Edwin I. Hatch Nuclear Plant – Unit 1
License Amendment Request Concerning Safety Limit
Minimum Critical Power Ratio

Enclosure 2

Non-Proprietary GNF Report GNF-002N9964-R1-NP

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PLM Specification 002N9964 R1

Non-Proprietary Information – Class I (Public)

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

Hatch 1 Cycle 28

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1.0 Summary

The requested changes to the Technical Specification (TS) Safety Limit Minimum Critical Power Ratio (SLMCPR) values are 1.09 for Two-Loop Operation (TLO) and 1.12 for Single Loop Operation (SLO) for Hatch 1 Cycle 28. Additional details are provided in Table 1.

One of the primary reasons for the change is that Cycle 28 will be the first full reload of GNF2 for Hatch 1. The critical power uncertainty for GNF2 is higher than the previous cycle's fuel type. As a result of the introduction of GNF2 fuel, the SLMCPR values have increased. Another reason for the change is that in the limiting case the core bundle-by-bundle Minimum Critical Power Ratio (MCPR) distribution is significantly flatter than the limiting case in the previous cycle. This difference caused the SLMCPR values to increase.

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.

The Hatch 1 construction permit was received under the 70 general design criteria discussed in "General Design Criteria for Nuclear Power Plant Construction," issued for comment in July 1967 and was not, therefore, developed in consideration of the 64 new general design criteria discussed in the "General Design Criteria for Nuclear Power Plants," effective May 21, 1971, and subsequently amended July 7, 1971. However, Criterion 6 of the design criteria on which the Hatch 1 construction permit was based is analogous to the current GDC 10.

3.0 Methodology

GNF performs Safety Limit Minimum Critical Power Ratio SLMCPR calculation in accordance with NEDE-24011-P-A "General Electric Standard Application for Reactor Fuel, (GESTAR II)" (Reference 1) for plants such as Hatch 1 that are equipped with the GNF 3DMonicore core monitoring system, by using the following Nuclear Regulatory Commission (NRC)-approved methodologies and uncertainties:

- NEDC-32601P-A, "Methodology and Uncertainties for Safety Limit MCPR Evaluations," August 1999. (Reference 2)
- NEDC-32694P-A, "Power Distribution Uncertainties for Safety Limit MCPR Evaluations," August 1999. (Reference 3)
- NEDC-32505P-A, "R-Factor Calculation Method for GE11, GE12 and GE13 Fuel," Revision 1, July 1999. (Reference 4)

These methodologies were used for the Hatch 1 Cycle 27 and Cycle 28 SLMCPR calculations.

3.1. Methodology Restrictions

Four restrictions were identified on page 3 of the NRC's Safety Evaluation (SE) relating to the General Electric (GE) Licensing Topical Reports (LTRs) NEDC-32601P, NEDC-32694P, and Amendment 25 to NEDE-24011-P-A (Reference 5).

The four restrictions were addressed for GE14 in FLN-2001-16 "Confirmation of 10x10 Fuel Design Applicability to Improved SLMCPR" (Reference 6) and FLN-2001-17 "Power Distribution and R-Factor Methodologies" (Reference 7).

The following statement was extracted from the generic compliance report for the GNF2 fuel assembly design (Reference 8) 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 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 9) 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 NRC's SE relating to the GE LTR NEDC-32505P (Reference 10). 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 11 and 12), 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 28 core bundle-by-bundle MCPR distribution is significantly flatter than Cycle 27. Also, Cycle 28 will be the first reload of GNF2 for Hatch 1. The GNF2 GEXL correlation uncertainty [[ ]] is larger than that of the GE14 fuel [[ ]] used in the prior cycle. These two changes 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 2 and 3). 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 13 technically justifies that a GEXL R-Factor uncertainty of [[ ]] accounts for a channel bow uncertainty of up to [[ ]]. The Hatch 1 Cycle 28 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 14 GNF committed to the expansion of the state points used in the determination of the SLMCPR. Consistent with the Reference 14 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 92.9% 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 92.9/100.

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 2. It was determined that the flow area uncertainty for GNF2 and GE14 would be conservatively bounded by a value of [[ ]]. Because this is larger than the Reference 2 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 15, 16, 17, and 18). 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.

5.0 References

1. Global Nuclear Fuel, "General Electric Standard Application for Reactor Fuel," NEDC-24011-P-A, Revision 21, May 2015.

2. GE Nuclear Energy, "Methodology and Uncertainties for Safety Limit MCPR Evaluations," NEDC-32601P-A, August 1999.

3. GE Nuclear Energy, "Power Distribution Uncertainties for Safety Limit MCPR Evaluations," NEDC-32694P-A, August 1999.

4. GE Nuclear Energy, "R-Factor Calculation Method for GE11, GE12 and GE13 Fuel," NEDC-32505P-A, Revision 1, July 1999.

5. 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.

6. 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.

7. 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.

8. Letter, Andrew A. Lingenfelter (GNF-A) to NRC Document Control Desk with cc to MC Honcharik (NRC), "GNF2 Advantage Generic Compliance with NEDC-24011P-A (GESTAR II), NEDC-33270P, March 2007, and GEXL17 Correlation for GNF2 Fuel, NEDC-33292P, March 2007," FLN-2007-11, March 14, 2007.

9. 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)

10. 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-046-098, January 11, 1999.

11. Global Nuclear Fuel, "GEXL14 Correlation for GE14 Fuel," NEDC-32851P-A, Revision 5, April 2011.

12. Global Nuclear Fuel, "GEXL17 Correlation for GNF2 Fuel," NEDC-33292P, Revision 3, April 2009.

13. 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.

14. Letter, Jason S. Post (GENE) to 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.

15. 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.

16. 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.

17. 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.

18. 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.

Table 1. Monte Carlo SLMCPR

	Previous Cycle Limiting Cases		**Current Cycle Limiting Cases**	
Description	**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))	BOC (TLO) / EOC (SLO)	BOC (TLO) / EOC (SLO)	EOC	EOC
Cycle Exposure at Limiting Point (MWd/STU)	0 / 15,661	0 / 15,661	15,910	15,910
[[				
				]]
Requested Change to the TS SLMCPR	N/A		1.09 (TLO)/ 1.12[1] (SLO)	

Note:
1. [[ ]]

Table 2. Description of Core

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Description	Previous Cycle	Current Cycle
Core Rated Power (MWt)	2804.0	2804.0
Minimum Flow at Rated Power (% rated core flow)	92.9	92.9
Number of Bundles in the Core	560	560
Batch Sizes and Types: (Number of Bundles in the Core) Fresh Once-Burnt Twice-Burnt Thrice-Burnt or more	 224 GE14 232 GE14 100 GE14[1] 4 GE14	 228 GNF2 224 GE14 104 GE14 4 GE14
Fresh Fuel Batch Average Enrichment (Weight %)	4.10	4.06
Core Monitoring System	3DMonicore	3DMonicore

Note:

1. Hatch 1 Cycle 27 contained four Westinghouse Optima2 Lead Use Assemblies (LUAs) which were on their third cycle of operation. These four LUAs were modeled as GE14 fuel.

Table 3. Deviations from Standard Uncertainties

Description	NRC Approved Value ± σ (%)	Previous Cycle	Current Cycle
Power Distribution Uncertainties			
GEXL R-Factor	[[ ]]	[[ ]]	[[ ]]
Random Effective TIP Reading All TLO Cases at Rated Power and Minimum Flow	1.2	1.292	1.292
Non-Power Distribution Uncertainties			
Channel Flow Area Variation	[[ ]]	[[ ]]	[[ ]]
Total Core Flow Measurement All TLO Cases at Rated Power and Minimum Flow	2.5	2.691	2.691