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GNRO-2016/00017

March 24, 2016

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555-0001

SUBJECT: Core Operating Limits Report Cycle 21
Grand Gulf Nuclear Station, Unit 1
Docket No. 50-416
License No. NPF-29

Dear Sir or Madam:

Entergy Operations Inc. (Entergy), is submitting a revised Core Operating Limits Report (COLR) for Grand Gulf Nuclear Station (GGNS) as required by GGNS Technical Specification (TS) 5.6.5.d. The revised COLR is for Cycle 21 operation. The analytical methods used to determine the Cycle 21 Core Operating Limits were previously approved by the Nuclear Regulatory Commission (NRC) and are listed in GGNS TS 5.6.5.

This letter contains no new commitments. Should you have any questions or require additional information, please contact James Nadeau at 601-437-2103.

Sincerely,

JJN/tmc

Attachment: Core Operating Limits Report (COLR) Cycle 21

cc: (see next page)

cc: U.S. Nuclear Regulatory Commission
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Attachment to

GNRO-2016/00017

Core Operating Limits Report (COLR) Cycle 21

Grand Gulf Nuclear Station

Core Operating Limits Report

CORE OPERATING LIMITS REPORT

REASON FOR REVISION

This revision provides the Cycle 21 core operating limits. These limits are based on a core power of 4408 MWt.

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CORE OPERATING LIMITS REPORT

1.0 PURPOSE

On October 4, 1988, the NRC issued Generic Letter 88-16 [3.1.1] encouraging licensees to remove cycle-specific parameter limits from Technical Specifications and to place these limits in a formal report to be prepared by the licensee. As long as the parameter limits were developed with NRC-approved methodologies, the letter indicated that this would remove unnecessary burdens on licensee and NRC resources.

On October 29, 1992, Entergy Operations submitted a Proposed Amendment to the Grand Gulf Operating License requesting changes to the GGNS Technical Specifications to remove certain reactor physics parameter limits that change each fuel cycle [3.1.2]. This amendment committed to placing these operating limits in a separate Core Operating Limits Report (COLR) which is defined in Technical Specifications. This PCOL was approved by the NRC by SER dated January 21, 1993 [3.1.3].

The COLR is controlled as a License Basis Document and revised accordingly for each fuel cycle or remaining portion of a fuel cycle. Any revisions to the COLR must be submitted to the NRC for information as required by Tech Spec 5.6.5 and tracked by Licensing Commitment 29132. This COLR reports the Cycle 21 core operating and stability setpoint confirmation and regions.

2.0 SCOPE

As defined in Technical Specification 1.1, the COLR is the GGNS document that provides the core operating limits for the current fuel cycle. This document is prepared in accordance with Technical Specification 5.6.5 for each reload cycle using NRC-approved analytical methods.

The Cycle 21 core operating and stability limits included in this report are:

- the Average Planar Linear Heat Generation Rate (APLHGR),
- the Minimum Critical Power Ratio (MCPR) (including EOC-RPT inoperable),
- the Linear Heat Generation Rate (LHGR) limit, and
- the DSS-CD stability setpoint confirmation and regions.

3.0 REFERENCES

This section contains the background, cycle-specific, and methodology references used in the safety analysis of Grand Gulf Cycle 21.

3.1 Background References

3.1.1 MAEC-88/0313, Generic Letter 88-16, "Removal of Cycle-Specific Parameter Limits from Technical Specifications", October 4, 1988.

3.1.2 GNRO-92-00093, Proposed Amendment to Grand Gulf Operating License, PCOL-92/07, dated October 29, 1992.

3.1.3 GNRI-93-0008, Amendment 106 to Grand Gulf Operating License, January 21, 1993.

3.1.4 GEXI 2000-00116, K.V. Walters to J.B. Lee, "Technical Specification and COLR References for Grand Gulf Nuclear Station and River Bend Station," November 3, 2000.

3.2 Current Cycle References

3.2.1 ECH-NE-16-00004 Revision 0, Supplemental Reload Licensing Report for Grand Gulf Nuclear Station Reload 20 Cycle 21, dated March 2016.

3.2.2 ECH-NE-10-00021 Revision 4, GNF2 Fuel Design Cycle-Independent Analyses for Entergy Grand Gulf Nuclear Station, dated November 2013.

3.2.3 ECH-NE-16-00006 Revision 0, Fuel Bundle Information Report for Grand Gulf Nuclear Station Reload 20 Cycle 21, dated October 2015.

3.2.4 NEDC-32910P, Revision 1, Grand Gulf Nuclear Station SAFER/GESTR-LOCA Accident Analysis With Relaxed ECCS Parameters, dated October 1999.

3.2.5 GGNS-NE-10-00022 Revision 0, Grand Gulf Nuclear Station MELLLA+ Task T0407, ECCS-LOCA Performance, dated September 2012.

3.2.6 GGNS-SA-09-00002 Revision 1, Grand Gulf Nuclear Station GNF2 ECCS-LOCA Evaluation, dated December 2009.

3.2.7 NEDC-33173P-A, Rev.4, Application of GE Methods to Expanded Operating Domains, dated November 2012

3.2.8 NEDC-33006P-A, Rev.3, GE BWR Maximum Extended Load Line Limit Analysis Plus, dated June2009

3.2.9 ECH-NE-16-00010, Revision 0, GGNS Cycle 21 GESTAR Assessment, dated March 2016.

3.2.10 ECH-NE-14-00014 Revision 2, GGNS RF19 Bundle Reconstitution Report - Bundle GEQ830, dated April 2015.

3.3 Methodology References

The Technical Specifications (TS) supported by each methodology reference are provided in brackets ({ }).

3.3.1 XN-NF-81-58(P)(A) Revision 2 and Supplements 1 and 2, "RODEX2 Fuel Rod Thermal-Mechanical Response Evaluation Model," Exxon Nuclear Company, March 1984 {TS 3.2.1, TS 3.2.2, TS 3.2.3}.

3.3.2 XN-NF-85-67(P)(A) Revision 1, "Generic Mechanical Design for Exxon Nuclear Jet Pump BWR Reload Fuel," Exxon Nuclear Company, September 1986 {TS 3.2.3}.

3.3.3 EMF-85-74(P) Revision 0 Supplement 1 (P)(A) and Supplement 2 (P)(A), "RODEX2A (BWR) Fuel Rod Thermal-Mechanical Evaluation Model, Siemens Power Corporation," February 1998 {TS 3.2.3}.

3.3.4 ANF-89-98(P)(A) Revision 1 and Supplement 1, "Generic Mechanical Design Criteria for BWR Fuel Designs," Advanced Nuclear Fuels Corporation, May 1995 {TS 3.2.3}.

3.3.5 Deleted

3.3.6 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 {TS 3.2.1, TS 3.2.2, TS 3.2.3}.

3.3.7 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 {TS 3.2.1, TS 3.2.2, TS 3.2.3}.

3.3.8 EMF-2158(P)(A) Revision 0, "Siemens Power Corporation Methodology for Boiling Water Reactors: Evaluation and Validation of CASMO-MICROBURN-B2, Siemens Power Corporation," October 1999 {TS 3.2.2, TS 3.2.3} .

3.3.9 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 {TS 3.2.2}.

3.3.10 XN-NF-84-105(P)(A), Volume 1 and Supplements 1 and 2, "XCOBRA-T: A Computer Code for BWR Transient Thermal Hydraulic Core Analysis," Exxon Nuclear Company, February 1987 {TS 3.2.2}.

3.3.11 ANF-524(P)(A) Revision 2 and Supplements 1 and 2, "ANF Critical Power Methodology for Boiling Water Reactors," Advanced Nuclear Fuels Corporation, November 1990 {TS 3.2.2}.

3.3.12 ANF-913 (P)(A), Volume 1, Revision 1 and Volume 1 Supplements 2, 3 and 4, "COTRANSA2: A Computer Program for Boiling Water Reactor Transient Analyses," Advanced Nuclear Fuels Corporation, August 1990 {TS 3.2.2}.

3.3.13 XN-NF-825(P)(A) Supplement 2, "BWR/6 Generic Rod Withdrawal Error Analysis, $MCPR_p$ for Plant Operation Within the Extended Operating Domain," Exxon Nuclear Company, October 1986 {TS 3.2.2}.

3.3.14 ANF-1358(P)(A) Revision 3, "The Loss of Feedwater Heating Transient in Boiling Water Reactors," Framatome ANP, September 2005 {TS 3.2.2}.

3.3 Methodology References (continued)

3.3.15 EMF-1997(P)(A) Revision 0, "ANFB-10 Critical Power Correlation," Siemens Power Corporation, July 1998 {TS 3.2.2}.

3.3.16 EMF-1997(P), Supplement 1(P)(A), Revision 0, "ANFB-10 Critical Power Correlation: High Local Peaking Results, Siemens Power Corporation," July 1998 {TS 3.2.2}.

3.3.17 EMF-2209(P)(A) Revision 2, "SPCB Critical Power Correlation, Siemens Power Corporation," September 2003 {TS 3.2.2}.

3.3.18 EMF-2245(P)(A) Revision 0, "Application of Siemens Power Corporation's Critical Power Correlations to Co-Resident Fuel," Siemens Power Corporation, August 2000 {TS 3.2.2}.

3.3.19 EMF-2361 (P)(A) Revision 0, "EXEM BWR-2000 ECCS Evaluation Model," Framatome ANP Richland, Inc., May 2001 {TS 3.2.1}.

3.3.20 Deleted

3.3.21 Deleted

3.3.22 NEDC-33383P, Revision 1, "GEXL97 Correlation Applicable to ATRIUM-10 Fuel," June, 2008 {TS 3.2.2}.

3.3.23 EMF-2292(P)(A) Revision 0, "ATRIUM-10: Appendix K Spray Heat Transfer Coefficients, Siemens Power Corporation," September 2000 {TS 3.2.1}.

3.3.24 Deleted

3.3.25* NEDE-24011-P-A, General Electric Standard Application for Reactor Fuel (GESTAR-II) {TS 3.2.1, TS 3.2.2, TS 3.2.3}.

3.3.26* NEDO-33075-A, Revision 8, Licensing Topical Report, Boiling Water Reactor Detect and Suppress Solution - Confirmation Density, November 2013 {TS 3.2.2, 3.3.1.1}

3.3.27* NEDO-33612-A, Revision 0, Safety Analysis Report for GGNS Maximum Extended Load Line Limit Analysis Plus, September 2013 {TS 3.2.2, 3.3.1.1}

3.3.28* GGNS-NE-10-00076 Revision 0 (GEH 0000-012101122-R0), <u>GGNS EPU Option B Scram Times</u>, dated September 2010. {TS 3.2.2}

* Note: These references are applicable when GE fuel is in the reactor.

CORE OPERATING LIMITS REPORT

4.0 DEFINITIONS

4.1 Average Planar Linear Heat Generation Rate (APLHGR) - the APLHGR shall be applicable to a specific planar height and is equal to the sum of the linear heat generation rates for all the fuel rods in the specified bundle at the specified height divided by the number of fuel rods in the fuel bundle at the specified height.

4.2 Average Planar Exposure - the Average Planar Exposure shall be applicable to a specific planar height and is equal to the sum of the exposure of all the fuel rods in the specified bundle at the specified height divided by the number of fuel rods in the fuel bundle at the specified height.

4.3 Critical Power Ratio (CPR) - the ratio of that power in the assembly, which is calculated by application of the fuel vendor's appropriate boiling correlation, to cause some point in the assembly to experience boiling transition, divided by the actual assembly operating.

4.4 Core Operating Limits Report (COLR) - The Grand Gulf Nuclear Station specific document that provides core operating limits for the current reload cycle in accordance with Technical Specification 5.6.5.

4.5 Linear Heat Generation Rate (LHGR) - the LHGR shall be the heat generation per unit length of fuel rod. It is the integral of the heat flux over the heat transfer area associated with the unit length.

4.6 Minimum Critical Power Ratio (MCPR) - the MCPR shall be the smallest CPR which exists in the core.

4.7 MCPR Safety Limit - the minimum value of the CPR at which the fuel could be operated with the expected number of rods in boiling transition not exceeding 0.1% of the fuel rods in the core.

4.8 Oscillation Power Range Monitor (OPRM) - Provides automatic detection and suppression of reactor core thermal-hydraulic instabilities through monitoring neutron flux changes.

4.9 Backup Stability Protection (BSP) Scram Region - The area of the core power and flow operating domain where the reactor is susceptible to reactor instabilities under conditions exceeding the licensing basis of the current reactor system. An immediate manual scram is required upon entry.

4.10 Backup Stability Protection (BSP) Controlled Entry Region - The area of the core power and flow operating domain where the reactor is susceptible to reactor instabilities. Compliance with at least one alternate stability control is required upon entry.

4.11 Automated Backup Stability Protection (ABSP) Scram Region - An automated reactor scram region that bounds the BSP Scram Region and is initiated by the APRM flow-biased scram setpoint upon entry.

4.12 End of Rated (EOR) - The Cycle exposure corresponding to all rods out, 100% power, 100% flow, and normal feedwater temperature [3.2.1].

4.13 Middle of Cycle (MOC) - The Cycle 21 MOC Core Average Exposure (CAE) is EOR-2,752 MWd/ST [3.2.1].

4.14 End of Cycle (EOC) - The Cycle 21 EOC CAE is 31,283 MWd/ST [3.2.1].

4.15 Maximum Extended Load Line Limit Analysis Plus (MELLLA+) - The GGNS MELLLA+ operating domain is depicted in Figure 4.

5.0 GENERAL REQUIREMENTS

5.1 Average Planar Linear Heat Generation Rates

Consistent with Technical Specification 3.2.1, all APLHGRs shall not exceed the exposure-dependent limits reported in Figure 1-1 [3.2.1].

5.2 Minimum Critical Power Ratio

Consistent with Technical Specification 3.2.2, the MCPR shall be equal to or greater than the limits reported in Figure(s) 2 as functions of power, flow, exposure, and scram speed. [3.2.1, 3.2.2, 3.3.28]. For operation at powers ≥35.4%, the power-dependent MCPR shall be determined based on scram time surveillance data as follows. [3.3.28]

1) If the average scram time (τ_{AVE}) satisfies the following:

$$\tau_{AVE} \leq \tau_B ,$$

then the power dependent MCPR shall be equal to or greater than the Option B limits reported in Figure(s) 2 as a function of exposure.

2) If the average scram time

$$\tau_{AVE} > \tau_B \text{ and } \tau \leq 0.2 ,$$

then the power-dependent MCPR shall be equal to or greater than the Tau = 0.2 limits reported in Figure(s) 2 as a function of exposure,

3) If the average scram time

$$\tau_{AVE} > \tau_B \text{ and } \tau > 0.2 ,$$

then the power-dependent MCPR shall be equal to or greater than the Option A limits reported in Figure(s) 2 as a function of exposure.

In the above equations:

τ_{AVE} = average scram time to the 20% insertion position as calculated by equation 1 of Reference 3.3.28,

τ_B = adjusted analysis mean scram time for 20% insertion as calculated by equation 3 of Reference 3.3.28

and

$$\tau = \frac{\tau_{AVE} - \tau_B}{\tau_A - \tau_B} ,$$

where

τ_A = the technical specification limit on core average scram time to the 20 percent insertion position (0.503 seconds).

The limits determined above support operation with Turbine Bypass Valves Out of Service as described in Technical Specification 3.7.7. Additional MCPR operating limits are provided to support operation with EOC-RPT inoperable as described in Technical Specification 3.3.4.1.

5.3 Linear Heat Generation Rate

Consistent with Technical Specification 3.2.3, the LHGRs for any GNF2 fuel rod at any axial location shall not exceed the nodal exposure-dependent limits reported in Reference 3.2.3 multiplied by the smaller of either the power-dependent or flow-dependent LHGR factors reported in Figures 3-1 and 3-2, respectively [3.2.1]. The limits determined above support operation with Turbine Bypass Valves Out of Service as described in Technical Specification 3.7.7.

5.4 Stability

The OPRM Upscale Confirmation Density Algorithm (CDA) Amplitude Discriminator setpoint is reported in Table 1.

The Backup Stability Protection (BSP) regions boundaries are reported in Figures 4 and 5 [3.2.1]. BSP measures support operation with the OPRM upscale trip function inoperable as described in Technical Specification 3.3.1.1 Condition J. The endpoints for the BSP region boundaries are provided for normal (NFWT) and reduced (RFWT) feedwater temperature operations in Tables 2 and 3, respectively. Figures 4 and 5 depict the BSP region boundaries for NFWT and RFWT operations. Note that Figures 4 and 5 also depict the MELLLA+ and MELLLA domains, consistent with feedwater temperature operating limitations.

The ABSP APRM Simulated Thermal Power (STP) setpoints associated with the ABSP Scram Region are provided in Table 4. The ABSP setpoints are applicable to TLO and SLO, and to both normal and reduced feedwater temperature operations.

The BSP Boundary and Manual BSP region boundaries for normal feedwater temperature operations are valid for reductions in normal feedwater temperature as much as (and including) -10.0 °F.

5.5 Applicability

The following core operating limits are applicable for operation in the Maximum Extended Operting Domain (MEOD), with Feedwater Heaters Out of Service (FHOOS), Turbine Bypass Out of Service (TBVOOS), and EOC-RPT inoperable. For operation with EOC-RPT inoperable, the alternate MCPR limits described in Section 5.2 above must be implemented. For single-loop operation (SLO), the following additional requirements must be satisfied.

1. THE APLHGRs shall not exceed the exposure-dependent limits determined in accordance with Section 5.1 reduced by a 0.83 SLO multiplier. [3.2.1].

2. THE LHGRs shall not exceed the smaller of the nodal exposure-dependent limits determined in accordance with Section 5.3 above or the nodal exposure-dependent limits reported in Reference 3.2.3 reduced by a 0.83 SLO multiplier [3.2.1].

3. The MCPR shall be equal to or greater than the limits determined in accordance with Section 5.2 above increased by 0.00 to account for the difference between the two-loop and single-loop MCPR safety limits for the allowable range of single-loop operation [3.2.1].

Note that the above described limits are applicable to all bundles in the core; however, a re-inserted bundle (GEQ830 - reconstituted in RF19) requires a multiplier to account for uncertainties in its predicted neutronic response during operation. After re-constitution, the vendor documented analyses to determine its performance in C21 [3.2.10]; which concluded that a 10% setdown was required for the TLs of GEQ830 (MFLCPR, MFLPD, MAPRAT). This additional factor has been incorporated into the C21 core monitoring system.

5.6 Limitations and Conditions

As required by Limitation and Condition 9.10/9.11 of licensing topical report NEDC-33173P-A [3.2.7], the limiting Thermal and Mechanical Overpower results are reported in Table 5. The results are summarized as a percent margin to both of these limits. The results are confirmed to meet the required 10% margin to the design limits [3.2.1].

As required by Limitation and Condition 12.10.b of licensing topical report NEDC-33006P-A [3.2.8], the off-rated limits assumed in the ECCS-LOCA analyses are confirmed to be consistent with the cycle-specific off-rated LHGR multipliers provided Figures 3-1 and 3-2. These off-rated LHGR multipliers provide adequate protection for MELLLA+ operation.

As required by Limitation and Condition 12.5.c of licensing topical report NEDC-33006P-A [3.2.8], the plant specific power/flow map specifying the GGNS licensed MELLLA+ operating domain is included as Figure 4.

As required by Limitation and Condition 12.5.b of licensing topical report NEDC-33006P-A [3.2.8], operation with Feedwater Heaters Out of Service (FWHOOS) is prohibited while in the MELLLA+ operating domain [3.2.1]. In addition, as required by Limitation and Condition 12.5.a of licensing topical report NEDC-33006P-A [3.2.8], and described in GGNS TS 3.4.1 LCO, SLO is prohibited in the MELLLA+ operating domain [3.2.1].Therefore, operations with RFWT and/or SLO must adhere to the operating domain shown in Figure 5.

Table 1
OPRM Upscale CDA Amplitude Discriminator Setpoint

Amplitude Discriminator Trip
1.10

Table 2
BSP Endpoints for Normal Feedwater Temperature

Endpoint	Power(%)	Flow(%)	Definition
A1	72.3	44.2	Scram Region Boundary, HFCL
B1	37.5	25.5	Scram Region Boundary, NCL
A2	67.3	50.0	Controlled Entry Region Boundary, HFCL
B2	26.4	24.4	Controlled Entry Region Boundary, NCL
A3	100.0	85.5	BSP Boundary Intercept, HFCL
B3	81.0	67.2	BSP Boundary Intercept, MELLLA Line

Table 3
BSP Endpoints for Reduced Feedwater Temperature

Endpoint	Power(%)	Flow(%)	Definition
A1	63.0	44.8	Scram Region Boundary, HFCL
B1	30.0	24.8	Scram Region Boundary, NCL
A2	67.3	50.0	Controlled Entry Region Boundary, HFCL
B2	26.4	24.4	Controlled Entry Region Boundary, NCL

Table 4
ABSP Setpoints for the Scram Region

Parameter	Symbol	Value
Slope of ABSP APRM flow-biased trip linear segment	m_{TRIP}	0.64
ABSP APRM flow-biased trip setpoint power intercept. Constant Power Line for Trip from zero Drive Flow to Flow Breakpoint.	$P_{BSP-TRIP}$	31.0% RTP[1]
ABSP APRM flow-biased trip setpoint drive flow intercept. Constant Flow Line for Trip.	$W_{BSP-TRIP}$	39.0% RDF[2]
Flow Breakpoint value	$W_{BSP-BREAK}$	2.0% RDF[2]

1. RTP - Rated Thermal Power
2. RDF - Recirculation Drive Flow

Table 5
Margin to Thermal Overpower and Mechanical Overpower Limits

Criteria	GNF2
Thermal Overpower Margin	55.2%
Mechanical Overpower Margin	56.2%

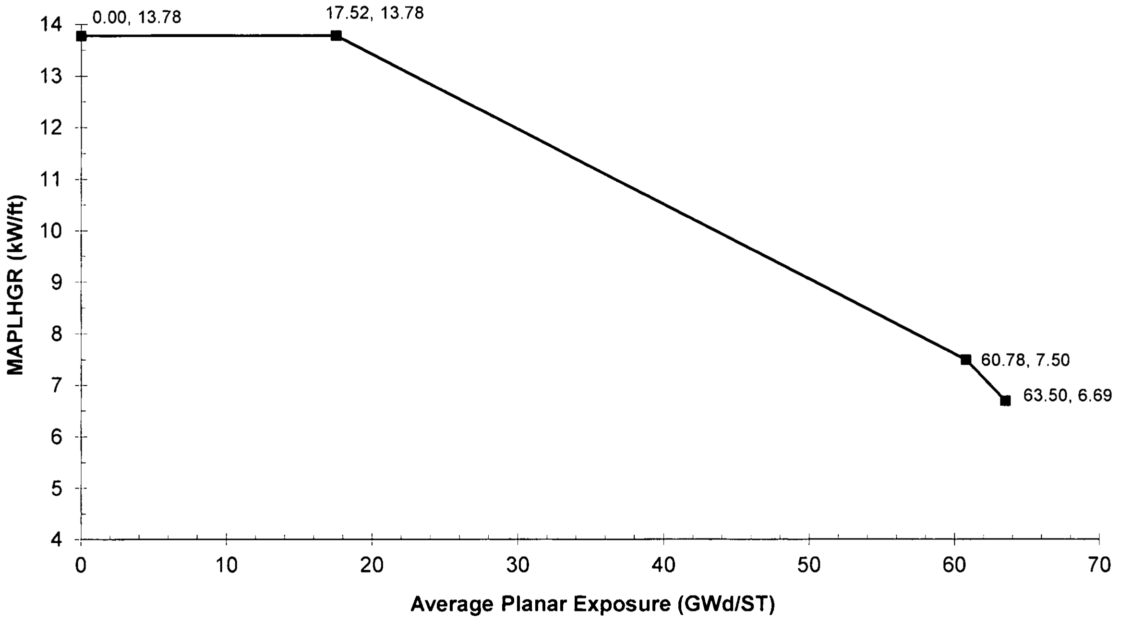

Figure 1-1
Maximum Average Planar Linear Heat Generation Rate
Note: Actual Limits described in Sections 5.1 and 5.5

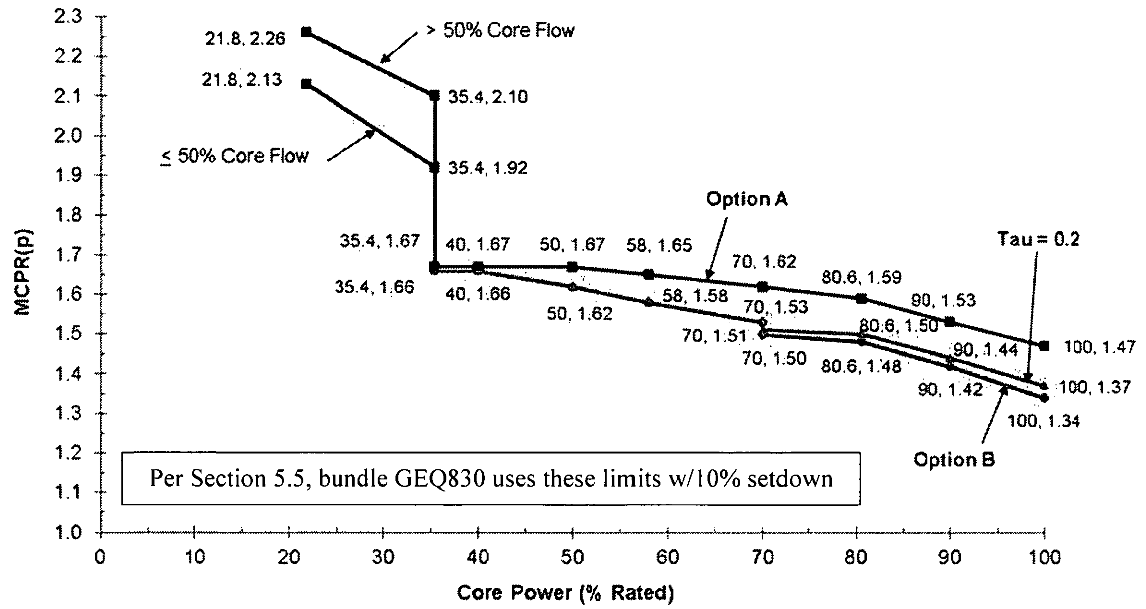

Figure 2-1
Cycle 21 Power-Dependent MCPR Limits
BOC to MOC

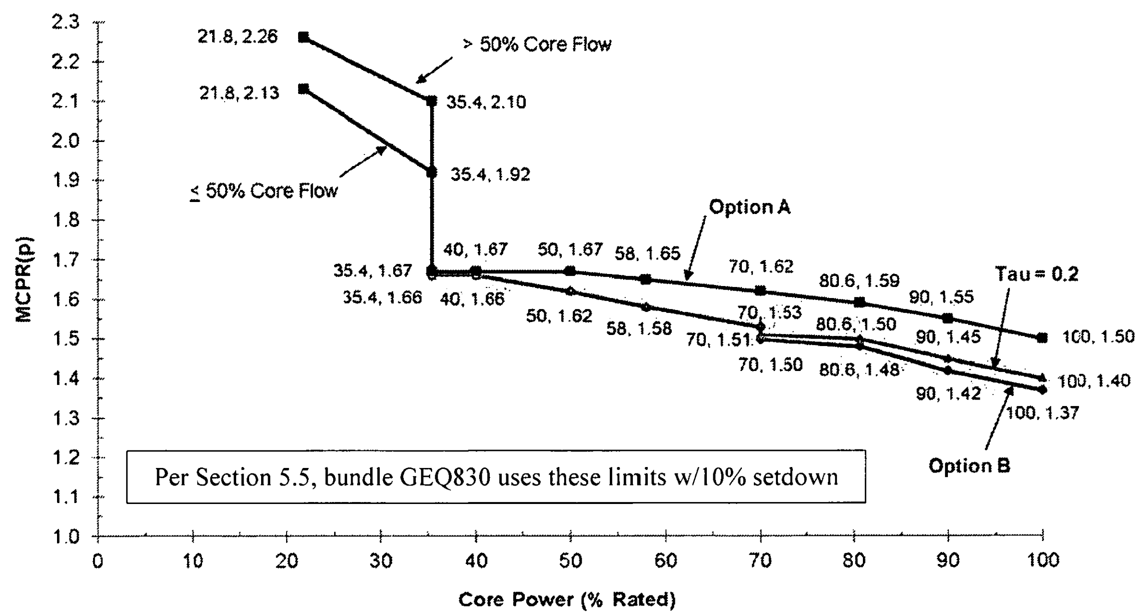

Figure 2-2
Cycle 21 Power-Dependent MCPR Limits
BOC to MOC with EOC-RPT Inoperable

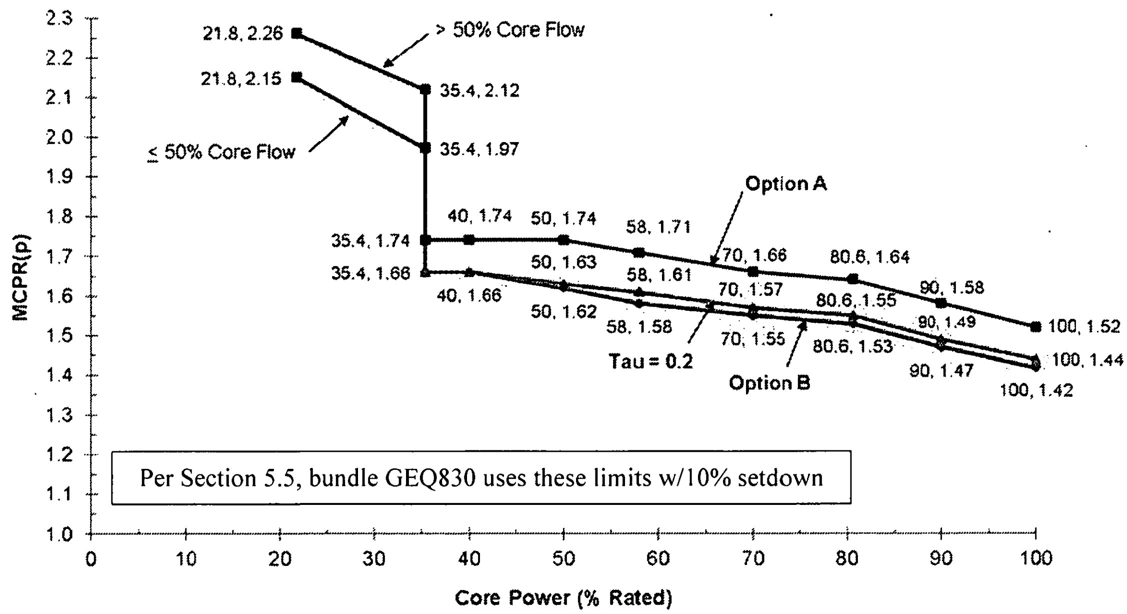

Figure 2-3
Cycle 21 Power-Dependent MCPR Limits
MOC to EOC

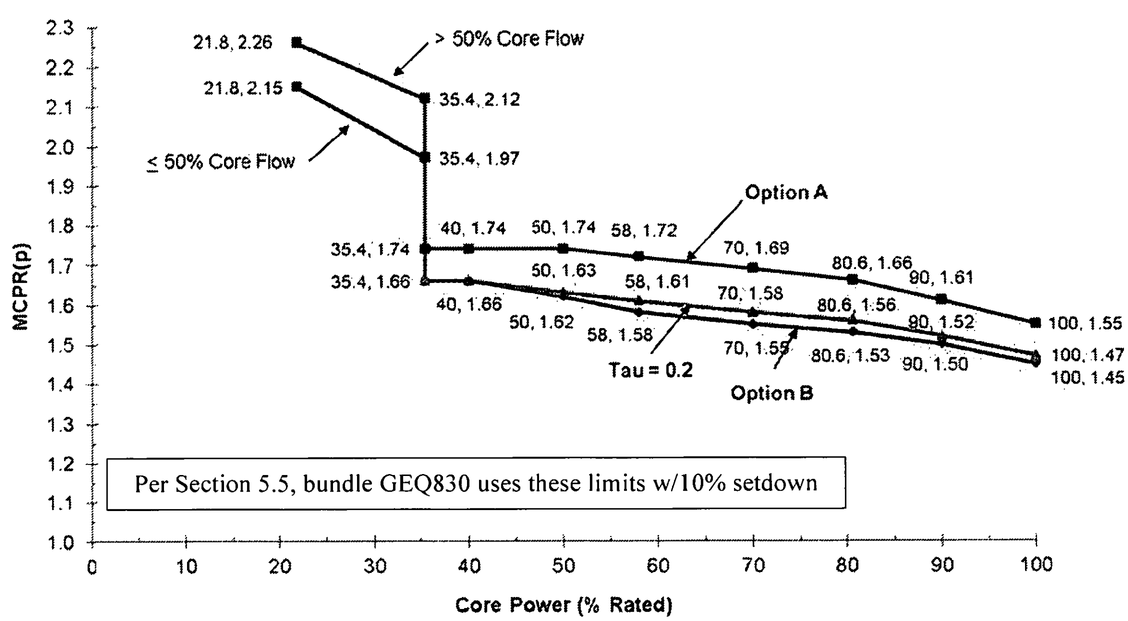

Figure 2-4
Cycle 21 Power-Dependent MCPR Limits
MOC to EOC with EOC-RPT Inoperable

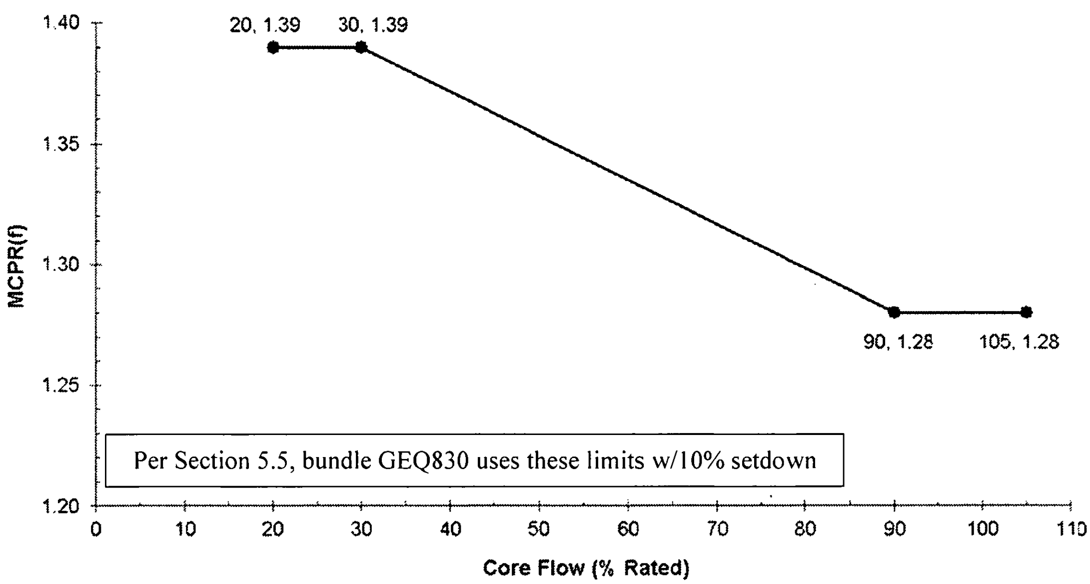

Figure 2-5
Cycle 21 Flow-Dependent MCPR Limits

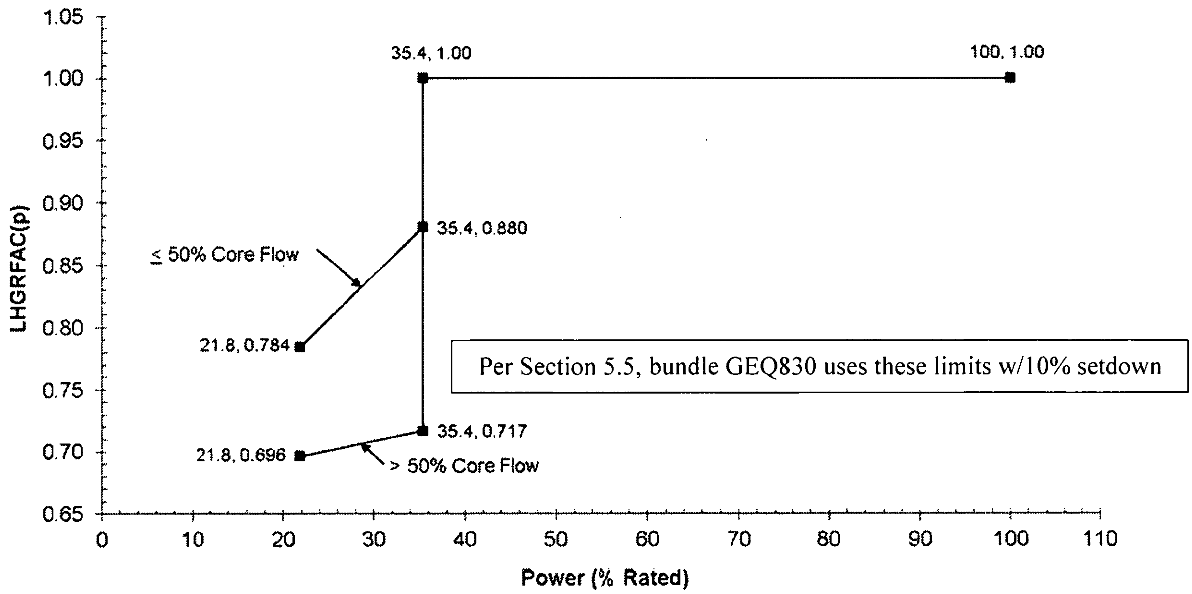

Figure 3-1a
Cycle 21 Power-Dependent LHGR Factor BOC-MOC
Note: These factors to be applied to the exposure-dependent limits as descibed in Section 5.3

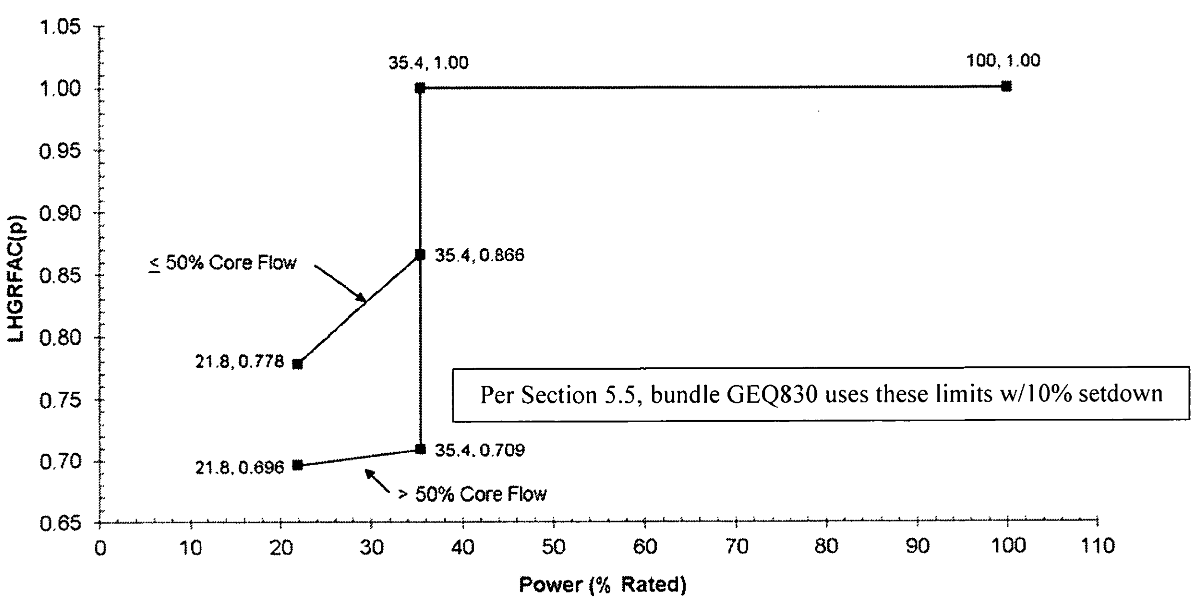

Figure 3-1b
Cycle 21 Power-Dependent LHGR Factor MOC-EOC
Note: These factors to be applied to the exposure-dependent limits as descibed in Section 5.3

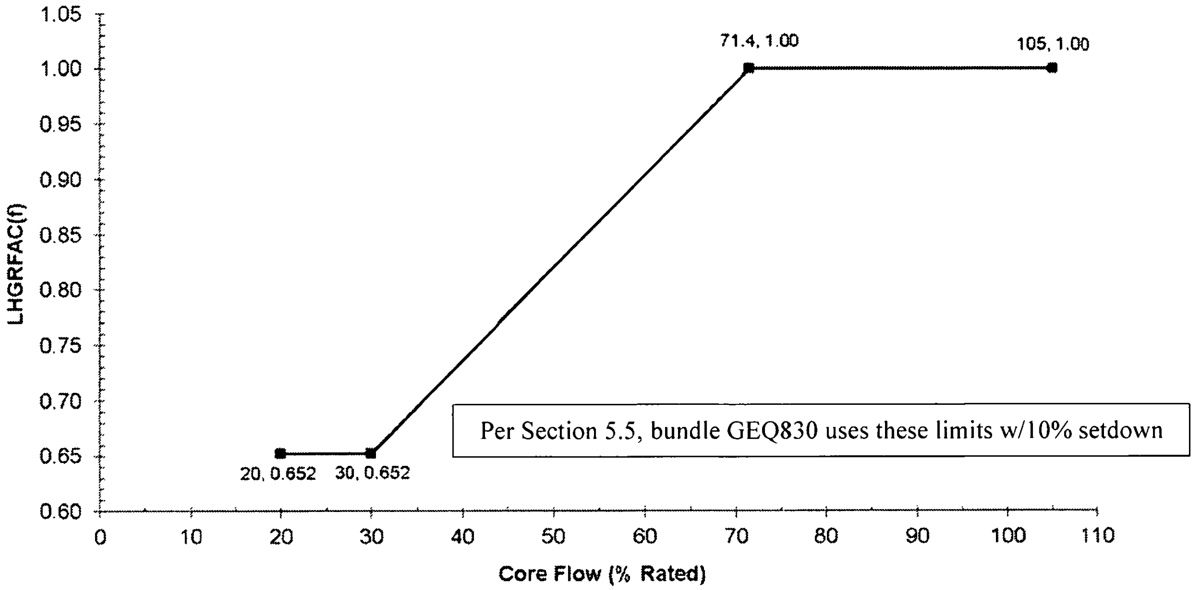

Figure 3-2
Cycle 21 Flow-Dependent LHGR Factor
Note: These factors to be applied to the exposure-dependent limits as descibed in Section 5.3

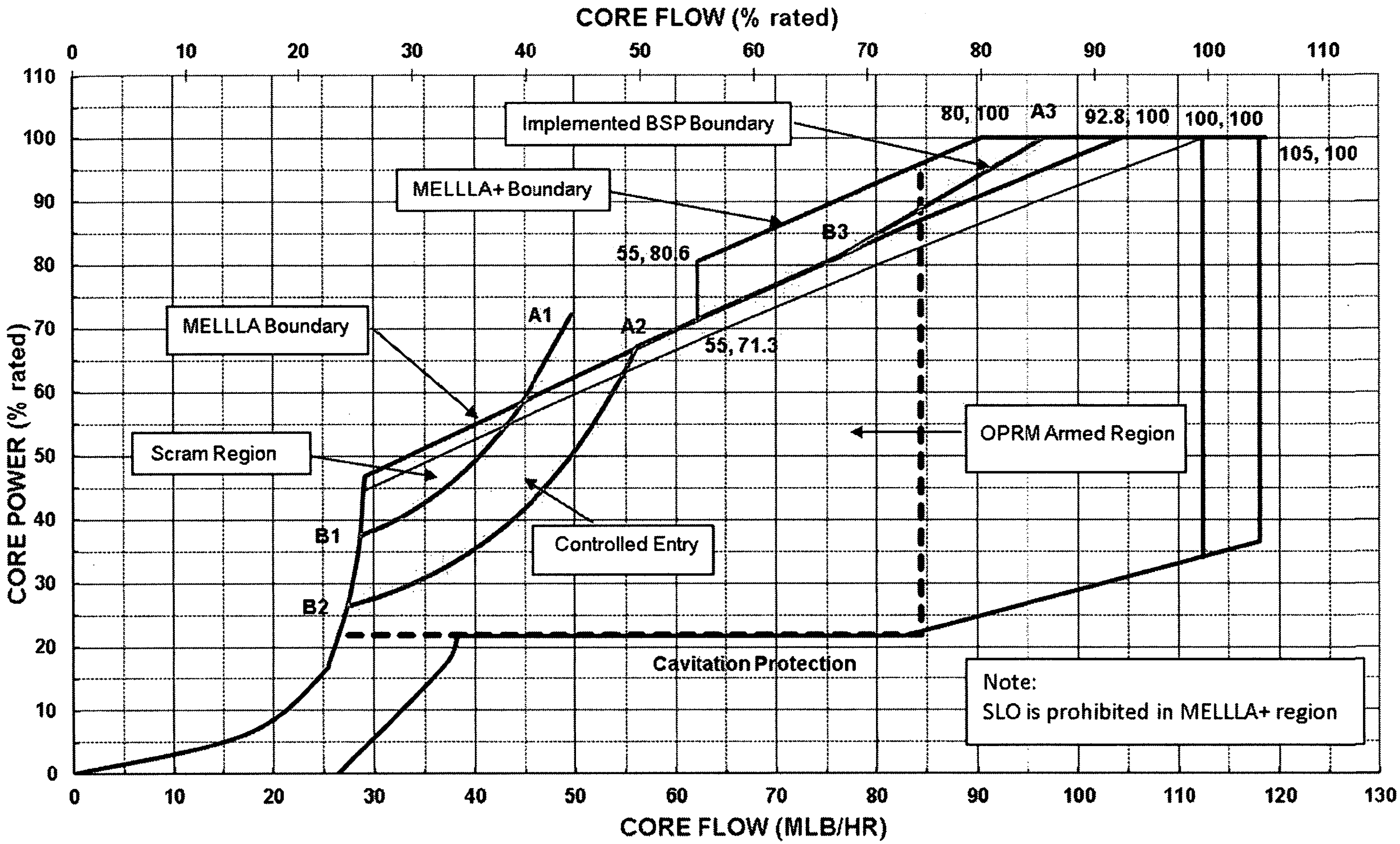

Figure 4 Backup Stability Protection Region Boundaries for Normal Feedwater Temperature (NFWT)

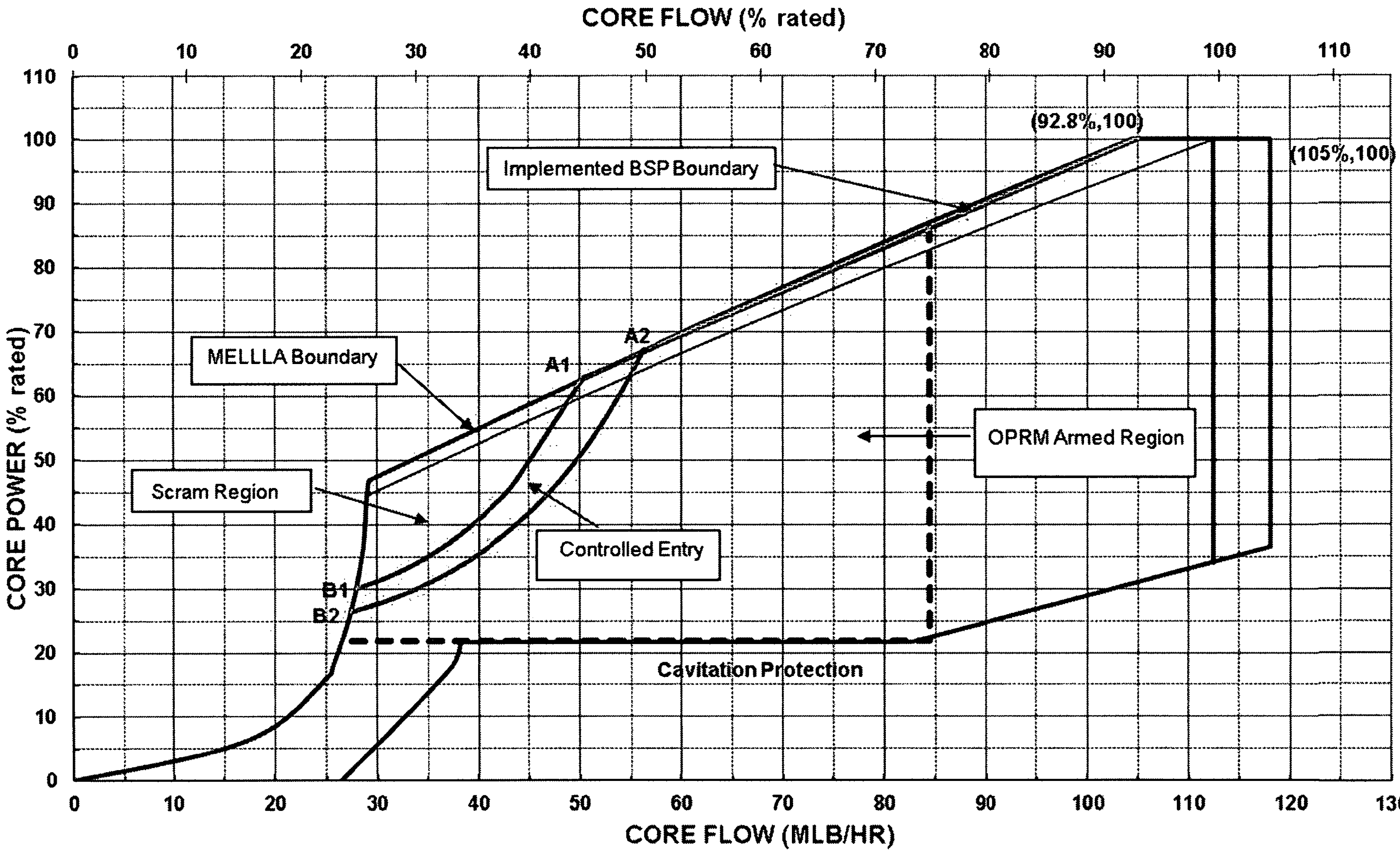

Figure 5 Backup Stability Protection Region Boundaries for Reduced Feedwater Temperature (RFWT)