SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO AMENDMENT NO. 183 TO FACILITY OPERATING LICENSE NO. NPF-39

EXELON GENERATION COMPANY, LLC

LIMERICK GENERATING STATION, UNIT 1

DOCKET NO. 50-352

1.0 INTRODUCTION

By application dated December 14, 2005, as supplemented by letter dated February 13, 2006, Exelon Generation Company, LLC (Exelon or the licensee) requested changes to the Technical Specifications (TSs) for the Limerick Generating Station (LGS), Unit 1. The supplement dated February 13, 2006, provided additional information that clarified the application, did not expand the scope of the application as originally noticed, and did not change the Nuclear Regulatory Commission (NRC or the Commission) staff's original proposed no significant hazards consideration determination as published in the *Federal Register* on January 17, 2006 (71 FR 2590).

The proposed changes would revise the safety limit minimum critical power ratio (SLMCPR) value in TS 2.1. Specifically, the SLMCPR value would be changed from 1.08 to 1.09 for single recirculation-loop operation due to the cycle-specific analysis.

2.0 REGULATORY EVALUATION

Part 50 of Title 10 of the *Code of Federal Regulations* (10 CFR), Appendix A, General Design Criterion (GDC) 10 states, in part, that the reactor core and associated coolant, control, and protective system shall be designed to assure that the specified acceptable fuel design limits are not exceeded during any condition of normal operation and anticipated operational occurrences (AOOs). Additionally, the Standard Review Plan (SRP) Section 4.4, "Thermal and Hydraulic Design," states that the critical power ratio (CPR) is to be established such that at least 99.9% of the fuel rods in the core would not be expected to experience departure from nucleate boiling or boiling transition during normal operation or AOOs. The guidance provided within the SRP forms the basis of the NRC staff's review and ensures that the criteria of GDC 10 are met.

Fuel design limits can be exceeded if the core exceeds critical power. Critical power is a term used for the power at which the fuel departs from nucleate boiling and enters a transition to film boiling. For boiling water reactors (BWRs), the critical power is predicted using a correlation known as the General Electric (GE) critical quality boiling length correlation, better known as the GEXL correlation. Due to core-wide and operational variations, the margin to boiling transition

is most easily described in terms of a CPR, which is defined as the rod critical power as calculated by GEXL divided by the actual rod power. The more a CPR value exceeds 1.0, the greater the margin to boiling transition. The SLMCPR is calculated using a statistical process that takes into account operating parameters and associated uncertainties. The operating limit MCPR (OLMCPR) is equal to the SLMCPR plus a CPR margin for transients. At the OLMCPR, at least 99.9% of the rods avoid boiling transition during steady state operation and transients caused by single operator error or equipment malfunction.

Safety limits are required to be included in the TSs by 10 CFR 50.36. The SLMCPR is calculated on a cycle-specific basis because it is necessary to account for the core configuration-specific neutronic and thermal-hydraulic response.

3.0 TECHNICAL EVALUATION

3.1 LGS Cycle 12 Core

LGS Unit 1 is a BWR/4 which has two forced recirculation loops. For single-loop operation (SLO), the licensee proposed to change the SLMCPR value in TS 2.1.2 from 1.08 to 1.09 with the reactor vessel steam dome pressure greater than, or equal to, 785 psig and core flow greater than, or equal to, 10% of rated core flow.

LGS Unit 1 Cycle 12 core loading consists of 764 GE14 fuel bundles total in the core. There will be 276 fresh fuel bundles, 264 once-burned fuel bundles, and 224 twice-burned fuel bundles.

3.2 Methodology

Global Nuclear Fuel (GNF) performed the LGS Unit 1 Cycle 12 SLMCPR limit calculation using the following NRC-approved methodologies and uncertainties:

- NEDC-32601P-A, “Methodology and Uncertainties for Safety Limit MCPR Evaluations” (Reference 3)
- NEDC-32694P, “Power Distribution Uncertainties for Safety Limit MCPR Evaluations” (Reference 10)
- NEDE-24011-P-A, “General Electric Standard Application for Reactor Fuel” (Reference 4)
- NEDC-32505P-A, “R-Factor Calculation Method for GE11, GE12 and GE13 Fuel” (Reference 5)
- NEDO-10958-A, “General Electric BWR Thermal Analysis Basis (GETAB): Data Correlation and Design Application” (Reference 6)

Plant-specific use of these methodologies must adhere to certain restrictions.

GNF calculates the SLO SLMCPR limit by increasing certain uncertainties on the dual-loop operation (DLO) SLMCPR calculation to account for the lower flow associated with SLOs.

3.3 Methodology Restrictions

Based on the review of the topical reports in References 3 and 4, the NRC staff applied the following restrictions on the use of the topical reports in its letter dated March 11, 1999 (Reference 7):

1. The TGBLA [lattice physics code] fuel rod power calculational uncertainty should be verified when applied to fuel designs not included in the benchmark comparisons of Table 3.1 of NEDC-32601P, since changes in fuel design can have a significant effect on calculation accuracy.

2. The effect of the correlation of rod power calculation uncertainties should be reevaluated to ensure the accuracy of R-Factor uncertainty when the methodology is applied to a new fuel lattice.

3. In view of the importance of [[ ]] and its potential sensitivity to changes in fuel bundle designs, core loading and operating strategies, the [[ ]] should be reviewed periodically as part of the procedural review process to ensure that the specific value recommended in NEDC-32601P is applicable to future designs and operating strategies.

4. The 3D-MONICORE bundle power calculational uncertainty should be verified when applied to fuel and core designs not included in the benchmark comparisons in Tables 3.1 and 3.2 of NEDC-32694P (Reference 10).

Data from GE14 fuel has not been used in the development of the approved methodologies; therefore, it is considered a change in fuel design, and a new fuel in context of these four restrictions.

There are also restrictions on NEDC-32505P-A (Reference 5) when this methodology is applied to a new fuel.

3.3.1 Restrictions (1) and (2)

Restrictions (1) and (2) are addressed in a letter from GNF to the NRC, “Confirmation of 10x10 Fuel Design Applicability to Improved SLMCPR, Power Distribution and R-Factor Methodologies,” dated September 24, 2001 (Reference 9). GNF states that these uncertainties are dominated by geometrical considerations in which GE14 is identical to GE12 and, therefore, these uncertainties remain valid for GE14 fuel.

3.3.2 Restriction (3)

The NRC staff requested information demonstrating the validity of the criterion in restriction (3) ([[ ]] criterion) for GE14 fuel and the minimum core flow condition (see Section 3.6). In GNF’s response dated February 13, 2006 (Reference 2), it is demonstrated that the [[ ]]

value for limiting rod patterns used for the SLMCPR determination are conservative in relation to the nominal rod pattens and that the [[ ]] criterion is still valid for the LGS Unit 1 Cycle 12 evaluations. The calculated [[

]].

3.3.3 Restriction (4)

Restriction (4) refers specifically to use of the reduced power uncertainties as defined in NEDC-32694P. The licensee chose to use the reduced power uncertainties as defined in NEDC-32694 for their Cycle 12 evaluations. Restriction (4) is addressed in a letter from GNF to the NRC, "Confirmation of 10x10 Fuel Design Applicability to Improved SLMCPR, Power Distribution and R-Factor Methodologies," dated September 24, 2001 (Reference 9). GNF states that the bundle power calculational uncertainties of NEDC-32694P-A apply to GE12 and GE14 10x10 fuel designs.

3.3.4 Restrictions Related to the R-Factor Methodology

For NEDC-32505P-A, Revision 1, the NRC staff stated the specific restriction that "if new fuel is introduced, General Electric Nuclear Energy (GENE) must confirm that the revised R-factor method is still valid based on new test data." [[

]] In its response to the staff's request for additional information (RAI) (Reference 2), the licensee states for the Limerick Unit 1 Cycle 12 amendment, this non-conservative condition does not exist since the R-factors used have been recalculated in accordance with NEDC-32505P-A, Revision 1 based on the GE14 ATLAS corrected test data. Therefore, no adjustments or penalties are necessary for the Cycle 12 SLMCPR.

The staff finds that the licensee has adequately addressed the restrictions of the Topical Reports NEDC-32601P-A, NEDC-32694P-A, Amendment 25 to NEDE-24011-P-A (GESTAR II) and NEDC-32505P-A, and that the use of these reports to evaluate the LGS Unit 1 Cycle 12 SLMCPR is acceptable.

3.4 Axial Power Shape Penalty Associated with GEXL14

GNF states that based on the expected core loading, the power shapes for which they do not have GE14 test data are not projected to be limiting for 100% rated power at both the 100% and 81% rated core flow conditions. Therefore, they did not incur any penalties. Based on GNF's conclusion, the NRC staff finds it acceptable that the licensee does not take any SLMCPR penalty associated with the presence of these power shapes (see Section 3.3.4).

3.5 Uncertainties

The uncertainties used for the SLMCPR calculation for LGS Unit 1 Cycle 12 are listed in the following table.

SLMCPR Methodology Uncertainties	
Non-Power Distribution Uncertainties	**Power Distribution Uncertainties**
Core flow rate	GEXL R-factor
Individual channel flow area	Random effective traversing in-core probe (TIP) reading
Individual channel friction factor	Systematic effective TIP reading
Friction factor multiplier	Integrated effective TIP reading
Reactor pressure	Bundle power
Core inlet temperature	Effective total bundle power uncertainty
Feedwater temperature	
Feedwater flow rate	

3.5.1 Non-Power Distribution Uncertainties

LGS Unit 1 used the approved values from revised NEDC-32601P-A for the non-power distribution uncertainties, with the exception of the total core flow measurement uncertainty. The NRC staff finds the use of approved values applicable and, therefore, acceptable for LGS Unit 1 Cycle 12.

3.5.2 Total Core Flow Measurement Uncertainty

GNF increased the total core flow measurement uncertainty due to performing the SLMCPR evaluation at the 100% rated power/81% rated flow instead of the 100% rated power/100% rated flow statepoint (see Section 3.6). GNF increased this value by the inverse of the core flow fraction. In response to the NRC staff's inquiries, GNF states that this increase is conservative based on the expectation that the variability in the absolute flow will decrease as flow decreases. GNF has decided to increase this uncertainty based on their historical precedent in which they increase this value when performing SLO calculations. The staff finds this conservatism acceptable for LGS Unit 1 Cycle 12.

3.5.3 Power Distribution Uncertainties

For the power distribution uncertainties, except for the GEXL R-Factor and the random effective TIP reading, GNF used uncertainties from the Reduced NEDC-32694P-A. Under NRC-approved methodologies, GNF is able to use either the GETAB NEDO-10958-A uncertainties or the Reduced NEDC-32694P-A uncertainties. The licensee has chosen to use

the Reduced NEDC-32694P-A. The NRC staff finds the use of approved values applicable and, therefore, acceptable for LGS Unit 1 Cycle 12.

3.5.4 R-factor Uncertainty

The R-factor is an input into the GEXL correlation used to describe the local pin-by-pin power distribution and the fuel assembly and channel geometry on the fuel assembly critical power. The R-factor uncertainty analysis includes an allowance for power peaking modeling uncertainty, manufacturing uncertainty and channel bow uncertainty. GNF has increased this uncertainty for all SLMCPR calculations to account for the potential impact of control blade shadow corrosion induced bow. In their response to the NRC staff's RAI (Reference 2), the licensee stated there is no evidence that LGS Unit 1 is experiencing control blade shadow corrosion induced bow. The licensee further states that LGS Unit 1 Cycle 12 has been designed such that no control rods are expected to require the Part 21 recommended testing as the result of Cycle 12 experiencing significant control blade shadow corrosion-induced channel bow. According to the licensee, the design for Cycle 12 is not expected to actually develop a no-settle condition due to shadow corrosion-induced channel bow in any cell. However, Exelon has decided to conservatively account for any reasonable potential of control blade shadow corrosion-induced channel bow in this SLMCPR amendment (Reference 1). GNF document FLN-2004-030 provides the justification for using a GEXL R-factor uncertainty of [[ ]] to account for an increase in channel bow due to control blade shadow corrosion-induced channel bow. FLN-2004-030 technically justifies that a GEXL R-factor uncertainty of [[ ]] accounts for a channel bow uncertainty of up to [[ ]]. The LGS Unit 1 Cycle 12 analysis shows a channel bow uncertainty of [[ ]], which is bounded by the use of a GEXL R-factor uncertainty of [[ ]]. The NRC staff finds that using the increased R-factor uncertainty is conservative and acceptable for LGS Unit 1 Cycle 12.

3.5.5 Random Effective TIP Reading Uncertainty

GNF increased the random effective TIP reading uncertainty due to performing the SLMCPR evaluation at the 100% rated power/81% rated flow statepoint instead of the 100% rated power/100% rated flow statepoint (see Section 3.6). GNF increased this value by the inverse of the core flow fraction. In response to the NRC staff's RAI (Reference 2), GNF states that there is no reason to believe that the uncertainty should increase as the core flow decreases for DLO. GNF decided to increase this uncertainty based on their historical precedent in which they increase this value when performing SLO calculations. The staff finds this conservative and acceptable for LGS Unit 1 Cycle 12.

3.6 Low-Flow Condition

On August 24, 2004, GNF issued "Part 21 Reportable Condition and 60-Day Interim Report; Notification: Non-conservative SLMCPR" (Reference 8), in accordance with 10 CFR Part 21. GNF and GENE determined that the current GNF process for determination of the SLMCPR can result in a non-conservative SLMCPR. In the approved methodologies, the SLMCPR is calculated at rated power/flow conditions. GNF discovered that it is possible that a lower flow condition at rated power can produce a more limiting (higher) SLMCPR value. In the instances where this concern was discovered, the control rod patterns used at the off-rated flow condition created a more limiting MCPR distribution than the control rod patterns used at 100% rated

power/100% rated flow. A flatter MCPR distribution produces a more limiting SLMCPR value because at a given critical power, there would be a larger number of rods that would reach boiling transition.

LGS Unit 1 is one of the plants listed in the Part 21 report as requiring a 60-day interim report notification pending verification completion. The Cycle 12 SLMCPR calculation was performed at both the minimum core flow (81% core flow) at rated power and at 100% core flow at rated power. The 81% core flow statepoint was the more limiting of the two SLMCPR evaluations.

GNF states that the rod patterns used to calculate the SLMCPR at 100% rated power/81% rated flow produce a limiting MCPR distribution that reasonably bounds the MCPR distributions that would be expected during the operation of the LGS Unit 1 core throughout Cycle 12. Consequently, the SLMCPR value calculated from the limiting MCPR distribution reasonably bounds a SLMCPR value that would be obtained using any MCPR distribution obtained during the operation of LGS Unit 1 Cycle 12. The NRC staff accepts the licensee's assurance that they will operate LGS Unit 1 with rod patterns that would result in an SLMCPR response that is bounded by the calculated SLMCPR value for the rated and off-rated conditions.

4.0 FINAL NO SIGNIFICANT HAZARDS CONSIDERATION DETERMINATION

4.1 Introduction

The Commission's regulations in 10 CFR 50.92 state that the Commission may make a final determination that a license amendment involves no significant hazards consideration if operation of the facility, in accordance with the amendment, would not: (1) involve a significant increase in the probability or consequences of an accident previously evaluated; (2) create the possibility of a new or different kind of accident from any accident previously evaluated; or (3) involve a significant reduction in a margin of safety.

As required by 10 CFR 50.91(a), the licensee provided its analysis of the issue of no significant hazards consideration in its December 14, 2005, amendment request. The NRC staff reviewed the licensee's analysis and, based on its review, it appeared that the three standards of 10 CFR 50.92(c) were satisfied. Therefore, the NRC staff proposed to determine that the amendment request involves no significant hazards consideration, and published its proposed determination in the *Federal Register* for public comment on January 17, 2006 (71 FR 2590).

The NRC staff has completed its evaluation of the licensee's proposed amendment as discussed in Section 3.0 above. Based on its evaluation, the staff has determined that the proposed amendment does not significantly increase the probability or consequences of an accident previously evaluated, does not create the possibility of a new or different kind of accident from any accident previously evaluated, and does not involve a significant reduction in a margin of safety. The following staff evaluation in relation to the three standards of 10 CFR 50.92 supports the staff's final no significant hazards consideration determination.

4.2 First Standard

"Involve a significant increase in the probability or consequences of an accident previously evaluated."

The derivation of the cycle-specific SLO SLMCPR for incorporation into the TSs, and its use to determine cycle-specific thermal limits, has been performed using the methodology discussed in "General Electric Standard Application for Reactor Fuel," NEDE-24011-P-A-15 (GESTAR-II), and U. S. Supplement, NEDE-24011-P-A-15-US, September 2005, which includes Amendment 25. Amendment 25 was approved by the NRC in a March 11, 1999, safety evaluation report.

The basis of the SLO SLMCPR calculation is to ensure that greater than 99.9% of all fuel rods in the core avoid transition boiling if the limit is not violated. The new SLO SLMCPR preserves the existing margin to transition boiling. The GE-14 fuel is in compliance with Amendment 22 to "General Electric Standard Application for Reactor Fuel," NEDE-24011-P-A-15 (GESTAR-II), and U. S. Supplement, NEDE-24011-P-A-15-US, September 2005, which provides the fuel licensing acceptance criteria. The probability of fuel damage will not be increased as a result of this change. Therefore, the proposed TS change does not involve a significant increase in the probability or consequences of an accident previously evaluated.

4.3 Second Standard

"Create the possibility of a new or different kind of accident from any previously analyzed."

The SLO SLMCPR is a TS numerical value, calculated to ensure that transition boiling does not occur in 99.9% of all fuel rods in the core if the limit is not violated. The new SLO SLMCPR is calculated using an NRC-approved methodology discussed in "General Electric Standard Application for Reactor Fuel," NEDE-24011-P-A-15 (GESTAR-II), and U.S. Supplement, NEDE-24011-P-A-15-US, September 2005, which includes Amendment 25. Additionally, the GE-14 fuel is in compliance with Amendment 22 to "General Electric Standard Application for Reactor Fuel," NEDE-24011-P-A-15 (GESTAR-II), and U. S. Supplement, NEDE-24011-P-A-15-US, September 2005, which provides the fuel licensing acceptance criteria. The SLO SLMCPR is not an accident initiator, and its revision will not create the possibility of a new or different kind of accident from any accident previously evaluated.

4.4 Third Standard

"Involve a significant reduction in a margin of safety."

There is no significant reduction in the margin of safety previously approved by the NRC as a result of the proposed change to the SLO SLMCPR, which includes the use of GE-14 fuel. The new SLO SLMCPR is calculated using the methodology discussed in "General Electric Standard Application for Reactor Fuel," NEDE-24011-P-A-15 (GESTAR-II), and U. S. Supplement, NEDE-24011-P-A-15-US, September 2005, which includes Amendment 25. The SLO SLMCPR ensures that greater than 99.9% of all fuel rods in the core will avoid transition

boiling if the limit is not violated when all uncertainties are considered, thereby preserving the fuel cladding integrity. Therefore, the proposed TS change will not involve a significant reduction in a margin of safety previously approved by the NRC.

On the basis of the above evaluation, the NRC staff concludes that the proposed amendment meets the three criteria of 10 CFR 50.92. Therefore, the staff has made a final determination that the proposed amendment does not involve a significant hazards consideration.

5.0 STATE CONSULTATION

In accordance with the Commission's regulations, the Pennsylvania State official was notified of the proposed issuance of the amendment. The State official had no comments.

6.0 ENVIRONMENTAL CONSIDERATION

The amendment changes a requirement with respect to installation or use of a facility component located within the restricted area as defined in 10 CFR Part 20. The NRC staff has determined that the amendment involves no significant increase in the amounts, and no significant change in the types, of any effluents that may be released offsite, and that there is no significant increase in individual or cumulative occupational radiation exposure. The Commission has previously issued a proposed finding that the amendment involves no significant hazards consideration, and there has been no public comment on such finding (71 FR 2590). Accordingly, the amendment meets the eligibility criteria for categorical exclusion set forth in 10 CFR 51.22(c)(9). Pursuant to 10 CFR 51.22(b), no environmental impact statement or environmental assessment need be prepared in connection with the issuance of the amendment.

7.0 CONCLUSION

The Commission has concluded, based on the considerations discussed above, that: (1) there is reasonable assurance that the health and safety of the public will not be endangered by operation in the proposed manner, (2) such activities will be conducted in compliance with the Commission's regulations, and (3) the issuance of the amendment will not be inimical to the common defense and security or to the health and safety of the public.

8.0 REFERENCES

1. Letter from Pamela B. Cowan (Exelon) to NRC, "License Amendment Request Single Loop Operation Safety Limit Critical Power Ratio (SLO SLMCPR) Change," dated December 14, 2005.

2. Letter from Pamela B. Cowan (Exelon) to NRC, "Response to Request for Additional Information - Single Loop Operation Safety Limit Critical Power Ratio (SLO SLMCPR) Change," dated February 13, 2006.

3. General Electric Nuclear Energy Licensing Topical Report NEDC-32601P-A, "Methodology and Uncertainties for Safety Limit MCPR Evaluations," dated July 1999.

4. Global Nuclear Fuels Licensing Topical Report NEDE-24011-P-A-14, "General Electric

Standard Application for Reactor Fuel," dated June 2000.

5. General Electric Nuclear Energy Licensing Topical Report NEDC-32505P-A, "R-Factor Calculation Method for GE11, GE12, and GE13 Fuel," dated July 1999.

6. General Electric Nuclear Energy Licensing Topical Report NEDO-10958-A "General Electric BWR Thermal Analysis Basis (GETAB): Data, Correlation and Design Application," January 1977.

7. Letter from Frank Akstulewicz (NRC) to Glen A. Watford (GE), "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," dated March 11, 1999.

8. Letter from Jason S. Post (GE) to NRC, "Part 21 Reportable Condition and 60-Day Interim Report; Notification: Non-Conservative SLMCPR," dated August 24, 2004.

9. Letter from Glen A. Watford (GNF) to NRC with attention to R. Pulsifier (NRC), "Confirmation of 10x10 Fuel Design Applicability to Improved SLMCPR, Power Distribution and R-Factor Methodologies," FLN-2001-016, dated September 24, 2001.

10. General Electric Nuclear Energy Licensing Topical Report NEDC-32694P-A, "Power Distribution Uncertainties for Safety Limit MCPR Evaluation," dated August 1999.

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