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10 CFR 50.46

October 29, 2022

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555-0001

Limerick Generating Station, Units 1 and 2
Renewed Facility Operating License Nos. NPF-39 and NPF-85
NRC Docket Nos. 50-352 and 50-353

Subject: 10 CFR 50.46 Annual Report

Reference:

Letter from David P. Helker (Exelon Generation Company, LLC) to U.S. Nuclear Regulatory Commission, "10 CFR 50.46 Annual Report," dated October 29, 2021

The purpose of this letter is to submit the 10 CFR 50.46 reporting information for Limerick Generating Station (LGS), Units 1 and 2. The most recent annual 10 CFR 50.46 Report for LGS, Units 1 and 2, (Reference) provided the cumulative Peak Cladding Temperature (PCT) errors for the most recent fuel design through October 29, 2021.

Five attachments are included with this letter that provide the current LGS, Units 1 and 2, 10 CFR 50.46 status. There are two fuel types, GNF2 and GNF3, in operation at LGS Units, 1 and 2. Attachment 1 provides the GNF2 Peak Cladding Temperature Rack-Up Sheet for Limerick Generating Station, Unit 1. Since this is the first annual report with GNF3 in operation at LGS Unit 1, Attachment 2 has been designated as GNF3 Peak Cladding Temperature Rack-Up Sheet for Limerick Generating Station, Unit 1. Therefore, Attachment 3 provides the GNF2 Peak Cladding Temperature Rack-Up Sheet for Limerick Generating Station, Unit 2, and Attachment 4 provides the GNF3 Peak Cladding

Temperature Rack-Up Sheet for Limerick Generating Station, Unit 2. Attachment 5, "Assessment Notes," contains a detailed description of each change/error reported.

Since the Reference report, there has been one change. It is provided in Note 2 of Attachment 5, "Assessment Notes." The change is applicable to GNF2 with a resulting impact of 0°F on GNF2 Net PCT. The change is not applicable to GNF3.

There are no regulatory commitments in this letter.

If you have any questions, please contact Steve Flickinger at 267-533-5302.

Respectfully,

David P. Helker

Sr. Manager - Licensing

Constellation Energy Generation, LLC

Attachments:

1) GNF2 Peak Cladding Temperature Rack-Up Sheet (Limerick Generating Station, Unit 1)
2) GNF3 Peak Cladding Temperature Rack-Up Sheet (Limerick Generating Station, Unit 1)
3) GNF2 Peak Cladding Temperature Rack-Up Sheet (Limerick Generating Station, Unit 2)
4) GNF3 Peak Cladding Temperature Rack-Up Sheet (Limerick Generating Station, Unit 2)
5) Assessment Notes (Limerick Generating Station, Units 1 and 2)

cc: USNRC Region I, Regional Administrator

USNRC Senior Resident Inspector, LGS

USNRC Project Manager, LGS

Director, Bureau of Radiation Protection – Pennsylvania Department of Environmental Protection

ATTACHMENT 1

10 CFR 50.46

"Acceptance criteria for emergency core cooling systems for light-water nuclear power reactors"

Report of the Emergency Core Cooling System Evaluation Model Changes and Errors

Assessments as of October 17, 2022

GNF2 Peak Cladding Temperature Rack-Up Sheet

Limerick Generating Station, Unit 1

Assessments as of October 17, 2022

Peak Cladding Temperature Rack-Up Sheet, LGS Unit 1

PLANT NAME: Limerick Unit 1

ECCS EVALUATION MODEL: SAFER/GESTR-LOCA Supplemented with PRIME

REPORT REVISION DATE: 10/17/2022

CURRENT OPERATING CYCLE: 20

ANALYSIS OF RECORD CALCULATIONS

"Limerick Generating Station Units 1 and 2 GNF2 ECCS-LOCA Evaluation," 0000-0111-9078-R0, February 2011.

Fuels Analyzed in Calculations and in Operation: **GNF2**

Limiting Fuel Type: **GNF2**

Limiting Single Failure (GNF2): **Battery Failure**

Limiting Break Location: **Recirculation Suction Line**

Limiting Break Size: **Double-Ended Guillotine Break**

Reference Peak Cladding Temperature (PCT): **1880°F**

MARGIN ALLOCATION

A. PRIOR LOCA MODEL ASSESSMENTS

10 CFR 50.46 Report dated November 23, 2011 (See Note 1.1)	GNF2 ΔPCT = +50°F
10 CFR 50.46 Report dated November 09, 2012 (See Note 1.2)	GNF2 ΔPCT = 0°F
10 CFR 50.46 Report dated December 12, 2012 (See Note 1.3)	GNF2 ΔPCT = +45°F
10 CFR 50.46 Report dated November 08, 2013 (See Note 1.4)	GNF2 ΔPCT = 0°F

10 CFR 50.46 Report dated November 07, 2014 (See Note 1.5)	GNF2 ΔPCT = +10°F
10 CFR 50.46 Report dated November 06, 2015 (See Note 1.6)	GNF2 ΔPCT = 0°F
10 CFR 50.46 Report dated November 04, 2016 (See Note 1.7)	GNF2 ΔPCT = 0°F
10 CFR 50.46 Report dated November 06, 2017 (See Note 1.8)	GNF2 ΔPCT = +30°F
10 CFR 50.46 Report dated November 06, 2018 (See Note 1.9)	GNF2 ΔPCT = 0°F
10 CFR 50.46 Report dated October 29, 2019 (See Note 1.10)	GNF2 ΔPCT = 0°F
10 CFR 50.46 Report dated October 29, 2020 (See Note 1.11)	GNF2 ΔPCT = 0°F
10 CFR 50.46 Report dated October 29, 2021 (See Note 1.12)	GNF2 ΔPCT = 0°F
Net PCT (GNF2)	**2015 °F**

B. CURRENT LOCA MODEL ASSESSMENTS

SAFER Decay Heat Model (See Note 2)	GNF2 ΔPCT = 0°F
Total PCT Change from Current Assessments (See Note 2)	GNF2 ΔPCT = 0°F
Cumulative PCT Change from Current Assessments	GNF2 ∑|ΔPCT| = 0°F
Net PCT (GNF2)	**2015 °F**

ATTACHMENT 2

10 CFR 50.46

"Acceptance criteria for emergency core cooling systems for light-water nuclear power reactors"

Report of the Emergency Core Cooling System Evaluation Model Changes and Errors

Assessments as of October 17, 2022

GNF3 Peak Cladding Temperature Rack-Up Sheet

Limerick Generating Station, Unit 1

Assessments as of October 17, 2022

GNF3 Peak Cladding Temperature Rack-Up Sheet, LGS Unit 1

PLANT NAME: Limerick Unit 1

ECCS EVALUATION MODEL: SAFER/PRIME-LOCA

REPORT REVISION DATE: 10/17/22

CURRENT OPERATING CYCLE: 20

ANALYSIS OF RECORD CALCULATIONS

"Limerick Generating Station Units 1 and 2 GNF3 ECCS-LOCA Evaluation," 005N3990 Rev 0, December 2020.

Fuels Analyzed in Calculations and in Operation: **GNF3**

Limiting Fuel Type: **GNF3**

Limiting Single Failure (GNF3): **Battery Failure**

Limiting Break Location: **Recirculation Suction Line**

Limiting Break Size: **Double-Ended Guillotine Break**

Reference Peak Cladding Temperature (PCT): **1940°F**

MARGIN ALLOCATION

A. PRIOR LOCA MODEL ASSESSMENTS

No prior LOCA Model Assessments have been provided as this is the first time this Analysis of Record is being reported for LGS Unit 1. (See Note 1)	N/A
Net PCT (GNF3)	**1940 °F**

B. CURRENT LOCA MODEL ASSESSMENTS

Total PCT Change from Current Assessments (See Note 2)	GNF3 ΔPCT = 0°F

Assessments as of October 17, 2022

GNF3 Peak Cladding Temperature Rack-Up Sheet, LGS Unit 1

Cumulative PCT Change from Current Assessments	GNF3 $\sum\|\Delta PCT\|$ = 0°F
Net PCT (GNF3)	**1940 °F**

ATTACHMENT 3

10 CFR 50.46

"Acceptance criteria for emergency core cooling systems for light-water nuclear power reactors"

Report of the Emergency Core Cooling System Evaluation Model Changes and Errors

Assessments as of October 17, 2022

GNF2 Peak Cladding Temperature Rack-Up Sheet

Limerick Generating Station, Unit 2

GNF2 Peak Cladding Temperature Rack-Up Sheet, LGS Unit 2

PLANT NAME: Limerick Unit 2

ECCS EVALUATION MODEL: SAFER/GESTR-LOCA Supplemented with PRIME

REPORT REVISION DATE: 10/17/2022

CURRENT OPERATING CYCLE: 17

ANALYSIS OF RECORD CALCULATIONS

"Limerick Generating Station Units 1 and 2 GNF2 ECCS-LOCA Evaluation," 0000-0111-9078-R0, February 2011.

Fuels Analyzed in Calculations and in Operation: **GNF2**

Limiting Fuel Type: **GNF2**

Limiting Single Failure (GNF2): **Battery Failure**

Limiting Break Location: **Recirculation Suction Line**

Limiting Break Size: **Double-Ended Guillotine Break**

Reference Peak Cladding Temperature (PCT): **1880°F**

MARGIN ALLOCATION

A. PRIOR LOCA MODEL ASSESSMENTS

10 CFR 50.46 Report dated November 23, 2011 (See Note 1.1)	GNF2 ΔPCT = +50°F
10 CFR 50.46 Report dated November 09, 2012 (See Note 1.2)	GNF2 ΔPCT = 0°F
10 CFR 50.46 Report dated December 12, 2012 (See Note 1.3)	GNF2 ΔPCT = +45°F
10 CFR 50.46 Report dated November 08, 2013 (See Note 1.4)	GNF2 ΔPCT = 0°F

10 CFR 50.46 Report dated November 07, 2014 (See Note 1.5)	GNF2 ΔPCT = +10°F
10 CFR 50.46 Report dated November 06, 2015 (See Note 1.6)	GNF2 ΔPCT = 0°F
10 CFR 50.46 Report dated November 04, 2016 (See Note 1.7)	GNF2 ΔPCT = 0°F
10 CFR 50.46 Report dated November 06, 2017 (See Note 1.8)	GNF2 ΔPCT = +30°F
10 CFR 50.46 Report dated November 06, 2018 (See Note 1.9)	GNF2 ΔPCT = 0°F
10 CFR 50.46 Report dated October 29, 2019 (See Note 1.10)	GNF2 ΔPCT = 0°F
10 CFR 50.46 Report dated October 29, 2020 (See Note 1.11)	GNF2 ΔPCT = 0°F
10 CFR 50.46 Report dated October 29, 2021 (See Note 1.12)	GNF2 ΔPCT = 0°F
Net PCT (GNF2)	**2015 °F**

B. CURRENT LOCA MODEL ASSESSMENTS

SAFER Decay Heat Model (See Note 2)	GNF2 ΔPCT = 0°F
Total PCT Change from Current Assessments (See Note 2)	GNF2 ΔPCT = 0°F
Cumulative PCT Change from Current Assessments	GNF2 ∑|ΔPCT| = 0°F
Net PCT (GNF2)	**2015 °F**

ATTACHMENT 4

10 CFR 50.46

"Acceptance criteria for emergency core cooling systems for light-water nuclear power reactors"

Report of the Emergency Core Cooling System Evaluation Model Changes and Errors

Assessments as of October 17, 2022

GNF3 Peak Cladding Temperature Rack-Up Sheet

Limerick Generating Station, Unit 2

Assessments as of October 17, 2022

GNF3 Peak Cladding Temperature Rack-Up Sheet, LGS Unit 2

PLANT NAME: Limerick Unit 2

ECCS EVALUATION MODEL: SAFER/PRIME-LOCA

REPORT REVISION DATE: 10/17/22

CURRENT OPERATING CYCLE: 17

ANALYSIS OF RECORD CALCULATIONS

"Limerick Generating Station Units 1 and 2 GNF3 ECCS-LOCA Evaluation," 005N3990 Rev 0, December 2020.

Fuels Analyzed in Calculations and in Operation: **GNF3**

Limiting Fuel Type: **GNF3**

Limiting Single Failure (GNF3): **Battery Failure**

Limiting Break Location: **Recirculation Suction Line**

Limiting Break Size: **Double-Ended Guillotine Break**

Reference Peak Cladding Temperature (PCT): **1940°F**

MARGIN ALLOCATION

A. PRIOR LOCA MODEL ASSESSMENTS

10 CFR 50.46 Report dated October 29, 2021 (See Note 1.12)	GNF3 ΔPCT = 0°F
Net PCT (GNF3)	**1940 °F**

B. CURRENT LOCA MODEL ASSESSMENTS

Total PCT Change from Current Assessments (See Note 2)	GNF3 ΔPCT = 0°F
Cumulative PCT Change from Current Assessments	GNF3 $\sum\|\Delta PCT\|$ = 0°F
Net PCT (GNF3)	**1940 °F**

Attachment 5

10 CFR 50.46

"Acceptance criteria for emergency core cooling systems for light-water nuclear power reactors"

Report of the Emergency Core Cooling System Evaluation Model Changes and Errors

Assessments as of October 17, 2022

Assessment Notes

Limerick Generating Station, Units 1 and 2

1. Prior LOCA Assessments

The last 10 CFR 50.46 annual report submitted to the NRC was on October 29, 2021 (Reference 1). That report documented a Total Net PCT of 2015°F for GNF2 fuel at Limerick Generation Station (LGS) Unit 1 and 2. A Total Net PCT of 1940°F for GNF3 fuel was provided in that report for LGS Unit 2, because GNF3 fuel was introduced into the core beginning with LGS Unit 2 Cycle 17. At the time of the Reference 1 report, LGS Unit 1 had not yet introduced GNF3 into the core. Beginning with LGS Unit 1 Cycle 20, GNF3 fuel has been introduced into the core. All of the listed prior LOCA assessments below are documented in the referenced letter.

[Reference 1: Letter from David P. Helker (Exelon Generation Company, LLC) to U.S. NRC, “10 CFR 50.46 Annual Report," dated October 29, 2021.]

1.1. Prior LOCA Assessment – 2011

The referenced letter provided an annual 50.46 report for Units 1 and 2. The referenced letter discussed the introduction of the GNF2 fuel design to the Limerick Unit 2 core. Subsequent to the referenced letter, the GNF2 fuel design was introduced to the Unit 1 core and the errors discussed in this note also apply to Unit 1 (See Note 1.2).

Also discussed in the referenced letter are two vendor notifications of Emergency Core Cooling System (ECCS) model error/changes for GNF2 fuel applicable to Limerick. The errors/changes are summarized below.

The first error involved the way input coefficients were used to direct the deposition of gamma radiation energy produced by the fuel. The impact of this error is estimated to be +45°F for GNF2 fuel.

The second error involved the contribution of heat from gamma ray absorption by the channel. The gamma ray absorption by the channel was found to have been minimized. The impact of this error is estimated to be +5°F for GNF2 fuel.

[Reference 1.1: Letter from Michael D. Jesse (Exelon Generation Company, LLC) to U.S. Nuclear Regulatory Commission, “10 CFR 50.46 Annual Report,” dated November 23, 2011.]

1.2. Prior LOCA Assessment - 2012

The referenced letter provided an annual 50.46 report for Units 1 and 2. There were no errors reported for the 2012 reporting period.

GNF2 fuel was introduced into the Unit 1 core during Reload 14 (Cycle 15) outage. The ECCS model error/changes discussed in Note 1.1 were applied to Unit 1 as Prior LOCA Model Assessments.

[Reference 1.2: Letter from Michael D. Jesse (Exelon Generation Company, LLC) to U.S. Nuclear Regulatory Commission, “10 CFR 50.46 Annual Report,” dated November 9, 2012.]

1.3. Prior LOCA Assessment – 2012 (30-day report)

The referenced letter provided a 50.46 30-day report for Units 1 and 2. To address inaccuracies in fuel pellet thermal conductivity as a function of exposure, commonly referred to as thermal conductivity degradation (TCD); GEH replaced the GESTR-LOCA model with a newer model, PRIME. The most dominant effect impacting PCT is from the way the PRIME fuel properties treat thermal conductivity, which results in a higher fuel stored energy. The PCT impact identified in the referenced letter reflects the difference between the existing GESTR analysis PCT and a conservatively postulated PCT if the analysis was performed with the PRIME model. The ECCS-LOCA analysis methodology remains GESTR based and will not be PRIME based until the ECCS-LOCA analysis is re-performed using PRIME.

[Reference 1.3: Letter from Michael D. Jesse (Exelon Generation Company, LLC) to U.S. Nuclear Regulatory Commission, “10 CFR 50.46 30-Day Report,” dated December 12, 2012.]

1.4. Prior LOCA Assessment - 2013

The referenced letter provided an annual 50.46 report for Units 1 and 2. There were no errors reported for the 2013 reporting period.

[Reference 1.4: Letter from James Barstow (Exelon Generation Company, LLC (EGC)) to U.S. NRC, “10 CFR 50.46 Annual Report," dated November 8, 2013.]

1.5. Prior LOCA Assessment - 2014

The referenced letter reported four vendor notifications that were received. The first notification addressed several accumulated updates to the SAFER04A model. The code maintenance changes had an individually and collectively insignificant effect on calculated peak cladding temperature. The impact of this error is estimated to be 0°F for GNF2 fuel. The second notification was for a correction to a logic error that was isolated, occurring with an indication that the expected systems mass diverged from the calculated actual system mass. This error affected the ECCS flow credited as reaching the core. The impact of this error is estimated to be +10°F for GNF2 fuel. The third notification addressed an error with the imposed minimum pressure differential (Δp) for droplet flow above a two-phase level in the core. This error could have offered an inappropriate steam cooling benefit above the core two phase level. To correct this error an explicit core Δp calculation was applied without regard to droplet condition. The impact of this error is estimated to be +20°F for GNF2 fuel. The fourth notification addressed an incorrect pressure head representation when defining the counter current flow limitation (CCFL). The impact of this error is estimated to be -20°F for GNF2 fuel.

[Reference 1.5: Letter from James Barstow (Exelon Generation Company, LLC (EGC)) to U.S. NRC, “10 CFR 50.46 Annual Report," dated November 7, 2014.]

1.6. Prior LOCA Assessment - 2015

The referenced letter provided an annual 50.46 report for LGS, Units 1 and 2. There were no errors reported for the 2015 reporting period. The referenced letter notes that LGS Unit 2 has unloaded all bundles of the GE14 fuel type from the core.

[Reference 1.6: Letter from James Barstow (Exelon Generation Company, LLC (EGC)) to U.S. NRC, “10 CFR 50.46 Annual Report," dated November 6, 2015.]

1.7. Prior LOCA Assessment - 2016

The referenced letter notes that LGS Unit 1 has unloaded all bundles of the GE14 fuel type from the core. There were no errors reported for the 2016 reporting period.

[Reference 1.7: Letter from James Barstow (Exelon Generation Company, LLC (EGC)) to U.S. NRC, “10 CFR 50.46 Annual Report," dated November 4, 2016.]

1.8. Prior LOCA Assessment – 2017

The referenced letter reported two vendor notifications regarding Emergency Core Cooling System (ECCS) modeling changes/errors applicable to LGS. These notifications described issues related to the improper modelling of lower tie plate leakage for the GNF2 fuel design (2017-01) and changes to modeling of the fuel rod plenum for 10x10 fuel (2017-02), respectively. The impact of the 2017-01 error is estimated to be +30°F for GNF2 fuel. The impact of the 2017-02 error is estimated to be 0°F for GNF2 fuel.

[Reference 1.8: Letter from David P. Helker (Exelon Generation Company, LLC) to U.S. NRC, “10 CFR 50.46 Annual Report," dated November 6, 2017.]

1.9. Prior LOCA Assessment - 2018

The referenced letter provided an annual 50.46 report for Units 1 and 2. There were no errors reported for the 2018 reporting period.

[Reference 1.9: Letter from David P. Helker (Exelon Generation Company, LLC) to U.S. NRC, “10 CFR 50.46 Annual Report," dated November 6, 2018.]

1.10. Prior LOCA Assessment - 2019

The referenced letter provided an annual 50.46 report for Units 1 and 2. There were no errors reported for the 2019 reporting period.

[Reference 1.10: Letter from David P. Helker (Exelon Generation Company, LLC) to U.S. NRC, “10 CFR 50.46 Annual Report," dated October 29, 2019.]

1.11. Prior LOCA Assessment - 2020

The referenced letter provided an annual 50.46 report for Units 1 and 2. There were three errors reported for the 2020 reporting period.

Notification 2019-05 identifies that the upper and lower limits for the SAFER code forward and backward bypass leakage were coded incorrectly for the control rod guide tube to control rod drive housing interface backward leakage path. The error was estimated to have a zero-degree impact upon the GNF2 fuel licensing basis PCT.

Notification 2020-01 identifies that the PRIME code contained errors in Zircaloy irradiation growth after a breakaway neutron fluence, Zircaloy thermal conductivity applied to the zirconium barrier for cladding temperature drop, and gap conductance during pellet-cladding gap closure. The errors were estimated to have a zero-degree impact upon the GNF2 fuel licensing basis PCT.

Notification 2020-03 identifies that the Analysis of Record (AOR) did not utilize the bounding dome pressure. The dome pressure of 1063 psia was used in the AOR; instead of the more bounding Technical Specification LCO value of 1068 psia. The error was estimated to have a zero-degree impact upon the GNF2 fuel licensing basis PCT.

[Reference 1.11: Letter from David P. Helker (Exelon Generation Company, LLC) to U.S. NRC, “10 CFR 50.46 Annual Report," dated October 29, 2020.]

1.12. Prior LOCA Assessment - 2021

The referenced letter provided an annual 50.46 report for Units 1 and 2. There were two errors reported for the 2021 reporting period.

Notification 2021-01 identifies an error in the fuel rod stress and perforation model due to an incorrect value used for the fuel pellet to plenum spring conductance input. The error was a result of an incorrect conversion from SI units in preparing the input for SAFER analyses. The error was estimated to have a zero degree impact upon the GNF2 fuel PCT.

Notification 2021-02 identifies an error in the inner cladding surface roughness value in the gap conductance model. An inconsistency was identified between the roughness value used in the fuel performance model PRIME and the input to the SAFER and TRACG calculations. The error was estimated to have a zero degree impact upon the GNF2 fuel PCT.

These Notifications were only applicable to the analysis of record documented in Attachments 1 and 3. The analysis of record documented in Attachment 2 and 4 was performed with corrected models and therefore these notifications were not applicable.

[Reference 1.12: Letter from David P. Helker (Exelon Generation Company, LLC) to U.S. NRC, “10 CFR 50.46 Annual Report," dated October 29, 2021.]

2. Current LOCA Assessment

Since the previous 10 CFR 50.46 report (Reference in Note 1.12) there has been one change. It was recently discovered that a change in 2011 was made to the decay heat (DH) input used in nominal calculations for the SAFER evaluation model. The updated DH model is a best estimate decay heat curve based on the 1979 ANS 5.1 standard and considers SIL 636. This change was discovered during review of the GNF3 New Fuel Introduction and additional vendor assessments estimated an impact of 0°F upon the GNF2 PCT. This change was already incorporated into the initial GNF3 LOCA evaluation and, therefore, has no impact on the GNF3 LOCA analysis of record.

No additional ECCS related changes or modifications occurred at LGS that affected the assumptions in the GNF2 or GNF3 LOCA analysis of record.