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**Enclosure 2**

**Non-Proprietary Version of GNF Report 003N5734-R1-NP**

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*Non-Proprietary Information – Class I (Public)*

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

**Hope Creek Cycle 21**

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## 1.0 Summary

The required values for the Technical Specification (TS) Safety Limit Minimum Critical Power Ratio (SLMCPR) are 1.08 for Two Recirculation Loop Operation (TLO) and 1.11 for Single Recirculation Loop Operation (SLO) for Hope Creek Cycle 21. Additional details are provided in Table 1.

There are multiple reasons for the change in calculated SLMCPR values. First, Cycle 21 will be the first full reload of GNF2 for Hope Creek. The critical power uncertainty for GNF2 is higher than that of the previous cycle's fuel type (GE14). In addition, in the limiting case for Cycle 21, the core bundle-by-bundle Minimum Critical Power Ratio (MCPR) distribution and the bundle pin-by-pin power/R-Factor distribution are flatter than that of the limiting case in the previous cycle. These differences tend to make the calculated SLMCPR values higher.

Both the TLO and SLO calculated SLMCPR values increased compared to Cycle 20 for the reasons discussed above; however, only the TS SLMCPR SLO value needs to be updated. This is because Cycle 21 will be the first cycle in which Hope Creek does not apply a 0.02 penalty to the calculated SLMCPR values since its Extended Power Uprate (EPU) in Cycle 15. The increase in the calculated SLMCPR TLO value is completely offset by the removal of the penalty. Additional details are provided in Table 1.

## 2.0 Regulatory Basis

10 Code of Federal Regulations (CFR) 50.36(c)(1), "Technical Specifications," requires that power reactor facility TS include safety limits for process variables that protect the integrity of certain physical barriers that guard against the uncontrolled release of radioactivity. The fuel cladding is one of the physical barriers that separate the radioactive materials from the environment. The purpose of the SLMCPR is to ensure that Specified Acceptable Fuel Design Limits (SAFDLs) are not exceeded during steady state operation and analyzed transients.

General Design Criterion (GDC) 10, "Reactor Design," of Appendix A to 10 CFR 50 states that the reactor core and associated coolant, control, and protection systems shall be designed with appropriate margin to assure that SAFDLs are not exceeded.

Guidance on the acceptability of the reactivity control systems, the reactor core, and fuel system design is provided in NUREG-0800, "Standard Review Plan [SRP] for the Review of Safety Analysis Reports for Nuclear Power Plants." Specifically, SRP, Section 4.2, "Fuel System Design," specifies all fuel damage criteria for evaluation of whether fuel designs meet the SAFDLs. SRP Section 4.4, "Thermal Hydraulic Design," provides guidance on the review of thermal-hydraulic design in meeting the requirement of GDC 10 and the fuel design criteria established in SRP Section 4.2.

### 3.0 Methodology

GNF performs SLMCPR calculations in accordance with NEDE-24011-P-A "General Electric Standard Application for Reactor Fuel, (GESTAR II)" (Reference 1) for plants such as Hope Creek that are equipped with either GNF 3DMonicores or ACUMEN<sup>1</sup> core monitoring systems, by using the following Nuclear Regulatory Commission (NRC) approved methodologies and uncertainties:

- NEDC-32601P-A, "Methodology and Uncertainties for Safety Limit MCPR Evaluations," (Reference 3).
- NEDC-32694P-A, "Power Distribution Uncertainties for Safety Limit MCPR Evaluations," (Reference 4).
- NEDC-32505P-A, "R-Factor Calculation Method for GE11, GE12 and GE13 Fuel," (Reference 5).

These methodologies were used for the Hope Creek Cycle 20 and the Cycle 21 SLMCPR calculations.

#### 3.1. Methodology Restrictions

Four restrictions were identified on page 3 of NRC's Safety Evaluation (SE) relating to the General Electric (GE) Licensing Topical Reports (LTRs) NEDC-32601P, NEDC-32694P, and in Amendment 25 to NEDE-24011-P-A (Reference 6).

The four restrictions were addressed for GE14 in FLN-2001-016 "Confirmation of 10x10 Fuel Design Applicability to Improved SLMCPR" (Reference 7) and FLN-2001-17 "Power Distribution and R-Factor Methodologies" (Reference 8).

The following statement was extracted from the generic compliance report for the GNF2 fuel assembly design (Reference 9) that GNF sent to the NRC in March of 2007:

"The NRC Safety Evaluation (SE) for NEDC-32694P-A provides four actions to follow whenever a new fuel design is introduced. These four conditions are listed in Section 3 of the SE. In the last paragraph of Section 3.2.2 of the Technical Evaluation Report included in the SE are the statements "GE has evaluated this effect for the 8x8, 9x9, and 10x10 lattices and has indicated that the R-Factor uncertainty will be increased ... to account for the correlation of rod power uncertainties" and "it is noted that the effect of the rod-to-rod correlation

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<sup>1</sup> As specified in Reference 2, the difference between the 3DMonicores and ACUMEN core monitoring systems is in user interface and name only, and in fact not in methodology. Therefore, all statements and values included in this document apply interchangeably to either core monitoring system.

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has a significant dependence on the fuel lattice (e.g., 9x9 versus 10x10). Therefore, in order to insure the adequacy of the R-Factor uncertainty, the effect of the correlation of rod power calculation uncertainties should be reevaluated when the NEDC-32601P methodology is applied to a new fuel lattice." Therefore, the definition of a new fuel design is based on the lattice array dimensions (e.g., NxN). Because GNF2 is a 10x10, and the evaluations in NEDC-32694P-A include 10x10, then these four actions are not applicable to GNF2."

In an NRC audit report (Reference 10) for this document, Section 3.4.1 page 59 states:

"The NRC staff's SE of NEDC-32694P-A (Reference 19 of NEDC-33270P) provides four actions to follow whenever a new fuel design is introduced. These four conditions are listed in Section 3.0 of the SE. The analysis and evaluation of the GNF2 fuel design was evaluated in accordance with the limitations and conditions stated in the NRC staff's SE, and is acceptable."

Another methodology restriction is identified on page 4 of the NRC's SE relating to the GE LTR NEDC-32505P (Reference 11). Specifically, it states that "if new fuel is introduced, GENE must confirm that the revised R-factor method is still valid based on new test data." NEDC-32505P addressed the GE12 10x10 lattice design (i.e., how the R-Factor for a rod is calculated based upon its immediate surroundings (fuel rods, water rods or channel wall)). Validation is provided by the fact that the methodology generates accurate predictions of Critical Power Ratio (CPR) with reasonable bias and uncertainty. The applicability of the R-Factor method is coupled and documented (along with fuel specific additive constants) with the GEXL correlation development (References 12 and 13), which is submitted as a part of GESTAR II compliance for each new fuel product line.

#### **4.0 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.

Table 2 provides the description of the current cycle and previous cycle for the reference loading pattern as defined by NEDE-24011-P-A (Reference 1).

##### **4.1. Major Contributors to SLMCPR Change**

In general, for a given power-flow statepoint, 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. Therefore, the

calculated SLMCPR may change whenever there are changes to the core configuration or to the fresh fuel designs. The plant-cycle specific SLMCPR methodology accounts for these factors.

The uncertainty in the MCPR boiling correlation (GEXL critical power uncertainty) varies from fuel product line to product line. Because the fresh fuel bundles generally dominate the SLMCPR calculation a change in product line provides a cause for a potentially significant change in the SLMCPR.

Cycle 21 will be the first reload of GNF2 for Hope Creek. The GNF2 GEXL correlation uncertainty [[ ]] is larger than that of the GE14 fuel [[ ]] used in the prior cycle. In addition, the Cycle 21 core bundle-by-bundle MCPR distribution and the bundle pin-by-pin power/R-Factor distribution are flatter than that of Cycle 20. These differences tend to make the final SLMCPR higher.

#### **4.2. Deviations from Standard Uncertainties**

Table 3 provides a list of deviations from NRC-approved uncertainties (References 3 and 4). A discussion of deviations from these NRC-approved values follows; all of which are conservative relative to NRC-approved values.

##### **4.2.1. R-Factor**

GNF has generically increased the GEXL R-Factor uncertainty from [[ ]] to account for an increase in channel bow due to the 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. Reference 14 technically justifies that a GEXL R-Factor uncertainty of [[ ]] accounts for a channel bow uncertainty of up to [[ ]]. The Hope Creek Cycle 21 analysis shows an expected channel bow uncertainty of [[ ]], which is bounded by a GEXL R-Factor uncertainty of [[ ]]. Thus, the use of a GEXL R-Factor uncertainty of [[ ]] adequately accounts for the expected control blade shadow corrosion-induced channel bow. The effect of this change is considered not significant (i.e., < 0.005 increase on SLMCPR).

##### **4.2.2. Core Flow Rate and Random Effective TIP Reading**

In Reference 15, GNF committed to the expansion of the state points used in the determination of the SLMCPR. Consistent with the Reference 15 commitments, GNF performs 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. The approved SLMCPR methodology is applied at each state point that is analyzed.



For the TLO calculations performed at 94.8% core flow, the approved uncertainty values for the core flow rate (2.5%) and the random effective Traversing In-Core Probe (TIP) reading (1.2%) are conservatively adjusted by dividing them by 94.8/100.

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.

#### **4.2.3. Flow Area Uncertainty**

GNF has calculated the flow area uncertainty for GNF2 and GE14 using the process described in Section 2.7 of Reference 3. It was determined that the flow area uncertainty for GNF2 and GE14 is conservatively bounded by a value of [[ ]]. Because this is larger than the Reference 3 value of [[ ]], the bounding value was used in the SLMCPR calculations. The effect of this change is considered not significant (i.e., < 0.005 increase on SLMCPR).

#### **4.2.4. Fuel Axial Power Shape Penalty**

The GEXL correlation critical power uncertainty and bias are established for each fuel product line according to a process described in NEDE-24011-P-A (Reference 1).

GNF determined that higher uncertainties and non-conservative biases in the GEXL correlations for certain types of axial power shapes could exist relative to the NRC-approved methodology values (References 16, 17, 18, and 19). The GE14 and GNF2 product lines are potentially affected in this manner only by Double-Hump (D-H) axial power shapes.

The D-H axial shape did not occur on any of the limiting bundles (i.e., those contributing to the 0.1% rods susceptible to transition boiling) in the current and/or prior cycle limiting cases. Therefore, D-H power shape penalties were not applied to the GEXL critical power uncertainty or bias.

#### **4.3. Additional SLMCPR Licensing Conditions**

As shown in Table 1, there are no added penalties applied to the calculated SLMCPR. Cycle 21 will be the first cycle in which Hope Creek does not apply an added penalty to the calculated SLMCPR since its EPU in Cycle 15, as permitted by References 20 and 21.

## 5.0 References

1. Global Nuclear Fuel, "General Electric Standard Application for Reactor Fuel," NEDE-24011-P-A, Revision 22, November 2015.
2. Letter, Brian R. Moore (GNF-A) to NRC Document Control Desk, "Amendment 42 to GESTAR II Supporting the Transition from the 3DMONICORE Core Monitoring System to ACUMEN," MFN 16-011, March 2, 2016.
3. GE Nuclear Energy, "Methodology and Uncertainties for Safety Limit MCPR Evaluations," NEDC-32601P-A, August 1999.
4. GE Nuclear Energy, "Power Distribution Uncertainties for Safety Limit MCPR Evaluations," NEDC-32694P-A, August 1999.
5. GE Nuclear Energy, "R-Factor Calculation Method for GE11, GE12 and GE13 Fuel," NEDC-32505P-A Revision 1, July 1999.
6. Letter, Frank Akstulewicz (NRC) to Glen A. Watford (GNF-A) "Acceptance for Referencing of Licensing Topical Reports NEDC-32601P, Methodology and Uncertainties for Safety Limit MCPR Evaluations; NEDC-32694P, Power Distribution Uncertainties for Safety Limit MCPR Evaluation; and Amendment 25 to NEDE-24011-P-A on Cycle-Specific Safety Limit MCPR (TAC Nos. M97490, M99069 and M97491)," MFN-003-099, March 11, 1999.
7. Letter, Glen A. Watford (GNF-A) to NRC 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.
8. Letter, Glen A. Watford (GNF-A) to NRC 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.
9. Letter, Andrew A. Lingenfelter (GNF-A) to NRC Document Control Desk with cc to MC Honcharik (NRC), "GNF2 Advantage Generic Compliance with NEDE-24011P-A (GESTAR II), NEDC-33270P, March 2007, and GEXL17 Correlation for GNF2 Fuel, NEDC-33292P, March 2007," FLN-2007-011, March 14, 2007.
10. Memorandum, Michelle C. Honcharik (NRC) to Stacy L. Rosenberg (NRC), "Audit Report for Global Nuclear Fuels GNF2 Advantage Fuel Assembly Design GESTAR II Compliance Audit," September 25, 2008, (ADAMS Accession Number ML081630579).

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11. Letter, Thomas H. Essig (NRC) to Glen A. Watford (GNF-A), "Acceptance for Referencing of Licensing Topical Report NEDC-32505P, Revision 1, 'R-factor Calculation Method for GE11, GE12 and GE13 Fuel,'" (TAC Nos. M99070 and M95081)," MFN-046-98, January 11, 1999.
12. Global Nuclear Fuel, "GEXL14 Correlation for GE14 Fuel," NEDC-32851P-A, Revision 5, April 2011.
13. Global Nuclear Fuel, "GEXL17 Correlation for GNF2 Fuel," NEDC-33292P, Revision 3, April 2009.
14. Letter, John F. Schardt (GNF-A) to NRC Document Control Desk with attention to Mel B. Fields (NRC), "Shadow Corrosion Effects on SLMCPR Channel Bow Uncertainty," FLN-2004-030, November 10, 2004.
15. Letter, Jason S. Post (GENE) to U.S. NRC 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.
16. Letter, Glen A. Watford (GNF-A) to NRC 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.
17. Letter, Glen A. Watford (GNF-A) to NRC 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.
18. Letter, Jens G. Munthe Andersen (GNF-A) to NRC Document Control Desk with attention to Alan Wang (NRC), "GEXL Correlation for 10X10 Fuel," FLN-2003-005, May 31, 2003.
19. Letter, Andrew A. Lingenfelter (GNF-A) to NRC 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.
20. GE Hitachi Nuclear Energy, "Licensing Topical Report Applicability of GE Methods to Expanded Operating Domains," NEDC-33173P-A, Revision 4, November 2012, MFN 12-124.
21. Letter, Robert A. Nelson (NRC) to Jerald G. Head (GEH), "Final Safety Evaluation for GE Hitachi Nuclear Energy Americas Topical Report NEDC-33173P, Revision 2 and Supplement 2, Parts 1-3, "Analysis of Gamma Scan Data and Removal of Safety Limit Critical power Ratio (SLMCPR) Margin" (TAC No. ME1891)," March 15, 2012.

**Table 1. Monte Carlo SLMCPR**

Description	Previous Cycle Limiting Cases		Current Cycle Limiting Cases	
	Rated Power Minimum Core Flow	Rated Power Rated Core Flow	Rated Power Minimum Core Flow	Rated Power Rated Core Flow
Limiting Cycle Exposure Point Beginning of Cycle (BOC) / Middle of Cycle (MOC) / End of Cycle (EOC)	EOC	EOC	EOC	EOC
Cycle Exposure at Limiting Point (MWd/STU)	10,500	10,500	10,000	10,000
[[				
				]]
Requested Change to the TS SLMCPR	N/A		1.08 (TLO) / 1.11 (SLO)	

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**Table 2. Description of Core**

Description	Previous Cycle	Current Cycle
Core Rated Power (MWt)	3,840.0	3,840.0
Minimum Flow at Rated Power (% rated core flow)	94.8	94.8
Number of Bundles in the Core	764	764
Batch Sizes and Types: (Number of Bundles in the Core)		
Fresh	220 GE14	212 GNF2
Once-Burnt	224 GE14	220 GE14
Twice-Burnt	232 GE14	224 GE14
Thrice-Burnt or more	88 GE14	108 GE14
Fresh Fuel Batch Average Enrichment (Weight%)	4.01	3.82
Core Monitoring System	3DMonicore	3DMonicore or ACUMEN

**Table 3. Deviations from Standard Uncertainties**

Description	NRC Approved Value $\pm \sigma$ (%)	Previous Cycle	Current Cycle
<b>Power Distribution Uncertainties</b>			
GEXL R-Factor	[[ ]]	[[ ]]	[[ ]]
Random Effective TIP Reading All TLO Cases at Rated Power and Minimum Flow (Non-MELLLA+)	1.2	1.266	1.266
<b>Non-Power Distribution Uncertainties</b>			
Reactor Pressure Measurement	[[ ]]	[[ ]]	[[ ]]
Channel Flow Area Variation	[[ ]]	[[ ]]	[[ ]]
Total Core Flow Measurement All TLO Cases at Rated Power and Minimum Flow (Non-MELLLA+)	2.5	2.637	2.637