Enclosure 1

GNF Additional Information Regarding the Requested Changes to the Technical Specification SLMCPR, Cooper Nuclear Station Cycle 31 (Non-Proprietary)

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Cooper Nuclear Station Cycle 31

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Table of Contents

List of Tables

1.0 Summary

The requested changes to the Technical Specification (TS) Safety Limit Minimum Critical Power Ratio (SLMCPR) values are 1.13 for Two-Loop Operation (TLO) and 1.16 for Single Loop Operation (SLO) for Cooper Nuclear Station Cycle 31. Additional details are provided in Table 1.

The previous cycle (Cycle 30) limiting case Monte Carlo SLMCPR results in Table 1 with a column header of TS Bases were the bases for the current Cooper Nuclear Station TS SLMCPR values. After the previous cycle analysis was completed, an error was discovered in the GESAM Engineering Computer Program (ECP) used to perform the Monte Carlo analysis. Section 5.0 below contains a summary of this GESAM error. The previous cycle limiting case Monte Carlo SLMCPR results in Table 1 with a column header of Corrected GESAM lists the Cycle 30 limiting values based on the correction of this GESAM error. The effect of this error on the previous cycle limiting case Monte Carlo SLMCPR TS Bases results ranged from an increase of 0.003 to an increase of 0.006.

Considering the GESAM ECP error mentioned above (which only affected Cycle 30) and the change in the method for treating some of the uncertainties discussed in Section 3.0 below, the primary reason for the change in the SLMCPR is that the Cycle 31 limiting case bundle pin-by-pin power/R-Factor distribution is flatter than the Cycle 30 limiting case. The change in this distribution is characteristic of cycle-to-cycle variation in bundle designs. This variation is the primary cause of 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.

Cooper Nuclear Station was not licensed to the 10 CFR 50, Appendix A, General Design Criteria (GDC). Cooper Nuclear Station was designed and constructed to meet the principal design criteria described in the Atomic Energy Commission's (AEC's) proposed rule, "General Design Criteria for Nuclear Power Plant Construction Permits," published in the Federal Register (FR) on July 11, 1967 (32 FR 10213). The degree of conformance to the 1967 proposed GDC is described in Appendix F, "Conformance to AEC Proposed General Design Criteria" to the Updated Safety Analysis Report for Cooper Nuclear Station. The Cooper Nuclear Station current licensing basis incorporates the proposed GDC Criterion 6 that is equivalent to 10 CFR 50 Appendix A GDC 10.

Criterion 6 of the proposed GDC is the equivalent of 10 CFR 50 Appendix A GDC 10:

> Criterion 6
>
> "The reactor core shall be designed to function throughout its design lifetime, without exceeding acceptable fuel damage limits which have been stipulated and justified. The core design, together with reliable process and decay heat removal systems shall provide for this capability under all expected conditions of normal operation with appropriate margins for uncertainties and for transient situations which can be anticipated, including the effects of the loss of power to recirculation pumps, tripping out of a turbine generator set, isolation of the reactor from its primary heat sink, and loss of all offsite power."

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 Cooper Nuclear Station that are equipped with a non-GNF supplied 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).
- NEDE-10958-PA, "General Electric Thermal Analysis Basis Data, Correlation and Design Application," January 1977. (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 Cooper Nuclear Station Cycle 30 and Cycle 31 SLMCPR calculations; however, there was a change in the treatment of the power distribution uncertainties and the Traversing In-Core Probe (TIP) uncertainties for these two cycles. For these uncertainties, the Cycle 30 current TS SLMCPR values used the Reference 3 method. After discovery of the GESAM ECP error, the Cycle 30 limiting rated power minimum core flow was reanalyzed using the corrected GESAM ECP and the Reference 2 method for these uncertainties.

Cycle 31 used the Reference 2 method for these uncertainties. The effect of this method change ranged from a decrease of 0.001 to a decrease of 0.005 on the Cycle 31 calculated Monte Carlo SLMCPR limiting case values.

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 Amendment 25 to NEDE-24011-P-A (Reference 5).

The following statement was extracted from the generic compliance report for the GNF2 fuel assembly design (Reference 6) 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 7) 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 8). 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 (Reference 9) 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 Minimum Critical Power Ratio (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.

For the Cycle 31 limiting TLO case (i.e., the rated core flow case), the core bundle-by-bundle MCPR distribution is slightly flatter compared to the Cycle 30 limiting TLO case (i.e., the minimum core flow case); however, the bundle pin-by-pin power/R-Factor distribution is much flatter. The combination of these two distributions being flatter for Cycle 31 versus Cycle 30 increased the SLMCPR with the bundle pin-by-pin power/R-Factor distribution being the primary reason.

The net effect of the GESAM ECP error on the Cycle 30 SLMCPR results coupled with the change in the method for treating some of the uncertainties is small, with each tending to cancel the other out. Hence, the Cycle 31 bundle pin-by-pin power/R-Factor distribution is the major contributor to the change in the Cycle 31 limiting TLO case SLMCPR.

The Cycle 31 change in the Monte Carlo SLO SLMCPR from Cycle 30 is consistent with the Monte Carlo TLO SLMCPR change between the two cycles. The SLO values are greater than the TLO values as expected due to the increase in uncertainties used for the SLO case.

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 10 technically justifies that a GEXL R-Factor uncertainty of [[ ]] accounts for a channel bow uncertainty of up to [[ ]]. The Cooper Nuclear Station Cycle 31 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 in SLMCPR).

4.2.2. Core Flow Rate and Random Effective TIP Reading

In Reference 11, GNF committed to the expansion of the statepoints used in the determination of the SLMCPR. Consistent with the Reference 11 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 statepoint that is analyzed.

For the TLO calculations performed at 76.8% 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 76.8/100.

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 those 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 using the process described in Section 2.7 of Reference 2. It was determined that the flow area uncertainty for GNF2 is 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 in 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 12, 13, and 14). The GNF2 product line is potentially affected in this manner only by Double-Hump (D-H) axial power shapes.

The D-H axial power shape occurred on some of the limiting bundles (i.e., those contributing to the 0.1% rods susceptible to transition boiling, all of which were GNF2 bundles) in a previous cycle limiting case (with the corrected GESAM), as indicated in Table 1. Therefore, D-H axial power shape penalties were applied to the GEXL critical power uncertainty and bias, as shown in Table 3.

The D-H axial power 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 cycle limiting cases. Therefore, D-H axial power shape penalties were not applied to the GEXL critical power uncertainty or bias.

5.0 GESAM Engineering Computer Program Error

GE-Hitachi Nuclear Energy Americas LLC (GEH) determined that the GESAM ECP contained an error in its Pseudo-Random Number Generator (PRNG) that is used for applied perturbations. This can cause non-random perturbations of various uncertainties and thus can lead to incorrect results.

The GESAM ECP is used in the calculation of SLMCPR values and either directly or by extension the Operating Limit Minimum Critical Power Ratio (OLMCPR).

In the case of Cooper Nuclear Station Cycle 30, the TS safety limit for SLO was affected by this error. The SLMCPR result from a corrected GESAM ECP executable, after rounding to 1.15, does not support the current TS value of 1.14. The basis of the Cycle 30 TS used the Reference 3 method as discussed in Section 3.0 above. The evaluation of the effect of the Cycle 30 results due to the GESAM error was performed with the application of the Reference 2 method as discussed in Section 3.0 above. The cumulative effect (a change of [[ ]]) is considered non-reportable under 10 CFR Part 21 because the change in the unrounded result is well within the nominal uncertainty value of the SLMCPR process of [[ ]].

The OLMCPR values for Cycle 30 were evaluated and confirmed to be adequate with the exception of the SLO MCPR operating adder and the Rated Equivalent SLO Pump Seizure value, which should be increased in proportion to the change in the SLO TS.

6.0 References

1. Global Nuclear Fuel, "General Electric Standard Application for Reactor Fuel," NEDE-24011-P-A, Revision 26, January 2018.

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

3. General Electric Company, "General Electric Thermal Analysis Basis Data, Correlation and Design Application," NEDE-10958-PA, January 1977.

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, 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.

7. 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)

8. 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.

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

10. 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.

11. 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.

12. 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.

13. 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.

14. 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.

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**
	TS Bases	**Corrected GESAM**	**TS Bases**	**Corrected GESAM**		
Limiting Cycle Exposure Point Beginning of Cycle (BOC) / Middle of Cycle (MOC) / End of Cycle (EOC)	EOC	EOC[1]	EOC	MOC/EOC	EOC	EOC
Cycle Exposure at Limiting Point (MWd/STU)	12,000	12,000	12,000	7,000/12,000	12,000	12,000
[[						
						]]
Requested Change to the TS SLMCPR	N/A				1.13 (TLO) / 1.16 (SLO)	

[1] Based on using the Reference 2 method for the treatment of the power distribution uncertainties and the TIP uncertainties, the corresponding TLO value is [[ ]] and the SLO value is [[ ]].

[2] Affected by D-H axial power shape penalties. The corresponding EOC value (which is the next most limiting for this condition and which is not affected by D-H axial power shape penalties) is [[ ]].

Table 2. Description of Core

Description	**Previous Cycle**	**Current Cycle**
Core Rated Power (MWt)	2419	2419
Minimum Core Flow at Rated Power (% rated core flow)	76.8	76.8
Number of Bundles in the Core	548	548
Batch Sizes and Types: (Number of Bundles in the Core) Fresh Once-Burnt Twice-Burnt Thrice-Burnt or more	 184 GNF2 176 GNF2 180 GNF2 8 GE14	 180 GNF2 184 GNF2 176 GNF2 8 GNF2
Fresh Fuel Batch Average Enrichment (Weight%)	3.92	3.92
Core Monitoring System	GARDEL (Non-GNF)	GARDEL (Non-GNF)

Table 3. Deviations from Standard Uncertainties

Description	NRC Approved Value	Previous Cycle	Current Cycle
Power Distribution Uncertainties			
GEXL R-Factor (± σ (%))	[[ ]]	[[ ]]	[[ ]]
Random Effective TIP Reading All TLO Cases at Rated Power and Minimum Core Flow (± σ (%))	1.2	1.5625	1.563
Non-Power Distribution Uncertainties			
Channel Flow Area Variation (± σ (%))	[[ ]]	[[ ]]	[[ ]]
Total Core Flow Measurement All TLO Cases at Rated Power and Minimum Core Flow (± σ (%))	2.5	3.26	3.255
GEXL Correlation Critical Power Uncertainty and Bias[3]			
GNF2 Critical Power Uncertainty (± σ (%))	[[ ]]	[[ ]]	No Deviation
GNF2 Critical Power Bias	[[ ]]	[[ ]]	No Deviation

[3] Deviation is to account only for those bundles with D-H axial power shapes. Bundles with other power shapes use the NRC-approved value.