Docket No. 50-271
BVY 09-063

Attachment 6

Vermont Yankee Nuclear Power Station

Proposed Technical Specification Change No. 287

GNF Summary of Technical Basis for SLMCPR Values

(Non-Proprietary Version)

9/21/2009

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

Vermont Yankee Cycle 28

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1.0 Methodology

GNF performed the Vermont Yankee Cycle 28 Safety Limit Minimum Critical Power Ratio (SLMCPR) calculation in accordance to NEDE-24011-P-A "General Electric Standard Application for Reactor Fuel" (Revision 16) 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).

Table 2 identifies the actual methodologies used for the previous Cycle 27 and the current Cycle 28 SLMCPR calculations.

2.0 Discussion

In this discussion, the TLO nomenclature is used for two recirculation loops in operation, and the SLO nomenclature is used for one recirculation loop in operation.

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 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 previous cycle and 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. In addition, Table 3 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 Vermont Yankee Cycle 28 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 3 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, Vermont Yankee has not experienced any control blade shadow corrosion-induced channel bow and is not expected to experience any in Cycle 28 to the extent that would invalidate the approved R-Factor uncertainty.

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 analyses at the rated core power and minimum licensed core flow point in addition to analyses 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.

The available flow range at rated power, 99% to 100% rated core flow, does not warrant analysis at the minimum core flow point.

2.3. Departure from NRC-Approved Methodology

No departures from NRC-approved methodologies were used in the Vermont Yankee Cycle 28 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, 7 and 8. 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. These axial power shapes are classified in accordance to the following table:

[[

{3}]]

If the limiting bundles in the SLMCPR calculation 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 Vermont Yankee Cycle 28 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, 3, and 9.

No new GNF fuel designs are being introduced in Vermont Yankee Cycle 28; 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. The GNF2 product line is not considered a new fuel design relative to the GE14 product line, as both consist of 10 x 10 lattice designs.

2.6. Minimum Core Flow Condition

The available flow range at rated power, 99% to 100% rated core flow, does not warrant analysis at the minimum core flow point.

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 Vermont Yankee Cycle 28.

2.8. Core Monitoring System

For Vermont Yankee Cycle 28, the 3D Monicore system will be used as the core monitoring system.

2.9. Power/Flow Map

The utility has provided the current and previous cycle power/flow map in a separate attachment.

2.10. Core Loading Diagram

Figures 1 and 2 provide the core loading diagram for the current and previous cycle respectively, which are the Reference Loading Pattern as defined by NEDE-24011-P-A. Table 1 provides a description of the core.

2.11. Figure References

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

2.12. Additional SLMCPR Licensing Conditions

For Vermont Yankee Cycle 28, the additional SLMCPR licensing condition (Reference 10) that the SLMCPR shall be established by adding 0.02 to the cycle-specific TLO SLMCPR value

calculated using the NRC-approved methodologies documented in NEDE-24011-P-A has been applied (see Table 3). This adder does not apply to the cycle-specific SLO SLMCPR, because such operation would by Technical Specification be limited to less than the 1593 MWt power threshold specified in Reference 10.

2.13. Summary

The requested changes to the Technical Specification SLMCPR values are 1.09 for TLO and 1.10 for SLO for Vermont Yankee Cycle 28.

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.

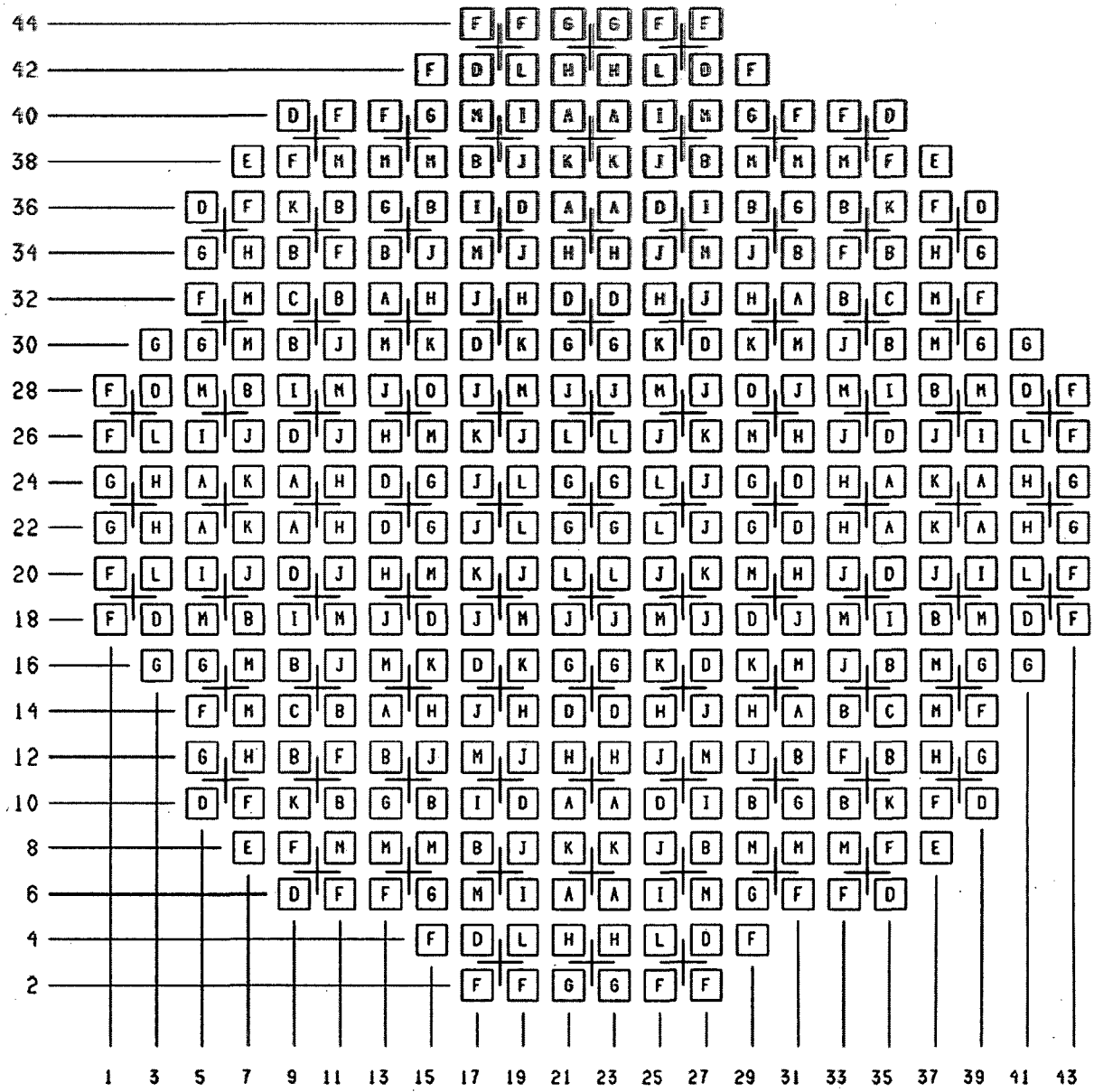
6. Letter, Glen A. Watford (GNF-A) to U.S. Nuclear Regulatory Commission Document Control Desk with attention to Alan Wang (NRC), "NRC Technology Update – Proprietary Slides – July 31 – August 1, 2002", FLN-2002-015, October 31, 2002.

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.

8. Letter, Andrew A. Lingenfelter (GNF-A) to U.S. Nuclear Regulatory Commission Document Control Desk with cc to MC Honcharik (NRC), "Removal of Penalty Being Applied to GE14 Critical Power Correlation for Outlet Peaked Axial Power Shapes", FLN-2007-031, September 18,2007.

9. Letter, Andrew A. Lingenfelter (GNF-A) to U.S. Nuclear Regulatory Commission Document Control Desk with cc to MC Honcharik (NRC), "GNF2 Advantage Generic Compliance with NEDE-24011-P-A (GESTAR II), NEDC-33270P, Revision 2, June 2009 and GEXL Correlation for GNF2 Fuel, NEDC-33292P, Revision 3, June 2009", MFN 09-436, June 30, 2009.

10. Letter, Richard B. Ennis (NRC) to Michael Kansler (Entergy Nuclear Operations, Inc.), "Vermont Yankee Nuclear Power Station – Issuance of Amendment Re: Extended Power Uprate (TAC No. MC0761)"m March 2, 2006.



FUEL TYPE	
A = GNF2-P10DG2B403-14G6.0-100T2-150-T6-3259	H = GE14-P10DNAB421-16GZ-100T-150-T6-3084
B = GNF2-P10DG2B404-14GZ-100T2-150-T6-3260	I = GNF2-P10DG2B403-11G6.0-100T2-150-T6-3261
C = GNF2-P10DG2B387-15GZ-100T2-150-T6-2977-LUA	J = GNF2-P10DG2B404-18GZ-100T2-150-T6-3262
D = GE14-P10DNAB422-14GZ-100T-150-T6-2965	K = GE14-P10DNAB388-15G6.0-100T-150-T6-3086
E = GE14-P10DNAB383-17G6.0-100T-150-T6-2865	L = GE14-P10DNAB420-16GZ-100T-150-T6-3085
F = GE14-P10DNAB388-15GZ-100T-150-T6-2968	M = GE14-P10DNAB388-16GZ-100T-150-T6-3087
G = GE14-P10DNAB388-15GZ-100T-150-T6-2969	

Figure 1. Current Cycle Core Loading Diagram

	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	31	33	35	37	39	41	43
44									C	L	B	B	L	C								
42								C	H	E	E	E	E	H	C							
40					L	K	B	B	H	A	H	H	A	H	B	B	K	L				
38				F	D	G	E	E	N	I	M	M	I	N	E	E	G	D	F			
36			J	H	G	M	I	I	A	I	G	G	I	A	I	I	M	G	H	J		
34			K	G	M	G	N	A	O	G	O	O	G	O	A	N	G	M	G	K		
32			B	E	I	N	H	O	A	O	A	A	O	A	O	H	N	I	E	B		
30		C	B	E	I	A	O	G	O	E	O	O	E	O	G	O	A	I	E	B	C	
28	C	H	H	N	A	O	A	O	A	G	H	H	G	A	O	A	O	A	N	H	H	C
26	L	E	A	I	I	G	O	E	G	A	M	M	A	G	E	O	G	I	I	A	E	L
24	B	E	H	M	G	O	A	O	H	M	C	C	M	H	O	A	O	G	M	H	E	B
22	B	E	H	M	G	O	A	O	H	M	C	C	M	H	O	A	O	G	M	H	E	B
20	L	E	A	I	I	G	O	E	G	A	M	M	A	G	E	O	G	I	I	A	E	L
18	C	H	H	N	A	O	A	O	A	G	H	H	G	A	O	A	O	A	N	H	H	C
16		C	B	E	I	A	O	G	O	E	O	O	E	O	G	O	A	I	E	B	C	
14			B	E	I	N	H	O	A	O	A	A	O	A	O	H	N	I	E	B		
12			K	G	M	G	N	A	O	G	O	O	G	O	A	N	G	M	G	K		
10			J	H	G	M	I	I	A	I	G	G	I	A	I	I	M	G	H	J		
8				F	D	G	E	E	N	I	M	M	I	N	E	E	G	D	F			
6					L	K	B	B	H	A	H	H	A	H	B	B	K	L				
4								C	H	E	E	E	E	H	C							
2									C	L	B	B	L	C								

Fuel Type	
A=GE14-P10DNAB422-16GZ-100T-150-T6-2862 (Cycle 25)	I=GE14-P10DNAB421-16GZ-100T-150-T6-3084 (Cycle 27)
B=GE14-P10DNAB383-14G6.0-100T-150-T6-2864 (Cycle 25)	J=GE14-P10DNAB383-14G6.0-100T-150-T6-2864 (Cycle 25)
C=GE14-P10DNAB383-13G6.0-100T-150-T6-2863 (Cycle 25)	K=GE14-P10DNAB383-13G6.0-100T-150-T6-2863 (Cycle 25)
D=GNF2-P10DG2B387-15GZ-100T2-150-T6-2977-LUA (Cycle 26)	L=GE14-P10DNAB383-17G6.0-100T-150-T6-2865 (Cycle 25)
E=GE14-P10DNAB422-14GZ-100T-150-T6-2965 (Cycle 26)	M=GE14-P10DNAB388-15G6.0-100T-150-T6-3086 (Cycle 27)
F=GE14-P10DNAB383-17G6.0-100T-150-T6-2865 (Cycle 25)	N=GE14-P10DNAB420-16GZ-100T-150-T6-3085 (Cycle 27)
G=GE14-P10DNAB388-15GZ-100T-150-T6-2968 (Cycle 26)	O=GE14-P10DNAB388-16GZ-100T-150-T6-3087 (Cycle 27)
H=GE14-P10DNAB388-15GZ-100T-150-T6-2969 (Cycle 26)	

Figure 2. Previous Cycle Core Loading Diagram

[[

{3}]]

Figure 3. Figure 4.1 from NEDC-32601-P-A

[[

{3}]]

Figure 4. Figure III.5-1 from NEDC-32601P-A

[[

{3}]]

Figure 5. Figure III.5-2 from NEDC-32601P-A

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	368		368	
Limiting Cycle Exposure Point (i.e. BOC/MOC/EOC)	N/A	EOC	N/A	EOC
Cycle Exposure at Limiting Point (MWd/STU)	N/A	10600	N/A	10600
% Rated Core Flow	N/A	100	N/A	100
Reload Fuel Type	GE14		GNF2	
Latest Reload Batch Fraction, %	32.6		31.5	
Latest Reload Average Batch Weight % Enrichment	4.01		4.04	
Core Fuel Fraction: GE14 GNF2	0.989 0.011		0.674 0.326	
Core Average Weight % Enrichment	3.99		4.01	

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	NEDC-32601-P-A		NEDC-32601-P-A	
Power Distribution Methodology	NEDC-32601-P-A		NEDC-32601-P-A	
Power Distribution Uncertainty	NEDC-32694-P-A		NEDC-32694-P-A	
Core Monitoring System	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}]]

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}]]	[[{3}]]	[[{3}]]	[[{3}]]	[[{3}]]
Feedwater Temperature Measurement	[[{3}]]	[[{3}]]	[[{3}]]	[[{3}]]	[[{3}]]
Reactor Pressure Measurement	[[{3}]]	[[{3}]]	[[{3}]]	[[{3}]]	[[{3}]]
Core Inlet Temperature Measurement	0.2	N/A	0.2	N/A	0.2
Total Core Flow Measurement	6.0 SLO / 2.5 TLO	N/A	6.0 SLO / 2.5 TLO	N/A	6.0 SLO / 2.5 TLO
Channel Flow Area Variation	[[{3}]]	[[{3}]]	[[{3}]]	[[{3}]]	[[{3}]]
Friction Factor Multiplier	[[{3}]]	[[{3}]]	[[{3}]]	[[{3}]]	[[{3}]]
Channel Friction Factor Multiplier	5.0	N/A	5.0	N/A	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}]]	[[{3}]]	[[{3}]]	[[{3}]]	[[{3}]]
Random Effective TIP Reading	2.85 SLO/1.2 TLO	N/A	2.85 SLO/1.2 TLO	N/A	2.85 SLO/1.2 TLO
TIP Integral	[[{3}]]	[[{3}]]	[[{3}]]	[[{3}]]	[[{3}]]
Four Bundle Power Distribution Surrounding TIP Location	[[{3}]]	[[{3}]]	[[{3}]]	[[{3}]]	[[{3}]]
Contribution to Bundle Power Uncertainty Due to LPRM Update	[[{3}]]	[[{3}]]	[[{3}]]	[[{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}]]	[[{3}]]	[[{3}]]	[[{3}]]	[[{3}]]
Contribution to Bundle Power Due to Failed LPRM	[[{3}]]	[[{3}]]	[[{3}]]	[[{3}]]	[[{3}]]
Total Uncertainty in Calculated Bundle Power	[[{3}]]	[[{3}]]	[[{3}]]	[[{3}]]	[[{3}]]
Uncertainty of TIP Signal Nodal Uncertainty	[[{3}]]	[[{3}]]	[[{3}]]	[[{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)]]