.842	926.007	0.604	0.259	4.272	2.554	1.242	0.838
52500.0	0.158	5.529	5.918	924.016	0.635	0.287	4.211	2.622	1.261	0.930
55000.0	0.151	4.753	5.977	921.968	0.665	0.314	4.149	2.681	1.275	1.024
57500.0	0.144	4.058	6.018	919.863	0.693	0.341	4.089	2.731	1.285	1.121
60000.0	0.138	3.443	6.043	917.703	0.719	0.368	4.031	2.773	1.291	1.220
62500.0	0.131	2.902	6.053	915.490	0.743	0.393	3.976	2.808	1.293	1.319
65000.0	0.125	2.431	6.049	913.226	0.764	0.417	3.925	2.836	1.293	1.419
67500.0	0.119	2.025	6.031	910.915	0.784	0.440	3.878	2.858	1.291	1.519
70000.0	0.113	1.678	6.002	908.560	0.800	0.462	3.836	2.874	1.287	1.618

Table C.23 [ ] Exposure-Dependent 40% Void Isotopics (kg/MTU Initial)

Exposure MWd/MTU	U-234	U-235	U-236	U-238	NP-237	PU-238	PU-239	PU-240	PU-241	PU-242
0.0	0.322	42.668	0.000	957.009	0.000	0.000	0.000	0.000	0.000	0.000
100.0	0.322	42.549	0.024	956.946	0.000	0.000	0.022	0.000	0.000	0.000
500.0	0.320	42.074	0.118	956.690	0.002	0.000	0.227	0.002	0.000	0.000
1000.0	0.318	41.491	0.233	956.370	0.004	0.000	0.491	0.008	0.000	0.000
1500.0	0.316	40.917	0.346	956.051	0.007	0.000	0.742	0.018	0.001	0.000
2000.0	0.314	40.353	0.457	955.731	0.010	0.000	0.980	0.032	0.003	0.000
2500.0	0.311	39.799	0.565	955.413	0.013	0.000	1.207	0.048	0.007	0.000
3000.0	0.309	39.253	0.672	955.094	0.016	0.001	1.423	0.067	0.011	0.000
3500.0	0.307	38.715	0.777	954.776	0.020	0.001	1.629	0.087	0.016	0.000
4000.0	0.305	38.185	0.880	954.459	0.024	0.001	1.825	0.110	0.023	0.001
4500.0	0.303	37.662	0.981	954.142	0.028	0.001	2.012	0.134	0.031	0.001
5000.0	0.301	37.147	1.080	953.825	0.032	0.002	2.191	0.160	0.040	0.001
5500.0	0.299	36.639	1.178	953.508	0.037	0.002	2.360	0.186	0.051	0.002
6000.0	0.297	36.137	1.274	953.192	0.041	0.002	2.522	0.214	0.062	0.003
6500.0	0.295	35.642	1.369	952.877	0.046	0.003	2.677	0.243	0.075	0.003
7000.0	0.293	35.153	1.462	952.562	0.051	0.003	2.824	0.272	0.088	0.004
7500.0	0.291	34.670	1.553	952.247	0.056	0.004	2.964	0.303	0.103	0.005
8000.0	0.289	34.192	1.644	951.934	0.061	0.005	3.097	0.334	0.118	0.007
8500.0	0.288	33.721	1.732	951.620	0.067	0.005	3.225	0.365	0.134	0.008
9000.0	0.286	33.254	1.820	951.307	0.072	0.006	3.345	0.397	0.151	0.010
9500.0	0.284	32.793	1.906	950.995	0.078	0.007	3.460	0.430	0.168	0.011
10000.0	0.282	32.337	1.990	950.684	0.084	0.008	3.569	0.463	0.186	0.013
10500.0	0.280	31.886	2.074	950.373	0.090	0.009	3.673	0.496	0.205	0.015
11000.0	0.278	31.440	2.156	950.063	0.096	0.010	3.771	0.530	0.224	0.018
11500.0	0.276	30.998	2.236	949.753	0.102	0.011	3.865	0.563	0.243	0.020
12000.0	0.275	30.561	2.316	949.444	0.108	0.012	3.953	0.598	0.262	0.023
12500.0	0.273	30.128	2.395	949.135	0.114	0.013	4.038	0.632	0.282	0.026
13000.0	0.271	29.699	2.472	948.827	0.120	0.014	4.117	0.667	0.302	0.029
13500.0	0.269	29.275	2.549	948.519	0.127	0.016	4.193	0.701	0.322	0.033
14000.0	0.268	28.855	2.624	948.211	0.133	0.017	4.265	0.736	0.342	0.036
14500.0	0.266	28.439	2.698	947.903	0.140	0.018	4.333	0.771	0.363	0.040
15000.0	0.264	28.026	2.771	947.596	0.146	0.020	4.397	0.806	0.383	0.044
15500.0	0.262	27.618	2.844	947.289	0.153	0.021	4.458	0.841	0.404	0.048
16000.0	0.261	27.213	2.915	946.981	0.159	0.023	4.516	0.876	0.425	0.052
16500.0	0.259	26.812	2.985	946.673	0.166	0.025	4.571	0.911	0.445	0.057
17000.0	0.257	26.415	3.055	946.365	0.173	0.026	4.623	0.946	0.466	0.062
17500.0	0.256	26.021	3.123	946.057	0.180	0.028	4.672	0.980	0.487	0.067
18000.0	0.254	25.632	3.191	945.747	0.187	0.030	4.720	1.015	0.508	0.072
18500.0	0.252	25.245	3.257	945.437	0.194	0.032	4.764	1.050	0.528	0.078
19000.0	0.251	24.863	3.323	945.127	0.201	0.034	4.807	1.084	0.549	0.083
19500.0	0.249	24.484	3.388	944.815	0.208	0.036	4.848	1.119	0.570	0.089
20000.0	0.247	24.109	3.452	944.502	0.215	0.039	4.886	1.153	0.591	0.095
20500.0	0.246	23.737	3.515	944.188	0.222	0.041	4.923	1.187	0.611	0.102
21000.0	0.244	23.369	3.577	943.873	0.229	0.043	4.958	1.221	0.632	0.108
21500.0	0.242	23.004	3.638	943.556	0.237	0.046	4.992	1.255	0.653	0.115
22000.0	0.241	22.644	3.699	943.238	0.244	0.048	5.023	1.289	0.673	0.122
22500.0	0.239	22.286	3.758	942.919	0.251	0.051	5.054	1.322	0.694	0.129
25000.0	0.231	20.553	4.043	941.303	0.289	0.065	5.185	1.485	0.795	0.168
27500.0	0.223	18.908	4.307	939.651	0.328	0.082	5.283	1.643	0.892	0.213
30000.0	0.215	17.348	4.550	937.963	0.368	0.100	5.354	1.794	0.984	0.263
32500.0	0.208	15.873	4.773	936.238	0.408	0.121	5.401	1.939	1.071	0.318
35000.0	0.200	14.481	4.977	934.476	0.448	0.144	5.428	2.077	1.150	0.377
37500.0	0.193	13.171	5.161	932.674	0.488	0.169	5.437	2.207	1.223	0.441
40000.0	0.186	11.940	5.327	930.832	0.527	0.196	5.431	2.330	1.288	0.510
42500.0	0.178	10.789	5.474	928.950	0.566	0.225	5.413	2.444	1.347	0.582
45000.0	0.172	9.715	5.603	927.027	0.603	0.255	5.385	2.550	1.399	0.657
47500.0	0.165	8.717	5.715	925.062	0.640	0.286	5.349	2.648	1.445	0.736
50000.0	0.158	7.793	5.810	923.056	0.674	0.318	5.307	2.738	1.484	0.817
52500.0	0.152	6.941	5.889	921.007	0.708	0.351	5.261	2.819	1.517	0.900
55000.0	0.146	6.160	5.952	918.917	0.740	0.385	5.211	2.892	1.545	0.986
57500.0	0.140	5.446	5.999	916.786	0.770	0.418	5.160	2.958	1.568	1.073
60000.0	0.134	4.797	6.033	914.615	0.798	0.451	5.108	3.016	1.586	1.162
62500.0	0.128	4.211	6.053	912.405	0.824	0.484	5.056	3.067	1.600	1.251
65000.0	0.123	3.684	6.060	910.158	0.848	0.516	5.006	3.111	1.611	1.341
67500.0	0.118	3.211	6.055	907.875	0.870	0.547	4.957	3.148	1.618	1.431
70000.0	0.113	2.791	6.039	905.559	0.890	0.576	4.910	3.180	1.623	1.521

Table C.24 [ ] Exposure-Dependent 80% Void Isotopics (kg/MTU Initial)

Exposure MWd/MTU	U-234	U-235	U-236	U-238	NP-237	PU-238	PU-239	PU-240	PU-241	PU-242
0.0	0.322	42.668	0.000	957.009	0.000	0.000	0.000	0.000	0.000	0.000
100.0	0.322	42.550	0.025	956.936	0.000	0.000	0.025	0.000	0.000	0.000
500.0	0.320	42.079	0.123	956.641	0.002	0.000	0.259	0.002	0.000	0.000
1000.0	0.317	41.501	0.244	956.271	0.005	0.000	0.560	0.009	0.001	0.000
1500.0	0.315	40.934	0.362	955.903	0.008	0.000	0.847	0.020	0.002	0.000
2000.0	0.312	40.379	0.478	955.535	0.012	0.000	1.119	0.035	0.005	0.000
2500.0	0.310	39.833	0.591	955.168	0.016	0.000	1.379	0.053	0.009	0.000
3000.0	0.307	39.297	0.701	954.801	0.020	0.001	1.627	0.073	0.014	0.000
3500.0	0.305	38.769	0.810	954.435	0.024	0.001	1.864	0.095	0.021	0.000
4000.0	0.303	38.251	0.917	954.069	0.029	0.001	2.090	0.119	0.030	0.001
4500.0	0.300	37.740	1.021	953.704	0.034	0.002	2.306	0.145	0.040	0.001
5000.0	0.298	37.237	1.124	953.339	0.039	0.002	2.512	0.172	0.051	0.002
5500.0	0.296	36.742	1.224	952.975	0.045	0.003	2.710	0.200	0.063	0.002
6000.0	0.294	36.254	1.323	952.612	0.050	0.003	2.899	0.229	0.077	0.003
6500.0	0.291	35.772	1.420	952.249	0.056	0.004	3.080	0.259	0.092	0.004
7000.0	0.289	35.298	1.516	951.886	0.062	0.005	3.253	0.290	0.108	0.005
7500.0	0.287	34.829	1.609	951.525	0.069	0.006	3.418	0.322	0.125	0.006
8000.0	0.285	34.367	1.702	951.163	0.075	0.007	3.577	0.355	0.143	0.008
8500.0	0.283	33.911	1.792	950.803	0.082	0.008	3.729	0.388	0.162	0.009
9000.0	0.281	33.460	1.881	950.443	0.088	0.009	3.874	0.421	0.181	0.011
9500.0	0.279	33.016	1.969	950.083	0.095	0.010	4.012	0.456	0.201	0.013
10000.0	0.276	32.576	2.055	949.725	0.102	0.011	4.145	0.490	0.221	0.015
10500.0	0.274	32.142	2.139	949.367	0.109	0.012	4.272	0.526	0.242	0.017
11000.0	0.272	31.713	2.223	949.010	0.116	0.014	4.393	0.561	0.264	0.020
11500.0	0.270	31.289	2.305	948.653	0.123	0.015	4.509	0.597	0.285	0.023
12000.0	0.268	30.870	2.386	948.297	0.131	0.017	4.620	0.633	0.307	0.026
12500.0	0.266	30.455	2.465	947.941	0.138	0.018	4.727	0.670	0.330	0.029
13000.0	0.264	30.045	2.543	947.585	0.146	0.020	4.828	0.706	0.352	0.032
13500.0	0.262	29.640	2.620	947.230	0.153	0.022	4.925	0.743	0.375	0.036
14000.0	0.261	29.238	2.696	946.875	0.161	0.024	5.018	0.780	0.398	0.039
14500.0	0.259	28.841	2.771	946.521	0.169	0.026	5.107	0.817	0.421	0.043
15000.0	0.257	28.449	2.844	946.167	0.176	0.028	5.192	0.855	0.444	0.048
15500.0	0.255	28.060	2.917	945.813	0.184	0.030	5.273	0.892	0.467	0.052
16000.0	0.253	27.675	2.988	945.458	0.192	0.032	5.351	0.930	0.490	0.056
16500.0	0.251	27.295	3.058	945.104	0.200	0.034	5.425	0.967	0.514	0.061
17000.0	0.249	26.918	3.127	944.750	0.208	0.037	5.497	1.005	0.537	0.066
17500.0	0.247	26.545	3.196	944.395	0.216	0.039	5.565	1.043	0.560	0.071
18000.0	0.246	26.176	3.263	944.040	0.224	0.042	5.631	1.080	0.584	0.076
18500.0	0.244	25.810	3.329	943.684	0.232	0.045	5.694	1.118	0.607	0.082
19000.0	0.242	25.449	3.394	943.328	0.240	0.047	5.754	1.155	0.630	0.088
19500.0	0.240	25.091	3.459	942.971	0.249	0.050	5.813	1.193	0.653	0.094
20000.0	0.239	24.736	3.522	942.614	0.257	0.053	5.868	1.230	0.676	0.100
20500.0	0.237	24.386	3.584	942.255	0.265	0.056	5.922	1.267	0.699	0.106
21000.0	0.235	24.038	3.646	941.896	0.274	0.059	5.974	1.304	0.722	0.112
21500.0	0.233	23.695	3.707	941.536	0.282	0.063	6.024	1.341	0.745	0.119
22000.0	0.232	23.355	3.766	941.175	0.290	0.066	6.072	1.378	0.768	0.126
22500.0	0.230	23.018	3.825	940.813	0.299	0.070	6.118	1.415	0.791	0.133
23000.0	0.228	22.685	3.883	940.449	0.307	0.073	6.163	1.451	0.814	0.140
23500.0	0.226	22.356	3.940	940.085	0.316	0.077	6.205	1.488	0.837	0.148
24000.0	0.225	22.030	3.996	939.719	0.324	0.081	6.247	1.524	0.859	0.155
24500.0	0.223	21.707	4.051	939.352	0.333	0.085	6.287	1.560	0.882	0.163
25000.0	0.221	21.388	4.106	938.984	0.341	0.088	6.325	1.596	0.904	0.171
27500.0	0.213	19.844	4.365	937.124	0.384	0.110	6.498	1.771	1.014	0.213
30000.0	0.205	18.382	4.604	935.232	0.427	0.134	6.641	1.941	1.121	0.259
32500.0	0.197	17.001	4.822	933.308	0.470	0.161	6.757	2.106	1.222	0.310
35000.0	0.190	15.698	5.021	931.351	0.513	0.190	6.850	2.264	1.319	0.364
37500.0	0.182	14.471	5.202	929.363	0.555	0.221	6.923	2.416	1.409	0.422
40000.0	0.175	13.317	5.363	927.342	0.597	0.254	6.979	2.561	1.494	0.482
42500.0	0.168	12.235	5.507	925.289	0.637	0.290	7.019	2.698	1.572	0.546
45000.0	0.162	11.221	5.634	923.205	0.677	0.327	7.046	2.829	1.645	0.612
47500.0	0.155	10.273	5.745	921.089	0.715	0.366	7.062	2.953	1.712	0.681
50000.0	0.149	9.390	5.840	918.943	0.752	0.406	7.068	3.069	1.774	0.751
52500.0	0.143	8.568	5.920	916.767	0.787	0.447	7.066	3.178	1.830	0.824
55000.0	0.138	7.805	5.985	914.562	0.821	0.489	7.058	3.280	1.881	0.898
57500.0	0.132	7.099	6.037	912.329	0.853	0.531	7.044	3.375	1.927	0.974
60000.0	0.127	6.447	6.076	910.069	0.882	0.574	7.026	3.463	1.969	1.052
62500.0	0.122	5.845	6.104	907.783	0.910	0.617	7.005	3.545	2.006	1.130
65000.0	0.118	5.292	6.119	905.472	0.936	0.659	6.981	3.620	2.040	1.210
67500.0	0.113	4.785	6.125	903.138	0.960	0.701	6.956	3.689	2.069	1.291
70000.0	0.109	4.321	6.120	900.781	0.982	0.742	6.929	3.752	2.095	1.372

Table C.25 [ ] Exposure-Dependent 0% Void Isotopics (kg/MTU Initial)

Exposure MWd/MTU	U-234	U-235	U-236	U-238	NP-237	PU-238	PU-239	PU-240	PU-241	PU-242
0.0	0.327	43.333	0.000	956.340	0.000	0.000	0.000	0.000	0.000	0.000
100.0	0.326	43.213	0.023	956.286	0.000	0.000	0.019	0.000	0.000	0.000
500.0	0.325	42.736	0.113	956.069	0.002	0.000	0.194	0.001	0.000	0.000
1000.0	0.323	42.147	0.223	955.796	0.003	0.000	0.421	0.007	0.000	0.000
1500.0	0.321	41.568	0.332	955.524	0.006	0.000	0.636	0.015	0.001	0.000
2000.0	0.319	40.996	0.439	955.251	0.008	0.000	0.842	0.027	0.002	0.000
2500.0	0.317	40.433	0.545	954.978	0.011	0.000	1.038	0.041	0.005	0.000
3000.0	0.316	39.877	0.649	954.705	0.013	0.000	1.226	0.057	0.008	0.000
3500.0	0.314	39.328	0.751	954.432	0.016	0.001	1.404	0.076	0.012	0.000
4000.0	0.312	38.786	0.851	954.159	0.020	0.001	1.575	0.096	0.017	0.000
4500.0	0.310	38.250	0.950	953.886	0.023	0.001	1.737	0.117	0.023	0.001
5000.0	0.308	37.721	1.048	953.613	0.026	0.001	1.892	0.140	0.030	0.001
5500.0	0.307	37.199	1.144	953.340	0.030	0.001	2.041	0.165	0.038	0.001
6000.0	0.305	36.682	1.239	953.067	0.034	0.002	2.182	0.190	0.047	0.002
6500.0	0.303	36.171	1.333	952.793	0.038	0.002	2.317	0.216	0.057	0.002
7000.0	0.301	35.665	1.425	952.520	0.042	0.002	2.445	0.243	0.067	0.003
7500.0	0.300	35.165	1.516	952.247	0.046	0.003	2.567	0.271	0.079	0.004
8000.0	0.298	34.671	1.605	951.974	0.050	0.003	2.684	0.299	0.091	0.005
8500.0	0.296	34.181	1.694	951.700	0.055	0.004	2.795	0.328	0.104	0.006
9000.0	0.294	33.696	1.781	951.427	0.059	0.004	2.901	0.358	0.118	0.007
9500.0	0.293	33.217	1.867	951.154	0.064	0.005	3.001	0.388	0.132	0.009
10000.0	0.291	32.742	1.952	950.882	0.069	0.006	3.097	0.419	0.147	0.011
10500.0	0.289	32.272	2.035	950.609	0.074	0.006	3.187	0.450	0.163	0.012
11000.0	0.288	31.806	2.118	950.337	0.079	0.007	3.273	0.481	0.178	0.014
11500.0	0.286	31.344	2.200	950.064	0.084	0.008	3.355	0.512	0.195	0.016
12000.0	0.284	30.887	2.280	949.792	0.089	0.009	3.432	0.544	0.211	0.019
12500.0	0.283	30.435	2.359	949.520	0.095	0.010	3.505	0.576	0.228	0.021
13000.0	0.281	29.986	2.438	949.248	0.100	0.010	3.574	0.609	0.245	0.024
13500.0	0.279	29.541	2.515	948.976	0.105	0.011	3.640	0.641	0.262	0.027
14000.0	0.278	29.100	2.591	948.704	0.111	0.012	3.701	0.674	0.280	0.030
14500.0	0.276	28.663	2.667	948.432	0.117	0.014	3.759	0.707	0.298	0.033
15000.0	0.274	28.229	2.741	948.160	0.122	0.015	3.814	0.740	0.315	0.037
15500.0	0.273	27.800	2.815	947.888	0.128	0.016	3.866	0.772	0.333	0.040
16000.0	0.271	27.374	2.887	947.617	0.134	0.017	3.915	0.805	0.351	0.044
16500.0	0.270	26.951	2.959	947.344	0.140	0.018	3.961	0.838	0.369	0.048
17000.0	0.268	26.532	3.030	947.072	0.145	0.020	4.004	0.871	0.387	0.053
17500.0	0.266	26.116	3.100	946.798	0.151	0.021	4.045	0.904	0.405	0.057
18000.0	0.265	25.705	3.169	946.524	0.157	0.023	4.083	0.937	0.423	0.062
18500.0	0.263	25.296	3.237	946.249	0.164	0.024	4.120	0.969	0.441	0.067
19000.0	0.262	24.891	3.305	945.973	0.170	0.026	4.154	1.002	0.460	0.072
19500.0	0.260	24.490	3.371	945.695	0.176	0.027	4.187	1.034	0.478	0.077
20000.0	0.259	24.093	3.437	945.417	0.182	0.029	4.218	1.067	0.496	0.083
20500.0	0.257	23.698	3.502	945.137	0.189	0.031	4.247	1.099	0.514	0.089
21000.0	0.255	23.308	3.566	944.856	0.195	0.033	4.275	1.131	0.532	0.095
22500.0	0.251	22.158	3.753	944.004	0.214	0.038	4.348	1.226	0.587	0.114
25000.0	0.243	20.313	4.049	942.555	0.248	0.050	4.444	1.381	0.676	0.152
27500.0	0.235	18.556	4.325	941.067	0.283	0.063	4.508	1.530	0.762	0.195
30000.0	0.228	16.886	4.580	939.540	0.319	0.078	4.546	1.673	0.842	0.243
32500.0	0.220	15.304	4.815	937.972	0.355	0.095	4.562	1.810	0.916	0.298
35000.0	0.212	13.809	5.030	936.359	0.392	0.113	4.559	1.940	0.983	0.358
37500.0	0.205	12.401	5.226	934.701	0.429	0.134	4.539	2.061	1.044	0.423
40000.0	0.197	11.081	5.402	932.995	0.466	0.156	4.507	2.175	1.097	0.494
42500.0	0.190	9.848	5.558	931.239	0.502	0.180	4.465	2.280	1.143	0.569
45000.0	0.183	8.703	5.695	929.431	0.538	0.205	4.415	2.376	1.182	0.649
47500.0	0.175	7.645	5.813	927.569	0.572	0.231	4.358	2.464	1.215	0.733
50000.0	0.168	6.674	5.912	925.652	0.606	0.258	4.299	2.542	1.241	0.821
52500.0	0.161	5.789	5.993	923.679	0.638	0.286	4.237	2.611	1.262	0.912
55000.0	0.154	4.989	6.056	921.649	0.668	0.313	4.175	2.672	1.277	1.006
57500.0	0.147	4.271	6.101	919.564	0.696	0.340	4.114	2.724	1.287	1.102
60000.0	0.141	3.632	6.130	917.422	0.723	0.367	4.055	2.768	1.294	1.200
62500.0	0.134	3.069	6.144	915.227	0.747	0.393	3.999	2.804	1.297	1.299
65000.0	0.128	2.577	6.143	912.981	0.769	0.418	3.946	2.833	1.297	1.398
67500.0	0.122	2.151	6.128	910.686	0.789	0.442	3.898	2.856	1.295	1.498
70000.0	0.116	1.786	6.102	908.347	0.807	0.463	3.854	2.873	1.292	1.597

Table C.26 [ ] Exposure-Dependent 40% Void Isotopics (kg/MTU Initial)

Exposure MWd/MTU	U-234	U-235	U-236	U-238	NP-237	PU-238	PU-239	PU-240	PU-241	PU-242
0.0	0.327	43.333	0.000	956.340	0.000	0.000	0.000	0.000	0.000	0.000
100.0	0.326	43.213	0.024	956.279	0.000	0.000	0.022	0.000	0.000	0.000
500.0	0.325	42.738	0.117	956.031	0.002	0.000	0.220	0.002	0.000	0.000
1000.0	0.323	42.153	0.232	955.721	0.004	0.000	0.475	0.008	0.000	0.000
1500.0	0.320	41.578	0.345	955.411	0.007	0.000	0.719	0.017	0.001	0.000
2000.0	0.318	41.013	0.455	955.101	0.009	0.000	0.951	0.030	0.003	0.000
2500.0	0.316	40.456	0.564	954.792	0.013	0.000	1.172	0.046	0.006	0.000
3000.0	0.314	39.907	0.670	954.482	0.016	0.000	1.383	0.064	0.010	0.000
3500.0	0.312	39.366	0.775	954.172	0.019	0.001	1.585	0.084	0.015	0.000
4000.0	0.310	38.833	0.878	953.862	0.023	0.001	1.777	0.106	0.021	0.001
4500.0	0.308	38.307	0.980	953.553	0.027	0.001	1.961	0.129	0.029	0.001
5000.0	0.306	37.789	1.080	953.243	0.031	0.002	2.136	0.154	0.038	0.001
5500.0	0.304	37.277	1.178	952.934	0.036	0.002	2.304	0.180	0.048	0.002
6000.0	0.302	36.771	1.274	952.624	0.040	0.002	2.464	0.207	0.059	0.002
6500.0	0.300	36.272	1.370	952.315	0.045	0.003	2.617	0.235	0.071	0.003
7000.0	0.298	35.779	1.463	952.006	0.050	0.003	2.763	0.264	0.084	0.004
7500.0	0.296	35.292	1.555	951.697	0.055	0.004	2.902	0.293	0.098	0.005
8000.0	0.294	34.810	1.646	951.388	0.060	0.004	3.036	0.324	0.112	0.006
8500.0	0.292	34.334	1.735	951.079	0.065	0.005	3.163	0.354	0.128	0.007
9000.0	0.291	33.863	1.823	950.771	0.071	0.006	3.284	0.386	0.144	0.009
9500.0	0.289	33.398	1.910	950.463	0.076	0.007	3.400	0.418	0.161	0.011
10000.0	0.287	32.938	1.996	950.155	0.082	0.007	3.510	0.450	0.178	0.012
10500.0	0.285	32.483	2.080	949.847	0.088	0.008	3.615	0.482	0.196	0.015
11000.0	0.283	32.032	2.163	949.539	0.094	0.009	3.715	0.515	0.215	0.017
11500.0	0.281	31.586	2.244	949.232	0.100	0.010	3.810	0.549	0.234	0.019
12000.0	0.280	31.145	2.325	948.925	0.106	0.011	3.901	0.582	0.253	0.022
12500.0	0.278	30.709	2.404	948.618	0.112	0.013	3.988	0.616	0.272	0.025
13000.0	0.276	30.276	2.482	948.311	0.119	0.014	4.070	0.650	0.292	0.028
13500.0	0.274	29.848	2.560	948.004	0.125	0.015	4.148	0.684	0.312	0.031
14000.0	0.272	29.424	2.636	947.697	0.131	0.016	4.222	0.718	0.332	0.034
14500.0	0.271	29.004	2.711	947.391	0.138	0.018	4.292	0.753	0.353	0.038
15000.0	0.269	28.589	2.785	947.084	0.145	0.019	4.359	0.787	0.373	0.042
15500.0	0.267	28.177	2.858	946.778	0.151	0.021	4.423	0.822	0.393	0.046
16000.0	0.265	27.768	2.930	946.471	0.158	0.022	4.483	0.857	0.414	0.050
16500.0	0.264	27.364	3.001	946.165	0.165	0.024	4.540	0.891	0.435	0.055
17000.0	0.262	26.963	3.071	945.858	0.171	0.026	4.594	0.926	0.455	0.059
17500.0	0.260	26.566	3.141	945.550	0.178	0.028	4.646	0.960	0.476	0.064
18000.0	0.259	26.173	3.209	945.242	0.185	0.029	4.695	0.995	0.497	0.069
18500.0	0.257	25.783	3.276	944.934	0.192	0.031	4.742	1.029	0.517	0.075
19000.0	0.255	25.397	3.343	944.624	0.199	0.033	4.786	1.064	0.538	0.080
19500.0	0.254	25.014	3.409	944.314	0.206	0.036	4.828	1.098	0.559	0.086
20000.0	0.252	24.636	3.473	944.003	0.214	0.038	4.869	1.132	0.579	0.092
20500.0	0.250	24.260	3.537	943.690	0.221	0.040	4.907	1.166	0.600	0.098
21000.0	0.249	23.889	3.600	943.377	0.228	0.042	4.944	1.200	0.621	0.104
21500.0	0.247	23.521	3.662	943.062	0.235	0.045	4.978	1.233	0.641	0.111
22000.0	0.245	23.156	3.724	942.746	0.243	0.047	5.012	1.267	0.662	0.118
22500.0	0.244	22.795	3.784	942.429	0.250	0.050	5.043	1.300	0.682	0.125
25000.0	0.236	21.044	4.073	940.822	0.288	0.064	5.181	1.463	0.783	0.163
27500.0	0.228	19.379	4.341	939.180	0.328	0.080	5.285	1.621	0.881	0.207
30000.0	0.220	17.801	4.588	937.503	0.368	0.099	5.361	1.772	0.973	0.256
32500.0	0.212	16.306	4.815	935.789	0.408	0.120	5.412	1.918	1.060	0.310
35000.0	0.204	14.895	5.023	934.038	0.448	0.143	5.443	2.056	1.141	0.368
37500.0	0.197	13.564	5.211	932.248	0.488	0.168	5.455	2.187	1.214	0.431
40000.0	0.189	12.313	5.381	930.419	0.528	0.194	5.452	2.310	1.281	0.498
42500.0	0.182	11.142	5.532	928.550	0.567	0.223	5.436	2.426	1.341	0.569
45000.0	0.175	10.047	5.666	926.640	0.604	0.253	5.410	2.533	1.394	0.644
47500.0	0.168	9.028	5.782	924.689	0.641	0.284	5.376	2.633	1.441	0.721
50000.0	0.162	8.083	5.881	922.696	0.677	0.317	5.335	2.724	1.481	0.802
52500.0	0.155	7.211	5.963	920.662	0.711	0.350	5.289	2.807	1.516	0.885
55000.0	0.149	6.409	6.030	918.586	0.743	0.384	5.240	2.882	1.545	0.969
57500.0	0.143	5.676	6.081	916.469	0.773	0.417	5.188	2.949	1.568	1.056
60000.0	0.137	5.008	6.118	914.313	0.802	0.451	5.136	3.008	1.587	1.144
62500.0	0.131	4.402	6.141	912.117	0.829	0.484	5.084	3.060	1.602	1.233
65000.0	0.126	3.857	6.151	909.883	0.853	0.516	5.033	3.106	1.614	1.322
67500.0	0.120	3.367	6.149	907.614	0.876	0.547	4.983	3.145	1.622	1.412
70000.0	0.115	2.930	6.136	905.310	0.896	0.578	4.935	3.178	1.627	1.502

Table C.27 [ ] Exposure-Dependent 80% Void Isotopics (kg/MTU Initial)

Exposure MWd/MTU	U-234	U-235	U-236	U-238	NP-237	PU-238	PU-239	PU-240	PU-241	PU-242
0.0	0.327	43.333	0.000	956.340	0.000	0.000	0.000	0.000	0.000	0.000
100.0	0.326	43.214	0.025	956.269	0.000	0.000	0.025	0.000	0.000	0.000
500.0	0.324	42.743	0.123	955.983	0.002	0.000	0.251	0.002	0.000	0.000
1000.0	0.322	42.164	0.243	955.625	0.005	0.000	0.543	0.009	0.001	0.000
1500.0	0.319	41.595	0.360	955.267	0.008	0.000	0.821	0.019	0.002	0.000
2000.0	0.317	41.038	0.476	954.910	0.012	0.000	1.086	0.034	0.004	0.000
2500.0	0.315	40.490	0.589	954.552	0.015	0.000	1.339	0.051	0.008	0.000
3000.0	0.312	39.951	0.699	954.195	0.019	0.001	1.581	0.070	0.013	0.000
3500.0	0.310	39.420	0.808	953.838	0.024	0.001	1.813	0.092	0.020	0.000
4000.0	0.308	38.898	0.915	953.481	0.028	0.001	2.034	0.115	0.028	0.001
4500.0	0.305	38.384	1.019	953.125	0.033	0.002	2.246	0.140	0.037	0.001
5000.0	0.303	37.878	1.122	952.768	0.038	0.002	2.449	0.166	0.048	0.002
5500.0	0.301	37.379	1.223	952.412	0.044	0.003	2.644	0.194	0.060	0.002
6000.0	0.299	36.886	1.323	952.056	0.049	0.003	2.830	0.222	0.073	0.003
6500.0	0.296	36.401	1.420	951.700	0.055	0.004	3.009	0.252	0.087	0.004
7000.0	0.294	35.922	1.516	951.344	0.061	0.005	3.181	0.282	0.103	0.005
7500.0	0.292	35.450	1.610	950.988	0.067	0.005	3.345	0.313	0.119	0.006
8000.0	0.290	34.983	1.703	950.633	0.073	0.006	3.503	0.345	0.136	0.007
8500.0	0.288	34.522	1.794	950.278	0.080	0.007	3.654	0.377	0.154	0.009
9000.0	0.286	34.068	1.884	949.923	0.086	0.008	3.799	0.410	0.173	0.010
9500.0	0.283	33.618	1.972	949.569	0.093	0.009	3.938	0.444	0.192	0.012
10000.0	0.281	33.174	2.059	949.214	0.100	0.011	4.072	0.478	0.212	0.014
10500.0	0.279	32.736	2.145	948.861	0.107	0.012	4.200	0.512	0.233	0.017
11000.0	0.277	32.302	2.229	948.507	0.114	0.013	4.322	0.547	0.254	0.019
11500.0	0.275	31.874	2.312	948.153	0.121	0.015	4.440	0.582	0.275	0.022
12000.0	0.273	31.450	2.394	947.800	0.129	0.016	4.552	0.618	0.297	0.024
12500.0	0.271	31.031	2.474	947.447	0.136	0.018	4.660	0.653	0.319	0.027
13000.0	0.269	30.617	2.553	947.094	0.144	0.019	4.764	0.689	0.341	0.031
13500.0	0.267	30.207	2.631	946.740	0.151	0.021	4.863	0.726	0.363	0.034
14000.0	0.265	29.802	2.708	946.388	0.159	0.023	4.959	0.762	0.386	0.038
14500.0	0.263	29.401	2.783	946.035	0.166	0.025	5.050	0.799	0.409	0.041
15000.0	0.261	29.004	2.858	945.682	0.174	0.027	5.137	0.836	0.432	0.045
15500.0	0.260	28.611	2.931	945.329	0.182	0.029	5.221	0.873	0.455	0.050
16000.0	0.258	28.223	3.004	944.976	0.190	0.031	5.301	0.910	0.478	0.054
16500.0	0.256	27.838	3.075	944.623	0.198	0.033	5.378	0.947	0.501	0.059
17000.0	0.254	27.458	3.145	944.270	0.206	0.036	5.452	0.984	0.524	0.063
17500.0	0.252	27.081	3.214	943.917	0.214	0.038	5.523	1.021	0.547	0.068
18000.0	0.250	26.708	3.282	943.563	0.222	0.041	5.591	1.059	0.571	0.074
18500.0	0.248	26.339	3.349	943.209	0.230	0.044	5.656	1.096	0.594	0.079
19000.0	0.247	25.973	3.415	942.854	0.239	0.046	5.718	1.133	0.617	0.084
19500.0	0.245	25.611	3.481	942.498	0.247	0.049	5.778	1.170	0.640	0.090
20000.0	0.243	25.253	3.545	942.142	0.255	0.052	5.836	1.207	0.663	0.096
20500.0	0.241	24.899	3.608	941.786	0.264	0.055	5.892	1.244	0.686	0.102
21000.0	0.239	24.548	3.670	941.428	0.272	0.058	5.945	1.281	0.709	0.109
21500.0	0.238	24.200	3.732	941.070	0.280	0.062	5.997	1.318	0.732	0.115
22000.0	0.236	23.856	3.793	940.710	0.289	0.065	6.047	1.354	0.755	0.122
22500.0	0.234	23.516	3.852	940.350	0.297	0.068	6.094	1.391	0.777	0.129
23000.0	0.232	23.179	3.911	939.988	0.306	0.072	6.141	1.427	0.800	0.136
23500.0	0.231	22.846	3.969	939.625	0.314	0.075	6.185	1.464	0.823	0.143
24000.0	0.229	22.516	4.026	939.262	0.323	0.079	6.228	1.500	0.845	0.150
24500.0	0.227	22.190	4.082	938.896	0.331	0.083	6.269	1.536	0.868	0.158
25000.0	0.226	21.867	4.137	938.530	0.340	0.087	6.309	1.571	0.890	0.166
25500.0	0.224	21.547	4.192	938.163	0.348	0.091	6.348	1.607	0.912	0.174
27500.0	0.217	20.303	4.401	936.680	0.383	0.108	6.488	1.747	1.000	0.207
30000.0	0.209	18.823	4.644	934.798	0.426	0.132	6.637	1.917	1.107	0.253
32500.0	0.201	17.423	4.867	932.884	0.470	0.159	6.758	2.082	1.209	0.302
35000.0	0.194	16.101	5.070	930.938	0.513	0.188	6.856	2.240	1.306	0.356
37500.0	0.186	14.854	5.254	928.960	0.556	0.219	6.933	2.393	1.397	0.412
40000.0	0.179	13.682	5.420	926.950	0.598	0.252	6.992	2.538	1.482	0.472
42500.0	0.172	12.580	5.568	924.908	0.639	0.288	7.035	2.677	1.562	0.535
45000.0	0.165	11.548	5.698	922.834	0.679	0.325	7.065	2.809	1.636	0.600
47500.0	0.159	10.582	5.813	920.730	0.717	0.364	7.083	2.934	1.704	0.668
50000.0	0.152	9.681	5.911	918.595	0.755	0.404	7.091	3.051	1.766	0.738
52500.0	0.146	8.841	5.994	916.430	0.791	0.445	7.091	3.162	1.823	0.810
55000.0	0.141	8.061	6.063	914.236	0.825	0.487	7.084	3.265	1.876	0.884
57500.0	0.135	7.338	6.118	912.013	0.857	0.530	7.071	3.362	1.923	0.959
60000.0	0.130	6.669	6.160	909.764	0.887	0.573	7.054	3.451	1.965	1.036
62500.0	0.125	6.052	6.190	907.488	0.916	0.616	7.033	3.534	2.003	1.114
65000.0	0.120	5.484	6.209	905.187	0.942	0.659	7.010	3.611	2.038	1.194
67500.0	0.116	4.962	6.217	902.862	0.967	0.701	6.984	3.681	2.068	1.274
70000.0	0.111	4.484	6.214	900.515	0.989	0.742	6.957	3.745	2.095	1.355

Table C.28 [ ] Exposure-Dependent 0% Void Isotopics (kg/MTU Initial)

Exposure MWd/MTU	U-234	U-235	U-236	U-238	NP-237	PU-238	PU-239	PU-240	PU-241	PU-242
0.0	0.332	43.981	0.000	955.687	0.000	0.000	0.000	0.000	0.000	0.000
100.0	0.332	43.861	0.022	955.636	0.000	0.000	0.016	0.000	0.000	0.000
500.0	0.330	43.383	0.111	955.433	0.002	0.000	0.177	0.001	0.000	0.000
1000.0	0.328	42.793	0.221	955.178	0.003	0.000	0.390	0.006	0.000	0.000
1500.0	0.327	42.210	0.329	954.923	0.005	0.000	0.593	0.014	0.001	0.000
2000.0	0.325	41.635	0.435	954.668	0.007	0.000	0.786	0.024	0.002	0.000
2500.0	0.323	41.067	0.540	954.413	0.010	0.000	0.971	0.037	0.004	0.000
3000.0	0.321	40.506	0.643	954.158	0.012	0.000	1.148	0.052	0.007	0.000
3500.0	0.319	39.952	0.745	953.903	0.015	0.000	1.316	0.069	0.010	0.000
4000.0	0.318	39.404	0.845	953.648	0.018	0.001	1.476	0.088	0.014	0.000
4500.0	0.316	38.863	0.944	953.393	0.021	0.001	1.629	0.108	0.020	0.001
5000.0	0.314	38.327	1.041	953.138	0.024	0.001	1.775	0.130	0.026	0.001
5500.0	0.312	37.797	1.137	952.884	0.028	0.001	1.915	0.153	0.033	0.001
6000.0	0.311	37.273	1.232	952.629	0.031	0.002	2.047	0.176	0.041	0.002
6500.0	0.309	36.754	1.326	952.375	0.035	0.002	2.174	0.201	0.049	0.002
7000.0	0.307	36.240	1.418	952.121	0.039	0.002	2.294	0.227	0.059	0.003
7500.0	0.306	35.731	1.509	951.867	0.043	0.003	2.409	0.253	0.069	0.003
8000.0	0.304	35.228	1.599	951.613	0.047	0.003	2.518	0.280	0.080	0.004
8500.0	0.302	34.729	1.687	951.360	0.051	0.003	2.621	0.308	0.092	0.005
9000.0	0.301	34.235	1.775	951.107	0.055	0.004	2.719	0.336	0.104	0.006
9500.0	0.299	33.745	1.862	950.854	0.059	0.004	2.812	0.365	0.117	0.008
10000.0	0.297	33.260	1.947	950.602	0.064	0.005	2.900	0.394	0.130	0.009
10500.0	0.296	32.779	2.031	950.350	0.068	0.006	2.984	0.424	0.144	0.011
11000.0	0.294	32.302	2.114	950.098	0.073	0.006	3.063	0.454	0.158	0.012
11500.0	0.293	31.830	2.197	949.846	0.077	0.007	3.138	0.484	0.173	0.014
12000.0	0.291	31.361	2.278	949.595	0.082	0.008	3.208	0.515	0.187	0.016
12500.0	0.289	30.896	2.358	949.344	0.087	0.008	3.275	0.546	0.203	0.018
13000.0	0.288	30.436	2.437	949.093	0.092	0.009	3.338	0.577	0.218	0.021
13500.0	0.286	29.978	2.515	948.843	0.097	0.010	3.396	0.608	0.234	0.023
14000.0	0.285	29.524	2.593	948.593	0.102	0.011	3.452	0.639	0.249	0.026
14500.0	0.283	29.074	2.669	948.343	0.107	0.012	3.504	0.671	0.265	0.029
15000.0	0.282	28.628	2.745	948.093	0.112	0.013	3.553	0.703	0.281	0.032
15500.0	0.280	28.184	2.820	947.843	0.117	0.014	3.599	0.734	0.297	0.035
16000.0	0.278	27.744	2.893	947.593	0.123	0.015	3.642	0.766	0.314	0.039
16500.0	0.277	27.308	2.966	947.342	0.128	0.016	3.683	0.798	0.330	0.043
17000.0	0.275	26.875	3.039	947.091	0.133	0.017	3.721	0.830	0.346	0.046
17500.0	0.274	26.445	3.110	946.839	0.139	0.018	3.757	0.861	0.363	0.051
18000.0	0.272	26.019	3.181	946.585	0.144	0.019	3.791	0.893	0.380	0.055
18500.0	0.271	25.596	3.250	946.331	0.150	0.021	3.823	0.925	0.396	0.059
19000.0	0.269	25.177	3.319	946.076	0.156	0.022	3.854	0.956	0.413	0.064
19500.0	0.268	24.761	3.387	945.819	0.161	0.023	3.882	0.988	0.430	0.069
20000.0	0.266	24.349	3.455	945.561	0.167	0.025	3.909	1.019	0.447	0.074
20500.0	0.265	23.940	3.521	945.302	0.173	0.026	3.935	1.050	0.463	0.079
22500.0	0.259	22.340	3.780	944.250	0.197	0.033	4.021	1.174	0.530	0.103
25000.0	0.251	20.417	4.085	942.902	0.229	0.043	4.100	1.324	0.613	0.138
27500.0	0.243	18.583	4.370	941.515	0.261	0.054	4.149	1.470	0.692	0.178
30000.0	0.236	16.835	4.635	940.087	0.295	0.067	4.172	1.611	0.766	0.225
32500.0	0.228	15.176	4.881	938.614	0.329	0.082	4.174	1.745	0.834	0.277
35000.0	0.220	13.606	5.106	937.095	0.364	0.098	4.158	1.872	0.896	0.336
37500.0	0.213	12.126	5.312	935.525	0.399	0.116	4.127	1.992	0.950	0.400
40000.0	0.205	10.738	5.497	933.902	0.434	0.136	4.085	2.104	0.998	0.470
42500.0	0.197	9.444	5.662	932.222	0.469	0.157	4.033	2.207	1.039	0.546
45000.0	0.190	8.244	5.807	930.482	0.503	0.179	3.974	2.301	1.072	0.626
47500.0	0.182	7.140	5.931	928.680	0.536	0.203	3.911	2.386	1.099	0.712
50000.0	0.174	6.133	6.035	926.813	0.568	0.227	3.846	2.461	1.120	0.802
52500.0	0.167	5.223	6.119	924.878	0.599	0.251	3.780	2.527	1.136	0.896
55000.0	0.159	4.408	6.183	922.876	0.628	0.276	3.716	2.584	1.146	0.994
57500.0	0.152	3.687	6.227	920.806	0.656	0.300	3.654	2.631	1.152	1.095
60000.0	0.145	3.057	6.254	918.669	0.681	0.324	3.595	2.670	1.154	1.198
62500.0	0.138	2.513	6.263	916.467	0.704	0.346	3.541	2.701	1.154	1.302
65000.0	0.131	2.048	6.257	914.205	0.725	0.368	3.492	2.725	1.151	1.407
67500.0	0.124	1.657	6.236	911.886	0.743	0.388	3.448	2.742	1.147	1.513
70000.0	0.117	1.332	6.203	909.516	0.759	0.406	3.409	2.755	1.141	1.618

Table C.29 [ ] Exposure-Dependent 40% Void Isotopics (kg/MTU Initial)

Exposure MWd/MTU	U-234	U-235	U-236	U-238	NP-237	PU-238	PU-239	PU-240	PU-241	PU-242
0.0	0.332	43.981	0.000	955.687	0.000	0.000	0.000	0.000	0.000	0.000
100.0	0.332	43.862	0.023	955.629	0.000	0.000	0.019	0.000	0.000	0.000
500.0	0.330	43.385	0.116	955.396	0.002	0.000	0.202	0.001	0.000	0.000
1000.0	0.328	42.798	0.230	955.104	0.004	0.000	0.443	0.007	0.000	0.000
1500.0	0.326	42.219	0.341	954.813	0.006	0.000	0.673	0.016	0.001	0.000
2000.0	0.324	41.649	0.451	954.521	0.009	0.000	0.893	0.028	0.003	0.000
2500.0	0.322	41.088	0.559	954.230	0.012	0.000	1.102	0.042	0.005	0.000
3000.0	0.320	40.534	0.665	953.939	0.015	0.000	1.302	0.059	0.009	0.000
3500.0	0.318	39.988	0.770	953.649	0.018	0.001	1.493	0.078	0.013	0.000
4000.0	0.316	39.448	0.872	953.358	0.022	0.001	1.675	0.098	0.019	0.000
4500.0	0.314	38.916	0.974	953.068	0.025	0.001	1.848	0.120	0.025	0.001
5000.0	0.312	38.390	1.073	952.778	0.029	0.001	2.014	0.144	0.033	0.001
5500.0	0.310	37.870	1.171	952.488	0.033	0.002	2.172	0.168	0.042	0.001
6000.0	0.308	37.357	1.268	952.199	0.037	0.002	2.323	0.194	0.052	0.002
6500.0	0.306	36.850	1.363	951.910	0.042	0.002	2.466	0.221	0.063	0.003
7000.0	0.304	36.348	1.457	951.621	0.046	0.003	2.603	0.248	0.074	0.003
7500.0	0.303	35.852	1.549	951.333	0.051	0.003	2.734	0.276	0.087	0.004
8000.0	0.301	35.361	1.640	951.045	0.056	0.004	2.858	0.305	0.100	0.005
8500.0	0.299	34.876	1.730	950.757	0.061	0.005	2.977	0.335	0.114	0.006
9000.0	0.297	34.395	1.818	950.470	0.066	0.005	3.089	0.365	0.129	0.008
9500.0	0.295	33.920	1.905	950.183	0.071	0.006	3.196	0.395	0.145	0.009
10000.0	0.293	33.449	1.991	949.897	0.076	0.007	3.298	0.427	0.160	0.011
10500.0	0.292	32.983	2.076	949.611	0.081	0.007	3.395	0.458	0.177	0.013
11000.0	0.290	32.522	2.159	949.326	0.087	0.008	3.487	0.490	0.194	0.015
11500.0	0.288	32.065	2.241	949.041	0.093	0.009	3.574	0.522	0.211	0.017
12000.0	0.286	31.612	2.323	948.756	0.098	0.010	3.656	0.554	0.229	0.019
12500.0	0.285	31.163	2.403	948.472	0.104	0.011	3.734	0.587	0.246	0.022
13000.0	0.283	30.719	2.482	948.188	0.110	0.012	3.808	0.620	0.265	0.025
13500.0	0.281	30.279	2.560	947.904	0.116	0.013	3.879	0.653	0.283	0.027
14000.0	0.279	29.842	2.637	947.621	0.122	0.014	3.945	0.686	0.301	0.031
14500.0	0.278	29.409	2.713	947.338	0.128	0.016	4.007	0.719	0.320	0.034
15000.0	0.276	28.980	2.788	947.055	0.134	0.017	4.066	0.753	0.339	0.037
15500.0	0.274	28.555	2.862	946.772	0.140	0.018	4.122	0.786	0.358	0.041
16000.0	0.273	28.133	2.935	946.490	0.146	0.020	4.175	0.819	0.376	0.045
16500.0	0.271	27.715	3.008	946.207	0.152	0.021	4.225	0.853	0.395	0.049
17000.0	0.269	27.300	3.079	945.923	0.159	0.022	4.272	0.886	0.414	0.053
17500.0	0.268	26.889	3.150	945.639	0.165	0.024	4.317	0.920	0.433	0.058
18000.0	0.266	26.481	3.219	945.355	0.171	0.026	4.359	0.953	0.453	0.063
18500.0	0.265	26.077	3.288	945.069	0.178	0.027	4.399	0.987	0.472	0.068
19000.0	0.263	25.677	3.356	944.783	0.184	0.029	4.437	1.020	0.491	0.073
19500.0	0.261	25.280	3.423	944.495	0.191	0.031	4.474	1.053	0.510	0.078
20000.0	0.260	24.886	3.489	944.207	0.198	0.033	4.508	1.086	0.529	0.084
20500.0	0.258	24.496	3.555	943.917	0.204	0.035	4.540	1.119	0.548	0.089
21000.0	0.256	24.109	3.619	943.626	0.211	0.037	4.571	1.151	0.567	0.095
21500.0	0.255	23.727	3.683	943.334	0.218	0.039	4.601	1.184	0.587	0.102
22500.0	0.252	22.971	3.808	942.746	0.232	0.043	4.655	1.249	0.625	0.115
25000.0	0.244	21.144	4.105	941.250	0.268	0.056	4.766	1.407	0.719	0.151
27500.0	0.236	19.403	4.382	939.719	0.304	0.070	4.846	1.560	0.809	0.193
30000.0	0.228	17.748	4.639	938.150	0.342	0.086	4.898	1.707	0.895	0.240
32500.0	0.220	16.178	4.876	936.543	0.381	0.104	4.927	1.849	0.975	0.293
35000.0	0.212	14.693	5.093	934.896	0.419	0.124	4.935	1.983	1.048	0.351
37500.0	0.205	13.291	5.290	933.207	0.457	0.146	4.927	2.110	1.114	0.414
40000.0	0.197	11.973	5.469	931.474	0.495	0.170	4.904	2.229	1.174	0.482
42500.0	0.190	10.738	5.628	929.696	0.533	0.196	4.870	2.341	1.226	0.553
45000.0	0.182	9.586	5.769	927.872	0.569	0.222	4.826	2.443	1.272	0.629
47500.0	0.175	8.516	5.891	926.000	0.605	0.250	4.776	2.537	1.310	0.709
50000.0	0.168	7.527	5.996	924.079	0.639	0.279	4.720	2.623	1.343	0.793
52500.0	0.161	6.619	6.082	922.108	0.672	0.309	4.661	2.699	1.369	0.879
55000.0	0.154	5.790	6.151	920.087	0.703	0.339	4.600	2.767	1.390	0.968
57500.0	0.148	5.037	6.204	918.017	0.733	0.368	4.538	2.827	1.405	1.059
60000.0	0.141	4.359	6.240	915.897	0.760	0.398	4.477	2.879	1.417	1.152
62500.0	0.135	3.752	6.261	913.729	0.786	0.427	4.419	2.923	1.424	1.246
65000.0	0.129	3.214	6.268	911.515	0.809	0.455	4.362	2.959	1.428	1.341
67500.0	0.123	2.738	6.262	909.256	0.830	0.481	4.309	2.989	1.429	1.436
70000.0	0.117	2.323	6.244	906.955	0.849	0.507	4.259	3.013	1.428	1.531

Table C.30 [ ] Exposure-Dependent 80% Void Isotopics (kg/MTU Initial)

Exposure MWd/MTU	U-234	U-235	U-236	U-238	NP-237	PU-238	PU-239	PU-240	PU-241	PU-242
0.0	0.332	43.981	0.000	955.687	0.000	0.000	0.000	0.000	0.000	0.000
100.0	0.331	43.862	0.024	955.619	0.000	0.000	0.022	0.000	0.000	0.000
500.0	0.330	43.389	0.122	955.347	0.002	0.000	0.233	0.002	0.000	0.000
1000.0	0.327	42.807	0.241	955.007	0.005	0.000	0.511	0.008	0.000	0.000
1500.0	0.325	42.235	0.358	954.667	0.008	0.000	0.777	0.018	0.002	0.000
2000.0	0.322	41.673	0.473	954.328	0.011	0.000	1.030	0.031	0.004	0.000
2500.0	0.320	41.119	0.585	953.989	0.015	0.000	1.272	0.047	0.007	0.000
3000.0	0.318	40.575	0.696	953.650	0.018	0.001	1.503	0.066	0.012	0.000
3500.0	0.316	40.039	0.804	953.312	0.022	0.001	1.723	0.086	0.018	0.000
4000.0	0.313	39.511	0.911	952.974	0.027	0.001	1.934	0.109	0.025	0.001
4500.0	0.311	38.990	1.015	952.637	0.031	0.002	2.136	0.132	0.033	0.001
5000.0	0.309	38.476	1.118	952.300	0.036	0.002	2.329	0.157	0.043	0.001
5500.0	0.307	37.970	1.219	951.963	0.041	0.002	2.514	0.184	0.054	0.002
6000.0	0.304	37.470	1.319	951.627	0.046	0.003	2.690	0.211	0.067	0.002
6500.0	0.302	36.976	1.417	951.291	0.052	0.004	2.859	0.239	0.080	0.003
7000.0	0.300	36.489	1.513	950.956	0.057	0.004	3.021	0.268	0.094	0.004
7500.0	0.298	36.008	1.607	950.621	0.063	0.005	3.176	0.298	0.110	0.005
8000.0	0.296	35.533	1.700	950.286	0.069	0.006	3.324	0.329	0.126	0.006
8500.0	0.294	35.063	1.792	949.952	0.075	0.006	3.465	0.360	0.142	0.008
9000.0	0.292	34.599	1.882	949.619	0.082	0.007	3.600	0.392	0.160	0.009
9500.0	0.290	34.140	1.971	949.286	0.088	0.008	3.729	0.425	0.178	0.011
10000.0	0.288	33.686	2.058	948.954	0.094	0.009	3.853	0.458	0.197	0.013
10500.0	0.286	33.238	2.144	948.622	0.101	0.011	3.971	0.491	0.216	0.015
11000.0	0.284	32.794	2.229	948.291	0.108	0.012	4.084	0.525	0.236	0.017
11500.0	0.282	32.355	2.313	947.960	0.114	0.013	4.191	0.559	0.256	0.020
12000.0	0.280	31.921	2.395	947.629	0.121	0.014	4.294	0.593	0.276	0.022
12500.0	0.278	31.491	2.476	947.299	0.128	0.016	4.393	0.628	0.297	0.025
13000.0	0.276	31.066	2.556	946.969	0.135	0.017	4.486	0.663	0.318	0.028
13500.0	0.274	30.645	2.634	946.639	0.142	0.019	4.576	0.698	0.339	0.031
14000.0	0.272	30.228	2.712	946.310	0.149	0.021	4.661	0.734	0.361	0.035
14500.0	0.270	29.816	2.788	945.980	0.157	0.022	4.743	0.769	0.382	0.038
15000.0	0.268	29.407	2.864	945.651	0.164	0.024	4.820	0.805	0.404	0.042
15500.0	0.267	29.002	2.938	945.322	0.171	0.026	4.894	0.841	0.425	0.046
16000.0	0.265	28.602	3.011	944.994	0.179	0.028	4.965	0.877	0.447	0.050
16500.0	0.263	28.205	3.084	944.665	0.186	0.030	5.032	0.913	0.469	0.054
17000.0	0.261	27.812	3.155	944.336	0.194	0.032	5.096	0.949	0.491	0.059
17500.0	0.259	27.422	3.225	944.007	0.202	0.034	5.157	0.985	0.513	0.064
18000.0	0.257	27.036	3.294	943.678	0.209	0.036	5.216	1.021	0.535	0.069
18500.0	0.256	26.654	3.362	943.348	0.217	0.039	5.272	1.058	0.556	0.074
19000.0	0.254	26.276	3.430	943.017	0.225	0.041	5.325	1.094	0.578	0.079
19500.0	0.252	25.901	3.496	942.686	0.233	0.044	5.377	1.130	0.600	0.084
20000.0	0.250	25.529	3.562	942.354	0.240	0.046	5.426	1.166	0.622	0.090
20500.0	0.249	25.161	3.626	942.022	0.248	0.049	5.473	1.201	0.644	0.096
21000.0	0.247	24.797	3.690	941.688	0.256	0.052	5.518	1.237	0.665	0.102
21500.0	0.245	24.436	3.753	941.353	0.264	0.055	5.561	1.273	0.687	0.108
22000.0	0.243	24.079	3.815	941.018	0.272	0.058	5.602	1.308	0.709	0.115
22500.0	0.242	23.725	3.876	940.681	0.280	0.061	5.642	1.344	0.730	0.122
23000.0	0.240	23.375	3.936	940.343	0.288	0.064	5.680	1.379	0.752	0.128
23500.0	0.238	23.028	3.995	940.004	0.296	0.067	5.716	1.414	0.773	0.135
24000.0	0.237	22.685	4.054	939.663	0.305	0.070	5.751	1.449	0.794	0.143
25000.0	0.233	22.008	4.168	938.978	0.321	0.077	5.817	1.518	0.837	0.158
27500.0	0.225	20.377	4.439	937.243	0.362	0.096	5.959	1.688	0.941	0.198
30000.0	0.217	18.829	4.690	935.475	0.404	0.118	6.071	1.852	1.042	0.244
32500.0	0.209	17.362	4.921	933.674	0.446	0.142	6.157	2.010	1.137	0.293
35000.0	0.201	15.975	5.131	931.838	0.488	0.168	6.220	2.163	1.227	0.347
37500.0	0.193	14.665	5.323	929.969	0.529	0.196	6.262	2.309	1.311	0.405
40000.0	0.186	13.432	5.496	928.064	0.570	0.226	6.288	2.448	1.389	0.466
42500.0	0.179	12.273	5.650	926.125	0.610	0.258	6.299	2.579	1.460	0.530
45000.0	0.172	11.187	5.787	924.151	0.650	0.292	6.297	2.703	1.526	0.598
47500.0	0.165	10.172	5.906	922.141	0.688	0.327	6.285	2.820	1.585	0.668
50000.0	0.158	9.226	6.009	920.096	0.725	0.364	6.264	2.929	1.638	0.741
52500.0	0.152	8.347	6.096	918.016	0.760	0.401	6.236	3.030	1.686	0.817
55000.0	0.146	7.533	6.167	915.902	0.794	0.440	6.203	3.123	1.728	0.894
57500.0	0.140	6.781	6.224	913.755	0.825	0.478	6.165	3.209	1.764	0.974
60000.0	0.134	6.089	6.267	911.574	0.855	0.517	6.124	3.287	1.797	1.055
62500.0	0.129	5.455	6.297	909.361	0.883	0.555	6.081	3.359	1.824	1.137
65000.0	0.124	4.875	6.314	907.118	0.909	0.594	6.037	3.423	1.848	1.221
67500.0	0.119	4.347	6.319	904.846	0.933	0.631	5.993	3.480	1.867	1.306
70000.0	0.114	3.867	6.314	902.545	0.954	0.668	5.949	3.531	1.884	1.391

Table C.31 [ ] Exposure-Dependent 0% Void Isotopics (kg/MTU Initial)

Exposure MWd/MTU	U-234	U-235	U-236	U-238	NP-237	PU-238	PU-239	PU-240	PU-241	PU-242
0.0	0.332	43.981	0.000	955.687	0.000	0.000	0.000	0.000	0.000	0.000
100.0	0.332	43.861	0.022	955.637	0.000	0.000	0.016	0.000	0.000	0.000
500.0	0.330	43.383	0.111	955.436	0.002	0.000	0.175	0.001	0.000	0.000
1000.0	0.328	42.793	0.220	955.185	0.003	0.000	0.384	0.006	0.000	0.000
1500.0	0.327	42.210	0.328	954.934	0.005	0.000	0.584	0.014	0.001	0.000
2000.0	0.325	41.634	0.434	954.683	0.007	0.000	0.775	0.024	0.002	0.000
2500.0	0.323	41.066	0.538	954.431	0.010	0.000	0.957	0.037	0.004	0.000
3000.0	0.321	40.505	0.641	954.180	0.012	0.000	1.131	0.052	0.006	0.000
3500.0	0.320	39.950	0.742	953.928	0.015	0.000	1.297	0.069	0.010	0.000
4000.0	0.318	39.402	0.842	953.676	0.018	0.001	1.455	0.087	0.014	0.000
4500.0	0.316	38.860	0.941	953.425	0.021	0.001	1.606	0.107	0.019	0.001
5000.0	0.314	38.323	1.038	953.173	0.024	0.001	1.750	0.128	0.025	0.001
5500.0	0.313	37.793	1.134	952.922	0.028	0.001	1.887	0.151	0.032	0.001
6000.0	0.311	37.268	1.228	952.671	0.031	0.001	2.018	0.174	0.040	0.002
6500.0	0.309	36.748	1.322	952.419	0.035	0.002	2.143	0.199	0.048	0.002
7000.0	0.308	36.233	1.414	952.168	0.038	0.002	2.262	0.224	0.057	0.003
7500.0	0.306	35.724	1.505	951.917	0.042	0.002	2.375	0.251	0.067	0.003
8000.0	0.304	35.220	1.594	951.666	0.046	0.003	2.483	0.277	0.078	0.004
8500.0	0.303	34.720	1.683	951.415	0.050	0.003	2.585	0.305	0.090	0.005
9000.0	0.301	34.225	1.770	951.165	0.054	0.004	2.682	0.333	0.102	0.006
9500.0	0.299	33.734	1.857	950.915	0.058	0.004	2.774	0.362	0.114	0.008
10000.0	0.298	33.248	1.942	950.665	0.063	0.005	2.861	0.391	0.127	0.009
10500.0	0.296	32.766	2.026	950.415	0.067	0.005	2.944	0.420	0.141	0.010
11000.0	0.294	32.289	2.109	950.165	0.072	0.006	3.022	0.450	0.155	0.012
11500.0	0.293	31.815	2.192	949.916	0.076	0.007	3.096	0.480	0.169	0.014
12000.0	0.291	31.346	2.273	949.667	0.081	0.007	3.166	0.510	0.184	0.016
12500.0	0.290	30.880	2.353	949.417	0.086	0.008	3.232	0.541	0.199	0.018
13000.0	0.288	30.419	2.432	949.168	0.091	0.009	3.294	0.572	0.214	0.021
13500.0	0.287	29.961	2.510	948.919	0.096	0.010	3.353	0.603	0.229	0.023
14000.0	0.285	29.506	2.588	948.670	0.101	0.011	3.408	0.634	0.245	0.026
14500.0	0.283	29.056	2.664	948.422	0.106	0.012	3.460	0.666	0.261	0.029
15000.0	0.282	28.608	2.740	948.173	0.111	0.012	3.508	0.697	0.277	0.032
15500.0	0.280	28.165	2.814	947.924	0.116	0.013	3.554	0.729	0.292	0.035
16000.0	0.279	27.724	2.888	947.675	0.121	0.014	3.596	0.761	0.309	0.039
16500.0	0.277	27.287	2.961	947.426	0.127	0.016	3.636	0.792	0.325	0.042
17000.0	0.276	26.853	3.033	947.177	0.132	0.017	3.674	0.824	0.341	0.046
17500.0	0.274	26.423	3.105	946.927	0.137	0.018	3.709	0.856	0.357	0.050
18000.0	0.273	25.996	3.175	946.677	0.143	0.019	3.742	0.888	0.373	0.055
18500.0	0.271	25.572	3.245	946.425	0.148	0.020	3.772	0.919	0.389	0.059
19000.0	0.270	25.152	3.314	946.173	0.154	0.022	3.801	0.951	0.406	0.064
19500.0	0.268	24.735	3.382	945.920	0.160	0.023	3.828	0.982	0.422	0.069
20000.0	0.267	24.321	3.450	945.665	0.165	0.024	3.854	1.013	0.438	0.074
20500.0	0.265	23.911	3.516	945.410	0.171	0.026	3.877	1.045	0.455	0.079
21000.0	0.264	23.504	3.582	945.153	0.177	0.028	3.900	1.076	0.471	0.085
21500.0	0.262	23.101	3.647	944.894	0.183	0.029	3.920	1.107	0.487	0.091
22500.0	0.259	22.304	3.775	944.373	0.195	0.032	3.958	1.168	0.520	0.103
25000.0	0.251	20.373	4.081	943.044	0.225	0.042	4.029	1.319	0.600	0.137
27500.0	0.244	18.529	4.367	941.674	0.257	0.053	4.072	1.464	0.677	0.178
30000.0	0.236	16.772	4.633	940.263	0.290	0.066	4.091	1.604	0.749	0.224
32500.0	0.229	15.103	4.880	938.806	0.324	0.080	4.089	1.737	0.815	0.277
35000.0	0.221	13.524	5.107	937.301	0.358	0.096	4.070	1.864	0.875	0.335
37500.0	0.213	12.036	5.313	935.745	0.393	0.114	4.036	1.983	0.928	0.399
40000.0	0.206	10.640	5.500	934.135	0.427	0.133	3.991	2.094	0.975	0.470
42500.0	0.198	9.339	5.666	932.466	0.461	0.153	3.938	2.196	1.014	0.545
45000.0	0.190	8.134	5.811	930.736	0.495	0.175	3.878	2.289	1.046	0.626
47500.0	0.182	7.026	5.936	928.941	0.528	0.198	3.814	2.373	1.072	0.712
50000.0	0.175	6.016	6.041	927.080	0.560	0.221	3.748	2.447	1.092	0.803
52500.0	0.167	5.106	6.125	925.149	0.590	0.245	3.682	2.512	1.106	0.898
55000.0	0.160	4.293	6.188	923.148	0.619	0.269	3.617	2.567	1.115	0.997
57500.0	0.152	3.575	6.233	921.077	0.645	0.292	3.556	2.614	1.121	1.098
60000.0	0.145	2.950	6.259	918.938	0.670	0.315	3.498	2.651	1.122	1.202
62500.0	0.138	2.412	6.268	916.732	0.693	0.337	3.445	2.681	1.121	1.308
65000.0	0.131	1.955	6.260	914.463	0.713	0.357	3.397	2.704	1.118	1.414
67500.0	0.124	1.573	6.239	912.137	0.731	0.376	3.354	2.721	1.114	1.520
70000.0	0.117	1.257	6.204	909.759	0.746	0.394	3.317	2.732	1.108	1.626

Table C.32 [ ] Exposure-Dependent 40% Void Isotopics (kg/MTU Initial)

Exposure MWd/MTU	U-234	U-235	U-236	U-238	NP-237	PU-238	PU-239	PU-240	PU-241	PU-242
0.0	0.332	43.981	0.000	955.687	0.000	0.000	0.000	0.000	0.000	0.000
100.0	0.331	43.862	0.023	955.630	0.000	0.000	0.018	0.000	0.000	0.000
500.0	0.330	43.385	0.115	955.399	0.002	0.000	0.199	0.001	0.000	0.000
1000.0	0.328	42.798	0.229	955.111	0.004	0.000	0.438	0.007	0.000	0.000
1500.0	0.326	42.219	0.340	954.822	0.006	0.000	0.666	0.016	0.001	0.000
2000.0	0.324	41.649	0.450	954.534	0.009	0.000	0.883	0.027	0.003	0.000
2500.0	0.322	41.088	0.557	954.246	0.012	0.000	1.090	0.042	0.005	0.000
3000.0	0.320	40.533	0.663	953.958	0.015	0.000	1.287	0.058	0.008	0.000
3500.0	0.318	39.987	0.767	953.670	0.018	0.001	1.476	0.077	0.013	0.000
4000.0	0.316	39.447	0.870	953.383	0.022	0.001	1.656	0.097	0.018	0.000
4500.0	0.314	38.914	0.971	953.095	0.025	0.001	1.828	0.119	0.025	0.001
5000.0	0.312	38.388	1.070	952.808	0.029	0.001	1.991	0.143	0.033	0.001
5500.0	0.310	37.868	1.168	952.521	0.033	0.002	2.148	0.167	0.041	0.001
6000.0	0.308	37.354	1.264	952.234	0.037	0.002	2.297	0.192	0.051	0.002
6500.0	0.306	36.846	1.359	951.948	0.041	0.002	2.439	0.219	0.062	0.003
7000.0	0.305	36.343	1.453	951.662	0.046	0.003	2.575	0.246	0.073	0.003
7500.0	0.303	35.847	1.545	951.376	0.050	0.003	2.704	0.274	0.085	0.004
8000.0	0.301	35.355	1.636	951.090	0.055	0.004	2.827	0.303	0.099	0.005
8500.0	0.299	34.869	1.725	950.805	0.060	0.004	2.945	0.332	0.113	0.006
9000.0	0.297	34.388	1.814	950.520	0.065	0.005	3.056	0.362	0.127	0.008
9500.0	0.295	33.912	1.901	950.236	0.070	0.006	3.162	0.393	0.142	0.009
10000.0	0.294	33.441	1.986	949.952	0.075	0.006	3.263	0.423	0.158	0.011
10500.0	0.292	32.974	2.071	949.668	0.081	0.007	3.359	0.455	0.174	0.013
11000.0	0.290	32.512	2.154	949.384	0.086	0.008	3.450	0.486	0.191	0.015
11500.0	0.288	32.054	2.236	949.101	0.092	0.009	3.536	0.518	0.208	0.017
12000.0	0.287	31.601	2.318	948.818	0.097	0.010	3.618	0.550	0.225	0.019
12500.0	0.285	31.152	2.398	948.535	0.103	0.011	3.696	0.583	0.243	0.022
13000.0	0.283	30.707	2.477	948.253	0.109	0.012	3.769	0.615	0.261	0.024
13500.0	0.281	30.266	2.555	947.971	0.115	0.013	3.839	0.648	0.279	0.027
14000.0	0.280	29.829	2.632	947.688	0.121	0.014	3.905	0.681	0.297	0.031
14500.0	0.278	29.396	2.708	947.406	0.127	0.015	3.967	0.715	0.316	0.034
15000.0	0.276	28.966	2.783	947.124	0.133	0.017	4.026	0.748	0.335	0.037
15500.0	0.275	28.541	2.857	946.842	0.139	0.018	4.082	0.781	0.353	0.041
16000.0	0.273	28.119	2.930	946.560	0.145	0.019	4.134	0.814	0.372	0.045
16500.0	0.271	27.700	3.002	946.278	0.151	0.021	4.183	0.848	0.391	0.049
17000.0	0.270	27.285	3.074	945.996	0.158	0.022	4.230	0.881	0.410	0.053
17500.0	0.268	26.874	3.144	945.714	0.164	0.024	4.273	0.915	0.429	0.058
18000.0	0.266	26.466	3.214	945.431	0.170	0.025	4.315	0.948	0.447	0.063
18500.0	0.265	26.061	3.283	945.148	0.177	0.027	4.354	0.981	0.466	0.068
19000.0	0.263	25.660	3.350	944.864	0.183	0.029	4.390	1.015	0.485	0.073
19500.0	0.262	25.262	3.417	944.580	0.190	0.031	4.425	1.048	0.504	0.078
20000.0	0.260	24.868	3.484	944.295	0.196	0.032	4.457	1.081	0.523	0.084
20500.0	0.258	24.477	3.549	944.008	0.203	0.034	4.488	1.114	0.541	0.090
21000.0	0.257	24.090	3.614	943.721	0.209	0.036	4.517	1.146	0.560	0.095
21500.0	0.255	23.705	3.677	943.432	0.216	0.038	4.545	1.179	0.579	0.102
22000.0	0.254	23.325	3.740	943.142	0.223	0.040	4.570	1.211	0.597	0.108
22500.0	0.252	22.948	3.802	942.851	0.230	0.043	4.595	1.244	0.616	0.115
23000.0	0.250	22.574	3.863	942.558	0.237	0.045	4.618	1.276	0.634	0.122
25000.0	0.244	21.114	4.100	941.374	0.265	0.055	4.697	1.402	0.707	0.151
27500.0	0.236	19.366	4.378	939.861	0.301	0.069	4.769	1.554	0.796	0.193
30000.0	0.228	17.703	4.635	938.310	0.339	0.085	4.814	1.701	0.880	0.241
32500.0	0.221	16.125	4.873	936.720	0.376	0.102	4.837	1.841	0.958	0.293
35000.0	0.213	14.632	5.091	935.089	0.414	0.122	4.840	1.974	1.029	0.351
37500.0	0.205	13.222	5.289	933.415	0.452	0.144	4.827	2.100	1.094	0.414
40000.0	0.198	11.897	5.469	931.697	0.490	0.167	4.800	2.218	1.151	0.482
42500.0	0.190	10.655	5.629	929.933	0.526	0.192	4.762	2.328	1.202	0.554
45000.0	0.183	9.496	5.771	928.121	0.563	0.218	4.716	2.429	1.246	0.631
47500.0	0.176	8.421	5.894	926.261	0.598	0.245	4.662	2.522	1.283	0.711
50000.0	0.169	7.428	5.999	924.350	0.632	0.274	4.604	2.605	1.313	0.795
52500.0	0.162	6.517	6.086	922.388	0.664	0.302	4.543	2.680	1.338	0.882
55000.0	0.155	5.685	6.155	920.375	0.695	0.331	4.480	2.747	1.357	0.971
57500.0	0.148	4.932	6.208	918.310	0.724	0.360	4.418	2.805	1.371	1.063
60000.0	0.142	4.255	6.244	916.195	0.751	0.389	4.356	2.855	1.381	1.157
62500.0	0.135	3.650	6.265	914.029	0.776	0.417	4.297	2.897	1.387	1.252
65000.0	0.129	3.114	6.272	911.816	0.799	0.444	4.240	2.932	1.390	1.347
67500.0	0.123	2.643	6.265	909.557	0.820	0.470	4.187	2.960	1.390	1.444
70000.0	0.117	2.232	6.246	907.256	0.838	0.494	4.137	2.983	1.388	1.540

Table C.33 [ ] Exposure-Dependent 80% Void Isotopics (kg/MTU Initial)

Exposure MWd/MTU	U-234	U-235	U-236	U-238	NP-237	PU-238	PU-239	PU-240	PU-241	PU-242
0.0	0.332	43.981	0.000	955.687	0.000	0.000	0.000	0.000	0.000	0.000
100.0	0.331	43.862	0.024	955.620	0.000	0.000	0.021	0.000	0.000	0.000
500.0	0.329	43.389	0.121	955.349	0.002	0.000	0.232	0.002	0.000	0.000
1000.0	0.327	42.807	0.241	955.010	0.005	0.000	0.509	0.008	0.000	0.000
1500.0	0.325	42.235	0.357	954.672	0.008	0.000	0.773	0.018	0.002	0.000
2000.0	0.322	41.673	0.472	954.334	0.011	0.000	1.025	0.031	0.004	0.000
2500.0	0.320	41.120	0.584	953.996	0.015	0.000	1.265	0.047	0.007	0.000
3000.0	0.318	40.576	0.694	953.659	0.018	0.001	1.495	0.066	0.012	0.000
3500.0	0.316	40.040	0.803	953.322	0.022	0.001	1.715	0.086	0.017	0.000
4000.0	0.313	39.512	0.909	952.985	0.027	0.001	1.925	0.108	0.025	0.001
4500.0	0.311	38.991	1.013	952.649	0.031	0.002	2.126	0.132	0.033	0.001
5000.0	0.309	38.477	1.116	952.313	0.036	0.002	2.318	0.157	0.043	0.001
5500.0	0.307	37.971	1.217	951.977	0.041	0.002	2.502	0.183	0.054	0.002
6000.0	0.305	37.471	1.316	951.642	0.046	0.003	2.678	0.210	0.066	0.002
6500.0	0.302	36.977	1.414	951.307	0.052	0.003	2.846	0.238	0.079	0.003
7000.0	0.300	36.490	1.510	950.973	0.057	0.004	3.007	0.267	0.094	0.004
7500.0	0.298	36.009	1.605	950.639	0.063	0.005	3.161	0.297	0.109	0.005
8000.0	0.296	35.533	1.697	950.305	0.069	0.006	3.309	0.328	0.125	0.006
8500.0	0.294	35.064	1.789	949.972	0.075	0.006	3.450	0.359	0.142	0.008
9000.0	0.292	34.600	1.879	949.639	0.082	0.007	3.585	0.391	0.159	0.009
9500.0	0.290	34.141	1.968	949.307	0.088	0.008	3.714	0.423	0.177	0.011
10000.0	0.288	33.687	2.055	948.976	0.094	0.009	3.837	0.456	0.196	0.013
10500.0	0.286	33.238	2.141	948.644	0.101	0.011	3.954	0.489	0.215	0.015
11000.0	0.284	32.795	2.226	948.313	0.108	0.012	4.067	0.523	0.234	0.017
11500.0	0.282	32.356	2.309	947.983	0.114	0.013	4.175	0.557	0.255	0.020
12000.0	0.280	31.922	2.391	947.652	0.121	0.014	4.277	0.591	0.275	0.022
12500.0	0.278	31.492	2.472	947.322	0.128	0.016	4.376	0.626	0.296	0.025
13000.0	0.276	31.067	2.552	946.992	0.135	0.017	4.469	0.660	0.317	0.028
13500.0	0.274	30.646	2.631	946.662	0.142	0.019	4.559	0.695	0.338	0.031
14000.0	0.272	30.230	2.708	946.333	0.150	0.020	4.644	0.731	0.359	0.035
14500.0	0.270	29.817	2.785	946.003	0.157	0.022	4.726	0.766	0.381	0.038
15000.0	0.268	29.409	2.860	945.674	0.164	0.024	4.804	0.802	0.402	0.042
15500.0	0.267	29.005	2.934	945.345	0.172	0.026	4.878	0.838	0.424	0.046
16000.0	0.265	28.604	3.007	945.016	0.179	0.028	4.948	0.874	0.446	0.050
16500.0	0.263	28.208	3.080	944.687	0.187	0.030	5.016	0.910	0.468	0.055
17000.0	0.261	27.815	3.151	944.357	0.194	0.032	5.080	0.946	0.490	0.059
17500.0	0.259	27.426	3.221	944.028	0.202	0.034	5.141	0.982	0.512	0.064
18000.0	0.258	27.041	3.290	943.698	0.210	0.036	5.199	1.018	0.533	0.069
18500.0	0.256	26.659	3.358	943.369	0.217	0.039	5.255	1.054	0.555	0.074
19000.0	0.254	26.281	3.425	943.039	0.225	0.041	5.307	1.090	0.577	0.079
19500.0	0.252	25.907	3.492	942.708	0.233	0.044	5.358	1.126	0.599	0.085
20000.0	0.250	25.536	3.557	942.377	0.241	0.046	5.406	1.162	0.621	0.091
20500.0	0.249	25.168	3.622	942.046	0.249	0.049	5.451	1.198	0.642	0.097
21000.0	0.247	24.804	3.685	941.714	0.256	0.052	5.495	1.234	0.664	0.103
21500.0	0.245	24.443	3.748	941.381	0.264	0.055	5.537	1.269	0.685	0.109
22000.0	0.244	24.086	3.810	941.047	0.272	0.058	5.576	1.305	0.707	0.115
22500.0	0.242	23.733	3.871	940.712	0.280	0.061	5.614	1.340	0.728	0.122
23000.0	0.240	23.382	3.931	940.376	0.288	0.064	5.651	1.376	0.749	0.129
23500.0	0.238	23.035	3.990	940.039	0.296	0.067	5.685	1.411	0.770	0.136
24000.0	0.237	22.692	4.048	939.701	0.304	0.070	5.718	1.446	0.791	0.143
24500.0	0.235	22.351	4.106	939.362	0.313	0.074	5.750	1.480	0.812	0.151
25000.0	0.233	22.015	4.163	939.022	0.321	0.077	5.780	1.515	0.833	0.158
25500.0	0.232	21.681	4.219	938.680	0.329	0.081	5.809	1.549	0.854	0.166
27500.0	0.225	20.381	4.434	937.300	0.362	0.096	5.913	1.685	0.936	0.199
30000.0	0.217	18.830	4.685	935.545	0.403	0.117	6.017	1.848	1.035	0.245
32500.0	0.209	17.360	4.915	933.757	0.445	0.141	6.096	2.006	1.129	0.295
35000.0	0.201	15.969	5.127	931.934	0.486	0.166	6.152	2.157	1.218	0.348
37500.0	0.194	14.655	5.319	930.077	0.527	0.194	6.189	2.302	1.300	0.406
40000.0	0.186	13.418	5.492	928.185	0.568	0.224	6.209	2.439	1.377	0.468
42500.0	0.179	12.255	5.647	926.257	0.608	0.256	6.215	2.570	1.447	0.532
45000.0	0.172	11.165	5.784	924.294	0.647	0.289	6.209	2.692	1.511	0.600
47500.0	0.165	10.146	5.904	922.295	0.685	0.324	6.193	2.807	1.569	0.671
50000.0	0.159	9.197	6.008	920.261	0.721	0.360	6.168	2.914	1.620	0.745
52500.0	0.152	8.314	6.095	918.192	0.757	0.397	6.136	3.014	1.667	0.820
55000.0	0.146	7.497	6.167	916.087	0.790	0.435	6.100	3.105	1.707	0.898
57500.0	0.140	6.742	6.224	913.948	0.822	0.473	6.059	3.189	1.743	0.978
60000.0	0.135	6.048	6.268	911.776	0.851	0.511	6.015	3.266	1.773	1.059
62500.0	0.129	5.412	6.298	909.571	0.879	0.549	5.970	3.335	1.799	1.142
65000.0	0.124	4.830	6.315	907.335	0.905	0.587	5.924	3.397	1.821	1.226
67500.0	0.119	4.301	6.321	905.069	0.928	0.623	5.877	3.453	1.840	1.311
70000.0	0.114	3.821	6.315	902.775	0.950	0.659	5.832	3.502	1.855	1.397

Table C.34 [ ] Exposure-Dependent 0% Void Isotopics (kg/MTU Initial)

Exposure MWd/MTU	U-234	U-235	U-236	U-238	NP-237	PU-238	PU-239	PU-240	PU-241	PU-242
0.0	0.330	43.715	0.000	955.955	0.000	0.000	0.000	0.000	0.000	0.000
100.0	0.330	43.594	0.022	955.907	0.000	0.000	0.015	0.000	0.000	0.000
500.0	0.328	43.116	0.110	955.712	0.001	0.000	0.167	0.001	0.000	0.000
1000.0	0.327	42.524	0.218	955.468	0.003	0.000	0.371	0.006	0.000	0.000
1500.0	0.325	41.940	0.325	955.224	0.005	0.000	0.566	0.013	0.001	0.000
2000.0	0.323	41.364	0.430	954.979	0.007	0.000	0.752	0.023	0.002	0.000
2500.0	0.321	40.795	0.534	954.735	0.009	0.000	0.929	0.036	0.004	0.000
3000.0	0.320	40.232	0.636	954.491	0.012	0.000	1.098	0.050	0.006	0.000
3500.0	0.318	39.675	0.737	954.246	0.014	0.000	1.260	0.067	0.009	0.000
4000.0	0.316	39.125	0.836	954.002	0.017	0.001	1.414	0.085	0.013	0.000
4500.0	0.315	38.581	0.934	953.758	0.020	0.001	1.561	0.105	0.018	0.001
5000.0	0.313	38.042	1.031	953.514	0.023	0.001	1.701	0.126	0.024	0.001
5500.0	0.311	37.510	1.126	953.270	0.026	0.001	1.834	0.148	0.030	0.001
6000.0	0.310	36.982	1.220	953.026	0.030	0.001	1.961	0.171	0.038	0.001
6500.0	0.308	36.460	1.313	952.782	0.033	0.002	2.082	0.195	0.046	0.002
7000.0	0.306	35.943	1.405	952.539	0.037	0.002	2.197	0.220	0.055	0.003
7500.0	0.305	35.431	1.496	952.295	0.040	0.002	2.306	0.246	0.064	0.003
8000.0	0.303	34.924	1.585	952.052	0.044	0.003	2.410	0.273	0.074	0.004
8500.0	0.302	34.421	1.673	951.809	0.048	0.003	2.509	0.300	0.085	0.005
9000.0	0.300	33.923	1.760	951.567	0.052	0.004	2.602	0.328	0.097	0.006
9500.0	0.298	33.430	1.847	951.324	0.056	0.004	2.691	0.356	0.109	0.007
10000.0	0.297	32.940	1.932	951.082	0.060	0.005	2.774	0.385	0.121	0.009
10500.0	0.295	32.455	2.016	950.841	0.064	0.005	2.853	0.414	0.134	0.010
11000.0	0.294	31.974	2.099	950.599	0.069	0.006	2.928	0.443	0.148	0.012
11500.0	0.292	31.497	2.181	950.358	0.073	0.006	2.998	0.473	0.162	0.013
12000.0	0.291	31.024	2.262	950.117	0.077	0.007	3.065	0.503	0.176	0.015
12500.0	0.289	30.555	2.342	949.876	0.082	0.008	3.127	0.534	0.190	0.018
13000.0	0.288	30.090	2.421	949.636	0.087	0.008	3.186	0.564	0.205	0.020
13500.0	0.286	29.628	2.499	949.396	0.091	0.009	3.241	0.595	0.219	0.022
14000.0	0.285	29.169	2.576	949.156	0.096	0.010	3.293	0.626	0.234	0.025
14500.0	0.283	28.714	2.653	948.916	0.101	0.011	3.341	0.657	0.250	0.028
15000.0	0.281	28.263	2.728	948.677	0.106	0.012	3.386	0.689	0.265	0.031
15500.0	0.280	27.814	2.803	948.438	0.111	0.012	3.428	0.720	0.280	0.034
16000.0	0.279	27.369	2.877	948.198	0.116	0.013	3.467	0.751	0.295	0.037
16500.0	0.277	26.927	2.950	947.959	0.121	0.014	3.504	0.783	0.311	0.041
17000.0	0.276	26.489	3.022	947.719	0.126	0.015	3.538	0.814	0.326	0.045
17500.0	0.274	26.053	3.094	947.478	0.131	0.017	3.570	0.846	0.342	0.049
18000.0	0.273	25.622	3.165	947.236	0.136	0.018	3.600	0.877	0.357	0.053
18500.0	0.271	25.193	3.235	946.994	0.141	0.019	3.628	0.908	0.373	0.057
19000.0	0.270	24.768	3.304	946.750	0.146	0.020	3.654	0.939	0.389	0.062
19500.0	0.268	24.346	3.372	946.506	0.152	0.021	3.678	0.970	0.404	0.066
20000.0	0.267	23.927	3.440	946.260	0.157	0.023	3.701	1.002	0.420	0.071
20500.0	0.265	23.512	3.507	946.013	0.163	0.024	3.722	1.032	0.436	0.077
21000.0	0.264	23.100	3.573	945.764	0.168	0.025	3.742	1.063	0.452	0.082
21500.0	0.262	22.692	3.638	945.514	0.174	0.027	3.760	1.094	0.467	0.088
22500.0	0.259	21.885	3.767	945.010	0.185	0.030	3.793	1.155	0.499	0.100
25000.0	0.252	19.929	4.074	943.722	0.215	0.039	3.854	1.304	0.576	0.134
27500.0	0.244	18.059	4.362	942.393	0.245	0.049	3.887	1.447	0.650	0.174
30000.0	0.237	16.278	4.630	941.020	0.277	0.061	3.897	1.586	0.719	0.220
32500.0	0.229	14.586	4.879	939.600	0.309	0.074	3.887	1.718	0.782	0.272
35000.0	0.221	12.985	5.107	938.128	0.342	0.089	3.861	1.843	0.839	0.331
37500.0	0.214	11.479	5.315	936.602	0.376	0.105	3.822	1.960	0.889	0.396
40000.0	0.206	10.069	5.503	935.016	0.409	0.123	3.772	2.069	0.932	0.467
42500.0	0.198	8.758	5.669	933.367	0.442	0.142	3.715	2.169	0.968	0.545
45000.0	0.190	7.549	5.814	931.651	0.475	0.163	3.652	2.260	0.997	0.628
47500.0	0.182	6.444	5.938	929.863	0.507	0.184	3.587	2.341	1.020	0.716
50000.0	0.175	5.445	6.039	928.001	0.538	0.206	3.521	2.412	1.036	0.810
52500.0	0.167	4.551	6.119	926.062	0.567	0.228	3.456	2.473	1.048	0.908
55000.0	0.159	3.763	6.178	924.045	0.595	0.251	3.394	2.525	1.055	1.010
57500.0	0.151	3.077	6.217	921.951	0.621	0.272	3.335	2.567	1.058	1.115
60000.0	0.144	2.489	6.236	919.781	0.644	0.294	3.282	2.601	1.058	1.223
62500.0	0.136	1.993	6.238	917.539	0.666	0.314	3.234	2.627	1.056	1.332
65000.0	0.129	1.581	6.223	915.231	0.685	0.332	3.191	2.646	1.052	1.442
67500.0	0.122	1.244	6.194	912.864	0.701	0.349	3.154	2.660	1.047	1.552
70000.0	0.115	0.972	6.153	910.446	0.715	0.365	3.122	2.668	1.041	1.661

Table C.35 [ ] Exposure-Dependent 40% Void Isotopics (kg/MTU Initial)

Exposure MWd/MTU	U-234	U-235	U-236	U-238	NP-237	PU-238	PU-239	PU-240	PU-241	PU-242
0.0	0.330	43.715	0.000	955.955	0.000	0.000	0.000	0.000	0.000	0.000
100.0	0.330	43.595	0.023	955.899	0.000	0.000	0.017	0.000	0.000	0.000
500.0	0.328	43.118	0.114	955.675	0.002	0.000	0.191	0.001	0.000	0.000
1000.0	0.326	42.529	0.227	955.393	0.004	0.000	0.424	0.007	0.000	0.000
1500.0	0.324	41.949	0.338	955.112	0.006	0.000	0.647	0.015	0.001	0.000
2000.0	0.322	41.378	0.446	954.831	0.008	0.000	0.860	0.027	0.003	0.000
2500.0	0.320	40.814	0.553	954.551	0.011	0.000	1.062	0.041	0.005	0.000
3000.0	0.318	40.259	0.658	954.270	0.014	0.000	1.255	0.057	0.008	0.000
3500.0	0.316	39.710	0.762	953.990	0.017	0.001	1.439	0.076	0.012	0.000
4000.0	0.315	39.168	0.864	953.710	0.021	0.001	1.615	0.096	0.017	0.000
4500.0	0.313	38.633	0.964	953.430	0.024	0.001	1.782	0.117	0.024	0.001
5000.0	0.311	38.105	1.063	953.151	0.028	0.001	1.941	0.140	0.031	0.001
5500.0	0.309	37.583	1.160	952.872	0.032	0.002	2.093	0.164	0.039	0.001
6000.0	0.307	37.066	1.256	952.593	0.036	0.002	2.238	0.190	0.049	0.002
6500.0	0.305	36.556	1.350	952.314	0.040	0.002	2.376	0.216	0.059	0.002
7000.0	0.304	36.051	1.443	952.036	0.044	0.003	2.508	0.243	0.070	0.003
7500.0	0.302	35.552	1.535	951.758	0.048	0.003	2.633	0.271	0.082	0.004
8000.0	0.300	35.058	1.626	951.481	0.053	0.004	2.752	0.299	0.095	0.005
8500.0	0.298	34.569	1.715	951.204	0.057	0.004	2.865	0.328	0.108	0.006
9000.0	0.296	34.085	1.803	950.927	0.062	0.005	2.972	0.358	0.122	0.007
9500.0	0.295	33.606	1.889	950.651	0.067	0.005	3.074	0.388	0.137	0.009
10000.0	0.293	33.131	1.975	950.376	0.072	0.006	3.171	0.419	0.152	0.010
10500.0	0.291	32.661	2.059	950.101	0.077	0.007	3.262	0.450	0.168	0.012
11000.0	0.289	32.196	2.142	949.826	0.083	0.008	3.349	0.481	0.184	0.014
11500.0	0.288	31.735	2.224	949.552	0.088	0.008	3.431	0.513	0.201	0.016
12000.0	0.286	31.278	2.305	949.278	0.093	0.009	3.509	0.545	0.218	0.019
12500.0	0.284	30.826	2.385	949.004	0.099	0.010	3.582	0.577	0.235	0.021
13000.0	0.283	30.377	2.464	948.731	0.104	0.011	3.652	0.609	0.252	0.024
13500.0	0.281	29.932	2.542	948.458	0.110	0.012	3.717	0.642	0.270	0.027
14000.0	0.279	29.491	2.618	948.185	0.116	0.013	3.778	0.675	0.288	0.030
14500.0	0.278	29.054	2.694	947.913	0.121	0.014	3.836	0.708	0.306	0.033
15000.0	0.276	28.621	2.769	947.641	0.127	0.015	3.890	0.741	0.324	0.036
15500.0	0.274	28.191	2.843	947.369	0.133	0.017	3.941	0.774	0.342	0.040
16000.0	0.273	27.764	2.916	947.098	0.139	0.018	3.989	0.807	0.360	0.044
16500.0	0.271	27.341	2.989	946.826	0.145	0.019	4.034	0.840	0.378	0.048
17000.0	0.270	26.922	3.060	946.554	0.151	0.021	4.076	0.873	0.396	0.052
17500.0	0.268	26.506	3.130	946.283	0.156	0.022	4.115	0.906	0.414	0.057
18000.0	0.266	26.093	3.200	946.010	0.163	0.024	4.153	0.939	0.432	0.061
18500.0	0.265	25.683	3.269	945.737	0.169	0.025	4.187	0.972	0.451	0.066
19000.0	0.263	25.277	3.337	945.464	0.175	0.027	4.220	1.005	0.469	0.071
19500.0	0.262	24.875	3.404	945.189	0.181	0.028	4.251	1.038	0.487	0.076
20000.0	0.260	24.476	3.471	944.914	0.187	0.030	4.280	1.071	0.505	0.082
20500.0	0.259	24.080	3.536	944.637	0.194	0.032	4.307	1.103	0.523	0.088
21000.0	0.257	23.687	3.601	944.359	0.200	0.034	4.332	1.135	0.541	0.094
21500.0	0.255	23.299	3.665	944.080	0.206	0.036	4.356	1.168	0.559	0.100
22000.0	0.254	22.913	3.728	943.800	0.213	0.038	4.379	1.200	0.577	0.106
22500.0	0.252	22.531	3.790	943.518	0.219	0.040	4.400	1.231	0.595	0.113
25000.0	0.245	20.672	4.089	942.088	0.253	0.051	4.487	1.387	0.684	0.149
27500.0	0.237	18.899	4.368	940.620	0.288	0.064	4.544	1.537	0.770	0.191
30000.0	0.229	17.213	4.627	939.114	0.324	0.078	4.576	1.681	0.850	0.239
32500.0	0.221	15.611	4.866	937.566	0.361	0.095	4.587	1.819	0.924	0.292
35000.0	0.214	14.096	5.085	935.976	0.397	0.113	4.578	1.949	0.992	0.351
37500.0	0.206	12.667	5.285	934.340	0.434	0.133	4.555	2.072	1.052	0.415
40000.0	0.199	11.325	5.465	932.657	0.471	0.155	4.519	2.187	1.106	0.484
42500.0	0.191	10.070	5.626	930.924	0.506	0.178	4.473	2.293	1.152	0.558
45000.0	0.184	8.902	5.768	929.139	0.542	0.203	4.419	2.390	1.191	0.636
47500.0	0.176	7.821	5.890	927.300	0.576	0.229	4.360	2.478	1.223	0.719
50000.0	0.169	6.828	5.993	925.406	0.609	0.255	4.297	2.557	1.249	0.806
52500.0	0.162	5.922	6.078	923.455	0.640	0.282	4.232	2.627	1.269	0.896
55000.0	0.155	5.102	6.144	921.446	0.670	0.309	4.167	2.688	1.284	0.989
57500.0	0.148	4.365	6.193	919.380	0.698	0.336	4.103	2.740	1.294	1.084
60000.0	0.141	3.709	6.225	917.257	0.724	0.362	4.042	2.784	1.300	1.181
62500.0	0.134	3.131	6.240	915.078	0.748	0.388	3.983	2.821	1.302	1.280
65000.0	0.128	2.625	6.241	912.847	0.770	0.412	3.929	2.850	1.302	1.379
67500.0	0.122	2.188	6.228	910.566	0.790	0.436	3.878	2.872	1.299	1.479
70000.0	0.116	1.813	6.203	908.238	0.807	0.457	3.832	2.889	1.295	1.579

Table C.36 [ ] Exposure-Dependent 80% Void Isotopics (kg/MTU Initial)

Exposure MWd/MTU	U-234	U-235	U-236	U-238	NP-237	PU-238	PU-239	PU-240	PU-241	PU-242
0.0	0.330	43.715	0.000	955.955	0.000	0.000	0.000	0.000	0.000	0.000
100.0	0.330	43.595	0.024	955.889	0.000	0.000	0.020	0.000	0.000	0.000
500.0	0.328	43.121	0.121	955.624	0.002	0.000	0.223	0.002	0.000	0.000
1000.0	0.325	42.538	0.239	955.292	0.005	0.000	0.496	0.008	0.000	0.000
1500.0	0.323	41.964	0.355	954.960	0.007	0.000	0.756	0.017	0.002	0.000
2000.0	0.321	41.400	0.469	954.629	0.011	0.000	1.004	0.031	0.004	0.000
2500.0	0.319	40.846	0.581	954.298	0.014	0.000	1.240	0.046	0.007	0.000
3000.0	0.316	40.300	0.690	953.968	0.018	0.001	1.466	0.065	0.011	0.000
3500.0	0.314	39.762	0.798	953.638	0.022	0.001	1.681	0.085	0.017	0.000
4000.0	0.312	39.231	0.904	953.308	0.026	0.001	1.887	0.107	0.024	0.001
4500.0	0.310	38.709	1.008	952.979	0.030	0.001	2.083	0.131	0.032	0.001
5000.0	0.308	38.193	1.110	952.651	0.035	0.002	2.271	0.156	0.042	0.001
5500.0	0.305	37.684	1.210	952.323	0.040	0.002	2.450	0.182	0.053	0.002
6000.0	0.303	37.182	1.309	951.995	0.045	0.003	2.622	0.209	0.065	0.002
6500.0	0.301	36.687	1.406	951.668	0.050	0.003	2.785	0.237	0.078	0.003
7000.0	0.299	36.197	1.502	951.342	0.055	0.004	2.942	0.266	0.092	0.004
7500.0	0.297	35.714	1.596	951.016	0.061	0.005	3.091	0.296	0.106	0.005
8000.0	0.295	35.236	1.688	950.690	0.067	0.005	3.234	0.326	0.122	0.006
8500.0	0.293	34.764	1.779	950.365	0.073	0.006	3.370	0.357	0.139	0.008
9000.0	0.291	34.297	1.869	950.041	0.079	0.007	3.500	0.389	0.156	0.009
9500.0	0.289	33.836	1.957	949.717	0.085	0.008	3.624	0.421	0.174	0.011
10000.0	0.287	33.380	2.044	949.394	0.091	0.009	3.742	0.454	0.192	0.013
10500.0	0.285	32.929	2.129	949.072	0.097	0.010	3.854	0.487	0.211	0.015
11000.0	0.283	32.483	2.214	948.750	0.104	0.011	3.962	0.520	0.230	0.017
11500.0	0.281	32.041	2.297	948.428	0.110	0.012	4.064	0.554	0.250	0.019
12000.0	0.279	31.604	2.379	948.107	0.117	0.014	4.161	0.588	0.270	0.022
12500.0	0.277	31.172	2.459	947.786	0.124	0.015	4.254	0.623	0.291	0.025
13000.0	0.275	30.744	2.539	947.465	0.130	0.016	4.343	0.657	0.311	0.028
13500.0	0.274	30.320	2.617	947.145	0.137	0.018	4.427	0.692	0.332	0.031
14000.0	0.272	29.901	2.694	946.825	0.144	0.019	4.507	0.728	0.353	0.034
14500.0	0.270	29.485	2.770	946.505	0.151	0.021	4.583	0.763	0.375	0.038
15000.0	0.268	29.074	2.845	946.186	0.158	0.023	4.655	0.798	0.396	0.042
15500.0	0.266	28.666	2.919	945.867	0.165	0.024	4.723	0.834	0.417	0.046
16000.0	0.264	28.263	2.992	945.548	0.173	0.026	4.788	0.870	0.439	0.050
16500.0	0.263	27.863	3.064	945.229	0.180	0.028	4.849	0.905	0.460	0.054
17000.0	0.261	27.467	3.135	944.911	0.187	0.030	4.908	0.941	0.482	0.059
17500.0	0.259	27.074	3.205	944.592	0.195	0.032	4.963	0.977	0.503	0.064
18000.0	0.257	26.685	3.274	944.274	0.202	0.034	5.015	1.013	0.524	0.069
18500.0	0.256	26.300	3.342	943.955	0.209	0.036	5.065	1.048	0.546	0.074
19000.0	0.254	25.918	3.409	943.636	0.217	0.039	5.112	1.084	0.567	0.079
19500.0	0.252	25.540	3.475	943.316	0.224	0.041	5.157	1.120	0.588	0.085
20000.0	0.251	25.165	3.540	942.996	0.232	0.044	5.199	1.155	0.609	0.091
20500.0	0.249	24.793	3.605	942.675	0.240	0.046	5.239	1.191	0.631	0.097
21000.0	0.247	24.425	3.668	942.354	0.247	0.049	5.278	1.226	0.652	0.103
21500.0	0.245	24.060	3.731	942.032	0.255	0.051	5.314	1.261	0.673	0.109
22000.0	0.244	23.699	3.793	941.709	0.263	0.054	5.349	1.296	0.693	0.116
22500.0	0.242	23.341	3.854	941.384	0.270	0.057	5.381	1.331	0.714	0.122
23000.0	0.240	22.987	3.914	941.059	0.278	0.060	5.413	1.366	0.735	0.129
23500.0	0.239	22.636	3.973	940.732	0.286	0.063	5.443	1.400	0.756	0.137
24000.0	0.237	22.288	4.031	940.405	0.294	0.066	5.471	1.435	0.776	0.144
24500.0	0.235	21.944	4.089	940.075	0.301	0.069	5.498	1.469	0.797	0.151
25000.0	0.234	21.603	4.146	939.745	0.309	0.072	5.524	1.503	0.817	0.159
27500.0	0.226	19.950	4.417	938.073	0.349	0.090	5.635	1.668	0.917	0.201
30000.0	0.218	18.379	4.668	936.367	0.389	0.110	5.718	1.828	1.013	0.247
32500.0	0.210	16.890	4.899	934.626	0.430	0.132	5.776	1.982	1.104	0.298
35000.0	0.202	15.482	5.111	932.850	0.470	0.156	5.814	2.128	1.189	0.353
37500.0	0.194	14.152	5.303	931.037	0.511	0.182	5.833	2.268	1.267	0.413
40000.0	0.187	12.900	5.476	929.188	0.551	0.210	5.836	2.400	1.339	0.476
42500.0	0.180	11.724	5.631	927.301	0.590	0.240	5.826	2.525	1.404	0.543
45000.0	0.173	10.624	5.768	925.376	0.628	0.272	5.805	2.641	1.463	0.614
47500.0	0.166	9.597	5.887	923.412	0.665	0.305	5.775	2.750	1.515	0.687
50000.0	0.159	8.642	5.989	921.411	0.701	0.338	5.737	2.850	1.561	0.764
52500.0	0.153	7.757	6.074	919.370	0.736	0.373	5.694	2.942	1.601	0.842
55000.0	0.146	6.940	6.144	917.291	0.768	0.409	5.647	3.026	1.636	0.923
57500.0	0.140	6.189	6.199	915.175	0.799	0.444	5.597	3.102	1.665	1.006
60000.0	0.134	5.502	6.239	913.021	0.828	0.480	5.546	3.170	1.689	1.091
62500.0	0.129	4.875	6.266	910.831	0.855	0.515	5.493	3.231	1.709	1.177
65000.0	0.123	4.307	6.279	908.607	0.880	0.550	5.441	3.284	1.725	1.264
67500.0	0.118	3.793	6.281	906.348	0.903	0.584	5.390	3.331	1.737	1.353
70000.0	0.113	3.331	6.271	904.058	0.924	0.616	5.340	3.371	1.746	1.442

Table C.37 [ ] Exposure-Dependent 0% Void Isotopics (kg/MTU Initial)

Exposure MWd/MTU	U-234	U-235	U-236	U-238	NP-237	PU-238	PU-239	PU-240	PU-241	PU-242
0.0	0.312	41.261	0.000	958.427	0.000	0.000	0.000	0.000	0.000	0.000
100.0	0.311	41.141	0.022	958.378	0.000	0.000	0.015	0.000	0.000	0.000
500.0	0.310	40.664	0.108	958.182	0.001	0.000	0.168	0.001	0.000	0.000
1000.0	0.308	40.075	0.215	957.936	0.003	0.000	0.373	0.006	0.000	0.000
1500.0	0.307	39.493	0.320	957.690	0.005	0.000	0.568	0.014	0.001	0.000
2000.0	0.305	38.920	0.424	957.444	0.007	0.000	0.754	0.025	0.002	0.000
2500.0	0.303	38.354	0.526	957.198	0.009	0.000	0.930	0.038	0.004	0.000
3000.0	0.302	37.795	0.626	956.953	0.012	0.000	1.098	0.054	0.006	0.000
3500.0	0.300	37.243	0.725	956.707	0.014	0.000	1.257	0.071	0.010	0.000
4000.0	0.299	36.697	0.822	956.462	0.017	0.001	1.409	0.090	0.014	0.000
4500.0	0.297	36.158	0.918	956.216	0.020	0.001	1.553	0.111	0.019	0.001
5000.0	0.295	35.625	1.012	955.971	0.023	0.001	1.689	0.133	0.025	0.001
5500.0	0.294	35.097	1.106	955.726	0.026	0.001	1.819	0.156	0.032	0.001
6000.0	0.292	34.575	1.198	955.481	0.029	0.001	1.942	0.181	0.039	0.002
6500.0	0.291	34.058	1.289	955.237	0.033	0.002	2.059	0.206	0.048	0.002
7000.0	0.289	33.547	1.378	954.993	0.036	0.002	2.169	0.232	0.057	0.003
7500.0	0.288	33.041	1.466	954.749	0.040	0.002	2.274	0.259	0.067	0.004
8000.0	0.286	32.540	1.554	954.506	0.043	0.003	2.373	0.287	0.077	0.005
8500.0	0.285	32.043	1.640	954.262	0.047	0.003	2.466	0.316	0.088	0.006
9000.0	0.283	31.552	1.725	954.020	0.051	0.004	2.554	0.345	0.100	0.007
9500.0	0.281	31.064	1.809	953.778	0.055	0.004	2.637	0.374	0.112	0.008
10000.0	0.280	30.582	1.891	953.536	0.059	0.005	2.715	0.404	0.125	0.010
10500.0	0.278	30.103	1.973	953.295	0.063	0.005	2.789	0.434	0.138	0.011
11000.0	0.277	29.628	2.054	953.053	0.067	0.006	2.858	0.465	0.151	0.013
11500.0	0.276	29.158	2.134	952.813	0.071	0.006	2.922	0.496	0.165	0.015
12000.0	0.274	28.691	2.212	952.572	0.076	0.007	2.983	0.527	0.179	0.017
12500.0	0.273	28.228	2.290	952.332	0.080	0.008	3.040	0.559	0.193	0.019
13000.0	0.271	27.769	2.367	952.093	0.084	0.008	3.093	0.590	0.208	0.022
13500.0	0.270	27.313	2.443	951.853	0.089	0.009	3.142	0.622	0.222	0.025
14000.0	0.268	26.861	2.518	951.614	0.093	0.010	3.188	0.654	0.237	0.027
14500.0	0.267	26.413	2.593	951.375	0.098	0.011	3.231	0.686	0.252	0.031
15000.0	0.265	25.968	2.666	951.135	0.103	0.011	3.271	0.718	0.267	0.034
15500.0	0.264	25.526	2.739	950.896	0.107	0.012	3.308	0.750	0.282	0.037
16000.0	0.262	25.087	2.811	950.656	0.112	0.013	3.343	0.782	0.297	0.041
16500.0	0.261	24.652	2.882	950.415	0.117	0.014	3.375	0.814	0.312	0.045
17000.0	0.260	24.221	2.952	950.173	0.122	0.015	3.406	0.846	0.328	0.049
17500.0	0.258	23.793	3.021	949.930	0.127	0.016	3.434	0.878	0.343	0.053
18000.0	0.257	23.368	3.090	949.686	0.132	0.017	3.460	0.910	0.358	0.058
18500.0	0.255	22.948	3.158	949.441	0.137	0.019	3.485	0.942	0.374	0.062
19000.0	0.254	22.530	3.225	949.195	0.142	0.020	3.507	0.974	0.389	0.067
19500.0	0.252	22.116	3.291	948.947	0.147	0.021	3.528	1.006	0.405	0.073
20000.0	0.251	21.706	3.357	948.698	0.152	0.022	3.548	1.037	0.420	0.078
20500.0	0.250	21.299	3.421	948.447	0.158	0.024	3.566	1.069	0.435	0.084
22500.0	0.244	19.709	3.672	947.428	0.180	0.030	3.625	1.192	0.497	0.109
25000.0	0.237	17.802	3.967	946.114	0.208	0.038	3.672	1.343	0.572	0.146
27500.0	0.229	15.989	4.242	944.755	0.238	0.048	3.692	1.488	0.642	0.189
30000.0	0.222	14.269	4.497	943.347	0.268	0.060	3.691	1.627	0.708	0.239
32500.0	0.214	12.645	4.732	941.884	0.300	0.073	3.671	1.758	0.766	0.296
35000.0	0.207	11.120	4.945	940.363	0.332	0.088	3.637	1.882	0.818	0.360
37500.0	0.199	9.697	5.136	938.780	0.364	0.104	3.592	1.997	0.863	0.430
40000.0	0.192	8.378	5.306	937.129	0.396	0.122	3.538	2.103	0.901	0.507
42500.0	0.184	7.167	5.454	935.407	0.427	0.140	3.479	2.199	0.931	0.591
45000.0	0.176	6.065	5.580	933.607	0.458	0.160	3.416	2.284	0.956	0.680
47500.0	0.168	5.075	5.683	931.729	0.488	0.180	3.354	2.359	0.974	0.776
50000.0	0.161	4.197	5.763	929.768	0.516	0.201	3.292	2.424	0.986	0.876
52500.0	0.153	3.430	5.822	927.725	0.543	0.222	3.233	2.478	0.994	0.980
55000.0	0.145	2.769	5.860	925.600	0.568	0.242	3.179	2.523	0.999	1.089
57500.0	0.137	2.210	5.878	923.396	0.591	0.262	3.130	2.558	1.000	1.199
60000.0	0.130	1.745	5.879	921.118	0.612	0.280	3.086	2.586	0.999	1.312
62500.0	0.123	1.364	5.863	918.774	0.630	0.298	3.048	2.606	0.996	1.425
65000.0	0.116	1.058	5.834	916.370	0.646	0.313	3.016	2.620	0.993	1.538
67500.0	0.109	0.814	5.793	913.917	0.659	0.328	2.988	2.629	0.989	1.650
70000.0	0.103	0.624	5.742	911.421	0.671	0.340	2.965	2.635	0.984	1.761

Table C.38 [ ] Exposure-Dependent 40% Void Isotopics (kg/MTU Initial)

Exposure MWd/MTU	U-234	U-235	U-236	U-238	NP-237	PU-238	PU-239	PU-240	PU-241	PU-242
0.0	0.312	41.261	0.000	958.427	0.000	0.000	0.000	0.000	0.000	0.000
100.0	0.311	41.142	0.023	958.371	0.000	0.000	0.017	0.000	0.000	0.000
500.0	0.310	40.666	0.113	958.143	0.002	0.000	0.193	0.001	0.000	0.000
1000.0	0.308	40.080	0.223	957.859	0.004	0.000	0.429	0.007	0.000	0.000
1500.0	0.306	39.504	0.332	957.574	0.006	0.000	0.652	0.016	0.001	0.000
2000.0	0.304	38.936	0.439	957.291	0.009	0.000	0.865	0.029	0.003	0.000
2500.0	0.302	38.377	0.544	957.007	0.011	0.000	1.067	0.044	0.005	0.000
3000.0	0.300	37.826	0.647	956.724	0.014	0.000	1.259	0.061	0.009	0.000
3500.0	0.299	37.283	0.748	956.441	0.017	0.001	1.441	0.081	0.013	0.000
4000.0	0.297	36.747	0.848	956.159	0.021	0.001	1.614	0.102	0.019	0.000
4500.0	0.295	36.218	0.946	955.877	0.024	0.001	1.778	0.125	0.025	0.001
5000.0	0.293	35.695	1.042	955.595	0.028	0.001	1.934	0.149	0.033	0.001
5500.0	0.291	35.179	1.137	955.314	0.032	0.002	2.083	0.174	0.042	0.002
6000.0	0.290	34.670	1.230	955.034	0.035	0.002	2.223	0.201	0.052	0.002
6500.0	0.288	34.166	1.322	954.754	0.040	0.002	2.357	0.228	0.062	0.003
7000.0	0.286	33.668	1.413	954.474	0.044	0.003	2.483	0.257	0.074	0.004
7500.0	0.285	33.176	1.502	954.195	0.048	0.003	2.603	0.286	0.086	0.005
8000.0	0.283	32.689	1.590	953.917	0.052	0.004	2.716	0.316	0.099	0.006
8500.0	0.281	32.208	1.677	953.640	0.057	0.004	2.824	0.346	0.113	0.007
9000.0	0.279	31.731	1.762	953.363	0.062	0.005	2.925	0.377	0.127	0.008
9500.0	0.278	31.259	1.846	953.086	0.066	0.005	3.021	0.409	0.142	0.010
10000.0	0.276	30.793	1.929	952.811	0.071	0.006	3.111	0.440	0.158	0.012
10500.0	0.274	30.330	2.011	952.536	0.076	0.007	3.196	0.473	0.174	0.014
11000.0	0.273	29.873	2.091	952.261	0.081	0.008	3.277	0.505	0.190	0.016
11500.0	0.271	29.419	2.171	951.987	0.086	0.008	3.352	0.538	0.207	0.018
12000.0	0.270	28.970	2.249	951.713	0.092	0.009	3.424	0.571	0.223	0.021
12500.0	0.268	28.525	2.326	951.439	0.097	0.010	3.491	0.604	0.241	0.024
13000.0	0.266	28.084	2.403	951.166	0.102	0.011	3.553	0.638	0.258	0.026
13500.0	0.265	27.647	2.478	950.893	0.108	0.012	3.612	0.671	0.275	0.030
14000.0	0.263	27.214	2.552	950.621	0.113	0.013	3.668	0.705	0.293	0.033
14500.0	0.262	26.785	2.626	950.349	0.119	0.014	3.720	0.739	0.311	0.036
15000.0	0.260	26.359	2.698	950.077	0.124	0.015	3.768	0.773	0.329	0.040
15500.0	0.259	25.937	2.770	949.805	0.130	0.017	3.813	0.807	0.346	0.044
16000.0	0.257	25.518	2.841	949.533	0.135	0.018	3.855	0.840	0.364	0.048
16500.0	0.256	25.103	2.910	949.261	0.141	0.019	3.895	0.874	0.382	0.053
17000.0	0.254	24.691	2.979	948.988	0.147	0.020	3.932	0.908	0.400	0.057
17500.0	0.252	24.283	3.047	948.715	0.153	0.022	3.967	0.942	0.418	0.062
18000.0	0.251	23.878	3.115	948.441	0.158	0.023	3.999	0.975	0.436	0.067
18500.0	0.249	23.477	3.181	948.165	0.164	0.025	4.030	1.009	0.454	0.072
19000.0	0.248	23.080	3.247	947.889	0.170	0.026	4.058	1.042	0.472	0.078
19500.0	0.246	22.686	3.311	947.612	0.176	0.028	4.085	1.075	0.490	0.084
20000.0	0.245	22.296	3.375	947.333	0.182	0.030	4.110	1.108	0.508	0.090
20500.0	0.243	21.910	3.438	947.053	0.189	0.032	4.134	1.141	0.525	0.096
21000.0	0.242	21.527	3.501	946.772	0.195	0.033	4.156	1.173	0.543	0.102
22500.0	0.237	20.399	3.682	945.918	0.214	0.039	4.213	1.270	0.596	0.123
25000.0	0.230	18.593	3.968	944.465	0.247	0.050	4.284	1.426	0.683	0.162
27500.0	0.222	16.877	4.234	942.970	0.281	0.063	4.326	1.576	0.765	0.208
30000.0	0.215	15.251	4.478	941.433	0.315	0.078	4.344	1.720	0.841	0.259
32500.0	0.207	13.716	4.703	939.851	0.351	0.094	4.342	1.856	0.910	0.317
35000.0	0.200	12.271	4.907	938.221	0.386	0.112	4.323	1.984	0.972	0.380
37500.0	0.192	10.917	5.091	936.541	0.421	0.132	4.290	2.103	1.027	0.449
40000.0	0.185	9.654	5.256	934.808	0.456	0.153	4.247	2.214	1.075	0.523
42500.0	0.178	8.483	5.400	933.019	0.491	0.176	4.195	2.315	1.115	0.603
45000.0	0.171	7.405	5.524	931.174	0.524	0.199	4.138	2.406	1.148	0.687
47500.0	0.163	6.418	5.629	929.269	0.556	0.224	4.078	2.488	1.174	0.775
50000.0	0.156	5.522	5.715	927.304	0.587	0.249	4.015	2.560	1.195	0.867
52500.0	0.149	4.716	5.781	925.278	0.616	0.274	3.953	2.623	1.210	0.962
55000.0	0.142	3.998	5.830	923.191	0.643	0.299	3.892	2.676	1.220	1.059
57500.0	0.136	3.363	5.861	921.044	0.669	0.324	3.834	2.721	1.226	1.159
60000.0	0.129	2.809	5.877	918.839	0.692	0.348	3.779	2.758	1.229	1.261
62500.0	0.123	2.329	5.877	916.579	0.713	0.371	3.728	2.787	1.229	1.363
65000.0	0.117	1.919	5.863	914.268	0.732	0.392	3.682	2.809	1.227	1.465
67500.0	0.111	1.572	5.837	911.909	0.749	0.412	3.640	2.826	1.223	1.567
70000.0	0.105	1.280	5.800	909.508	0.763	0.431	3.603	2.838	1.218	1.668

Table C.39 [ ] Exposure-Dependent 80% Void Isotopics (kg/MTU Initial)

Exposure MWd/MTU	U-234	U-235	U-236	U-238	NP-237	PU-238	PU-239	PU-240	PU-241	PU-242
0.0	0.312	41.261	0.000	958.427	0.000	0.000	0.000	0.000	0.000	0.000
100.0	0.311	41.142	0.024	958.360	0.000	0.000	0.020	0.000	0.000	0.000
500.0	0.309	40.670	0.119	958.088	0.002	0.000	0.228	0.002	0.000	0.000
1000.0	0.307	40.090	0.236	957.749	0.005	0.000	0.505	0.008	0.000	0.000
1500.0	0.305	39.521	0.350	957.411	0.008	0.000	0.769	0.019	0.002	0.000
2000.0	0.303	38.963	0.461	957.073	0.011	0.000	1.019	0.033	0.004	0.000
2500.0	0.301	38.414	0.571	956.735	0.014	0.000	1.257	0.050	0.007	0.000
3000.0	0.298	37.874	0.678	956.399	0.018	0.001	1.483	0.070	0.012	0.000
3500.0	0.296	37.343	0.784	956.063	0.022	0.001	1.697	0.091	0.019	0.000
4000.0	0.294	36.820	0.887	955.728	0.026	0.001	1.902	0.115	0.026	0.001
4500.0	0.292	36.305	0.988	955.394	0.031	0.002	2.096	0.140	0.035	0.001
5000.0	0.290	35.797	1.088	955.061	0.035	0.002	2.282	0.166	0.045	0.002
5500.0	0.288	35.297	1.186	954.728	0.040	0.002	2.458	0.194	0.057	0.002
6000.0	0.286	34.804	1.282	954.395	0.045	0.003	2.626	0.223	0.070	0.003
6500.0	0.284	34.317	1.376	954.064	0.050	0.003	2.785	0.252	0.083	0.004
7000.0	0.282	33.837	1.469	953.733	0.056	0.004	2.937	0.283	0.098	0.005
7500.0	0.280	33.362	1.560	953.403	0.061	0.005	3.082	0.314	0.114	0.006
8000.0	0.278	32.894	1.649	953.074	0.067	0.006	3.219	0.346	0.130	0.007
8500.0	0.276	32.432	1.737	952.746	0.073	0.006	3.350	0.379	0.147	0.009
9000.0	0.274	31.975	1.824	952.419	0.079	0.007	3.474	0.412	0.165	0.010
9500.0	0.272	31.524	1.909	952.092	0.085	0.008	3.592	0.446	0.183	0.012
10000.0	0.270	31.077	1.993	951.766	0.091	0.009	3.704	0.480	0.202	0.015
10500.0	0.268	30.636	2.076	951.441	0.097	0.010	3.810	0.514	0.222	0.017
11000.0	0.267	30.200	2.157	951.116	0.104	0.011	3.911	0.549	0.242	0.019
11500.0	0.265	29.769	2.237	950.792	0.110	0.013	4.007	0.584	0.262	0.022
12000.0	0.263	29.342	2.316	950.468	0.116	0.014	4.098	0.620	0.282	0.025
12500.0	0.261	28.920	2.393	950.145	0.123	0.015	4.184	0.655	0.303	0.028
13000.0	0.259	28.502	2.470	949.822	0.130	0.017	4.266	0.691	0.324	0.031
13500.0	0.257	28.089	2.545	949.499	0.136	0.018	4.344	0.727	0.345	0.035
14000.0	0.256	27.680	2.619	949.177	0.143	0.020	4.417	0.763	0.366	0.039
14500.0	0.254	27.275	2.693	948.855	0.150	0.021	4.487	0.800	0.387	0.043
15000.0	0.252	26.874	2.765	948.533	0.157	0.023	4.553	0.836	0.409	0.047
15500.0	0.250	26.476	2.836	948.212	0.164	0.025	4.615	0.872	0.430	0.051
16000.0	0.249	26.083	2.906	947.890	0.171	0.027	4.674	0.909	0.452	0.056
16500.0	0.247	25.694	2.975	947.568	0.178	0.028	4.730	0.945	0.473	0.061
17000.0	0.245	25.308	3.043	947.247	0.185	0.030	4.783	0.982	0.494	0.066
17500.0	0.244	24.926	3.110	946.925	0.192	0.032	4.832	1.018	0.516	0.071
18000.0	0.242	24.548	3.176	946.604	0.200	0.035	4.879	1.055	0.537	0.076
18500.0	0.240	24.173	3.241	946.282	0.207	0.037	4.924	1.091	0.558	0.082
19000.0	0.239	23.802	3.305	945.959	0.214	0.039	4.966	1.127	0.579	0.088
19500.0	0.237	23.434	3.368	945.636	0.221	0.041	5.006	1.163	0.600	0.094
20000.0	0.235	23.070	3.431	945.312	0.229	0.044	5.044	1.199	0.621	0.100
20500.0	0.234	22.710	3.492	944.986	0.236	0.046	5.079	1.235	0.642	0.107
21000.0	0.232	22.353	3.553	944.660	0.244	0.049	5.114	1.271	0.663	0.113
21500.0	0.230	22.000	3.613	944.333	0.251	0.052	5.146	1.306	0.684	0.120
22000.0	0.229	21.650	3.672	944.005	0.259	0.054	5.177	1.341	0.705	0.127
22500.0	0.227	21.304	3.730	943.675	0.266	0.057	5.206	1.376	0.725	0.135
23000.0	0.226	20.961	3.787	943.344	0.274	0.060	5.233	1.411	0.746	0.142
25000.0	0.219	19.626	4.007	942.007	0.305	0.073	5.331	1.548	0.827	0.174
27500.0	0.211	18.036	4.263	940.303	0.344	0.090	5.426	1.713	0.925	0.219
30000.0	0.204	16.531	4.499	938.562	0.383	0.110	5.493	1.871	1.018	0.269
32500.0	0.196	15.110	4.714	936.786	0.423	0.132	5.538	2.023	1.105	0.324
35000.0	0.189	13.772	4.910	934.971	0.462	0.156	5.562	2.167	1.185	0.383
37500.0	0.181	12.515	5.086	933.119	0.501	0.182	5.570	2.302	1.259	0.447
40000.0	0.174	11.337	5.244	931.227	0.539	0.210	5.563	2.430	1.326	0.514
42500.0	0.167	10.238	5.383	929.296	0.577	0.239	5.545	2.550	1.386	0.585
45000.0	0.161	9.214	5.504	927.325	0.613	0.270	5.518	2.660	1.439	0.660
47500.0	0.154	8.265	5.608	925.314	0.649	0.302	5.482	2.762	1.485	0.737
50000.0	0.148	7.388	5.695	923.262	0.683	0.335	5.441	2.856	1.526	0.817
52500.0	0.141	6.582	5.766	921.171	0.715	0.368	5.396	2.941	1.560	0.900
55000.0	0.135	5.843	5.821	919.041	0.746	0.402	5.348	3.017	1.589	0.984
57500.0	0.129	5.170	5.862	916.872	0.774	0.435	5.298	3.086	1.613	1.070
60000.0	0.124	4.558	5.889	914.666	0.801	0.469	5.248	3.146	1.633	1.158
62500.0	0.118	4.006	5.903	912.424	0.826	0.502	5.198	3.200	1.649	1.247
65000.0	0.113	3.509	5.905	910.148	0.848	0.534	5.149	3.246	1.661	1.337
67500.0	0.108	3.065	5.896	907.839	0.868	0.565	5.102	3.286	1.669	1.427
70000.0	0.104	2.670	5.876	905.499	0.887	0.594	5.057	3.320	1.676	1.518

Table C.40 [ ] Exposure-Dependent 0% Void Isotopics (kg/MTU Initial)

Exposure MWd/MTU	U-234	U-235	U-236	U-238	NP-237	PU-238	PU-239	PU-240	PU-241	PU-242
0.0	0.309	40.975	0.000	958.716	0.000	0.000	0.000	0.000	0.000	0.000
100.0	0.309	40.855	0.022	958.669	0.000	0.000	0.015	0.000	0.000	0.000
500.0	0.308	40.377	0.108	958.479	0.001	0.000	0.163	0.001	0.000	0.000
1000.0	0.306	39.787	0.214	958.242	0.003	0.000	0.361	0.006	0.000	0.000
1500.0	0.304	39.205	0.318	958.004	0.005	0.000	0.550	0.014	0.001	0.000
2000.0	0.303	38.631	0.421	957.766	0.007	0.000	0.729	0.024	0.002	0.000
2500.0	0.301	38.063	0.522	957.529	0.009	0.000	0.899	0.037	0.004	0.000
3000.0	0.300	37.503	0.622	957.292	0.011	0.000	1.061	0.052	0.006	0.000
3500.0	0.298	36.949	0.720	957.055	0.014	0.000	1.215	0.069	0.009	0.000
4000.0	0.296	36.402	0.817	956.818	0.016	0.001	1.361	0.088	0.013	0.000
4500.0	0.295	35.860	0.912	956.581	0.019	0.001	1.500	0.108	0.018	0.001
5000.0	0.293	35.324	1.006	956.344	0.022	0.001	1.631	0.130	0.023	0.001
5500.0	0.292	34.794	1.099	956.108	0.025	0.001	1.756	0.153	0.030	0.001
6000.0	0.290	34.270	1.191	955.872	0.028	0.001	1.875	0.177	0.037	0.002
6500.0	0.289	33.750	1.281	955.637	0.031	0.002	1.987	0.202	0.045	0.002
7000.0	0.287	33.236	1.371	955.402	0.034	0.002	2.093	0.227	0.053	0.003
7500.0	0.286	32.726	1.459	955.167	0.038	0.002	2.193	0.254	0.063	0.003
8000.0	0.284	32.221	1.546	954.933	0.041	0.003	2.288	0.281	0.072	0.004
8500.0	0.283	31.721	1.632	954.700	0.045	0.003	2.377	0.309	0.083	0.005
9000.0	0.281	31.225	1.717	954.467	0.048	0.003	2.461	0.337	0.094	0.006
9500.0	0.280	30.733	1.801	954.236	0.052	0.004	2.540	0.366	0.105	0.007
10000.0	0.278	30.245	1.883	954.004	0.056	0.004	2.614	0.396	0.117	0.009
10500.0	0.277	29.761	1.965	953.774	0.059	0.005	2.684	0.425	0.129	0.010
11000.0	0.276	29.281	2.046	953.543	0.063	0.005	2.749	0.455	0.141	0.012
11500.0	0.274	28.805	2.126	953.313	0.067	0.006	2.811	0.485	0.154	0.014
12000.0	0.273	28.332	2.205	953.082	0.071	0.006	2.869	0.516	0.167	0.016
12500.0	0.271	27.864	2.283	952.851	0.075	0.007	2.924	0.547	0.181	0.018
13000.0	0.270	27.399	2.360	952.618	0.080	0.008	2.977	0.577	0.195	0.020
13500.0	0.268	26.938	2.437	952.385	0.084	0.008	3.026	0.609	0.209	0.023
14000.0	0.267	26.481	2.512	952.151	0.088	0.009	3.073	0.640	0.223	0.025
14500.0	0.266	26.028	2.587	951.915	0.093	0.010	3.117	0.671	0.237	0.028
15000.0	0.264	25.579	2.661	951.679	0.097	0.011	3.159	0.702	0.252	0.031
15500.0	0.263	25.134	2.733	951.441	0.102	0.011	3.199	0.734	0.267	0.035
17500.0	0.257	23.391	3.017	950.474	0.122	0.015	3.338	0.860	0.329	0.050
20000.0	0.250	21.297	3.352	949.231	0.148	0.021	3.469	1.016	0.407	0.074
22500.0	0.242	19.299	3.667	947.949	0.175	0.028	3.560	1.171	0.485	0.105
25000.0	0.235	17.395	3.961	946.623	0.204	0.037	3.616	1.322	0.561	0.142
27500.0	0.228	15.587	4.235	945.250	0.234	0.047	3.645	1.469	0.632	0.185
30000.0	0.220	13.876	4.487	943.826	0.265	0.059	3.649	1.610	0.697	0.235
32500.0	0.213	12.264	4.719	942.347	0.297	0.072	3.633	1.744	0.756	0.293
35000.0	0.205	10.754	4.929	940.808	0.329	0.087	3.602	1.870	0.808	0.357
37500.0	0.198	9.348	5.117	939.205	0.361	0.103	3.560	1.987	0.854	0.428
40000.0	0.190	8.050	5.283	937.533	0.393	0.121	3.508	2.094	0.892	0.506
42500.0	0.182	6.861	5.426	935.788	0.425	0.139	3.451	2.191	0.923	0.590
45000.0	0.174	5.785	5.547	933.964	0.456	0.159	3.390	2.278	0.947	0.681
47500.0	0.166	4.821	5.645	932.060	0.486	0.180	3.329	2.354	0.966	0.777
50000.0	0.159	3.970	5.720	930.073	0.514	0.200	3.269	2.420	0.979	0.878
52500.0	0.151	3.231	5.774	928.003	0.541	0.221	3.213	2.474	0.987	0.984
55000.0	0.143	2.598	5.807	925.851	0.566	0.241	3.161	2.519	0.992	1.093
57500.0	0.135	2.065	5.821	923.622	0.588	0.261	3.114	2.555	0.994	1.205
60000.0	0.128	1.625	5.817	921.320	0.608	0.279	3.072	2.582	0.993	1.318
62500.0	0.121	1.266	5.798	918.954	0.626	0.297	3.036	2.603	0.991	1.432
65000.0	0.114	0.979	5.765	916.532	0.642	0.312	3.006	2.617	0.988	1.545
67500.0	0.107	0.752	5.722	914.061	0.655	0.326	2.980	2.627	0.985	1.658
70000.0	0.101	0.575	5.670	911.552	0.666	0.338	2.959	2.632	0.981	1.768

Table C.41 [ ] Exposure-Dependent 40% Void Isotopics (kg/MTU Initial)

Exposure MWd/MTU	U-234	U-235	U-236	U-238	NP-237	PU-238	PU-239	PU-240	PU-241	PU-242
0.0	0.309	40.975	0.000	958.716	0.000	0.000	0.000	0.000	0.000	0.000
100.0	0.309	40.855	0.022	958.662	0.000	0.000	0.017	0.000	0.000	0.000
500.0	0.307	40.379	0.112	958.443	0.002	0.000	0.186	0.001	0.000	0.000
1000.0	0.305	39.793	0.221	958.169	0.004	0.000	0.413	0.007	0.000	0.000
1500.0	0.304	39.215	0.329	957.896	0.006	0.000	0.628	0.016	0.001	0.000
2000.0	0.302	38.647	0.435	957.623	0.008	0.000	0.832	0.028	0.003	0.000
2500.0	0.300	38.086	0.539	957.350	0.011	0.000	1.026	0.042	0.005	0.000
3000.0	0.298	37.533	0.641	957.077	0.013	0.000	1.211	0.059	0.008	0.000
3500.0	0.297	36.988	0.742	956.805	0.016	0.001	1.386	0.078	0.012	0.000
4000.0	0.295	36.450	0.840	956.534	0.020	0.001	1.552	0.099	0.017	0.000
4500.0	0.293	35.918	0.938	956.262	0.023	0.001	1.709	0.122	0.024	0.001
5000.0	0.291	35.393	1.034	955.991	0.026	0.001	1.859	0.145	0.031	0.001
5500.0	0.290	34.874	1.128	955.721	0.030	0.001	2.001	0.170	0.039	0.001
6000.0	0.288	34.361	1.221	955.451	0.034	0.002	2.136	0.196	0.048	0.002
6500.0	0.286	33.854	1.313	955.182	0.037	0.002	2.264	0.223	0.058	0.003
7000.0	0.285	33.353	1.403	954.913	0.041	0.003	2.385	0.251	0.069	0.003
7500.0	0.283	32.857	1.492	954.645	0.045	0.003	2.499	0.280	0.081	0.004
8000.0	0.281	32.366	1.580	954.378	0.050	0.003	2.608	0.309	0.093	0.005
8500.0	0.280	31.880	1.666	954.111	0.054	0.004	2.710	0.339	0.106	0.006
9000.0	0.278	31.399	1.751	953.845	0.058	0.004	2.807	0.369	0.120	0.008
9500.0	0.276	30.923	1.835	953.580	0.063	0.005	2.898	0.400	0.134	0.009
10000.0	0.275	30.451	1.918	953.316	0.067	0.006	2.984	0.432	0.148	0.011
10500.0	0.273	29.984	2.000	953.052	0.072	0.006	3.064	0.463	0.163	0.013
11000.0	0.272	29.520	2.080	952.789	0.077	0.007	3.140	0.495	0.178	0.015
11500.0	0.270	29.061	2.160	952.527	0.082	0.008	3.212	0.527	0.194	0.017
12000.0	0.269	28.606	2.238	952.264	0.087	0.008	3.280	0.560	0.209	0.019
12500.0	0.267	28.155	2.316	952.001	0.092	0.009	3.345	0.592	0.225	0.022
13000.0	0.265	27.708	2.392	951.738	0.097	0.010	3.405	0.625	0.242	0.025
13500.0	0.264	27.265	2.468	951.474	0.102	0.011	3.463	0.658	0.259	0.028
14000.0	0.262	26.826	2.543	951.209	0.107	0.012	3.518	0.691	0.275	0.031
14500.0	0.261	26.391	2.616	950.943	0.112	0.013	3.570	0.724	0.293	0.034
15000.0	0.259	25.960	2.689	950.676	0.118	0.014	3.620	0.757	0.310	0.038
15500.0	0.258	25.533	2.761	950.407	0.123	0.015	3.667	0.790	0.328	0.041
16000.0	0.256	25.110	2.832	950.138	0.129	0.017	3.712	0.823	0.345	0.045
16500.0	0.255	24.691	2.902	949.867	0.135	0.018	3.755	0.856	0.363	0.050
17500.0	0.252	23.865	3.040	949.321	0.146	0.020	3.834	0.922	0.399	0.059
20000.0	0.244	21.868	3.368	947.930	0.177	0.028	3.998	1.085	0.490	0.086
22500.0	0.236	19.966	3.675	946.503	0.208	0.037	4.118	1.245	0.581	0.119
25000.0	0.229	18.160	3.960	945.036	0.242	0.048	4.202	1.402	0.668	0.158
27500.0	0.221	16.448	4.224	943.528	0.276	0.061	4.254	1.553	0.750	0.203
30000.0	0.214	14.829	4.466	941.976	0.311	0.076	4.280	1.698	0.826	0.255
32500.0	0.206	13.304	4.688	940.377	0.347	0.092	4.284	1.836	0.896	0.313
35000.0	0.198	11.871	4.890	938.730	0.383	0.110	4.270	1.966	0.958	0.376
37500.0	0.191	10.532	5.070	937.032	0.418	0.130	4.242	2.087	1.013	0.446
40000.0	0.184	9.287	5.231	935.279	0.453	0.151	4.202	2.199	1.061	0.521
42500.0	0.176	8.136	5.371	933.470	0.488	0.174	4.153	2.302	1.102	0.601
45000.0	0.169	7.078	5.491	931.603	0.521	0.198	4.098	2.395	1.135	0.685
47500.0	0.162	6.115	5.591	929.675	0.553	0.222	4.040	2.478	1.162	0.774
50000.0	0.155	5.243	5.671	927.686	0.584	0.248	3.980	2.551	1.183	0.867
52500.0	0.148	4.462	5.733	925.636	0.613	0.273	3.920	2.615	1.198	0.963
55000.0	0.141	3.769	5.777	923.524	0.640	0.298	3.861	2.669	1.209	1.062
57500.0	0.134	3.160	5.804	921.353	0.665	0.323	3.805	2.714	1.215	1.162
60000.0	0.127	2.630	5.815	919.124	0.688	0.346	3.753	2.751	1.218	1.264
62500.0	0.121	2.174	5.810	916.841	0.709	0.369	3.705	2.780	1.219	1.367
65000.0	0.115	1.786	5.793	914.508	0.728	0.390	3.661	2.803	1.217	1.470
67500.0	0.109	1.458	5.764	912.129	0.744	0.410	3.622	2.820	1.214	1.572
70000.0	0.103	1.185	5.724	909.710	0.758	0.428	3.587	2.832	1.210	1.674

Table C.42 [ ] Exposure-Dependent 80% Void Isotopics (kg/MTU Initial)

Exposure MWd/MTU	U-234	U-235	U-236	U-238	NP-237	PU-238	PU-239	PU-240	PU-241	PU-242
0.0	0.309	40.975	0.000	958.716	0.000	0.000	0.000	0.000	0.000	0.000
100.0	0.309	40.856	0.024	958.652	0.000	0.000	0.020	0.000	0.000	0.000
500.0	0.307	40.383	0.118	958.391	0.002	0.000	0.219	0.002	0.000	0.000
1000.0	0.305	39.803	0.233	958.066	0.004	0.000	0.484	0.008	0.000	0.000
1500.0	0.303	39.233	0.346	957.742	0.007	0.000	0.736	0.018	0.002	0.000
2000.0	0.301	38.673	0.456	957.418	0.010	0.000	0.976	0.032	0.004	0.000
2500.0	0.298	38.122	0.564	957.095	0.014	0.000	1.203	0.049	0.007	0.000
3000.0	0.296	37.580	0.671	956.772	0.017	0.001	1.419	0.068	0.012	0.000
3500.0	0.294	37.047	0.775	956.450	0.021	0.001	1.624	0.089	0.017	0.000
4000.0	0.292	36.522	0.877	956.128	0.025	0.001	1.820	0.112	0.024	0.001
4500.0	0.290	36.004	0.978	955.807	0.029	0.001	2.006	0.137	0.033	0.001
5000.0	0.288	35.493	1.077	955.486	0.033	0.002	2.182	0.163	0.043	0.001
5500.0	0.286	34.990	1.174	955.166	0.038	0.002	2.351	0.190	0.053	0.002
6000.0	0.284	34.493	1.269	954.847	0.043	0.003	2.511	0.218	0.065	0.003
6500.0	0.282	34.003	1.363	954.528	0.048	0.003	2.663	0.247	0.078	0.003
7000.0	0.280	33.519	1.455	954.210	0.053	0.004	2.808	0.278	0.092	0.004
7500.0	0.278	33.041	1.546	953.892	0.058	0.004	2.946	0.308	0.107	0.006
8000.0	0.277	32.569	1.635	953.575	0.064	0.005	3.077	0.340	0.123	0.007
8500.0	0.275	32.103	1.723	953.259	0.069	0.006	3.202	0.372	0.139	0.008
9000.0	0.273	31.642	1.809	952.944	0.075	0.007	3.320	0.405	0.156	0.010
9500.0	0.271	31.186	1.894	952.630	0.081	0.008	3.432	0.438	0.173	0.012
10000.0	0.269	30.735	1.978	952.316	0.087	0.008	3.538	0.472	0.191	0.014
10500.0	0.267	30.289	2.060	952.003	0.092	0.009	3.639	0.506	0.210	0.016
11000.0	0.266	29.847	2.141	951.691	0.098	0.010	3.735	0.540	0.228	0.018
11500.0	0.264	29.410	2.221	951.379	0.105	0.012	3.826	0.575	0.247	0.021
12000.0	0.262	28.978	2.300	951.067	0.111	0.013	3.912	0.609	0.267	0.024
12500.0	0.260	28.550	2.378	950.756	0.117	0.014	3.995	0.644	0.286	0.027
13000.0	0.259	28.126	2.454	950.444	0.123	0.015	4.073	0.680	0.306	0.030
13500.0	0.257	27.707	2.530	950.133	0.130	0.017	4.148	0.715	0.326	0.033
14000.0	0.255	27.292	2.604	949.821	0.136	0.018	4.219	0.750	0.346	0.037
14500.0	0.253	26.881	2.677	949.508	0.143	0.020	4.287	0.786	0.367	0.040
15000.0	0.252	26.474	2.750	949.195	0.150	0.021	4.352	0.821	0.387	0.044
15500.0	0.250	26.071	2.821	948.881	0.156	0.023	4.414	0.857	0.408	0.049
16000.0	0.248	25.673	2.891	948.566	0.163	0.025	4.473	0.893	0.429	0.053
16500.0	0.247	25.278	2.961	948.249	0.170	0.026	4.530	0.928	0.450	0.058
17000.0	0.245	24.888	3.029	947.932	0.177	0.028	4.585	0.964	0.471	0.062
17500.0	0.243	24.501	3.096	947.613	0.184	0.030	4.637	0.999	0.492	0.068
18000.0	0.242	24.119	3.162	947.293	0.192	0.032	4.687	1.035	0.513	0.073
20000.0	0.235	22.628	3.418	946.000	0.221	0.041	4.867	1.176	0.598	0.096
22500.0	0.227	20.853	3.717	944.352	0.259	0.054	5.051	1.349	0.704	0.130
25000.0	0.219	19.172	3.994	942.670	0.298	0.070	5.195	1.519	0.807	0.170
27500.0	0.211	17.582	4.249	940.951	0.338	0.087	5.304	1.683	0.905	0.215
30000.0	0.203	16.081	4.483	939.197	0.377	0.107	5.384	1.842	0.998	0.265
32500.0	0.195	14.667	4.696	937.404	0.417	0.129	5.438	1.995	1.085	0.320
35000.0	0.188	13.338	4.889	935.574	0.457	0.153	5.471	2.140	1.166	0.379
37500.0	0.180	12.092	5.062	933.704	0.496	0.179	5.485	2.277	1.239	0.443
40000.0	0.173	10.928	5.216	931.795	0.535	0.207	5.484	2.407	1.306	0.511
42500.0	0.166	9.844	5.351	929.845	0.573	0.236	5.471	2.528	1.366	0.582
45000.0	0.159	8.838	5.468	927.855	0.609	0.267	5.447	2.640	1.419	0.657
47500.0	0.153	7.907	5.568	925.824	0.645	0.299	5.415	2.743	1.466	0.735
50000.0	0.146	7.050	5.650	923.753	0.678	0.332	5.377	2.838	1.507	0.816
52500.0	0.140	6.264	5.717	921.641	0.711	0.365	5.335	2.924	1.541	0.899
55000.0	0.134	5.546	5.768	919.490	0.741	0.399	5.290	3.001	1.571	0.984
57500.0	0.128	4.893	5.805	917.300	0.769	0.433	5.243	3.071	1.595	1.071
60000.0	0.122	4.303	5.827	915.073	0.796	0.466	5.196	3.132	1.615	1.159
62500.0	0.117	3.772	5.837	912.810	0.820	0.499	5.149	3.186	1.631	1.249
65000.0	0.112	3.296	5.835	910.513	0.842	0.531	5.103	3.232	1.644	1.339
67500.0	0.107	2.872	5.822	908.185	0.862	0.561	5.059	3.273	1.653	1.430
70000.0	0.102	2.495	5.799	905.826	0.880	0.591	5.016	3.307	1.660	1.521

Table C.43 [ ] Exposure-Dependent 0% Void Isotopics (kg/MTU Initial)

Exposure MWd/MTU	U-234	U-235	U-236	U-238	NP-237	PU-238	PU-239	PU-240	PU-241	PU-242
0.0	0.339	44.888	0.000	954.773	0.000	0.000	0.000	0.000	0.000	0.000
100.0	0.338	44.768	0.023	954.721	0.000	0.000	0.019	0.000	0.000	0.000
500.0	0.337	44.290	0.113	954.510	0.002	0.000	0.189	0.001	0.000	0.000
1000.0	0.335	43.700	0.224	954.245	0.003	0.000	0.409	0.006	0.000	0.000
1500.0	0.333	43.118	0.333	953.979	0.005	0.000	0.620	0.014	0.001	0.000
2000.0	0.331	42.544	0.441	953.714	0.008	0.000	0.821	0.025	0.002	0.000
2500.0	0.329	41.978	0.547	953.448	0.010	0.000	1.013	0.039	0.004	0.000
3000.0	0.327	41.419	0.651	953.181	0.013	0.000	1.197	0.054	0.007	0.000
3500.0	0.325	40.867	0.754	952.915	0.016	0.000	1.373	0.072	0.011	0.000
4000.0	0.324	40.321	0.856	952.648	0.019	0.001	1.541	0.091	0.016	0.000
4500.0	0.322	39.781	0.956	952.382	0.022	0.001	1.702	0.112	0.021	0.001
5000.0	0.320	39.248	1.054	952.114	0.026	0.001	1.855	0.134	0.028	0.001
5500.0	0.318	38.721	1.152	951.847	0.029	0.001	2.002	0.157	0.035	0.001
6000.0	0.316	38.200	1.247	951.580	0.033	0.002	2.143	0.181	0.044	0.002
6500.0	0.315	37.684	1.342	951.312	0.037	0.002	2.277	0.206	0.053	0.002
7000.0	0.313	37.173	1.435	951.044	0.041	0.002	2.406	0.233	0.063	0.003
7500.0	0.311	36.668	1.527	950.776	0.045	0.003	2.529	0.259	0.074	0.004
8000.0	0.309	36.168	1.618	950.508	0.050	0.003	2.646	0.287	0.086	0.005
8500.0	0.307	35.673	1.708	950.239	0.054	0.004	2.758	0.315	0.099	0.006
9000.0	0.306	35.183	1.797	949.971	0.059	0.004	2.865	0.343	0.112	0.007
9500.0	0.304	34.698	1.884	949.702	0.063	0.005	2.967	0.373	0.125	0.008
10000.0	0.302	34.217	1.970	949.434	0.068	0.005	3.064	0.402	0.140	0.010
10500.0	0.300	33.741	2.055	949.165	0.073	0.006	3.157	0.432	0.155	0.011
11000.0	0.299	33.270	2.139	948.896	0.078	0.007	3.245	0.462	0.170	0.013
11500.0	0.297	32.802	2.222	948.628	0.083	0.008	3.329	0.493	0.186	0.015
12000.0	0.295	32.339	2.304	948.359	0.088	0.008	3.408	0.524	0.202	0.017
12500.0	0.294	31.880	2.385	948.090	0.094	0.009	3.484	0.555	0.218	0.020
13000.0	0.292	31.425	2.465	947.821	0.099	0.010	3.556	0.587	0.235	0.022
13500.0	0.290	30.974	2.544	947.552	0.105	0.011	3.625	0.618	0.252	0.025
14000.0	0.289	30.527	2.622	947.283	0.110	0.012	3.690	0.650	0.269	0.028
14500.0	0.287	30.084	2.699	947.014	0.116	0.013	3.751	0.682	0.286	0.031
15000.0	0.285	29.645	2.775	946.744	0.122	0.014	3.809	0.714	0.304	0.034
15500.0	0.284	29.209	2.850	946.475	0.128	0.015	3.864	0.746	0.322	0.038
16000.0	0.282	28.776	2.924	946.205	0.133	0.017	3.916	0.778	0.340	0.041
16500.0	0.280	28.348	2.997	945.935	0.139	0.018	3.966	0.810	0.357	0.045
17000.0	0.279	27.922	3.069	945.665	0.145	0.019	4.012	0.842	0.375	0.049
17500.0	0.277	27.500	3.141	945.395	0.151	0.021	4.056	0.875	0.393	0.054
18000.0	0.276	27.082	3.212	945.124	0.157	0.022	4.097	0.907	0.411	0.058
18500.0	0.274	26.667	3.282	944.852	0.164	0.024	4.136	0.939	0.429	0.063
19000.0	0.272	26.256	3.351	944.580	0.170	0.025	4.173	0.971	0.447	0.068
19500.0	0.271	25.847	3.419	944.307	0.176	0.027	4.208	1.003	0.465	0.073
20000.0	0.269	25.443	3.486	944.033	0.182	0.028	4.240	1.035	0.483	0.078
20500.0	0.267	25.042	3.553	943.758	0.189	0.030	4.271	1.067	0.501	0.084
21000.0	0.266	24.644	3.618	943.481	0.195	0.032	4.301	1.098	0.519	0.089
21500.0	0.264	24.249	3.683	943.204	0.202	0.034	4.328	1.130	0.537	0.095
22000.0	0.263	23.858	3.747	942.925	0.208	0.036	4.354	1.161	0.555	0.101
22500.0	0.261	23.471	3.811	942.645	0.215	0.038	4.379	1.193	0.573	0.108
23000.0	0.260	23.087	3.873	942.364	0.222	0.040	4.402	1.224	0.591	0.114
23500.0	0.258	22.706	3.935	942.082	0.228	0.042	4.424	1.255	0.609	0.121
25000.0	0.253	21.585	4.115	941.225	0.249	0.049	4.481	1.346	0.661	0.143
27500.0	0.245	19.785	4.400	939.768	0.284	0.062	4.552	1.495	0.747	0.184
30000.0	0.237	18.070	4.664	938.273	0.320	0.077	4.597	1.638	0.828	0.230
32500.0	0.230	16.440	4.909	936.738	0.357	0.093	4.619	1.774	0.904	0.282
35000.0	0.222	14.895	5.134	935.161	0.394	0.112	4.620	1.904	0.973	0.339
37500.0	0.214	13.435	5.340	933.540	0.431	0.132	4.605	2.027	1.036	0.402
40000.0	0.207	12.061	5.527	931.873	0.468	0.154	4.577	2.142	1.091	0.469
42500.0	0.199	10.772	5.694	930.158	0.505	0.178	4.537	2.249	1.140	0.542
45000.0	0.192	9.569	5.842	928.393	0.542	0.203	4.488	2.348	1.181	0.619
47500.0	0.184	8.452	5.971	926.576	0.577	0.229	4.433	2.438	1.216	0.700
50000.0	0.177	7.421	6.081	924.706	0.611	0.256	4.373	2.519	1.245	0.785
52500.0	0.170	6.476	6.173	922.781	0.644	0.284	4.310	2.591	1.268	0.874
55000.0	0.163	5.615	6.247	920.800	0.676	0.312	4.247	2.655	1.285	0.965
57500.0	0.156	4.836	6.302	918.763	0.706	0.340	4.183	2.711	1.297	1.059
60000.0	0.149	4.139	6.341	916.670	0.733	0.368	4.121	2.758	1.305	1.155
62500.0	0.142	3.519	6.364	914.523	0.759	0.395	4.061	2.797	1.309	1.253
65000.0	0.136	2.973	6.372	912.323	0.783	0.420	4.005	2.830	1.310	1.351
67500.0	0.129	2.496	6.365	910.072	0.804	0.445	3.952	2.855	1.309	1.450
70000.0	0.123	2.084	6.346	907.774	0.823	0.468	3.904	2.875	1.305	1.549

Table C.44 [ ] Exposure-Dependent 40% Void Isotopics (kg/MTU Initial)

Exposure MWd/MTU	U-234	U-235	U-236	U-238	NP-237	PU-238	PU-239	PU-240	PU-241	PU-242
0.0	0.339	44.888	0.000	954.773	0.000	0.000	0.000	0.000	0.000	0.000
100.0	0.338	44.768	0.024	954.714	0.000	0.000	0.021	0.000	0.000	0.000
500.0	0.336	44.292	0.117	954.474	0.002	0.000	0.213	0.002	0.000	0.000
1000.0	0.334	43.705	0.233	954.173	0.004	0.000	0.462	0.007	0.000	0.000
1500.0	0.332	43.128	0.346	953.871	0.007	0.000	0.699	0.016	0.001	0.000
2000.0	0.330	42.559	0.457	953.570	0.009	0.000	0.926	0.029	0.003	0.000
2500.0	0.328	41.999	0.566	953.268	0.012	0.000	1.142	0.043	0.006	0.000
3000.0	0.326	41.447	0.674	952.966	0.016	0.000	1.349	0.061	0.009	0.000
3500.0	0.324	40.902	0.779	952.664	0.019	0.001	1.547	0.080	0.014	0.000
4000.0	0.322	40.365	0.884	952.362	0.023	0.001	1.737	0.101	0.020	0.000
4500.0	0.320	39.834	0.986	952.060	0.027	0.001	1.918	0.123	0.027	0.001
5000.0	0.318	39.310	1.087	951.758	0.031	0.001	2.092	0.147	0.035	0.001
5500.0	0.316	38.793	1.186	951.455	0.035	0.002	2.259	0.172	0.044	0.002
6000.0	0.314	38.282	1.284	951.152	0.039	0.002	2.418	0.197	0.055	0.002
6500.0	0.312	37.778	1.380	950.849	0.044	0.003	2.571	0.224	0.066	0.003
7000.0	0.310	37.279	1.475	950.546	0.049	0.003	2.717	0.252	0.078	0.004
7500.0	0.308	36.786	1.569	950.243	0.054	0.004	2.857	0.280	0.092	0.005
8000.0	0.306	36.298	1.661	949.940	0.059	0.004	2.991	0.310	0.106	0.006
8500.0	0.304	35.816	1.752	949.636	0.064	0.005	3.120	0.339	0.120	0.007
9000.0	0.302	35.339	1.841	949.333	0.070	0.006	3.242	0.370	0.136	0.008
9500.0	0.300	34.867	1.930	949.030	0.075	0.006	3.360	0.400	0.152	0.010
10000.0	0.298	34.401	2.017	948.726	0.081	0.007	3.472	0.432	0.169	0.011
10500.0	0.296	33.939	2.102	948.423	0.087	0.008	3.580	0.463	0.186	0.013
11000.0	0.294	33.482	2.187	948.120	0.093	0.009	3.682	0.495	0.204	0.015
11500.0	0.292	33.029	2.270	947.816	0.099	0.010	3.780	0.527	0.222	0.018
12000.0	0.291	32.582	2.352	947.513	0.105	0.011	3.874	0.560	0.241	0.020
12500.0	0.289	32.138	2.433	947.209	0.111	0.012	3.964	0.593	0.260	0.023
13000.0	0.287	31.699	2.513	946.906	0.118	0.013	4.049	0.626	0.279	0.026
13500.0	0.285	31.264	2.592	946.602	0.124	0.015	4.131	0.659	0.299	0.029
14000.0	0.283	30.833	2.670	946.298	0.131	0.016	4.209	0.692	0.319	0.032
14500.0	0.281	30.407	2.747	945.994	0.137	0.017	4.283	0.726	0.339	0.035
15000.0	0.280	29.984	2.823	945.690	0.144	0.019	4.354	0.759	0.359	0.039
15500.0	0.278	29.566	2.897	945.385	0.151	0.020	4.421	0.793	0.380	0.043
16000.0	0.276	29.151	2.971	945.081	0.158	0.022	4.485	0.827	0.400	0.047
16500.0	0.274	28.740	3.044	944.776	0.165	0.024	4.546	0.861	0.421	0.051
17000.0	0.273	28.332	3.116	944.472	0.171	0.025	4.604	0.895	0.441	0.055
17500.0	0.271	27.929	3.187	944.166	0.178	0.027	4.659	0.929	0.462	0.060
18000.0	0.269	27.529	3.257	943.861	0.185	0.029	4.712	0.963	0.482	0.065
18500.0	0.267	27.132	3.326	943.555	0.192	0.031	4.761	0.996	0.503	0.070
19000.0	0.266	26.739	3.394	943.249	0.200	0.033	4.809	1.030	0.524	0.075
19500.0	0.264	26.349	3.462	942.942	0.207	0.035	4.854	1.064	0.544	0.081
20000.0	0.262	25.963	3.528	942.635	0.214	0.037	4.897	1.098	0.565	0.086
20500.0	0.261	25.581	3.594	942.326	0.221	0.039	4.937	1.131	0.585	0.092
21000.0	0.259	25.202	3.658	942.017	0.229	0.042	4.976	1.165	0.606	0.098
21500.0	0.257	24.826	3.722	941.707	0.236	0.044	5.013	1.198	0.626	0.104
22000.0	0.255	24.454	3.785	941.395	0.244	0.047	5.048	1.231	0.646	0.111
22500.0	0.254	24.086	3.847	941.083	0.251	0.049	5.082	1.264	0.667	0.118
23000.0	0.252	23.721	3.909	940.770	0.259	0.052	5.113	1.297	0.687	0.124
23500.0	0.250	23.359	3.969	940.455	0.266	0.054	5.144	1.330	0.707	0.132
24000.0	0.249	23.000	4.029	940.139	0.274	0.057	5.173	1.363	0.727	0.139
24500.0	0.247	22.646	4.087	939.822	0.282	0.060	5.200	1.395	0.747	0.146
25000.0	0.246	22.294	4.145	939.503	0.289	0.063	5.226	1.427	0.767	0.154
25500.0	0.244	21.946	4.202	939.184	0.297	0.066	5.251	1.459	0.786	0.162
26000.0	0.242	21.601	4.259	938.863	0.305	0.069	5.274	1.491	0.806	0.170
27500.0	0.237	20.587	4.423	937.891	0.329	0.079	5.337	1.585	0.864	0.196
30000.0	0.229	18.965	4.679	936.244	0.369	0.098	5.419	1.737	0.957	0.242
32500.0	0.221	17.424	4.916	934.561	0.410	0.118	5.477	1.882	1.045	0.294
35000.0	0.213	15.966	5.134	932.841	0.451	0.141	5.513	2.021	1.128	0.350
37500.0	0.206	14.587	5.332	931.085	0.491	0.166	5.530	2.153	1.203	0.410
40000.0	0.198	13.287	5.512	929.290	0.531	0.192	5.531	2.278	1.273	0.475
42500.0	0.191	12.065	5.674	927.456	0.571	0.221	5.518	2.395	1.335	0.544
45000.0	0.184	10.920	5.817	925.582	0.610	0.251	5.495	2.505	1.391	0.616
47500.0	0.177	9.849	5.943	923.668	0.647	0.282	5.462	2.607	1.440	0.691
50000.0	0.170	8.853	6.052	921.713	0.684	0.315	5.422	2.700	1.483	0.769
52500.0	0.163	7.929	6.144	919.717	0.719	0.348	5.376	2.786	1.520	0.850
55000.0	0.156	7.076	6.220	917.680	0.752	0.382	5.326	2.864	1.551	0.933
57500.0	0.150	6.292	6.281	915.602	0.784	0.417	5.274	2.934	1.577	1.018
60000.0	0.144	5.575	6.326	913.484	0.814	0.451	5.220	2.996	1.598	1.105
62500.0	0.138	4.921	6.357	911.326	0.842	0.485	5.166	3.052	1.614	1.192
65000.0	0.132	4.329	6.375	909.130	0.868	0.518	5.112	3.100	1.627	1.281
67500.0	0.127	3.794	6.380	906.897	0.892	0.551	5.059	3.142	1.636	1.370
70000.0	0.122	3.315	6.374	904.628	0.913	0.582	5.008	3.178	1.642	1.459

Table C.45 [ ] Exposure-Dependent 80% Void Isotopics (kg/MTU Initial)

Exposure MWd/MTU	U-234	U-235	U-236	U-238	NP-237	PU-238	PU-239	PU-240	PU-241	PU-242
0.0	0.339	44.888	0.000	954.773	0.000	0.000	0.000	0.000	0.000	0.000
100.0	0.338	44.769	0.025	954.705	0.000	0.000	0.024	0.000	0.000	0.000
500.0	0.336	44.296	0.123	954.428	0.002	0.000	0.243	0.002	0.000	0.000
1000.0	0.334	43.715	0.243	954.081	0.005	0.000	0.526	0.008	0.000	0.000
1500.0	0.331	43.144	0.361	953.733	0.008	0.000	0.796	0.018	0.002	0.000
2000.0	0.329	42.583	0.477	953.386	0.011	0.000	1.055	0.032	0.004	0.000
2500.0	0.326	42.031	0.591	953.039	0.015	0.000	1.303	0.048	0.007	0.000
3000.0	0.324	41.488	0.702	952.691	0.019	0.001	1.540	0.066	0.012	0.000
3500.0	0.322	40.953	0.812	952.344	0.023	0.001	1.767	0.087	0.018	0.000
4000.0	0.319	40.426	0.919	951.996	0.028	0.001	1.985	0.109	0.025	0.001
4500.0	0.317	39.907	1.025	951.648	0.032	0.002	2.194	0.133	0.034	0.001
5000.0	0.315	39.395	1.129	951.300	0.037	0.002	2.395	0.158	0.044	0.001
5500.0	0.312	38.890	1.232	950.952	0.043	0.003	2.588	0.184	0.055	0.002
6000.0	0.310	38.391	1.332	950.604	0.048	0.003	2.774	0.212	0.068	0.003
6500.0	0.308	37.899	1.431	950.256	0.054	0.004	2.952	0.240	0.081	0.003
7000.0	0.306	37.414	1.529	949.907	0.060	0.004	3.123	0.269	0.096	0.004
7500.0	0.303	36.935	1.625	949.558	0.066	0.005	3.288	0.299	0.111	0.005
8000.0	0.301	36.461	1.719	949.210	0.072	0.006	3.447	0.329	0.128	0.007
8500.0	0.299	35.994	1.812	948.861	0.079	0.007	3.599	0.361	0.145	0.008
9000.0	0.297	35.532	1.903	948.512	0.085	0.008	3.746	0.392	0.163	0.009
9500.0	0.295	35.075	1.993	948.163	0.092	0.009	3.887	0.425	0.181	0.011
10000.0	0.293	34.624	2.082	947.815	0.099	0.010	4.022	0.457	0.201	0.013
10500.0	0.291	34.178	2.169	947.466	0.106	0.011	4.153	0.491	0.220	0.015
11000.0	0.288	33.737	2.255	947.117	0.113	0.013	4.278	0.524	0.241	0.017
11500.0	0.286	33.301	2.340	946.768	0.120	0.014	4.399	0.559	0.261	0.020
12000.0	0.284	32.869	2.423	946.419	0.127	0.015	4.515	0.593	0.282	0.022
12500.0	0.282	32.443	2.506	946.070	0.135	0.017	4.626	0.628	0.304	0.025
13000.0	0.280	32.021	2.587	945.721	0.142	0.019	4.733	0.663	0.325	0.028
13500.0	0.278	31.604	2.666	945.371	0.150	0.020	4.837	0.698	0.347	0.031
14000.0	0.276	31.191	2.745	945.021	0.158	0.022	4.936	0.733	0.370	0.035
14500.0	0.274	30.782	2.823	944.671	0.166	0.024	5.031	0.769	0.392	0.038
15000.0	0.272	30.378	2.899	944.321	0.174	0.026	5.123	0.805	0.415	0.042
15500.0	0.270	29.978	2.974	943.971	0.182	0.028	5.211	0.841	0.438	0.046
16000.0	0.268	29.582	3.049	943.620	0.190	0.030	5.296	0.877	0.460	0.050
16500.0	0.266	29.190	3.122	943.270	0.198	0.033	5.378	0.913	0.483	0.055
17000.0	0.264	28.802	3.194	942.918	0.206	0.035	5.456	0.949	0.506	0.059
17500.0	0.263	28.417	3.265	942.567	0.214	0.037	5.531	0.986	0.530	0.064
18000.0	0.261	28.037	3.335	942.215	0.222	0.040	5.603	1.022	0.553	0.069
18500.0	0.259	27.660	3.404	941.863	0.231	0.043	5.673	1.059	0.576	0.074
19000.0	0.257	27.288	3.472	941.511	0.239	0.045	5.739	1.095	0.599	0.079
19500.0	0.255	26.918	3.539	941.158	0.247	0.048	5.803	1.132	0.622	0.085
20000.0	0.253	26.553	3.605	940.805	0.256	0.051	5.865	1.169	0.645	0.090
20500.0	0.251	26.191	3.670	940.451	0.264	0.054	5.924	1.205	0.668	0.096
21000.0	0.250	25.832	3.735	940.097	0.273	0.057	5.980	1.242	0.691	0.102
21500.0	0.248	25.478	3.798	939.742	0.281	0.061	6.035	1.278	0.714	0.108
22000.0	0.246	25.126	3.860	939.386	0.290	0.064	6.087	1.314	0.736	0.115
22500.0	0.244	24.778	3.922	939.029	0.298	0.067	6.138	1.350	0.759	0.121
23000.0	0.242	24.434	3.983	938.672	0.307	0.071	6.186	1.387	0.782	0.128
23500.0	0.241	24.093	4.042	938.313	0.315	0.074	6.233	1.423	0.804	0.135
24000.0	0.239	23.755	4.101	937.954	0.324	0.078	6.278	1.459	0.827	0.142
24500.0	0.237	23.421	4.159	937.594	0.333	0.082	6.321	1.494	0.849	0.149
25000.0	0.235	23.090	4.216	937.232	0.341	0.086	6.363	1.530	0.871	0.156
25500.0	0.234	22.762	4.273	936.870	0.350	0.090	6.403	1.565	0.893	0.164
26000.0	0.232	22.438	4.328	936.506	0.359	0.094	6.442	1.601	0.915	0.172
26500.0	0.230	22.117	4.383	936.141	0.367	0.098	6.480	1.636	0.937	0.180
27000.0	0.228	21.799	4.437	935.776	0.376	0.103	6.516	1.671	0.959	0.188
27500.0	0.227	21.485	4.490	935.408	0.385	0.107	6.550	1.706	0.981	0.196
28000.0	0.225	21.174	4.542	935.040	0.394	0.111	6.584	1.740	1.002	0.205
28500.0	0.223	20.866	4.593	934.671	0.402	0.116	6.616	1.775	1.024	0.213
29000.0	0.222	20.561	4.643	934.300	0.411	0.121	6.647	1.809	1.045	0.222
29500.0	0.220	20.260	4.693	933.928	0.420	0.126	6.676	1.843	1.066	0.231
30000.0	0.218	19.962	4.742	933.555	0.429	0.131	6.705	1.877	1.087	0.240
30500.0	0.217	19.667	4.790	933.181	0.438	0.136	6.733	1.910	1.108	0.249
31000.0	0.215	19.375	4.837	932.805	0.446	0.141	6.759	1.944	1.128	0.258
32500.0	0.210	18.518	4.974	931.670	0.473	0.157	6.832	2.043	1.189	0.287
35000.0	0.202	17.151	5.187	929.754	0.517	0.186	6.936	2.202	1.287	0.339
37500.0	0.195	15.860	5.381	927.805	0.560	0.217	7.018	2.355	1.380	0.393
40000.0	0.187	14.642	5.556	925.826	0.603	0.250	7.081	2.502	1.468	0.451
42500.0	0.180	13.495	5.714	923.814	0.645	0.285	7.128	2.643	1.549	0.512
45000.0	0.173	12.417	5.854	921.771	0.686	0.323	7.161	2.776	1.625	0.576
47500.0	0.166	11.406	5.977	919.698	0.726	0.362	7.182	2.903	1.696	0.642
50000.0	0.160	10.460	6.085	917.594	0.764	0.402	7.192	3.023	1.760	0.710
52500.0	0.154	9.576	6.176	915.459	0.801	0.444	7.194	3.136	1.820	0.780
55000.0	0.148	8.753	6.254	913.296	0.836	0.486	7.187	3.242	1.874	0.853
57500.0	0.142	7.987	6.317	911.104	0.870	0.530	7.175	3.341	1.924	0.927
60000.0	0.136	7.276	6.366	908.884	0.901	0.573	7.158	3.433	1.968	1.002
62500.0	0.131	6.619	6.403	906.637	0.931	0.617	7.136	3.519	2.008	1.079
65000.0	0.126	6.012	6.429	904.365	0.959	0.661	7.112	3.598	2.044	1.157
67500.0	0.122	5.452	6.442	902.068	0.985	0.704	7.085	3.672	2.077	1.236
70000.0	0.117	4.938	6.446	899.748	1.008	0.747	7.057	3.739	2.105	1.316

Table C.46 [ ] Exposure-Dependent 0% Void Isotopics (kg/MTU Initial)

Exposure MWd/MTU	U-234	U-235	U-236	U-238	NP-237	PU-238	PU-239	PU-240	PU-241	PU-242
0.0	0.342	45.279	0.000	954.379	0.000	0.000	0.000	0.000	0.000	0.000
100.0	0.341	45.159	0.022	954.330	0.000	0.000	0.016	0.000	0.000	0.000
500.0	0.340	44.680	0.111	954.131	0.001	0.000	0.173	0.001	0.000	0.000
1000.0	0.338	44.089	0.221	953.882	0.003	0.000	0.380	0.006	0.000	0.000
1500.0	0.336	43.505	0.330	953.633	0.005	0.000	0.579	0.013	0.001	0.000
2000.0	0.335	42.928	0.436	953.384	0.007	0.000	0.768	0.023	0.002	0.000
2500.0	0.333	42.358	0.541	953.135	0.010	0.000	0.950	0.036	0.004	0.000
3000.0	0.331	41.795	0.645	952.886	0.012	0.000	1.123	0.050	0.006	0.000
3500.0	0.329	41.238	0.747	952.636	0.015	0.000	1.288	0.067	0.009	0.000
4000.0	0.327	40.688	0.848	952.387	0.018	0.001	1.447	0.085	0.014	0.000
4500.0	0.326	40.143	0.947	952.137	0.021	0.001	1.598	0.104	0.018	0.001
5000.0	0.324	39.605	1.045	951.887	0.024	0.001	1.743	0.125	0.024	0.001
5500.0	0.322	39.071	1.142	951.637	0.027	0.001	1.881	0.147	0.031	0.001
6000.0	0.320	38.544	1.237	951.387	0.031	0.001	2.013	0.170	0.038	0.001
6500.0	0.319	38.021	1.332	951.137	0.034	0.002	2.139	0.194	0.047	0.002
7000.0	0.317	37.504	1.425	950.887	0.038	0.002	2.259	0.219	0.056	0.003
7500.0	0.315	36.992	1.517	950.637	0.042	0.002	2.374	0.244	0.066	0.003
8000.0	0.314	36.484	1.608	950.387	0.046	0.003	2.483	0.271	0.076	0.004
8500.0	0.312	35.981	1.697	950.137	0.050	0.003	2.587	0.298	0.087	0.005
9000.0	0.310	35.483	1.786	949.888	0.054	0.004	2.686	0.325	0.099	0.006
9500.0	0.309	34.989	1.873	949.638	0.058	0.004	2.781	0.353	0.112	0.007
10000.0	0.307	34.500	1.960	949.389	0.063	0.005	2.870	0.382	0.125	0.009
10500.0	0.305	34.015	2.045	949.139	0.067	0.005	2.956	0.410	0.138	0.010
11000.0	0.304	33.534	2.129	948.890	0.072	0.006	3.037	0.440	0.152	0.012
11500.0	0.302	33.057	2.213	948.641	0.077	0.007	3.113	0.469	0.166	0.013
12000.0	0.300	32.584	2.295	948.391	0.081	0.007	3.186	0.499	0.181	0.015
12500.0	0.299	32.115	2.376	948.142	0.086	0.008	3.255	0.529	0.195	0.017
13000.0	0.297	31.649	2.457	947.893	0.091	0.009	3.321	0.559	0.211	0.020
13500.0	0.296	31.188	2.536	947.644	0.096	0.010	3.382	0.590	0.226	0.022
14000.0	0.294	30.730	2.614	947.395	0.101	0.011	3.441	0.621	0.242	0.025
14500.0	0.292	30.275	2.692	947.146	0.107	0.011	3.496	0.652	0.257	0.028
15000.0	0.291	29.824	2.769	946.897	0.112	0.012	3.548	0.683	0.273	0.031
15500.0	0.289	29.376	2.845	946.649	0.117	0.013	3.596	0.714	0.289	0.034
16000.0	0.288	28.932	2.920	946.400	0.122	0.014	3.642	0.745	0.306	0.037
16500.0	0.286	28.491	2.994	946.151	0.128	0.016	3.686	0.776	0.322	0.041
17000.0	0.284	28.054	3.067	945.901	0.133	0.017	3.726	0.807	0.338	0.044
17500.0	0.283	27.619	3.140	945.651	0.139	0.018	3.765	0.838	0.354	0.048
18000.0	0.281	27.188	3.212	945.400	0.144	0.019	3.801	0.869	0.371	0.052
18500.0	0.280	26.760	3.283	945.149	0.150	0.020	3.835	0.901	0.387	0.057
19000.0	0.278	26.336	3.353	944.896	0.156	0.022	3.867	0.932	0.404	0.061
19500.0	0.277	25.915	3.422	944.643	0.161	0.023	3.897	0.963	0.420	0.066
20000.0	0.275	25.497	3.491	944.389	0.167	0.025	3.925	0.994	0.437	0.071
20500.0	0.274	25.083	3.559	944.133	0.173	0.026	3.952	1.025	0.454	0.076
21000.0	0.272	24.672	3.626	943.876	0.179	0.028	3.977	1.055	0.470	0.081
21500.0	0.270	24.264	3.692	943.618	0.185	0.029	4.001	1.086	0.487	0.087
22000.0	0.269	23.860	3.758	943.359	0.191	0.031	4.023	1.117	0.503	0.092
22500.0	0.267	23.459	3.822	943.099	0.197	0.033	4.043	1.147	0.520	0.098
23000.0	0.266	23.061	3.886	942.837	0.203	0.034	4.063	1.177	0.536	0.104
25000.0	0.260	21.504	4.134	941.774	0.229	0.042	4.127	1.297	0.601	0.131
27500.0	0.252	19.634	4.427	940.412	0.261	0.053	4.182	1.442	0.681	0.170
30000.0	0.244	17.850	4.700	939.010	0.295	0.066	4.210	1.582	0.755	0.215
32500.0	0.236	16.150	4.953	937.566	0.329	0.081	4.217	1.716	0.824	0.265
35000.0	0.229	14.538	5.187	936.077	0.364	0.097	4.205	1.843	0.887	0.321
37500.0	0.221	13.014	5.402	934.540	0.400	0.115	4.178	1.964	0.944	0.383
40000.0	0.213	11.579	5.596	932.952	0.435	0.134	4.138	2.076	0.993	0.450
42500.0	0.205	10.234	5.771	931.310	0.470	0.155	4.088	2.181	1.036	0.523
45000.0	0.197	8.983	5.925	929.610	0.505	0.177	4.031	2.277	1.072	0.601
47500.0	0.190	7.825	6.060	927.850	0.539	0.201	3.968	2.364	1.101	0.684
50000.0	0.182	6.762	6.174	926.027	0.572	0.225	3.903	2.442	1.124	0.771
52500.0	0.174	5.795	6.268	924.139	0.604	0.249	3.835	2.510	1.141	0.863
55000.0	0.167	4.923	6.342	922.184	0.634	0.274	3.769	2.570	1.153	0.959
57500.0	0.159	4.145	6.397	920.161	0.662	0.299	3.704	2.620	1.160	1.057
60000.0	0.152	3.460	6.433	918.071	0.688	0.323	3.642	2.662	1.163	1.158
62500.0	0.144	2.862	6.451	915.915	0.712	0.347	3.585	2.696	1.163	1.261
65000.0	0.137	2.347	6.452	913.696	0.734	0.369	3.532	2.722	1.161	1.365
67500.0	0.130	1.910	6.439	911.418	0.754	0.390	3.484	2.742	1.157	1.470
70000.0	0.124	1.543	6.411	909.086	0.771	0.409	3.441	2.756	1.151	1.575

Table C.47 [ ] Exposure-Dependent 40% Void Isotopics (kg/MTU Initial)

Exposure MWd/MTU	U-234	U-235	U-236	U-238	NP-237	PU-238	PU-239	PU-240	PU-241	PU-242
0.0	0.342	45.279	0.000	954.379	0.000	0.000	0.000	0.000	0.000	0.000
100.0	0.341	45.159	0.023	954.323	0.000	0.000	0.018	0.000	0.000	0.000
500.0	0.340	44.682	0.116	954.096	0.002	0.000	0.196	0.001	0.000	0.000
1000.0	0.338	44.093	0.230	953.812	0.004	0.000	0.431	0.007	0.000	0.000
1500.0	0.336	43.513	0.342	953.528	0.006	0.000	0.656	0.015	0.001	0.000
2000.0	0.334	42.941	0.452	953.244	0.009	0.000	0.871	0.026	0.003	0.000
2500.0	0.332	42.377	0.560	952.959	0.011	0.000	1.076	0.040	0.005	0.000
3000.0	0.330	41.821	0.667	952.675	0.015	0.000	1.272	0.056	0.008	0.000
3500.0	0.328	41.271	0.772	952.391	0.018	0.001	1.460	0.075	0.012	0.000
4000.0	0.326	40.729	0.875	952.107	0.021	0.001	1.639	0.094	0.018	0.000
4500.0	0.324	40.193	0.977	951.823	0.025	0.001	1.810	0.116	0.024	0.001
5000.0	0.322	39.663	1.078	951.539	0.029	0.001	1.974	0.138	0.031	0.001
5500.0	0.320	39.140	1.177	951.254	0.033	0.002	2.131	0.162	0.040	0.001
6000.0	0.318	38.622	1.274	950.970	0.037	0.002	2.281	0.187	0.049	0.002
6500.0	0.316	38.111	1.370	950.686	0.041	0.002	2.424	0.212	0.059	0.002
7000.0	0.314	37.605	1.465	950.402	0.045	0.003	2.562	0.239	0.070	0.003
7500.0	0.312	37.104	1.558	950.119	0.050	0.003	2.692	0.266	0.082	0.004
8000.0	0.310	36.609	1.650	949.835	0.055	0.004	2.818	0.294	0.095	0.005
8500.0	0.308	36.119	1.741	949.551	0.060	0.004	2.937	0.323	0.109	0.006
9000.0	0.307	35.633	1.830	949.268	0.065	0.005	3.051	0.352	0.123	0.007
9500.0	0.305	35.153	1.919	948.985	0.070	0.006	3.160	0.382	0.138	0.009
10000.0	0.303	34.678	2.006	948.702	0.075	0.006	3.263	0.412	0.153	0.010
10500.0	0.301	34.207	2.092	948.419	0.081	0.007	3.362	0.443	0.169	0.012
11000.0	0.299	33.740	2.176	948.137	0.086	0.008	3.456	0.474	0.186	0.014
11500.0	0.298	33.278	2.260	947.854	0.092	0.009	3.546	0.505	0.202	0.016
12000.0	0.296	32.820	2.342	947.572	0.097	0.010	3.631	0.536	0.220	0.018
12500.0	0.294	32.367	2.424	947.289	0.103	0.011	3.712	0.568	0.237	0.021
13000.0	0.292	31.917	2.504	947.007	0.109	0.012	3.789	0.600	0.255	0.023
13500.0	0.290	31.472	2.584	946.725	0.115	0.013	3.863	0.632	0.273	0.026
14000.0	0.289	31.031	2.662	946.443	0.121	0.014	3.932	0.665	0.291	0.029
14500.0	0.287	30.593	2.739	946.161	0.127	0.015	3.999	0.697	0.310	0.032
15000.0	0.285	30.159	2.816	945.878	0.133	0.016	4.061	0.730	0.329	0.035
15500.0	0.284	29.729	2.891	945.597	0.140	0.018	4.121	0.763	0.347	0.039
16000.0	0.282	29.302	2.966	945.315	0.146	0.019	4.177	0.796	0.366	0.043
16500.0	0.280	28.879	3.039	945.033	0.152	0.021	4.230	0.829	0.385	0.047
17000.0	0.278	28.460	3.112	944.750	0.158	0.022	4.280	0.862	0.404	0.051
17500.0	0.277	28.043	3.184	944.468	0.165	0.024	4.328	0.895	0.423	0.055
18000.0	0.275	27.631	3.255	944.185	0.171	0.025	4.373	0.927	0.442	0.060
18500.0	0.273	27.222	3.325	943.902	0.178	0.027	4.415	0.960	0.461	0.064
19000.0	0.272	26.816	3.394	943.618	0.184	0.029	4.456	0.993	0.480	0.069
19500.0	0.270	26.413	3.463	943.333	0.191	0.030	4.494	1.026	0.499	0.074
20000.0	0.268	26.014	3.530	943.048	0.198	0.032	4.530	1.059	0.518	0.080
20500.0	0.267	25.619	3.597	942.761	0.204	0.034	4.564	1.091	0.537	0.085
21000.0	0.265	25.226	3.663	942.474	0.211	0.036	4.597	1.124	0.556	0.091
21500.0	0.263	24.838	3.728	942.185	0.218	0.038	4.628	1.156	0.575	0.097
22000.0	0.262	24.452	3.792	941.896	0.225	0.040	4.657	1.188	0.594	0.103
22500.0	0.260	24.070	3.856	941.605	0.232	0.043	4.685	1.220	0.613	0.109
23000.0	0.259	23.692	3.918	941.313	0.239	0.045	4.711	1.252	0.632	0.116
23500.0	0.257	23.316	3.980	941.019	0.246	0.047	4.735	1.284	0.650	0.123
24000.0	0.255	22.945	4.041	940.725	0.253	0.050	4.758	1.315	0.669	0.130
24500.0	0.254	22.576	4.101	940.429	0.261	0.052	4.780	1.347	0.687	0.137
25000.0	0.252	22.211	4.160	940.132	0.268	0.055	4.801	1.378	0.706	0.144
27500.0	0.244	20.436	4.445	938.624	0.305	0.069	4.886	1.531	0.796	0.185
30000.0	0.236	18.745	4.709	937.080	0.343	0.085	4.944	1.678	0.883	0.230
32500.0	0.228	17.137	4.954	935.499	0.382	0.103	4.977	1.819	0.964	0.281
35000.0	0.220	15.612	5.180	933.879	0.420	0.123	4.990	1.954	1.038	0.337
37500.0	0.213	14.169	5.386	932.219	0.459	0.145	4.985	2.082	1.107	0.397
40000.0	0.205	12.808	5.573	930.517	0.497	0.168	4.966	2.202	1.168	0.463
42500.0	0.197	11.529	5.741	928.770	0.535	0.194	4.934	2.315	1.222	0.532
45000.0	0.190	10.332	5.891	926.979	0.572	0.220	4.892	2.419	1.270	0.606
47500.0	0.183	9.216	6.022	925.141	0.609	0.248	4.843	2.516	1.311	0.684
50000.0	0.175	8.180	6.135	923.256	0.644	0.277	4.787	2.603	1.345	0.765
52500.0	0.168	7.224	6.231	921.322	0.677	0.307	4.728	2.683	1.373	0.849
55000.0	0.161	6.347	6.309	919.338	0.709	0.337	4.666	2.753	1.396	0.936
57500.0	0.154	5.547	6.370	917.305	0.740	0.368	4.603	2.816	1.413	1.026
60000.0	0.148	4.822	6.415	915.223	0.768	0.398	4.540	2.870	1.426	1.117
62500.0	0.141	4.170	6.444	913.092	0.795	0.427	4.479	2.917	1.434	1.210
65000.0	0.135	3.587	6.458	910.914	0.819	0.456	4.420	2.956	1.439	1.304
67500.0	0.129	3.070	6.458	908.691	0.842	0.484	4.363	2.988	1.441	1.398
70000.0	0.123	2.615	6.446	906.424	0.862	0.510	4.310	3.015	1.441	1.493

Table C.48 [ ] Exposure-Dependent 80% Void Isotopics (kg/MTU Initial)

Exposure MWd/MTU	U-234	U-235	U-236	U-238	NP-237	PU-238	PU-239	PU-240	PU-241	PU-242
0.0	0.342	45.279	0.000	954.379	0.000	0.000	0.000	0.000	0.000	0.000
100.0	0.341	45.160	0.024	954.313	0.000	0.000	0.021	0.000	0.000	0.000
500.0	0.339	44.686	0.122	954.049	0.002	0.000	0.226	0.002	0.000	0.000
1000.0	0.337	44.102	0.241	953.719	0.005	0.000	0.496	0.007	0.000	0.000
1500.0	0.335	43.528	0.358	953.388	0.008	0.000	0.755	0.017	0.001	0.000
2000.0	0.332	42.963	0.473	953.058	0.011	0.000	1.002	0.030	0.003	0.000
2500.0	0.330	42.407	0.586	952.728	0.014	0.000	1.239	0.045	0.007	0.000
3000.0	0.328	41.860	0.697	952.398	0.018	0.001	1.465	0.063	0.011	0.000
3500.0	0.325	41.320	0.806	952.068	0.022	0.001	1.682	0.082	0.016	0.000
4000.0	0.323	40.788	0.913	951.738	0.026	0.001	1.889	0.104	0.023	0.001
4500.0	0.321	40.263	1.019	951.408	0.031	0.001	2.088	0.127	0.031	0.001
5000.0	0.319	39.745	1.122	951.078	0.035	0.002	2.279	0.151	0.040	0.001
5500.0	0.316	39.234	1.224	950.748	0.040	0.002	2.462	0.176	0.051	0.002
6000.0	0.314	38.729	1.325	950.418	0.045	0.003	2.638	0.202	0.063	0.002
6500.0	0.312	38.230	1.424	950.089	0.051	0.003	2.806	0.230	0.075	0.003
7000.0	0.310	37.738	1.521	949.759	0.056	0.004	2.968	0.258	0.089	0.004
7500.0	0.308	37.252	1.617	949.430	0.062	0.005	3.122	0.287	0.103	0.005
8000.0	0.306	36.771	1.711	949.101	0.068	0.005	3.271	0.317	0.119	0.006
8500.0	0.303	36.296	1.804	948.772	0.074	0.006	3.414	0.347	0.135	0.007
9000.0	0.301	35.826	1.895	948.443	0.080	0.007	3.550	0.378	0.152	0.009
9500.0	0.299	35.361	1.985	948.115	0.087	0.008	3.681	0.409	0.169	0.010
10000.0	0.297	34.902	2.074	947.786	0.093	0.009	3.807	0.441	0.187	0.012
10500.0	0.295	34.448	2.161	947.458	0.100	0.010	3.927	0.474	0.206	0.014
11000.0	0.293	33.998	2.248	947.130	0.106	0.011	4.043	0.506	0.225	0.016
11500.0	0.291	33.553	2.333	946.802	0.113	0.013	4.153	0.539	0.245	0.018
12000.0	0.289	33.113	2.416	946.475	0.120	0.014	4.259	0.573	0.265	0.021
12500.0	0.287	32.678	2.499	946.147	0.127	0.015	4.361	0.607	0.285	0.023
13000.0	0.285	32.246	2.580	945.819	0.134	0.017	4.458	0.641	0.306	0.026
13500.0	0.283	31.820	2.661	945.491	0.141	0.018	4.551	0.675	0.326	0.029
14000.0	0.281	31.397	2.740	945.163	0.149	0.020	4.641	0.710	0.348	0.033
14500.0	0.279	30.979	2.818	944.835	0.156	0.022	4.726	0.744	0.369	0.036
15000.0	0.277	30.564	2.895	944.507	0.163	0.023	4.808	0.779	0.390	0.040
15500.0	0.276	30.154	2.970	944.179	0.171	0.025	4.886	0.815	0.412	0.043
16000.0	0.274	29.748	3.045	943.851	0.178	0.027	4.961	0.850	0.434	0.047
16500.0	0.272	29.345	3.119	943.523	0.186	0.029	5.033	0.885	0.455	0.051
17000.0	0.270	28.946	3.192	943.195	0.194	0.031	5.101	0.921	0.477	0.056
17500.0	0.268	28.552	3.263	942.867	0.201	0.034	5.166	0.956	0.499	0.060
18000.0	0.266	28.160	3.334	942.538	0.209	0.036	5.228	0.992	0.521	0.065
18500.0	0.264	27.773	3.404	942.210	0.217	0.038	5.288	1.027	0.543	0.070
19000.0	0.263	27.388	3.473	941.881	0.225	0.041	5.345	1.063	0.565	0.075
19500.0	0.261	27.008	3.541	941.551	0.233	0.043	5.399	1.098	0.586	0.080
20000.0	0.259	26.631	3.608	941.221	0.241	0.046	5.451	1.134	0.608	0.086
20500.0	0.257	26.257	3.674	940.891	0.249	0.048	5.501	1.169	0.630	0.091
21000.0	0.255	25.887	3.739	940.559	0.257	0.051	5.548	1.205	0.651	0.097
21500.0	0.254	25.521	3.803	940.228	0.265	0.054	5.594	1.240	0.673	0.103
22000.0	0.252	25.157	3.867	939.895	0.273	0.057	5.637	1.276	0.695	0.109
22500.0	0.250	24.797	3.929	939.561	0.281	0.060	5.679	1.311	0.716	0.116
23000.0	0.248	24.441	3.991	939.227	0.289	0.063	5.719	1.346	0.738	0.122
23500.0	0.247	24.088	4.052	938.891	0.297	0.066	5.757	1.381	0.759	0.129
24000.0	0.245	23.738	4.112	938.554	0.305	0.070	5.793	1.415	0.780	0.136
24500.0	0.243	23.392	4.171	938.216	0.314	0.073	5.828	1.450	0.801	0.143
25000.0	0.241	23.049	4.229	937.878	0.322	0.077	5.862	1.485	0.822	0.151
25500.0	0.240	22.710	4.287	937.537	0.330	0.080	5.894	1.519	0.843	0.158
26000.0	0.238	22.373	4.343	937.196	0.338	0.084	5.925	1.553	0.864	0.166
26500.0	0.236	22.040	4.399	936.854	0.347	0.088	5.954	1.587	0.885	0.174
27000.0	0.235	21.711	4.454	936.510	0.355	0.091	5.982	1.621	0.905	0.182
27500.0	0.233	21.384	4.508	936.165	0.363	0.095	6.009	1.655	0.926	0.190
28000.0	0.231	21.061	4.562	935.819	0.372	0.099	6.034	1.688	0.946	0.198
28500.0	0.230	20.741	4.614	935.471	0.380	0.104	6.059	1.721	0.966	0.207
29000.0	0.228	20.425	4.666	935.123	0.388	0.108	6.082	1.754	0.986	0.216
30000.0	0.225	19.801	4.767	934.421	0.405	0.117	6.125	1.820	1.026	0.233
32500.0	0.217	18.298	5.005	932.644	0.447	0.140	6.216	1.979	1.122	0.281
35000.0	0.209	16.873	5.224	930.833	0.490	0.166	6.284	2.132	1.213	0.333
37500.0	0.201	15.526	5.424	928.989	0.532	0.194	6.331	2.278	1.299	0.389
40000.0	0.193	14.254	5.605	927.111	0.573	0.224	6.360	2.418	1.378	0.448
42500.0	0.186	13.056	5.768	925.198	0.614	0.256	6.374	2.551	1.452	0.511
45000.0	0.179	11.930	5.913	923.251	0.654	0.290	6.375	2.677	1.519	0.577
47500.0	0.172	10.875	6.040	921.269	0.693	0.325	6.364	2.796	1.580	0.646
50000.0	0.165	9.889	6.151	919.252	0.731	0.362	6.345	2.907	1.636	0.717
52500.0	0.158	8.971	6.246	917.201	0.767	0.400	6.318	3.010	1.685	0.791
55000.0	0.152	8.117	6.325	915.115	0.802	0.438	6.285	3.106	1.729	0.867
57500.0	0.146	7.326	6.389	912.995	0.834	0.477	6.247	3.194	1.768	0.945
60000.0	0.140	6.596	6.439	910.843	0.865	0.517	6.205	3.275	1.802	1.025
62500.0	0.134	5.925	6.475	908.658	0.894	0.556	6.161	3.348	1.831	1.106
65000.0	0.129	5.309	6.499	906.442	0.921	0.595	6.116	3.415	1.856	1.189
67500.0	0.124	4.746	6.510	904.196	0.946	0.633	6.070	3.475	1.877	1.273
70000.0	0.119	4.233	6.510	901.922	0.969	0.671	6.023	3.529	1.895	1.357

Table C.49 [ ] Exposure-Dependent 0% Void Isotopics (kg/MTU Initial)

Exposure MWd/MTU	U-234	U-235	U-236	U-238	NP-237	PU-238	PU-239	PU-240	PU-241	PU-242
0.0	0.341	45.159	0.000	954.501	0.000	0.000	0.000	0.000	0.000	0.000
100.0	0.340	45.038	0.022	954.452	0.000	0.000	0.016	0.000	0.000	0.000
500.0	0.339	44.559	0.111	954.257	0.001	0.000	0.170	0.001	0.000	0.000
1000.0	0.337	43.968	0.220	954.012	0.003	0.000	0.375	0.006	0.000	0.000
1500.0	0.335	43.384	0.328	953.766	0.005	0.000	0.570	0.013	0.001	0.000
2000.0	0.334	42.807	0.434	953.521	0.007	0.000	0.757	0.023	0.002	0.000
2500.0	0.332	42.237	0.539	953.275	0.010	0.000	0.935	0.035	0.004	0.000
3000.0	0.330	41.674	0.642	953.029	0.012	0.000	1.106	0.050	0.006	0.000
3500.0	0.328	41.117	0.744	952.783	0.015	0.000	1.269	0.066	0.009	0.000
4000.0	0.327	40.566	0.844	952.537	0.018	0.001	1.425	0.084	0.013	0.000
4500.0	0.325	40.021	0.943	952.290	0.021	0.001	1.574	0.103	0.018	0.001
5000.0	0.323	39.482	1.041	952.044	0.024	0.001	1.716	0.124	0.024	0.001
5500.0	0.322	38.948	1.137	951.797	0.027	0.001	1.852	0.146	0.030	0.001
6000.0	0.320	38.420	1.233	951.551	0.030	0.001	1.982	0.169	0.038	0.001
6500.0	0.318	37.897	1.327	951.304	0.034	0.002	2.106	0.193	0.046	0.002
7000.0	0.316	37.379	1.419	951.057	0.038	0.002	2.224	0.217	0.055	0.003
7500.0	0.315	36.866	1.511	950.810	0.041	0.002	2.337	0.243	0.064	0.003
8000.0	0.313	36.358	1.602	950.563	0.045	0.003	2.445	0.269	0.075	0.004
8500.0	0.311	35.854	1.691	950.316	0.049	0.003	2.547	0.295	0.086	0.005
9000.0	0.310	35.355	1.779	950.070	0.053	0.004	2.645	0.323	0.097	0.006
9500.0	0.308	34.861	1.867	949.823	0.058	0.004	2.737	0.351	0.109	0.007
10000.0	0.306	34.371	1.953	949.576	0.062	0.005	2.826	0.379	0.122	0.009
10500.0	0.305	33.885	2.038	949.330	0.066	0.005	2.909	0.408	0.135	0.010
11000.0	0.303	33.403	2.122	949.083	0.071	0.006	2.989	0.437	0.149	0.012
11500.0	0.302	32.925	2.205	948.836	0.075	0.007	3.064	0.466	0.162	0.013
12000.0	0.300	32.452	2.287	948.590	0.080	0.007	3.136	0.496	0.177	0.015
12500.0	0.298	31.982	2.369	948.343	0.085	0.008	3.204	0.526	0.191	0.017
13000.0	0.297	31.516	2.449	948.096	0.090	0.009	3.268	0.556	0.206	0.020
13500.0	0.295	31.054	2.528	947.849	0.095	0.009	3.329	0.586	0.221	0.022
14000.0	0.294	30.595	2.606	947.602	0.100	0.010	3.387	0.617	0.237	0.025
14500.0	0.292	30.140	2.684	947.356	0.105	0.011	3.441	0.648	0.252	0.028
15000.0	0.290	29.688	2.761	947.109	0.110	0.012	3.492	0.679	0.268	0.031
15500.0	0.289	29.240	2.836	946.862	0.115	0.013	3.540	0.709	0.284	0.034
16000.0	0.287	28.795	2.911	946.615	0.121	0.014	3.585	0.741	0.300	0.037
16500.0	0.286	28.353	2.985	946.368	0.126	0.015	3.627	0.772	0.316	0.041
17000.0	0.284	27.915	3.059	946.121	0.131	0.016	3.667	0.803	0.332	0.044
17500.0	0.283	27.480	3.131	945.873	0.137	0.018	3.704	0.834	0.348	0.048
18000.0	0.281	27.048	3.203	945.626	0.142	0.019	3.739	0.865	0.364	0.052
18500.0	0.280	26.619	3.274	945.377	0.148	0.020	3.771	0.896	0.380	0.057
19000.0	0.278	26.194	3.344	945.128	0.153	0.021	3.802	0.927	0.396	0.061
19500.0	0.276	25.772	3.413	944.878	0.159	0.023	3.831	0.958	0.412	0.066
20000.0	0.275	25.353	3.482	944.627	0.165	0.024	3.858	0.989	0.428	0.071
20500.0	0.273	24.937	3.550	944.375	0.171	0.026	3.883	1.020	0.444	0.076
21000.0	0.272	24.525	3.617	944.121	0.176	0.027	3.907	1.051	0.460	0.081
21500.0	0.270	24.116	3.683	943.866	0.182	0.029	3.929	1.081	0.477	0.087
22000.0	0.269	23.710	3.749	943.610	0.188	0.030	3.949	1.112	0.493	0.092
22500.0	0.267	23.308	3.813	943.353	0.194	0.032	3.969	1.142	0.509	0.098
25000.0	0.260	21.347	4.125	942.044	0.225	0.041	4.047	1.291	0.589	0.131
27500.0	0.252	19.470	4.418	940.696	0.257	0.052	4.096	1.435	0.666	0.170
30000.0	0.244	17.679	4.692	939.309	0.290	0.065	4.121	1.575	0.739	0.215
32500.0	0.236	15.974	4.946	937.878	0.324	0.079	4.124	1.708	0.806	0.265
35000.0	0.229	14.356	5.180	936.400	0.358	0.095	4.109	1.835	0.867	0.321
37500.0	0.221	12.827	5.395	934.874	0.393	0.112	4.079	1.955	0.922	0.383
40000.0	0.213	11.388	5.589	933.295	0.428	0.131	4.036	2.067	0.969	0.451
42500.0	0.205	10.042	5.764	931.660	0.462	0.151	3.985	2.170	1.010	0.524
45000.0	0.197	8.789	5.918	929.967	0.497	0.173	3.926	2.265	1.045	0.603
47500.0	0.190	7.632	6.052	928.210	0.530	0.196	3.863	2.351	1.072	0.686
50000.0	0.182	6.572	6.166	926.389	0.562	0.219	3.796	2.428	1.094	0.774
52500.0	0.174	5.610	6.259	924.500	0.593	0.243	3.729	2.495	1.110	0.867
55000.0	0.166	4.745	6.332	922.542	0.623	0.267	3.663	2.554	1.120	0.963
57500.0	0.159	3.976	6.386	920.514	0.651	0.291	3.599	2.603	1.127	1.063
60000.0	0.151	3.300	6.420	918.416	0.676	0.315	3.538	2.643	1.129	1.165
62500.0	0.144	2.714	6.436	916.251	0.700	0.337	3.482	2.676	1.129	1.270
65000.0	0.137	2.213	6.436	914.022	0.721	0.358	3.431	2.701	1.126	1.375
67500.0	0.130	1.789	6.421	911.733	0.740	0.378	3.384	2.720	1.122	1.481
70000.0	0.123	1.436	6.392	909.388	0.757	0.397	3.344	2.733	1.116	1.586

Table C.50 [ ] Exposure-Dependent 40% Void Isotopics (kg/MTU Initial)

Exposure MWd/MTU	U-234	U-235	U-236	U-238	NP-237	PU-238	PU-239	PU-240	PU-241	PU-242
0.0	0.341	45.159	0.000	954.501	0.000	0.000	0.000	0.000	0.000	0.000
100.0	0.340	45.039	0.023	954.445	0.000	0.000	0.018	0.000	0.000	0.000
500.0	0.339	44.561	0.115	954.221	0.002	0.000	0.194	0.001	0.000	0.000
1000.0	0.337	43.973	0.229	953.940	0.004	0.000	0.426	0.006	0.000	0.000
1500.0	0.335	43.393	0.340	953.659	0.006	0.000	0.648	0.015	0.001	0.000
2000.0	0.333	42.821	0.450	953.378	0.009	0.000	0.861	0.026	0.002	0.000
2500.0	0.331	42.257	0.558	953.097	0.011	0.000	1.063	0.040	0.005	0.000
3000.0	0.329	41.700	0.664	952.816	0.014	0.000	1.257	0.056	0.008	0.000
3500.0	0.327	41.150	0.769	952.535	0.018	0.001	1.442	0.074	0.012	0.000
4000.0	0.325	40.608	0.872	952.254	0.021	0.001	1.619	0.094	0.017	0.000
4500.0	0.323	40.072	0.973	951.973	0.025	0.001	1.788	0.115	0.023	0.001
5000.0	0.321	39.542	1.073	951.691	0.028	0.001	1.950	0.137	0.031	0.001
5500.0	0.319	39.018	1.172	951.410	0.032	0.002	2.105	0.161	0.039	0.001
6000.0	0.317	38.500	1.269	951.129	0.036	0.002	2.253	0.186	0.048	0.002
6500.0	0.315	37.988	1.365	950.848	0.041	0.002	2.394	0.211	0.058	0.002
7000.0	0.313	37.482	1.459	950.567	0.045	0.003	2.530	0.238	0.069	0.003
7500.0	0.312	36.981	1.552	950.286	0.050	0.003	2.659	0.265	0.081	0.004
8000.0	0.310	36.485	1.644	950.005	0.054	0.004	2.782	0.293	0.094	0.005
8500.0	0.308	35.994	1.735	949.724	0.059	0.004	2.900	0.321	0.107	0.006
9000.0	0.306	35.509	1.824	949.443	0.064	0.005	3.012	0.350	0.121	0.007
9500.0	0.304	35.028	1.912	949.163	0.069	0.006	3.119	0.380	0.136	0.009
10000.0	0.302	34.552	1.999	948.883	0.074	0.006	3.221	0.410	0.151	0.010
10500.0	0.301	34.081	2.084	948.602	0.080	0.007	3.319	0.441	0.167	0.012
11000.0	0.299	33.614	2.169	948.322	0.085	0.008	3.411	0.471	0.183	0.014
11500.0	0.297	33.151	2.252	948.042	0.091	0.009	3.499	0.502	0.199	0.016
12000.0	0.295	32.693	2.335	947.762	0.096	0.010	3.583	0.534	0.216	0.018
12500.0	0.294	32.239	2.416	947.482	0.102	0.011	3.663	0.565	0.234	0.021
13000.0	0.292	31.789	2.496	947.202	0.108	0.012	3.739	0.597	0.251	0.023
13500.0	0.290	31.343	2.575	946.922	0.114	0.013	3.812	0.629	0.269	0.026
14000.0	0.288	30.901	2.653	946.642	0.120	0.014	3.880	0.662	0.287	0.029
14500.0	0.287	30.463	2.731	946.362	0.126	0.015	3.946	0.694	0.306	0.032
15000.0	0.285	30.029	2.807	946.081	0.132	0.016	4.007	0.727	0.324	0.036
15500.0	0.283	29.598	2.882	945.801	0.138	0.018	4.066	0.759	0.343	0.039
16000.0	0.281	29.171	2.957	945.521	0.144	0.019	4.121	0.792	0.361	0.043
16500.0	0.280	28.748	3.030	945.241	0.151	0.020	4.173	0.825	0.380	0.047
17000.0	0.278	28.328	3.103	944.961	0.157	0.022	4.222	0.858	0.399	0.051
17500.0	0.276	27.912	3.174	944.680	0.163	0.023	4.269	0.891	0.417	0.055
18000.0	0.275	27.498	3.245	944.400	0.170	0.025	4.312	0.923	0.436	0.060
18500.0	0.273	27.089	3.315	944.119	0.176	0.027	4.354	0.956	0.455	0.065
19000.0	0.271	26.682	3.384	943.837	0.182	0.028	4.393	0.989	0.473	0.069
19500.0	0.270	26.279	3.453	943.556	0.189	0.030	4.429	1.022	0.492	0.075
20000.0	0.268	25.880	3.520	943.273	0.196	0.032	4.464	1.054	0.511	0.080
20500.0	0.266	25.483	3.587	942.990	0.202	0.034	4.497	1.087	0.529	0.085
21000.0	0.265	25.090	3.653	942.705	0.209	0.036	4.528	1.119	0.548	0.091
21500.0	0.263	24.701	3.718	942.420	0.216	0.038	4.557	1.152	0.566	0.097
22000.0	0.262	24.314	3.782	942.133	0.223	0.040	4.584	1.184	0.585	0.103
22500.0	0.260	23.932	3.845	941.846	0.229	0.042	4.610	1.216	0.603	0.110
23000.0	0.258	23.552	3.908	941.557	0.236	0.044	4.635	1.248	0.622	0.116
23500.0	0.257	23.176	3.969	941.267	0.243	0.047	4.658	1.279	0.640	0.123
24000.0	0.255	22.803	4.030	940.975	0.250	0.049	4.679	1.311	0.658	0.130
24500.0	0.254	22.434	4.090	940.683	0.258	0.051	4.700	1.342	0.676	0.137
25000.0	0.252	22.068	4.150	940.389	0.265	0.054	4.719	1.373	0.694	0.145
27500.0	0.244	20.288	4.434	938.896	0.301	0.068	4.797	1.525	0.783	0.185
30000.0	0.236	18.592	4.699	937.367	0.339	0.083	4.849	1.671	0.867	0.231
32500.0	0.228	16.979	4.944	935.800	0.377	0.101	4.877	1.812	0.946	0.282
35000.0	0.220	15.449	5.169	934.193	0.415	0.121	4.885	1.945	1.019	0.338
37500.0	0.213	14.002	5.375	932.545	0.453	0.142	4.875	2.072	1.085	0.399
40000.0	0.205	12.638	5.562	930.854	0.491	0.165	4.852	2.191	1.145	0.464
42500.0	0.197	11.356	5.731	929.118	0.528	0.190	4.817	2.302	1.197	0.534
45000.0	0.190	10.157	5.880	927.336	0.565	0.216	4.772	2.406	1.243	0.609
47500.0	0.183	9.040	6.012	925.506	0.601	0.243	4.720	2.500	1.282	0.687
50000.0	0.175	8.004	6.125	923.627	0.635	0.272	4.662	2.586	1.314	0.769
52500.0	0.168	7.050	6.219	921.698	0.668	0.301	4.601	2.664	1.341	0.854
55000.0	0.161	6.176	6.297	919.718	0.700	0.330	4.538	2.733	1.362	0.942
57500.0	0.154	5.380	6.357	917.687	0.730	0.359	4.474	2.793	1.378	1.032
60000.0	0.148	4.660	6.401	915.605	0.758	0.389	4.410	2.846	1.389	1.124
62500.0	0.141	4.014	6.429	913.473	0.784	0.417	4.348	2.890	1.396	1.218
65000.0	0.135	3.439	6.442	911.293	0.808	0.445	4.289	2.928	1.399	1.313
67500.0	0.129	2.930	6.441	909.066	0.830	0.471	4.233	2.959	1.400	1.409
70000.0	0.123	2.484	6.428	906.794	0.850	0.497	4.181	2.983	1.399	1.504

Table C.51 [ ] Exposure-Dependent 80% Void Isotopics (kg/MTU Initial)

Exposure MWd/MTU	U-234	U-235	U-236	U-238	NP-237	PU-238	PU-239	PU-240	PU-241	PU-242
0.0	0.341	45.159	0.000	954.501	0.000	0.000	0.000	0.000	0.000	0.000
100.0	0.340	45.039	0.024	954.435	0.000	0.000	0.021	0.000	0.000	0.000
500.0	0.338	44.565	0.121	954.173	0.002	0.000	0.225	0.002	0.000	0.000
1000.0	0.336	43.982	0.240	953.844	0.005	0.000	0.494	0.007	0.000	0.000
1500.0	0.334	43.408	0.357	953.515	0.008	0.000	0.751	0.017	0.001	0.000
2000.0	0.331	42.844	0.472	953.186	0.011	0.000	0.997	0.030	0.003	0.000
2500.0	0.329	42.288	0.584	952.857	0.014	0.000	1.232	0.045	0.007	0.000
3000.0	0.327	41.741	0.695	952.529	0.018	0.001	1.456	0.063	0.011	0.000
3500.0	0.325	41.201	0.804	952.200	0.022	0.001	1.672	0.082	0.016	0.000
4000.0	0.322	40.669	0.911	951.872	0.026	0.001	1.878	0.104	0.023	0.001
4500.0	0.320	40.145	1.016	951.543	0.031	0.001	2.076	0.126	0.031	0.001
5000.0	0.318	39.627	1.119	951.215	0.035	0.002	2.265	0.151	0.040	0.001
5500.0	0.316	39.116	1.221	950.886	0.040	0.002	2.447	0.176	0.051	0.002
6000.0	0.313	38.611	1.321	950.558	0.045	0.003	2.621	0.202	0.062	0.002
6500.0	0.311	38.113	1.420	950.230	0.051	0.003	2.789	0.229	0.075	0.003
7000.0	0.309	37.621	1.517	949.901	0.056	0.004	2.949	0.258	0.088	0.004
7500.0	0.307	37.135	1.612	949.573	0.062	0.005	3.103	0.287	0.103	0.005
8000.0	0.305	36.654	1.706	949.246	0.068	0.005	3.250	0.316	0.118	0.006
8500.0	0.303	36.179	1.799	948.918	0.074	0.006	3.392	0.346	0.134	0.007
9000.0	0.301	35.710	1.890	948.590	0.080	0.007	3.527	0.377	0.151	0.009
9500.0	0.299	35.245	1.980	948.263	0.086	0.008	3.657	0.409	0.168	0.010
10000.0	0.297	34.786	2.068	947.936	0.093	0.009	3.782	0.441	0.186	0.012
10500.0	0.295	34.332	2.155	947.609	0.099	0.010	3.901	0.473	0.205	0.014
11000.0	0.293	33.883	2.241	947.282	0.106	0.011	4.016	0.506	0.224	0.016
11500.0	0.291	33.438	2.326	946.955	0.113	0.013	4.125	0.539	0.243	0.018
12000.0	0.289	32.998	2.410	946.628	0.120	0.014	4.230	0.572	0.263	0.021
12500.0	0.287	32.563	2.492	946.302	0.127	0.015	4.331	0.606	0.284	0.024
13000.0	0.285	32.132	2.573	945.975	0.134	0.017	4.428	0.640	0.304	0.026
13500.0	0.283	31.705	2.653	945.648	0.141	0.018	4.520	0.674	0.325	0.030
14000.0	0.281	31.283	2.732	945.321	0.148	0.020	4.609	0.708	0.346	0.033
14500.0	0.279	30.865	2.810	944.994	0.155	0.022	4.694	0.743	0.367	0.036
15000.0	0.277	30.451	2.887	944.666	0.163	0.023	4.775	0.778	0.389	0.040
15500.0	0.275	30.041	2.962	944.339	0.170	0.025	4.852	0.813	0.410	0.044
16000.0	0.273	29.635	3.037	944.012	0.178	0.027	4.927	0.848	0.432	0.048
16500.0	0.271	29.233	3.111	943.684	0.186	0.029	4.997	0.883	0.454	0.052
17000.0	0.269	28.834	3.183	943.357	0.193	0.031	5.065	0.919	0.475	0.056
17500.0	0.268	28.440	3.255	943.029	0.201	0.033	5.129	0.954	0.497	0.061
18000.0	0.266	28.049	3.325	942.701	0.209	0.036	5.191	0.990	0.519	0.065
18500.0	0.264	27.662	3.395	942.373	0.216	0.038	5.250	1.025	0.541	0.070
19000.0	0.262	27.278	3.463	942.045	0.224	0.040	5.306	1.061	0.562	0.076
19500.0	0.260	26.898	3.531	941.717	0.232	0.043	5.359	1.096	0.584	0.081
20000.0	0.258	26.521	3.598	941.388	0.240	0.046	5.410	1.132	0.606	0.086
20500.0	0.257	26.148	3.664	941.058	0.248	0.048	5.458	1.167	0.627	0.092
21000.0	0.255	25.779	3.729	940.728	0.256	0.051	5.505	1.203	0.649	0.098
21500.0	0.253	25.412	3.793	940.398	0.264	0.054	5.549	1.238	0.670	0.104
22000.0	0.251	25.049	3.856	940.067	0.272	0.057	5.591	1.273	0.691	0.110
22500.0	0.250	24.690	3.919	939.735	0.280	0.060	5.631	1.308	0.713	0.117
23000.0	0.248	24.333	3.980	939.402	0.288	0.063	5.669	1.343	0.734	0.123
23500.0	0.246	23.981	4.041	939.068	0.296	0.066	5.706	1.378	0.755	0.130
24000.0	0.244	23.631	4.100	938.733	0.304	0.069	5.741	1.413	0.776	0.137
24500.0	0.243	23.285	4.159	938.397	0.312	0.073	5.775	1.448	0.797	0.144
25000.0	0.241	22.942	4.218	938.061	0.321	0.076	5.806	1.482	0.818	0.152
25500.0	0.239	22.602	4.275	937.723	0.329	0.080	5.837	1.516	0.838	0.159
26000.0	0.238	22.266	4.331	937.383	0.337	0.083	5.866	1.550	0.859	0.167
26500.0	0.236	21.933	4.387	937.043	0.345	0.087	5.894	1.584	0.879	0.175
27000.0	0.234	21.604	4.442	936.701	0.354	0.091	5.921	1.618	0.900	0.183
27500.0	0.233	21.277	4.496	936.358	0.362	0.095	5.946	1.652	0.920	0.191
28000.0	0.231	20.954	4.549	936.014	0.370	0.099	5.970	1.685	0.940	0.200
28500.0	0.229	20.634	4.601	935.669	0.378	0.103	5.993	1.718	0.960	0.208
30000.0	0.224	19.694	4.754	934.624	0.403	0.116	6.056	1.816	1.018	0.235
32500.0	0.216	18.190	4.992	932.857	0.445	0.139	6.140	1.974	1.113	0.283
35000.0	0.208	16.765	5.210	931.056	0.487	0.165	6.201	2.126	1.203	0.335
37500.0	0.201	15.417	5.410	929.221	0.529	0.192	6.243	2.271	1.287	0.391
40000.0	0.193	14.145	5.591	927.352	0.570	0.222	6.267	2.410	1.366	0.451
42500.0	0.186	12.947	5.753	925.448	0.611	0.254	6.276	2.542	1.438	0.514
45000.0	0.178	11.821	5.898	923.509	0.651	0.287	6.273	2.666	1.503	0.581
47500.0	0.172	10.766	6.025	921.534	0.689	0.322	6.259	2.783	1.563	0.650
50000.0	0.165	9.781	6.135	919.524	0.727	0.358	6.236	2.892	1.617	0.722
52500.0	0.158	8.863	6.230	917.479	0.763	0.396	6.205	2.993	1.665	0.796
55000.0	0.152	8.011	6.308	915.400	0.797	0.434	6.169	3.087	1.707	0.873
57500.0	0.146	7.221	6.372	913.286	0.829	0.472	6.129	3.174	1.745	0.951
60000.0	0.140	6.493	6.421	911.138	0.860	0.511	6.085	3.253	1.777	1.031
62500.0	0.134	5.824	6.457	908.958	0.889	0.549	6.039	3.324	1.805	1.113
65000.0	0.129	5.210	6.480	906.746	0.915	0.587	5.991	3.389	1.828	1.196
67500.0	0.124	4.650	6.491	904.503	0.940	0.625	5.943	3.447	1.848	1.281
70000.0	0.119	4.141	6.491	902.231	0.962	0.662	5.896	3.498	1.864	1.366

Table C.52 [ ] Exposure-Dependent 0% Void Isotopics (kg/MTU Initial)

Exposure MWd/MTU	U-234	U-235	U-236	U-238	NP-237	PU-238	PU-239	PU-240	PU-241	PU-242
0.0	0.338	44.776	0.000	954.886	0.000	0.000	0.000	0.000	0.000	0.000
100.0	0.338	44.655	0.022	954.839	0.000	0.000	0.014	0.000	0.000	0.000
500.0	0.336	44.176	0.110	954.649	0.001	0.000	0.163	0.001	0.000	0.000
1000.0	0.335	43.583	0.218	954.410	0.003	0.000	0.362	0.005	0.000	0.000
1500.0	0.333	42.999	0.325	954.172	0.005	0.000	0.553	0.013	0.001	0.000
2000.0	0.331	42.421	0.431	953.933	0.007	0.000	0.735	0.022	0.002	0.000
2500.0	0.330	41.849	0.535	953.694	0.009	0.000	0.909	0.035	0.003	0.000
3000.0	0.328	41.285	0.637	953.455	0.012	0.000	1.075	0.049	0.006	0.000
3500.0	0.326	40.726	0.738	953.216	0.014	0.000	1.234	0.065	0.009	0.000
4000.0	0.324	40.174	0.838	952.976	0.017	0.001	1.386	0.082	0.012	0.000
4500.0	0.323	39.627	0.936	952.737	0.020	0.001	1.530	0.101	0.017	0.000
5000.0	0.321	39.086	1.033	952.497	0.023	0.001	1.669	0.122	0.023	0.001
5500.0	0.319	38.551	1.129	952.258	0.026	0.001	1.801	0.143	0.029	0.001
6000.0	0.318	38.021	1.224	952.018	0.029	0.001	1.927	0.166	0.036	0.001
6500.0	0.316	37.496	1.317	951.779	0.032	0.002	2.047	0.189	0.044	0.002
7000.0	0.315	36.976	1.410	951.539	0.036	0.002	2.161	0.214	0.052	0.002
7500.0	0.313	36.460	1.501	951.300	0.040	0.002	2.270	0.239	0.061	0.003
8000.0	0.311	35.950	1.591	951.060	0.043	0.003	2.374	0.265	0.071	0.004
8500.0	0.310	35.444	1.680	950.821	0.047	0.003	2.473	0.291	0.082	0.005
9000.0	0.308	34.942	1.768	950.581	0.051	0.003	2.567	0.318	0.093	0.006
9500.0	0.306	34.445	1.855	950.342	0.055	0.004	2.656	0.346	0.105	0.007
10000.0	0.305	33.952	1.941	950.103	0.059	0.004	2.740	0.374	0.117	0.008
10500.0	0.303	33.464	2.025	949.865	0.063	0.005	2.820	0.402	0.129	0.010
11000.0	0.302	32.979	2.109	949.626	0.068	0.005	2.896	0.431	0.142	0.011
11500.0	0.300	32.498	2.192	949.387	0.072	0.006	2.968	0.461	0.156	0.013
12000.0	0.299	32.021	2.274	949.149	0.076	0.007	3.036	0.490	0.170	0.015
12500.0	0.297	31.548	2.355	948.911	0.081	0.007	3.100	0.520	0.184	0.017
13000.0	0.295	31.079	2.435	948.672	0.086	0.008	3.160	0.550	0.198	0.019
13500.0	0.294	30.613	2.514	948.434	0.090	0.009	3.218	0.580	0.212	0.021
14000.0	0.292	30.151	2.592	948.196	0.095	0.010	3.271	0.610	0.227	0.024
14500.0	0.291	29.692	2.670	947.958	0.100	0.010	3.322	0.641	0.242	0.027
15000.0	0.289	29.236	2.746	947.720	0.105	0.011	3.369	0.671	0.257	0.029
15500.0	0.288	28.784	2.822	947.482	0.110	0.012	3.413	0.702	0.272	0.033
16000.0	0.286	28.335	2.897	947.245	0.115	0.013	3.454	0.733	0.287	0.036
16500.0	0.285	27.889	2.971	947.007	0.120	0.014	3.493	0.764	0.303	0.039
17000.0	0.283	27.446	3.044	946.769	0.125	0.015	3.529	0.795	0.318	0.043
17500.0	0.282	27.007	3.117	946.530	0.130	0.016	3.563	0.826	0.333	0.047
18000.0	0.280	26.571	3.188	946.291	0.135	0.017	3.595	0.856	0.349	0.051
18500.0	0.279	26.138	3.259	946.051	0.141	0.018	3.624	0.887	0.364	0.055
19000.0	0.277	25.708	3.330	945.811	0.146	0.020	3.652	0.918	0.380	0.059
19500.0	0.276	25.281	3.399	945.569	0.151	0.021	3.678	0.949	0.395	0.064
20000.0	0.274	24.858	3.468	945.326	0.157	0.022	3.702	0.979	0.411	0.069
20500.0	0.273	24.438	3.536	945.082	0.162	0.024	3.725	1.010	0.427	0.074
21000.0	0.271	24.021	3.603	944.837	0.168	0.025	3.746	1.040	0.442	0.079
21500.0	0.270	23.607	3.669	944.590	0.173	0.026	3.766	1.071	0.458	0.084
22000.0	0.268	23.197	3.735	944.342	0.179	0.028	3.784	1.101	0.473	0.090
22500.0	0.267	22.790	3.800	944.093	0.185	0.030	3.801	1.131	0.489	0.096
25000.0	0.259	20.806	4.113	942.824	0.214	0.038	3.868	1.278	0.566	0.128
27500.0	0.251	18.907	4.407	941.515	0.245	0.048	3.907	1.421	0.640	0.167
30000.0	0.244	17.094	4.682	940.164	0.276	0.060	3.922	1.559	0.709	0.211
32500.0	0.236	15.369	4.937	938.767	0.309	0.073	3.917	1.691	0.774	0.262
35000.0	0.228	13.733	5.172	937.322	0.342	0.088	3.894	1.816	0.832	0.318
37500.0	0.221	12.188	5.388	935.823	0.376	0.104	3.858	1.934	0.883	0.381
40000.0	0.213	10.738	5.583	934.268	0.410	0.122	3.811	2.044	0.927	0.450
42500.0	0.205	9.384	5.757	932.652	0.443	0.141	3.755	2.146	0.965	0.525
45000.0	0.197	8.130	5.911	930.971	0.476	0.161	3.694	2.238	0.996	0.605
47500.0	0.189	6.978	6.043	929.221	0.509	0.182	3.628	2.321	1.020	0.691
50000.0	0.181	5.930	6.153	927.398	0.540	0.204	3.561	2.395	1.038	0.782
52500.0	0.173	4.986	6.242	925.499	0.570	0.227	3.495	2.458	1.051	0.878
55000.0	0.165	4.148	6.310	923.524	0.599	0.249	3.431	2.513	1.059	0.978
57500.0	0.157	3.413	6.357	921.471	0.625	0.272	3.370	2.558	1.063	1.082
60000.0	0.149	2.778	6.384	919.342	0.650	0.293	3.313	2.594	1.064	1.188
62500.0	0.142	2.237	6.393	917.139	0.672	0.314	3.262	2.623	1.062	1.296
65000.0	0.134	1.784	6.384	914.868	0.692	0.333	3.216	2.644	1.058	1.406
67500.0	0.127	1.410	6.361	912.534	0.710	0.351	3.176	2.659	1.053	1.515
70000.0	0.120	1.106	6.324	910.144	0.725	0.367	3.142	2.669	1.047	1.624

Table C.53 [ ] Exposure-Dependent 40% Void Isotopics (kg/MTU Initial)

Exposure MWd/MTU	U-234	U-235	U-236	U-238	NP-237	PU-238	PU-239	PU-240	PU-241	PU-242
0.0	0.338	44.776	0.000	954.886	0.000	0.000	0.000	0.000	0.000	0.000
100.0	0.338	44.655	0.023	954.832	0.000	0.000	0.017	0.000	0.000	0.000
500.0	0.336	44.177	0.114	954.613	0.002	0.000	0.186	0.001	0.000	0.000
1000.0	0.334	43.588	0.227	954.339	0.004	0.000	0.413	0.006	0.000	0.000
1500.0	0.332	43.007	0.338	954.065	0.006	0.000	0.631	0.014	0.001	0.000
2000.0	0.330	42.434	0.446	953.791	0.008	0.000	0.839	0.026	0.002	0.000
2500.0	0.328	41.868	0.554	953.517	0.011	0.000	1.037	0.039	0.004	0.000
3000.0	0.327	41.310	0.659	953.243	0.014	0.000	1.226	0.055	0.008	0.000
3500.0	0.325	40.759	0.763	952.969	0.017	0.001	1.407	0.073	0.011	0.000
4000.0	0.323	40.214	0.865	952.695	0.020	0.001	1.579	0.092	0.016	0.000
4500.0	0.321	39.676	0.966	952.421	0.024	0.001	1.744	0.113	0.022	0.001
5000.0	0.319	39.145	1.065	952.148	0.027	0.001	1.902	0.135	0.029	0.001
5500.0	0.317	38.619	1.163	951.874	0.031	0.001	2.052	0.159	0.037	0.001
6000.0	0.315	38.099	1.260	951.600	0.035	0.002	2.196	0.183	0.046	0.002
6500.0	0.313	37.585	1.355	951.327	0.039	0.002	2.333	0.209	0.056	0.002
7000.0	0.312	37.076	1.449	951.053	0.043	0.003	2.464	0.235	0.067	0.003
7500.0	0.310	36.573	1.541	950.780	0.047	0.003	2.589	0.262	0.078	0.004
8000.0	0.308	36.075	1.633	950.507	0.052	0.003	2.708	0.290	0.090	0.005
8500.0	0.306	35.582	1.723	950.234	0.056	0.004	2.822	0.318	0.103	0.006
9000.0	0.304	35.094	1.811	949.961	0.061	0.005	2.930	0.347	0.117	0.007
9500.0	0.303	34.611	1.899	949.689	0.066	0.005	3.033	0.376	0.131	0.008
10000.0	0.301	34.132	1.985	949.417	0.071	0.006	3.130	0.406	0.146	0.010
10500.0	0.299	33.658	2.071	949.145	0.076	0.007	3.223	0.437	0.161	0.012
11000.0	0.297	33.188	2.155	948.873	0.081	0.007	3.311	0.467	0.177	0.013
11500.0	0.296	32.723	2.238	948.602	0.087	0.008	3.395	0.498	0.193	0.015
12000.0	0.294	32.262	2.320	948.331	0.092	0.009	3.475	0.529	0.209	0.018
12500.0	0.292	31.804	2.400	948.060	0.098	0.010	3.550	0.561	0.226	0.020
13000.0	0.290	31.351	2.480	947.789	0.103	0.011	3.622	0.593	0.243	0.023
13500.0	0.289	30.902	2.559	947.518	0.109	0.012	3.690	0.625	0.261	0.025
14000.0	0.287	30.457	2.637	947.247	0.115	0.013	3.754	0.657	0.278	0.028
14500.0	0.285	30.015	2.714	946.976	0.120	0.014	3.814	0.689	0.296	0.031
15000.0	0.284	29.577	2.790	946.706	0.126	0.015	3.871	0.721	0.314	0.035
15500.0	0.282	29.143	2.865	946.435	0.132	0.016	3.925	0.754	0.332	0.038
16000.0	0.280	28.712	2.939	946.165	0.138	0.018	3.975	0.786	0.350	0.042
16500.0	0.279	28.285	3.013	945.895	0.144	0.019	4.023	0.819	0.368	0.046
17000.0	0.277	27.861	3.085	945.625	0.150	0.020	4.068	0.851	0.386	0.050
17500.0	0.276	27.440	3.157	945.355	0.156	0.022	4.110	0.884	0.404	0.054
18000.0	0.274	27.023	3.228	945.084	0.162	0.023	4.149	0.917	0.422	0.059
18500.0	0.272	26.609	3.298	944.813	0.168	0.025	4.186	0.949	0.440	0.063
19000.0	0.271	26.198	3.367	944.542	0.174	0.026	4.221	0.982	0.458	0.068
19500.0	0.269	25.791	3.435	944.270	0.180	0.028	4.253	1.014	0.476	0.073
20000.0	0.268	25.387	3.502	943.997	0.187	0.030	4.284	1.046	0.494	0.078
20500.0	0.266	24.986	3.569	943.723	0.193	0.031	4.313	1.078	0.512	0.084
21000.0	0.264	24.588	3.635	943.448	0.199	0.033	4.340	1.110	0.530	0.090
21500.0	0.263	24.194	3.700	943.172	0.206	0.035	4.366	1.142	0.548	0.096
22000.0	0.261	23.804	3.764	942.895	0.212	0.037	4.390	1.174	0.566	0.102
22500.0	0.260	23.416	3.828	942.616	0.219	0.039	4.413	1.206	0.584	0.108
23000.0	0.258	23.032	3.890	942.337	0.226	0.041	4.434	1.237	0.602	0.115
23500.0	0.256	22.652	3.952	942.056	0.232	0.043	4.453	1.268	0.619	0.121
24000.0	0.255	22.274	4.013	941.773	0.239	0.045	4.472	1.299	0.637	0.128
25000.0	0.252	21.530	4.133	941.204	0.253	0.050	4.505	1.361	0.672	0.143
27500.0	0.244	19.728	4.418	939.756	0.288	0.063	4.568	1.511	0.758	0.183
30000.0	0.236	18.010	4.683	938.270	0.324	0.077	4.606	1.655	0.839	0.229
32500.0	0.228	16.377	4.929	936.744	0.361	0.094	4.621	1.792	0.914	0.281
35000.0	0.220	14.829	5.155	935.176	0.398	0.112	4.617	1.923	0.983	0.338
37500.0	0.213	13.365	5.362	933.565	0.435	0.132	4.597	2.047	1.045	0.400
40000.0	0.205	11.986	5.549	931.907	0.472	0.154	4.563	2.162	1.100	0.467
42500.0	0.197	10.694	5.717	930.201	0.508	0.177	4.519	2.270	1.148	0.539
45000.0	0.190	9.487	5.866	928.445	0.544	0.201	4.467	2.369	1.189	0.616
47500.0	0.182	8.367	5.996	926.635	0.578	0.227	4.409	2.459	1.223	0.696
50000.0	0.175	7.333	6.107	924.772	0.612	0.253	4.346	2.540	1.251	0.781
52500.0	0.168	6.386	6.199	922.852	0.644	0.280	4.281	2.613	1.273	0.869
55000.0	0.161	5.525	6.273	920.876	0.675	0.308	4.215	2.676	1.289	0.961
57500.0	0.153	4.747	6.329	918.843	0.704	0.335	4.149	2.731	1.300	1.055
60000.0	0.147	4.051	6.367	916.753	0.731	0.362	4.086	2.777	1.307	1.151
62500.0	0.140	3.434	6.390	914.607	0.756	0.388	4.025	2.816	1.310	1.248
65000.0	0.133	2.892	6.396	912.407	0.778	0.413	3.968	2.847	1.310	1.347
67500.0	0.127	2.420	6.389	910.155	0.799	0.437	3.914	2.872	1.308	1.446
70000.0	0.121	2.013	6.368	907.856	0.817	0.460	3.866	2.890	1.304	1.545

Table C.54 [ ] Exposure-Dependent 80% Void Isotopics (kg/MTU Initial)

Exposure MWd/MTU	U-234	U-235	U-236	U-238	NP-237	PU-238	PU-239	PU-240	PU-241	PU-242
0.0	0.338	44.776	0.000	954.886	0.000	0.000	0.000	0.000	0.000	0.000
100.0	0.338	44.656	0.024	954.822	0.000	0.000	0.019	0.000	0.000	0.000
500.0	0.336	44.181	0.120	954.565	0.002	0.000	0.217	0.002	0.000	0.000
1000.0	0.334	43.596	0.239	954.242	0.004	0.000	0.482	0.007	0.000	0.000
1500.0	0.331	43.021	0.355	953.920	0.007	0.000	0.735	0.017	0.001	0.000
2000.0	0.329	42.455	0.469	953.597	0.010	0.000	0.976	0.029	0.003	0.000
2500.0	0.327	41.898	0.580	953.275	0.014	0.000	1.207	0.045	0.006	0.000
3000.0	0.324	41.349	0.690	952.953	0.017	0.001	1.428	0.062	0.010	0.000
3500.0	0.322	40.807	0.798	952.632	0.021	0.001	1.639	0.082	0.016	0.000
4000.0	0.320	40.274	0.905	952.310	0.025	0.001	1.841	0.103	0.022	0.001
4500.0	0.318	39.747	1.009	951.988	0.029	0.001	2.034	0.126	0.030	0.001
5000.0	0.316	39.228	1.112	951.667	0.034	0.002	2.219	0.150	0.039	0.001
5500.0	0.314	38.715	1.213	951.346	0.039	0.002	2.397	0.175	0.049	0.002
6000.0	0.311	38.209	1.313	951.025	0.044	0.003	2.567	0.201	0.061	0.002
6500.0	0.309	37.709	1.410	950.704	0.049	0.003	2.729	0.229	0.073	0.003
7000.0	0.307	37.215	1.507	950.384	0.054	0.004	2.885	0.257	0.087	0.004
7500.0	0.305	36.727	1.602	950.063	0.060	0.004	3.034	0.286	0.101	0.005
8000.0	0.303	36.244	1.695	949.743	0.065	0.005	3.177	0.315	0.116	0.006
8500.0	0.301	35.767	1.787	949.424	0.071	0.006	3.313	0.345	0.132	0.007
9000.0	0.299	35.296	1.878	949.104	0.077	0.007	3.444	0.376	0.148	0.009
9500.0	0.297	34.829	1.967	948.785	0.083	0.008	3.569	0.408	0.166	0.010
10000.0	0.295	34.368	2.055	948.466	0.090	0.009	3.688	0.439	0.183	0.012
10500.0	0.293	33.912	2.142	948.147	0.096	0.010	3.802	0.472	0.202	0.014
11000.0	0.291	33.460	2.227	947.829	0.102	0.011	3.911	0.504	0.221	0.016
11500.0	0.289	33.013	2.312	947.511	0.109	0.012	4.016	0.537	0.240	0.018
12000.0	0.287	32.571	2.395	947.193	0.115	0.013	4.115	0.571	0.259	0.021
12500.0	0.285	32.133	2.477	946.875	0.122	0.014	4.211	0.604	0.279	0.023
13000.0	0.283	31.700	2.557	946.557	0.129	0.016	4.302	0.638	0.300	0.026
13500.0	0.281	31.271	2.637	946.239	0.136	0.017	4.389	0.672	0.320	0.029
14000.0	0.279	30.846	2.715	945.922	0.143	0.019	4.471	0.707	0.341	0.033
14500.0	0.278	30.425	2.793	945.604	0.150	0.020	4.551	0.741	0.362	0.036
15000.0	0.276	30.009	2.869	945.286	0.157	0.022	4.626	0.776	0.383	0.040
15500.0	0.274	29.596	2.944	944.969	0.164	0.024	4.698	0.811	0.404	0.044
16000.0	0.272	29.187	3.018	944.651	0.172	0.026	4.766	0.846	0.425	0.048
16500.0	0.270	28.782	3.092	944.334	0.179	0.027	4.831	0.881	0.447	0.052
17000.0	0.268	28.381	3.164	944.016	0.186	0.029	4.893	0.916	0.468	0.056
17500.0	0.267	27.984	3.235	943.699	0.194	0.031	4.951	0.951	0.490	0.061
18000.0	0.265	27.590	3.305	943.382	0.201	0.034	5.007	0.986	0.511	0.066
18500.0	0.263	27.199	3.375	943.064	0.209	0.036	5.060	1.021	0.532	0.071
19000.0	0.261	26.812	3.443	942.746	0.216	0.038	5.110	1.057	0.553	0.076
19500.0	0.260	26.429	3.510	942.428	0.224	0.040	5.158	1.092	0.575	0.081
20000.0	0.258	26.049	3.577	942.110	0.231	0.043	5.203	1.127	0.596	0.087
20500.0	0.256	25.672	3.642	941.791	0.239	0.045	5.246	1.162	0.617	0.092
21000.0	0.254	25.299	3.707	941.472	0.247	0.048	5.286	1.197	0.638	0.098
21500.0	0.253	24.929	3.771	941.152	0.254	0.050	5.325	1.232	0.659	0.104
22000.0	0.251	24.563	3.834	940.831	0.262	0.053	5.362	1.267	0.680	0.111
22500.0	0.249	24.200	3.896	940.509	0.270	0.056	5.397	1.301	0.700	0.117
23000.0	0.247	23.840	3.958	940.187	0.278	0.059	5.430	1.336	0.721	0.124
23500.0	0.246	23.484	4.018	939.863	0.286	0.062	5.461	1.370	0.742	0.131
24000.0	0.244	23.131	4.078	939.538	0.293	0.065	5.492	1.405	0.762	0.138
24500.0	0.242	22.781	4.137	939.212	0.301	0.068	5.520	1.439	0.783	0.145
25000.0	0.241	22.435	4.195	938.885	0.309	0.071	5.547	1.472	0.803	0.153
25500.0	0.239	22.092	4.252	938.557	0.317	0.075	5.573	1.506	0.823	0.160
26000.0	0.237	21.752	4.308	938.227	0.325	0.078	5.598	1.539	0.843	0.168
26500.0	0.236	21.416	4.364	937.897	0.333	0.082	5.621	1.573	0.863	0.176
27000.0	0.234	21.082	4.419	937.565	0.341	0.085	5.643	1.606	0.883	0.185
27500.0	0.232	20.753	4.472	937.231	0.349	0.089	5.664	1.639	0.902	0.193
30000.0	0.224	19.152	4.730	935.544	0.390	0.109	5.753	1.799	0.999	0.238
32500.0	0.216	17.633	4.968	933.822	0.431	0.130	5.816	1.953	1.091	0.287
35000.0	0.208	16.193	5.186	932.066	0.472	0.154	5.858	2.100	1.177	0.341
37500.0	0.201	14.831	5.385	930.274	0.512	0.180	5.881	2.241	1.256	0.399
40000.0	0.193	13.547	5.565	928.446	0.553	0.209	5.888	2.374	1.330	0.461
42500.0	0.186	12.338	5.726	926.581	0.592	0.238	5.880	2.500	1.397	0.526
45000.0	0.179	11.205	5.869	924.679	0.631	0.270	5.862	2.618	1.457	0.595
47500.0	0.171	10.144	5.995	922.738	0.669	0.303	5.833	2.728	1.511	0.667
50000.0	0.165	9.156	6.104	920.760	0.706	0.337	5.797	2.831	1.559	0.742
52500.0	0.158	8.238	6.196	918.743	0.741	0.372	5.754	2.925	1.601	0.819
55000.0	0.152	7.388	6.272	916.688	0.775	0.408	5.707	3.011	1.637	0.899
57500.0	0.145	6.605	6.332	914.595	0.806	0.444	5.657	3.089	1.668	0.981
60000.0	0.139	5.886	6.378	912.465	0.836	0.480	5.604	3.160	1.694	1.064
62500.0	0.133	5.228	6.410	910.299	0.864	0.516	5.551	3.223	1.715	1.150
65000.0	0.128	4.630	6.429	908.097	0.890	0.551	5.497	3.278	1.732	1.236
67500.0	0.122	4.087	6.435	905.861	0.914	0.586	5.444	3.327	1.745	1.324
70000.0	0.117	3.598	6.429	903.593	0.935	0.619	5.393	3.370	1.755	1.412

Table C.55 [ ] Exposure-Dependent 0% Void Isotopics (kg/MTU Initial)

Exposure MWd/MTU	U-234	U-235	U-236	U-238	NP-237	PU-238	PU-239	PU-240	PU-241	PU-242
0.0	0.334	44.230	0.000	955.436	0.000	0.000	0.000	0.000	0.000	0.000
100.0	0.334	44.109	0.022	955.389	0.000	0.000	0.015	0.000	0.000	0.000
500.0	0.333	43.631	0.110	955.198	0.001	0.000	0.163	0.001	0.000	0.000
1000.0	0.331	43.039	0.218	954.958	0.003	0.000	0.363	0.005	0.000	0.000
1500.0	0.329	42.455	0.325	954.719	0.005	0.000	0.554	0.013	0.001	0.000
2000.0	0.327	41.877	0.430	954.480	0.007	0.000	0.736	0.023	0.002	0.000
2500.0	0.326	41.307	0.533	954.241	0.009	0.000	0.909	0.035	0.003	0.000
3000.0	0.324	40.743	0.635	954.002	0.012	0.000	1.075	0.049	0.006	0.000
3500.0	0.322	40.186	0.736	953.763	0.014	0.000	1.233	0.065	0.009	0.000
4000.0	0.321	39.634	0.835	953.525	0.017	0.001	1.383	0.083	0.013	0.000
4500.0	0.319	39.088	0.933	953.287	0.020	0.001	1.526	0.102	0.017	0.000
5000.0	0.317	38.548	1.030	953.049	0.023	0.001	1.662	0.123	0.023	0.001
5500.0	0.316	38.013	1.125	952.812	0.026	0.001	1.792	0.144	0.029	0.001
6000.0	0.314	37.483	1.220	952.575	0.029	0.001	1.915	0.167	0.036	0.001
6500.0	0.313	36.959	1.312	952.338	0.033	0.002	2.032	0.191	0.044	0.002
7000.0	0.311	36.439	1.404	952.102	0.036	0.002	2.143	0.215	0.052	0.002
7500.0	0.309	35.924	1.495	951.866	0.040	0.002	2.249	0.240	0.061	0.003
8000.0	0.308	35.414	1.584	951.631	0.043	0.003	2.349	0.266	0.071	0.004
8500.0	0.306	34.908	1.673	951.397	0.047	0.003	2.444	0.293	0.081	0.005
9000.0	0.305	34.406	1.760	951.163	0.051	0.003	2.533	0.320	0.092	0.006
9500.0	0.303	33.909	1.847	950.930	0.055	0.004	2.618	0.348	0.104	0.007
10000.0	0.301	33.415	1.932	950.697	0.059	0.004	2.697	0.376	0.115	0.008
10500.0	0.300	32.926	2.016	950.465	0.063	0.005	2.772	0.404	0.128	0.010
11000.0	0.298	32.440	2.099	950.234	0.067	0.005	2.843	0.433	0.140	0.011
11500.0	0.297	31.958	2.182	950.003	0.071	0.006	2.909	0.462	0.153	0.013
12000.0	0.295	31.480	2.263	949.773	0.075	0.007	2.972	0.492	0.166	0.015
12500.0	0.294	31.005	2.343	949.544	0.080	0.007	3.030	0.522	0.180	0.017
13000.0	0.292	30.534	2.423	949.315	0.084	0.008	3.085	0.552	0.193	0.019
13500.0	0.291	30.065	2.502	949.086	0.088	0.009	3.136	0.582	0.207	0.021
14000.0	0.289	29.600	2.580	948.858	0.093	0.009	3.185	0.612	0.221	0.024
14500.0	0.288	29.139	2.657	948.630	0.097	0.010	3.230	0.642	0.235	0.026
15000.0	0.286	28.680	2.733	948.401	0.102	0.011	3.272	0.673	0.249	0.029
15500.0	0.285	28.225	2.808	948.173	0.107	0.012	3.312	0.703	0.264	0.032
16000.0	0.283	27.773	2.883	947.943	0.111	0.013	3.349	0.734	0.278	0.035
16500.0	0.282	27.324	2.957	947.714	0.116	0.014	3.384	0.764	0.293	0.038
17000.0	0.280	26.878	3.030	947.483	0.121	0.015	3.417	0.795	0.307	0.042
17500.0	0.279	26.436	3.103	947.251	0.126	0.016	3.448	0.825	0.322	0.046
18000.0	0.278	25.997	3.174	947.018	0.131	0.017	3.477	0.856	0.337	0.050
18500.0	0.276	25.561	3.245	946.785	0.136	0.018	3.505	0.886	0.352	0.054
19000.0	0.275	25.128	3.315	946.549	0.141	0.019	3.531	0.917	0.367	0.058
19500.0	0.273	24.699	3.384	946.313	0.146	0.020	3.555	0.947	0.382	0.063
20000.0	0.272	24.274	3.453	946.075	0.152	0.021	3.578	0.977	0.398	0.067
22500.0	0.264	22.196	3.785	944.864	0.179	0.028	3.671	1.126	0.474	0.094
25000.0	0.257	20.203	4.097	943.614	0.207	0.037	3.732	1.272	0.549	0.127
27500.0	0.249	18.296	4.391	942.324	0.237	0.046	3.765	1.414	0.620	0.165
30000.0	0.242	16.476	4.665	940.990	0.268	0.057	3.775	1.551	0.687	0.210
32500.0	0.234	14.746	4.919	939.609	0.300	0.070	3.765	1.683	0.748	0.261
35000.0	0.226	13.108	5.154	938.175	0.332	0.084	3.738	1.807	0.803	0.318
37500.0	0.219	11.564	5.368	936.685	0.365	0.100	3.699	1.925	0.852	0.381
40000.0	0.211	10.118	5.561	935.135	0.398	0.117	3.649	2.034	0.893	0.451
42500.0	0.203	8.773	5.733	933.519	0.431	0.136	3.591	2.134	0.928	0.527
45000.0	0.195	7.533	5.883	931.833	0.463	0.155	3.528	2.226	0.956	0.610
47500.0	0.187	6.400	6.011	930.072	0.495	0.176	3.462	2.307	0.978	0.698
50000.0	0.179	5.377	6.117	928.232	0.525	0.197	3.396	2.379	0.994	0.791
52500.0	0.171	4.464	6.200	926.311	0.554	0.219	3.331	2.441	1.005	0.890
55000.0	0.163	3.662	6.261	924.307	0.582	0.240	3.268	2.493	1.011	0.992
57500.0	0.154	2.968	6.302	922.221	0.607	0.261	3.211	2.536	1.014	1.099
60000.0	0.147	2.377	6.321	920.054	0.630	0.282	3.158	2.570	1.013	1.208
62500.0	0.139	1.882	6.323	917.811	0.651	0.301	3.111	2.596	1.011	1.319
65000.0	0.131	1.476	6.307	915.498	0.670	0.319	3.070	2.615	1.007	1.431
67500.0	0.124	1.147	6.277	913.124	0.686	0.335	3.035	2.628	1.002	1.543
70000.0	0.117	0.884	6.235	910.695	0.700	0.350	3.005	2.636	0.997	1.654

Table C.56 [ ] Exposure-Dependent 40% Void Isotopics (kg/MTU Initial)

Exposure MWd/MTU	U-234	U-235	U-236	U-238	NP-237	PU-238	PU-239	PU-240	PU-241	PU-242
0.0	0.334	44.230	0.000	955.436	0.000	0.000	0.000	0.000	0.000	0.000
100.0	0.334	44.110	0.023	955.381	0.000	0.000	0.017	0.000	0.000	0.000
500.0	0.332	43.632	0.114	955.159	0.002	0.000	0.188	0.001	0.000	0.000
1000.0	0.330	43.044	0.227	954.882	0.004	0.000	0.418	0.006	0.000	0.000
1500.0	0.328	42.463	0.337	954.605	0.006	0.000	0.637	0.015	0.001	0.000
2000.0	0.326	41.891	0.446	954.329	0.009	0.000	0.846	0.026	0.002	0.000
2500.0	0.325	41.327	0.553	954.053	0.011	0.000	1.045	0.040	0.005	0.000
3000.0	0.323	40.770	0.658	953.777	0.014	0.000	1.235	0.056	0.008	0.000
3500.0	0.321	40.220	0.762	953.502	0.017	0.001	1.415	0.074	0.012	0.000
4000.0	0.319	39.678	0.864	953.227	0.021	0.001	1.588	0.094	0.017	0.000
4500.0	0.317	39.141	0.964	952.953	0.024	0.001	1.751	0.115	0.023	0.001
5000.0	0.315	38.611	1.063	952.680	0.028	0.001	1.908	0.137	0.030	0.001
5500.0	0.313	38.087	1.160	952.407	0.031	0.002	2.056	0.161	0.038	0.001
6000.0	0.311	37.568	1.256	952.134	0.035	0.002	2.197	0.186	0.047	0.002
6500.0	0.310	37.055	1.351	951.862	0.039	0.002	2.332	0.212	0.057	0.002
7000.0	0.308	36.548	1.444	951.591	0.044	0.003	2.460	0.238	0.068	0.003
7500.0	0.306	36.046	1.536	951.321	0.048	0.003	2.581	0.265	0.079	0.004
8000.0	0.304	35.549	1.626	951.051	0.052	0.004	2.696	0.293	0.091	0.005
8500.0	0.303	35.057	1.716	950.782	0.057	0.004	2.805	0.322	0.104	0.006
9000.0	0.301	34.570	1.804	950.514	0.061	0.005	2.909	0.351	0.118	0.007
9500.0	0.299	34.087	1.891	950.247	0.066	0.005	3.006	0.381	0.132	0.009
10000.0	0.297	33.609	1.976	949.981	0.071	0.006	3.099	0.411	0.146	0.010
10500.0	0.296	33.135	2.061	949.715	0.076	0.007	3.186	0.441	0.161	0.012
11000.0	0.294	32.665	2.144	949.451	0.081	0.007	3.269	0.472	0.177	0.014
11500.0	0.292	32.200	2.227	949.187	0.086	0.008	3.346	0.503	0.192	0.016
12000.0	0.291	31.738	2.308	948.923	0.091	0.009	3.420	0.535	0.208	0.018
12500.0	0.289	31.280	2.388	948.661	0.097	0.010	3.489	0.566	0.225	0.020
13000.0	0.287	30.826	2.467	948.399	0.102	0.011	3.554	0.598	0.241	0.023
13500.0	0.286	30.375	2.546	948.137	0.107	0.012	3.615	0.630	0.258	0.025
14000.0	0.284	29.929	2.623	947.875	0.113	0.013	3.673	0.662	0.274	0.028
14500.0	0.282	29.485	2.699	947.614	0.118	0.014	3.727	0.694	0.291	0.031
15000.0	0.281	29.045	2.775	947.353	0.124	0.015	3.779	0.727	0.309	0.035
15500.0	0.279	28.609	2.850	947.092	0.129	0.016	3.827	0.759	0.326	0.038
16000.0	0.278	28.176	2.923	946.831	0.135	0.017	3.872	0.791	0.343	0.042
16500.0	0.276	27.746	2.996	946.569	0.141	0.018	3.915	0.824	0.360	0.046
17000.0	0.274	27.320	3.068	946.307	0.146	0.020	3.955	0.856	0.378	0.050
17500.0	0.273	26.897	3.140	946.044	0.152	0.021	3.993	0.888	0.395	0.054
18000.0	0.271	26.478	3.210	945.781	0.158	0.022	4.029	0.920	0.413	0.058
18500.0	0.270	26.061	3.280	945.517	0.164	0.024	4.063	0.953	0.430	0.063
19000.0	0.268	25.649	3.349	945.252	0.170	0.025	4.094	0.985	0.448	0.068
19500.0	0.267	25.239	3.417	944.985	0.176	0.027	4.125	1.017	0.465	0.073
20000.0	0.265	24.833	3.484	944.718	0.182	0.029	4.153	1.048	0.483	0.078
20500.0	0.263	24.431	3.551	944.449	0.188	0.030	4.180	1.080	0.501	0.084
22500.0	0.257	22.855	3.808	943.360	0.214	0.038	4.273	1.205	0.571	0.108
25000.0	0.249	20.962	4.112	941.967	0.247	0.048	4.358	1.358	0.658	0.143
27500.0	0.242	19.155	4.396	940.538	0.281	0.061	4.414	1.505	0.741	0.183
30000.0	0.234	17.433	4.660	939.069	0.317	0.075	4.445	1.648	0.819	0.230
32500.0	0.226	15.797	4.905	937.560	0.353	0.091	4.453	1.784	0.891	0.282
35000.0	0.218	14.247	5.129	936.006	0.389	0.109	4.443	1.913	0.957	0.339
37500.0	0.211	12.784	5.335	934.407	0.425	0.128	4.418	2.035	1.016	0.402
40000.0	0.203	11.408	5.520	932.759	0.461	0.149	4.380	2.149	1.067	0.471
42500.0	0.196	10.121	5.686	931.060	0.497	0.171	4.331	2.255	1.112	0.544
45000.0	0.188	8.922	5.833	929.307	0.532	0.195	4.276	2.352	1.150	0.622
47500.0	0.180	7.814	5.959	927.499	0.566	0.220	4.214	2.439	1.180	0.704
50000.0	0.173	6.795	6.067	925.632	0.598	0.246	4.149	2.518	1.205	0.791
52500.0	0.166	5.867	6.155	923.705	0.630	0.272	4.083	2.588	1.223	0.881
55000.0	0.158	5.028	6.224	921.717	0.660	0.298	4.016	2.648	1.237	0.975
57500.0	0.151	4.276	6.275	919.669	0.688	0.324	3.951	2.700	1.245	1.071
60000.0	0.144	3.609	6.308	917.560	0.714	0.350	3.889	2.743	1.250	1.169
62500.0	0.137	3.023	6.325	915.392	0.738	0.374	3.830	2.778	1.251	1.269
65000.0	0.131	2.515	6.326	913.167	0.759	0.398	3.775	2.806	1.249	1.370
67500.0	0.124	2.077	6.313	910.889	0.779	0.420	3.725	2.828	1.246	1.471
70000.0	0.118	1.705	6.286	908.562	0.796	0.441	3.679	2.843	1.241	1.572

Table C.57 [ ] Exposure-Dependent 80% Void Isotopics (kg/MTU Initial)

Exposure MWd/MTU	U-234	U-235	U-236	U-238	NP-237	PU-238	PU-239	PU-240	PU-241	PU-242
0.0	0.334	44.230	0.000	955.436	0.000	0.000	0.000	0.000	0.000	0.000
100.0	0.334	44.110	0.024	955.370	0.000	0.000	0.020	0.000	0.000	0.000
500.0	0.332	43.636	0.121	955.106	0.002	0.000	0.222	0.002	0.000	0.000
1000.0	0.330	43.053	0.239	954.776	0.005	0.000	0.493	0.008	0.000	0.000
1500.0	0.327	42.479	0.356	954.446	0.008	0.000	0.751	0.017	0.001	0.000
2000.0	0.325	41.915	0.470	954.117	0.011	0.000	0.997	0.030	0.004	0.000
2500.0	0.323	41.360	0.581	953.789	0.014	0.000	1.232	0.046	0.007	0.000
3000.0	0.320	40.813	0.691	953.461	0.018	0.001	1.455	0.064	0.011	0.000
3500.0	0.318	40.275	0.799	953.134	0.022	0.001	1.669	0.084	0.017	0.000
4000.0	0.316	39.744	0.905	952.808	0.026	0.001	1.872	0.105	0.023	0.001
4500.0	0.314	39.220	1.009	952.482	0.030	0.001	2.067	0.129	0.032	0.001
5000.0	0.312	38.703	1.112	952.157	0.035	0.002	2.252	0.153	0.041	0.001
5500.0	0.310	38.194	1.212	951.833	0.040	0.002	2.429	0.179	0.052	0.002
6000.0	0.307	37.690	1.311	951.510	0.045	0.003	2.598	0.206	0.063	0.002
6500.0	0.305	37.193	1.409	951.187	0.050	0.003	2.759	0.234	0.076	0.003
7000.0	0.303	36.702	1.504	950.866	0.056	0.004	2.913	0.262	0.090	0.004
7500.0	0.301	36.216	1.599	950.545	0.061	0.005	3.060	0.292	0.104	0.005
8000.0	0.299	35.737	1.691	950.225	0.067	0.005	3.199	0.322	0.120	0.006
8500.0	0.297	35.263	1.782	949.906	0.073	0.006	3.332	0.353	0.136	0.007
9000.0	0.295	34.794	1.872	949.587	0.079	0.007	3.459	0.384	0.153	0.009
9500.0	0.293	34.330	1.961	949.270	0.085	0.008	3.580	0.416	0.170	0.011
10000.0	0.291	33.871	2.048	948.954	0.091	0.009	3.695	0.448	0.188	0.012
10500.0	0.289	33.417	2.134	948.638	0.097	0.010	3.804	0.481	0.206	0.014
11000.0	0.287	32.968	2.218	948.324	0.103	0.011	3.907	0.514	0.225	0.017
11500.0	0.285	32.523	2.302	948.010	0.110	0.012	4.006	0.547	0.244	0.019
12000.0	0.283	32.083	2.384	947.697	0.116	0.013	4.100	0.581	0.264	0.021
12500.0	0.282	31.647	2.465	947.384	0.123	0.015	4.189	0.615	0.283	0.024
13000.0	0.280	31.215	2.545	947.072	0.130	0.016	4.274	0.649	0.303	0.027
13500.0	0.278	30.787	2.623	946.761	0.136	0.017	4.354	0.684	0.323	0.030
14000.0	0.276	30.363	2.701	946.450	0.143	0.019	4.431	0.718	0.344	0.033
14500.0	0.274	29.944	2.778	946.139	0.150	0.020	4.503	0.753	0.364	0.037
15000.0	0.272	29.528	2.853	945.828	0.157	0.022	4.573	0.788	0.385	0.041
15500.0	0.271	29.115	2.928	945.517	0.164	0.024	4.638	0.823	0.406	0.044
16000.0	0.269	28.707	3.001	945.206	0.171	0.026	4.701	0.858	0.426	0.048
16500.0	0.267	28.302	3.074	944.895	0.178	0.027	4.760	0.893	0.447	0.053
17000.0	0.265	27.901	3.145	944.585	0.185	0.029	4.817	0.928	0.468	0.057
17500.0	0.263	27.504	3.216	944.273	0.193	0.031	4.871	0.963	0.489	0.062
18000.0	0.262	27.110	3.285	943.962	0.200	0.033	4.922	0.998	0.510	0.067
18500.0	0.260	26.719	3.354	943.650	0.207	0.036	4.970	1.033	0.531	0.072
19000.0	0.258	26.332	3.422	943.337	0.215	0.038	5.016	1.068	0.552	0.077
19500.0	0.257	25.949	3.489	943.024	0.222	0.040	5.060	1.103	0.573	0.082
20000.0	0.255	25.569	3.555	942.711	0.229	0.042	5.102	1.138	0.593	0.088
20500.0	0.253	25.192	3.620	942.396	0.237	0.045	5.142	1.173	0.614	0.094
21000.0	0.251	24.819	3.684	942.081	0.244	0.047	5.180	1.207	0.635	0.100
21500.0	0.250	24.449	3.748	941.764	0.252	0.050	5.216	1.242	0.656	0.106
22000.0	0.248	24.083	3.810	941.447	0.260	0.053	5.250	1.276	0.676	0.112
22500.0	0.246	23.720	3.872	941.128	0.267	0.055	5.283	1.310	0.697	0.119
23000.0	0.245	23.361	3.933	940.809	0.275	0.058	5.314	1.344	0.717	0.126
23500.0	0.243	23.005	3.993	940.488	0.283	0.061	5.344	1.378	0.738	0.133
25000.0	0.238	21.957	4.168	939.517	0.306	0.070	5.425	1.479	0.798	0.155
27500.0	0.230	20.278	4.444	937.872	0.346	0.088	5.535	1.642	0.897	0.195
30000.0	0.222	18.681	4.699	936.194	0.386	0.107	5.617	1.799	0.992	0.241
32500.0	0.214	17.167	4.934	934.481	0.427	0.129	5.674	1.951	1.082	0.291
35000.0	0.206	15.732	5.150	932.733	0.467	0.152	5.709	2.096	1.166	0.346
37500.0	0.198	14.377	5.346	930.948	0.508	0.178	5.726	2.234	1.243	0.404
40000.0	0.191	13.099	5.523	929.126	0.548	0.206	5.727	2.365	1.314	0.467
42500.0	0.184	11.899	5.682	927.267	0.587	0.235	5.715	2.488	1.378	0.534
45000.0	0.176	10.774	5.823	925.368	0.625	0.266	5.691	2.604	1.435	0.604
47500.0	0.169	9.724	5.946	923.431	0.663	0.299	5.658	2.711	1.486	0.677
50000.0	0.163	8.747	6.051	921.454	0.699	0.332	5.618	2.810	1.531	0.753
52500.0	0.156	7.841	6.140	919.437	0.734	0.366	5.572	2.901	1.570	0.831
55000.0	0.150	7.004	6.213	917.381	0.767	0.401	5.522	2.984	1.603	0.912
57500.0	0.143	6.235	6.271	915.286	0.798	0.437	5.469	3.059	1.631	0.995
60000.0	0.137	5.532	6.313	913.153	0.827	0.472	5.414	3.126	1.654	1.080
62500.0	0.131	4.890	6.342	910.981	0.855	0.507	5.359	3.186	1.672	1.167
65000.0	0.126	4.309	6.357	908.774	0.880	0.541	5.305	3.238	1.687	1.254
67500.0	0.120	3.784	6.360	906.531	0.903	0.574	5.251	3.284	1.698	1.343
70000.0	0.115	3.313	6.351	904.255	0.924	0.607	5.199	3.323	1.706	1.432

Table C.58 [ ] Exposure-Dependent 0% Void Isotopics (kg/MTU Initial)

Exposure MWd/MTU	U-234	U-235	U-236	U-238	NP-237	PU-238	PU-239	PU-240	PU-241	PU-242
0.0	0.322	42.654	0.000	957.024	0.000	0.000	0.000	0.000	0.000	0.000
100.0	0.322	42.533	0.022	956.978	0.000	0.000	0.014	0.000	0.000	0.000
500.0	0.320	42.055	0.109	956.790	0.001	0.000	0.161	0.001	0.000	0.000
1000.0	0.319	41.464	0.215	956.555	0.003	0.000	0.357	0.006	0.000	0.000
1500.0	0.317	40.880	0.321	956.321	0.005	0.000	0.543	0.013	0.001	0.000
2000.0	0.316	40.304	0.425	956.086	0.007	0.000	0.721	0.023	0.002	0.000
2500.0	0.314	39.734	0.527	955.852	0.009	0.000	0.890	0.035	0.003	0.000
3000.0	0.312	39.171	0.628	955.618	0.011	0.000	1.051	0.050	0.006	0.000
3500.0	0.311	38.614	0.727	955.385	0.014	0.000	1.204	0.066	0.009	0.000
4000.0	0.309	38.063	0.825	955.152	0.016	0.001	1.349	0.084	0.012	0.000
4500.0	0.308	37.518	0.922	954.920	0.019	0.001	1.488	0.103	0.017	0.000
5000.0	0.306	36.978	1.017	954.688	0.022	0.001	1.619	0.124	0.022	0.001
5500.0	0.304	36.444	1.111	954.456	0.025	0.001	1.743	0.146	0.028	0.001
6000.0	0.303	35.915	1.204	954.226	0.028	0.001	1.861	0.169	0.035	0.001
6500.0	0.301	35.390	1.296	953.996	0.031	0.002	1.973	0.193	0.043	0.002
7000.0	0.300	34.870	1.386	953.767	0.034	0.002	2.078	0.217	0.051	0.002
7500.0	0.298	34.355	1.476	953.539	0.038	0.002	2.178	0.243	0.059	0.003
8000.0	0.297	33.845	1.564	953.311	0.041	0.002	2.272	0.269	0.069	0.004
8500.0	0.295	33.338	1.651	953.085	0.044	0.003	2.361	0.296	0.079	0.005
9000.0	0.294	32.836	1.737	952.860	0.048	0.003	2.445	0.323	0.089	0.006
9500.0	0.292	32.337	1.822	952.635	0.052	0.004	2.524	0.350	0.100	0.007
10000.0	0.291	31.843	1.907	952.411	0.055	0.004	2.598	0.378	0.111	0.008
10500.0	0.289	31.352	1.990	952.187	0.059	0.005	2.669	0.407	0.123	0.009
11000.0	0.288	30.865	2.072	951.963	0.063	0.005	2.735	0.436	0.134	0.011
11500.0	0.286	30.381	2.154	951.739	0.067	0.006	2.798	0.465	0.147	0.012
12000.0	0.285	29.902	2.234	951.514	0.071	0.006	2.858	0.494	0.159	0.014
12500.0	0.284	29.426	2.314	951.289	0.075	0.007	2.914	0.523	0.172	0.016
13000.0	0.282	28.954	2.393	951.063	0.079	0.007	2.968	0.553	0.186	0.018
13500.0	0.281	28.485	2.471	950.836	0.083	0.008	3.019	0.583	0.199	0.021
14000.0	0.279	28.020	2.548	950.608	0.088	0.009	3.068	0.613	0.213	0.023
14500.0	0.278	27.559	2.624	950.378	0.092	0.009	3.114	0.643	0.227	0.026
15000.0	0.276	27.102	2.699	950.148	0.097	0.010	3.158	0.674	0.242	0.028
15500.0	0.275	26.648	2.774	949.916	0.102	0.011	3.199	0.704	0.256	0.031
16000.0	0.273	26.198	2.848	949.684	0.106	0.012	3.239	0.734	0.271	0.035
17500.0	0.269	24.870	3.064	948.977	0.121	0.015	3.345	0.826	0.316	0.045
20000.0	0.262	22.729	3.409	947.771	0.147	0.021	3.485	0.979	0.394	0.068
22500.0	0.254	20.680	3.734	946.527	0.175	0.028	3.585	1.130	0.471	0.096
25000.0	0.247	18.721	4.038	945.243	0.204	0.036	3.649	1.279	0.547	0.130
27500.0	0.239	16.854	4.323	943.915	0.234	0.046	3.685	1.423	0.618	0.170
30000.0	0.232	15.079	4.588	942.540	0.265	0.057	3.695	1.563	0.685	0.217
32500.0	0.224	13.401	4.832	941.114	0.297	0.070	3.685	1.697	0.745	0.270
35000.0	0.217	11.819	5.055	939.631	0.329	0.085	3.658	1.824	0.799	0.330
37500.0	0.209	10.339	5.256	938.088	0.362	0.101	3.617	1.942	0.846	0.397
40000.0	0.201	8.962	5.436	936.479	0.394	0.118	3.567	2.053	0.887	0.470
42500.0	0.193	7.692	5.594	934.799	0.427	0.137	3.510	2.153	0.920	0.550
45000.0	0.185	6.532	5.729	933.044	0.459	0.156	3.448	2.244	0.947	0.637
47500.0	0.177	5.484	5.841	931.210	0.489	0.177	3.384	2.324	0.967	0.729
50000.0	0.169	4.550	5.931	929.294	0.519	0.198	3.321	2.394	0.982	0.826
52500.0	0.161	3.729	5.998	927.294	0.547	0.219	3.260	2.453	0.992	0.929
55000.0	0.153	3.018	6.043	925.209	0.573	0.240	3.203	2.503	0.997	1.035
57500.0	0.145	2.414	6.068	923.042	0.598	0.261	3.151	2.542	1.000	1.145
60000.0	0.137	1.909	6.074	920.798	0.619	0.280	3.105	2.573	0.999	1.257
62500.0	0.130	1.494	6.062	918.483	0.639	0.298	3.065	2.597	0.997	1.370
65000.0	0.122	1.158	6.036	916.105	0.656	0.315	3.030	2.614	0.994	1.483
67500.0	0.115	0.892	5.997	913.671	0.671	0.330	3.000	2.625	0.990	1.596
70000.0	0.108	0.682	5.947	911.192	0.683	0.344	2.976	2.632	0.986	1.707

Table C.59 [ ] Exposure-Dependent 40% Void Isotopics (kg/MTU Initial)

Exposure MWd/MTU	U-234	U-235	U-236	U-238	NP-237	PU-238	PU-239	PU-240	PU-241	PU-242
0.0	0.322	42.654	0.000	957.024	0.000	0.000	0.000	0.000	0.000	0.000
100.0	0.322	42.534	0.023	956.971	0.000	0.000	0.016	0.000	0.000	0.000
500.0	0.320	42.057	0.113	956.754	0.002	0.000	0.184	0.001	0.000	0.000
1000.0	0.318	41.469	0.223	956.483	0.004	0.000	0.409	0.006	0.000	0.000
1500.0	0.317	40.890	0.332	956.213	0.006	0.000	0.622	0.015	0.001	0.000
2000.0	0.315	40.318	0.439	955.943	0.008	0.000	0.825	0.026	0.002	0.000
2500.0	0.313	39.755	0.545	955.674	0.011	0.000	1.018	0.040	0.005	0.000
3000.0	0.311	39.199	0.648	955.405	0.014	0.000	1.201	0.057	0.008	0.000
3500.0	0.309	38.650	0.750	955.137	0.016	0.001	1.376	0.075	0.012	0.000
4000.0	0.307	38.108	0.850	954.869	0.020	0.001	1.542	0.095	0.017	0.000
4500.0	0.306	37.572	0.949	954.602	0.023	0.001	1.699	0.116	0.022	0.001
5000.0	0.304	37.043	1.046	954.336	0.026	0.001	1.849	0.139	0.029	0.001
5500.0	0.302	36.519	1.142	954.071	0.030	0.001	1.990	0.163	0.037	0.001
6000.0	0.300	36.001	1.236	953.806	0.034	0.002	2.125	0.188	0.046	0.002
6500.0	0.299	35.489	1.329	953.542	0.037	0.002	2.253	0.214	0.055	0.002
7000.0	0.297	34.982	1.421	953.280	0.041	0.002	2.374	0.241	0.066	0.003
7500.0	0.295	34.480	1.512	953.018	0.045	0.003	2.488	0.268	0.077	0.004
8000.0	0.294	33.983	1.601	952.757	0.050	0.003	2.597	0.296	0.089	0.005
8500.0	0.292	33.490	1.689	952.497	0.054	0.004	2.699	0.325	0.101	0.006
9000.0	0.290	33.002	1.775	952.239	0.058	0.004	2.796	0.354	0.114	0.007
9500.0	0.289	32.519	1.861	951.981	0.063	0.005	2.887	0.384	0.127	0.008
10000.0	0.287	32.039	1.945	951.724	0.067	0.005	2.973	0.414	0.141	0.010
10500.0	0.285	31.564	2.028	951.468	0.072	0.006	3.055	0.444	0.155	0.012
11000.0	0.284	31.093	2.111	951.212	0.076	0.007	3.132	0.475	0.170	0.013
11500.0	0.282	30.626	2.192	950.957	0.081	0.008	3.205	0.506	0.185	0.015
12000.0	0.281	30.163	2.272	950.701	0.086	0.008	3.274	0.537	0.200	0.017
12500.0	0.279	29.704	2.351	950.445	0.091	0.009	3.340	0.569	0.216	0.020
13000.0	0.277	29.249	2.430	950.188	0.096	0.010	3.402	0.600	0.232	0.022
13500.0	0.276	28.797	2.507	949.930	0.101	0.011	3.462	0.632	0.248	0.025
14000.0	0.274	28.350	2.583	949.672	0.107	0.012	3.519	0.664	0.265	0.028
14500.0	0.273	27.906	2.659	949.412	0.112	0.013	3.573	0.696	0.281	0.031
15000.0	0.271	27.467	2.734	949.152	0.118	0.014	3.624	0.727	0.298	0.034
15500.0	0.270	27.031	2.807	948.890	0.123	0.015	3.674	0.759	0.316	0.038
16000.0	0.268	26.599	2.880	948.627	0.129	0.016	3.721	0.792	0.333	0.041
16500.0	0.266	26.171	2.952	948.363	0.134	0.017	3.765	0.824	0.350	0.045
17000.0	0.265	25.747	3.024	948.097	0.140	0.019	3.808	0.856	0.368	0.049
17500.0	0.263	25.326	3.094	947.830	0.146	0.020	3.848	0.888	0.386	0.054
20000.0	0.256	23.280	3.432	946.476	0.176	0.027	4.022	1.047	0.476	0.078
22500.0	0.248	21.327	3.750	945.086	0.208	0.036	4.151	1.204	0.566	0.109
25000.0	0.240	19.466	4.046	943.660	0.242	0.047	4.244	1.359	0.653	0.145
27500.0	0.232	17.695	4.321	942.194	0.276	0.060	4.304	1.509	0.736	0.187
30000.0	0.225	16.015	4.576	940.688	0.311	0.074	4.337	1.653	0.814	0.236
32500.0	0.217	14.426	4.810	939.137	0.347	0.090	4.347	1.791	0.885	0.290
35000.0	0.209	12.927	5.023	937.540	0.384	0.108	4.337	1.922	0.950	0.350
37500.0	0.202	11.519	5.217	935.894	0.420	0.128	4.312	2.046	1.007	0.416
40000.0	0.194	10.203	5.390	934.196	0.456	0.149	4.274	2.160	1.057	0.487
42500.0	0.186	8.980	5.543	932.443	0.491	0.172	4.226	2.266	1.100	0.563
45000.0	0.179	7.850	5.676	930.634	0.526	0.195	4.171	2.363	1.136	0.645
47500.0	0.172	6.814	5.788	928.765	0.559	0.220	4.111	2.450	1.165	0.730
50000.0	0.164	5.870	5.881	926.835	0.591	0.246	4.048	2.527	1.188	0.820
52500.0	0.157	5.019	5.955	924.843	0.621	0.272	3.985	2.595	1.205	0.913
55000.0	0.150	4.257	6.010	922.789	0.650	0.297	3.923	2.653	1.217	1.010
57500.0	0.143	3.583	6.047	920.673	0.677	0.323	3.862	2.702	1.225	1.109
60000.0	0.136	2.993	6.066	918.496	0.701	0.348	3.805	2.743	1.229	1.209
62500.0	0.129	2.482	6.070	916.262	0.724	0.372	3.752	2.775	1.230	1.311
65000.0	0.123	2.044	6.059	913.974	0.744	0.394	3.704	2.801	1.228	1.414
67500.0	0.116	1.673	6.036	911.635	0.762	0.415	3.660	2.820	1.225	1.516
70000.0	0.110	1.361	6.000	909.252	0.777	0.435	3.621	2.834	1.221	1.618

Table C.60 [ ] Exposure-Dependent 80% Void Isotopics (kg/MTU Initial)

Exposure MWd/MTU	U-234	U-235	U-236	U-238	NP-237	PU-238	PU-239	PU-240	PU-241	PU-242
0.0	0.322	42.654	0.000	957.024	0.000	0.000	0.000	0.000	0.000	0.000
100.0	0.322	42.534	0.024	956.960	0.000	0.000	0.019	0.000	0.000	0.000
500.0	0.320	42.061	0.119	956.703	0.002	0.000	0.216	0.002	0.000	0.000
1000.0	0.318	41.478	0.235	956.382	0.005	0.000	0.479	0.008	0.000	0.000
1500.0	0.315	40.906	0.350	956.061	0.007	0.000	0.729	0.017	0.001	0.000
2000.0	0.313	40.343	0.461	955.741	0.010	0.000	0.967	0.031	0.003	0.000
2500.0	0.311	39.788	0.571	955.422	0.014	0.000	1.194	0.046	0.007	0.000
3000.0	0.309	39.243	0.679	955.103	0.017	0.001	1.409	0.065	0.011	0.000
3500.0	0.307	38.705	0.785	954.785	0.021	0.001	1.614	0.085	0.016	0.000
4000.0	0.305	38.175	0.889	954.468	0.025	0.001	1.809	0.107	0.023	0.001
4500.0	0.303	37.653	0.991	954.152	0.029	0.001	1.995	0.131	0.031	0.001
5000.0	0.301	37.137	1.092	953.836	0.033	0.002	2.172	0.155	0.040	0.001
5500.0	0.299	36.628	1.190	953.521	0.038	0.002	2.341	0.182	0.051	0.002
6000.0	0.297	36.125	1.288	953.207	0.043	0.003	2.502	0.209	0.062	0.002
6500.0	0.295	35.629	1.383	952.894	0.048	0.003	2.655	0.237	0.075	0.003
7000.0	0.293	35.139	1.477	952.581	0.053	0.004	2.800	0.266	0.088	0.004
7500.0	0.291	34.654	1.569	952.270	0.058	0.004	2.939	0.295	0.102	0.005
8000.0	0.289	34.175	1.660	951.959	0.064	0.005	3.070	0.326	0.117	0.006
8500.0	0.287	33.702	1.750	951.650	0.069	0.006	3.195	0.357	0.133	0.007
9000.0	0.285	33.233	1.838	951.341	0.075	0.007	3.314	0.388	0.149	0.009
9500.0	0.283	32.770	1.925	951.034	0.081	0.007	3.427	0.420	0.166	0.011
10000.0	0.281	32.311	2.010	950.727	0.086	0.008	3.535	0.453	0.183	0.012
10500.0	0.279	31.857	2.094	950.422	0.092	0.009	3.636	0.486	0.201	0.014
11000.0	0.277	31.407	2.177	950.117	0.098	0.010	3.733	0.519	0.219	0.017
11500.0	0.276	30.962	2.259	949.813	0.104	0.011	3.825	0.552	0.237	0.019
12000.0	0.274	30.521	2.340	949.509	0.111	0.013	3.913	0.586	0.256	0.021
12500.0	0.272	30.084	2.420	949.204	0.117	0.014	3.997	0.620	0.275	0.024
13000.0	0.270	29.652	2.498	948.900	0.123	0.015	4.076	0.654	0.294	0.027
13500.0	0.269	29.223	2.575	948.596	0.130	0.016	4.153	0.688	0.314	0.030
14000.0	0.267	28.799	2.652	948.291	0.136	0.018	4.226	0.723	0.334	0.033
14500.0	0.265	28.379	2.727	947.985	0.143	0.019	4.296	0.757	0.354	0.037
15000.0	0.263	27.963	2.802	947.678	0.150	0.021	4.363	0.792	0.374	0.040
15500.0	0.262	27.551	2.875	947.371	0.156	0.022	4.427	0.826	0.394	0.044
16000.0	0.260	27.143	2.947	947.062	0.163	0.024	4.489	0.861	0.415	0.048
16500.0	0.258	26.738	3.019	946.753	0.170	0.026	4.548	0.896	0.435	0.053
17000.0	0.256	26.338	3.089	946.442	0.177	0.028	4.605	0.930	0.456	0.057
17500.0	0.255	25.942	3.158	946.130	0.184	0.030	4.659	0.965	0.477	0.062
18000.0	0.253	25.550	3.227	945.817	0.192	0.032	4.712	1.000	0.498	0.067
18500.0	0.251	25.161	3.295	945.503	0.199	0.034	4.762	1.034	0.519	0.072
19000.0	0.249	24.777	3.361	945.187	0.206	0.036	4.810	1.069	0.540	0.077
19500.0	0.248	24.396	3.427	944.870	0.214	0.038	4.856	1.104	0.561	0.083
20000.0	0.246	24.019	3.492	944.552	0.221	0.040	4.900	1.138	0.582	0.088
22500.0	0.238	22.191	3.802	942.942	0.259	0.053	5.095	1.309	0.687	0.120
25000.0	0.229	20.455	4.090	941.297	0.299	0.068	5.248	1.476	0.791	0.157
27500.0	0.221	18.808	4.357	939.618	0.339	0.086	5.366	1.639	0.890	0.199
30000.0	0.213	17.249	4.603	937.904	0.379	0.105	5.454	1.798	0.984	0.246
32500.0	0.205	15.775	4.828	936.154	0.419	0.127	5.515	1.951	1.073	0.298
35000.0	0.198	14.385	5.033	934.367	0.460	0.151	5.554	2.097	1.155	0.355
37500.0	0.190	13.078	5.218	932.541	0.500	0.177	5.573	2.236	1.231	0.416
40000.0	0.183	11.852	5.384	930.676	0.539	0.205	5.575	2.367	1.301	0.481
42500.0	0.175	10.706	5.531	928.772	0.578	0.234	5.564	2.491	1.363	0.550
45000.0	0.168	9.638	5.659	926.828	0.616	0.265	5.542	2.606	1.419	0.622
47500.0	0.161	8.646	5.770	924.843	0.652	0.297	5.511	2.713	1.468	0.697
50000.0	0.155	7.729	5.863	922.817	0.687	0.331	5.472	2.812	1.511	0.776
52500.0	0.148	6.884	5.940	920.751	0.721	0.365	5.428	2.901	1.548	0.857
55000.0	0.142	6.110	6.001	918.645	0.752	0.399	5.381	2.983	1.579	0.940
57500.0	0.136	5.403	6.046	916.498	0.782	0.434	5.331	3.056	1.606	1.025
60000.0	0.130	4.761	6.077	914.313	0.810	0.468	5.281	3.121	1.627	1.112
62500.0	0.124	4.181	6.095	912.091	0.836	0.502	5.230	3.178	1.644	1.200
65000.0	0.119	3.659	6.099	909.832	0.859	0.535	5.180	3.228	1.658	1.289
67500.0	0.114	3.192	6.092	907.540	0.881	0.567	5.132	3.271	1.668	1.379
70000.0	0.109	2.777	6.074	905.215	0.900	0.598	5.085	3.308	1.675	1.470

Appendix D Lattice Enrichment Distribution Maps

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Figure D.1 [ ] Enrichment Distribution

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Figure D.2 [ ] Enrichment Distribution

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Figure D.3 [ ] Enrichment Distribution

Figure D.4 [ ] Enrichment Distribution

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Figure D.5 [ ] Enrichment Distribution

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Figure D.6 [ ] Enrichment Distribution

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Figure D.7 [ ] Enrichment Distribution

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Figure D.8 [ ] Enrichment Distribution

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Figure D.9 [ ] Enrichment Distribution

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Figure D.10 [ ] Enrichment Distribution

Figure D.11 [ ] Enrichment Distribution

Figure D.12 [ ] Enrichment Distribution

Figure D.13 [ ] Enrichment Distribution

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Figure D.14 [ ] Enrichment Distribution

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Figure D.15 [ ] Enrichment Distribution

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Figure D.16 [ ] Enrichment Distribution

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Figure D.17 [ ] Enrichment Distribution

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Figure D.18 [ ] Enrichment Distribution

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Figure D.19 [ ] Enrichment Distribution

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Figure D.20 [ ] Enrichment Distribution

Figure D.21 [ ] Enrichment Distribution

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Figure D.22 [ ] Enrichment Distribution

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Figure D.23 [ ] Enrichment Distribution

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Figure D.24 [ ] Enrichment Distribution

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Figure D.25 [ ] Enrichment Distribution

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Figure D.26 [ ] Enrichment Distribution

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Figure D.27 [ ] Enrichment Distribution

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Figure D.28 [ ] Enrichment Distribution

Figure D.29 [ ] Enrichment Distribution

ATTACHMENT 8a

ANP-3860P Revision 1

(Proprietary)

Mechanical Design Report for Browns Ferry ATRIUM 11 Fuel Assemblies

ATTACHMENT 8b

ANP-3860NP Revision 1

(Non Proprietary)

Mechanical Design Report for Browns Ferry ATRIUM 11 Fuel Assemblies

Mechanical Design Report for Browns Ferry ATRIUM 11 Fuel Assemblies

ANP-3860NP
Revision 1

Licensing Report

June 2022

Nature of Changes

Item	Section(s) or Page(s)	Description and Justification
1	1.0	Spacer material, “made of nickel alloy 718”, is not proprietary, redaction marking updated.
2	2.1.1, p. 2-3	Entire paragraph discussing fuel assembly features is non-proprietary, redaction marking updated.
3	2.1.4, p. 2-7	Changed the first sentence in 2nd paragraph to be non-proprietary, redaction markings updated.
4	Table 2-1	Updated to reflect accurate non-proprietary information, redaction markings updated.

Contents

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Nomenclature

Acronym	Definition
AFC	Advanced fuel channel
AOO	Anticipated operational occurrences
ARS	Acceleration response spectra
ASME	American Society of Mechanical Engineers
B&PV	Boiler and pressure vessel
BQ	Beta-quench
BWR	Boiling water reactor
ELC	Enhanced load chain
EOL	End of life
HALC	Harmonized advanced load chain
LTA	Lead test assembly
LOCA	Loss-of-coolant accident
LTP	Lower tie plate
MWd/kgU	Megawatt-days per kilogram of Uranium
NRC	U. S. Nuclear Regulatory Commission
PLFR	Part-length fuel rods
SRP	Standard review plan
UTP	Upper tie plate
Z4B	Proprietary Zircaloy BWR material similar to Zircaloy-4
Zry-4	Zircaloy-4
Zry-2	Zircaloy-2
3GFG	3rd Generation FUELGUARD

1.0 INTRODUCTION

This report documents the successful completion of all licensing analyses and related testing necessary to verify that the mechanical design criteria are met for the ATRIUM™ 11 Fuel Assemblies supplied by Framatome Inc. (Framatome) for insertion into Browns Ferry Units. This report also provides a description of the mechanical design and licensing methods. The scope of this report is limited to an evaluation of the mechanical design of the fuel assembly and fuel channel.

The ATRIUM 11 design is a Framatome advanced boiling water reactor (BWR) fuel design that builds on the history of proven ATRIUM family of fuel designs. The design uses an 11x11 fuel array, a [ ] fuel rod, a central water channel that displaces a 3x3 array of rods and is made from an advanced Zirconium alloy Z4B material, a modular lower tie plate with a 3rd generation FUELGUARD and nine ULTRAFLOW spacer grids made of nickel alloy 718.

The fuel assembly design was evaluated according to the Framatome BWR generic mechanical design criteria (Reference 1). The fuel channel design was evaluated to the criteria given in the fuel channel topical reports (References 2 and 3). The generic design criteria have been approved by the U.S. Nuclear Regulatory Commission (NRC) and the criteria are applicable to the subject fuel assembly and channel design. Mechanical analyses have been performed using NRC-approved design analysis methodology (References 1, 2, 3 and 4). The methodology permits maximum licensed assembly and fuel channel exposures of [ ] (Reference 4, Section 1.0).

The fuel assembly and fuel channel meet all mechanical compatibility requirements for use in Browns Ferry Units. This includes compatibility with both co-resident fuel and the reactor core internals.

2.0 DESIGN DESCRIPTION

This section provides a design description of the ATRIUM 11 fuel assembly and fuel channel. Reload-specific design information is available in the design package provided by Framatome for each reload delivery.

2.1 *Overview*

Browns Ferry has successfully operated for several cycles with reload quantities of ATRIUM-10 and ATRIUM 10XM fuel assemblies. Browns Ferry will operate with ATRIUM 11 fuel assemblies in reload quantities starting with Browns Ferry Unit 2 Cycle 23. The ATRIUM 11 bundle consists of an 11x11 fuel lattice with a square internal water channel that displaces a 3x3 array of rods.

The ATRIUM 11 incorporates key design features relative to previous ATRIUM designs as described in Reference 5.

Table 2-1 lists the key design parameters of the ATRIUM 11 fuel assembly.

2.1.1 Fuel Assembly

Figure 2-1 provides an illustration of the fuel assembly, and Table 2-1 lists the main fuel assembly attributes. The fuel assembly is accompanied by a fuel channel, as described later in this section.

The ATRIUM 11 fuel assembly consists of a lower tie plate (LTP), an upper tie plate (UTP), 112 fuel rods, nine spacer grids, a central water channel, and miscellaneous assembly hardware. Of the 112 fuel rods, twenty are part length fuel rods (PLFRs) of which twelve are short PLFRs and eight are long PLFRs. The structural members of the fuel assembly include the tie plates, spacer grids, water channel, and connecting hardware. The structural connection between the LTP and the UTP is provided by the central water channel. The lowest of the nine spacer grids is located just above the LTP to laterally restrain the lower ends of the fuel rods.

2.1.2 Upper Tie Plate and Connecting Hardware

Figure 2-2 provides an illustration of the UTP and connecting hardware.

[ ]

2.1.3 Water Channel

Figure 2-1 and Figure 2-2 provides an illustration of the water channel, and Table 2-1 lists the main water channel attributes.

[ ]

2.1.4 Spacer Grid

Figure 2-3 provides illustration of the spacer grid, and Table 2-1 lists the main spacer grid attributes.

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The ATRIUM 11 variant of the ULTRAFLOW spacer grid is constructed entirely from nickel alloy 718. [

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2.1.5 Lower Tie Plate

Figure 2-4 provides an illustration of the 3GFG FUELGUARD.

[ ]

2.1.6 Fuel Rods

This mechanical design report documents the fuel structural analyses. The fuel rod thermal-mechanical report provides fuel rod design description detail. Figure 2-5 provides an illustration of the full-length and the two part-length fuel rods.

2.2 *Fuel Channel and Components*

Figure 2-6 provides an illustration of the fuel channel and components, and Table 2-2 lists the fuel channel component attributes.

[

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Table 2-1
Fuel Assembly and Component Description

Characteristic	Value
Fuel Bundle	
Fuel rod array	11x11
Number of non-fueled elements	1 square water channel displaces a 3x3 array
Number of fueled rods Full-length Part-length	 92 8 Long / 12 Short
[	]
Debris filter style	3rd Generation FUELGUARD
[	]
Water Channel	
Water channel material	Z4B
Outside dimension, inch	1.299 (33 mm)
[	]

Table 2-1
Fuel Assembly and Component Description
(Continued)

Characteristic	Value
Spacer Grid	
Variant name	AH75/3, AH76/3, AH77/3 ULTRAFLOW
Material	Ni alloy 718
[ ]	
Number of spacer grids	9
[ ]	

Table 2-2
Fuel Channel and Channel Spacer Assembly Description

[ ]

3.0 FUEL DESIGN EVALUATION

This section provides a summary of the mechanical methodology and results from the structural design evaluations. Results from the mechanical design evaluation demonstrate that the design satisfies the mechanical criteria to the analyzed exposure limit. Sections 3.1 through 3.4 correspond to the fuel assembly criteria sections within Section 3.0 of Reference 1. Section 3.5 and Table 3-2 corresponds to the advanced fuel channel criteria sections within Table 1.1 and 1.2 of Reference 2.

3.1 *Objectives*

The objectives of designing fuel assemblies (systems) to specific criteria are to provide assurance that:

- The fuel assembly (system) shall not fail as a result of normal operation and anticipated operational occurrences (AOOs). The fuel assembly (system) dimensions shall be designed to remain within operational tolerances, and the functional capabilities of the fuel shall be established to either meet or exceed those assumed in the safety analysis.
- Fuel assembly (system) damage shall never prevent control rod insertion when it is required.
- The number of fuel rod failures shall be conservatively estimated for postulated accidents.
- Fuel coolability shall always be maintained.
- The mechanical design of fuel assemblies shall be compatible with co-resident fuel and the reactor core internals.
- Fuel assemblies shall be designed to withstand the loads from handling and shipping.

The first four objectives are those cited in the Standard Review Plan (SRP). The latter two objectives are to assure the structural integrity of the fuel and the compatibility with the existing reload fuel. To satisfy these objectives, the criteria are applied to the fuel rod and the fuel assembly (system) designs. Specific component criteria are also necessary to assure compliance. The criteria established to meet these objectives include those given in Chapter 4.2 of the SRP.

3.2 *Fuel Rod Evaluation*

The mechanical design report documents the fuel structural analyses only. The fuel rod evaluation will be documented in the fuel rod thermal-mechanical report. However, the fuel rod mechanical fracturing (Reference 1, Section 3.2.7) is evaluated in Section 3.4.4 *Structural Deformations.*

3.3 *Fuel System Evaluation*

The detailed fuel system design evaluation is performed to ensure the structural integrity of the design under normal operation, AOO, faulted conditions, handling operations, and shipping. The analysis methods are based on fundamental mechanical engineering techniques, often employing finite element analysis, prototype testing, and correlations based on in-reactor performance data. Summaries of the major assessment topics and associated testing are described in the sections that follow.

Prototype testing is an essential element of Framatome methodology for demonstrating compliance with structural design requirements. Results from design verification testing may directly demonstrate compliance with criteria or may be used as input to design analyses.

Testing performed to qualify the mechanical design or evaluate assembly characteristics includes:

- Fuel assembly axial load structural strength
- Fuel assembly fretting
- Fuel assembly static lateral deflection
- Fuel assembly lateral vibration
- Fuel assembly impact
- Spacer grid lateral impact strength
- Tie plate lateral load strength

3.3.1 Stress, Strain, or Loading Limits on Assembly Components

The structural integrity of the fuel assemblies is assured by setting design limits on stresses and deformations due to various handling, operational, AOOs, and accident or faulted loads. Framatome uses Section III of the American Society of Mechanical Engineers (ASME) boiler and pressure vessel (B&PV) code as a guide to establish acceptable stress, deformation, and load limits for standard assembly components. These limits are applied to the design and evaluation of the UTP, LTP, spacer grids, springs, and load chain components, as applicable.

All significant loads experienced during normal operation, AOOs, and under faulted conditions are evaluated to confirm the structural integrity of the fuel assembly components. Outside of faulted conditions, most structural components are under the most limiting loading conditions during fuel handling. See Section 3.3.9 for a discussion of fuel handling loads and Section 3.4.4 for the structural evaluation of faulted conditions. Although normal operation and AOO loads are often not limiting for structural components, a stress evaluation may be performed to confirm the design margin and to establish a baseline for adding accident loads. The stress calculations use conventional, open-literature equations. A general-purpose, finite element stress analysis code, such as ANSYS, may be used to calculate component stresses.

3.3.2 Fatigue

Section addressed in the fuel rod thermal-mechanical report.

3.3.3 Fretting Wear

Fuel rod failures due to grid-to-rod fretting shall not occur. [

] .

Fretting wear is evaluated by testing, as described in Section 3.3.3.1. The testing is conducted by [

] . The inspection measurements for wear are documented. The lack of significant wear demonstrates adequate rod restraint geometry at the contact locations. Also, the lack of significant wear at the spacer cell locations [ ] provides further assurance that no significant fretting will occur at higher exposure levels.

3.3.3.1 Fuel Assembly Fretting Test

A fretting test was conducted on a full-size test assembly to evaluate the ATRIUM 11 fuel rod support design. [

] . After the test, the assembly was inspected for signs of fretting wear. No significant wear was found on fuel rods in contact with spacer springs [

] . The results agree with past test results on BWR designs where no noticeable wear was found on the fuel rods or other interfacing components following exposure to coolant flow conditions.

3.3.4 Oxidation, Hydriding, and Crud Buildup

Section addressed in the fuel rod thermal-mechanical report.

3.3.5 Rod Bow

The predicted rod-to-rod gap closure due to bow is assessed by thermal hydraulics group for impact on thermal margins.

Differential expansion between the fuel rods and cage structure, and lateral thermal and flux gradients can lead to lateral creep bow of the rods in the spans between spacer grids. This lateral creep bow alters the pitch between the rods and may affect the peaking and local heat transfer. The Framatome design criterion for fuel rod bowing is [

].

Visual exams on ATRIUM 11 have not revealed any unusual fuel rod bow behavior for exposures up to [ ] based on the latest experience from Lead Test Assembly post-irradiation exams. This exposure is beyond the threshold where increasing rod bow had been observed on other designs. Therefore, the ATRIUM 11 fuel design has been shown to have minimal rod bow. A rod gap closure ratio curve is provided in Reference 4.

3.3.6 Axial Irradiation Growth

Reference 4 requires [

] .

The fuel rod growth correlation is established from [

] .

Assembly growth is established from ATRIUM 10x10 and 11x11 arrayed fuel assemblies with water channels made of Z4B material. It is based on the ATRIUM fuel assembly growth data only and excludes designs with load bearing tie rods as well as the European bundle-in-basket designs. [

] .

The fuel rod and assembly growth approved correlations are described within Reference 4 along with the respective tolerance limits.

3.3.7 Rod Internal Pressure

Section addressed in the fuel rod thermal-mechanical report.

3.3.8 Assembly Lift-off

Fuel assembly lift-off is evaluated under both normal operating conditions (including AOOs) and under faulted conditions. The fuel shall not levitate under normal operating or AOO conditions. Under postulated accident conditions, the fuel shall not become disengaged from the fuel support. These criteria assure control blade insertion is not impaired.

For normal operating conditions, the net axial force acting on the fuel assembly is calculated by adding the loads from gravity, hydraulic resistance from coolant flow, difference in fluid flow entrance and exit momentum, and buoyancy. The calculated net force is confirmed to be in the downward direction, indicating no assembly lift-off. [

].

Mixed core conditions for assembly lift-off are considered on a cycle-specific basis, as determined by the plant operating conditions and other fuel types. Analyses to date indicate a large margin to assembly lift-off under normal operating conditions.

For faulted conditions, [

]. The fuel will not lift under normal or AOO conditions, it will not become disengaged from the fuel support under faulted conditions, nor block insertion of the control blade in all operating conditions.

3.3.9 Fuel Assembly Handling

The fuel assembly shall withstand, without permanent deformation, all normal axial loads from shipping and fuel handling operations. Analyses or testing shall demonstrate that the fuel is capable of [ ] .

The fuel assembly structural components are assessed for axial fuel handling loads by analyses and testing. To demonstrate compliance with the criteria, the tests and analyses are performed by loading a test assembly or the individual components of the load chain to an axial tensile force greater than [ ] . An acceptable test and analysis demonstrates no yielding after loading.

Handling requirements for the fuel rod plenum spring are addressed in the fuel rod thermal-mechanical report.

3.3.9.1 Fuel Assembly Axial Load Tests

Each test is used in support of analytical or Finite Element Analysis to demonstrate that no significant permanent deformation occurs for loads [

] .

Descriptions of tests:

[

]

3.3.10 Miscellaneous Components

3.3.10.1 Compression Spring Forces

The compression spring force shall support the weight of the upper tie plate and channel throughout the design life of the fuel. The ATRIUM 11 has a single large compression spring mounted on the central water channel. The compression spring serves the same function as previous ATRIUM family of fuel designs by providing support for the UTP and fuel channel. The spring force is calculated based on the installed deflection and specified spring force requirements to meet support criteria. Irradiation-induced relaxation is taken into account for EOL conditions. The minimum compression spring force at EOL is greater than the combined weight of the UTP assembly and fuel channel assembly. Since the compression spring design of the ATRIUM family of fuel assemblies load chain designs do not interact with the fuel rods, no consideration is required for fuel rod buckling loads.

3.3.10.2 LTP Seal Spring

The LTP seal spring shall limit the bypass coolant leakage rate between the LTP and fuel channel. The seal spring shall accommodate expected channel deformation while remaining in contact with the fuel channel. Also, the seal spring shall have adequate corrosion resistance and be able to withstand the operating stresses without yielding.

Flow testing is used to confirm acceptable bypass flow characteristics. The seal spring is designed with adequate deflection to accommodate the maximum expected channel bulge while maintaining acceptable bypass flow. [ ] is selected as the material because of its high strength at elevated temperature and its excellent corrosion resistance. Seal spring stresses are analyzed using a finite element method.

3.4 *Fuel Coolability*

For accidents in which severe fuel damage might occur, core coolability and the capability to insert control blades are essential. Chapter 4.2 of the SRP provides several specific areas important to fuel coolability, as discussed below.

3.4.1 Cladding Embrittlement

This evaluation is not part of the mechanical design analysis.

3.4.2 Violent Expulsion of Fuel

This evaluation is not part of the mechanical design analysis.

3.4.3 Fuel Ballooning

This evaluation is not part of the mechanical design analysis.

3.4.4 Structural Deformations

ATRIUM 11 structural component deformations or stresses from postulated accidents are limited according to requirements contained in the ASME B&PV Code, Section III, Division 1, Appendix F, and SRP Section 4.2, Appendix A.

The methodology for analyzing the fuel under the influence of accident loads is described in the Mechanical Designs for BWR Fuel Channels Topical Report (Reference 2) and is further discussed in Section 3.5.2. Evaluations performed for the fuel under accident conditions include

[

] .

Dynamic properties of the ATRIUM 11 fuel assembly are provided to Browns Ferry in support of evaluations assessing the impact of the introduction of the ATRIUM 11 to the reactor pressure vessel, internal reactor components and other applicable evaluations.

3.4.4.1 Test Verifications

Fuel assemblies are tested with, and without, a fuel channel as described in Appendix C of Reference 2. Testing is performed to obtain the dynamic characteristics of the fuel assembly and spacer grids. The stiffness, natural frequencies and damping values derived from the tests are used as inputs for analytical models of the fuel assembly and fuel channel. In general, the testing and analyses have shown the dynamic response of ATRIUM 11 to be similar to ATRIUM-10 and ATRIUM 10XM fuel assemblies.

3.4.4.1.1 Fuel Assembly Static Lateral Deflection Test

A lateral deflection test is performed to determine the fuel assembly stiffness, both with and without a fuel channel. The stiffness is obtained by supporting the fuel assembly at the two ends in a vertical position, applying a side displacement at the central spacer location, and measuring the corresponding force.

3.4.4.1.2 Fuel Assembly Lateral Vibration Tests

The lateral vibration testing consists of both a free vibration test and a forced vibration test

[ ] .

The test setup for the free vibration test [ ] .

The forced vibration test [ ] .

3.4.4.1.3 Fuel Assembly Impact Tests

Impact testing was performed in a similar manner to the lateral deflection tests. The unchanneled assembly is supported in a vertical position with both ends fixed. The assembly is displaced a specified amount and then released. [

] .

3.4.4.1.4 Spacer Grid Lateral Impact Strength Test

Spacer grid impact strength is determined by a [

] .

The maximum force prior to the onset of buckling was determined from the tests. The results were adjusted to reactor operating temperature conditions to establish an allowable lateral load.

3.4.4.1.5 Tie Plate Strength Tests

In addition to the axial tensile tests described in Section 3.3.9.1, a lateral load test is performed on the UTP and LTP.

The UTP lateral load test was conducted on a test machine which applied [

]. This provides a limiting lateral load for accident conditions.

To determine a limiting lateral load for accident conditions for the 3GFG LTP, a lateral load test was conducted by attaching the grid of the tie plate to a rigid vertical plate [

].

The results were adjusted to reactor operating temperature conditions to establish an allowable lateral load per Reference 1, Section 3.3.1.

3.5 *Fuel Channel and Components*

The fuel channel assembly design criteria are summarized below, and evaluation results are summarized in Table 3-2. The analysis methods are described in detail in Reference 2.

3.5.1 Design Criteria for Normal Operation

Stress due to Pressure Differential. The stress limits during normal operation are obtained from the ASME B&PV Code, Section III, Division 1, Subsection NG for Service Level A. The calculated stress intensities are due to the differential pressure across the fuel channel wall. The pressure loading includes the normal operating pressure plus the increase during AOO. The unirradiated properties of the fuel channel material are used since the yield and ultimate tensile strength increase during irradiation (Reference 7). As an alternative to the elastic analysis stress intensity limits, a plastic analysis may be performed as permitted by paragraph NB-3228.3 of the ASME B&PV Code.

In the case of AOOs, the amount of bulging is limited to that value which will permit control blade movement. During normal operation, any significant permanent deformation due to yielding is precluded by restricting the maximum stresses at the inner and outer faces of the channel to be less than the yield strength.

Fatigue. Cyclic changes in power and flow during operation impose a duty loading on the fuel channel. The cyclic duty from pressure fluctuations is limited to less than the fatigue lifetime of the fuel channel. The fatigue life is based on the O’Donnell and Langer curve (Reference 6), which includes a factor of 2 on stress amplitude or a factor of 20 on the number of cycles, whichever is more conservative.

Oxidation and Hydriding. Oxidation reduces the material thickness and results in less load-carrying capacity. The fuel channels have thicker walls than other components (e.g., fuel rods), and the normal amounts of oxidation and hydrogen pickup are not limiting provided: the alloy composition and impurity limits are carefully selected; the heat treatments are also carefully chosen; and the plant water chemistry will be maintained in accordance with approved EPRI BWR Water Chemistry Guidelines. [

] .

Long-Term Deformation. Changes to the geometry of the fuel channel occur due to creep deformation during the long term exposure in the reactor core environment. Overall deformation of the fuel channel occurs from a combination of bulging and bowing. Bulging of the side walls occurs because of the differential pressure across the wall. Lateral bowing of the channel is caused primarily from the neutron flux and thermal gradients. Too much deflection may prevent normal control blade maneuvers and it may increase control blade insertion time above the Technical Specification limits. The total channel deformation must not stop free movement of the control blade. [

] .

3.5.2 Design Criteria for Accident Conditions

Fuel Channel Stresses, Load Limit, and Vertical Acceleration. The criteria are based on the ASME B&PV Code, Section III, Appendix F, for faulted conditions (Service Level D). Component support criteria for elastic system analysis are used as defined in paragraphs

F-1332.1 and F-1332.2. The unirradiated properties of the fuel channel material are used since the yield and ultimate tensile strength increase during irradiation (Reference 7). [

] .

Vertical acceleration produces a membrane stress in the axial direction due to a postulated impact of the channeled fuel assembly impacting the fuel support after liftoff.

The amount of bulging remains limited to that value which will permit control blade insertion.

Channel Bending from Combined Horizontal Excitations. [

] .

Fuel Channel Gusset Strength. [

] .

Table 3-1
Results for ATRIUM 11 Fuel Assembly Criteria

Criteria Section	Description	Criteria	Results
ANF-89-98(P)(A) (Reference 1) Associated Mechanical Design Criteria Sections			
3.3	**Fuel System Criteria**		
3.3.1	Stress, strain and loading limits on assembly components	The ASME B&PV Code Section III is used to establish acceptable stress levels or load limits for assembly structural components. The design limits for accident conditions are derived from Appendix F of Section III.	[ ].
3.3.3	Fretting wear	[ ].	[ ].
3.3.5	Rod bow	Protect thermal limits	[ ]
3.3.6	Axial irradiation growth		
	Upper end cap clearance	Clearance always exists	[ ]
3.3.8	Assembly lift-off		
	Normal operation (including AOOs)	No lift-off from fuel support	[ ]
	Postulated accident	No disengagement from fuel support	[ ].

Table 3-1
Results for ATRIUM 11 Fuel Assembly Criteria
(Continued)

Criteria Section	Description	Criteria	Results
3.3	**Fuel System Criteria** (Continued)		
3.3.9	Fuel assembly handling	[ ]	Verified by testing and Analyses to meet requirement
3.3.10	Miscellaneous components		
3.3.10.1	Compression spring forces	Support weight of UTP and fuel channel throughout design life	The design criteria are met
3.3.10.2	LTP seal spring	Accommodate fuel channel deformation, adequate corrosion, and withstand operating stresses	The design criteria are met
3.4	**Fuel Coolability**		
3.4.4	Structural deformations	Maintain coolable geometry and ability to insert control blades. SRP 4.2, App. A, and ASME Section III, App. F.	[ ] .

Table 3-2
Results for ATRIUM 11 Advanced Fuel Channel Criteria

Criteria Section	Description	Criteria	Results
EMF-93-177(P)(A) (Reference 2) Associated Fuel Channel (FC) Criteria Sections			
FC 3.2	**ATRIUM 11 Advanced Fuel Channel – Normal Operation**		
FC 3.2.1	Stress due to pressure differential	The pressure load including AOO is limited to [ ] according to ASME B&PV Code, Section III. The pressure load is also limited such that [ ].	The deformation during AOO remains within functional limits for normal control blade operation and the [ ] is met. There is no significant plastic deformation.
FC 3.2.2	Fatigue	Cumulative cyclic loading to be less than the design cyclic fatigue life for Zircaloy.	Expected number of cycles is less than allowable
FC 3.2.3	Oxidation and hydriding	Oxidation shall be accounted for in the stress and fatigue analyses	The maximum expected oxidation is low in relation to the wall thickness. Oxidation was accounted for in the stress and fatigue analyses.
FC 7.0	Long-term deformation (bulge creep and bow)	Bulge and bow shall not interfere with free movement of the control blade	Margin to a stuck control blade remains positive

Table 3-2
Results for ATRIUM 11 Advanced Fuel Channel Criteria
(Continued)

Criteria Section	Description	Criteria	Results
FC 3.3	**ATRIUM 11 Advanced Fuel Channel – Accident Conditions**		
FC 3.3.1	Fuel channel stresses and load limit and vertical accelerations	The pressure load is limited to [ ]. The pressure load is also limited such that [ ].	The deformation during blowdown does not interfere with control blade insertion. This also satisfies the less restrictive [ ].
FC 3.3.1 (continued)	Channel bending from combined horizontal excitations	Allowable bending moment based on ASME Code, Section III, Appendix F [ ].	[ ]
FC 3.3.2	Fuel channel gusset strength	Vertical load must be less than ASME allowable load rating based on testing.	[ ].

4.0 REFERENCES

1. ANF-89-98(P)(A) Revision 1 and Supplement 1, "Generic Mechanical Design Criteria for BWR Fuel Designs," Advanced Nuclear Fuels Corporation, May 1995.

2. EMF-93-177(P)(A) Revision 1, "Mechanical Design for BWR Fuel Channels," Framatome ANP Inc., August 2005.

3. EMF-93-177P-A Revision 1, Supplement 1P-A, Revision 0, "Mechanical Design for BWR Fuel Channels Supplement 1: Advanced Methods for New Channel Designs," AREVA NP Inc., September 2013.

4. BAW-10247P-A Supplement 2P-A Revision 0, "Realistic Thermal-Mechanical Fuel Rod Methodology for Boiling Water Reactors, Supplement 2: Mechanical Methods," Framatome Inc., August 2018.

5. ANP-3653P, Revision 0, "Fuel Design Evaluation for ATRIUM 11 BWR Reload Fuel," Information Design Report, Framatome Inc., September 2018.

6. W. J. O'Donnell and B. F. Langer, "Fatigue Design Basis for Zircaloy Components," Nuclear Science and Engineering, Volume 20, January 1964.

7. Huang, P. Y., Mahmood, S. T., and Adamson, R. B. "Effects of Thermomechanical Processing on In-Reactor Corrosion and Post-Irradiation Properties of Zircaloy-2," *Zirconium in the Nuclear Industry: Eleventh International Symposium*, ASTM STP 1295, E. R. Bradley and G. P. Sabol, Eds., American Society for Testing and Materials, 1996, pp. 726-757.

ATTACHMENT 9a

ANP-3866P Revision 2

(Proprietary)

Browns Ferry ATRIUM 11 Fuel Rod Thermal-Mechanical Evaluation for Browns Ferry LAR

ATTACHMENT 9b

ANP-3866NP Revision 2

(Non Proprietary)

Browns Ferry ATRIUM 11 Fuel Rod Thermal-Mechanical Evaluation for Browns Ferry LAR

ATRIUM 11 Fuel Rod Thermal-Mechanical Evaluation for Browns Ferry LAR

ANP-3866NP
Revision 2

Licensing Report

August 2022

Nature of Changes

Item	Section(s) or Page(s)	Description and Justification
1	Pages 3-1, 3-11	Minor modifications in the proprietary markings for consistency. The active fuel length of the full length rods was moved out of the proprietary markings in Table 3-1 as it is a non-proprietary information.
2	Page 3-11	Adjusted one proprietary value in Table 3-1 to update the value from the lead test assemblies value to the production ATRIUM11 fuel value.
3	Page 3-13	Adjusted one proprietary value in Table 3-2 to correct an error. The reported value was incorrect.

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Nomenclature

Acronym	Definition
3GFG	3rd generation FUELGUARD
AOO	anticipated operational occurrences
ASME	American Society of Mechanical Engineers
B&PV	Boiler and Pressure Vessel
BOL	beginning of life
BWR	boiling water reactor
CRWE	control rod withdrawal error
CUF	cumulative usage factor
EOL	end of life
EPU	extended power uprate
FDL	fuel design limit
ID	inside diameter
LAR	License Amendment Request
LHGR	linear heat generation rate
LTP	lower tie plate
MWd/kgU	megawatt days per kilogram of initial uranium
MELLLA+	maximum extended load line limit analysis plus
NRC	Nuclear Regulatory Commission, U. S.
OD	outside diameter
PCI	pellet-to-cladding-interaction
PLFR	part length fuel rod
ppm	parts per million
SRA	stress relieved annealed
S-N	stress amplitude versus number of cycles
UTL	upper tolerance limit

1.0 INTRODUCTION

This document reports the results of thermal-mechanical analyses for the performance of ATRIUM 11 fuel assemblies inserted into to an equilibrium cycle for the Browns Ferry units and demonstrates that the design criteria relevant to these limits are satisfied. This report is intended to support a License Amendment Request (LAR) for the approval to use the Framatome advanced analysis methods that will be deployed coincident with the implementation of the ATRIUM 11 fuel assembly design. These analyses assume the use of chromia additive in the enriched urania portions of the fuel and assume operation in the Maximum Extended Load Line Limit Plus (MELLLA+) operation domain at Extended Power Uprate (EPU) conditions. Both the design criteria and the analysis methodology have been approved by the U. S. NRC (NRC).

The analysis results are evaluated according to the generic fuel rod thermal and mechanical design criteria contained in ANF-89-98(P)(A) Revision 1 and Supplement 1 (Reference 1) along with design criteria provided in the RODEX4 fuel rod thermal-mechanical topical report (Reference 2)*. Approved methodology for the inclusion of chromia additive in the fuel pellets is also used (Reference 3).

The RODEX4 fuel rod thermal-mechanical analysis code is used to analyze the fuel rod for fuel centerline temperature, cladding strain, rod internal pressure, cladding collapse, cladding fatigue and external oxidation. The code and application methodology are described in the RODEX4 topical report (Reference 2). The cladding steady-state stress and plenum spring design methodology are summarized in Reference 1.

The following sections describe the fuel rod design, design criteria and methodology with reference to the source topical reports. Results from the analyses are summarized for comparison to the design criteria.

---

* (N.B., the cladding external oxidation limit from that topical report of **[ ]** was reduced to **[ ]** when the RODEX4 methodology was approved for application to the Browns Ferry units (Reference 4)).

2.0 SUMMARY AND CONCLUSIONS

Key results are compared against each design criterion in Table 3-2. Results are presented for the limiting cases. Additional RODEX4 results are given in Section 3.0.

The analyses support a maximum fuel rod discharge exposure of 62 MWd/kgU.

Fuel rod criteria applicable to the design are summarized in Section 3.0. Analyses show the criteria are satisfied when the fuel is operated at or below the LHGR (linear heat generation rate) limit (Fuel Design Limit – FDL) presented in Figure 2-1.

Table 2-1 Summary of Fuel Rod Design Evaluation Results (MELLLA+)

Criteria Section*	Description	Criteria	Result, Margin† or Comment
3.2	**Fuel Rod Criteria**		
3.2.1	Internal hydriding	[	]
(3.1.1)	Cladding collapse	[	]
(3.1.2)	Overheating of fuel pellets	No fuel melting margin to fuel melt > 0. °C	[ ]
3.2.5	Stress and strain limits		
(3.1.1) (3.1.2)	Pellet-cladding interaction	[	]
3.2.5.2	Cladding steady-state stresses	[	]
3.3	**Fuel System Criteria**		
(3.1.1)	Fatigue	[	]
(3.1.1)‡	Oxidation, hydriding, and crud buildup	[	]
(3.1.1) (3.1.2)	Rod internal pressure	[	]
3.3.9	Fuel rod plenum spring (fuel handling)	Plenum spring to [	]

* Numbers in the column refer to paragraph sections in the generic design criteria document, ANF-89-98(P)(A) Revision 1 and Supplement 1 (Reference 1). A number in parentheses is the paragraph section in the RODEX4 fuel rod topical report (Reference 2).

† Margin is defined as (limit – result).

‡ The cladding external oxidation limit is restricted to [ ] by Reference 4.

[

]

Figure 2-1 LHGR Limit (Normal Operation)

3.0 FUEL ROD DESIGN EVALUATION

Summaries of the design criteria and methodology are provided in this section along with analysis results in comparison to criteria. Both the fuel rod criteria and fuel system criteria as directly related to the fuel rod analyses are covered.

The fuel rod analyses cover normal operating conditions and AOOs (anticipated operational occurrences). The fuel centerline temperature analysis (overheating of fuel) and cladding strain analysis take into account slow transients at rated operating conditions.

Other fuel rod-related topics on overheating of cladding, cladding rupture, fuel rod mechanical fracturing, rod bow, axial irradiation growth, cladding embrittlement, violent expulsion of fuel and fuel ballooning are evaluated as part of the respective fuel assembly structural analysis, thermal hydraulic analyses, or LOCA analyses and are reported elsewhere. The evaluation of fast transients and transients at off-rated conditions also are reported separately from this report.

3.1 *Fuel Rod Design*

The ATRIUM 11 fuel rod is conventional in design configuration and very similar to past designs such as the ATRIUM 10XM, ATRIUM-10 and ATRIUM-9 fuel rods.

The fuel rods are made with Zircaloy-2 cladding **[**

] plenum spring on the upper end of the fuel column assists in maintaining a compact fuel column during shipment and initial reactor operation.

There are two Part-length Fuel Rod (PLFR) designs incorporated in the fuel assembly. The longer is **[** **]** long, while the shorter is **[** **]** long. **[**

] .

[

]

As on previous ATRIUM fuel designs that incorporated the 3rd generation FUELGUARD (3GFG) Lower Tie Plate (LTP), the PLFR's have a **[**

]

Table 3-1 lists the main parameters for the fuel rod and components.

3.2 *RODEX4 and Statistical Methodology Summary*

RODEX4 evaluates the thermal-mechanical response of the fuel rod surrounded by coolant. The fuel rod model considers the fuel column, gap region, cladding, gas plena and the fill gas and released fission gases. The fuel rod is divided into axial and radial regions with conditions computed for each region. The operational conditions are controlled by the **[**

].

The heat conduction in the fuel and clad is **[**

].

Mechanical processes include **[**

].

As part of the methodology, fuel rod power histories are generated **[**

].

Since RODEX4 is a best-estimate code, uncertainties are taken into account by a **[**

]. Uncertainties taken into account in the analysis are summarized as:

- Power measurement and operational uncertainties – **[**

  ].
- Manufacturing uncertainties – **[** **]**.
- Model uncertainties – **[**

  ].

[

].

3.3 *Summary of Fuel Rod Design Evaluation*

Results from the analyses are listed in Table 3-2. Summaries of the methods and codes used in the evaluation are provided in the following paragraphs. The design criteria also are listed along with references to the sections of the design criteria topical reports (References 1 and 2).

The fuel rod thermal and mechanical design criteria are summarized as follows.

- **Internal Hydriding**. The fabrication limit **[** **]** to preclude cladding failure caused by internal sources of hydrogen (Section 3.2.1 of Reference 1).

- **Cladding Collapse**. Clad creep collapse shall be prevented. **[** **]** (Section 3.1.1 of Reference 2).

- **Overheating of Fuel Pellets**. The fuel pellet centerline temperature during anticipated transients shall remain below the melting temperature (Section 3.1.2 of Reference 2).

- **Stress and Strain Limits**. **[** **]** during normal operation and during anticipated transients (Sections 3.1.1 and 3.1.2 of Reference 2).

  Fuel rod cladding steady-state stresses are restricted to satisfy limits derived from the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel (B&PV) Code (Section 3.2.5.2 of Reference 1).

- **Cladding Fatigue**. The fatigue cumulative usage factor for clad stresses during normal operation and design cyclic maneuvers shall be below **[** **]** (Section 3.1.1 of Reference 2).

- **Cladding Oxidation, Hydriding and Crud Buildup**. Section 3.1.1 of Reference 2 limits the maximum cladding oxidation to less than **[** **]** to prevent clad corrosion failure. The oxidation limit is further reduced to **[** **]** (Reference 4).

- **Rod Internal Pressure**. The rod internal pressure is limited **[** **]** to ensure that significant outward clad creep does not occur and unfavorable hydride reorientation on cooldown does not occur (Section 3.1.1 of Reference 2).

- **Plenum Spring Design (Fuel Handling)**. The rod plenum spring must maintain a force against the fuel column stack **[** **]** (Section 3.3.9 of Reference 1).

Cladding collapse, overheating of fuel, cladding transient strain, cladding cyclic fatigue, cladding oxidation, and rod pressure are evaluated **[** **]**. Cladding stress and the plenum spring are evaluated **[** **]**.

3.3.1 Internal Hydriding

The absorption of hydrogen by the cladding can result in cladding failure due to reduced ductility and formation of hydride platelets. Careful moisture control during fuel fabrication reduces the potential for hydrogen absorption on the inside of the cladding. The fabrication limit **[**

] is verified by quality control inspection during fuel manufacturing.

3.3.2 Cladding Collapse

Creep collapse of the cladding and the subsequent potential for fuel failure is avoided in the design by limiting the axial gap formation due to fuel densification subsequent to pellet-clad contact. The size of the axial gaps which may form due to densification following first pellet-clad contact shall be less than **[** **].**

The evaluation is performed using the RODEX4 code and methodology. RODEX4 takes into account the **[**

].

Table 3-2 lists the results for an equilibrium cycle operating in the MELLLA+ operating domain for EPU conditions.

3.3.3 Overheating of Fuel Pellets

Fuel failure from the overheating of the fuel pellets is not allowed. The centerline temperature of the fuel pellets must remain below melting during normal operation and AOOs. The melting point of the fuel includes adjustments for **[** **]**. Framatome establishes an LHGR limit to protect against fuel centerline melting during steady-state operation and during AOOs.

Fuel centerline temperature is evaluated using the RODEX4 code and methodology for both normal operating conditions and AOOs.

Table 3-2 lists the results for an equilibrium cycle operating in the MELLLA+ operating domain for EPU conditions.

3.3.4 Stress and Strain Limits

3.3.4.1 Pellet/Cladding Interaction

Cladding strain caused by transient-induced deformations of the cladding is calculated using the RODEX4 code and methodology. **[**

]. The strain limit is 1%.

Table 3-2 lists the results for an equilibrium cycle operating in the MELLLA+ operating domain for EPU conditions.

3.3.4.2 Cladding Stress

Cladding stresses are calculated using solid mechanics elasticity solutions and finite element methods. The stresses are conservatively calculated for the individual loadings and are categorized as follows:

Category	Membrane	Bending
Primary	**[**	**]**
Secondary	**[**	**]**

Stresses are calculated at the cladding outer and inner diameter in the three principal directions for both beginning of life (BOL) and end of life (EOL) conditions. At EOL, the stresses due to mechanical bow and contact stress are decreased due to irradiation relaxation. The separate stress components are then combined, and the stress intensities for each category are compared to their respective limits.

The cladding-to-end cap weld stresses are evaluated for loadings from differential pressure, differential thermal expansion, rod weight, and plenum spring force.

The design limits are derived from the ASME (American Society of Mechanical Engineers) Boiler and Pressure Vessel (B&PV) Code Section III (Reference 5) and the minimum specified material properties.

Table 3-3 lists the results in comparison to the limits for Beginning-of-Life (BOL) Hot conditions and End-of-Life (EOL) at both Hot and Cold conditions.

3.3.5 Fuel Densification and Swelling

Fuel densification and swelling are limited by the design criteria for fuel temperature, cladding strain, cladding collapse, and rod internal pressure criteria. Although there are no explicit criteria for fuel densification and swelling, the effect of these phenomena are included in the RODEX4 code and methodology.

3.3.6 Fatigue

Fuel rod cladding fatigue is calculated using the RODEX4 code and methodology. **[**

]. The CUF (cumulative usage factor) is summed for each of the axial regions of the fuel rod using Miner's rule. The axial region with the highest CUF is used in the subsequent **[**

]. The maximum CUF for the cladding must remain below **[ ]** to satisfy the design criterion. Table 3-2 lists the results for an equilibrium cycle operating in the MELLLA+ operating domain for EPU conditions.

3.3.7 Oxidation, Hydriding, and Crud Buildup

Cladding external oxidation is calculated using the RODEX4 code and methodology. The corrosion model includes an enhancement factor that is derived from poolside measurement data to obtain a fit of the expected oxide thickness. An uncertainty value for the model enhancement factor also is determined from the data. The model uncertainty is included as part of the **[ ]**.

[

].

In the event abnormal crud is observed at a plant, a specific analysis is required to address the higher crud level. An abnormal level of crud is defined by a formation that increases the calculated fuel average temperature by 25°C above the design basis calculation. The formation of crud is not calculated within RODEX4. Instead, an upper bound of expected crud based on plant observations is input by the use of the crud heat transfer coefficient. The corrosion model also takes into consideration the effect of the higher thermal resistance from the crud on the corrosion rate. A higher corrosion rate is therefore included as part of the abnormal crud evaluation. A similar specific analysis is required if an abnormal corrosion layer is observed instead of crud.

In the case of the Browns Ferry units, no additional crud is taken into account in the calculations because an abnormal crud or corrosion layer (beyond the design basis) has not been observed at the Browns Ferry units.

[

].

Currently, [

].

The oxide limit is evaluated such that greater than [

].

Table 3-2 lists the results for an equilibrium cycle operating in the MELLLA+ operating domain for EPU conditions.

3.3.8 Rod Internal Pressure

Fuel rod internal pressure is calculated using the RODEX4 code and methodology. The maximum rod pressure is calculated under steady-state conditions and also takes into account slow transients. Rod internal pressure is limited to **[** **]**. The expected upper bound of rod pressure **[** **]** is calculated for comparison to the limit.

Table 3-2 lists the results for an equilibrium cycle operating in the MELLLA+ operating domain for EPU conditions.

3.3.9 Plenum Spring Design (Fuel Assembly Handling)

The plenum spring must maintain a force against the fuel column to prevent **[** **]**. This is accomplished by designing and verifying the spring force in relation to the fuel column weight. The plenum spring is designed such that the **[** **]**.

Table 3-1 Key Fuel Rod Design Parameters, ATRIUM 11 for Browns Ferry LAR

[

]

Active fuel length, inch	
Full length rod	150.00

* The theoretical density of enriched UO_2-Cr is 10.94 g/cm^3 while that for UO_2-Gd_2O_3 and naturally enriched UO_2 is 10.96 g/cm^3.

Table 3-1 Key Fuel Rod Design Parameters, ATRIUM 11 for Browns Ferry LAR **(cont'd)**

[

]

Table 3-2 RODEX4 Fuel Rod Results Equilibrium Cycle—MELLLA+*

[

]

* Note that the results are provided up to fuel assembly discharge.

† Margin is defined as (limit – result).

Table 3-3 Cladding and Cladding-End Cap Steady-State Stresses

Description, Stress Category	Criteria	Result		
		BOL Cold	BOL Hot	EOL Hot
Cladding stress				
P_m (primary membrane stress)	[			]
$P_m + P_b$ (primary membrane + bending)	[			]
P + Q (primary + secondary)	[			]
Cladding-End Cap stress				
$P_m + P_b$	[			]

4.0 REFERENCES

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ATTACHMENT 10a

ANP-3859P Revision 1

(Proprietary)

Browns Ferry Thermal-Hydraulic Design Report for ATRIUM 11 Fuel Assemblies

ATTACHMENT 10b

ANP-3859NP Revision 1

(Non Proprietary)

Browns Ferry Thermal-Hydraulic Design Report for ATRIUM 11 Fuel Assemblies

Browns Ferry Thermal-Hydraulic Design Report for ATRIUM 11 Fuel Assemblies

ANP-3859NP
Revision 1

June 2022

Nature of Changes

Item	Section(s) or Page(s)	Description and Justification
1	Page 3-10	Marked the Fuel clad OD value for ATRIUM 11 fuel as proprietary.
2	Page 3-11	Proprietary markings are adjusted on Table 3.3 to remove them from the second footnote on the page.

Contents

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Nomenclature

Acronym	Definition
AOO	anticipated operational occurrences
ASME	American Society of Mechanical Engineers
BWR	boiling water reactor
BWROG	BWR Owners Group
CHF	critical heat flux
CPR	critical power ratio
CRDA	control rod drop accident
ECCS	emergency core cooling system
EPU	extended power uprate (defined as 120% OLTP, 3952 MWt)
LOCA	loss-of-coolant accident
LTP	lower tie plate
MAPLHGR	maximum average planar linear heat generation rate
MCPR	minimum critical power ratio
MWR	metal-water reaction
NRC	Nuclear Regulatory Commission, U.S.
OLMCPR	operating limit minimum critical power ratio
OLTP	original licensed thermal power (3293 MWt)
OPRM	oscillation power range monitor
PCT	peak cladding temperature
RPF	radial peaking factor
SER	safety evaluation report
SLMCPR	safety limit minimum critical power ratio
UO_2	uranium dioxide
UTP	upper tie plate

1.0 INTRODUCTION

The results of Browns Ferry thermal-hydraulic analyses are presented to demonstrate that Framatome ATRIUM 11 fuel is hydraulically compatible with the previously loaded ATRIUM 10XM fuel design at extended power uprate (EPU) maximum extended load line limit analysis plus (MELLLA+) conditions. This report also provides the hydraulic characterization of the ATRIUM 11 and the coresident ATRIUM 10XM fuel designs for Browns Ferry.

The generic thermal-hydraulic design criteria applicable to the design have been reviewed and approved by the U.S. Nuclear Regulatory Commission (NRC) in the topical report ANF-89-98(P)(A) Revision 1 and Supplement 1 (Reference 1). In addition, thermal-hydraulic criteria applicable to the design have also been reviewed and approved by the NRC in the topical report XN-NF-80-19(P)(A) Volume 4 Revision 1 (Reference 2).

2.0 SUMMARY AND CONCLUSIONS

The thermal-hydraulic evaluations presented in this report are for the various, expected core configurations that include ATRIUM 11 and ATRIUM 10XM fuel designs at EPU MELLLA+ operation. These fuel designs have been determined to be hydraulically compatible at Browns Ferry for the entire range of the licensed EPU MELLLA+ power-to-flow operating map. Detailed calculation results supporting this conclusion are provided in Section 3.2 and Tables 3.2–3.10.

The ATRIUM 11 and the ATRIUM 10XM fuel assemblies are geometrically different, but hydraulically the two designs are compatible at EPU MELLLA+ operation. **[**

]

Core bypass flow is not significantly affected by any combination core loading of ATRIUM 11 and ATRIUM 10XM fuel for EPU MELLLA+ operation. Analyses at rated conditions show the core bypass flow varying between **[ ]** of rated flow. Analyses at rated power and the MELLLA+ region boundary of 85% flow show the core bypass flow varying between **[ ]**.

Analyses demonstrate the design criteria discussed in Section 3.0 are satisfied for the Browns Ferry EPU MELLLA+ core configurations consisting of ATRIUM 11 and ATRIUM 10XM fuel combinations. These analyses were performed for expected EPU MELLLA+ core power distributions and core flow conditions encountered during operation.

3.0 THERMAL-HYDRAULIC DESIGN EVALUATION

Thermal-hydraulic analyses are performed to verify that design criteria are satisfied and to help establish thermal operating limits with acceptable margins of safety during normal reactor operation and anticipated operational occurrences (AOOs). The design criteria that are applicable to the Framatome fuel designs are described in Reference 1. To the extent possible, these analyses are performed on a generic fuel design basis. However, due to reactor and cycle operating differences, many of the analyses supporting these thermal-hydraulic operating limits are performed on a plant- and cycle-specific basis and are documented in plant- and cycle-specific reports (Reference 2).

The thermal-hydraulic design criteria are summarized below:

- **Hydraulic compatibility.** The hydraulic flow resistance of the reload fuel assemblies shall be sufficiently similar to the existing fuel in the reactor such that there is no significant impact on total core flow or the flow distribution among assemblies in the core. This criterion evaluation is addressed in Sections 3.1 and 3.2.

- **Thermal margin performance.** Fuel assembly geometry, including spacer design and rod-to-rod local power peaking, should minimize the likelihood of boiling transition during normal reactor operation as well as during AOOs. The fuel design should fall within the bounds of the applicable empirically based boiling transition correlation approved for Framatome reload fuel. Within other applicable mechanical, nuclear, and fuel performance constraints, the fuel design should achieve good thermal margin performance. The thermal-hydraulic design impact on steady-state thermal margin performance is addressed in Section 3.3. Additional thermal margin performance evaluations dependent on the cycle-specific design are addressed in the reload licensing report.

- **Fuel centerline temperature.** Fuel design and operation shall be such that fuel centerline melting is not projected for normal operation and AOOs. This criterion evaluation is addressed in the fuel rod thermal and mechanical design report.

- **Rod bow.** The anticipated magnitude of fuel rod bowing under irradiation shall be accounted for in establishing thermal margin requirements. This criterion is addressed in Section 3.4.

- **Bypass flow.** The bypass flow characteristics of the reload fuel assemblies shall not differ significantly from the existing fuel in order to provide adequate flow in the bypass region. This criterion evaluation is addressed in Section 3.5.
- **Stability.** Reactors fueled with new fuel designs must be stable in the approved power and flow operating region. The stability performance of new fuel designs will be equivalent to, or better than, existing (approved) Framatome fuel designs. This criterion evaluation is addressed in Section 3.6. Additional core stability evaluations dependent on the cycle-specific design are addressed in the reload licensing report.
- **Loss-of-coolant accident (LOCA) analysis.** LOCAs are analyzed in accordance with Appendix K modeling requirements using NRC-approved models. The criteria are defined in 10 CFR 50.46. LOCA analysis results are presented in the LOCA report.
- **Control rod drop accident (CRDA) analysis.** The results from the CRDA analysis must meet the criteria of Regulatory Guide 1.236.
- **ASME overpressurization analysis.** ASME pressure vessel code requirements must be satisfied. This criterion evaluation is addressed in the reload licensing report.
- **Seismic/LOCA liftoff.** Under accident conditions, the assembly must remain engaged in the fuel support. This criterion evaluation is addressed in the mechanical design report.

A summary of the thermal-hydraulic design evaluation is given in Table 3.1.

3.1 *Hydraulic Characterization*

The basic geometric parameters for ATRIUM 11 and ATRIUM 10XM fuel designs are summarized in Table 3.2. Component loss coefficients for the fuels mentioned are based on documented tests and are presented in Table 3.3. These loss coefficients include modifications to the test data reduction process **[**

] The bare rod, ULTRAFLOW spacer, UTP and LTP losses for ATRIUM 11 and ATRIUM 10XM are based on tests performed at Framatome's Portable

Hydraulic Test Facility. [

]

The primary resistance for the leakage flow through the LTP flow holes is [

]

The resistances for the leakage paths are shown in Table 3.3.

3.2 *Hydraulic Compatibility*

The thermal-hydraulic analyses were performed in accordance with the Framatome thermal-hydraulic methodology for BWRs (Reference 2). The methodology and constitutive relationships used by Framatome for the calculation of pressure drop in BWR fuel assemblies are presented in Reference 3 and are implemented in the XCOBRA code. The XCOBRA code predicts steady-state thermal-hydraulic performance of the fuel assemblies of BWR cores at various operating conditions and power distributions. XCOBRA received NRC approval in Reference 4. The NRC reviewed the information provided in Reference 5 regarding inclusion of water rod models in XCOBRA and accepted the inclusion in Reference 6.

Hydraulic compatibility, as it relates to the relative performance of the ATRIUM 11 and coresident ATRIUM 10XM fuel designs, has been evaluated. Detailed analyses were performed for full cores of each fuel design presented herein. Analyses for mixed cores with ATRIUM 11 and ATRIUM 10XM fuel were also performed to demonstrate that the thermal-hydraulic design criteria are satisfied for transition core configurations under EPU MELLLA+ operation.

The hydraulic compatibility analysis is based on [

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[

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Table 3.4 summarizes the input conditions for the analyses. These conditions reflect four of the statepoints considered in the analyses: 100% power/100% flow, 100% power/85% flow, 77.6% power/55% flow and 54.3% power/37.3% flow. Table 3.4 also defines the core loadings for the transition core configurations. Input for other core configurations is similar in that core operating conditions remain the same and the same axial power distribution is used. Evaluations were made with the bottom-, middle-, and top-peaked axial power distributions presented in Figure 3.1. Results presented in Tables 3.5 - 3.10 and Figures 3.2 - 3.9 are for bottom peaked power distribution. Results for the middle-peaked and top-peaked axial power distributions show similar trends.

Table 3.5 – Table 3.6 provide a summary of calculated thermal-hydraulic results for the core configurations provided in Table 3.4. Tables 3.7 -3.10 provide a summary of results for all core configurations evaluated.

Core Loading 1 (Table 3.4) is a core consisting of approximately one third ATRIUM 11 fuel with the remainder ATRIUM 10XM fuel. This represents a core with a single reload of ATRIUM 11 fuel. The core average results and the differences between the fuel designs for both rated and off-rated statepoints are within the range considered hydraulically compatible. As shown in Table 3.5, [

] Differences in assembly flow between the fuel designs as a function of assembly power level are shown in Figure 3.2 - Figure 3.5. Core pressure drop and core bypass flow fraction are also provided for *Core Loading 1* (Table 3.7-3.10). Based on the reported changes in pressure drop and assembly flow caused by the first reload of ATRIUM 11, the ATRIUM 11 design is considered hydraulically compatible with the coresident ATRIUM 10XM design for EPU MELLLA+ operation since the thermal-hydraulic design criteria are satisfied.

Core Loading 2 (Table 3.4) is a core consisting of approximately two thirds ATRIUM 11 fuel with the remainder ATRIUM 10XM fuel. This represents a core with two reloads of ATRIUM 11 fuel. The core average results and the differences between the fuel designs for both rated and off-rated statepoints are within the range considered hydraulically compatible. As shown in Table 3.6, **[**

] Differences in assembly flow between the fuel designs as a function of assembly power level are shown in Figure 3.6 - Figure 3.9. Core pressure drop and core bypass flow fraction are also provided for *Core Loading 2* (Table 3.7–3.10). Based on the reported changes in pressure drop and assembly flow caused by the second reload of ATRIUM 11, the ATRIUM 11 design is considered hydraulically compatible with the coresident ATRIUM 10XM design for EPU MELLLA+ operation since the thermal-hydraulic design criteria are satisfied.

3.3 *Thermal Margin Performance*

Relative thermal margin analyses were performed in accordance with the thermal-hydraulic methodology for Framatome XCOBRA code. The calculation of the fuel assembly CPR (thermal margin performance) is established by means of an empirical correlation based on results of boiling transition test programs. The CPR methodology is the approach used by Framatome to determine the margin to thermal limits for BWRs.

CPR values for ATRIUM 11 fuel are calculated with the ACE/ATRIUM 11 critical power correlation (Reference 7) while the CPR values for ATRIUM 10XM fuel are calculated with the ACE/ATRIUM 10XM critical power correlation (Reference 8). Assembly design features are incorporated in the CPR calculation through the K-factor term in the ACE correlations. The K-factors are based on the local power peaking for the nuclear design and on additive constants determined in accordance with approved procedures. The local peaking factors are a function of assembly void and exposure.

For the compatibility evaluation, steady-state analyses evaluated ATRIUM 11 and ATRIUM 10XM fuel assemblies with radial peaking factors (RPFs) between **[**

] Table 3.5 - Table 3.6 show representative CPRs of the ATRIUM 11 and ATRIUM 10XM fuel designs. Table 3.7 - Table 3.10 show similar comparisons of CPR and assembly flow for the various mixed core configurations evaluated. Analysis results indicate ATRIUM 11 fuel will not adversely affect the thermal margin performance of the coresident ATRIUM 10XM fuel.

3.4 *Rod Bow*

[

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3.5 *Bypass Flow*

Total core bypass flow is defined as leakage flow through the LTP flow holes, channel seal, core support plate, and LTP-fuel support interface. Table 3.7 shows that total core bypass flow (excluding water rod flow) fraction at rated conditions changes from **[** **]** of rated core flow while transitioning through the core configurations presented (bottom-peaked power shape). Table 3.8 shows that the total core bypass flow (excluding water rod flow) fraction at 100% power/85% flow changes from [ ] of rated core flow during the transition from a full core of ATRIUM 10XM to a full core of ATRIUM 11 (bottom-peaked power shape). [ ] In summary, adequate bypass flow will be available with the introduction of the ATRIUM 11 fuel design and applicable design criteria are met.

3.6 *Stability*

Each new fuel design is analyzed to demonstrate that the stability performance is equivalent to or better than an existing Framatome fuel design. The stability performance is a function of the core power, core flow, core power distribution and, to a lesser extent, the fuel design. [ ] A comparative stability analysis was performed with the NRC-approved STAIF code (Reference 9). The analysis shows that the ATRIUM 11 fuel design has decay ratios equivalent to or better than other Framatome fuel designs.

As stated above, the stability performance of a core is strongly dependent on the core power, core flow, and power distribution in the core. Therefore, core stability is evaluated on a cycle-specific basis and addressed in the reload licensing report.

Table 3.1 Design Evaluation of Thermal and Hydraulic Criteria for the ATRIUM 11 Fuel Assembly

Criteria Section	Description	Criteria	Results or Disposition
3.0	**Thermal and Hydraulic Criteria**		
3.2	Hydraulic compatibility	Hydraulic flow resistance shall be sufficiently similar to existing fuel such that there is no significant impact on total core flow or flow distribution among assemblies.	Verified on a plant-specific basis. ATRIUM 11 demonstrated to be compatible with ATRIUM 10XM fuel. [ ]
3.3	Thermal margin performance	Fuel design shall be within the limits of applicability of an approved CHF correlation.	ACE/ATRIUM 11 critical power correlation is applied to the ATRIUM 11 fuel. ACE/ATRIUM 10XM critical power correlation is applied to the ATRIUM 10XM fuel.
		< 0.1% of rods in boiling transition.	Verified on cycle-specific basis for Chapter 14 analyses.
---	Fuel centerline temperature	No centerline melting.	Plant- and fuel-specific analyses are performed. Addressed in the mechanical design report.
3.4	Rod bow	Rod bow must be accounted for in establishing thermal margins.	The lateral displacement of the fuel rods due to fuel rod bowing is not of sufficient magnitude to impact thermal margins. Verified on a cycle-specific basis.
3.5	Bypass flow	Bypass flow characteristics shall be similar among assemblies to provide adequate bypass flow.	Verified on a plant-specific basis. Analysis results demonstrate that adequate bypass flow is provided.

Table 3.1 Design Evaluation of Thermal and Hydraulic Criteria for the ATRIUM 11 Fuel Assembly *(Continued)*

Criteria Section	Description	Criteria	Results or Disposition
3.0	**Thermal and Hydraulic Criteria** *(Continued)*		
3.6	Stability	New fuel designs are stable in the approved power and flow operating region, and stability performance will be equivalent to (or better than) existing (approved) Framatome fuel designs.	ATRIUM 11 channel and core decay ratios have been demonstrated to be equivalent to or better than other approved Framatome fuel designs. Core stability behavior is evaluated on a cycle-specific basis.
---	LOCA analysis	LOCA analyzed in accordance with Appendix K modeling requirements. Criteria defined in 10 CFR 50.46.	Plant- and fuel-specific analysis is performed with Appendix K LOCA models and verified with cycle-specific calculations.
---	CRDA analysis	Criteria defined in Regulatory Guide 1.236	Cycle-specific analysis is performed. Results must ensure that the number of effective fuel rod failures remains bounded by the licensing basis CRDA dose analysis.
---	ASME over-pressurization analysis	ASME pressure vessel core requirements shall be satisfied.	Cycle-specific analysis is performed.
---	Seismic/LOCA liftoff	Assembly remains engaged in fuel support.	Plant- and fuel-specific analyses are performed. Addressed in the mechanical design report.

Table 3.2 Comparative Description of Browns Ferry ATRIUM 11 and ATRIUM 10XM Fuel

Fuel Parameter	ATRIUM 10XM	ATRIUM 11
Number of fuel rods		
Full-length fuel rods	79	92
PLFRs	12	
Short PLFRs		12
Long PLFRs		8
Fuel clad OD, in	0.4047	[ ]
Number of spacers	9*	9*
Active fuel length, ft		
Full-length fuel rods	12.500	12.500
PLFRs	6.25	
Short PLFRs		4.66
Long PLFRs		7.34
Hydraulic resistance characteristics	Table 3.3	Table 3.3
Number of water rods	1	1
Water rod OD, in	1.378†	1.299†

* The ATRIUM 10XM and ATRIUM 11 fuel designs have 9 spacers. For both fuel designs, the losses associated with the bottom spacer are combined with the orifice/LTP model, so that only 8 spacers are explicitly modeled for these two fuels.

† Square water channel outer width.

Table 3.3 Hydraulic Characterization Comparison Between Browns Ferry ATRIUM 10XM and ATRIUM 11 Fuel

† The ATRIUM 10XM and ATRIUM 11 fuel designs have 9 spacers. For both fuel designs, the losses associated with the bottom spacer are combined with the orifice/LTP model, so that only 8 spacers are explicitly modeled for these two fuels.

Table 3.4 Browns Ferry EPU MELLLA+
Thermal-Hydraulic Design Conditions

Reactor Conditions	100%P / 100%F	100%P / 85%F	77.6%P / 55% F	54.3%P / 37.3%F
Core power level, MWt	3952	3952	3067	2146
Core exit pressure, psia	1060	1062	1038	987
Core inlet enthalpy, Btu/lbm	523.2	517.9	504.2	492.2
Total core coolant flow, Mlbm/hr	102.5	87.1	56.4	38.2
Axial power shape	Bottom-peaked (Figure 3.1)	Bottom-peaked (Figure 3.1)	Bottom-peaked (Figure 3.1)	Bottom-peaked (Figure 3.1)

	Number of Assemblies	
	Central Region	Peripheral Region
Core Loading 1		
[		]
Core Loading 2		
[		]

**Table 3.5 Browns Ferry EPU MELLLA+ Core Loading 1
Thermal-Hydraulic Results**

Table 3.5 Browns Ferry EPU MELLLA+ Core Loading 1 Thermal-Hydraulic Results (*continued)*

**Table 3.6 Browns Ferry EPU MELLLA+ Core Loading 2
Thermal-Hydraulic Results**

Table 3.6 Browns Ferry EPU MELLLA+ Core Loading 2
Thermal-Hydraulic Results (*continued*)

Table 3.7 Browns Ferry Thermal-Hydraulic Results at 100% Power / 100% Flow Conditions

[ ]

Table 3.8 Browns Ferry Thermal-Hydraulic Results at 100% Power / 85% Flow Conditions

Table 3.9 Browns Ferry Thermal-Hydraulic Results at 77.6% Power / 55% Core Flow Conditions

Table 3.10 Browns Ferry Thermal-Hydraulic Results at 54.3% Power / 37.3% Flow Conditions

[ ]

Figure 3.1 Axial Power Shapes

Figure 3.2 Core Loading 1:
Hydraulic Demand Curves 100% Power / 100% Flow

[ ]

Figure 3.3 Core Loading 1:
Hydraulic Demand Curves 100% Power / 85% Flow

[ ]

Figure 3.4 Core Loading 1:
Hydraulic Demand Curves 77.6% Power / 55% Flow

[ ]

**Figure 3.5 Core Loading 1:
Hydraulic Demand Curves 54.3% Power / 37.3% Flow**

[

]

**Figure 3.6 Core Loading 2:
Hydraulic Demand Curves 100% Power / 100% Flow**

**Figure 3.7 Core Loading 2:
Hydraulic Demand Curves 100% Power / 85% Flow**

[ ]

Figure 3.8 Core Loading 2:
Hydraulic Demand Curves 77.6% Power / 55% Flow

Figure 3.9 Core Loading 2:
Hydraulic Demand Curves 54.3% Power / 37.3% Flow

[ ]

4.0 REFERENCES

1. ANF-89-98(P)(A) Revision 1 and Supplement 1*, Generic Mechanical Design Criteria for BWR Fuel Designs*, Advanced Nuclear Fuels Corporation, May 1995.

2. XN-NF-80-19(P)(A) Volume 4 Revision 1, *Exxon Nuclear Methodology for Boiling Water Reactors: Application of the ENC Methodology to BWR Reloads*, Exxon Nuclear Company, June 1986.

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9. EMF-CC-074(P)(A) Volume 1, *STAIF – A Computer Program for BWR Stability Analysis in the Frequency Domain;* and Volume 2, *STAIF – A Computer Program for BWR Stability Analysis in the Frequency Domain – Code Qualification Report*, Siemens Power Corporation, July 1994.

ATTACHMENT 11a

ANP-3908P Revision 4

(Proprietary)

Applicability of Framatome BWR Methods to Browns Ferry with ATRIUM 11 Fuel

ATTACHMENT 11b

ANP-3908NP Revision 4

(Non Proprietary)

Applicability of Framatome BWR Methods to Browns Ferry with ATRIUM 11 Fuel

framatome

Applicability of Framatome BWR Methods to Browns Ferry with ATRIUM 11 Fuel

ANP-3908NP
Revision 4

June 2022

Nature of Changes

Item	Section(s) or Page(s)	Description and Justification
1	3.0, P. 3-2	Description of the 3GFG filter insert and Z4B material changed to non-proprietary. Redaction markings updated.
2	3.0, P. 3-3	Water channel OD changed to non-proprietary. Redaction markings updated.
3	9.0, P. 9-2	Update Reference 19 (ANP-3854) to Revision 2.

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Nomenclature

Acronym	**Definition**
3GFG	Third Generation FUELGUARD
ACE	Framatome's advanced critical power correlation [ ]
AFC	Advanced Fuel Channel
AOO	Anticipated Operational Occurrences
ASME	American Society of Mechanical Engineers
ATWS	anticipated transient without scram
BOC	beginning of cycle
BWR	boiling water reactor
CDA	confirmation density algorithm
CFD	computational fluid dynamics
CFR	Code of Federal Regulations
CHF	critical heat flux
CPR	critical power ratio
CRDA	control rod drop accident
EOC	end of cycle
EPU	extended power uprate
FWCF	feedwater controller failure
HPCI	High Pressure Coolant Injection
IHPS	Inadvertant HPCI startup
KATHY	Karlstein thermal hydraulic test facility
LHGR	linear heat generation rate
LOFH	loss of feedwater heating
LOCA	loss of coolant accident
LTP	lower Tie Plate
LTR	licensing topical report
LUC	Lead use channel
LUT	look up table
MAPLHGR	maximum average planar linear heat generation rate
MCPR	minimum critical power ratio

Acronym	Definition
NRC	Nuclear Regulatory Commission, U. S.
OLMCPR	operating limit minimum critical power ratio
PCMI	pellet clad mechanical interaction
PHTF	Portable Hydraulic Test Facility
PLFR	part length fuel rod
RAI	request for additional information
RHR	residual heat removal
RSAR	reload safety analysis report
SLC	standby liquid control
SLMCPR	safety limit minimum critical power ratio
SER	safety evaluation report
UTP	Upper Tie Plate
Z4B	Zircolay BWR material similar to Zircaloy-4
Zry-4	Zircaloy-4

1.0 INTRODUCTION

This document reviews the Framatome approved licensing methodologies to demonstrate that they are applicable to licensing and operation of the Browns Ferry Nuclear Plant with ATRIUM 11 in the extended power uprate (EPU) operating domain with a representative power/flow operating map in Figure 1-1. Application of the new methods added for ATRIUM 11 (ACE ATRIUM 11, RODEX-4 for Chromia doped fuel, AURORA-B AOO, CRDA* and LOCA) for EPU applications are addressed in this document or in plant specific applications of the new methodologies. Application of Framatome methods to ATWS-I and the application of Framatome BEO-III stability methods with CDA are not addressed here and are discussed in separate reports, ANP-3906P and ANP-3907P respectively. These methodologies have all been approved for application to mixed core loadings as discussed in Appendix A including the ATRIUM 10XM and ATRIUM 11 fuel.

The **[ ]** applied for CRDA startup range evaluation in AURORA-B CRDA and the use of a modified Framatome hydrogen uptake model are the only plant specific applications addressed in this report.

This document applies to all three Browns Ferry units since all Browns Ferry BWR/4s have only minor differences. The most significant difference between the units is the core loadings and corresponding core designs. The impact of the differences in core designs between units and cycles is addressed in the cycle specific reload report for each unit.

---

* For the Browns Ferry ATRIUM 11 plant-specific application of CRDA, **[ ]** has been applied for the startup range evaluations.

For the introduction of ATRIUM 11 at EPU conditions a review of the RAI's received from previous license applications was used to identify anything that needed to be addressed. Most of the issues identified in previous license applications have been addressed by the NRC approved methodologies that are being used for the licensing of ATRIUM 11 fuel in Browns Ferry.

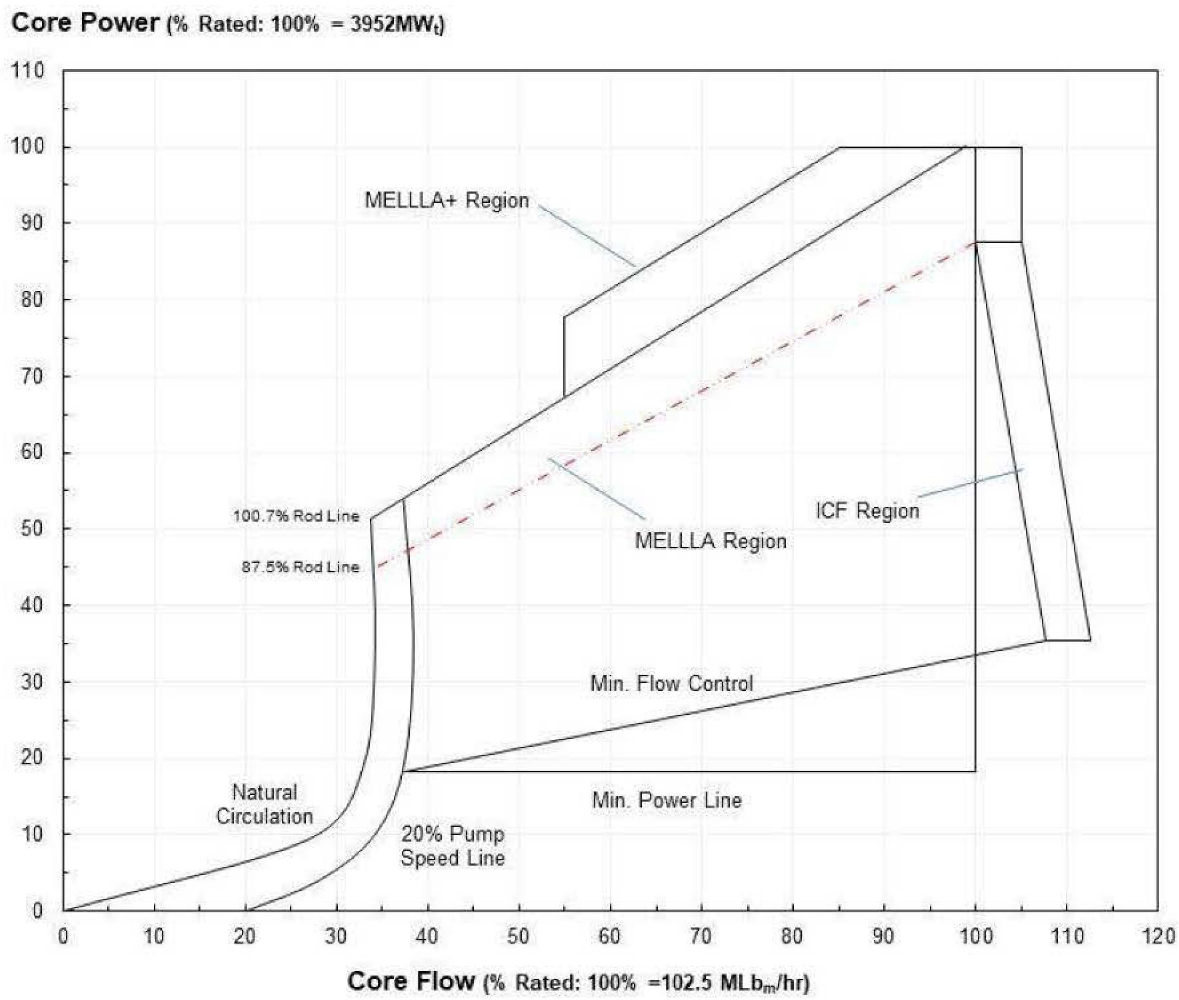

Figure 1-1
Browns Ferry Power Flow Operating Map

2.0 OVERVIEW

The introduction of ATRIUM 11 fuel coincides with the application of a new modern suite of methodologies (References 1 through 9) that also address a number of industry concerns. This is the third application of the entire suite of new and upgraded methodologies. Browns Ferry currently operates with ATRIUM 10XM fuel and is transitioning to ATRIUM 11. The design characteristics of the ATRIUM 10XM and ATRIUM 11 are explicitly accounted for in all of the models for operation with EPU and extended flow domains. The differences in fuel design characteristics between the ATRIUM 10XM and ATRIUM 11 are discussed in Section 3.0.

The first step in determining the applicability of current licensing methods to Browns Ferry operating conditions was a review of Framatome BWR topical reports listed in Table 2-1 and the Browns Ferry facility operating license conditions to identify SER restrictions. This review identified that there are no SER restrictions on core power level or core flow for the Framatome topical reports up to and including EPU/extended flow window. The review also indicated that the [ ]. This is discussed in the Thermal Hydraulics section.

Based on the fundamental characteristics of the fuel designs, each of the major analysis domains thermal-mechanics, thermal-hydraulics, mechanics, core neutronics, transient analysis, LOCA and stability are assessed to determine any challenges to application.

Table 2-1 Framatome Licensing Topical Reports

Document Number	Document Title
XN-NF-79-56(P)(A) Revision 1 and Supplement 1(P)(A)	"Gadolinia Fuel Properties for LWR Fuel Safety Evaluation," Exxon Nuclear Company, November 1981
XN-NF-85-67(P)(A) Revision 1	"Generic Mechanical Design for Exxon Nuclear Jet Pump BWR Reload Fuel," Exxon Nuclear Company, July 1986
XN-NF-85-92(P)(A)	"Exxon Nuclear Uranium Dioxide/Gadolinia Irradiation Examination and Thermal Conductivity Results," Exxon Nuclear Company, November 1986
ANF-89-98(P)(A) Revision 1 and Supplement 1	"Generic Mechanical Design Criteria for BWR Fuel Designs," Advanced Nuclear Fuels Corporation, May 1995
ANF-90-82(P)(A) Revision 1	"Application of ANF Design Methodology for Fuel Assembly Reconstitution," Advanced Nuclear Fuels Corporation, May 1995
EMF-93-177(P)(A) Revision 1	"Mechanical Design for BWR Fuel Channels," Framatome ANP, August 2005
EMF-93-177P-A Revision 1 Supplement 1P-A Revision 0	"Mechanical Design for BWR Fuel Channels Supplement 1: Advanced Methods for New Channel Designs," AREVA Inc., September 2013
EMF-93-177 Revision 1 Supplement 2P-A Revision 1	"Mechanical Design for BWR Fuel Channels: Z4B Material," Framatome Inc., June 2019
BAW-10247PA Revision 0	"Realistic Thermal-Mechanical Fuel Rod Methodology for Boiling Water Reactors," AREVA NP, February 2008
BAW-10247PA Revision 0 Supplement 1P-A, Revision 0	"Realistic Thermal-Mechanical Fuel Rod Methodology for Boiling Water Reactors Supplement 1: Qualification of RODEX4 for Recrystallized Zircaloy-2 Cladding", April 2017
BAW-10247P-A, Supplement 2P-A, Revision 0	"Realistic Thermal-Mechanical Fuel Rod Methodology for Boiling Water Reactors Supplement 2: Mechanical Methods", Framatome Inc., August 2018
ANP-10340P-A Revision 0	"Incorporation of Chromium-Doped Fuel in AREVA Approved Methods", Framatome Inc., May 2018

Table 2-1 Framatome Licensing Topical Reports *(Continued)*

Document Number	Document Title
XN-NF-80-19(P)(A) Volume 1 and Supplements 1 and 2	"Exxon Nuclear Methodology for Boiling Water Reactors - Neutronic Methods for Design and Analysis," Exxon Nuclear Company, March 1983
XN-NF-80-19(P)(A) Volume 4 Revision 1	"Exxon Nuclear Methodology for Boiling Water Reactors: Application of the ENC Methodology to BWR Reloads," Exxon Nuclear Company, June 1986
EMF-2158(P)(A) Revision 0	"Siemens Power Corporation Methodology for Boiling Water Reactors: Evaluation and Validation of CASMO-4/ MICROBURN-B2," Siemens Power Corporation, October 1999
XN-NF-79-59(P)(A)	"Methodology for Calculation of Pressure Drop in BWR Fuel Assemblies," Exxon Nuclear Company, November 1983
XN-NF-80-19(P)(A) Volume 3 Revision 2	"Exxon Nuclear Methodology for Boiling Water Reactors, THERMEX: Thermal Limits Methodology Summary Description," Exxon Nuclear Company, January 1987
ANP-10298P-A Revision 1	"ACE/ATRIUM 10XM Critical Power Correlation," AREVA, March 2014
ANP-10335P-A Revision 0	"ACE/ATRIUM 11 Critical Power Correlation", Framatome Inc., May 2018
ANP-10307PA Revision 0	"AREVA MCPR Safety Limit Methodology for Boiling Water Reactors," AREVA NP, June 2011
ANF-1358(P)(A) Revision 3	"The Loss of Feedwater Heating Transient in Boiling Water Reactors," Framatome ANP, September 2005
ANP-10300P-A Revision 1	"AURORA-B: An Evaluation Model for Boiling Water Reactors; Application to Transient and Accident Scenarios" Framatome Inc., January 2018
ANP-10332P-A Revision 0	"AURORA-B: An Evaluation Model for Boiling Water Reactors; Application to Loss of Coolant Accident Scenarios" Framatome Inc., March 2019
ANP-10333P-A Revision 0	"AURORA-B: An Evaluation Model for Boiling Water Reactors; Application to Control Rod Drop Accident Scenarios", Framatome Inc., March 2018

3.0 ATRIUM 11 FUEL ASSEMBLY DESIGN

The ATRIUM 11 fuel assembly design consists of a lower tie plate (LTP) and upper tie plate (UTP), 112 fuel rods, 9 spacer grids, a central water channel, and miscellaneous assembly hardware.

The fuel design utilizes a square internal water channel which occupies nine (3x3) lattice positions. The upper and lower ends of the water channel are attached to connecting hardware which provides a load chain between the upper and lower tie plates.

The 11x11 rod array is comprised of 92 full length fuel rods, 8 long part length fuel rods (PLFR) and 12 short PLFRs. The PLFRs are captured in the LTP grid to prevent axial movement.

The fuel rod pitch is slightly larger in the upper section of the assembly relative to the fuel rod pitch in the lower section of the assembly. The array of fuel rods remain orthogonal throughout the assembly.

The nine ULTRAFLOW™ spacers are fabricated from Alloy 718 material and utilize integrated spring and dimple elements. Eight spacers are axially distributed over the heated length, while a ninth spacer is located just above the LTP to restrain the lower ends of the fuel rods.

[

] The LTP utilizes the 3rd Generation FUELGUARD™ (3GFG) filter insert [

] Z4B is an advanced material with similar composition to that of Zry-4 with higher Iron (Fe) and Chromium (Cr) content [

]

Details of the fuel design characteristics are presented in Table 3-1 and Table 3-2 along with the equivalent values for the ATRIUM 10XM fuel design which is currently used and licensed in the Browns Ferry units.

Table 3-1 Fuel Assembly and Component Description

Characteristic	ATRIUM 10XM	ATRIUM 11
Fuel Bundle		
Fuel rod array	10x10	11X11
Number of non-fueled elements	1 square water channel displaces a 3x3 array	1 square water channel displaces a 3x3 array
Number of fueled rods Full-length / Part-length	79 / 12	92 / 8 long / 12 short
[		]
Debris filter style	3GFG	3GFG
Fuel Rod		
Cladding material	Zry-2	Zry-2
Liner material	Fe-enhanced zirconium liner	Non Liner
Cladding heat treatment	stress-relief annealed	stress-relief annealed
[		]
Water Channel		
Outside dimension, inch	1.378	1.299
[		]
Spacer Grid		
Variant name: ULTRAFLOW	AH62	AH 75/3 (Bottom [ ]) AH 76/3 (Middle [ ]) AH 77/3 (Top [ ])
Material	Alloy 718	Alloy 718
[		]

Table 3-2 Fuel Channel and Fastener Description

Characteristic	ATRIUM 10XM	ATRIUM 11
Advanced Fuel Channel		
Material	Zry-4, Z4B(LUC)	Z4B
[ ]		
Channel Fastener (ATRIUM 10XM) / Channel Spacer Assembly (ATRIUM 11)		
[ ]		

4.0 THERMAL-MECHANICAL LIMITS METHODOLOGY

The LHGR limit is established to support plant operation while satisfying the fuel thermal-mechanical design criteria. The methodology for performing the fuel rod evaluation is described in References 3 through 5. The extension of these methods to fuel incorporating chromia is described in Reference 6. Fuel rod design criteria evaluated by the methodology are contained in References 3 and 10.

Fuel rod power histories are generated as part of the methodology for equilibrium cycle conditions as well as cycle-specific operation. These power histories include the effect of channel bow as described in Reference 3. The uncertainties of the important physical phenomenon are taken into account in the categories of operating power uncertainties, code model parameter uncertainties, and fuel manufacturing tolerances. In addition, adjustments are made to the power history inputs for possible differences in planned versus actual operation. Upper limits on the analysis results are obtained for comparison to the design limits for fuel melt, cladding strain, rod internal pressure and other characteristics as described by the design criteria.

Since the power history inputs, which include LHGR, fast neutron flux, reactor coolant pressure and reactor coolant temperature, are used as input to the analysis, the results explicitly account for conditions representative of the ATRIUM 11 operation. The resulting LHGR limit is used to monitor the fuel so it is maintained within the same maximum allowable steady-state power envelope as analyzed.

5.0 THERMAL HYDRAULICS

5.1 *ATRIUM 11 Void Fraction*

The [ ] void-quality correlation has been qualified by Framatome against both the FRIGG void measurements, ATRIUM-10 and ATRIUM 10XM measurements. The standard deviation for the FRIGG tests was shown to be [ ] while the standard deviation for the ATRIUM-10 and ATRIUM 10XM tests was found to be [ ] respectively. [

] the use of the [ ] correlation for ATRIUM 11 is justified.

The ATRIUM 11 [ ] void fraction measurements. S-RELAP5 was assessed against previous measurements based upon fundamental hydraulic characteristics. The Marviken assembly of FRIGG had a 2-sigma error of [ ] in void prediction. The ATRIUM-10 has a 2-sigma error of [ ] for void. [ ]; therefore, the use of a 2-sigma error of [ ] is justified for the ATRIUM 11.

5.2 *ACE/ATRIUM 11 Critical Power Ratio Correlation*

The critical power ratio (CPR) correlation used in MICROBURN-B2, SAFLIM3D, S-RELAP5, RAMONA5-FA, and X-COBRA is based on the ACE/ATRIUM 11 critical power correlation described in Reference 7. As with all Framatome correlations, the range of applicability is enforced in Framatome methods through automated bounds checking and corrective actions. The ATRIUM 11 bounds checking process is similar to the ATRIUM 10XM as provided in Table 5-1. The ACE CPR correlation uses K-factor values to account for rod local peaking, rod location and bundle geometry effects.

The K-factor parameter is described in detail in Section 6.10 of Reference 7.

The ranges of applicability of the ACE/ATRIUM 11 and ACE/ATRIUM 10XM are compared in Table 5-2.

Table 5-1 ACE/ATRIUM 10XM Bounds Checking

[ ]

Table 5-2 Comparison of the Range of Applicability for the ACE/ATRIUM 11 and ACE/ATRIUM 10XM Correlations

[ ]

5.3 *Loss Coefficients*

Wall friction and component loss coefficients were determined for Browns Ferry based on single-phase testing of a prototypic ATRIUM 11 fuel assembly in the Portable Hydraulic Test Facility (PHTF). Prototypical fuel rods, spacer grids, flow channel, upper tie plate and lower tie plate were used in the testing. A description of the PHTF facility and an overview of the process for determining the component loss coefficients are described in Reference 11.

The ATRIUM 11 PHTF tests form the basis for the single phase loss coefficients currently used for design and licensing analyses supporting U.S. BWRs. The PHTF is used by Framatome to obtain single phase loss coefficients for the spacers. The friction factor correlation is a Reynolds dependent function based on the Moody friction model and the measured surface roughness. The pressure drops across the spacers are measured in the PHTF for each new design. [

]

The wall friction and component loss coefficients determined from the PHTF and utilized in the validation of the MICROBURN-B2 pressure drop model for the ATRIUM 11 fuel design are provided in Table 5-3.

PHTF data was reduced to determine single phase losses for the spacers in the [

] of the bundle. The values have been selected because they are representative of the hydraulic characteristics of actual ATRIUM 11 fuel assemblies loaded into the reactor.

The modeling of the two-phase spacer pressure drop multiplier for the ATRIUM 11 fuel design has been confirmed with two-phase pressure drop measurements taken in the KATHY facility.

Figure 5-1 shows measured versus the MICROBURN-B2 predicted two phase pressure drop for a range of conditions. This figure confirms the applicability of the thermal-hydraulic models to predict pressure drop for the ATRIUM 11 design.

Table 5-3 Hydraulic Characteristics of ATRIUM 11 Fuel Assemblies

[

]

* Loss coefficients are referenced to the adjacent assembly bare rod flow area.

† [

]

Figure 5-1 Measured versus Predicted (MICROBURN-B2) Bundle Pressure Drop

6.0 TRANSIENTS AND ACCIDENTS

6.1 *Void Calculation Uncertainties*

The Framatome analyses methods and the correlations used are applicable for all Framatome designs in EPU conditions. The approach for addressing bias and uncertainties in the void calculation remains unchanged and is applicable for Browns Ferry operation with the ATRIUM 11 fuel design.

The OLMCPR is determined based on the safety limit MCPR (SLMCPR) methodology and the transient analysis (ΔCPR) methodology. Void prediction uncertainty is not a direct input to either of these methodologies; however, the impact of void prediction uncertainty is inherently incorporated in both methodologies as discussed below.

The SLMCPR methodology explicitly considers important uncertainties in the Monte Carlo calculation performed to determine the number of rods in boiling transition. One of the uncertainties considered in the SLMCPR methodology is the bundle power uncertainty. This uncertainty is determined through comparison of calculated to measured core power distributions. Any miscalculation of void conditions will increase the error between the calculated and measured power distributions and be reflected in the bundle power uncertainty. Therefore, void prediction uncertainty is an inherent component of the bundle power uncertainty used in the SLMCPR methodology.

The transient analyses methodology utilizes a [

]

The transient analyses methodology results in predicted power increases that are bounding relative to benchmark tests. In addition, for licensing calculations [

] as defined in the transient analyses methodology. Therefore, uncertainty in the void prediction is inherently incorporated in the transient analysis methodology.

In addition to the impact of void prediction uncertainty being inherently incorporated in the analytical methods used to determine the OLMCPR, biasing of important input parameters in licensing calculations provides additional conservatism in establishing the OLMCPR. No additional adjustments to the OLMCPR are required to address void prediction uncertainty.

6.2 *Assessment of the Void-Quality Correlation*

As discussed in Section 5.1, the [ ] is equally applicable to the ATRIUM 11 applications at Browns Ferry.

6.3 [ ]

[

]

Section 3.5.2.7 documented the NRC's review of this response as such:

However, the NRC staff does not agree with AREVA's third response. [

]

The result of this conclusion was Limitation and Condition 12 of AURORA-B AOO which requires plant-specific approval for any changes made to the transient coolant mixing. This section is intended to provide the description of the method used to determine [

].

6.3.1 Transient Mixing Determination

For Browns Ferry, the mixing is evaluated using [

]

[

]

[ ]

Figure 6-1

6.3.2 Implementation in AURORA-B AOO Licensing

Once the amount of mixing has been determined, the AURORA-B licensing model will be constructed. In order to ensure a conservative estimation of mixing is used, [

]

6.4 *Control Rod Drop Accident*

[

]

[

]

[

]

[

]

[ ]

Figure 6-2 Total Enthalpy Rise with CHF Multipliers

[

]

Figure 6-3

]

[ ]

Figure 6-4 [ ]

6.5 *Loss of Coolant Accident*

The approved AURORA-B LOCA methodology, Reference 9, has been approved to be applicable to BWR/3 to BWR/6 with conditions extending up to EPU with extended flow windows. In addition, Limitation and Condition 27 of Reference 9 addresses the application of the methodology to [

].

6.6 *AURORA-B AOO Time Step Size*

Section 6.8.2 of ANP-10300P-A, Reference 1, provides a discussion of a time step size sensitivity study using the AURORA-B AOO methodology. The conclusion of this section states:

> *[*
>
> *]*

This conclusion was based off of a set of sensitivity studies which [

]

[ ]

[ ]

7.0 ATWS

7.1 *ATWS General*

The AURORA-B methodology is used for the ATWS overpressurization analysis. The ACE/ATRIUM 11 critical power correlation pressure limit is not a factor in the analysis.

Dryout might occur in the limiting (high power) channels of the core during the ATWS event. For the ATWS overpressurization analysis, ignoring dryout for the hot channels is conservative in that it maximizes the heat transferred to the coolant and results in a higher calculated pressure.

The ATWS event is not limiting relative to acceptance criteria identified in 10 CFR 50.46. The core remains covered and adequately cooled during the event. Following the initial power increase during the pressurization phase, the core returns to natural circulation conditions after the recirculation pumps trip and fuel cladding temperatures are maintained at acceptable low levels. The ATWS event is significantly less limiting than the loss of coolant accident relative to 10 CFR 50.46 acceptance criteria.

7.2 *Void Prediction*

Framatome performs cycle-specific ATWS analyses of the short-term reactor vessel peak pressure using the AURORA-B methodology. The ATWS peak pressure calculation is a core-wide pressurization event that is sensitive to similar phenomenon as other pressurization transients. Bundle design is included in the development of input for the coupled neutronic and thermal-hydraulic S-RELAP5 core model. Important inputs to the S-RELAP5 system model are biased in a conservative direction.

The Framatome transient analysis methodology utilizes a non-parametric uncertainty analysis which includes the uncertainties in individual phenomena. The methodology

[

]

[

] As demonstrated in Section 5.1 the void prediction is robust for past and present designs including the ATRIUM 11.

The reference ATWS analysis evaluation presented in the topical report (Reference 1) of the core active density response, which is closely related to the void response, showed minimal changes in the peak vessel pressure. A study was also performed for the ASME overpressure event (FWCF) with similar results.

7.3 *ATWS Containment Heatup*

Fuel design differences may impact the power and pressure excursion experienced during the ATWS event. This in turn may impact the amount of steam discharged to the suppression pool and containment.

[

]

[ ]

Table 7-1 [

]

[

]

Table 7-2 [**]**

[

]

* Boron worth is quoted as a positive value since it refers to the boron defect. The ppm boron used is 720 at 68 F. The calculation uses the equivalent boron at 365.8 F, used in Browns Ferry SLCS calculations.

8.0 NEUTRONICS

From the neutronics perspective, the ATRIUM 11 fuel design differs from the ATRIUM 10XM fuel design primarily in the fuel rod diameter and pitch and position and number of the part length rods. The CASMO-4 code is designed to model a wide range of fuel rod diameters and pitches. The neutronic models have already been demonstrated to accurately model the vacant positions and this continues to be true for the ATRIUM 11 fuel design.

8.1 *Shutdown Margin*

The part length rod in the corner of the assembly improves the shutdown margin performance of the fuel design because of the flux trap that is created in the cold condition with the vacant rod position of all four assemblies in a control cell being in close proximity. The heterogeneous solution of CASMO-4 accurately models the vacant rod position and the associated reactivity. No change in predicted hot operating or cold critical eigenvalue is anticipated with the ATRIUM 11 fuel design.

8.2 *Monitoring*

The part length rod in the corner of the assembly has an impact on the corner flux that influences the detector response. The heterogeneous solution of CASMO-4 accurately calculates this corner flux depression. This characterization is used directly in the MICROBURN-B2 determination of the predicted detector response. For the Browns Ferry analyses the plena have been explicitly modeled with the heterogeneous CASMO-4 model, thus providing the most accurate model available.

8.3 *Bypass modeling*

The bypass behavior of the ATRIUM 11 fuel design is identical to the ATRIUM 10XM fuel design, thus there is no difference in the modeling. Any differences in bypass heat deposition are treated explicitly.

Cycle-specific validation that the allowable bypass voiding at the LPRM D level has been met will continue to be performed. This validation will be documented in the corresponding Reload Safety Analysis Report for that cycle.

8.4 *Vessel fluence*

Comparisons of ATRIUM 11 and ATRIUM 10XM peripheral fast fluence were performed using the equilibrium fuel cycle designs of References 19 and 20, respectively. The results of this comparison as summarized in Figure 8-1 and Figure 8-2 show that the peripheral fluence of the ATRIUM 11 equilibrium core design remains bounded by the previous ATRIUM 10XM equilibrium design. This is a reasonable result due to the lower batch fraction of the ATRIUM 11 equilibrium cycle design. The lower batch fraction results in higher burnup and lower power for the assemblies loaded on the periphery of the core.

The results also include core-wide comparisons between the two equilibrium cycles. As illustrated in Figure 8-2 the ATRIUM 11 core wide results are not bound by the previous ATRIUM 10XM results. This is also consistent with the lower batch fraction since the interior assemblies operate at a higher overall power to compensate for the lower power on the periphery. The more bottom peaked distribution for ATRIUM 11 is also consistent with expectations for this fuel design. However, it is also noted that even with the overall increases in the central portion of the core, the upper and lower nodes have essentially the same accumulated fluence minimizing any impact to lower or upper core components.

Based upon the above discussion, the implementation of ATRIUM 11 fuel will not have an adverse impact on the existing vessel fluence evaluation or to the lower and upper core components.

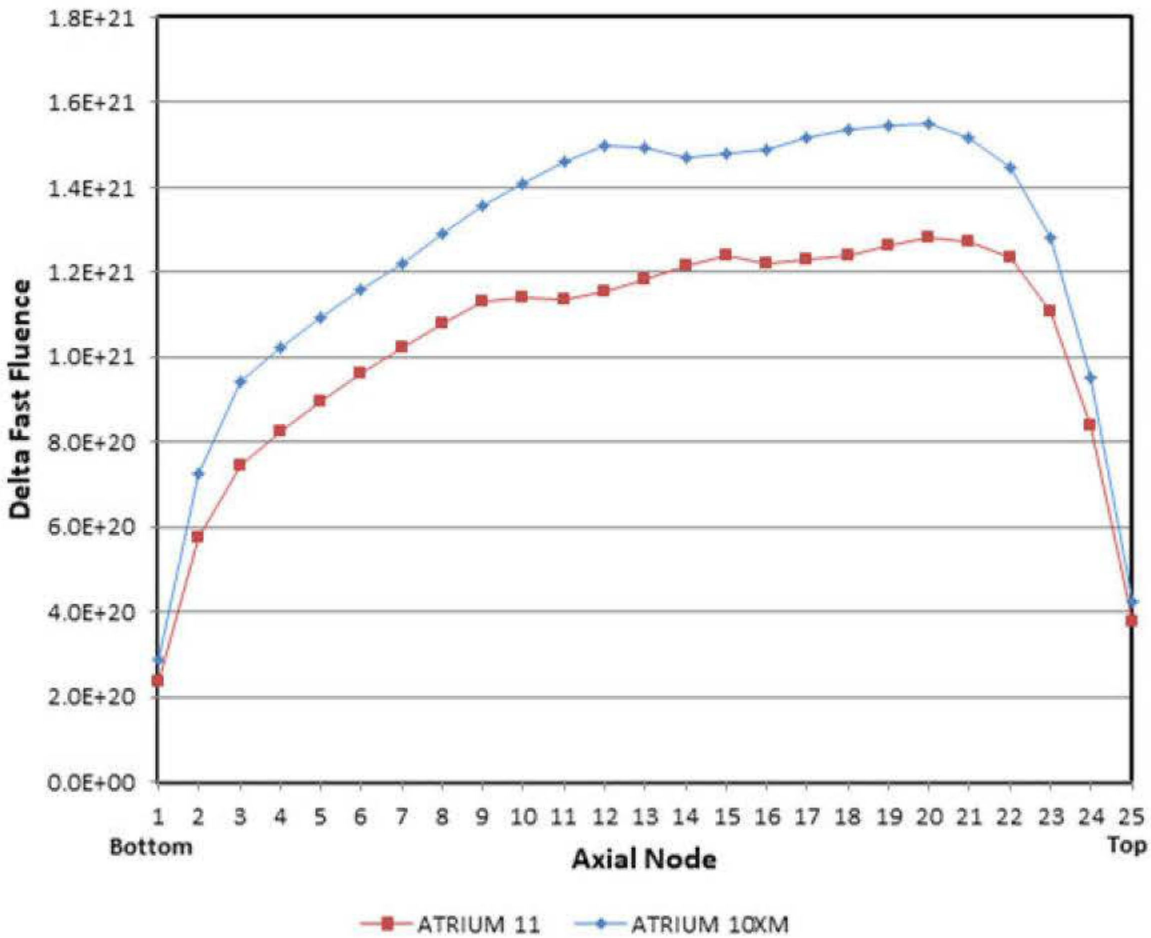

Figure 8-1 Comparison of Peripheral Assembly Planar Average Fluence Accumulation for Equilibrium Cycles of ATRIUM 10XM and ATRIUM 11

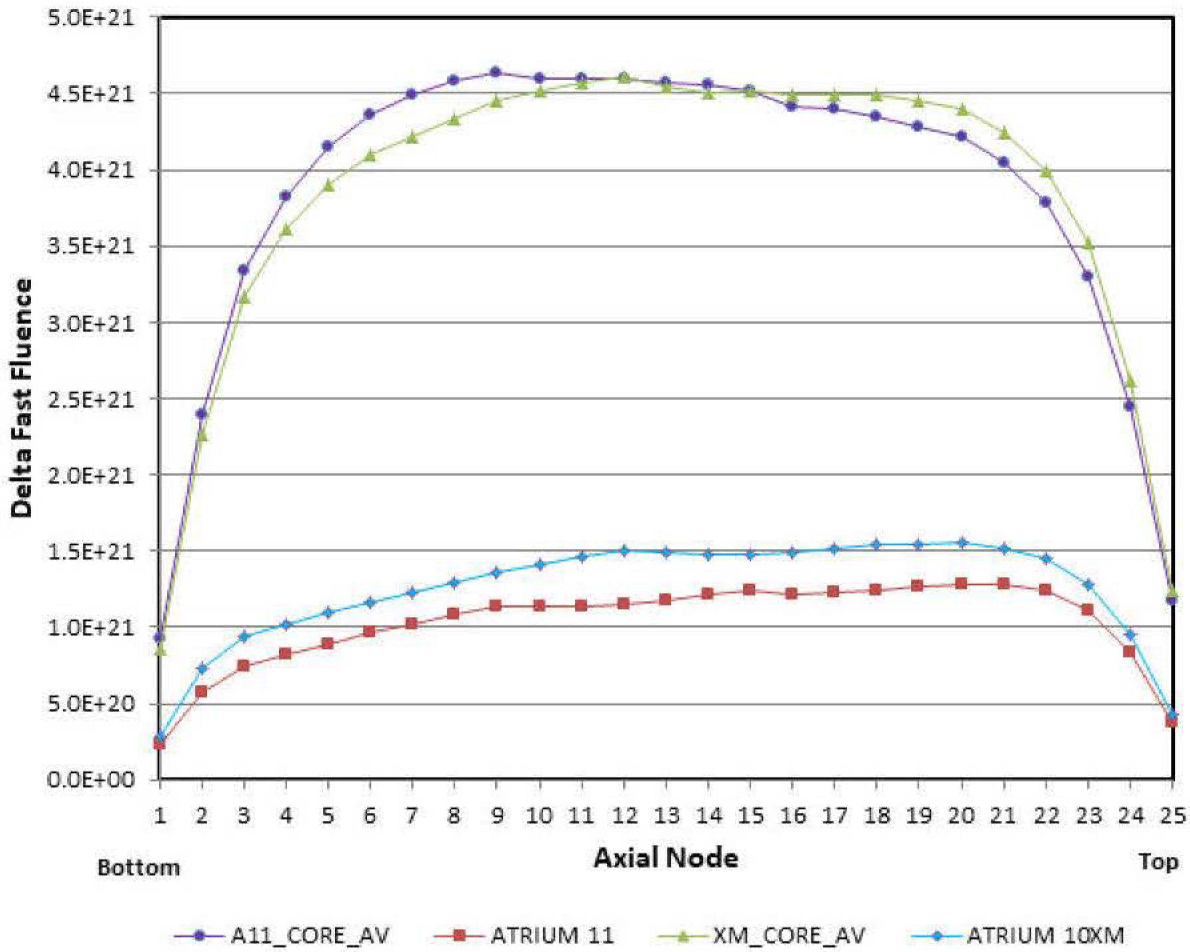

Figure 8-2 Comparison of Core and Peripheral Assembly Planar Average Fluence Accumulation for Equilibrium Cycles of ATRIUM 10XM and ATRIUM 11

9.0 REFERENCES

1. ANP-10300P-A Revision 1, "AURORA-B: An Evaluation Model for Boiling Water Reactors; Application to Transient and Accident Scenarios," Framatome Inc., January 2018.

2. ANP-10333P-A Revision 0, "AURORA-B: An Evaluation Model for Boiling Water Reactors; Application to Control Rod Drop Accident (CRDA) ," Framatome Inc., March 2018

3. BAW-10247PA Revision 0, "Realistic Thermal-Mechanical Fuel Rod Methodology for Boiling Water Reactors," AREVA NP Inc., February 2008.

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6. ANP-10340P-A Revision 0, "Incorporation of Chromia-Doped Fuel Properties in AREVA Approved Methods," Framatome Inc., May 2018.

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8. EMF-93-177P-A Revision 1 Supplement 1P-A Revision 0 "Mechanical Design for BWR Fuel Channels Supplement 1: Advanced Methods for New Channel Designs," AREVA Inc., September 2013.

9. ANP-10332P-A Revision 0, AURORA-B: An Evaluation Model for Boiling Water Reactors; Application to Loss of Coolant Accident Scenarios, March 2019.

10. ANF-89-98(P)(A) Revision 1 and Supplement 1, "Generic Mechanical Design Criteria for BWR Fuel Designs," Advanced Nuclear Fuels Corporation, May 1995.

11. I.K. Madni, et al., "Development of Correlations for Pressure Loss/Drop Coefficients Obtained From Flow Testing of Fuel Assemblies In Framatome ANP'S PHTF," Paper Number 22428, Proceedings of ICONE10, Arlington, VA, April 14-18,2002.

12. [ ]

13. [ ]

14. [ ]

15. [ ]

16. [ ]

17. [ ]

18. [ ]

19. ANP-3854P, Revision 2, “Browns Ferry ATRIUM 11 Equilibrium Cycle Fuel Cycle Design Report”, Framatome Inc., June 2022.

20. ANP-3544P Revision 0, “Browns Ferry EPU (120% OLTP) MELLLA+ Equilibrium Fuel Cycle Design”, AREVA Inc., December 2016.

21. Regulatory Guide 1.236, *Pressurized-Water Reactor Control Rod Ejection and Boiling-Water Reactor Control Rod Drop Accidents*, June 2020 (NRC ADAMS ML20055F490).

22. Draft Regulatory Guide 1327, *Pressurized-Water Reactor Control Rod Ejection and Boiling-Water Reactor Control Rod Drop Accidents*, November 2016 (NRC ADAMS ML16124A200).

APPENDIX A APPLICATION OF FRAMATOME METHODOLOGY FOR MIXED CORES

A.1. DISCUSSION

Framatome has considerable experience analyzing fuel design transition cycles and has methodology and procedures to analyze mixed cores composed of multiple fuel types. For each core design, analyses are performed to confirm that all design and licensing criteria are satisfied. The analyses performed explicitly include each fuel type in the core. The analyses consider the cycle-specific core loading and use input data appropriate for each fuel type in the core. The mixed core analyses are performed using generically approved methodology in a manner consistent with NRC approval of the methodology. Based on results from the analyses, operating limits are established for each fuel type present in the core. During operation, each fuel type is monitored against the appropriate operating limits.

Thermal hydraulic characteristics are determined for each fuel type that will be present in the core. The thermal hydraulic characteristics used in core design, safety analysis, and core monitoring are developed on a consistent basis for both Framatome fuel and other vendor co-resident fuel to minimize variability due to methods. For Browns Ferry operation, the entire core will be composed of Framatome fuel designs.

For core design and nuclear safety analyses, the neutronic cross-section data is developed for each fuel type in the core using CASMO-4. MICROBURN-B2 is used to design the core and provide input to safety analyses (core neutronic characteristics, power distributions, etc.). Each fuel assembly is explicitly modeled in MICROBURN-B2 using cross-section data from CASMO-4 and geometric data appropriate for the fuel design.

Fuel assembly thermal-mechanical limits for all fuel are verified and monitored for each mixed core designed by Framatome. Framatome performs design and licensing analyses to demonstrate that the core design meets steady-state limits and that transient limits are not exceeded during anticipated operational occurrences.

The critical power ratio (CPR) is evaluated for each fuel type in the core using calculated local fluid conditions and an appropriate critical power correlation. Fuel type specific correlation coefficients for Framatome fuel are based on data from the Framatome critical power test facility. The ACE/ATRIUM 10XM critical power correlation will be used for monitoring ATRIUM 10XM fuel present during the transition to operation with ATRIUM 11 at Browns Ferry. The CPR correlation used for the ATRIUM 11 fuel is the ACE/ATRIUM 11 critical power correlation described in Reference 7. The ACE CPR correlation uses K-factor values to account for rod local peaking, rod location and bundle geometry effects.

In the safety limit MCPR analysis each fuel type present in the core is explicitly modeled using appropriate geometric data, thermal hydraulic characteristics, and power distribution information (from CASMO-4 and MICROBURN-B2 analyses). CPR is evaluated for each assembly using fuel type specific correlation coefficients. Plant and fuel type specific uncertainties are considered in the statistical analysis performed to determine the safety limit MCPR. The safety limit MCPR analysis is performed each cycle and uses the cycle specific core configuration.

An operating limit MCPR is established for each fuel type in the core. For fast transients the AURORA-B code (Reference 1) is used to determine the overall system and hot channel response. The core nuclear characteristics used in AURORA-B are obtained from MICROBURN-B2 and reflect the actual core loading pattern. Critical power performance is evaluated using local fluid conditions and fuel type specific CPR correlation coefficients. The transient CPR response is used to establish an operating limit MCPR for each fuel type.

For transient events that are sufficiently slow such that the heat transfer remains in phase with changes in neutron flux during the transient, evaluations are performed with steady state codes such as MICROBURN-B2 in accordance with NRC approval. Such slow transients are modeled by performing a series of steady state solutions with appropriate boundary conditions using the cycle specific design core loading plan. Each fuel assembly type in the core is explicitly modeled. The change in CPR between the initial and final condition after the transient is determined, and if the CPR change is more severe than those determined from fast transient analyses, the slow transient result is used to determine the MCPR operating limit.

MAPLHGR operating limits are established and monitored for each fuel type in the core to ensure that 10 CFR 50.46 acceptance criteria are met during a postulated LOCA. The S-RELAP5 code is used to determine the overall system and hot channel response during a postulated LOCA. While system analyses are typically performed on an equilibrium core basis, the thermal hydraulic characteristics of all fuel assemblies in the core are considered to ensure the LOCA analysis results are applicable to mixed core configurations.

The core monitoring system will monitor each fuel assembly in the core. Each assembly is modeled with geometric, thermal hydraulic, neutronic, and CPR correlation input data appropriate for the specific fuel type. Each assembly in the core will be monitored relative to thermal limits that have been explicitly developed for each fuel type.

In summary, Framatome methodology is used consistent with NRC approval to perform design and licensing analyses for mixed cores. The cycle design and licensing analyses explicitly consider each fuel type in mixed core configurations. Limits are established for each fuel type and operation within these limits is verified by the monitoring system during operation.

ATTACHMENT 12a

ANP-3905P Revision 2

(Proprietary)

Browns Ferry Units 1, 2, and 3 LOCA Analysis for ATRIUM 11 Fuel

ATTACHMENT 12b

ANP-3905NP Revision 2

(Non Proprietary)

Browns Ferry Units 1, 2, and 3 LOCA Analysis for ATRIUM 11 Fuel

framatome

Browns Ferry Units 1, 2, and 3 LOCA Analysis for ATRIUM 11 Fuel

ANP-3905NP
Revision 2

June 2022

Nature of Changes

Item	Section(s) or Page(s)	Description and Justification
1.	Table 4.3	Proprietary markings are adjusted on Table 4.3.
2.	Appendix A	Proprietary markings are adjusted for Limitation & Condition numbers 4, 6, 9-14, 16, 18-22, 25, and 26.

Contents

Tables

Figures

Nomenclature

ADS	automatic depressurization system
ADSVOOS	ADS valve out-of-service
BWR	boiling-water reactor
CFR	Code of Federal Regulations
CHF	critical heat flux
CMWR	core average metal-water reaction
DC	direct current
DEG	double-ended guillotine
DG	diesel generator
ECCS	emergency core cooling system
FHOOS	feedwater heaters out-of-service
HPCI	high-pressure coolant injection
ICF	increased core flow
ID	inside diameter
LHGR	linear heat generation rate
LOCA	loss-of-coolant accident
LPCI	low-pressure coolant injection
LPCS	low-pressure core spray
MAPLHGR	maximum average planar linear heat generation rate
MCPR	minimum critical power ratio
MELLLA+	maximum extended load line limit analysis plus
MSIV	main stream isolation valve
MWR	metal-water reaction
NSSS	nuclear steam supply system
NRC	Nuclear Regulatory Commission, U.S.
OD	outside diameter
PCT	peak cladding temperature

Nomenclature (continued)

RCIC	reactor core isolation cooling
RDIV	recirculation discharge isolation valve
RWCU	reactor water cleanup
SE	Safety Evaluation
SF-ADS	single failure of ADS
SF-ADS|IL	single failure of ADS, initiation logic
SF-ADS|SV	single failure of ADS, single valve
SF-BATT	single failure of battery (DC) power
SF-BATT|BA	single failure of battery (DC) power, board A
SF-BATT|BB	single failure of battery (DC) power, board B
SF-BATT|BC	single failure of battery (DC) power, board C
SF-DGEN	single failure of a diesel generator
SF-HPCI	single failure of the HPCI system
SF-LOCA	single failure of opposite unit false LOCA signal
SF-LPCI	single failure of a LPCI valve
SLO	single-loop operation
TLO	two-loop operation

1.0 Introduction

The results of a loss-of-coolant accident (LOCA) break spectrum and emergency core cooling system (LOCA-ECCS) analyses for Browns Ferry Units 1, 2, and 3 are documented in this report. The purpose of the break spectrum analysis is to identify the break characteristics that result in the highest calculated peak cladding temperature (PCT) **[ ]** during a postulated LOCA. The results provide the maximum average planar linear heat generation rate (MAPLHGR) limit for ATRIUM™ 11 fuel as a function of exposure for normal (two-loop) operation.

Variation in the following LOCA parameters is examined:

- Break location
- Break type (double-ended guillotine (DEG) or split)
- Break size
- Limiting ECCS single failure
- Axial power shape (top- or mid-peaked)
- Initial statepoint
- Fuel rod type

The analyses documented in this report are performed with LOCA Evaluation Models developed by Framatome*, and approved for reactor licensing analyses by the U.S. Nuclear Regulatory Commission (NRC). The models and computer codes used by Framatome for LOCA analyses are collectively referred to as the AURORA-B LOCA Evaluation Model (References 1 – 3). The calculations described in this report are performed in conformance with 10 CFR 50 Appendix K requirements and satisfy the event acceptance criteria identified in 10 CFR 50.46.

Key model characteristics included in the report analyses are shown below. Other initial conditions used in the analyses are described in Section 4.0.

- Operation in the MELLLA+ domain of Figure 1.1 is supported. **[**

]

* Framatome Inc. formerly known as AREVA Inc.

[

]

- **[**

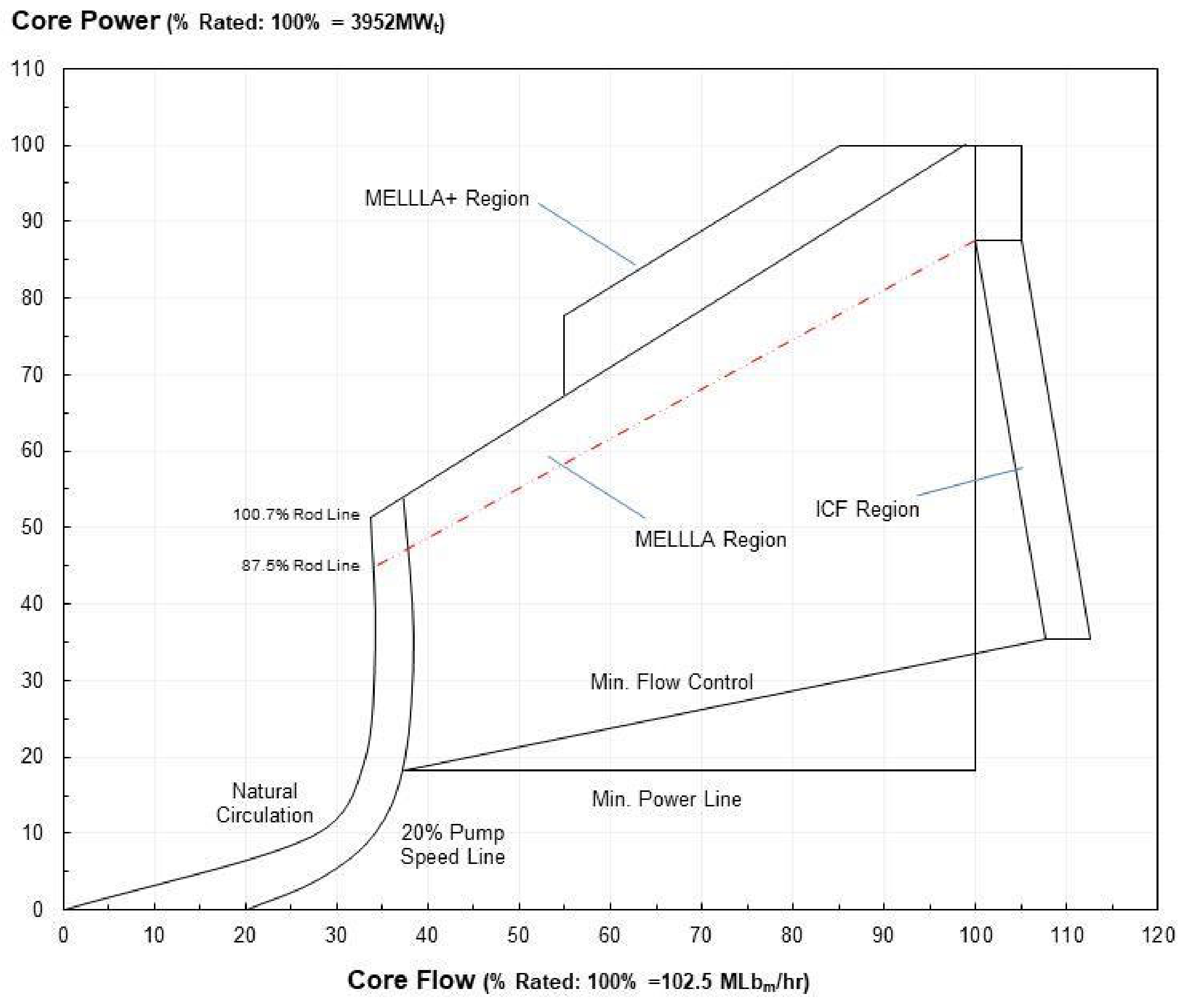
  ]
- The core is composed entirely of ATRIUM 11 fuel.
- A 2.0% increase in initial core power to address the maximum uncertainty in monitoring reactor power, as per NRC requirements, is included.
- **[** **]** were assumed to be at the MAPLHGR limit shown in Figure 2.1.
- **[**

  ]

The limiting break characteristics from the break spectrum study are used in analyses to determine the MAPLHGR limit and **[** **]** versus exposure. Even though the limiting break will not change with exposure, the value of PCT calculated for any given set of break characteristics is dependent on exposure and the corresponding MAPLHGR and **[** **]**.

Single-loop operation (SLO) results are discussed in Section 7.0. Long term coolability is addressed in Section 8.0.

Figure 1.1 Browns Ferry MELLLA+ Power / Flow Map



2.0 Summary of Results

The LOCA analysis results presented in this report are applicable to Browns Ferry Units 1, 2, and 3. A more detailed discussion of results is provided in Sections 6.0 – 7.0.

The PCT and metal-water reaction (MWR) results, from the ATRIUM 11 fuel exposure-dependent analysis presented in Section 9.0, are presented below.

Parameter	ATRIUM 11*
Peak cladding temperature (°F)	1898 [ ]
Local cladding oxidation (max %)	8.27 [ ]
Total hydrogen generated (% of total hydrogen possible)	< 0.73

The MAPLHGR limit was determined by applying the AURORA-B LOCA Evaluation Model for the analysis of the limiting LOCA event. The exposure-dependent MAPLHGR limit for ATRIUM 11 fuel is shown in Figure 2.1. Exposure dependent results with the **[ ]** are presented in Section 9.0. The results of these calculations confirm that the LOCA acceptance criteria in the Code of Federal Regulations (10 CFR 50.46) are met for operation at or below these limits.

The LOCA analysis results (i.e., the limiting break characteristics and exposure analysis) presented in this report are applicable for a full core of ATRIUM 11 fuel as well as transition cores containing ATRIUM 11 fuel. **[ ]**

* **[ ]**

[

]

The SLO LOCA analyses support operation with an ATRIUM 11 multiplier of 0.85 applied to the normal two-loop operation MAPLHGR limit. [

]

The long-term coolability evaluation confirms that the ECCS capacity is sufficient to maintain adequate cooling in an ATRIUM 11 core for an extended period after a LOCA.

Available ADS valves are presented in Tables 5.1 and 5.2. No additional valves are assumed to be out-of-service (ADSVOOS). All analyses also support the [

]

All analyses were [

]

Therefore, this LOCA analysis supports FHOOS operation.

The analysis supports operation in the MELLLA+ domain of the Browns Ferry power/flow map shown in Figure 1.1.

Figure 2.1 MAPLHGR Limit for ATRIUM 11 Fuel

Figure 2.2 [ ]
for ATRIUM 11 Fuel

[ ]

3.0 LOCA Description

3.1 *Accident Description*

The LOCA is described in the Code of Federal Regulations 10 CFR 50.46 as a hypothetical accident that results in a loss of reactor coolant from breaks in reactor coolant pressure boundary piping up to and including a break equivalent in size to a double-ended rupture of the largest pipe in the reactor coolant system. There is not a specifically identified cause that results in the pipe break. However, for the purpose of identifying a design basis accident, the pipe break is postulated to occur inside the primary containment before the first isolation valve.

For a boiling water reactor (BWR), a LOCA may occur over a wide spectrum of break locations and sizes. Responses to the break vary significantly over the break spectrum. The largest possible break is a double-ended rupture of a recirculation pipe; however, this is not necessarily the most severe challenge to the ECCS. A double-ended rupture of a main steam line causes the most rapid primary system depressurization, but because of other phenomena, steam line breaks are seldom limiting with respect to the event acceptance criteria (10 CFR 50.46). Because of these complexities, an analysis covering the full range of break sizes and locations is performed to identify the limiting break characteristics.

Regardless of the initiating break characteristics, the event response is conveniently separated into three phases: the blowdown phase, the refill phase, and the reflood phase. The relative duration of each phase is strongly dependent upon the break size and location. **[**

]

During the blowdown phase of a LOCA, there is a net loss of coolant inventory, an increase in fuel cladding temperature due to core flow degradation, and for the larger breaks, the core becomes fully or partially uncovered. There is a rapid decrease in pressure during the blowdown phase. During the early phase of the depressurization, the exiting coolant provides core cooling. Consistent with the discussion presented in Reference 1, [

]

In the refill phase of a LOCA, the ECCS is functioning and there is a net increase of coolant inventory. During this phase the core sprays provide core cooling and, along with low-pressure and high-pressure coolant injection (LPCI and HPCI), supply liquid to refill the lower portion of the reactor vessel. In general, the core heat transfer to the coolant is less than the fuel decay heat rate and the fuel cladding temperature continues to increase during the refill phase.

In the reflood phase, the coolant inventory has increased to the point where the mixture level re-enters the core region. During the core reflood phase, cooling is provided above the mixture level by entrained reflood liquid and below the mixture level by pool boiling. Sufficient coolant eventually reaches the core hot node and the fuel cladding temperature decreases. [

]

3.2 *Acceptance Criteria*

A LOCA is a potentially limiting event that may place constraints on fuel design, local power peaking, and in some cases, acceptable core power level. During a LOCA, the normal transfer of heat from the fuel to the coolant is disrupted. As the liquid inventory in the reactor decreases, the decay heat and stored energy of the fuel cause a heatup of the undercooled fuel assembly. In order to limit the amount of heat that can contribute to the heatup of the fuel assembly during a LOCA, an operating limit on the MAPLHGR is applied to each fuel assembly in the core.

The Code of Federal Regulations prescribes specific acceptance criteria (10 CFR 50.46) for a LOCA event as well as specific requirements and acceptable features for Evaluation Models (10 CFR 50 Appendix K). The conformance of the AURORA-B LOCA Evaluation Models to Appendix K is described in Reference 1. The ECCS must be designed such that the plant response to a LOCA meets the following acceptance criteria specified in 10 CFR 50.46:

- The calculated maximum fuel element cladding temperature shall not exceed 2200°F.
- The calculated local oxidation of the cladding shall nowhere exceed 0.17 times the local cladding thickness.
- The calculated total amount of hydrogen generated from the chemical reaction of the cladding with water or steam shall not exceed 0.01 times the hypothetical amount that would be generated if all of the metal in the cladding cylinders surrounding the fuel, except the cladding surrounding the plenum volume, were to react.
- Calculated changes in core geometry shall be such that the core remains amenable to cooling.
- After any calculated successful initial operation of the ECCS, the calculated core temperature shall be maintained at an acceptably low value and decay heat shall be removed for the extended period of time required by the long-lived radioactivity remaining in the core.

These criteria are commonly referred to as the PCT criterion, the local oxidation criterion, the hydrogen generation criterion, the coolable geometry criterion, and the long-term cooling criterion. A MAPLHGR limit is established for each fuel type to ensure that these criteria are met.

LOCA results are provided in Section 6.0 to identify the LOCA events which produce the highest PCT [ ] LOCA analysis results demonstrating that the PCT, local oxidation, and hydrogen generation (core wide oxidation) criteria are met are provided in Section 9.0. Compliance with these three criteria ensures that a coolable geometry is maintained. Long-term coolability criterion is discussed in Section 8.0.

4.0 LOCA Analysis Description

The Evaluation Model used for the break spectrum analysis is the AURORA-B LOCA analysis methodology described in Reference 1. The AURORA-B LOCA methodology employs two major computer codes to evaluate the system and fuel response during all phases of a LOCA. These are the S-RELAP5 and RODEX4 computer codes. A **[**

] of the LOCA to determine the PCT and maximum local clad oxidation for **[** **]**

A complete analysis starts with the specification of fuel parameters using RODEX4 (Reference 3). RODEX4 is used to determine the **[**

] The initial stored energy used in S-RELAP5 is **[**

]

4.1 *Break Spectrum Analysis*

S-RELAP5 is used to calculate the thermal-hydraulic response during all phases of the LOCA using a **[**

] The reactor vessel nodalization is shown in Figure 4.1 and the core nodalization is shown in Figure 4.2 consistent with those in the topical report approved by the NRC (Reference 1). The reactor core is modeled with heat generation rates determined from reactor kinetics equations with reactivity feedback and decay heat as required by Appendix K of 10 CFR 50. The clad swelling and rupture models from NUREG-0630 (Reference 2) have been incorporated into S-RELAP5.

The S-RELAP5 model is executed over a range of break locations, break sizes, break types, initial statepoints, axial shapes and assumed single-failures to determine the break that yields the highest PCT [

]

4.2 *Exposure Analysis*

The [

] from beginning-of-life to end-of-life [ ] increments to determine an exposure-dependent MAPLHGR limit and [

] Figures of merit including PCT, local cladding oxidation, and core-wide metal-water reaction are evaluated over the range of exposures to confirm the acceptability of the LOCA analysis with respect to 10 CFR 50.46 criteria. [

]

4.3 *Plant Parameters*

The LOCA analysis is performed using the plant parameters provided by the utility. Table 4.1 provides a summary of reactor initial conditions used in the break spectrum analysis. Table 4.2 lists selected reactor system parameters.

The LOCA analysis is performed for a full core of ATRIUM 11 fuel. Some of the key fuel parameters used in the analysis are summarized in Table 4.3.

4.4 *ECCS Parameters*

The ECCS configuration is shown in Figure 4.3. Table 4.4 – Table 4.7 provide the important ECCS characteristics assumed in the analysis. The ECCS is modeled as time-dependent junctions connected to the appropriate reactor locations: LPCS injects into the upper plenum, HPCI injects into the upper downcomer, and LPCI injects into the recirculation lines.

The flow through each ECCS valve is determined based on system pressure and valve position. Flow versus pressure for a fully open valve is obtained by linearly interpolating the pump capacity data provided in Table 4.4 – Table 4.6. No credit for ECCS flow is assumed until the ECCS injection valves open and the ECCS pumps reach rated speed.

The ADS valves are modeled as a junction connecting the reactor steam line to the suppression pool. The flow through the ADS valves is calculated based on pressure and valve flow characteristics. The valve flow characteristics are determined such that the calculated flow is equal to the rated capacity at the reference pressure shown in Table 4.7.

In the Framatome LOCA analysis model, ECCS initiation is assumed to occur when the water level drops to the applicable level setpoint. No credit is assumed for the start of HPCI, LPCS, or LPCI due to high drywell pressure. **[**

]

The recirculation discharge isolation valve (RDIV) parameters are shown in Table 4.8.

Table 4.1 Initial Conditions*

Reactor power (% of rated)	102	102	[	]
[				]
Reactor power (MWt)	4031	4031	[	]
[				]
[				]
Steam flow rate (Mlb/hr)	16.7	16.7	[	]
Steam dome pressure (psia)	1051	1051	[	]
[				]
[				]
[				]
[				]
Rod average power distributions	Figure 4.4	Figure 4.5	Figure 4.6	Figure 4.7

* [

]

† [ ]

Table 4.2 Reactor System Parameters

Parameter	Value
Vessel ID (in)	251
Number of fuel assemblies	764
Recirculation suction pipe area (ft^2)	3.507
1.0 DEG suction break area (ft^2)	7.013
Recirculation discharge pipe area (ft^2)	3.507
1.0 DEG discharge break area (ft^2)	7.013

Table 4.3 ATRIUM 11 Fuel Assembly Parameters

Parameter	Value
Fuel rod array	11x11
Number of fuel rods per assembly	92 (full-length rods) 8 (long part-length rods) 12 (short part-length rods)
Non-fuel rod type	Water channel replaces 9 fuel rods
Fuel rod OD (in)	[ ]
Active fuel length (in) (including blankets)	150.0 (full-length rods) [ ]
Water channel outside width (in)	1.299
[	]

* Does not include additional inner channel milling near the top of the channel.

Table 4.4 High-Pressure Coolant Injection Parameters

Parameter	Value
Coolant temperature (°F)	120
Initiating Signals and Setpoints	
Water level*	L2 (448 in)
High drywell pressure (psig)	Not credited
Time Delays	
Time for HPCI pump to reach rated speed and injection valve wide open (sec)	35
Delivered Coolant Flow Rate Versus Pressure	
Vessel to Torus ΔP (psid)	Flow Rate (gpm)
0	0
150	5000
1120	5000
1174	3600

* Relative to vessel zero.

Table 4.5 Low-Pressure Coolant Injection Parameters

Parameter	Value
Reactor pressure permissive for opening valves (psia)	350
Coolant temperature (°F)	120
Initiating Signals and Setpoints	
Water level*	L1 (372.5 in)
High drywell pressure (psig)	Not credited
Time Delays	
Time for LPCI pumps to reach ADS permissive (maximum) (sec)†	32‡
Time for LPCI pumps to reach rated speed (maximum) (sec)†	44
LPCI injection valve stroke time (sec)	40

Delivered Coolant Flow Rate Versus Pressure

Vessel to Drywell ΔP (psid)	Flow Rate for 2 Pumps Injecting Into 1 Recirculation Loop (gpm)	Flow Rate for 4 Pumps Injecting Into 2 Recirculation Loops (gpm)
0	17,240	34,480
20	16,540	33,080§
319.5	0	0

* Relative to vessel zero.

† Includes 13-second delay for diesel generator start. 2-second signal processing delay for water level trip L1 is assumed in parallel with diesel generator delay.

‡ Analyses assume the longer delay time from LPCS (40 sec) for ADS ready permissive. Refer to Table 4.6.

§ Conservative value. Modeling limitations require the more conservative value of either the specified 4 pumps into 2 loops flow or twice the specified 2 pumps into 1 loop flow be used.

Table 4.6 Low-Pressure Core Spray Parameters

Parameter	Value	
Reactor pressure permissive for opening valves (psia)	350	
Coolant temperature (°F)	120	
Initiating Signals and Setpoints		
Water level*	L1 (372.5 in)	
High drywell pressure (psig)	Not credited	
Time Delays		
Time for LPCS pumps to reach ADS permissive (maximum) (sec) †	40	
Time for LPCS pumps to reach rated speed (maximum) (sec) †	43	
LPCS injection valve stroke time (sec)	33	
Delivered Coolant Flow Rate Versus Pressure‡		
Vessel to Drywell ΔP (psid)	Flow Rate for 2 Pumps Into 1 Sparger (gpm)	Flow Rate for 4 Pumps Into 2 Spargers (gpm)
0	6,785	13,570
105	5,285	10,570
200	3,685	7,370
289	0	0

* Relative to vessel zero.

† Includes 13-second delay for diesel generator start. 2-second signal processing delay for water level trip L1 is assumed in parallel with diesel generator delay.

‡ Flow rates have been reduced to account for leakages associated with the Lower Sectional Hardware mod as discussed in GE Safety Communication SC 10-05. This further reduction applies only to the configuration at Unit 3 and can be conservatively applied to Units 1 and 2.

Table 4.7 Automatic Depressurization System Parameters

Parameter	Value
Number of valves installed	6
Number of valves available	6
Minimum flow capacity of available valves (Mlbm/hr at psig)	4.8 at 1125
Initiating Signals and Setpoints	
Water level*	L1 (372.5 in)
Time Delays	
Delay time (from ADS initiating signal to time valves are open (sec)†	120

* Relative to vessel zero.

† ADS time initiation occurs after L1 setpoint trip. ADS valves are opened after the timer has elapsed and LPCS or LPCI pumps reach the ADS ready permissive. Analyses assume the longer delay from LPCS for ADS ready permissive (see Table 4.6).

Table 4.8 Recirculation Discharge Isolation Valve Parameters

Parameter	Value
Reactor pressure permissive for closing valves – analytical (psia)	215
RDIV stroke time after pressure permissive (sec)	36

Figure 4.1 S-RELAP5 Vessel Model

Figure 4.2 S-RELAP5 Core Model

Figure 4.3 ECCS Schematic

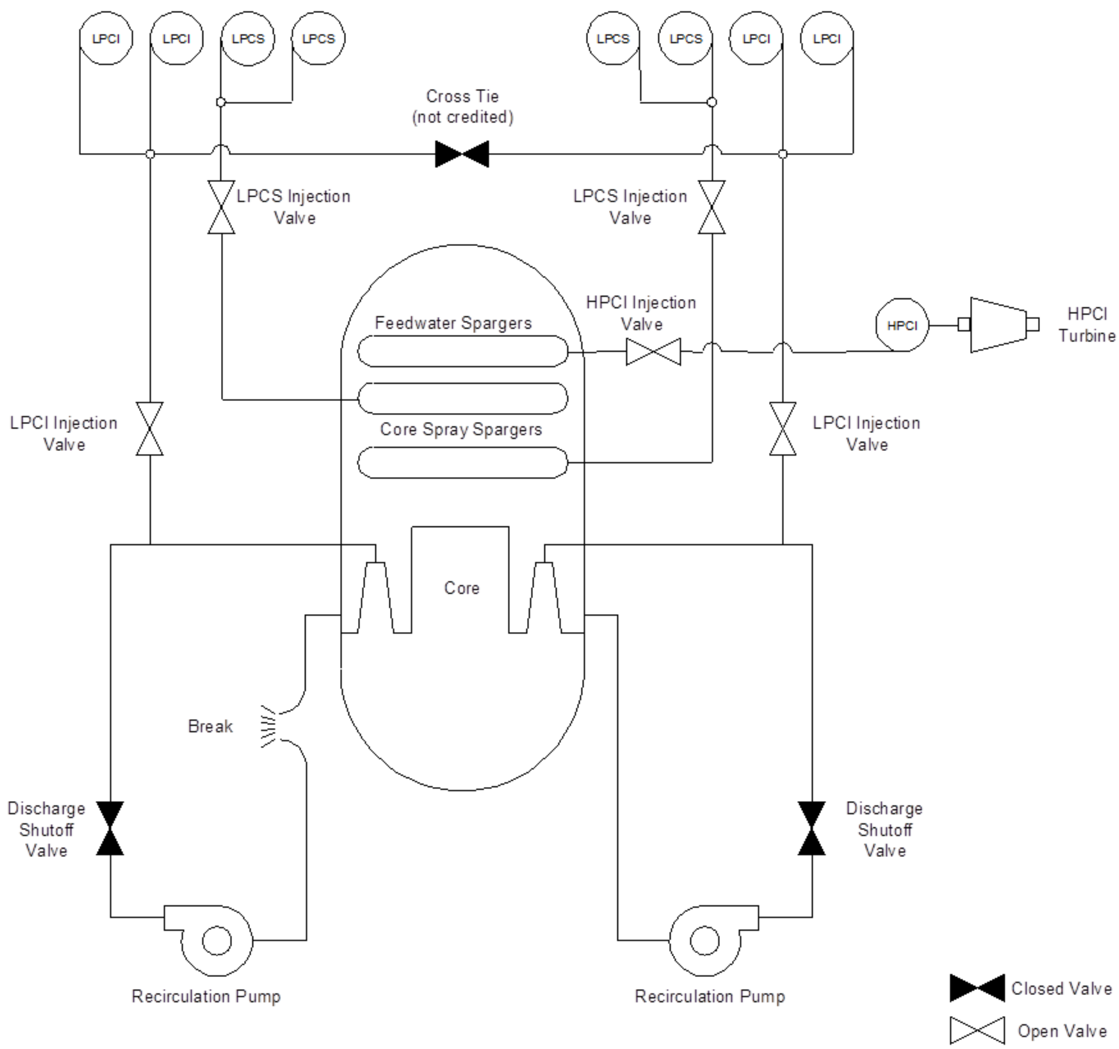


Figure 4.4 Rod Average Power Distributions for 102%P and [ ] Mid- and Top-Peaked

[

]

Figure 4.5 Rod Average Power Distributions for 102%P and [ ] Mid- and Top-Peaked

[ ]

Figure 4.6 Rod Average Power Distributions
for [ ]
Mid- and Top-Peaked

[ ]

Figure 4.7 Rod Average Power Distributions for [ ] Mid- and Top-Peaked

[

]

5.0 Break Spectrum Analysis Description

The objective of the LOCA break spectrum analyses is to ensure that the operating conditions, break location, break type, break size, and ECCS single failure that produce the maximum PCT **[** **]** are identified. The LOCA response scenario varies considerably over the spectrum of break locations. Potential break locations have been separated into two groups: recirculation line breaks and non-recirculation line breaks. The basis for the break locations and potentially limiting single failures analyzed in this report is described in the following sections.

5.1 *Limiting Single Failure*

Regulatory requirements specify that the LOCA analysis consider availability of offsite power supplies and that only safety grade systems and components are available. In addition, regulatory requirements also specify that the most limiting single failure of ECCS equipment must be assumed in the LOCA analysis. The term "most limiting" refers to the ECCS equipment failure that produces the greatest challenge to event acceptance criteria. The limiting single failure can be a common power supply, an injection valve, a system pump, or system initiation logic. The most limiting single failure may vary with break size and location. The equipment identified that may produce a limiting single failure (SF) is shown below:

- Backup battery power (SF-BATT)
    - Board A (SF-BATT|BA)
    - Board B (SF-BATT|BB)
    - Board C (SF-BATT|BC)
- Opposite unit false LOCA signal (SF-LOCA)
- Low pressure coolant injection (SF-LPCI)
- Diesel generator (SF-DGEN)
- High-pressure coolant injection system (SF-HPCI)
- Automatic depressurization system (SF-ADS)
    - Failure of initiation logic (SF-ADS|IL)
    - Failure of single ADS valve (SF-ADS|SV)

The single failures and the available ECCS for each failure assumed in these analyses are summarized in Table 5.1 for recirculation line breaks and in Table 5.2 for non-recirculation line breaks. Other potential failures are not specifically considered because they result in as much or more ECCS capacity.

5.2 *Recirculation Line Breaks*

The response during a recirculation line LOCA is dependent on break size. The rate of reactor vessel depressurization decreases as the break size decreases. The high-pressure ECCS and ADS will assist in reducing the reactor vessel pressure to the pressure where the LPCI and LPCS flows start. For large breaks, rated LPCS and LPCI flow is generally reached before or shortly after the time when the ADS valves open so the ADS system is not required to mitigate the LOCA. ADS operation is an important emergency system for small breaks where it assists in depressurizing the reactor system faster, and thereby reduces the time required to reach rated LPCS and LPCI flow. The availability of ADS for each single failure is presented in Table 5.1, which shows a single failure of the battery for board A or board B results in the least amount of ECCS capacity and is therefore limiting. It should be noted that SF-LOCA and SF-DGEN are identical.

The two largest flow resistances in the recirculation piping are the recirculation pump and the jet pump nozzle. For breaks in the discharge piping, there is a major flow resistance in both flow paths from the reactor vessel to the break. For breaks in the suction piping, both major flow resistances are in the flow path from the vessel to the pump side of the break. As a result, pump suction side breaks experience a more rapid blowdown, which tends to make the event more severe (if ECCS capacity is equal). For suction side breaks, the recirculation discharge isolation valve on the broken loop closes which allows the LPCI flow to fill the discharge piping and supply flow to the lower plenum and core. For discharge side breaks, the LPCI flow in the broken loop is assumed to exit the system through the break resulting in a decrease in available LPCI flow to the core, thereby increasing the severity of the event. Both suction and discharge recirculation pipe breaks are considered in the break spectrum analysis.

Two break types (geometries) are considered for the recirculation line break. The two types are the double-ended guillotine (DEG) break and the split break.

For a DEG break, the piping is assumed to be completely severed resulting in two independent flow paths to the containment. The DEG break is modeled by setting the break area (at both ends of the pipe) equal to the full pipe cross-sectional area and varying the discharge coefficient between 1.0 and 0.4. The range of discharge coefficients is used to cover uncertainty in the actual geometry at the break. [

] The most limiting DEG break is determined by varying the discharge coefficient.

A split type break is assumed to be a longitudinal opening or hole in the piping that results in a single break flow path to the containment. Appendix K of 10 CFR 50 defines the cross-sectional area of the piping as the maximum split break area required for analysis.

Break types, break sizes, and single failures are analyzed for both suction and discharge recirculation line breaks.

Section 6.0 provides a description and results summary for breaks in the recirculation line.

5.3 *Non-Recirculation Line Breaks*

In addition to breaks in the recirculation line, breaks in other reactor coolant system piping must be considered in the LOCA break spectrum analysis. Although the recirculation line large breaks result in the largest coolant inventory loss, they do not necessarily result in the most severe challenge to event acceptance criteria. The double-ended rupture of a main steam line is expected to result in the fastest depressurization of the reactor vessel. Special consideration is required when the postulated break occurs in ECCS piping. Although ECCS piping breaks are small relative to a recirculation pipe DEG break, they disable an ECCS system and therefore, increase the postulated break severity. Table 5.2 summarizes the available ECCS components of the potentially limiting single failures. The following sections address potential LOCAs due to breaks in non-recirculation line piping.

Non-recirculation line breaks outside containment are inherently less challenging to fuel limits than breaks inside containment. For breaks outside containment, isolation or check valve closure will terminate break flow prior to the loss of significant liquid inventory and the core will remain covered. If high-pressure coolant inventory makeup cannot be reestablished, ADS actuation may become necessary. [

] Although analyses of breaks outside containment may be required to address non-fuel related regulatory requirements, these breaks are not limiting relative to fuel acceptance criteria such as PCT.

5.3.1 Main Steam Line Breaks

A steam line break [

] The break results in high steam flow out of the broken line and into the containment. Prior to MSIV closure, a steam line break also results in high steam flow in the intact steam lines as they feed the break via the steam line manifold. A steam line break inside containment results in a rapid depressurization of the reactor vessel. Initially the break flow will be high quality steam; however, the rapid depressurization produces a water level swell that results in liquid discharge at the break. For steam line breaks, the largest break size is most limiting because it results in the most level swell and liquid loss out of the break.

[

]

5.3.2 Feedwater Line Breaks

[

]

A feedwater line break also removes HPCI availability because the injection line is connected to the feedwater line. However, the available ECCS remains bounded as shown in Table 5.2.

5.3.3 HPCI Line Breaks

The HPCI injection line is connected to the feedwater line outside containment.

[

]

The HPCI steam supply line is connected to the main steam line inside containment.

[

]

5.3.4 LPCS Line Breaks

A break in the LPCS line is expected to have many characteristics similar to [ ] However, some characteristics of the LPCS line break are unique and are not addressed in other LOCA analyses. Two important differences from other LOCA analyses are that the break flow will exit from the region inside the core shroud and the break will disable one LPCS system. The LPCS line break is assumed to occur just outside the reactor vessel. [ ]

5.3.5 LPCI Line Breaks

The LPCI injection lines are connected to the larger recirculation discharge lines. A break in a LPCI line would result in the partial or full loss of LPCI injection. [ ]

5.3.6 RCIC Line Breaks

The RCIC discharges to the feedwater line; [ ]

The steam supply to the RCIC turbine comes from the main steam line from the reactor vessel; **[** **]**

5.3.7 RWCU Line Breaks

The reactor water cleanup (RWCU) extraction line is connected to a recirculation suction line with an additional connection to the vessel bottom head. **[** **]**

The RWCU return line is connected to the feedwater line; **[** **]**

5.3.8 Shutdown Cooling Line Breaks

The shutdown cooling suction piping is connected to a recirculation suction line and the shutdown cooling return line is connected to a recirculation discharge line. **[** **]**

5.3.9 Instrument Line Breaks

[**]**

Table 5.1 Available ECCS for Recirculation Line Break LOCAs

Assumed Failure	Systems* † Remaining: Recirculation‡ Suction Break	Systems* † Remaining: Recirculation Discharge Break	Disposition
SF-BATT|BA	6 ADS, 1 LPCS, 2 LPCI	6 ADS, 1 LPCS	Analyze
SF-BATT|BB	4 ADS, HPCI, 1 LPCS, 2 LPCI	4 ADS, HPCI, 1 LPCS	Analyze
SF-BATT|BC§	4 ADS, HPCI, 1 LPCS, 3 LPCI	4 ADS, HPCI, 1 LPCS, 1 LPCI	Bounded by SF-BATT|BB
SF-LOCA	6 ADS, HPCI, 1 LPCS, 2 LPCI	6 ADS, HPCI, 1 LPCS	Bounded by SF-BATT|BA and SF-BATT|BB
SF-LPCI	6 ADS, HPCI, 2 LPCS, 2 LPCI	6 ADS, HPCI, 2 LPCS	Bounded by SF-BATT|BA and SF-BATT|BB
SF-DGEN	6 ADS, HPCI 1 LPCS, 2 LPCI	6 ADS, HPCI, 1 LPCS	Bounded by SF-BATT|BA and SF-BATT|BB
SF-HPCI	6 ADS, 2 LPCS, 4 LPCI	6 ADS, 2 LPCS, 2 LPCI	Bounded by SF-BATT|BA
SF-ADS|IL	4 ADS, HPCI, 2 LPCS, 4 LPCI	4 ADS, HPCI, 2 LPCS, 2 LPCI	Bounded by SF-BATT|BB
SF-ADS|SV	5 ADS, HPCI, 2 LPCS, 4 LPCI	5 ADS, HPCI, 2 LPCS, 2 LPCI	Bounded by SF-BATT|BB

* Each LPCS means operation of two core spray pumps in a system. It is assumed that both pumps in a system must operate to take credit for core spray cooling or inventory makeup. Furthermore, 2 LPCI refers to two LPCI pumps into one loop, 3 LPCI refers to two LPCI pumps into one loop and one LPCI pump into one loop. 4 LPCI refers to four LPCI pumps into two loops, two per loop.

† 4 ADS, 5 ADS, and 6 ADS means the number of ADS valves available for automatic activation.

‡ Systems remaining, as identified in this table for recirculation suction line breaks, are applicable to other non-ECCS line breaks. For a LOCA from an ECCS line break, the systems remaining are those listed for recirculation suction breaks, less the ECCS in which the break is assumed.

§ Unit 3 systems remaining. Conservative for Units 1 and 2.

Table 5.2 Available ECCS for Non-Recirculation Line Break LOCAs

Non-Recirculation Line Break	Assumed Failure	Available ECCS*	Disposition
HPCI† Feedwater line† Steam line†	SF-BATT|BA	6 ADS, 1 LPCS, 2 LPCI	Bounded by SF-BATT|BB
	SF-BATT|BB	4 ADS, 1 LPCS, 2 LPCI	Bounded by SF-BATT|BA LPCS break
	SF-BATT|BC	4 ADS, 1 LPCS, 3 LPCI	Bounded by SF-BATT|BB
	SF-LOCA	6 ADS, 1 LPCS, 2 LPCI	Bounded by SF-BATT|BB
	SF-LPCI	6 ADS, 2 LPCS, 2 LPCI	Bounded by SF-BATT|BB
	SF-DGEN	6 ADS, 1 LPCS, 2 LPCI	Bounded by SF-BATT|BB
	SF-HPCI	6 ADS, 2 LPCS, 4 LPCI	Bounded by SF-BATT|BB
	SF-ADS|IL	4 ADS, 2 LPCS, 4 LPCI	Bounded by SF-BATT|BB
	SF-ADS|SV	5 ADS, 2 LPCS, 4 LPCI	Bounded by SF-BATT|BB

* Refer to footnotes of Table 5.1 for additional information.

† Assumes no credit for HPCI flow.

Table 5.2 Available ECCS for Non-Recirculation Line Break LOCAs *(Continued)*

Non-Recirculation Line Break	Assumed Failure	Available ECCS*	Disposition
LPCS	SF-BATT|BA	6 ADS, 2 LPCI	Analyze
	SF-BATT|BB	4 ADS, HPCI, 2 LPCI	Analyze
	SF-BATT|BC	4 ADS, HPCI, 3 LPCI	Bounded by SF-BATT|BB
	SF-LOCA	6 ADS, HPCI, 2 LPCI	Bounded by SF-BATT|BA and SF-BATT|BB
	SF-LPCI	6 ADS, HPCI, 1 LPCS, 2 LPCI	Bounded by SF-BATT|BA and SF-BATT|BB
	SF-DGEN	6 ADS, HPCI, 2 LPCI	Bounded by SF-BATT|BA and SF-BATT|BB
	SF-HPCI	6 ADS, 1 LPCS, 4 LPCI	Bounded by SF-BATT|BA
	SF-ADS|IL	4 ADS, HPCI, 1 LPCS, 4 LPCI	Bounded by SF-BATT|BB
	SF-ADS|SV	5 ADS, HPCI, 1 LPCS, 4 LPCI	Bounded by SF-BATT|BB

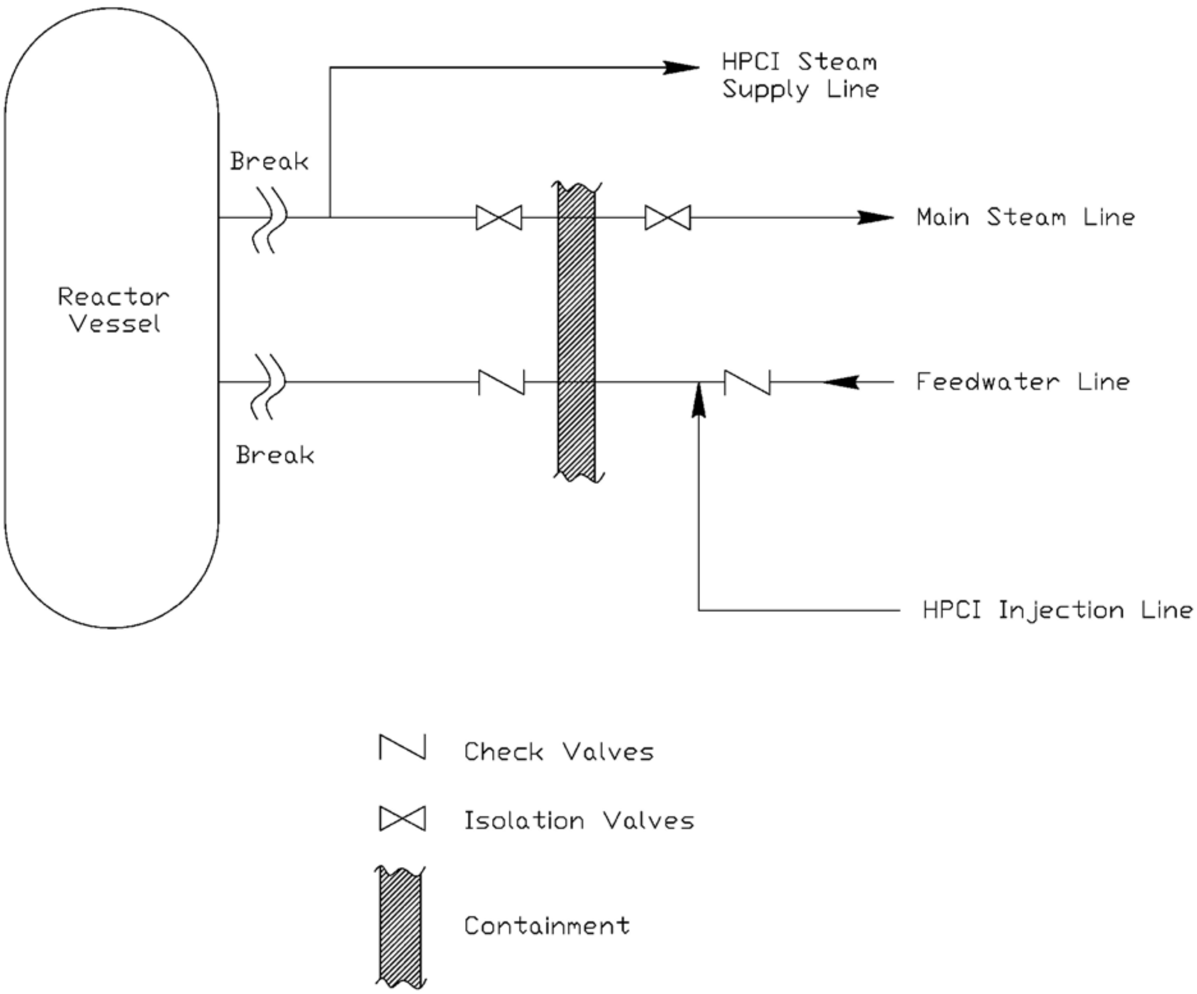
* Refer to footnotes of Table 5.1 for additional information.

Table 5.2 Available ECCS for Non-Recirculation Line Break LOCAs *(Continued)*

Non-Recirculation Line Break	Assumed Failure	Available ECCS*	Disposition
LPCI	SF-BATT|BA	6 ADS, 1 LPCS	Equivalent to recirculation pump discharge breaks (SF-BATT|BA). Additional analysis not required.
	SF-BATT|BB	4 ADS, HPCI, 1 LPCS	Equivalent to recirculation pump discharge breaks (SF-BATT|BB). Additional analysis not required.
	SF-BATT|BC	4 ADS, HPCI, 1 LPCS, 1 LPCI	Bound by SF-BATT|BB
	SF-LOCA	6 ADS, HPCI, 1 LPCS	Bounded by SF-BATT|BA and SF-BATT|BB
	SF-LPCI	6 ADS, HPCI, 2 LPCS	Bounded by SF-BATT|BA and SF-BATT|BB
	SF-DGEN	6 ADS, HPCI, 1 LPCS	Bounded by SF-BATT|BA and SF-BATT|BB
	SF-HPCI	6 ADS, 2 LPCS, 2 LPCI	Bounded by SF-BATT|BA
	SF-ADS|IL	4 ADS, HPCI, 2 LPCS, 2 LPCI	Bounded by SF-BATT|BB
	SF-ADS|SV	5 ADS, HPCI, 2 LPCS, 2 LPCI	Bounded by SF-BATT|BB

* Refer to footnotes of Table 5.1 for additional information.

Figure 5.1 Steam, Feedwater, and HPCI Lines



6.0 TLO Recirculation Line Break Spectrum Analyses

The largest diameter recirculation system pipes are the suction line between the reactor vessel and the recirculation pump and the discharge line between the recirculation pump and the riser manifold ring. LOCA analyses are performed for breaks in both of these locations with consideration for both DEG and split break geometries. The break sizes considered included DEG breaks with discharge coefficients from 1.0 to 0.4 and split breaks with areas ranging between the full pipe area and [ ] ft^2. As shown in Table 5.1, the limiting single failures considered in the recirculation line break analyses are SF-BATT|BA and SF-BATT|BB.

[ ]

6.1 *Break Spectrum Analysis Results*

The break spectrum analyses demonstrate that the recirculation line break case with the [ ] is the 3.5 ft^2 break in the pump discharge piping with a single failure of SF-BATT|BB and a top-peaked axial power shape when operating at 102% rated core power and [ ] The break case with the [ ] is also presented in Table 6.1.

Table 6.2 provides a summary of the [ ] from the recirculation line break calculations for each of the single failures, state points, and axial power shapes. The event times for the 3.5 ft^2 break in the pump discharge piping with a single failure of SF-BATT|BB and a top-peaked axial power shape when operating at 102% rated core power and [ ] are presented in Table 6.3 and plots of key parameters from the LOCA analyses of this case are provided in Figures 6.1 – 6.15.

Table 6.1 Break Spectrum Results* for TLO Recirculation Line Breaks

Break spectrum case resulting **[ ]**	3.5 ft^2 pump discharge SF-BATT|BB Top-peaked axial 102%P/**[ ]**
[ ]	**[ ]**

* **[ ]**

Table 6.2 Summary of Break Spectrum [ ] for TLO Recirculation Line Breaks

[

]

Table 6.3 Event Times for the [ ] from the TLO Recirculation Line Break Spectrum Analysis

[ ]

Figure 6.1 [ ] from the
TLO Recirculation Line Break Spectrum Analysis
Upper Plenum Pressure

[ ]

Figure 6.2 [ ] from the
TLO Recirculation Line Break Spectrum Analysis
Total Break Flow Rate

[ ]

**Figure 6.3 [ ] from the
TLO Recirculation Line Break Spectrum Analysis
Core Inlet Flow Rate**

[ ]

**Figure 6.4 [ ] from the
TLO Recirculation Line Break Spectrum Analysis
ADS Flow**

[ ]

**Figure 6.5 [ ] from the
TLO Recirculation Line Break Spectrum Analysis
HPCI Flow**

[

]

**Figure 6.6 [ ] from the
TLO Recirculation Line Break Spectrum Analysis
LPCS Flow**

[

]

Figure 6.7 [ ] from the TLO Recirculation Line Break Spectrum Analysis LPCI Flow

[ ]

Figure 6.8 [ ] from the TLO Recirculation Line Break Spectrum Analysis RDIV Flows

[ ]

**Figure 6.9 [ ] from the
TLO Recirculation Line Break Spectrum Analysis
Relief Valve Flow**

[ ]

**Figure 6.10 [ ] from the
TLO Recirculation Line Break Spectrum Analysis
Downcomer LOCA Water Level**

[ ]

**Figure 6.11 [ ] from the
TLO Recirculation Line Break Spectrum Analysis
Upper Plenum Liquid Level**

[ ]

**Figure 6.12 [ ] from the
TLO Recirculation Line Break Spectrum Analysis
Hot Channel Liquid Level**

[ ]

Figure 6.13 [ ] from the TLO Recirculation Line Break Spectrum Analysis Core Bypass Liquid Level

[ ]

Figure 6.14 [ ] from the TLO Recirculation Line Break Spectrum Analysis Lower Plenum Liquid Level

[ ]

Figure 6.15 [ ] from the TLO Recirculation Line Break Spectrum Analysis Hot Channel Inlet Flow

7.0 Single-Loop Operation LOCA Analysis

During SLO, the pump in one recirculation loop is not operating. A break may occur in either loop, but results from a break in the inactive loop would be similar to those from a two-loop operation break. If a break occurs in the inactive loop during SLO, the intact active loop flow to the reactor vessel would continue during the recirculation pump coastdown period and would provide core cooling similar to that which would occur in breaks during TLO. The system response would be similar to that resulting from an equal-sized break during two-loop operation. A break in the active loop during SLO results in a more rapid loss of core flow and earlier degraded core conditions relative to those from a break in the inactive loop. Therefore, only breaks in the active recirculation loop are analyzed.

A break in the active recirculation loop during SLO will result in an earlier loss of core heat transfer relative to a similar break occurring during two-loop operation. This occurs because there will be an immediate loss of jet pump drive flow. Therefore, fuel rod surface temperatures will increase faster in an SLO LOCA relative to a TLO LOCA. Also, the early loss of core heat transfer will result in higher stored energy in the fuel rods at the start of the heatup. The increased severity of an SLO LOCA can be reduced by applying an SLO multiplier to the two-loop MAPLHGR limit.

7.1 *SLO Analysis Modeling Methodology*

[

]

[ ] SLO is not considered for the MELLLA+ region since SLO is not allowed in the MELLLA+ region.

7.2 *SLO Analysis Results*

[ ]

The SLO analyses are performed with a 0.85 multiplier applied to the two-loop MAPLHGR limit resulting in an SLO MAPLHGR limit of [ ] kW/ft. [ ] The analyses are performed at maximum stored energy fuel conditions. The limiting SLO LOCA is the 3.5 ft^2 break in the pump discharge piping with a single failure of SF-BATT|BB and a top-peaked axial power shape when operating at [ ]

A comparison of the limiting SLO and the limiting two-loop results is provided in Table 7.1. The results in Table 7.1 show that the two-loop LOCA results bound the limiting SLO results when a 0.85 multiplier is applied to the two-loop MAPLHGR limit. [ ]

**Table 7.1 Single- and Two-Loop Operation
PCT Summary**

Operation	Limiting Case	PCT (°F)
Single-loop	3.5 ft^2 pump discharge top-peaked SF-BATT|BB	[ ]
Two-loop	3.5 ft^2 pump discharge top-peaked SF-BATT|BB	[ ]

8.0 Long-Term Coolability

Long-term coolability addresses the issue of reflooding the core and maintaining a water level adequate to cool the core and remove decay heat for an extended time period following a LOCA. For non-recirculation line breaks, the core can be reflooded to the top of the active fuel and be adequately cooled indefinitely. For recirculation line breaks, the core will initially remain covered following reflood due to the static head provided by the water filling the jet pumps to a level of approximately two-thirds core height. Eventually, the heat flux in the core will not be adequate to maintain a two-phase water level over the entire length of the core. Beyond this time, the upper third of the core will remain wetted and adequately cooled by core spray. Maintaining water level at two-thirds core height with one core spray system operating is sufficient to maintain long-term coolability as demonstrated by the NSSS vendor (Reference 4). Since fuel temperatures during long-term cooling are low relative to the PCT and are not significantly affected by fuel design, this conclusion is applicable to ATRIUM 11 fuel. This LOCA analysis assesses conditions from the time of the initiation of the break to the time when long term cooling conditions can be established as demonstrated in Reference 4.

9.0 Exposure-Dependent LOCA Analysis Description and Results

Exposure-dependent LOCA results for ATRIUM 11 fuel are obtained by repeated analyses [ ] from the break spectrum analysis [ ]

Table 9.1 shows the exposure-dependent LOCA analysis results for the ATRIUM 11 fuel. The S-RELAP5 model is applied to obtain these results as described in Section 4.2. The analysis is performed at [ ] which ensures appropriate limits are applied up to the monitored maximum assembly average and rod average exposure limits. The MAPLHGR input is consistent with the data in Figure 2.1. [ ] Exposure-dependent fuel rod data is provided from RODEX4 results [ ] The impact of thermal conductivity degradation is addressed with RODEX4.

The ATRIUM 11 limiting PCT is 1898°F at [ ] exposure for the 3.5 ft^2 break in the pump discharge piping with a single failure of SF-BATT|BB and a top-peaked axial power shape when operating at 102% rated core power and [ ]. The maximum local MWR of 8.27% occurred at [ ] exposure, [ ] Analysis results show that the hot rod average MWR is 0.73%. Since all other rods in the core are at lower power, the core average metal water reaction (CMWR) will be significantly less.

Figure 9.1 shows the cladding temperature of the ATRIUM 11 PCT rod as a function of time for the limiting PCT result from the exposure-dependent LOCA analysis. The maximum temperature of 1898°F occurs at **[ ]**. These results demonstrate the acceptability of the ATRIUM 11 MAPLHGR limit shown in Figure 2.1.

Table 9.1 ATRIUM 11 Exposure-Dependent LOCA Analysis Results

[ ]

CMWR is < 0.73% at all exposures.*

* The rod average MWR for the hot rod is 0.73% which supports the conclusion that the CMWR is less than 0.73%.

Figure 9.1 Limiting [ ] PCT
Exposure-Dependent LOCA Analysis

[

]

10.0 Conclusions

The AURORA-B LOCA Evaluation Model was applied to confirm the acceptability of the ATRIUM 11 MAPLHGR limit and **[ ]** for Browns Ferry Units 1, 2, and 3. The following conclusions were made from the analyses presented in this report.

- The limiting PCT is obtained from Section 9.0 based on a recirculation line break of 3.5 ft^2 break in the pump discharge piping with a single failure of SF-BATT|BB and a top-peaked axial power shape when operating at 102% of rated core power and **[ ]**.
- The limiting break analysis identified above satisfies all the acceptance criteria specified in 10 CFR 50.46. The analysis is performed in accordance with 10 CFR 50 Appendix K requirements.
- The multiplier applied to the MAPLHGR limit for SLO is 0.85 for ATRIUM 11 fuel. **[ ]** This multiplier ensures that a LOCA from SLO is less limiting than a LOCA from two-loop operation.
- The acceptance criteria of the Code of Federal Regulations (10 CFR 50.46) are met for operation at or below the ATRIUM 11 MAPLHGR limit given in Figure 2.1 **[ ]**.
  - Peak PCT < 2200°F.
  - Local cladding oxidation thickness < 17%.
  - Total hydrogen generation < 1%.
  - Coolable geometry, satisfied by meeting peak PCT, local cladding oxidation, and total hydrogen generation criteria.
  - Core long-term cooling, satisfied by concluding core flooded to top of active fuel or core flooded to the jet pump suction elevation (Reference 4).
- The MAPLHGR limit and **[ ]** are applicable for ATRIUM 11 full cores as well as transition cores containing ATRIUM 11 fuel.

11.0 References

1. ANP-10332P-A Revision 0, *AURORA-B: An Evaluation Model for Boiling Water Reactors; Application to Loss of Coolant Accident Scenarios,* Framatome, March 2019.

2. XN-NF-82-07(P)(A) Revision 1, *Exxon Nuclear Company ECCS Cladding Swelling and Rupture Model*, Exxon Nuclear Company, November 1982.

3. BAW-10247PA Revision 0, *Realistic Thermal-Mechanical Fuel Rod Methodology for Boiling Water Reactors,* Framatome, February 2008.

4. NEDO-20566A*, General Electric Company Analytical Model for Loss of Coolant Analysis in Accordance with 10CFR50 Appendix K*, September 1986.

Appendix A Limitations from the Safety Evaluation for LTR ANP-10332PA

Compliance to the limitations and conditions from Section 5 of the safety evaluation in ANP-10332PA, "AURORA-B: An Evaluation Model for Boiling Water Reactors; Application to Loss of Coolant Accident Scenarios" (Reference 1) is discussed in the following table.

Appendix A *(Continued)*

Limitation and Condition Number	Limitation and Condition Description	Disposition/Discussion
1	The AURORA-B LOCA evaluation model shall be supported by an approved nodal core simulator and lattice physics methodology. Plant-specific licensing applications referencing the AURORA-B LOCA evaluation model shall identify the nodal core simulator and lattice physics methods supporting the AURORA-B LOCA analysis and reference an NRC-approved TR confirming their acceptability for the intended application.	MICROBURN-B2 and the underlying cross section generation code, CASMO-4, are used for the nodal core simulator and lattice physics methodology from the following NRC-approved TR: EMF-2158(P)(A) Revision 0, "Siemens Power Corporation Methodology for Boiling Water Reactors: Evaluation and Validation of CASMO-4 / MICROBURN-B2," Siemens Power Corporation, October 1999.
2	The full, stand-alone version of the RODEX4 code shall be used in accordance with an approved methodology to supply steady-state fuel thermal-mechanical inputs to the AURORA-B LOCA evaluation model.	The stand-alone version of RODEX4 is used to supply steady-state fuel thermal-mechanical input in accordance with the following NRC-approved methodology: BAW-10247PA Revision 0, "Realistic Thermal-Mechanical Fuel Rod Methodology for Boiling Water Reactors," AREVA NP Inc., February 2008.
3	The AURORA-B LOCA evaluation model may not be used to perform analyses that result in any of its constituent components or supporting codes (i.e., S-RELAP5, RODEX4 kernel, RODEX4, core simulator and lattice physics methods) being operated outside approved limits documented in their respective TRs, SEs, code manuals, and plant-specific licensing applications.	The analyses are within the limits of the TRs, SEs, code manuals and plant-specific licensing applications.
4	TR ANP-10332P does not provide a technical basis to support satisfaction of the requirement in 10 CFR 50.46(b)(5) for long-term core cooling, and, as such, has not been approved for this purpose.	[ ] LOCA report.

Limitation and Condition Number	Limitation and Condition Description	Disposition/Discussion
5	As discussed above in Section 2.1, the conclusions of this SE apply only to the use of the AURORA-B LOCA evaluation model for the purpose of demonstrating compliance with relevant regulatory requirements in effect at the time the NRC staff's technical review of ANP-10332P was completed (i.e., as of December 31, 2018).	The analyses only apply regulatory requirements in effect at the time the NRC staff's review was completed. They **[ ]**.
6	This SE does not constitute approval of the PIRT rankings in Table 4-1 of ANP-10332P. Framatome's PIRT rankings represent an informed opinion of phenomenon importance that the NRC staff referred to as supporting information in its review of the AURORA-B LOCA evaluation model; beyond this, they remain subjective judgments that are not integral to the acceptability of the evaluation model.	The evaluation model **[ ]**.
7	**[ ]**.	The **[ ]**.
8	**[ ]**.	The **[ ]** in the analyses.

Limitation and Condition Number	Limitation and Condition Description	Disposition/Discussion
9	Safety analyses performed with the AURORA-B LOCA evaluation model may not credit a limit on **[** **]**, absent a plant-specific determination from the NRC staff that such credit is consistent with the requirements of 10 CFR 50.36. Absent such a determination, **[** **]**.	**[** **]**.
10	To ensure adequate conservatism in future plant-specific safety analyses, absent specific NRC staff approval for higher values, this SE limits credit for gamma energy deposition outside of a fuel rod to no more than **[** **]**.	A **[** **]**.
11	Plant-specific licensing applications referencing the AURORA-B LOCA evaluation model shall adequately justify the averaging method for determining the temperature ramp rate used in the calculation of cladding swelling and rupture.	BWR fuel rods are **[** **]**.
12	The Appendix K lockout preventing the return to nucleate boiling shall be **[** **]**.	The analyses **[** **]**.

Limitation and Condition Number	Limitation and Condition Description	Disposition/Discussion
13	**[ ]** shall be taken into account when determining the start of the refill and reflood phases and the release of Appendix K heat transfer lockouts.	**[ ]**.
14	Plant-specific licensing applications referencing the AURORA-B LOCA evaluation model **[ ]**. When figures of merit are reported in licensing submittals to the NRC, they shall show results for **[ ]**.	Analyses **[ ]**.
15	**[ ]**.	The **[ ]**.
16	Plant-specific licensing applications referencing the AURORA-B LOCA evaluation model shall justify that the input conditions assumed in the analysis are bounding across the entire approved operating domain, which may include, for example, extended power uprates, extended flow windows, equipment out of service (e.g., automatic depressurization system valves, feedwater heaters, single-loop operation), and feedwater temperature reduction. If necessary, analysis of multiple initial operating states shall be performed to ensure that the most limiting conditions with respect to the acceptance criteria of 10 CFR 50.46 have been calculated.	**[ ]**.

Limitation and Condition Number	Limitation and Condition Description	Disposition/Discussion
17	To assure satisfaction of GDC 35 (or similar plant-specific design criterion), **[** **]**.	A **[** **]**.
18	Safety analyses performed with the AURORA-B LOCA evaluation model shall include justification for any credit taken for the drywell high pressure trip signal.	**[** **]**.
19	Safety analyses for mixed-core configurations shall appropriately justify application of the AURORA-B LOCA evaluation model and any supporting methodologies (e.g., nodal core simulator and lattice physics methods, fuel thermal-mechanical performance methods) to legacy fuel assemblies designed by other vendors. Furthermore, **[** **]**.	The application of AURORA-B LOCA **[** **]**. **[** **]**.

Limitation and Condition Number	Limitation and Condition Description	Disposition/Discussion
		Approximately [ ].
20	Simulations supporting plant safety analyses should be run to completion of quenching on all potentially limiting fuel rods. If premature termination occurs, [ ].	Simulations [ ].

Limitation and Condition Number	Limitation and Condition Description	Disposition/Discussion
21	As discussed in Section 3.3.5.7, Framatome used a non-representative modeling practice of [ ]. Prior to implementing this practice in future plant safety analyses, the practice must be adequately defined in the AURORA-B LOCA modeling guidelines. Furthermore, this practice may not be implemented in the safety analysis for any given plant without explicit plant-specific approval by the NRC staff (e.g., in conjunction with a license amendment request to implement the AURORA-B LOCA evaluation model). Licensees requesting credit for this non-representative modeling practice must adequately describe the extent of its intended use and justify its conservatism. The justification must address the potential for [ ] excessive sensitivity to timestep and nodalization variations, as discussed further in Section 3.5.	The [ ].
22	The NRC staff has not specifically reviewed any plant parameters in ANP-10332P or deemed them acceptable for use in plant safety analyses. Therefore, each licensee using the AURORA-B LOCA evaluation model is responsible for confirming that all plant specific design parameters are consistent with the assumptions made in the analysis. This includes, for example, [ ].	The licensee [ ].

Limitation and Condition Number	Limitation and Condition Description	Disposition/Discussion
23	Safety analyses performed with the AURORA-B LOCA evaluation model shall include justification that [ ].	A [ ].
24	[ ].	[ ].
25	Plant-specific licensing applications referencing the AURORA-B LOCA evaluation model shall justify the acceptability of the following evaluation model changes Framatome implemented during the NRC staff's review of ANP-10332P: [ ]	The [ ].

Limitation and Condition Number	Limitation and Condition Description	Disposition/Discussion
26	Plant-specific licensing applications referencing the AURORA-B LOCA evaluation model shall confirm that **[** **]**.	The **[** **]**.
27	As discussed in Section 4.3 of this SE, new or modified Framatome **[** **]**.	The analyses **[** **]**.

ATTACHMENT 15a

ANP-3874P Revision 3

(Proprietary)

Browns Ferry ATRIUM 11 Control Rod Drop Accident Analysis with the AURORA-B CRDA Methodology

ATTACHMENT 15b

ANP-3874NP Revision 3

(Non Proprietary)

Browns Ferry ATRIUM 11 Control Rod Drop Accident Analysis with the AURORA-B CRDA Methodology

Browns Ferry ATRIUM 11 Control Rod Drop Accident Analysis with the AURORA-B CRDA Methodology

ANP-3874NP
Revision 3

June 2022

Nature of Changes

Item	Section(s) or Page(s)	Description and Justification
1	Section 9.0	Update Reference 1

Contents

List of Tables

List of Figures

Nomenclature

Acronym	Definition
AOO	anticipated operational occurrence
ASME	American Society of Mechanical Engineers
BOC	beginning of cycle
BPWS	Banked Position Withdrawal Sequence
BWR	boiling water reactor
CCD	component calculational device
CFR	code of federal regulations
CHF	critical heat flux
CPR	critical power ratio
CRDA	control rod drop position
CWSR	cold work stress relief aka SRA
CZP	cold zero power
EFP	end of full power
EM	evaluation model
EOC	end of cycle
GMUL	TFGR weighting factor
LAR	license amendment request
LOCA	loss of coolant accident
LBRF	licensing basis release fraction
LWR	light water reactor
LUT	look up table
L&C	limitation and condition
MOC	middle of cycle corresponding to peak hot excess reactivity
NRC	Nuclear Regulatory Commission, U.S.
PCMI	pellet-clad mechanical interaction
RAI	request for additional information
RG	regulatory guide
SER	safety evaluation report
SRA	stress relief annealed
SRP	standard review plan
SSRF	steady state release fraction

Acronym	**Definition**
TFGR	transient fission gas release
TH	thermal hydraulic
TOTR	total release fraction
UFSAR	updated final safety analysis report
U.S. NRC	Nuclear Regulatory Commission, U.S.
ΔH	transient change in enthalpy
Δk	change in eigenvalue

1.0 INTRODUCTION

The Framatome AURORA-B CRDA methodology has been used to evaluate the Browns Ferry ATRIUM 11 equilibrium fuel cycle (Reference 1). The methodology includes the use of a nodal three-dimensional kinetics solution with both thermal-hydraulic (TH) and fuel temperature feedback. These models provide more precise localized neutronic and thermal conditions than previous methods to show compliance with regulatory guidance criteria presented in Regulatory Guide RG 1.236 (Reference 3). The report summarizes the application of the AURORA-B CRDA methodology (Reference 5) on the Browns Ferry ATRIUM 11 equilibrium cycle.

The control rod drop calculations were performed with the AURORA-B CRDA methodology. All startup sequences were evaluated and no fuel rod failures were identified through end of full power. Evaluations of the drops at the licensing basis end of cycle identified potential fuel rod failures in one startup sequence.

2.0 REGULATORY BASIS

This demonstration evaluation utilizing the methodology of Reference 5 is applied using the acceptance criteria of RG 1.236 (Reference 3).

3.0 INITIAL METHODOLOGY DEMONSTRATION

The initial application of the AURORA-B CRDA methodology involves sensitivity studies and determination of an evaluation boundary. The determination of the evaluation boundary provided in Appendix A is a demonstration of the process discussed in Reference 5 for Browns Ferry with ATRIUM 11 fuel.

3.1 *Initial Conditions*

Sensitivity studies are performed [

]

3.2 *Group Pull Sequence*

All allowed pull orders are evaluated such that each control rod group, with the exception of groups 5 and 6, is pulled as the second group as indicated in Table 3-1. The third and fourth groups are assumed to be banked. It is assumed that the first and second groups selected for withdrawal are completely withdrawn prior to pulling control rods in the third group. For clarification since both the first and second groups must be out before the third group, both pull sequences A1234 and A2134 have the same starting control rod pattern for the third group. Therefore the sequences A1234 and A2143 also cover sequences A2134 and A1243.

Table 3-1 Group Pull Sequences

	Analyzed Groups for both A and B sequences
1st and 2nd groups	(1,2), (2,1), (3,4), (4,3)
3rd and 4th groups	(3,4), (4,3), (1,2), (2,1)

3.3 *Inoperable Control Rod Position*

A maximum of 8 inoperable control rods are allowed for this plant with up to three inoperable per group. To maximize the worth of the drops in the second and third groups, three inoperable control rods are assigned to both the first and second group in each sequence and then two more are assigned to the third. The assignment of inoperable control rods adhered to the separation criteria on group bases.

The locations of high worth control rod drops without inoperable control rods were identified as indicated in Figure 3-1. Only control rod drops with static worth greater than 6 mk are shown. Banked groups produced low static rod worth, so investigation of control rod worth was constrained to rods dropped in second group with no banking. Inoperable control rods were assigned to increase these dropped worth values as indicated in Figure 3-2. Where possible, they are selected to be in the opposite half the core as the highest worth rods while avoiding locations known to have low impact on static rod worth. Because of inoperable rod spacing requirements, it was not possible to get the third group’s rods into the same half, but they are selected outside of the quadrant where the dominant rods are located.

Figure 3-1 Second Group Rod Drops with All Rods Operable

BOC

X,Y	2	6	10	14	18	22	26	30	34	38	42	46	50	54	58	
59																1
55								0.00666								3
51																5
47						0.00616	0.00601	0.00636		0.00617						7
43					0.00751	0.00634				0.00637	0.00755					9
39					0.0064						0.00643	0.00604				11
35																13
31				0.006												15
27																17
23				0.00609	0.00641						0.00641	0.00602				19
19					0.00754	0.00636				0.00634	0.00756					21
15						0.00616		0.00633		0.00614						23
11																25
7								0.00626								27
3																29
	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	I,J

MOC

X,Y	2	6	10	14	18	22	26	30	34	38	42	46	50	54	58	
59																1
55							0.00645		0.0065							3
51																5
47								0.00727								7
43																9
39																11
35								0.00618								13
31				0.00715			0.00621		0.00624			0.00716				15
27							0.00601	0.00628	0.006							17
23																19
19																21
15								0.00733								23
11																25
7							0.006		0.00603							27
3																29
	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	I,J

EFP

X,Y	2	6	10	14	18	22	26	30	34	38	42	46	50	54	58	
59																1
55						0.00999	0.00985	0.00652	0.01	0.01005						3
51																5
47				0.0071				0.00624				0.00711				7
43																9
39		0.00972												0.00955		11
35		0.0098												0.00952		13
31		0.00642												0.00625		15
27		0.01002												0.00975		17
23		0.01002												0.00977		19
19																21
15				0.00714				0.00612				0.00723				23
11																25
7						0.0095	0.00904	0.00608	0.00923	0.00953						27
3																29
	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	I,J

EOC

X,Y	2	6	10	14	18	22	26	30	34	38	42	46	50	54	58	
59																1
55						0.01349	0.00968		0.00978	0.01338						3
51																5
47				0.00661								0.00662				7
43																9
39		0.01348												0.01358		11
35		0.00981												0.00979		13
31		0.00603												0.00614		15
27		0.00978												0.00979		17
23		0.01347												0.01354		19
19																21
15				0.00674								0.00661				23
11																25
7						0.01378	0.00979	0.00627	0.00994	0.01372						27
3																29
	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	I,J

*

* Values provided are the dropped rod's static worth (Δk).

Figure 3-2 Browns Ferry Inoperable Rods

[

]

* [

]

3.4 *Time in Cycle*

[

]

3.5 *Group Critical Position*

The first step is to evaluate the end of group or bank position k-effective values to determine where criticality is anticipated to occur for the given control rod withdrawal sequence. The near critical range, determined per Section 7.4.1 of Reference 5, is given in Table 3-2. The calculated k-effective values at the end of groups 1 through 4 for the A and B sequence withdrawals are given in Table 3-3. The highlighted groups and bank positions in Table 3-3 will be considered as credibly near critical.

Table 3-2 Near Critical Range

[

]

Table 3-3 Group Position Eigenvalues

[ ]

3.6 *Determination of Static Control Rod Worth*

Based on the results of the group worth, static control rod worths were then determined. From the static rod drops, [

] The rods selected for transient evaluation are given in Table 3-4.

Table 3-4 Selected Rods with Inoperable Control Rods

[

]

* Notation here identifies control rod withdrawal sequence, BPWS group, and the position in which that group was dropped. For example, "AG4D2" would signify that the group 4 of A-sequence was the 2nd group dropped.

† The value shown here is the notch position of the rods in the same group as the dropped rod. Control rods in the second group are dropped un-banked and are denoted with "--". [

]

3.7 *Transient Evaluation*

The evaluation of each rod drop is performed with the AURORA-B system. The initial pre-rod drop state point is established with the MICROBURN-B2 core simulator. The initial conditions used for the transient calculation are identified in Table 3-5.

Table 3-5 Initial Conditions

[ ]

The channel grouping with a [ ] is used for this analysis (Figure 3-3 illustrates the assemblies evaluated for the drop of control rod [ ]). Once the channel grouping is defined, the power history information is processed to obtain the fuel rod characteristics for use in the RODEX-4 fuel rod mechanical models. The maximum prompt enthalpy increase for the peak fuel rod and the maximum total enthalpy reported include the application of the uncertainty multiplier of [ ] on the enthalpy increase (L&C 34 of Reference 5). The prompt enthalpy increase along with total enthalpy for the drops is given in Table 3-6. Although there are high worth banked drops, the actual nodal enthalpy increase is small for the BOC banked drops compared to drops later in cycle with a top peaked power shape.

Figure 3-3 Map of Assemblies Evaluated for Drop of Control Rod [ ]

[

]

Table 3-6 Maximum Prompt Enthalpy Rise and Total Enthalpy

Table 3-6 Maximum Prompt Enthalpy Rise and Total Enthalpy (continued)

4.0 EVALUATION AGAINST CLADDING FAILURE CRITERIA

4.1 *High Temperature Cladding Failure*

All of the control rod drops which had inoperable control rods were evaluated against the high temperature failure threshold at nominal fuel rod pressure utilizing nominal burnup. For each assembly, the fuel rod with the highest enthalpy was evaluated against the high temperature threshold from RG 1.236. One case had assemblies with enthalpy values which exceeded the high temperature cladding failure criteria as indicated in Table 4-1.

Table 4-1 shows the maximum enthalpy for all assemblies from all drops with at least one assembly exceeding 100 cal/g maximum radial enthalpy. An additional evaluation was performed to investigate the impact of utilizing a high burnup power history wherein these cases were re-evaluated at a bounding pressure by utilizing a high fuel rod burnup. The evaluation was performed with the **[ ]** assemblies around the dropped control rod with both nominal fuel rod pressure and bounding fuel rod pressure. Only the clad differential pressure from the high burnup evaluation is indicated in Table 4-1. Nominal and elevated differential pressure cases are shown together in Figure 4-1 to illustrate the difference. The primary impact of the high burnup is lowering the failure threshold a small amount. The assembly circled in red in Figure 4-1 shows how fuel that was initially below the high temperature failure threshold might exceed it after increasing the burnup.

Table 4-1 Assemblies with Fuel Rod High Temperature Failures

[ ]

Figure 4-1 High Temperature Nominal and High Burnup Total Enthalpy

[ ]

4.2 *PCMI Cladding Failure*

The ATRIUM 11 fuel is clad with stress relief annealed (SRA) Zircaloy-2 cladding. (Framatome uses the term Cold Work Stress Relieved CWSR to refer to SRA material.) Therefore, the SRA low temperature failure threshold from Reference 3 is applied.

To establish the minimum failure threshold, the maximum fuel rod nodal hydrogen at end of cycle was tabulated for each assembly using the hydrogen model of Reference 8 **[**

]

The cladding failure threshold for the core is shown in Figure 4-2.

Figure 4-2 Minimum Failure Threshold Based on EOC Hydrogen Content

Since 150 Δcal/g is the maximum of the failure threshold curve, [ ] The rod drops are evaluated with assumed inoperable control rods. [ ] There were no failures before or at end of full power. The assemblies with fuel rod failures are given in Table 4-2.

Table 4-2 Assemblies with Fuel Rod PCMI Failures

[ ]

Figure 4-3 PCMI Cladding Failure Results

[ ]

4.3 *Molten Fuel Cladding Failure Threshold*

[ ]

5.0 RADIOLOGICAL CONSEQUENCES

The dose consequences for the CRDA event determined for Browns Ferry are summarized in the UFSAR. The licensing basis dose evaluation determined that 850 8x8 fuel rods could fail. A smaller dose would result if the same number of 11x11 rods were to fail, given the smaller rod diameter. Therefore, demonstrating that there is significantly less than 850 fuel rod failures will confirm that the radiological consequences are bounded by those in the Browns Ferry UFSAR.

Evaluation of dose consequences for fuel rod failures

Since fuel rod failures had been identified, revised release fractions or total release fraction (TOTR) are determined using the values from RG 1.183 as the steady state release fraction (SSRF) with the transient fission gas release (TFGR) as described in DG-1327 (Reference 2). A ratio of the new TOTR to the licensing basis release fractions (LBRF) used in the original licensing basis is then generated following the method in ANP-10333P-A to determine the dose-equivalent weight of each failed fuel rod.

The transient release terms from Reference 2 expressed as a fraction are:

$$TFGR = \begin{cases} \dfrac{0.26 \cdot \Delta H - 13}{100}, & Pellet\ BU < 50\ GWd/MTU \\[2ex] \dfrac{0.26 \cdot \Delta H - 5}{100}, & Pellet\ BU \geq 50\ GWd/MTU \end{cases}$$

The TOTR is dependent on the nuclide group and the enthalpy-dependent TFGR averaged over the 25 nodes of fuel for full length fuel rods (if the fuel failure were in a shorter fuel rod, the number of axial nodes would decrease accordingly).

$$TOTR_i = SSRF_i + GMUL_i \cdot \frac{1}{25}\sum_{k=1}^{25} TFGR_k$$

Where,

ΔH is the fuel enthalpy increase (cal/g)

$TFGR_k$ is the transient fission gas release fraction as determined above at the kth axial node

$SSRF_i$ is the steady state release fraction of the ith isotope group

$GMUL_i$ is the TFGR weighting factor from Reference 2 for the ith isotope group

$TOTR_i$ is the total release fraction of a given rod weighted by the ith isotope group

Three TFGR weighting multipliers are established by DG-1327:

Isotope Group	GMUL	Applied to
Stable, long-lived isotopes (e.g. Kr-85)	1.0	Kr-85
Cs-134 and Cs-137	1.414	Alkali Metals
Short-lived radioactive isotopes (e.g. halogens, Xe and Kr noble gases other than Kr-85)	0.333	Iodines, nobles, halogens

For this analysis of the ATRIUM 11 fuel, a maximum of [ ] full length and [ ] part length fuel rods exceeded one or more failure criteria in any control rod drop case. Based on the enthalpy increase, the enthalpy dependent release terms were determined for the fuel rods. The transient fission gas release fractions for the limiting fuel rod are provided in Table 5-1 based on nodal values of the peak fuel rod enthalpy increase. [

]

Table 5-4 shows that a total of [ ] dose-equivalent fuel rods fail for the limiting control rod drop accident, which is less than the 850 allowed in the licensing basis dose evaluation.

Table 5-1 Transient Fission Gas Release Fractions from Limiting Fuel Rod [ ]

[ ]

Table 5-2 Fission Gas Release Fractions and Weighting Factors

[ ]

* [ ]

Table 5-3 TOTR to LBRF Ratio [ ]

[ ]

Table 5-4 Fuel Rod Failures

[ ]

---

* Unique rod failures

6.0 SYSTEM PRESSURE AND CPR

The impact of the CRDA on system pressure was addressed in Reference 5 and does not cause stresses to exceed Emergency Condition (Service Level C), as defined in Section III of the ASME Boiler and Pressure Vessel code. This generic evaluation on the impact of CRDA on system pressure remains applicable for Browns Ferry. The CPR response was evaluated in Section 7.7 of Reference 5 and resulted in a conclusion that the CRDA in the power range is

[

]

7.0 CORE COOLABILITY

Two criteria are identified in Reference 3 for allowable limits with respect to core coolability:

- Peak radial average enthalpy < 230cal/g
- The peak fuel temperature in the outer 90 percent of the pellet's volume must remain below incipient fuel melting conditions

[

]

Table 7-1 Peak Radial Average Fuel Enthalpy

[

]

8.0 LIMITATIONS AND CONDITIONS

The SER for the Reference methodology included a number of limitations and conditions. Some of the conditions are from the base AURORA-B AOO methodology (Reference 6) and additions specific to the CRDA are included. The numbering of the limitations and conditions below is consistent with that found in the AURORA-B CRDA SER.

1. AURORA-B may not be used to perform analyses that result in one or more of its CCDs (S-RELAP5, MB2-K, MICROBURN-B2, RODEX4) operating outside the limits of approval specified in their respective TRs, SEs, and plant-specific license amendment requests (LARs). In the case of MB2-K, MB2-K is subject to the same limitations and conditions as MICROBURN-B2. *(This is Condition 1 of the SE for the base AURORA-B TR. It remains applicable to CRDA analyses for BWRs/2-6.)*

This condition is met for the application of AURORA-B CRDA methodology to Browns Ferry.

14. The scope of the NRC staff's approval of AURORA-B does not include the ABWR design. (This is Condition 14 of the SE for the base AURORA-B TR. It remains applicable to CRDA analyses for BWRs/2-6.)

This condition is met for all Browns Ferry Units since they are BWR/4 designs.

20. The implementation of any new methodology within the AURORA-B EM (i.e., replacement of an existing CCD) is not acceptable unless the AURORA-B EM with the new methodology incorporated into it has received NRC review and approval. An existing NRC-approved methodology cannot be implemented within the AURORA-B EM without NRC review of the updated EM. *(This is a revised version of Condition 20 of the SE for the base AURORA-B TR, rewritten to be specific to the CRDA application. It remains applicable to CRDA analyses for BWRs/2-6.)*

The evaluation model will be implemented for Browns Ferry as described in the base AURORA-B and AURORA-B CRDA Topical Reports. No CCD as described in the TR are replaced and therefore the intent of this condition is met.

21. NRC-approved changes that revise or extend the capabilities of the individual CCDs comprising the AURORA-B EM may not be incorporated into the EM without prior NRC

approval. *(This is Condition21 of the SE for the base AURORA-B TR. It remains applicable to CRDA analyses for BWRs/2-6.)*

22. As discussed in Section 3.3.1.5 and Section 4.0 of Reference 6 (the SE for the base AURORA-B TR), the SPCB and ACE CPR correlations for the ATRIUM-10 and ATRIUM-10XM fuels, respectively, are approved for use with the AURORA-B EM. Other CPR correlations (existing and new) that would be used with the AURORA-B EM must be reviewed and approved by the NRC or must be developed with an NRC-approved approach such as that described in EMF-2245(P)(A), Revision 0, "Application of Siemens Power Corporation's Critical Power Correlations to Co-Resident Fuel". Furthermore, if transient thermal-hydraulic simulations are performed in the process of applying AREVA CPR correlations to co-resident fuel, these calculations should use the AURORA-B methodology. *(This is Condition 22 of the SE for the base AURORA-B TR. It remains applicable to at-power CRDA analyses for BWRs/2-6.)*

Approved CPR correlations are used for at-power CRDA analyses.

23. Except when prohibited elsewhere, the AURORA-B EM may be used with new or revised fuel designs without prior NRC approval provided that the new or revised fuel designs are

substantially similar to those fuel designs already approved for use in the AURORA-B EM (i.e., thermal energy is conducted through a cylindrical ceramic fuel pellet surrounded by metal cladding, flow in the fuel channels develops into a predominantly vertical annular flow regime, etc.). New fuel designs exhibiting a large deviation from these behaviors will require NRC review and approval prior to their implementation in AURORA-B. *(This is Condition 23 of the SE for the base AURORA-B TR. It remains applicable to CRDA analyses for BWRs/2-6.)*

The condition is met as ATRIUM 11 exhibits the structural similarities described in the restriction.

24. Changes may be made to the AURORA-B EM in the [

] areas discussed in Section 4.0 of Reference 6 (the SE for the base AURORA-B TR) without prior NRC approval. (This is Condition 24 of the SE for the base AURORA-B TR. It remains applicable to CRDA analyses for BWRs/2-6.).

No confirmation is required for this condition.

25. The parallelization of individual CCDs may be performed without prior NRC approval as discussed in Section 4.0 of Reference 6 (the SE for the base AURORA-B TR). (This is Condition 25 of the SE for base AURORA-B TR. It remains applicable to CRDA analyses for BWRs/2-6.)

No confirmation is required for this condition.

26. AREVA must continue to use existing regulatory processes for any code modifications made in the [

] areas discussed in Section 4.0 of Reference 6 (the SE for the base AURORA-B TR). *(This is Condition 26 of the SE for the base AURORA-B TR. It remains applicable to CRDA analyses for BWRs/2-6.)*

This condition is met through the use of the Framatome software development procedures, which provides information for use in the licensee’s 10 CFR 50.59 licensing evaluation.

27. The control rod model at each location in the core used for CRDA analyses with the AURORA-B EM shall use a control rod geometry and composition that is verified to bound the control rod worth for the physical control rod used that location, for all axial elevations. *(This is a new condition from this report.)*

[

] Therefore, this condition is met.

28. Licensees utilizing AURORA-B to perform CRDA analyses using the methodology described in this TR shall confirm that the recommended maximum rod velocity of 3.11 ft/s is conservative for their control rods. *(This is a new condition from this report.)*

The licensee has confirmed the conservatism of this value.

29. If the check to verify that the total enthalpy is limiting at 10 percent core flow CZP conditions by [

] fails, AREVA shall perform a more comprehensive evaluation to verify that they have identified the limiting initial conditions for that plant. This evaluation should consider a range of flow values and corresponding plant-specific minimum temperatures that is sufficiently broad to clearly identify the combination of initial conditions which maximizes the total enthalpy for the limiting rod. *(This is a new condition from this report.)*

[

] is conservative for Browns Ferry with ATRIUM 11 for determining total enthalpy.

30. When individual control rods are evaluated using the CRDA analysis methodology, if necessary, alternate distributions of inoperable rods should be utilized to ensure inclusion of at least one evaluation within each group of 4 quadrant symmetric control rods that maximizes the change in face- and/or diagonally-adjacent uncontrolled cells as a result of the candidate control rod withdrawal. *(This is a new condition from this report.)*

The inoperable control blade patterns were evaluated for all rods [

] For the Browns Ferry core, localizing the inoperable rods to one area of the core increases the static worth of the dropped rod in the opposite part of the core.

31. The evaluation boundary curve used to determine candidate control rods for further evaluation based on their static rod worths must be verified to bound the following local characteristics of the fuel being evaluated: design pin peaking factors, fuel assembly design, location in or adjacent to the outermost ring of control rods, and average burnup for the 16 fuel assemblies surrounding the rod of interest.

This evaluation boundary region of applicability is presented in Appendix A of this analysis and shows that this condition is met.

32. If the highest worth rod at a given core statepoint results in a total enthalpy that is higher than the minimum high temperature failure threshold (i.e., lowest threshold for all rod internal pressures), additional rods must be considered for evaluation. This may be done by evaluating the next highest worth rods at the core statepoint of interest until the minimum high temperature failure threshold is met, or by using an approach analogous to the evaluation boundary curve used for the PCMI failure threshold (as subject to condition 29).

The highest rod dropped resulted in a total enthalpy which exceeded the minimum high temperature failure threshold. Therefore, additional rods were evaluated to address this condition.

33. If the methodology described in ANP-10333 is used to analyze the CRDA event with a fuel assembly design that has a different fuel rod geometry and/or manufacturing tolerances than the one used as a basis for the sensitivity study on gap width, the sensitivity study shall be repeated for the new fuel assembly design, using bounding values consistent with the uncertainty range for [

] limiting increase in the peak total enthalpy, the total uncertainty shall be increased accordingly for total enthalpies calculated based on the new fuel assembly design. *(This is a new condition from this report.)*

The ATRIUM 11 product line requires an evaluation of the gap sensitivity study. The sensitivity studies were performed with a bounding value for the uncertainty range of [ ] The resulting increase in peak total enthalpy is [ ]

34. The uncertainty designated in the CRDA TR of [ ] for the enthalpy rises calculated using the CRDA analysis methodology may not be reduced without prior NRC approval. (This is a new condition from this report.)

The uncertainty of [ ] is used in this evaluation.

9.0 REFERENCES

1. ANP-3854P, Revision 2, *Browns Ferry ATRIUM 11 Equilibrium Cycle, Fuel Cycle Design*, Framatome, June 2022.

2. DG-1327, *Pressurized-Water Reactor Control Rod Ejection and Boiling-Water Reactor Control Rod Drop Accidents*, July 2019 (NRC ADAMS ML18302A106).

3. RG 1.236, *Pressurized-Water Reactor Control Rod Ejection and Boiling-Water Reactor Control Rod Drop Accidents*, June 2020 (NRC ADAMS ML20055F490).

4. RG 1.183, *Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors*, July 2000 (ML003716792).

5. ANP-10333P-A, Revision 0, *AURORA-B: An Evaluation Model for Boiling Water Reactors; Application to Control Rod Drop Accident (CRDA)*, Framatome Inc., March 2018.

6. ANP-10300P-A, Revision 1, *AURORA-B: An Evaluation Model for Boiling Water Reactors; Application to Transient and Accident Scenarios*, Framatome Inc., January 2018.

7. ANP-10335P-A, Revision 0, A*CE/ATRIUM 11 Critical Power Correlation Topical Report*, Framatome Inc., May 2018.

8. BAW-10247PA Revision 0 Supplement 1P-A Revision 0, *Realistic Thermal- Mechanical Fuel Rod Methodology for Boiling Water Reactors Supplement 1: Qualification of RODEX4 for Recrystallized Zircaloy-2 Cladding*, AREVA Inc., April 2017.

9. BRUNSWICK STEAM ELECTRIC PLANT, UNITS 1 AND 2 – ISSUANCE OF AMENDMENT NOS. 299 AND 327 TO REVISE TECHNICAL SPECIFICATION 5.6.5b TO ALLOW APPLICATION OF ADVANCED FRAMATOME ATRIUM 11 FUEL METHODOLOGIES (EPID L-2018-LLA-0273) (ADAMS ML 20073F186).

Appendix A Evaluation Threshold Determination

Limitation and Condition 31 states:

31. The evaluation boundary curve used to determine candidate control rods for further evaluation based on their static rod worths must be verified to bound the following local characteristics of the fuel being evaluated: design pin peaking factors, fuel assembly design, location in or adjacent to the outermost ring of control rods, and average burnup for the 16 fuel assemblies surrounding the rod of interest.

The process to generate an evaluation threshold is demonstrated based upon the process described in the response to RAI-5 in ANP-10333Q1P (included in Reference 5). The peak fuel rod enthalpy rise was elevated using a multiplication factor of [ ] to double the uncertainty. The elevated enthalpy rise values were then tabulated against the static control rod worth.

Figure A-1 Establishing Evaluation Boundary

[ ]

Figure A-2 Evaluation Boundary for ATRIUM 11 Core

The local characteristics of fuel used to establish the evaluation boundary with respect to design fuel rod peaking factors, fuel assembly design, core location, and the average burnup of the 16 assemblies around the dropped rod have been are provided in Table A-1. This table is for use with future core licensing to confirm the applicability of the evaluation boundary curve.

Table A-1 Example Evaluation Boundary Characteristics

Appendix B Critical Heat Flux Application in Startup Range

Figure B-1 Total Enthalpy Rise with CHF Multipliers

B-1. [ ]

B-2. [ ]

B-3. [ ]

B-4. [ ]

B-5. [ ]

B-6. [ ]

B-7. [ ]

ATTACHMENT 16a

ANP-3904P Revision 5

(Proprietary)

Browns Ferry ATRIUM 11 Transient Demonstration

ATTACHMENT 16b

ANP-3904NP Revision 5

(Non Proprietary)

Browns Ferry ATRIUM 11 Transient Demonstration

framatome

Browns Ferry ATRIUM 11 Transient Demonstration

ANP-3904NP
Revision 5

July 2022

Nature of Changes

Item	Section(s) or Page(s)	Description and Justification
1	Table 4.8	Updated results for both Reduced Feedwater Temperature at Startup cases.
2	Page 5-1	Updated proprietary markings in Section 5.1.1.
3	Section 6.0	Updated revision number and date issued for References 3, 4, and 5.

Contents

Tables

Figures

Nomenclature

AOO	anticipated operational occurrence
AOT	abnormal operational transient
ASME	American Society of Mechanical Engineers
AST	alternate source term
ATWS	anticipated transient without scram
ATWS-RPT	anticipated transient without scram recirculation pump trip
BFN	Browns Ferry Nuclear Plant
BOC	beginning of cycle
BWR	boiling water reactors
COLR	core operating limits report
CRDA	control rod drop accident
EM	evaluation model
EOC-RPT	end of cycle recirculation pump trip
EOC-RPT-OOS	end of cycle recirculation pump trip out of service
EOCLB	end of cycle licensing basis
EOFP	end of full power
EOOS	equipment out of service
FFTR	final feedwater temperature reduction
FHOOS	feedwater heater out of service
FoM	figure of merit
FSAR	final safety analysis report
FWCF	feedwater controller failure
HPCI	high pressure coolant injection
IHPS	inadvertent HPCI pump start
IORV	inadvertent opening of relief valve
LAR	license amendment request
LFWH	loss of feedwater heating
LHGR	linear heat generation rate
LHGRFACp	power dependent linear heat generation rate multipliers
LOCA	loss of coolant accident
LOFW	loss of feedwater flow
LRNB	generator load rejection no bypass
LTR	licensing topical report

Nomenclature (continued)

MAPLHGR	maximum average planar linear heat generation rate
MCPR	minimum critical power ratio
MCPRp	power dependent minimum critical power ratio
MELLLA+	maximum extended load line limit analysis plus
MSIV	main steam isolation valve
NEOC	near end of cycle
NRC	Nuclear Regulatory Commission, U.S.
NSS	nominal scram speed
Pbypass	power below which direct scram on TSV/TCV closure is bypassed
PLU	power load unbalance
PLUOOS	power load unbalance out of service
PRFO	pressure regulator failure open
RHR	residual heat removal
RPT	recirculation pump trip
SRV	safety/relief valve
SRVOOS	safety/relief valve out-of-service
TBVOOS	turbine bypass valves out of service
TCV	turbine control valve
TSV	turbine stop valve
TTNB	turbine trip no bypass
ΔMCPR	change in minimum critical power ratio

1.0 INTRODUCTION

This report summarizes the results of a subset of transient analyses performed to support the license amendment request (LAR) to include the Reference 1 and Reference 2 Licensing Topical Reports (LTR) into the Browns Ferry Nuclear Plant (BFN) Technical Specifications.

For a typical reload, a full assessment of the power/flow map, cycle exposure, and scram speed are done on a cycle specific basis for the actual core configuration to develop thermal limits. The intention of this report is to demonstrate the applicability of the AURORA-B AOO methodology (Reference 1) to Browns Ferry for the transient analyses that are typically limiting on a cycle-specific basis. Therefore, this document is a subset of transient analysis typically performed for each cycle.

The analyses presented in Section 4 of this document are based upon a representative equilibrium cycle of ATRIUM 11 fuel, Reference 3. A variety of power/flow state points are performed at a cycle exposure and scram speed discussed in each subsection of Section 4.

The AURORA-B AOO analysis is used to calculate the change in the minimum critical power ratio (ΔMCPR) during the anticipated operational occurrence (AOO). The ΔMCPR is combined with the safety limit MCPR to establish or confirm the plant operating limits for MCPR.

The AURORA-B AOO analysis is also used to calculate the maximum reactor vessel pressure and the maximum dome pressure during the ASME and ATWS events. The calculated maximum reactor vessel pressure is compared to the ASME acceptance criterion (110% of vessel design pressure) and the calculated maximum steam dome pressure is compared to the pressure safety limit in the plant Technical Specifications. For the ATWS event, the calculated maximum reactor vessel pressure is compared to ASME Service Level C (120% of design pressure) to demonstrate that the event acceptance criterion is met. Meeting the acceptance criteria confirms that the plant safety valve performance (number of valves available, capacity per valve, and setpoints) is acceptable.

The ACE/ATRIUM 11 critical power correlation (Reference 2) is used to evaluate the thermal margin of the ATRIUM 11 fuel.

2.0 ANTICIPATED OPERATIONAL OCCURRENCES

2.1 *AURORA-B AOO Evaluation Model*

AURORA-B is a comprehensive evaluation model developed for predicting the dynamic response of boiling water reactors (BWRs) during transient, postulated accident, and beyond design-basis accident scenarios. The evaluation model (EM) contains a multi-physics code system with flexibility to incorporate all the necessary elements for analysis of the full spectrum of BWR events that are postulated to affect the nuclear steam supply system of the BWR plant. Deterministic analysis principles are applied to satisfy plant operational and Technical Specification requirements through the use of conservative initial conditions and boundary conditions.

The foundation of AURORA-B AOO is built upon three computer codes, S-RELAP5, MB2-K, and RODEX4. Working together as a system, they make up the multi-physics evaluation model that provides the necessary systems, components, geometries, processes, etc. to assure adequate predictions of the relevant BWR event characteristics for its intended applications. The three codes making up the foundation of the code system are:

- S-RELAP5 – This code provides the transient thermal-hydraulic, thermal conduction, control systems, and special process capabilities (i.e., valves, jet-pumps, steam separator, critical power correlations, etc.) necessary to simulate a BWR plant.

- MB2-K – This code uses advanced nodal expansion methods to solve the three-dimensional, two-group, neutron kinetics equations. The MB2-K code is consistent with the MICROBURN-B2 steady state core simulator. MB2-K receives a significant portion of its input from the steady state core simulator.

- RODEX4 – A subset of routines from this code are used to evaluate the transient thermal-mechanical fuel rod (including fuel/clad gap) properties as a function of temperature, rod internal pressure, etc. The fuel rod properties are used by S-RELAP5 when solving the transient thermal conduction equations in lieu of standard S-RELAP5 material property tables.

2.2 *Description of [ ] Analysis Process*

The AURORA-B AOO methodology (Reference 1) includes an evaluation of the impact of code uncertainties on Figures of Merit (FoM) (e.g., ΔMCPR, peak pressure) **[**

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that has wide acceptance in the nuclear industry.

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Table 2.1 [

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2.2.1 **Sampled Parameters [ ]**

The set of code and modeling uncertainty parameters to be sampled for AOO calculations is shown in Table 2.2.

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2.2.2 **Sampling Ranges**

The sampling ranges shown in Table 2.2 are applicable to Browns Ferry Units 1, 2, and 3. Per the approved methodology (Reference 1), the sampling ranges address uncertainties inherent in the S-RELAP5 models **[**

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* Framatome Inc. formerly known as AREVA Inc.

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A description of the basis for the sampling ranges used for each of the above sampled variables is found in Reference 1 Safety Evaluation, Sections 3.6.4.1 – 3.6.4.17.

Table 2.2 Sampling Ranges for Uncertainty Parameters

2.3 *Application [ ] for Demonstration Cases*

The statistical analysis process presented in the previous sections will be used to determine the **[ ]** values for FoMs associated with the nominal transient simulations performed to demonstrate the methodology application to the equilibrium ATRIUM 11 core. Section 3.6.5 of the Safety Evaluation (Reference 1) allows for subsequent analyses to utilize the **[ ]** to determine base conservative measures to be applied for calculation of the key FoM in future reload licensing. **[ ]**

3.0 AURORA-B AOO METHODOLOGY IMPLEMENTATION TO BROWNS FERRY FSAR CHAPTER 14 EVENTS

3.1 *Disposition of Events*

The objective of the disposition of events is to identify the limiting events which must be analyzed to support operation at the Browns Ferry Nuclear Plant with the introduction of ATRIUM 11 fuel. Events and analyses identified as potentially limiting are either evaluated generically or on a cycle-specific basis.

The first step is to identify the licensing basis of the plant. Included in the licensing basis are descriptions of the postulated events/analyses and the associated criteria. Fuel-related system design criteria must be met, ensuring regulatory compliance and safe operation. The licensing basis, related to fuel and applicable for reload analysis, is contained in the Final Safety Analysis Report (FSAR), the Technical Specifications, Core Operating Limits Reports (COLR), and other reload analysis reports.

For the introduction of ATRIUM 11 fuel, Framatome reviewed all fuel-related design criteria, events, and analyses identified in the licensing basis. In many cases, when operating limits are established to ensure acceptable consequences of an abnormal operational transient (AOT) or accident, the fuel-related aspects of the system design criteria are met. All fuel-related events were reviewed and dispositioned into one of the following categories:

1. No further analysis required. This classification may result from one of the following:
    a. The consequences of the event are bound by consequences of a different event.
    b. The consequences of the event are benign, i.e., the event causes no significant change in margins to the operating limits.
    c. The event is not affected by the introduction of ATRIUM 11 fuel and/or the current analysis of record remains applicable.
2. Address event each reload. The consequences of the event are potentially limiting and need to be addressed each reload.

3. Address for initial reload. This classification may result from one of the following:
    a. The analysis is performed using conservative bounding assumptions and inputs such that the initial reload results will remain applicable for future reloads of the same fuel design.
    b. Results from the first reload will be used to quantitatively demonstrate that the results remain applicable for future reloads of the same fuel design because the consequences are benign or bound by those of another event.

A disposition of events summary is presented in Table 3.1. The disposition summary presents a list of the events and analyses, the corresponding FSAR section, the disposition status, and any applicable comments. In each comment, the basis of the disposition is categorized as:

- FSAR analysis
- Generic analysis. A bounding analysis that is independent of plant type.
- Plant specific analysis. The analysis is based on Browns Ferry (independent of unit) and is bounding for cycle-to-cycle variations.
- Cycle specific analysis. The analysis is specific to the Unit and Cycle.

Table 3.1 Disposition of Events Summary for Introduction of ATRIUM 11 Fuel at Browns Ferry

FSAR Section	Event /Analysis	Disposition Status	Comments
14.5.2.1	Generator trip (TCV fast closure)	No further analyses required	Bound by the generator trip with turbine bypass valve failure.
14.5.2.2	Generator trip (TCV fast closure) with turbine bypass valve failure	Address each reload	Cycle specific analysis. This event is a potentially limiting AOT.
14.5.2.2.4	LRNB with EOC-RPT-OOS	Address each reload	Cycle specific analysis. This event is a potentially limiting AOT.
14.5.2.3	Loss of condenser vacuum	No further analyses required	FSAR analysis. Transient is equivalent to the turbine trip with bypass operable; therefore, this event is bound by the turbine trip with turbine bypass valve failure.
14.5.2.4	Turbine trip (TSV closure)	No further analyses required	Bound by the turbine trip with turbine bypass valve failure.
14.5.2.5	Turbine bypass valves failure following turbine trip (TTNB), high power	Address initial reload	Plant specific analysis, unless determined to potentially be limiting. Generally bound by the generator trip with turbine bypass valve failure. Comparison provided in Table 4.1.
14.5.2.6	Turbine bypass valves failure following turbine trip (TTNB), low power	No further analysis required.	FSAR analysis. Generally bound by the generator trip with turbine bypass valve failure. Comparison provided in Table 4.1.
14.5.2.7	Main steam isolation valve closure	No further analyses required	FSAR analysis. The MSIV closure is bound by the LRNB event.
14.5.2.8	Pressure regulator failure (downscale)	No further analyses required	FSAR analysis. Eliminated as an AOT by the installation of a digital fault-tolerant main turbine electro-hydraulic control system.

Table 3.1 Disposition of Events Summary for Introduction of ATRIUM 11 Fuel at Browns Ferry *(continued)*

FSAR Section	Event /Analysis	Disposition Status	Comments
14.5.3.1	Loss of feedwater heater (LFWH)	Address each reload	Cycle specific analysis. Generally bound by the FWCF event. Addressed each cycle to demonstrate it remains bound by the other events.
14.5.3.2	Shutdown cooling (RHR) malfunction – decreasing temperature	No further analyses required	FSAR analysis. Benign event.
14.5.3.3	Inadvertent HPCI pump start (IHPS)	Address for initial reload	Plant specific analysis. Generally bound by the FWCF event. The IHPS event is similar to the LFWH event. The IHPS is slightly more CPR limiting, whereas the LFWH is slightly more thermal-mechanical limiting. Both IHPS and LFWH events have considerable margin to the limiting FWCF event. The LFWH transient is analyzed for each cycle to demonstrate, on a relative basis, that the LFWH and IHPS events remain non-limiting.
14.5.4.1	Continuous rod withdrawal during power range operation	Address each reload	Cycle specific analysis. This event is a potentially limiting AOT.
14.5.4.2	Continuous rod withdrawal during reactor startup	No further analyses required	FSAR analysis. Benign event.
14.5.4.3	Control rod removal error during refueling	No further analyses required	FSAR analysis. Event is not credible.
14.5.4.4	Fuel assembly insertion error during refueling	No further analyses required	FSAR analysis. An unplanned criticality during refueling due to a single fuel assembly insertion error is not credible.
	Mislocated or misoriented fuel assembly	Address each reload	Cycle specific analysis

Table 3.1 Disposition of Events Summary for
Introduction of ATRIUM 11 Fuel at Browns Ferry *(continued)*

FSAR Section	Event /Analysis	Disposition Status	Comments
14.5.5.1	Pressure regulator failure open (PRFO)	Address each reload	FSAR analysis and cycle specific analysis. The pressure regulator failure open – maximum steam demand is a potentially limiting ATWS overpressurization event, which is addressed each reload. Relative to AOT thermal operating limits, the PRFO is a benign event.
14.5.5.2	Inadvertent opening of a MSRV (IORV)	No further analysis required	FSAR analysis. Benign event.
14.5.5.3	Loss of feedwater flow (LOFW)	No further analysis required	FSAR analysis. Benign event.
14.5.5.4	Loss of auxiliary power	No further analyses required	FSAR analysis. Benign event.
14.5.6.1	Recirculation flow control failure – decreasing flow	No further analysis required	FSAR analysis. Consequences of the event are bound by the pump seizure event.
14.5.6.2	Trip of one recirculation pump	No further analyses required	FSAR analysis. Consequences of this event are benign and bound by the TTNB event.
14.5.6.3	Trip of two recirculation pumps	No further analyses required	FSAR analysis. Consequences of this event are benign and bound by the TTNB event.
14.5.6.4	Recirculation pump seizure	Address initial reload	Plant specific analysis unless determined to be limiting. Evaluate the TLO and SLO pump seizure event as part of the initial reload to determine the impact, if any, on thermal limits.
14.5.7.1	Recirculation flow control failure - increasing flow	Address each reload	Cycle specific analysis. Consequences of the slow flow run-up event determine the flow-dependent MCPR and LHGR operating limits and are evaluated each reload.

Table 3.1 Disposition of Events Summary for Introduction of ATRIUM 11 Fuel at Browns Ferry *(continued)*

FSAR Section	Event /Analysis	Disposition Status	Comments
14.5.7.2	Startup of idle recirculation loop	No further analysis required	FSAR analysis. Benign event.
14.5.8.1	Feedwater controller failure (FWCF) - maximum demand	Address each reload	Cycle specific analysis. This event is a potentially limiting AOT.
14.5.8.2	Feedwater controller failure (FWCF) - maximum demand with EOC-RPT-OOS	Address each reload	Cycle specific analysis. This event is a potentially limiting AOT.
14.5.8.3	Feedwater controller failure (FWCF) - maximum demand with TBVOOS	Address each reload	Cycle specific analysis. This event is a potentially limiting AOT.
14.5.9	Loss of habitability of the control room	No further analyses required	FSAR analysis. This is postulated as a special event to demonstrate the ability to safely shutdown the reactor from outside the control room. Not impacted by AURORA-B AOO implementation or addition of ATRIUM 11 fuel design.
14.6.2	Control rod drop accident (CRDA)	Address each reload	Cycle specific analysis. Consequences of the CRDA are evaluated to confirm the acceptance criteria are satisfied.
14.6.3	Loss-of-coolant accident (LOCA)	Address initial reload	Plant specific analysis and cycle specific parameter confirmation. The break spectrum analysis is addressed for the initial ATRIUM 11 reload, Reference 5. Consequences of the LOCA are evaluated to determine appropriate fuel-specific MAPLHGR limits which are independent of cycle specific assembly designs. Limiting power history, gad LHGR confirmation, and MAPLHGR checks are performed for follow-on reloads.

Table 3.1 Disposition of Events Summary for
Introduction of ATRIUM 11 Fuel at Browns Ferry *(continued)*

FSAR Section	Event /Analysis	Disposition Status	Comments
14.6.4	Refueling accident	Address each reload	Plant specific analysis. Consequences of the refueling accident are evaluated to confirm the acceptance criteria are satisfied.
14.6.5	Main steam line break accident	No further analysis required	FSAR analysis and Reference 5. The consequences of a large steam line break are far from limiting with respect to 10 CFR 50.46 acceptance criteria. Radiological dose consequences are performed utilizing AST in accordance with 10 CFR 50.67. The consequences of the event are not a function of fuel type since no fuel failures are calculated to occur. The dose is a function of the radionuclide inventory in the coolant itself prior to the event.
10.11	Fire protection systems	Address initial reload	Plant specific analysis. Confirmation of NFPA 805 acceptance criteria for ATRIUM 11 will be addressed in the Reload Safety Analysis report.

3.2 *Cycle-Specific Calculation Plan Development and Analysis Considerations for Limit Generation and Plant Operation*

The disposition of events evaluation for a plant defines the transient events to be analyzed on a cycle specific basis. Prior to a specific cycle's licensing campaign, a calculation plan is generated, which defines the minimum analysis set required to license a given cycle. This plan is reviewed and approved by Browns Ferry. Additional analyses may be added during the evaluation process if unexpected trends arise. These are added on an as-needed basis to ensure that the thermal limits used to monitor actual plant operation are appropriately developed.

The calculation plan will also define all operational flexibility options that are to be supported. System pressurization transient results are sensitive to scram speed assumptions. The calculation plan will provide details regarding what scram insertion speeds will be supported for cycle specific analyses. Additional items discussed are equipment out-of-service options (EOOS) and exposure windows.

3.2.1 Exposure Analysis

Cycle specific thermal limits are developed based on exposure ranges discussed in the calculation plan. The limiting exposure for rated power pressurization transients is typically at end of full power (EOFP) when the control rods are fully withdrawn. To provide additional margin to the operating limits, thermal limits are typically developed for multiple exposures ranges for the cycle being evaluated. The typical exposure ranges cover beginning-of-cycle (BOC) to a near end-of-cycle (NEOC) core average exposure, BOC to the end-of-cycle licensing basis (EOCLB) analysis, and BOC to extended cycle operation with FFTR and power coastdown.

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3.2.2 State Point Determination

The statepoints to be analyzed are also defined in the calculation plan. The initial transition to AURORA-B methods will include **[**

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4.0 ANALYSIS OF PLANT TRANSIENTS

Framatome's licensing methodology is based upon core conditions established by a detailed step-through calculation. In support of demonstrating the AURORA-B AOO method to the Browns Ferry units, plant transients are analyzed for a small subset of power and flow conditions at a cycle exposure and scram speed discussed in each subsection. The transient analyses, presented in this section, are performed using plant parameters provided by the utility for a full core of ATRIUM 11 fuel.

The transient events chosen to demonstrate the application of the AURORA-B AOO method are typical limiting events for Browns Ferry as determined from previous cycle analyses and a review of Chapter 14 of the final safety analysis report (FSAR), as shown in Section 3.1 of this report.

4.1 *Transient Events – Base Case*

4.1.1 Load Rejection No Bypass (LRNB)

Load rejection causes a fast closure of the turbine control valves. The resulting compression wave travels through the steam lines into the vessel and creates a rapid pressurization. The increase in pressure causes a decrease in core voids, which in turn causes a rapid increase in power. Fast closure of the turbine control valves also causes a reactor scram and recirculation pump trip (RPT). Turbine bypass system operation, which also mitigates the consequences of the event, is not credited. The excursion of the core power due to the void collapse is terminated primarily by the reactor scram and revoiding of the core.

LRNB analyses assume the power load unbalance (PLU) is inoperable for power levels less than 50% of rated. The LRNB sequence of events is different than the standard event when the PLU is inoperable. Instead of a fast closure, the TCVs close in servo mode and there is no direct scram on TCV closure. The power and pressure excursion continues until the high pressure scram occurs. Given that there is no direct scram when the PLU is inoperable, the LRNB event above and below P_{bypass} at 26% power is identical for the same state point.

To demonstrate the AURORA-B AOO transient methodology models the LRNB event appropriately, LRNB analyses were performed for the following range of conditions within the approved MELLLA+ power/flow map:

- 100% core power, with 105%, 95%, and 85% core flow
- 77.6% core power, with 109% and 95% core flow
- 50% core power, with 113% core flow
- 26% core power above Pbypass, with 113% core flow
- 26% core power below Pbypass, with 100% core flow

Table 4.1 presents the change in MCPR for the LRNB event. The transient analyses are performed at the end of full power (EOFP) cycle exposure, utilizing NSS insertion times. Table 4.2 presents the sequence of event timing for the LRNB event at 100% power with 105% core flow. Figures 4.1 – 4.3 show the responses of various reactor and plant parameters during the LRNB event initiated at 100% of rated power and 105% of rated core flow with NSS insertion times.

4.1.2 Turbine Trip No Bypass (TTNB)

A turbine trip event can be initiated as a result of several different signals. The initiating signal causes the TSV to close in order to prevent damage to the turbine. The TSV closure creates a compression wave traveling through the steam lines into the vessel causing a rapid pressurization. The increase in pressure results in a decrease in core voids, which in turn causes a rapid increase in power. Closure of the TSV also causes a reactor scram and an RPT which helps mitigate the pressurization effects. In addition to the TSV closure, the TCVs also close in the fast closure mode. Because of the partially closed initial position of the control valves, they will typically close faster than the stop valves and control the pressurization portion of the event. However, TCV closure characteristics are nonlinear so that the resulting core pressurization and

ΔMCPR results may not always bound those of the slower TSV closure at rated power. The limiting of TCV or TSV closure, for the initial operating conditions, was used in the TTNB analyses based on sensitivity analyses. Turbine bypass system operation, which also mitigates the consequences of the event, is not credited. The excursion of the core power due to the void collapse is terminated primarily by the reactor scram and revoiding of the core.

To demonstrate the AURORA-B AOO transient methodology models the TTNB event appropriately, TTNB analyses were performed for the following range of conditions within the approved MELLLA+ power/flow map:

- 100% core power, with 105%, 95%, and 85% core flow
- 77.6% core power, with 109% and 95% core flow
- 26% core power above Pbypass, with 113% core flow
- 26% core power below Pbypass, with 100% core flow

Table 4.1 presents the change in MCPR for the TTNB event. The transient analyses are performed at the EOFP cycle exposure, utilizing NSS insertion times. Table 4.3 presents the sequence of event timing for the TTNB event at 100% power with 105% core flow. Figures 4.4 – 4.6 show the responses of various reactor and plant parameters during the TTNB event initiated at 100% of rated power and 105% of rated core flow with NSS insertion times.

4.1.3 **Feedwater Controller Failure (FWCF)**

The increase in feedwater flow due to a failure of the feedwater control system to maximum demand results in an increase in the water level and a decrease in the coolant temperature at the core inlet. The increase in core inlet subcooling causes an increase in core power. As the feedwater flow continues at maximum demand, the water level continues to rise and eventually reaches the high water level trip setpoint. The initial water level is conservatively assumed to be at the low level normal operating range to delay the high-level trip and maximize the core inlet subcooling resulting from the FWCF. The high water level trip causes the TSVs to close in order to prevent damage to the turbine from excessive liquid inventory in the steam line. Valve closure creates a compression wave traveling back to the core, causing void collapse and subsequent rapid power excursion. The closure of the TSVs also initiates a reactor scram and an RPT. In addition to the TSV closure, the TCVs also close in the fast closure mode. Because of the partially closed initial position of the control valves, they will typically close faster than the stop valves and control the pressurization portion of the event. However, TCV closure characteristics are nonlinear so that the resulting core pressurization and ΔMCPR results may not always bound those of the slower TSV closure at rated power (steam flow increases above rated before fast TCV closure). The limiting of TCV or TSV closure, for the initial operating conditions, was used in the FWCF analyses based on sensitivity analyses. The turbine bypass valves are assumed operable and provide some pressure relief. The core power excursion is mitigated in part by pressure relief, but the primary mechanisms for termination of the event are reactor scram and revoiding of the core.

To demonstrate the AURORA-B AOO transient methodology models the FWCF event appropriately, FWCF analyses were performed for the following range of conditions within the approved MELLLA+ power/flow map:

- 100% core power, with 105%, 95%, and 85% core flow
- 77.6% core power, with 109%, 95%, and 55% core flow
- 26% core power above Pbypass, with 113% core flow
- 26% core power below Pbypass, with 100% core flow

Table 4.1 presents the change in MCPR for the FWCF event. The transient analyses are performed at the EOFP cycle exposure, utilizing NSS insertion times. Table 4.4 presents the sequence of event timing for the FWCF event at 100% power with 105% core flow. Figures 4.7 – 4.9 show the responses of various reactor and plant parameters during the FWCF event initiated at 100% of rated power and 105% of rated core flow with NSS insertion times.

4.1.4 ASME Overpressurization Analysis

This section describes the maximum overpressurization analyses performed to demonstrate compliance with the ASME Boiler and Pressure Vessel Code. The analysis shows that the safety/relief valves at Browns Ferry have sufficient capacity and performance to prevent the reactor vessel pressure from reaching the safety limit of 110% of the design pressure.

To demonstrate the applicability of the AURORA-B AOO (Reference 1) methodology for ASME overpressurization analyses, a main steam isolation valve (MSIV) closure analysis was performed for 102% power and 105% flow and 102% power and 85% flow at the latest exposure in the cycle design. The MSIV closure event is similar to the other steam line valve closure events in that the valve closure results in a rapid pressurization of the core. The increase in pressure causes a decrease in void which in turn causes a rapid increase in power. The following assumptions were made in the analysis:

- The most critical active component (direct scram on valve position) was assumed to fail. However, scram on high neutron flux and high dome pressure is available.
- The plant configuration analyzed assumed that one of the lowest setpoint safety/relief valves (SRVs) was inoperable.
- TSSS insertion times were used.
- The initial dome pressure was set at the maximum allowed by the Technical Specifications plus an additional 5 psi bias, 1070 psia (1055 psig).
- A fast MSIV closure time of 3.0 seconds was used.
- The analytical limit ATWS-RPT setpoint and function were assumed.
- The SRV opening setpoints used in the analysis were set to the Technical Specification values increased by 3%, plus an additional 5 psi.

Results of the MSIV closure overpressurization analysis are presented in Table 4.5 and demonstrate that the maximum vessel pressure limit of 1375 psig and dome pressure limit of 1325 psig are not exceeded. Table 4.6 presents the sequence of event timing for the ASME event at 102% power with 105% core flow. Figures 4.10 – 4.13 show the response of various reactor plant parameters during the MSIV closure event.

4.1.5 ATWS Overpressurization Analysis

This section describes the analyses performed to demonstrate that the peak vessel pressure for the limiting ATWS event is less than the ASME Service Level C limit of 120% of the design pressure (1500 psig). To demonstrate the applicability of the AURORA-B AOO (Reference 1) methodology for ATWS overpressurization analyses, the ATWS event analyses were performed at 100% power at 85% and 105% flow at the beginning of cycle (BOC) exposure based on historically limiting analyses. The MSIV closure and pressure regulator failure open (PRFO) events were evaluated. Failure of the pressure regulator in the open position causes the turbine control and turbine bypass valves to open such that steam flow increases until the maximum combined steam flow limit is attained. The system pressure decreases until the low pressure setpoint is reached, resulting in the closure of the MSIVs. The resulting pressurization wave causes a decrease in core voids and an increase in core pressure thereby increasing the core power.

The following assumptions were made in the analyses:

- The analytical limit ATWS-RPT setpoint and function were assumed.
- To support operation with one SRVOOS, the plant configuration analyzed assumed that one of the lowest setpoint SRVs was inoperable.
- All scram functions were disabled.
- The initial dome pressure was set to the nominal pressure of 1050 psia.
- The MSIV closure is based on a nominal closure time of 4.0 seconds for both events.
- The SRV opening setpoints used in the analysis were set to the Technical Specification values increased by 3%, plus an additional 5 psi.

Results of the ATWS overpressurization analyses are presented in Table 4.5 and demonstrate that the ATWS maximum vessel pressure limit of 1500 psig is not exceeded. Table 4.7 presents the sequence of event timing for the ATWS MSIV closure event at 100% power with 85% core flow. Figures 4.14 – 4.17 show the response of various reactor plant parameters during the ATWS MSIV closure event, the event which results in the maximum vessel pressure.

4.2 *Transient Events – Equipment Out-Of-Service*

4.2.1 EOC Recirculation Pump Trip Out-of-Service (EOC-RPT-OOS)

When EOC-RPT is inoperable, no credit is assumed for RPT on TSV position or TCV fast closure. The function of the EOC-RPT feature is to reduce the severity of the core power excursion caused by the pressurization transient. The RPT accomplishes this by helping revoid the core, thereby reducing the magnitude of the reactivity insertion resulting from the pressurization transient. Failure of the RPT feature can result in more restrictive operating limits.

Analyses were performed for LRNB and FWCF events assuming EOC-RPT-OOS at the end of full power (EOFP) cycle exposure, utilizing NSS insertion times. Results for the LRNB and FWCF events at 100% power with 105% core flow are presented in Table 4.8 for the EOC-RPT-OOS EOOS scenario.

4.2.2 Turbine Bypass Valves Out-of-Service (TBVOOS)

The effect of operation with TBVOOS is a reduction in the system pressure relief capacity, which makes the pressurization events more severe. While the base case LRNB and TTNB events are analyzed assuming the turbine bypass valves out-of-service, operation with TBVOOS has an adverse effect on the FWCF event.

Analyses of the FWCF event with TBVOOS were performed at the end of full power (EOFP) cycle exposure, utilizing NSS insertion times. Results for the FWCF event at 100% power with 105% core flow are presented in Table 4.8 for the TBVOOS EOOS scenario.

4.2.3 **Feedwater Heaters Out-of-Service (FHOOS)**

The FHOOS scenario assumes a feedwater temperature reduction of 70°F (55°F + 15°F bias) at rated power and steam flow. The effect of reduced feedwater temperature is an increase in core inlet subcooling, changing axial power shape and core void fraction. Additionally, steam flow for a given power level decreases because more power is required to increase coolant enthalpy to saturated conditions. Generally, LRNB and TTNB events are less severe with FHOOS conditions due to the decrease in steam flow relative to nominal conditions. FWCF events with FHOOS conditions are generally worse due to a larger change in inlet subcooling and core power prior to the pressurization phase of the event.

Analyses were performed for LRNB and FWCF events assuming FHOOS at the end of full power (EOFP) cycle exposure, utilizing NSS insertion times. Results for the LRNB and FWCF events at 100% power with 105% core flow are presented in Table 4.8 for the FHOOS EOOS scenario.

4.2.4 **Power Load Unbalance Out-of-Service (PLUOOS)**

The power load unbalance (PLU) device in normal operation is assumed to not function below 50% power. PLUOOS is assumed to mean the PLU device does not function for any power level, and does not initiate fast TCV closure. The following PLUOOS scenario was assumed for the load reject event.

- Initially, the TCVs remain in pressure/speed control mode. There is no direct scram or EOC-RPT on valve motion.
- Loss of load results in increasing turbine speed. Depending on initial power, a turbine overspeed condition may be reached to initiate a turbine trip resulting in scram and EOC-RPT.
- Without a turbine trip signal, scram occurs on either high flux or high dome pressure to terminate the event.

Analyses were performed for the LRNB event assuming PLUOOS at the end of full power (EOFP) cycle exposure, utilizing NSS insertion times. Results for the LRNB event at 100% power with 105% core flow are presented in Table 4.8 for the PLUOOS EOOS scenario.

4.2.5 **Reduced Feedwater Temperature at Startup**

During reactor startup, it is beneficial to reduce feedwater temperature to avoid excessive wear on reactor equipment. The desired feedwater temperature is less than the temperature assumed in the FHOOS licensing analyses performed each cycle. Therefore, previously defined EOOS scenarios are not adequate to cover operation during startup with the desired reduction in feedwater temperature. The reduced feedwater temperatures supporting this EOOS scenario are only applicable at 50% of rated power, and below.

Analyses were performed for the FWCF event assuming these reduced feedwater temperatures, supporting both with and without TBVOOS at the beginning of cycle (BOC) exposure based on historically limiting analyses, utilizing NSS insertion times. Results for the FWCF event at 50% power with 113% core flow are presented in Table 4.8 for the reduced feedwater temperature at startup EOOS scenario.

Table 4.1 Base Case Transient Results

State Point Power / Flow (% of rated)	**ATRIUM 11 ΔMCPR**
Load Rejection No Bypass	
100 / 105	[ ]
100 / 95	[ ]
100 / 85	[ ]
77.6 / 109	[ ]
77.6 / 95	[ ]
50 / 113	[ ]
26 / 113	[ ]
26 / 100 below Pbypass	[ ]
Turbine Trip No Bypass	
100 / 105	[ ]
100 / 95	[ ]
100 / 85	[ ]
77.6 / 109	[ ]
77.6 / 95	[ ]
26 / 113	[ ]
26 / 100 below Pbypass	[ ]
Feedwater Controller Failure	
100 / 105	[ ]
100 / 95	[ ]
100 / 85	[ ]
77.6 / 109	[ ]
77.6 / 95	[ ]
77.6 / 55	[ ]
26 / 113	[ ]
26 / 100 below Pbypass	[ ]

Table 4.2 Sequence of Events Timing for the LRNB Event

Event	Time (sec)
TCV Closure Event	0.000
TCV Fast Closure Scram Signal	0.090
Reactor Scram	0.090
Time of TCV Full Closure	0.100
Recirculation Pump Trip	0.185
Peak Power	0.545
Peak Heat Flux	0.655
Time of critical heat flux	0.665
SRV Actuation	1.600
Peak Dome Pressure (1266.79 psia)	1.825
Peak Vessel Pressure (1297.17 psia)	1.830
Peak Steam Line Pressure (1279.62 psia)	2.105

Table 4.3 Sequence of Events Timing for the TTNB Event

Event	Time (sec)
TSV/TCV Closure Event*	0.000
TSV/TCV Fast Closure Scram Signal *	0.090
Reactor Scram	0.090
Time of TSV Full Closure *	0.100
Time of TCV Full Closure *	0.100
Recirculation Pump Trip	0.185
Peak Power	0.545
Peak Heat Flux	0.655
Time of critical heat flux	0.665
SRV Actuation	1.600
Peak Dome Pressure (1266.75 psia)	1.825
Peak Vessel Pressure (1297.13 psia)	1.830
Peak Steam Line Pressure (1279.63 psia)	2.105

* Analyses performed with the limiting TCV or TSV valve closure, based on sensitivity results. See Section 4.1.2 for further discussion.

Table 4.4 Sequence of Events Timing for the FWCF Event

Event	Time (sec)
FWCF Event Initiator	0.000
Level 8 – High Water Level – Trip	16.535
Level 8 – TSV/TCV Closure Signal*	18.690
TSV/TCV Motion Scram Signal*	18.780
Reactor Scram	18.780
Turbine Bypass Valves Open	18.795
Recirculation Pump Trip	18.875
Peak Power	19.235
Peak Heat Flux	19.340
Time of critical heat flux	19.350
SRV Actuation	20.445
Peak Steam Line Pressure (1233.67 psia)	20.550
Peak Dome Pressure (1238.23 psia)	20.605
Peak Vessel Pressure (1267.70 psia)	20.610

* Analyses performed with the limiting TCV or TSV valve closure, based on sensitivity results. See Section 4.1.3 for further discussion.

Table 4.5 ASME and ATWS Overpressurization Analysis Results

Event	Maximum Vessel Pressure Lower Plenum (psig)	Maximum Dome Pressure (psig)
ASME Overpressurization		
MSIV closure (102P/105F)	1346	1313
MSIV closure (102P/85F)	1341	1313
ATWS Overpressurization		
MSIV closure (100P/105F)	1,419	1,400
MSIV closure (100P/85F)	1,454	1,438

Table 4.6 Sequence of Events Timing for the ASME Overpressurization Event

Event	Time (sec)
MSIV Closure Event Initiator (3.0 sec full closure time)	0.000
High Neutron Flux Setpoint	2.545
Reactor Scram	2.640
Peak Power	3.195
SRV Actuation	3.855
Recirculation Pump Trip	4.040
Peak Heat Flux	4.135
Peak Vessel Pressure (1359.57 psia)	4.845
Peak Steam Line Pressure (1325.69 psia)	5.150
Peak Dome Pressure (1326.94 psia)	5.155

Table 4.7 Sequence of Events Timing for the ATWS Overpressurization Event

Event	Time (sec)
MSIV Closure Event Initiator (4.0 sec full closure time)	0.000
Recirculation Pump Trip Setpoint – High Pressure	4.325
Peak Power	4.840
SRV Actuation	4.890
Peak Heat Flux	5.035
Recirculation Pump Trip – High Pressure	5.080
Peak Vessel Pressure (1,468.36 psia)	11.740
Peak Steam Line Pressure (1,450.09 psia)	11.865
Peak Dome Pressure (1,451.70 psia)	11.915

Table 4.8 EOOS Transient Results

State Point Power / Flow (% of rated)	ATRIUM 11 ΔMCPR
100 / 105 Base Case – all equipment in service	
FWCF	[ ]
LRNB	[ ]
100 / 105 EOC-RPT-OOS	
FWCF	[ ]
LRNB	[ ]
100 / 105 FHOOS	
FWCF	[ ]
LRNB	[ ]
100 / 105 FHOOS with EOC-RPT-OOS	
FWCF	[ ]
LRNB	[ ]
100 / 105 PLUOOS	
LRNB	[ ]
100 / 105 PLUOOS with EOC-RPT-OOS	
LRNB	[ ]
100 / 105 PLUOOS with FHOOS	
LRNB	[ ]
100 / 105 PLUOOS, FHOOS with EOC-RPT-OOS	
LRNB	[ ]
100 / 105 TBVOOS	
FWCF	[ ]
100 / 105 TBVOOS with EOC-RPT-OOS	
FWCF	[ ]
100 / 105 TBVOOS with FHOOS	
FWCF	[ ]
100 / 105 TBVOOS, FHOOS with EOC-RPT-OOS	
FWCF	[ ]
50 / 113 Reduced Feedwater Temperature at Startup	
FWCF with startup FHOOS	[ ]
FWCF with startup FHOOS and TBVOOS	[ ]

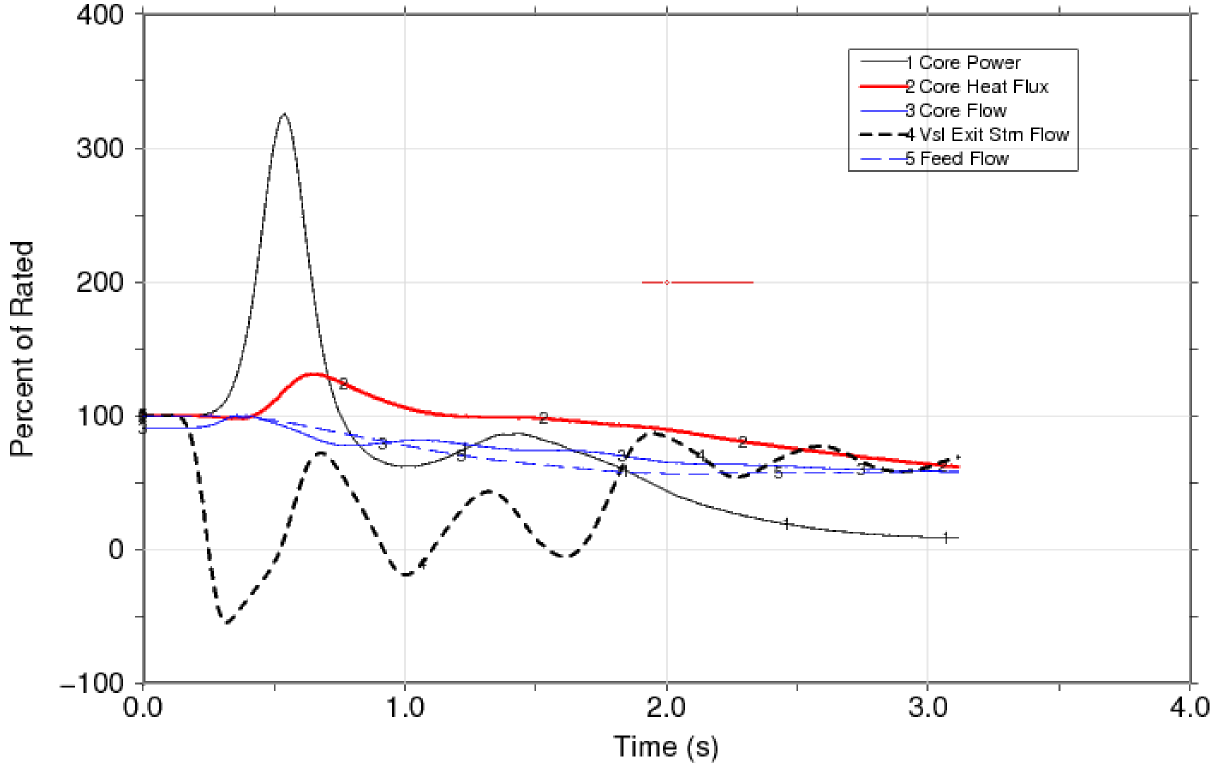

Figure 4.1 EOFP LRNB at 100P/105F – NSS Key Parameters

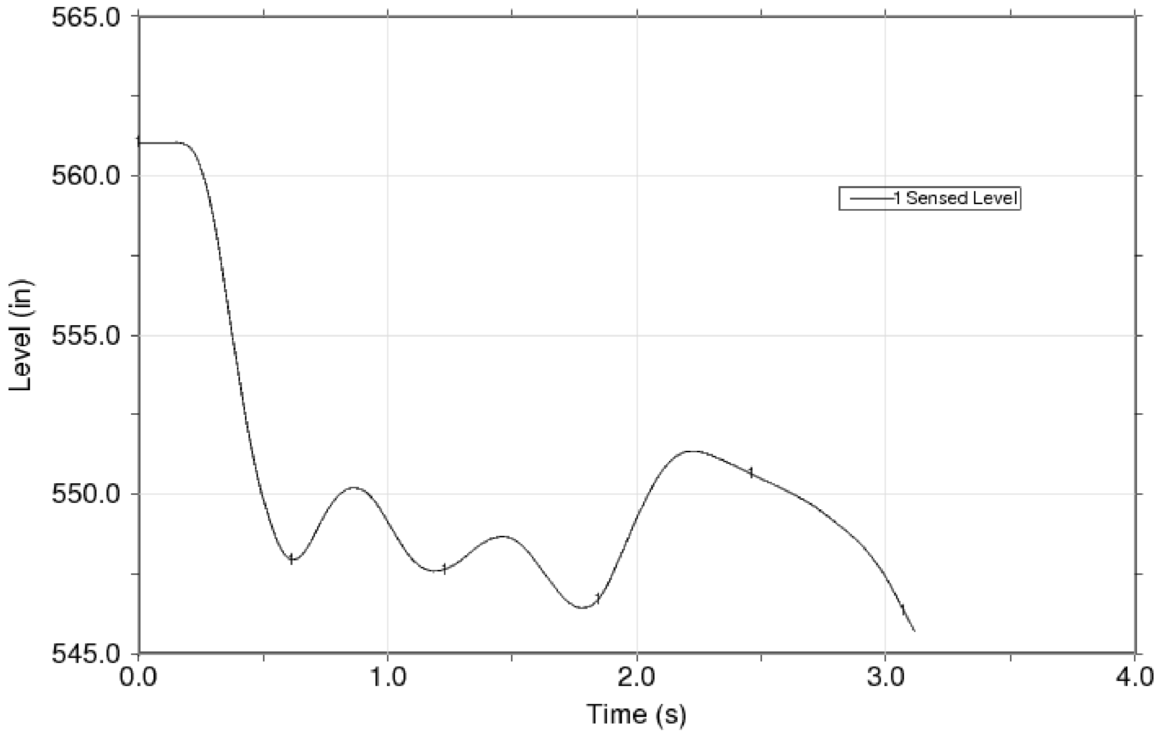

Figure 4.2 EOFP LRNB at 100P/105F – NSS Sensed Water Level

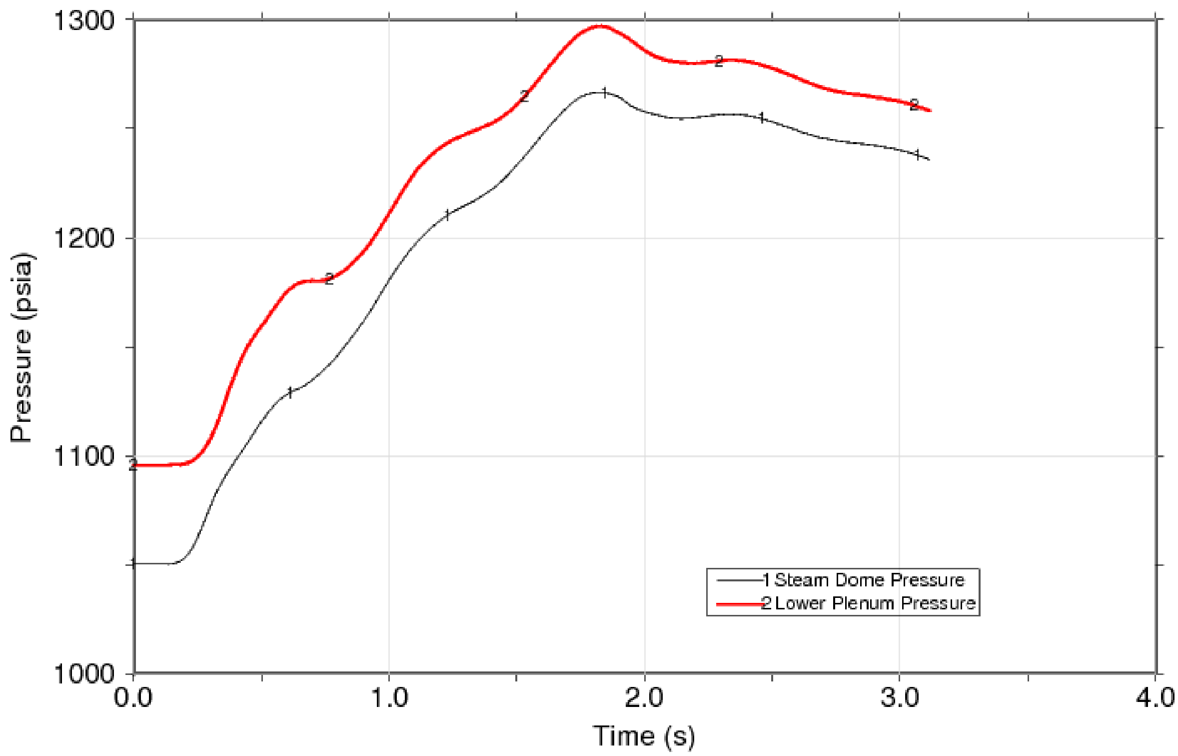

Figure 4.3 EOFP LRNB at 100P/105F – NSS Vessel Pressures

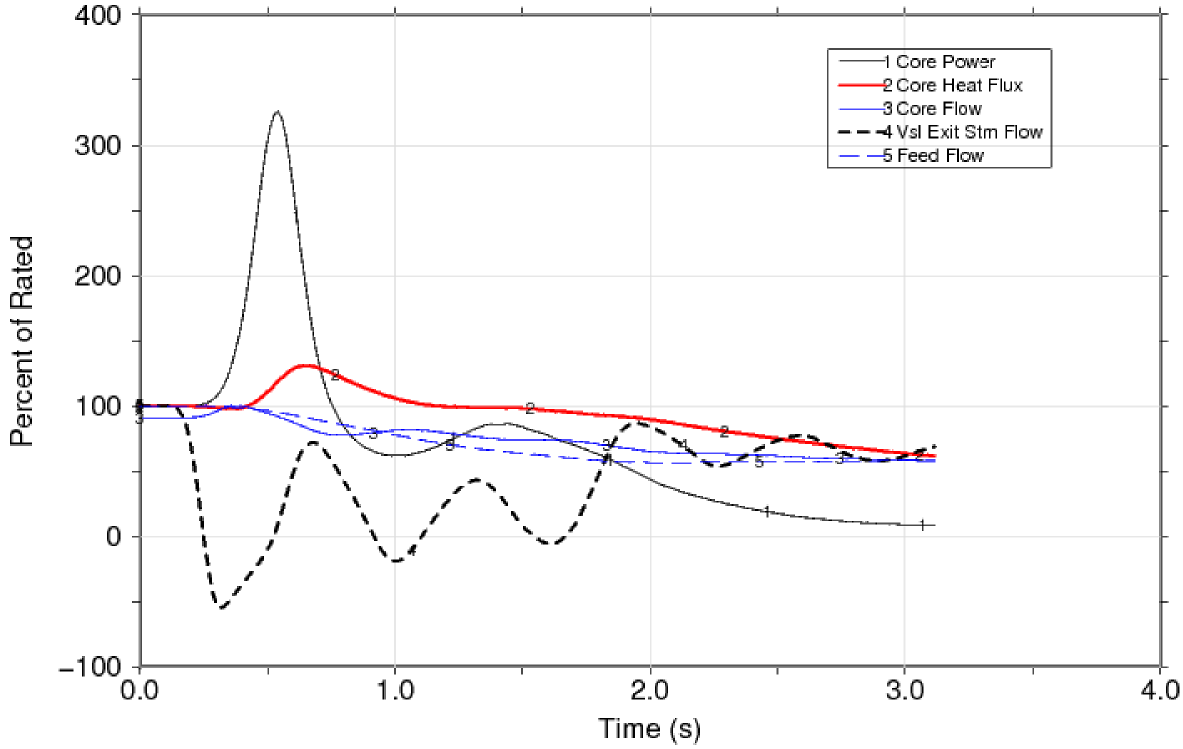

Figure 4.4 EOFP TTNB at 100P/105F – NSS
Key Parameters

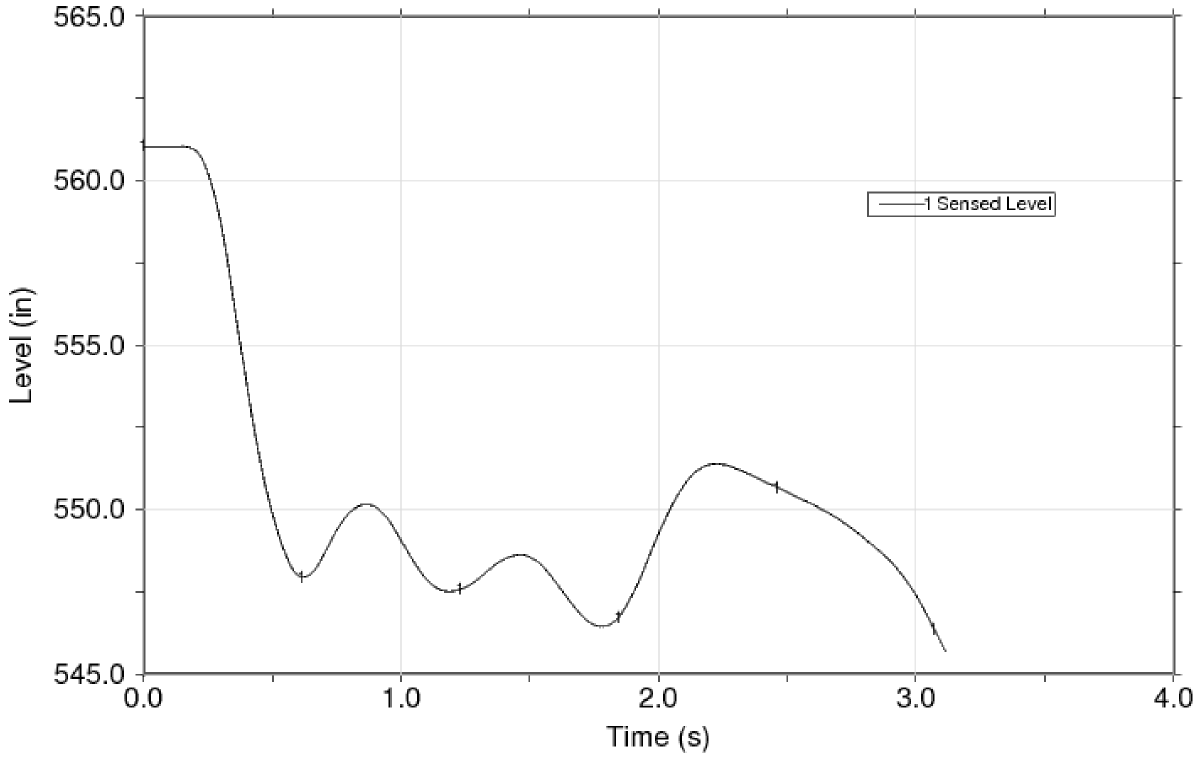

**Figure 4.5 EOFP TTNB at 100P/105F – NSS
Sensed Water Level**

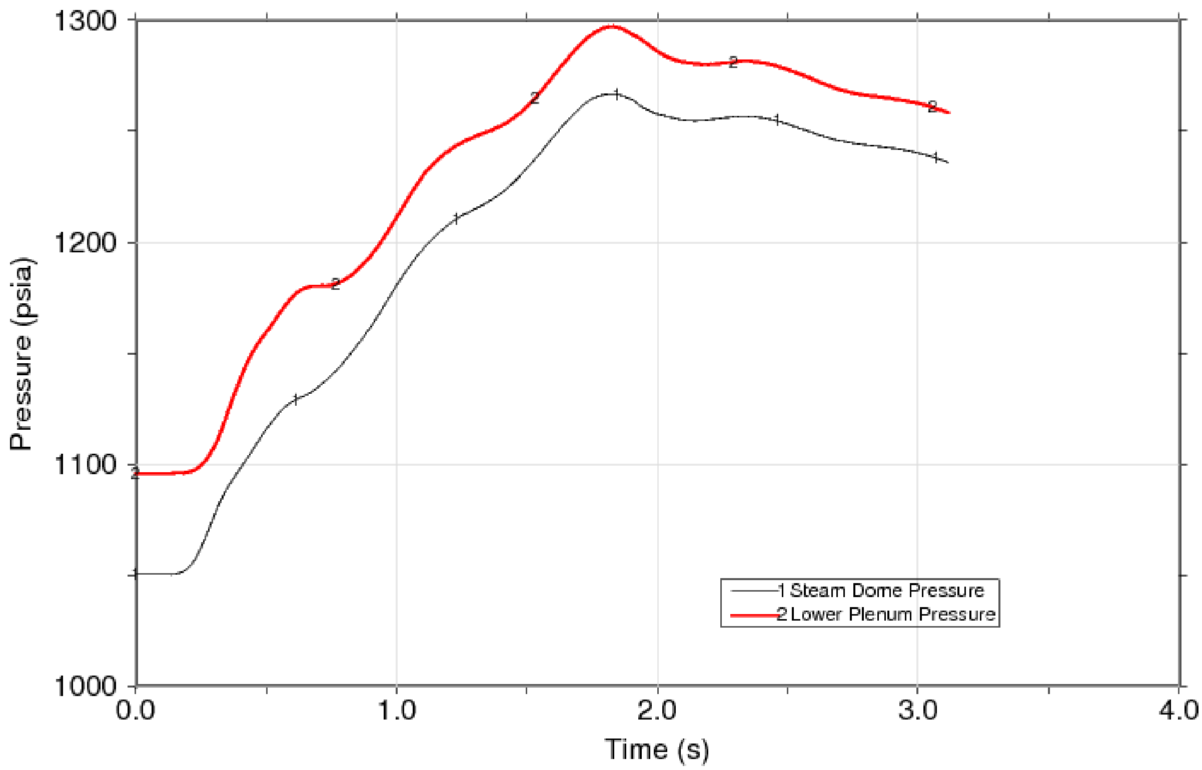

Figure 4.6 EOFP TTNB at 100P/105F – NSS Vessel Pressures

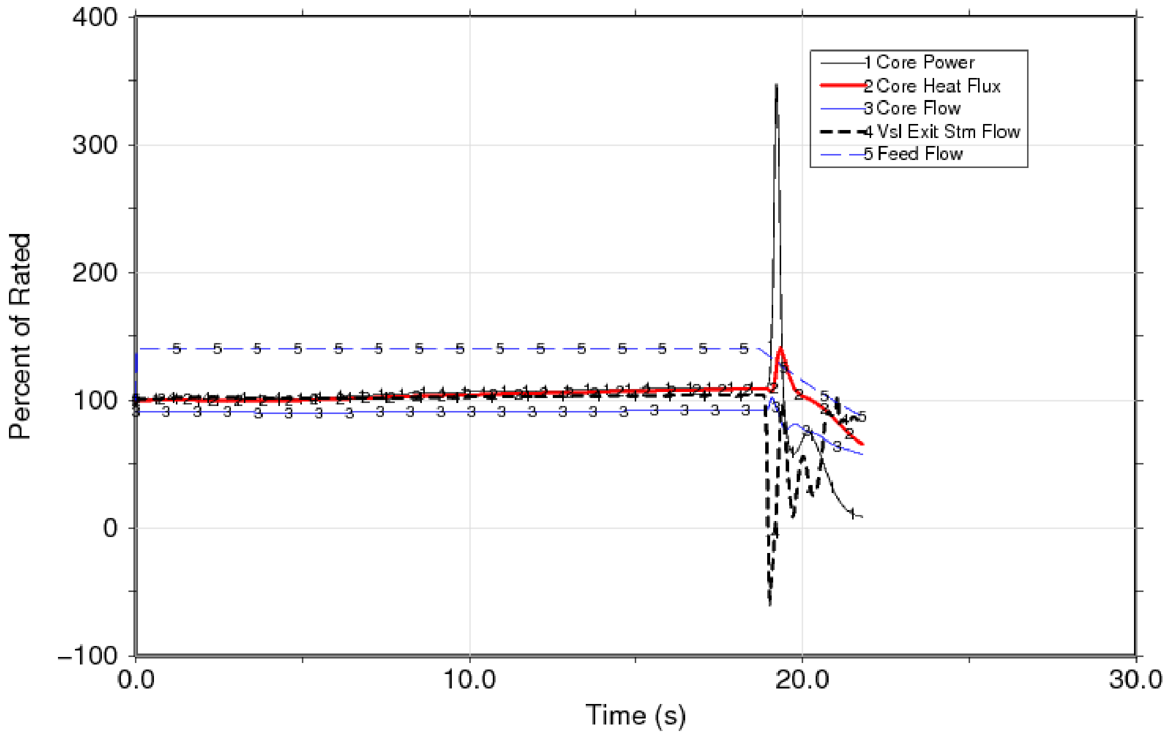

Figure 4.7 EOFP FWCF at 100P/105F – NSS Key Parameters

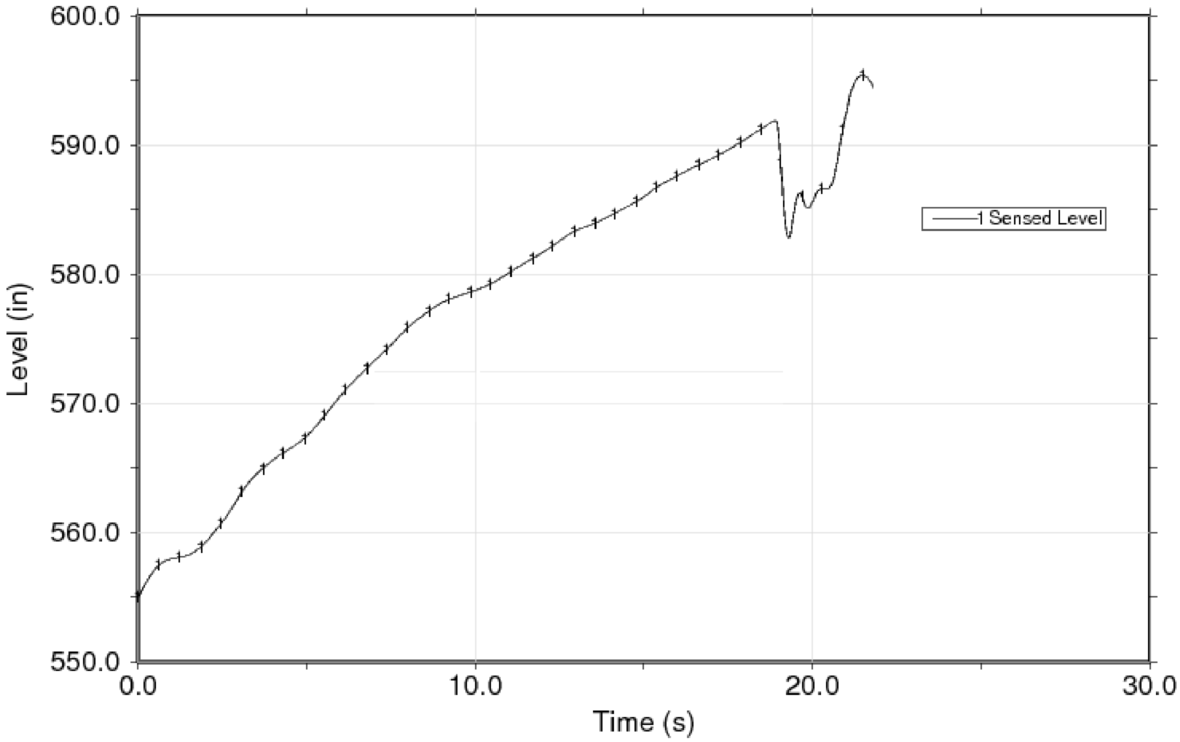

Figure 4.8 EOFP FWCF at 100P/105F – NSS Sensed Water Level

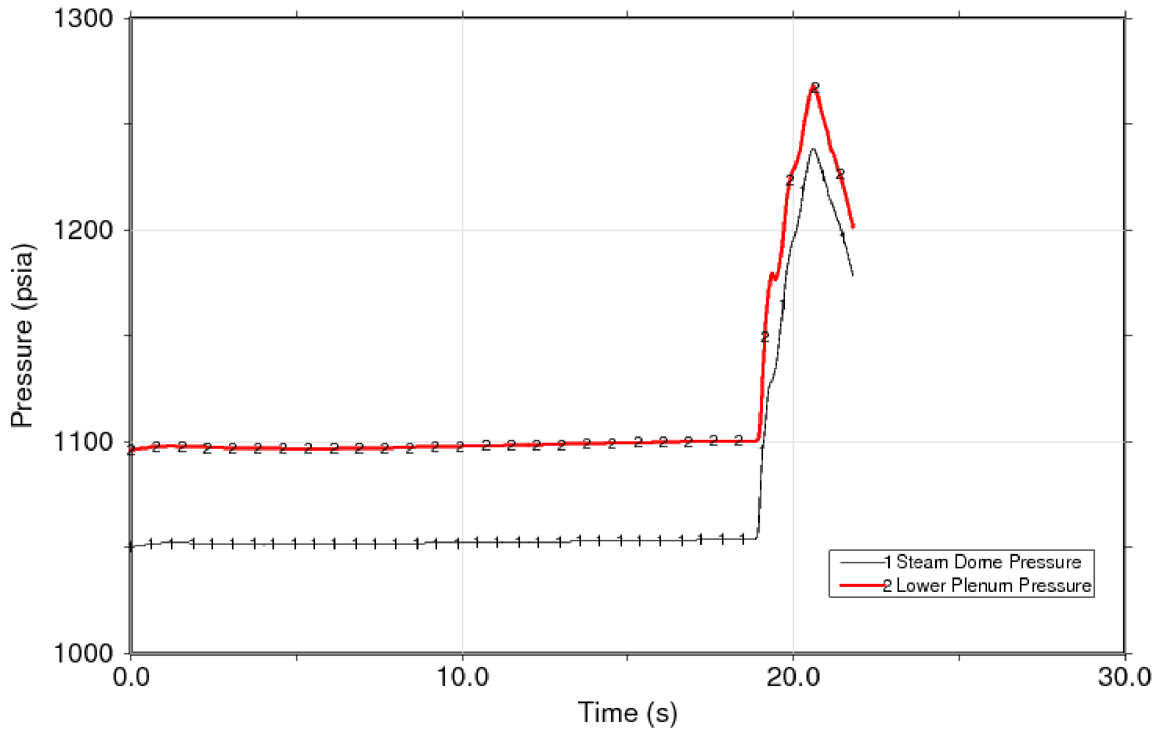

Figure 4.9 EOFP FWCF at 100P/105F – NSS Vessel Pressures

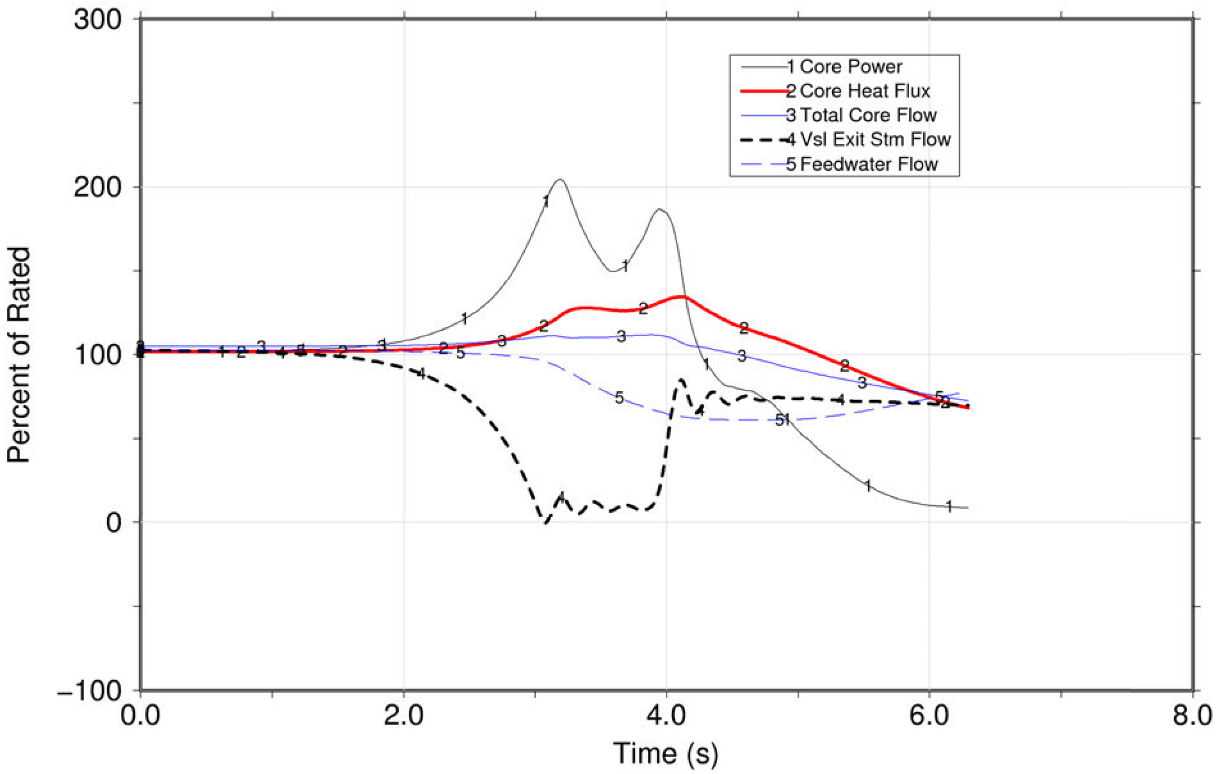

Figure 4.10 MSIV Overpressurization Event at 102P/105F – Key Parameters

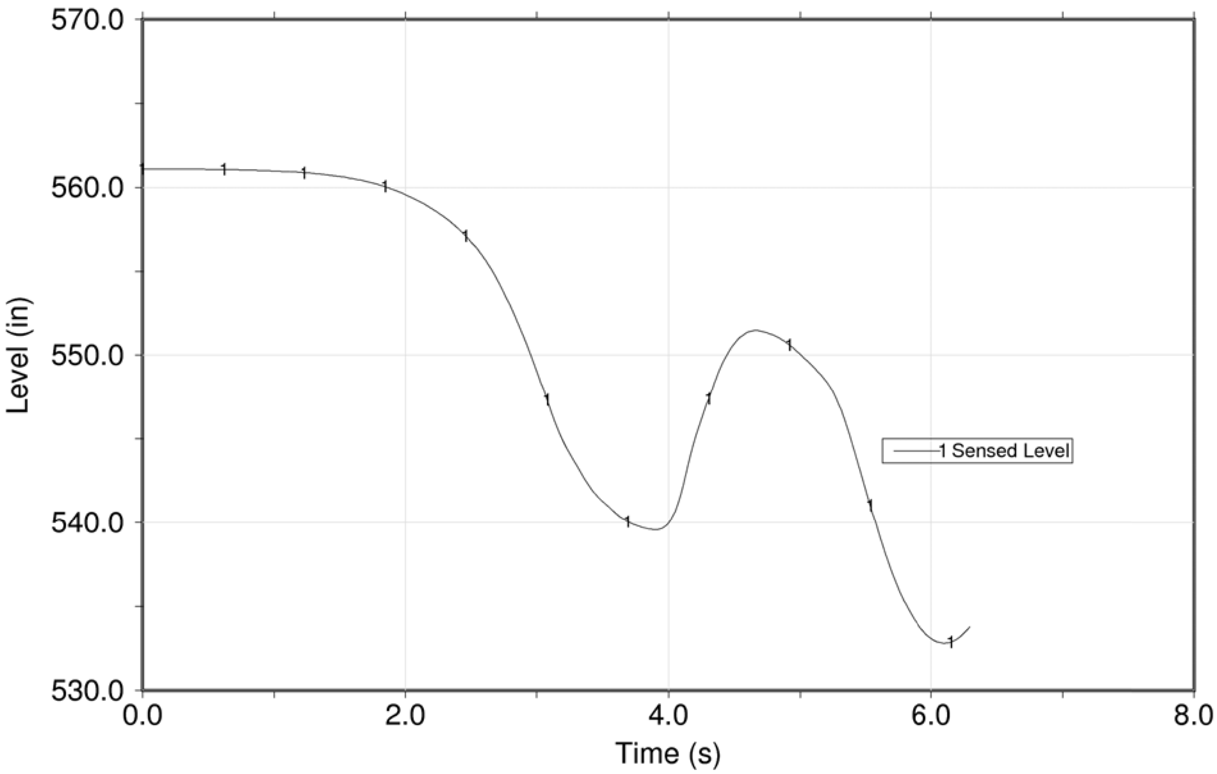

Figure 4.11 MSIV Overpressurization Event at 102P/105F – Sensed Water Level

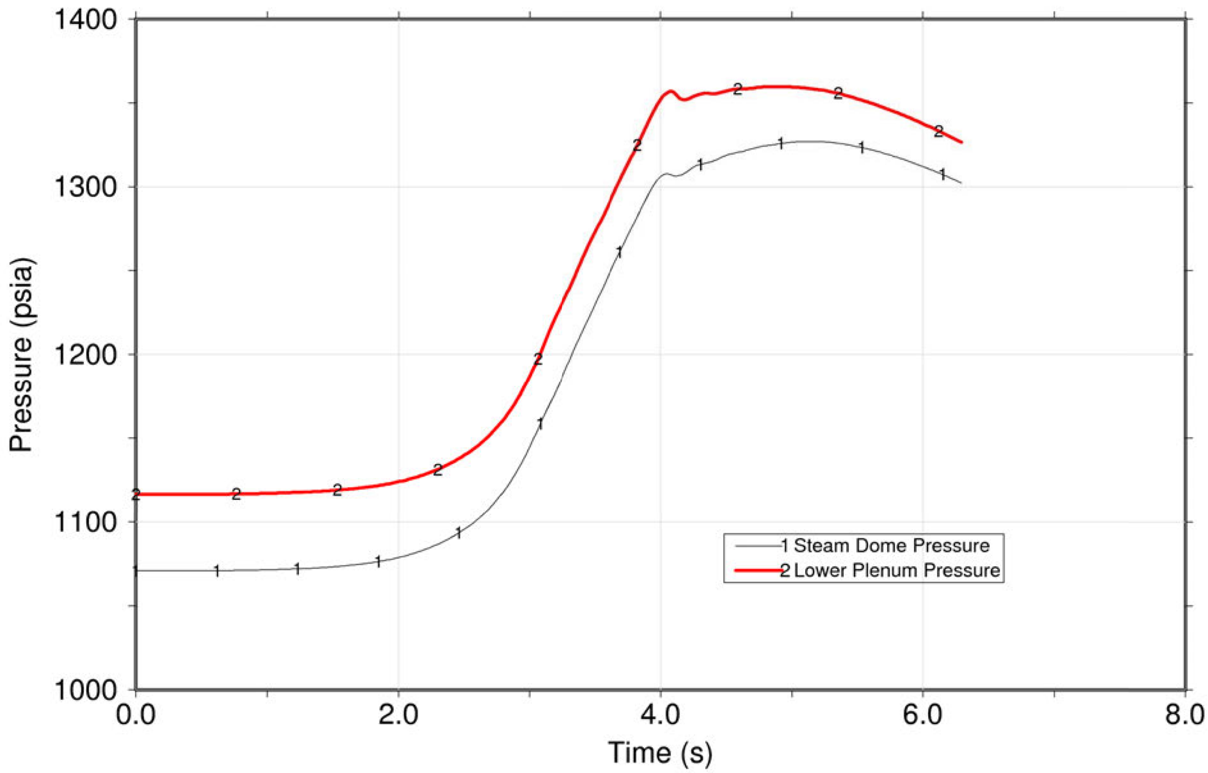

Figure 4.12 MSIV Overpressurization Event at 102P/105F – Vessel Pressures

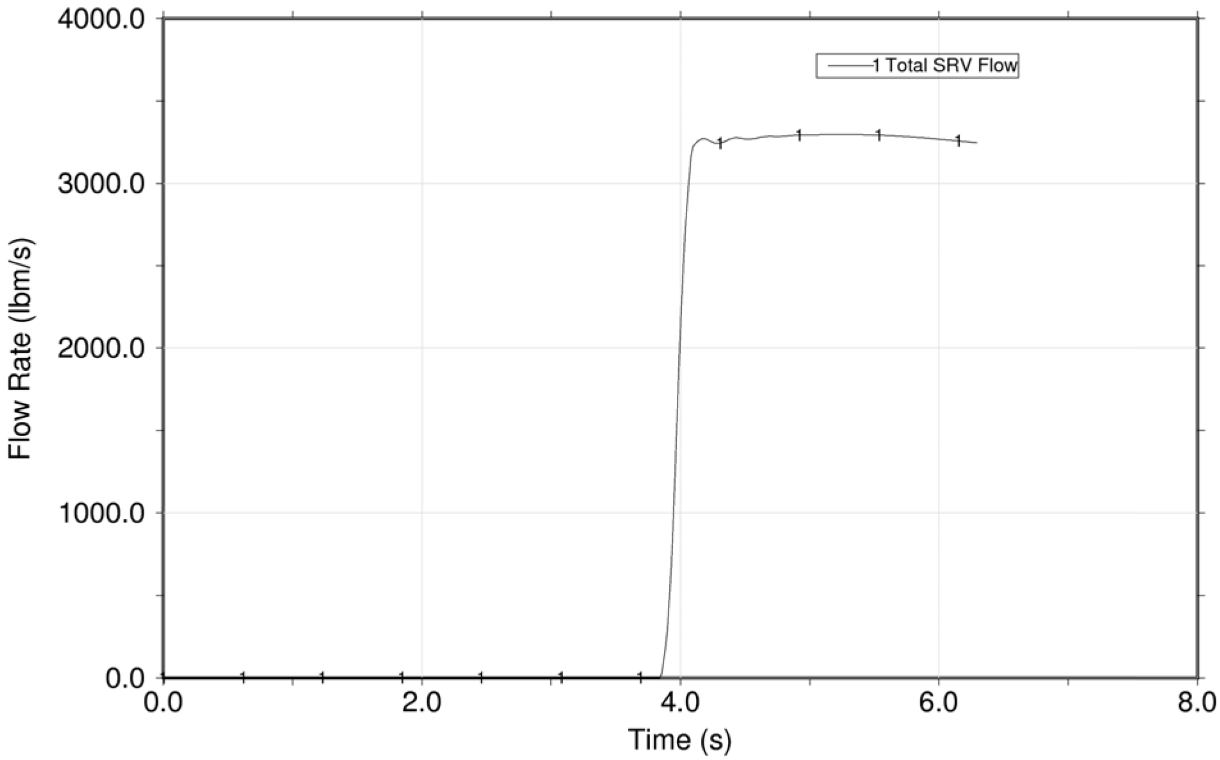

Figure 4.13 MSIV Overpressurization Event at 102P/105F – Safety/Relief Valve Flow Rates

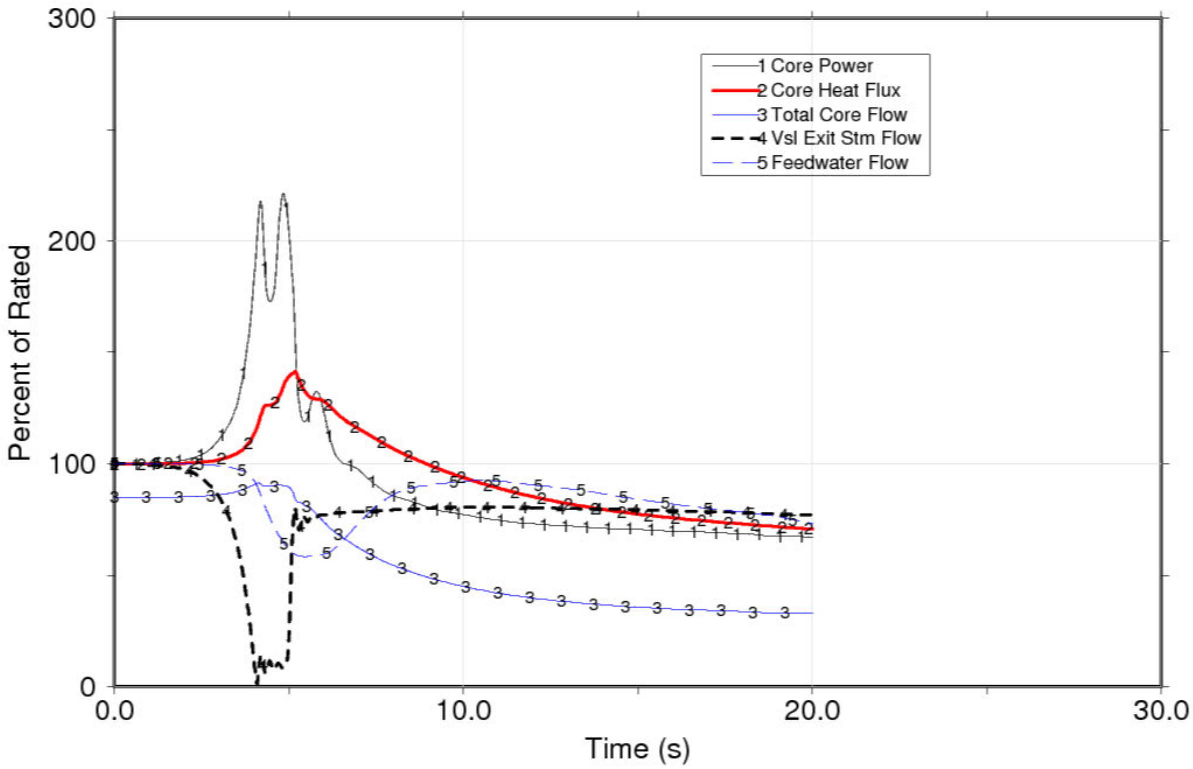

Figure 4.14 MSIV ATWS Overpressurization Event at 100P/85F – Key Parameters

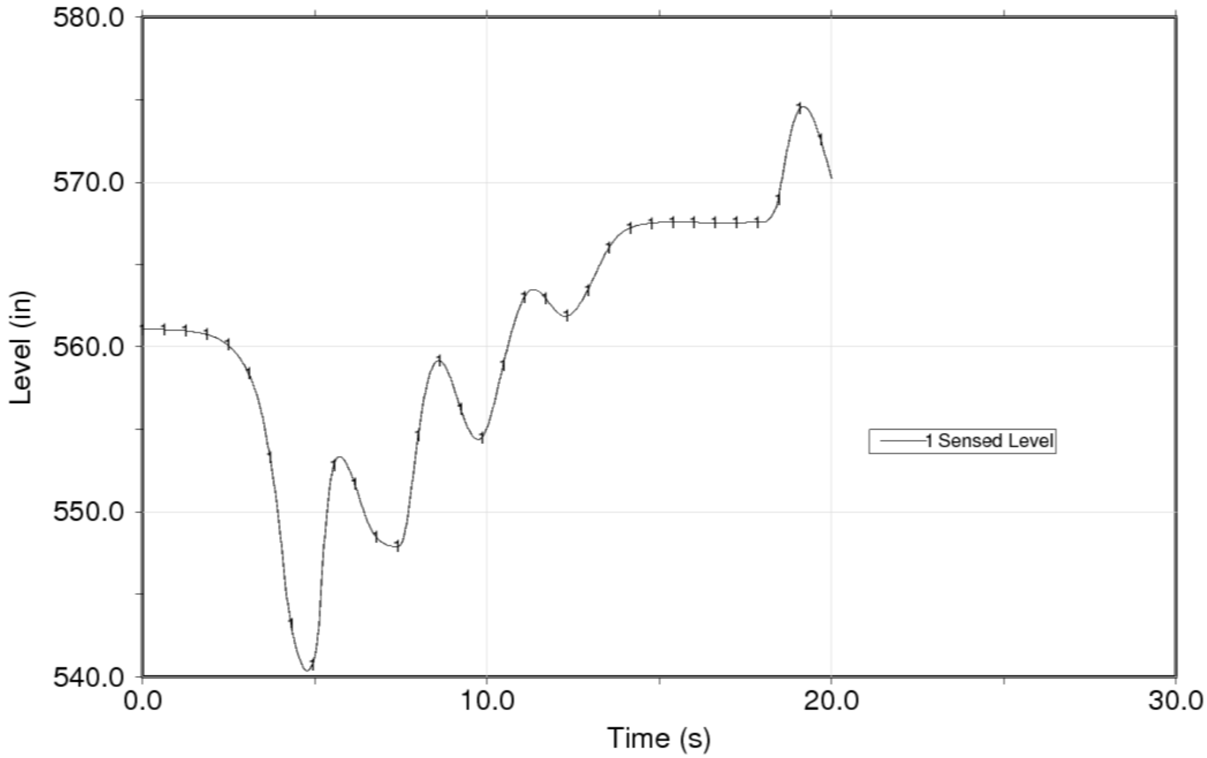

Figure 4.15 MSIV ATWS Overpressurization Event at 100P/85F – Sensed Water Level

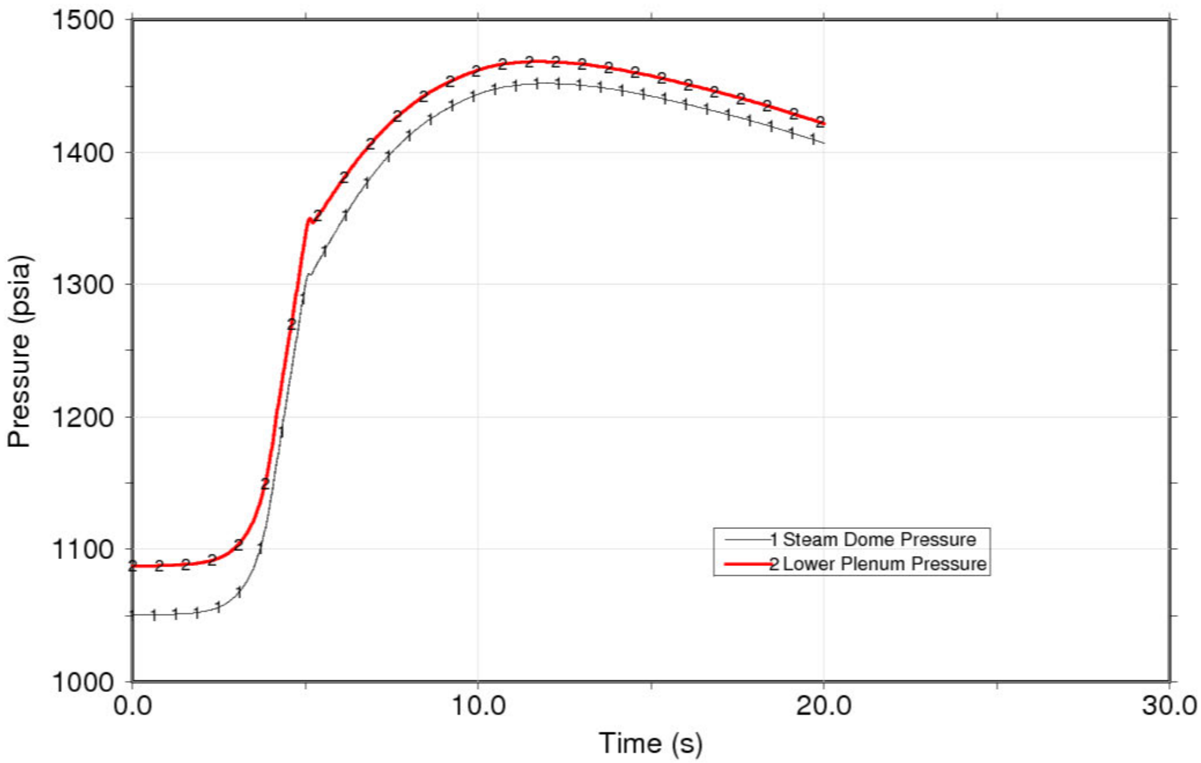

Figure 4.16 MSIV ATWS Overpressurization Event at 100P/85F – Vessel Pressures

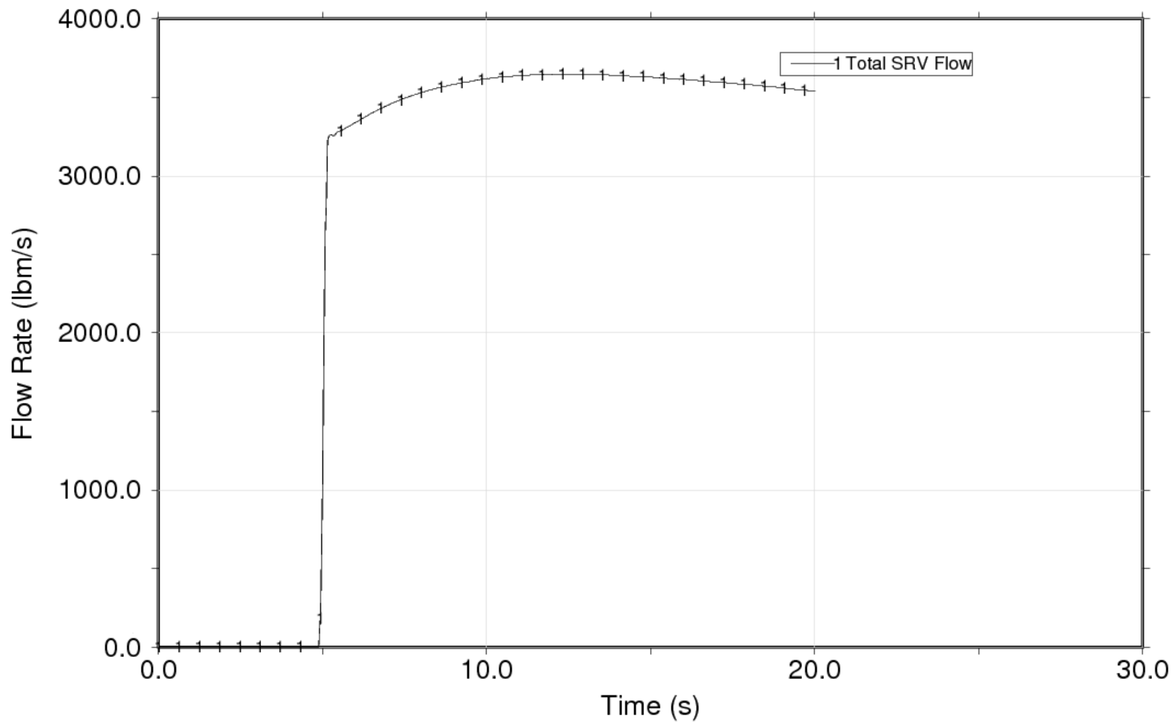

Figure 4.17 MSIV ATWS Overpressurization Event at 100P/85F – Safety/Relief Valve Flow Rates

5.0 PREVIOUSLY REQUESTED ADDITIONAL INFORMATION FROM THE NRC

The following subsections provide information responsive to applicable requests for additional information by the NRC which supports the introduction of ATRIUM 11 fuel to Browns Ferry.

5.1 *Decay Heat and Station Blackout*

5.1.1 Decay Heat

In general, the decay heat results are **[** **]** the fission fractions for the ^{235}U, ^{238}U, and ^{239}Pu isotopes. The following table presents the range of fission fractions for these isotopes from **[** **]** of GE14, ATRIUM-10, ATRIUM 10XM, and ATRIUM 11 lattices.

Fuel Design	^{235}U Fission Fraction	^{238}U Fission Fraction	^{239}Pu Fission Fraction
GE14	0.4821 - 0.5363	0.0699 - 0.0997	0.3938 – 0.4182
ATRIUM-10	0.4902 - 0.5367	0.0710 – 0.0961	0.3923 - 0.4137
ATRIUM 10XM	0.4635 - 0.5547	0.0703 - 0.1020	0.3750 - 0.4346
ATRIUM 11	0.4439 – 0.5362	0.0703 – 0.1058	0.3936 – 0.4502

[

]

5.1.2 **Station Blackout**

The licensing basis analysis remains applicable to Framatome fuel since station blackout is solely driven by decay heat. All other criteria are not fuel dependent. As discussed in Section 5.1.1, the decay heat is insignificantly impacted by the introduction of the ATRIUM 11 fuel design. Framatome fuel is designed to perform in a manner similar to and analogous with fuel of current and previous designs.

5.2 *Event Changes Potentially Impacting Mass and Energy Release*

[

] No other plant design changes are planned during this transition to ATRIUM 11 fuel. Therefore the analysis of record is not impacted by the introduction of ATRIUM 11 fuel. In the future, plant modifications will be dispositioned for their impact on the licensing basis events and analyses will be updated as necessary.

5.3 *Implementation of Transition Cycle Transient Limitation and Conditions*

Appendix A provides a listing of, and initial compliance with, the limitations and conditions (L&Cs) related to the AURORA-B AOO topical report, Reference 1. As noted in the Appendix, a few L&Cs require plant specific review which will be provided as part of the initial application (first transition licensing reports). The initial application cycle reload report is scheduled to be provided for information at a later date and will contain compliance with the 4 remaining, plant specific L&Cs 7, 11, 16, and 18a. The application of the L&Cs to the Browns Ferry licensing evaluations are discussed below:

Limitation and Condition 7

> *As discussed in Section 3.6 of this SE, licensees should provide justification for the key plant parameters and initial conditions selected for performing sensitivity analyses on an event-specific basis. Licensees should further justify that the input values ultimately chosen for these key plant parameters and initial*

> *conditions will result in a conservative prediction of FoMs when performing calculations according to the AURORA-B EM described in ANP-10300P.*

As part of the initial preparations for licensing Browns Ferry, Framatome will review the plant parameters document for the key parameters associated with the potentially limiting events. Framatome would also look for parameters that have a range of values that may be allowed for operational flexibility. Likewise, for initial conditions, Framatome will examine the range allowed during normal operation. This will include initial conditions such as power, flow, pressure, and inlet subcooling. Sensitivity studies will be performed for all of these key parameters/conditions for all FoM (MCPR, LHGR, and overpressure) and **[**

]

Limitation and Condition 11

> *AREVA will provide justification for the uncertainties used for the highly ranked plant specific PIRT parameters C12, R01, R02, and SL02 on a plant-specific basis, as described in Table 3.2 of this SE.*

The parameter C12 is the **[**

]

[

]

Limitation and Condition 16

> ***[*** ***]*** *is not sampled as part of the methodology, justification should be provided on a plant-specific basis that a conservative flow rate has been assumed* ***[*** ***]***

The **[** **]** is provided by Browns Ferry in the plant parameters document. This flow accounts for **[** **]**. The AURORA-B model **[**

]

Limitation and Condition 18a

> *Plant-specific licensing applications shall describe and provide justification for the method for determining and applying conservative measures in future deterministic analyses for each FoM (e.g. , biasing calculational inputs, postprocessing adjustments to calculated nominal results).*

For licensing calculations at Browns Ferry, **[**

]

For the LHGRFACp evaluations **[**

]

6.0 REFERENCES

1. ANP-10300P-A Revision 1, “AURORA-B: An Evaluation Model for Boiling Water Reactors; Application to Transient and Accident Scenarios”, Framatome Inc., January 2018.

2. ANP-10335P-A Revision 0, “ACE/ATRIUM 11 Critical Power Correlation”, Framatome Inc., May 2018.

3. ANP-3854P Revision 2, “Browns Ferry ATRIUM 11 Equilibrium Cycle Fuel Cycle Design Report”, Framatome Inc., June 2022.

4. ANP-3908P Revision 4, “Applicability of Framatome BWR Methods to Browns Ferry with ATRIUM 11 Fuel”, Framatome Inc., June 2022.

5. ANP-3905P Revision 2, “Browns Ferry Units 1, 2, and 3 LOCA Analysis for ATRIUM 11 Fuel”, Framatome Inc., June 2022.

Appendix A LIMITATIONS FROM THE SAFETY EVALUATION FOR LTR ANP-10300P-A REVISION 1

Compliance to the limitations and conditions from Section 5 of the safety evaluation in ANP-10300P-A Revision 1, “AURORA-B: An Evaluation Model for Boiling Water Reactors; Application to Transient and Accident Scenarios” (Reference 1) is discussed in the following table.

Appendix A *(Continued)*

Limitation and Condition Number	Limitation and Condition Description	Disposition/Discussion
1	AURORA-B may not be used to perform analyses that result in one or more of its CCDs (S-RELAP5, MB2-K, MICROBURN-B2, RODEX4) operating outside the limits of approval specified in their respective TRs, SEs, and plant-specific LARs. In the case of MB2-K, MB2-K is subject to the same limitations and conditions as MICROBURN-B2.	All methods are used within their limits of approval.
2	The regulatory limit contained in 10 CFR 50.46(b)(2) , requiring cladding oxidation not to exceed 17 percent of the initial cladding thickness prior to oxidation, is based on the use of the Baker-Just oxidation correlation. Because AURORA-B makes use of the Cathcart-Pawel oxidation correlation, this limit shall be reduced to 13 percent, inclusive of pre-transient oxide layer thickness (See Section 3.4.3.1). Should the NRC staff position regarding the appropriate acceptance criterion for the Cathcart-Pawel correlation change, the NRC will notify AREVA with a letter either revising this limitation or stating that it is removed.	[ ]

Limitation and Condition Number	Limitation and Condition Description	Disposition/Discussion
3	Parameter uncertainty distributions and their characterizing upper and lower *2σ* levels are presented in Table 3.6 and discussed in Section 3.6 of this SE. The distribution types will not be changed and the characterizing upper and lower *2σ* uncertainties will not be reduced without prior NRC approval. In the cases of the parameters **[ ]**, the respective methodologies discussed in Section 3.6.4.10 and Section 3.6.4.17 shall be used when determining the associated upper and lower *2σ* levels. The **[ ]** is subject to Limitation and Condition No. 4, below.	**[ ]**
4	As discussed in Section 3.3.1.2, before new fuel designs (i.e., designs other than ATRIUM-10 and ATRIUM-10XM) are modeled in licensing analyses using AURORA-B, AREVA must justify that the AURORA-B EM can acceptably predict void fraction results for the new fuel designs within the **[ ]** prediction uncertainty bands. Otherwise, the prediction uncertainty bands should be appropriately expanded, and the **[ ]** should be appropriately updated utilizing the methodology discussed in Section O of this SE.	Justification of void fraction application to ATRIUM 11 fuel is provided in Section 5.1 of Reference 4.
5	As discussed in Section 3.3.2.4.4, before new fuel designs (i.e., designs other than ATRIUM-10 and ATRIUM-10XM) are included in licensing analyses performed using the AURORA-B EF, AREVA must justify that the **[ ]** void-quality correlation within MICROBURN-B2 is valid for the new fuel designs at EPU and EFW conditions.	Justification of void fraction application to ATRIUM 11 fuel is provided in Section 5.1 of Reference 4.

Limitation and Condition Number	Limitation and Condition Description	Disposition/Discussion
6	The *2σ* ranges [ ] until AREVA supplies additional justification (e.g., as part of a first-time application analysis) demonstrating an acceptable alternative for NRC review and approval. For [ ] will be utilized when performing licensing analyses to determine peak cladding temperature and maximum local oxidation. Should the NRC staff position regarding these uncertainties change as a result of additional justification, the NRC will notify AREVA with a letter either revising this limitation or stating that it is removed.	[ ]
7	As discussed in Section 3.6 of this SE, licensees should provide justification for the key plant parameters and initial conditions selected for performing sensitivity analyses on an event-specific basis. Licensees should further justify that the input values ultimately chosen for these key plant parameters and initial conditions will result in a conservative prediction of FoMs when performing calculations according to the AURORA-B EM described in ANP-10300P.	See Section 5.3 for further discussion of this L&C. The justification for the key plant parameters and initial conditions will be thoroughly explored for the first application cycle for Browns Ferry.
8	The sampling ranges for uncertainty distributions used in the non-parametric order statistics analyses will be truncated at no less than ±*6σ* [ ]	[ ]

Limitation and Condition Number	Limitation and Condition Description	Disposition/Discussion
9	For any highly ranked PIRT phenomena whose uncertainties are not addressed in a given non-parametric order statistics analysis via sampling , AREVA will address the associated uncertainties by modeling the phenomena as described in Table 3.2 of this SE. For any pertinent medium ranked PIRT phenomena whose uncertainties are not addressed in a given non-parametric order statistics analysis via sampling, AREVA will address the associated uncertainties by modeling the phenomena as described in Table 3.4 of this SE.	Framatome analyses comply with the requirements of Tables 3.2 and 3.4 of the SE.
10	The assumptions of [ ] will be used in the AURORA-B EM to ensure the uncertainty in SL03: [ ] is conservatively accounted for.	[ ]
11	AREVA will provide justification for the uncertainties used for the highly ranked plant-specific PIRT parameters C12, R01, R02, and SL02 on a plant-specific basis, as described in Table 3.2 of this SE.	See Section 5.3 for further discussion of this L&C. [ ]
12	When applying the AURORA-B EM to the [ ] , any changes to AURORA-B to enhance [ ] on a plant-specific basis without prior NRG review and approval are not approved as part of this SE, as described in Table 3.2 of this SE.	[ ]

Limitation and Condition Number	Limitation and Condition Description	Disposition/Discussion
13	The AURORA-B uncertainty methodology discussed in Section 3.6 of this SE may be used in licensing applications for the events listed in Section 3.1 of this SE, with the exception of three specific events identified in Section 3.6.2 of this SE : **[** **]**. These events are generally expected to be benign and hence nonlimiting. While the NRC staff's review concluded that the AURORA-B EM contains code models and correlations sufficient for simulating these events, the uncertainty methodology developed in the TR did not address certain important phenomena or conditions associated therewith. Therefore, while licensing applications may rely on nominal calculations with the AURORA-B EM for these events in the course of demonstrating that all regulatory limits are satisfied with significant margin, the existing uncertainty methodology may not be applied directly to these specific events.	**[** **]**
14	The scope of the NRC staff's approval for AURORA-B does not include the ABWR design.	Not applicable to TVA. Browns Ferry is not an ABWR design.
15	For application to BWR/2s at EPU or EFW conditions, plant-specific justification should be provided for the applicability of AURORA-B, as discussed in Section 3 .1 of this SE.	Not applicable to TVA. Browns Ferry is not a BWR/2
16	**[** **]** is not sampled as part of the methodology, justification should be provided on a plant-specific basis that a conservative flow rate has been assumed **[** **]**.	See Section 5.3 for further discussion of this L&C. **[** **]** will be conservatively modeled for the first application cycle for Brown Ferry.

Limitation and Condition Number	Limitation and Condition Description	Disposition/Discussion
17	If the AURORA-B EM calculates that the film boiling regime is entered during a transient or accident, AREVA must justify that the uncertainty associated with heat transfer predictions in the film boiling regime is adequately addressed.	[ ]
18	As discussed in Section 3.6.5 of this SE regarding conservative measures : a. Plant-specific licensing applications shall describe and provide justification for the method for determining and applying conservative measures in future deterministic analyses for each FoM (e.g., biasing calculational inputs, post-processing adjustments to calculated nominal results), and	See Section 5.3 for further discussion of this L&C. Compliance with this item will be demonstrated for the first application cycle for Browns Ferry.
	b. If the 95/95 FoM for a given parameter calculated according to the defined conservative measures during a deterministic analysis shows a difference in magnitude exceeding 1σ from the corresponding value calculated in the most recent baseline full statistical analysis, AREVA must re-perform the full statistical analysis for the affected scenario and determine new conservative measures.	[ ]
19	As discussed in Section 3.6.5 of this SE, the following stipulations are necessary to ensure that the FoMs calculated by AREVA in accordance with ANP-10300P would satisfy the 95/95 criterion: a. AREVA will use multivariate order statistics when multiple FoMs are drawn from a single set of statistical calculations,	Framatome calculations will utilize the multivariate order statistics when a single transient is used to determine multiple figures of merits.
	b. AREVA will choose the sample size prior to initiating statistical calculations,	Framatome will choose the sample size prior to initiating statistical calculations.

Limitation and Condition Number	Limitation and Condition Description	Disposition/Discussion
	c. AREVA will not arbitrarily discard undesirable statistical results, and	Framatome will not arbitrarily discard undesirable statistical results.
	d. AREVA will maintain an auditable record to demonstrate that its process for performing statistical licensing calculations has been executed in an unbiased manner.	Framatome will maintain an auditable record to demonstrate the process for performing statistical licensing calculations is being executed in an unbiased manner.
20	The implementation of any new methodology within the AURORA-B EM (i.e., replacement of an existing CCD) is not acceptable unless the AURORA-B EM with the new methodology incorporated into it has received NRC review and approval. An existing NRC-approved methodology cannot be implemented within the AURORA-B EM without NRC review of the updated EM.	The evaluation model is implemented as described in Reference 1. No CCD as described in Reference 1 is replaced.
21	NRC-approved changes that revise or extend the capabilities of the individual CCDs comprising the AURORA-B EM may not be incorporated into the EM without prior NRC approval.	Framatome regulatory procedures require use of NRC approved methodologies within the applicability defined for that methodology.
22	As discussed in Section 3.3.1.5 and Section 4.0 of this SE, the SPCB and ACE CPR correlations for the ATRIUM-10 and ATRIUM-10XM fuels, respectively, are approved for use with the AURORA-B EF. Other CPR correlations (existing and new) that would be used with the AURORA-B EM must be reviewed and approved by the NRC or must be developed with an NRC-approved approach such as that described in EMF-2245(P)(A), Revision 0, "Application of Siemens Power Corporation's Critical Power Correlations to Co-Resident Fuel" (Reference 50). Furthermore, if transient thermal-hydraulic simulations are performed in the process of applying AREVA CPR correlations to co-resident fuel, these calculations should use the AURORA-B methodology.	Framatome regulatory procedures require use of NRC approved methodologies. The applicability of the ACE/ATRIUM 11 correlation for use in the AURORA-B AOO methodology is described in Reference 2.

Limitation and Condition Number	Limitation and Condition Description	Disposition/Discussion
23	Except when prohibited elsewhere, the AURORA-B EM may be used with new or revised fuel designs without prior NRC approval provided that the new or revised fuel designs are substantially similar to those fuel designs already approved for use in the AURORA-B EM (i.e., thermal energy is conducted through a cylindrical ceramic fuel pellet surrounded by metal cladding, flow in the fuel channels develops into a predominantly vertical annular flow regime, etc.). New fuel designs exhibiting a large deviation from these behaviors will require NRC review and approval prior to their implementation in AURORA-B.	Framatome has no fuel designs that exhibit a large deviation from the behaviors described in this limitation and condition. If a fuel design is developed that is significantly difference, this fuel design will be submitted to the NRC for approval.
24	Changes may be made to the AURORA-B EM in the [ ] areas discussed in Section 4.0 of this SE without prior NRC approval.	[ ]
25	The parallelization of individual CCDs may be performed without prior NRC approval as discussed in Section 4.0 of this SE.	[ ]
26	AREVA must continue to use existing regulatory processes for any code modifications made in the [ ] areas discussed in Section 4.0 of this SE.	[ ]

ATTACHMENT 17

Browns Ferry Nuclear Plant (BFN)
Units 1, 2, and 3

Affidavits for Attachments 6a, 7a, 8a, 9a, 10a, 11a, 12a, 15a, and 16a

A F F I D A V I T

1. My name is Alan B. Meginnis. I am Manager, Product Licensing, for Framatome Inc. and as such I am authorized to execute this Affidavit.

2. I am familiar with the criteria applied by Framatome to determine whether certain Framatome information is proprietary. I am familiar with the policies established by Framatome to ensure the proper application of these criteria.

3. I am familiar with the Framatome information contained in the report ANP-3854P, Revision 2, “Browns Ferry ATRIUM 11 Equilibrium Cycle, Fuel Cycle Design Report,” dated June 2022 and referred to herein as “Document.” Information contained in this Document has been classified by Framatome as proprietary in accordance with the policies established by Framatome for the control and protection of proprietary and confidential information.

4. This Document contains information of a proprietary and confidential nature and is of the type customarily held in confidence by Framatome and not made available to the public. Based on my experience, I am aware that other companies regard information of the kind contained in this Document as proprietary and confidential.

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(b) Use of the information by a competitor would permit the competitor to significantly reduce its expenditures, in time or resources, to design, produce, or market a similar product or service.

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8. Framatome policy requires that proprietary information be kept in a secured file or area and distributed on a need-to-know basis.

9. The foregoing statements are true and correct to the best of my knowledge, information, and belief.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on: June 8, 2022

MEGINNIS Alan Digitally signed by MEGINNIS Alan
Date: 2022.06.08 14:47:11 -07'00'

Alan Meginnis

A F F I D A V I T

1. My name is Alan B. Meginnis. I am Manager, Product Licensing, for Framatome Inc. and as such I am authorized to execute this Affidavit.

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3. I am familiar with the Framatome information contained in the report ANP-3850P, Revision 1, “Browns Ferry ATRIUM 11 Equilibrium Cycle Nuclear Fuel Design Report,” dated April 2022 and referred to herein as “Document.” Information contained in this Document has been classified by Framatome as proprietary in accordance with the policies established by Framatome for the control and protection of proprietary and confidential information.

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9. The foregoing statements are true and correct to the best of my knowledge, information, and belief.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on: April 15, 2022

MEGINNIS Alan Digitally signed by MEGINNIS Alan
Date: 2022.04.15 14:14:26 -07'00'

Alan B. Meginnis

A F F I D A V I T

1. My name is Alan B. Meginnis. I am Manager, Product Licensing, for Framatome Inc. and as such I am authorized to execute this Affidavit.

2. I am familiar with the criteria applied by Framatome to determine whether certain Framatome information is proprietary. I am familiar with the policies established by Framatome to ensure the proper application of these criteria.

3. I am familiar with the Framatome information contained in the report ANP-3860P, Revision 1, “Mechanical Design Report for Browns Ferry ATRIUM 11 Fuel Assemblies,” dated June 2022 and referred to herein as “Document.” Information contained in this Document has been classified by Framatome as proprietary in accordance with the policies established by Framatome for the control and protection of proprietary and confidential information.

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I declare under penalty of perjury that the foregoing is true and correct.

Executed on: June 8, 2022

MEGINNIS Alan Digitally signed by MEGINNIS Alan
Date: 2022.06.08 11:56:34 -07'00'

Alan Meginnis

A F F I D A V I T

1. My name is Gayle Elliott. I am Deputy Director, Licensing and Regulatory Affairs, for Framatome Inc. (Framatome) and as such I am authorized to execute this Affidavit.

2. I am familiar with the criteria applied by Framatome to determine whether certain Framatome information is proprietary. I am familiar with the policies established by Framatome to ensure the proper application of these criteria.

3. I am familiar with the Framatome information contained in Licensing Report ANP-3866P, Revision 2, entitled “ATRIUM 11 Fuel Rod Thermal-Mechanical Evaluation for Browns Ferry LAR,” dated August 2022 and referred to herein as “Document.” Information contained in this Document has been classified by Framatome as proprietary in accordance with the policies established by Framatome for the control and protection of proprietary and confidential information.

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9. The foregoing statements are true and correct to the best of my knowledge, information, and belief.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on: August 5, 2022

ELLIOTT Gayle Digitally signed by ELLIOTT Gayle
Date: 2022.08.05 23:23:32 -04'00'

Gayle Elliott

A F F I D A V I T

1. My name is Alan B. Meginnis. I am Manager, Product Licensing, for Framatome Inc. and as such I am authorized to execute this Affidavit.

2. I am familiar with the criteria applied by Framatome to determine whether certain Framatome information is proprietary. I am familiar with the policies established by Framatome to ensure the proper application of these criteria.

3. I am familiar with the Framatome information contained in the report ANP-3859P, Revision 1, "Browns Ferry Thermal-Hydraulic Design Report for ATRIUM 11 Fuel Assemblies," dated June 2022 and referred to herein as "Document." Information contained in this Document has been classified by Framatome as proprietary in accordance with the policies established by Framatome for the control and protection of proprietary and confidential information.

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I declare under penalty of perjury that the foregoing is true and correct.

Executed on: June 20, 2022

MEGINNIS Alan Digitally signed by MEGINNIS Alan Date: 2022.06.20 14:33:17 -07'00'

Alan Meginnis

A F F I D A V I T

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Executed on: June 8, 2022

MEGINNIS Alan Digitally signed by MEGINNIS Alan
Date: 2022.06.08 12:16:00 -07'00'

Alan B. Meginnis

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Executed on: June 27, 2022

MEGINNIS Alan Digitally signed by MEGINNIS Alan
Date: 2022.06.27 12:02:53 -07'00'

Alan B. Meginnis

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3. I am familiar with the Framatome information contained in the report ANP-3874P, Revision 3 “Browns Ferry ATRIUM 11 Control Rod Drop Accident Analysis with the AURORA-B CRDA Methodology,” dated June 2022 and referred to herein as “Document.” Information contained in this Document has been classified by Framatome as proprietary in accordance with the policies established by Framatome for the control and protection of proprietary and confidential information.

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Executed on: June 14, 2022

MEGINNIS Alan Digitally signed by MEGINNIS Alan Date: 2022.06.14 09:26:11 -07'00'

Alan Meginnis

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Executed on: July 11, 2022

MEGINNIS Alan Digitally signed by MEGINNIS Alan
Date: 2022.07.11 12:43:43 -07'00'

Alan B. Meginnis