11/2/2006

eDRFSection: 0000-0044-1500, Rev.1

GNF Additional Information Regarding the Requested Changes to the Technical Specification SLMCPR

Browns Ferry Unit 1

Cycle 7

Proprietary Information Notice

This document is the GNF non-proprietary version of the GNF proprietary report. From the GNF proprietary version, the information denoted as GNF proprietary (enclosed in double brackets) was deleted to generate this version.

Table of Contents

1.0 METHODOLOGY **4**

2.0 DISCUSSION **4**

2.1. MAJOR CONTRIBUTORS TO SLMCPR CHANGE 4
2.2. DEVIATIONS IN NRC-APPROVED UNCERTAINTIES 5
2.2.1. R-Factor *5*
2.2.2. Core Flow Rate and Random Effective TIP Reading *5*
2.3. DEPARTURE FROM NRC-APPROVED METHODOLOGY 6
2.4. FUEL AXIAL POWER SHAPE PENALTY 7
2.5. METHODOLOGY RESTRICTIONS 7
2.6. MINIMUM CORE FLOW CONDITION 7
2.7. LIMITING CONTROL ROD PATTERNS 8
2.8. CORE MONITORING SYSTEM 8
2.9. POWER/FLOW MAP 8
2.10. CORE LOADING DIAGRAM 8
2.11. FIGURE REFERENCES 8
2.12. ADDITIONAL SLMCPR LICENSING CONDITIONS 8
2.13. SUMMARY 9

3.0 REFERENCES **10**

List of Figures

FIGURE 1. CURRENT CYCLE CORE LOADING DIAGRAM 11
FIGURE 2. FIGURE 4.1 FROM NEDC-32601-P-A 12
FIGURE 3. FIGURE III.5-1 FROM NEDC-32601P-A 13
FIGURE 4. FIGURE III.5-2 FROM NEDC-32601P-A 14

List of Tables

TABLE 1. DESCRIPTION OF CORE 15
TABLE 2. SLMCPR CALCULATION METHODOLOGIES 16
TABLE 3. MONTE CARLO CALCULATED SLMCPR VS. ESTIMATE 17
TABLE 4. NON-POWER DISTRIBUTION UNCERTAINTIES 19
TABLE 5. POWER DISTRIBUTION UNCERTAINTIES 21
TABLE 6. CRITICAL POWER UNCERTAINTIES 23

1.0 Methodology

GNF performed the Browns Ferry Unit 1 Cycle 7 Safety Limit Minimum Critical Power Ratio (SLMCPR) calculation in accordance to NEDE-24011-P-A "General Electric Standard Application for Reactor Fuel" (Revision 15) using the following NRC-approved methodologies and uncertainties:

- NEDC-32601P-A "Methodology and Uncertainties for Safety Limit MCPR Evaluations" (August 1999).
- NEDC-32694P-A "Power Distribution Uncertainties for Safety Limit MCPR Evaluations" (August 1999).
- NEDC-32505P-A "R-Factor Calculation Method for GE11, GE12 and GE13 Fuel" (Revision 1, July 1999).
- NEDO-10958-A "General Electric BWR Thermal Analysis Basis (GETAB): Data, Correlation and Design Application" (January 1977).

2.0 Discussion

Browns Ferry 1 Cycle 7 is the first cycle after a long shut down period and, therefore, no comparisons with previous cycle results are relevant and no previous cycle data is provided in this document. However, the Browns Ferry Cycle 7 SLMCPR results are well in line with other similar reactor/cycles results.

2.1. Major Contributors to SLMCPR Change

In general, the calculated safety limit is dominated by two key parameters: (1) flatness of the core bundle-by-bundle MCPR distribution, and (2) flatness of the bundle pin-by-pin power/R-factor distribution. Greater flatness in either parameter yields more rods susceptible to boiling transition and thus a higher calculated SLMCPR. MIP (MCPR Importance Parameter) measures the core bundle-by-bundle MCPR distribution and RIP (R-factor Importance Parameter) measures the bundle pin-by-pin power/R-factor distribution. The impact of the fuel loading pattern on the calculated Two Loop Operation (TLO) SLMCPR using rated core power and rated core flow conditions has been correlated to the parameter MIPRIP, which combines the MIP and RIP values.

Table 3 presents the MIP and RIP parameters for the current cycle along with the TLO SLMCPR estimate using the MIPRIP correlation. If the minimum core flow case is applicable, the TLO SLMCPR estimate is also provided for that case although the MIPRIP correlation is only applicable to the rated core flow case. This is done only to provide some reasonable assessment basis of the minimum core flow case trend. Table 3 in addition presents estimated impacts on the TLO SLMCPR due to methodology deviations, penalities, and/or uncertainties deviations

from approved values. Based on the MIPRIP correlation and any impacts due to deviations from approved values, a final estimated TLO SLMCPR is determined. Table 3 also provides the actual calculated Monte Carlo SLMCPRs. Given the bias and uncertainty in the MIPRIP correlation [[{3}]] and the inherent variation in the Monte Carlo results [[{3}]], the change in the Browns Ferry Unit 1 Cycle 7 calculated Monte Carlo TLO SLMCPR using rated core power and rated core flow conditions is consistent with the corresponding estimated TLO SLMCPR value.

2.2. Deviations in NRC-Approved Uncertainties

Tables 4 and 5 provide a list of NRC-approved uncertainties along with values actually used. A discussion of deviations from these NRC-approved values follows; all of which are conservative relative to NRC-approved values. Also, estimated impact on the SLMCPR is provided in Table 3 for each deviation.

2.2.1. R-Factor

At this time, GNF has generically increased the GEXL R-Factor uncertainty from [[{3}]] to account for an increase in channel bow due to the emerging unforeseen phenomena called control blade shadow corrosion-induced channel bow, which is not accounted for in the channel bow uncertainty component of the approved R-Factor uncertainty. The step "σ RPEAK" in Figure 4.1 from NEDC-32601P-A, which has been provided for convenience in Figure 2 of this attachment, is affected by this deviation. Reference 4 technically justifies that a GEXL R-Factor uncertainty of [[{3}]] accounts for a channel bow uncertainty of up to [[{3}]].

Currently, Browns Ferry Unit 1 has not experienced any control blade shadow corrosion-induced channel bow and is not expected to experience any in Cycle 7 to the extent that would invalidate the approved R-Factor uncertainty. [[

{3}]].

2.2.2. Core Flow Rate and Random Effective TIP Reading

At this time, GNF has not been able to show that the NRC-approved process to calculate the SLMCPR only at the rated core power and rated core flow condition is adequately bounding relative to the SLMCPR calculated at rated core power and minimum core flow; see Reference 5. The minimum core flow condition can be more limiting due to the control rod pattern used. GNF has modified the NRC-approved process for determining the SLMCPR to include an analysis at the rated core power and minimum licensed core flow point in addition to the analysis at the rated core power and rated core flow point. GNF believes this modification is conservative and may in the future provide justification that the original NRC-approved process is adequately bounding.

For the TLO calculations performed at 81% core flow, the approved uncertainty values for the core flow rate (2.5%) and the random effective TIP reading (1.2%) are conservatively adjusted by dividing them by 81/100. The steps "σ CORE FLOW" and "σ TIP (INSTRUMENT)" in Figure 4.1 from NEDC-32601P-A, which has been provided for convenience in Figure 2 of this attachment, are affected by this deviation, respectively.

Historically, these values have been construed to be somewhat dependent on the core flow conditions as demonstrated by the fact that higher values have always been used when performing Single Loop Operation (SLO) calculations. It is for this reason that GNF determined that it is appropriate to consider an increase in these two uncertainties when the core flow is reduced. The amount of increase is determined in a conservative way. For both parameters it is assumed that the absolute uncertainty remains the same as the flow is decreased so that the percentage uncertainty increases inversely proportional to the change in core flow. This is conservative relative to the core flow uncertainty since the variability in the absolute flow is expected to decrease somewhat as the flow decreases. For the random effective TIP uncertainty, there is no reason to believe that the percentage uncertainty should increase as the core flow decreases for TLO. Nevertheless, this uncertainty is also increased as is done in the more extreme case for SLO primarily to preserve the historical precedent established by the SLO evaluation. Note that the TLO condition is different than the SLO condition because for TLO there is no expected tilting of the core radial power shape.

The treatment of the core flow and random effective TIP reading uncertainties is based on the assumption that the signal to noise ratio deteriorates as core flow is reduced. GNF believes this is conservative and may in the future provide justification that the original uncertainties (non-flow dependent) are adequately bounding.

The core flow and random TIP reading uncertainties used in the SLO minimum core flow SLMCPR analysis remain the same as in the rated core flow SLO SLMCPR analysis because these uncertainties (which are substantially larger than used in the TLO analysis) already account for the effects of operating at reduced core flow.

2.3. Departure from NRC-Approved Methodology

No departures from NRC-approved methodologies were used in the Browns Ferry Unit 1 Cycle 7 SLMCPR calculations.

2.4. Fuel Axial Power Shape Penalty

At this time, GNF has determined that higher uncertainties and non-conservative biases in the GEXL correlations for the various types of axial power shapes (i.e., inlet, cosine, outlet and double hump) could potentially exist relative to the NRC-approved methodology values; see References 3, 6, and 7. The following table identifies, by marking with an "X", this potential for each GNF product line currently being offered:

[[

[3]]]

Axial bundle power shapes corresponding to the limiting SLMCPR control blade patterns are determined using the PANACEA 3D core simulator. If the bundles that could participate in setting the SLMCPR (i.e., the limiting bundles) exhibit an axial power shape identified by this table, GNF penalizes the GEXL critical power uncertainties to conservatively account for the impact of the axial power shape. Table 6 provides a list of the GEXL critical power uncertainties determined in accordance to the NRC-approved methodology contained in NEDE-24011-P-A along with values actually used.

For the limiting bundles, the fuel axial power shapes in the SLMCPR analysis were examined to determine the presence of axial power shapes identified in the above table. These power shapes were not found; therefore, no power shape penalties were applied to the calculated Browns Ferry Unit 1 Cycle 7 SLMCPR values.

2.5. Methodology Restrictions

The four restrictions identified on Page 3 of NRC's Safety Evaluation relating to the General Electric Licensing Topical Reports NEDC-32601P, NEDC-32694P, and Amendment 25 to NEDE-24011-P-A (March 11, 1999) are addressed in References 1, 2, and 3.

No new GNF fuel designs are being introduced in Browns Ferry Unit 1 Cycle 7, therefore, the NEDC-32505-P-A statement "...if new fuel is introducted, GENE must confirm that the revised R-Factor method is still valid based on new test data" is not applicable.

2.6. Minimum Core Flow Condition

For Browns Ferry Unit 1 Cycle 7, the minimum core flow SLMCPR calculation performed at 81% core flow and rated core power condition was limiting as compared to the rated core flow and rated core power condition. For convenience, Figures III.5-1 and III.5-2 from

NEDC-32601P-A have been provided in Figures 3 and 4 in order to show this minimum core flow conditon relative relationship to the data on these figures. For this condition the MIP [[

{3}]]; therefore, this demonstrates that the MIP criterion for determining what constitutes a reasonably bounding limiting rod pattern is still valid for this minimum core flow condition.

2.7. Limiting Control Rod Patterns

The limiting control rod patterns used to calculate the SLMCPR reasonably assures that at least 99.9% of the fuel rods in the core would not be expected to experience boiling transition during normal operation or anticipated operational occurrences during the operation of Browns Ferry Unit 1 Cycle 7.

2.8. Core Monitoring System

For Browns Ferry Unit 1 Cycle 7, the 3D MONICORE system will be used as the core monitoring system.

2.9. Power/Flow Map

The utility has provided the Cycle 7 power/flow map in a separate submittal.

2.10. Core Loading Diagram

Figure 1 provides the core loading diagram for Cycle 7, which is the Reference Loading Pattern as defined by NEDE-24011-P-A.

2.11. Figure References

Figure 2 is Figure 4.1 from NEDC-32601-P-A. Figure 3 is Figure III.5-1 from NEDC-32601P-A. Figure 4 is Figure III.5-2 from NEDC-32601P-A.

2.12. Additional SLMCPR Licensing Conditions

For Browns Ferry 1 Cycle 7, no additional SLMCPR licensing conditions are included in the analysis.

2.13. Summary

The calculated SLMCPR values for Browns Ferry 1 Cycle 7 at the reactor power level of 3458 MWth are 1.07 for Two Loop Operation and 1.09 for Single Loop Operation.

3.0 References

1. Letter, Glen A. Watford (GNF-A) to U.S. Nuclear Regulatory Commission Document Control Desk with attention to R. Pulsifer (NRC), "Confirmation of 10x10 Fuel Design Applicability to Improved SLMCPR, Power Distribution and R-Factor Methodologies", FLN-2001-016, September 24, 2001.

2. Letter, Glen A. Watford (GNF-A) to U.S. Nuclear Regulatory Commission Document Control Desk with attention to J. Donoghue (NRC), "Confirmation of the Applicability of the GEXL14 Correlation and Associated R-Factor Methodology for Calculating SLMCPR Values in Cores Containing GE14 Fuel", FLN-2001-017, October 1, 2001.

3. Letter, Glen A. Watford (GNF-A) to U.S. Nuclear Regulatory Commission Document Control Desk with attention to Joseph E. Donoghue (NRC), "Final Presentation Material for GEXL Presentation-February 11, 2002", FLN-2002-004, February 12, 2002.

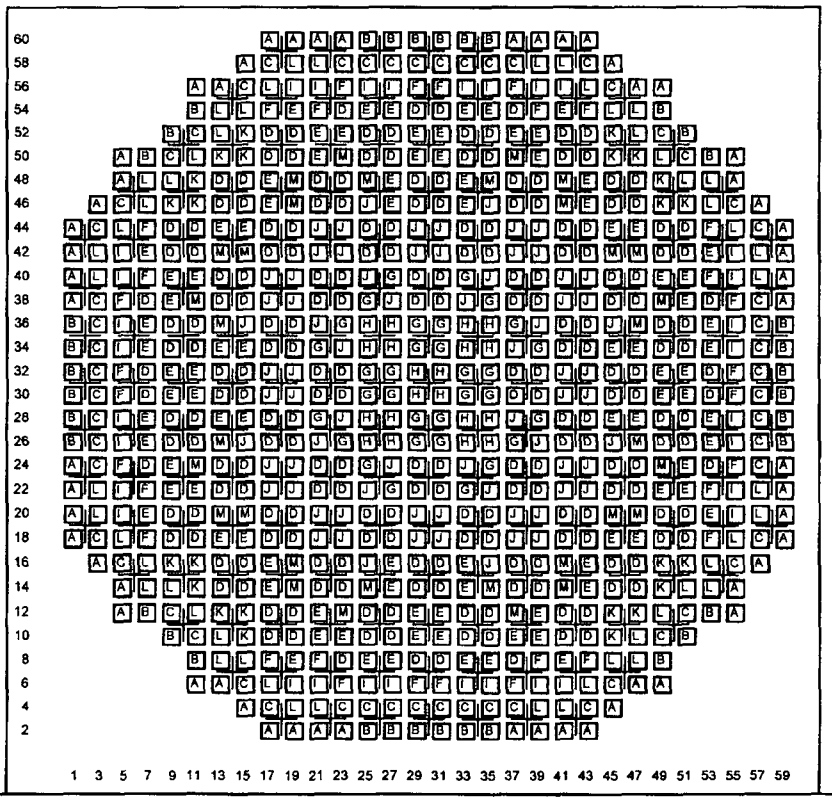
4. Letter, John F. Schardt (GNF-A) to U.S. Nuclear Regulatory Commission Document Control Desk with attention to Mel B. Fields (NRC), "Shadow Corrosion Effects on SLMCPR Channel Bow Uncertainty", FLN-2004-030, November 10, 2004.

5. Letter, Jason S. Post (GENE) to U.S. Nuclear Regulatory Commission Document Control Desk with attention to Chief, Information Management Branch, et al. (NRC), "Part 21 Final Report: Non-Conservative SLMCPR", MFN 04-108, September 29, 2004.

6. Letter, Glen A. Watford (GNF-A) to U.S. Nuclear Regulatory Commission Document Control Desk with attention to Alan Wang (NRC), "NRC Technology Update – Proprietary Slides-July 31-August 1, 2002", FLN-2002-015, October 31, 2002.

7. Letter, Jens G. Munthe Andersen (GNF-A) to U.S. Nuclear Regulatory Commission Document Control Desk with attention to Alan Wang (NRC), "GEXL Correlation for 10X10 Fuel", FLN-2003-005, May 31, 2003.

Figure 1. Current Cycle Core Loading Diagram



Code	Bundle Name	Number Loaded	Cycle Loaded
A	GE13-P9DTB391-13GZ-100T-146-T6-3964	56	BF213
B	GE14-P10DNAB200-3GZ-100T-150-T6-2609	36	BF213
C	GE13-P9DTB156-NOG-100T-146-T6-2887	56	7
D	GE14-P10DNAB157-NOG-100T-150-T6-2889	224	7
E	GE14-P10DNAB377-16GZ-100T-150-T6-2890	96	7
F	GE14-P10DNAB402-16GZ-100T-150-T6-2891	32	7
G	GE14-P10DNAB350-16GZ-100T-150-T6-2892	32	7
H	GE14-P10DNAB147-NOG-100T-150-T6-2893	20	7
I	GE14-P10DNAB419-16GZ-100T-150-T6-2894	32	7
J	GE14-P10DNAB368-15GZ-100T-150-T6-2895	72	7
K	GE14-P10DNAB402-19GZ-100T-150-T6-2896	24	7
L	GE13-P9DTB163-NOG-100T-146-T6-2888	52	7
M	GE14-P10DNAB377-17GZ-100T-150-T6-2897	32	7

[[

{3}]]

Figure 2. Figure 4.1 from NEDC-32601-P-A

[[

{3}]]

Figure 3. Figure III.5-1 from NEDC-32601P-A[1]

[1] Note the callouts are for illustrative purpose only.

[[

{3}]]

Figure 4. Figure III.5-2 from NEDC-32601P-A[2]

[2] Note the callouts are for illustrative purpose only.

Table 1. Description of Core

Description	Previous Cycle Minimum Core Flow Limiting Case	Previous Cycle Rated Core Flow Limiting Case	Current Cycle Minimum Core Flow Limiting Case	Current Cycle Rated Core Flow Limiting Case
Number of Bundles in the Core	N/A	N/A	764	764
Limiting Cycle Exposure Point (i.e. BOC/MOC/EOC)	N/A	N/A	EOC	PHE
Cycle Exposure at Limiting Point (MWd/STU)	N/A	N/A	13500	10000
% Rated Core Flow	N/A	N/A	81.0	100.0
Reload Fuel Type	N/A	N/A	GE14/GE13	GE14/GE13
Latest Reload Batch Fraction, %	N/A	N/A	88.0	88.0
Latest Reload Average Batch Weight % Enrichment	N/A	N/A	2.63	2.63
Core Fuel Fraction: GE14 GE13	N/A	N/A	78.5 21.5	78.5 21.5
Core Average Weight % Enrichment	N/A	N/A	2.70	2.70

Table 2. SLMCPR Calculation Methodologies

Description	Previous Cycle Minimum Core Flow Limiting Case	Previous Cycle Rated Core Flow Limiting Case	Current Cycle Minimum Core Flow Limiting Case	Current Cycle Rated Core Flow Limiting Case
Non-power Distribution Uncertainty	N/A	N/A	NEDC-32601-P-A	NEDC-32601-P-A
Power Distribution Methodology	N/A	N/A	NEDC-32694-P-A	NEDC-32694-P-A
Power Distribution Uncertainty	N/A	N/A	NEDC-32694-P-A	NEDC-32694-P-A
Core Monitoring System	N/A	N/A	3D MONICORE	3D MONICORE

Table 3. Monte Carlo Calculated SLMCPR vs. Estimate

Description	Previous Cycle Minimum Core Flow Limiting Case	Previous Cycle Rated Core Flow Limiting Case	Current Cycle Minimum Core Flow Limiting Case	Current Cycle Rated Core Flow Limiting Case
[[				

Table 3. Monte Carlo Calculated SLMCPR vs. Estimate

Description	Previous Cycle Minimum Core Flow Limiting Case	Previous Cycle Rated Core Flow Limiting Case	Current Cycle Minimum Core Flow Limiting Case	Current Cycle Rated Core Flow Limiting Case

{3}]]

[3] The SLO SLMCPR is from the EOC at 13500 MWd/ST cycle exposure.

Table 4. Non-Power Distribution Uncertainties

	Nominal (NRC-Approved) Value ± σ (%)	Previous Cycle Minimum Core Flow Limiting Case	Previous Cycle Rated Core Flow Limiting Case	Current Cycle Minimum Core Flow Limiting Case	Current Cycle Rated Core Flow Limiting Case
GETAB					
Feedwater Flow Measurement	1.76	N/A	N/A	N/A	N/A
Feedwater Temperature Measurement	0.76	N/A	N/A	N/A	N/A
Reactor Pressure Measurement	0.50	N/A	N/A	N/A	N/A
Core Inlet Temperature Measurement	0.20	N/A	N/A	N/A	N/A
Total Core Flow Measurement	6.0 SLO/2.5 TLO	N/A	N/A	N/A	N/A
Channel Flow Area Variation	3.0	N/A	N/A	N/A	N/A
Friction Factor Multiplier	10.0	N/A	N/A	N/A	N/A
Channel Friction Factor Multiplier	5.0	N/A	N/A	N/A	N/A

Table 4. Non-Power Distribution Uncertainties

	Nominal (NRC-Approved) Value ± σ (%)	Previous Cycle Minimum Core Flow Limiting Case	Previous Cycle Rated Core Flow Limiting Case	Current Cycle Minimum Core Flow Limiting Case	Current Cycle Rated Core Flow Limiting Case
NEDC-32601-P-A					
Feedwater Flow Measurement	[[{3}]]	N/A	N/A	[[{3}]]	[[{3}]]
Feedwater Temperature Measurement	[[{3}]]	N/A	N/A	[[{3}]]	[[{3}]]
Reactor Pressure Measurement	[[{3}]]	N/A	N/A	[[{3}]]	[[{3}]]
Core Inlet Temperature Measurement	0.2	N/A	N/A	0.2	0.2
Total Core Flow Measurement	6.0 SLO/2.5 TLO	N/A	N/A	6.0 SLO/3.09 TLO	6.0 SLO/2.5 TLO
Channel Flow Area Variation	[[{3}]]	N/A	N/A	[[{3}]]	[[{3}]]
Friction Factor Multiplier	[[{3}]]	N/A	N/A	[[{3}]]	[[{3}]]
Channel Friction Factor Multiplier	5.0	N/A	N/A	5.0	5.0

Table 5. Power Distribution Uncertainties

Description	Nominal (NRC-Approved) Value ± σ (%)	Previous Cycle Minimum Core Flow Limiting Case	Previous Cycle Rated Core Flow Limiting Case	Current Cycle Minimum Core Flow Limiting Case	Current Cycle Rated Core Flow Limiting Case
GETAB/NEDC-32601-P-A					
GEXL R-Factor	[[{3}]]	N/A	N/A	N/A	N/A
Random Effective TIP Reading	2.85 SLO/1.2 TLO	N/A	N/A	N/A	N/A
Systematic Effective TIP Reading	8.6	N/A	N/A	N/A	N/A
NEDC-32694-P-A, 3DMONICORE					
GEXL R-Factor	[[{3}]]	N/A	N/A	[[{3}]]	[[{3}]]
Random Effective TIP Reading	2.85 SLO/1.2 TLO	N/A	N/A	2.85 SLO/1.5 TLO	2.85 SLO/1.2 TLO
TIP Integral	[[{3}]]	N/A	N/A	[[{3}]]	[[{3}]]
Four Bundle Power Distribution Surrounding TIP Location	[[{3}]]	N/A	N/A	[[{3}]]	[[{3}]]
Contribution to Bundle Power Uncertainty Due to LPRM Update	[[{3}]]	N/A	N/A	[[{3}]]	[[{3}]]

Table 5. Power Distribution Uncertainties

Description	Nominal (NRC-Approved) Value ± σ (%)	Previous Cycle Minimum Core Flow Limiting Case	Previous Cycle Rated Core Flow Limiting Case	Current Cycle Minimum Core Flow Limiting Case	Current Cycle Rated Core Flow Limiting Case
Contribution to Bundle Power Due to Failed TIP	[[{3}]]	N/A	N/A	[[{3}]]	[[{3}]]
Contribution to Bundle Power Due to Failed LPRM	[[{3}]]	N/A	N/A	[[3}]]	[[{3}]]
Total Uncertainty in Calculated Bundle Power	[[{3}]]	N/A	N/A	[[{3}]]	[[{3}]]
Uncertainty of TIP Signal Nodal Uncertainty	[[{3}]]	N/A	N/A	[[{3}]]	[[{3}]]

Table 6. Critical Power Uncertainties

Description	Nominal Value ± σ (%)	Previous Cycle Minimum Core Flow Limiting Case	Previous Cycle Rated Core Flow Limiting Case	Current Cycle Minimum Core Flow Limiting Case	Current Cycle Rated Core Flow Limiting Case

[[

{3}]]