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T.S. 6.9.1.12

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

Limerick Generating Station, Unit 1
Facility Operating License No. NPF-39
NRC Docket Nos. 50-352

Subject: Issuance of the Core Operating Limits Report For Cycle14 Revision 8

Enclosed is a copy of the Core Operating Limits Report (COLR) for Limerick Generating Station (LGS). Unit 1 Cycle 14 Revision 8 of this report incorporates the revised cycle specific parameters resulting from the new configuration implemented during the LGS, Unit 1 refueling outage.

The COLR is being submitted to the NRC in accordance LGS, Unit 1 Technical Specification 6.9.12.

All licensing work bounds the final Measurement Uncertainty Recapture (MUR) power level and the current power level.

If you have any questions or require additional information, please do not hesitate to contact us.

Sincerely,

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Exelon Generation Company, LLC

Enclosure: Unit 1 COLR for Cycle 14 Rev. 8

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# CORE OPERATING LIMITS REPORT

# FOR

# LIMERICK GENERATING STATION

# UNIT 1 RELOAD 13 CYCLE 14

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## Table of Contents

## List of Tables

## 1.0 Terms and Definitions

| | |
|---|---|
| ARTS | APRM and RBM Technical Specification Analysis |
| BASE CASE | A case analyzed with Turbine Bypass System in service and Recirculation Pump Trip in service and Feedwater Temperature Reduction allowed (FFWTR includes feedwater heater OOS or final feedwater temperature reduction) at any point in the cycle operation in Dual Loop mode. |
| DTSP | Rod Block Monitor Downscale Trip Setpoint |
| EOOS | Equipment Out of Service |
| EOR | End of Rated. The cycle exposure at which reactor power is equal to rated thermal power with recirculation system flow equal to 100%, all control rods fully withdrawn, all feedwater heating in service and equilibrium Xenon. |
| FFWTR | Final Feedwater Temperature Reduction |
| FWHOOS | Feedwater Heaters Out of Service |
| HTSP | Rod Block Monitor High Trip Setpoint |
| ICF | Increased Core Flow |
| ITSP | Rod Block Monitor Intermediate Trip Setpoint |
| Kp | Off-rated power dependent OLMCPR multiplier |
| LHGR | Linear Heat Generation Rate |
| LHGRFAC(F) | Off-rated flow dependent LHGR multiplier |
| LHGRFAC(P) | Off-rated power dependent LHGR multiplier |
| LTSP | Rod Block Monitor Low Trip Setpoint |
| MAPLHGR | Maximum Average Planar Linear Heat Generation Rate |
| MAPLHGR(F) | Off-rated flow dependent MAPLHGR multiplier |
| MAPLHGR(P) | Off-rated flow dependent MAPLHGR multiplier |
| MCPR | Minimum Critical Power Ratio |
| MCPR(F) | Off-rated flow dependent OLMCPR |
| MCPR(P) | Off-rated power dependent OLMCPR |

| | |
|---|---|
| MELLLA | Maximum Extended Load Line Limit Analysis |
| OLMCPR | Operating Limit Minimum Critical Power Ratio |
| OPRM | Oscillation Power Range Monitor |
| RBM | Rod Block Monitor |
| RPTOOS | Recirculation Pump Trip Out of Service |
| SLMCPR | Safety Limit Minimum Critical Power Ratio |
| SLO | Single Loop Operation |
| TBVOOS | Turbine Bypass Valves Out of Service |

## 2.0 General Information

This report is prepared in accordance with Technical Specification 6.9.1.9 of Reference 1. Power and flow dependent limits are listed for various power and flow levels. Linear interpolation is to be used to find intermediate values.

The data presented in this report is valid for all licensed operating domains on the operating map, including:

- Maximum Extended Load Line Limit down to the minimum licensed core flow during full power operation
- Increased Core Flow (ICF) up to 110% of rated core flow
- Final Feedwater Temperature Reduction (FFWTR) up to 105.1°F during cycle extension operation
- Feedwater Heater Out of Service (FWHOOS) up to 60.1°F feedwater temperature reduction at any time during the cycle prior to cycle extension.

## 3.0 Maximum Average Planar Linear Heat Generation Rate Limits

3.1 Technical Specification

Section 3.2.1

3.2 Description

The limiting MAPLHGR value for the most limiting lattice (excluding natural uranium) of each fuel type as a function of average planar exposure is given in Table 3-1. The limiting MAPLHGR value is the same for all fuel types in Limerick Unit 1 Cycle 14. For single loop operation, a multiplier is used which is shown in Table 3-2. The power and flow dependent multipliers for MAPLHGR have been removed and replaced with LHGRFAC(P) and LHGRFAC(F), therefore MAPLHGR(P) and MAPLHGR(F) are equal to 1 (Reference 2).

**Table 3-1**
**MAPLHGR Versus Average Planar Exposure**
**All Fuel Types**
**(Reference 2)**

| Average Planar Exposure (GWD/ST) | MAPLHGR Limit (kW/ft) |
|---|---|
| 0.0 | 12.82 |
| 14.51 | 12.82 |
| 19.13 | 12.82 |
| 57.61 | 8.00 |
| 63.50 | 5.00 |

**Table 3-2**
**MAPLHGR Single Loop Operation (SLO) Multiplier**
**(Reference 2)**

| | |
|---|---|
| SLO Multiplier | 0.80 |

## 4.0 Minimum Critical Power Ratio Limits

4.1 Technical Specification

Section 3.2.3

4.2 Description

Table 4-1 is derived from the Reference 2 analyses and is valid for all Cycle 14 fuel types and operating domains. Table 4-1 includes treatment of these MCPR limits for all conditions listed in Section 9.0, Modes of Operation. The cycle exposure that represents EOR is given in the latest verified and approved Cycle Management Report or an associated Engineering Change Request.

ARTS provides for power- and flow-dependent thermal limit adjustments and multipliers, which allow for a more reliable administration of the MCPR thermal limit. The flow-dependent adjustment MCPR(F) and power-dependent adjustment MCPR(P) are sufficiently generic to apply to all fuel types and operating domains. The MCPR(P) values are independent of recirculation pump trip operability (Reference 3). MCPR(P) and MCPR(F) are independent of Scram Time Option. These adjustments are provided in Table 4-2 and 4-3. The OLMCPR is determined for a given power and flow condition by evaluating the power-dependent MCPR and the flow-dependent MCPR and selecting the greater of the two.

When the actual Scram speed falls between Option B (Tau = 0) and Option A (Tau = 1), linear interpolation shall be used to determine MCPR limits.

**Table 4-1**
**Operating Limit Minimum Critical Power Ratio (OLMCPR)**
**All Fuel Types**
**(Reference 2)**

| EOOS Combination | SCRAM Time Option | Cycle Exposure | |
|---|---|---|---|
| | | < EOR – 2725 MWd/ST | ≥ EOR – 2725 MWd/ST |
| BASE | B | 1.34 | 1.39 |
| | A | 1.37 | 1.42 |
| BASE SLO | B | 1.44[1] | 1.44[1] |
| | A | 1.44[1] | 1.44 |
| TBVOOS | B | 1.38 | 1.43 |
| | A | 1.41 | 1.46 |
| TBVOOS SLO | B | 1.44[1] | 1.45 |
| | A | 1.44[1] | 1.48 |
| RPTOOS | B | 1.40 | 1.46 |
| | A | 1.51 | 1.63 |
| RPTOOS SLO | B | 1.44[1] | 1.48 |
| | A | 1.53 | 1.65 |

[1] OLMCPR limit set by the Single Loop Operation Recirculation Pump Seizure Event (Reference 2).

**TABLE 4-2**
**Power Dependent MCPR Limit Adjustments And Multipliers**
**(Reference 2)**

| EOOS Combination | Core Flow (% of rated) | Core Thermal Power (% of Rated) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 0 | 25 | < 30 | ≥ 30 | 45 | 60 | 100 |
| | | Operating Limit MCPR, MCPR(P) | | | Operating Limit MCPR Multiplier, Kp | | | |
| Base | ≤ 60 | 2.66 | 2.66 | 2.44 | 1.481 | 1.280 | 1.150 | 1.000 |
| | > 60 | 3.39 | 3.39 | 2.93 | | | | |
| Base SLO | ≤ 60 | 2.68 | 2.68 | 2.46 | 1.481 | 1.280 | 1.150 | 1.000 |
| | > 60 | 3.41 | 3.41 | 2.95 | | | | |
| RPTOOS | ≤ 60 | 2.66 | 2.66 | 2.44 | 1.481 | 1.280 | 1.150 | 1.000 |
| | > 60 | 3.39 | 3.39 | 2.93 | | | | |
| RPTOOS SLO | ≤ 60 | 2.68 | 2.68 | 2.46 | 1.481 | 1.280 | 1.150 | 1.000 |
| | > 60 | 3.41 | 3.41 | 2.95 | | | | |
| TBVOOS | ≤ 60 | 3.07 | 3.07 | 2.63 | 1.481 | 1.280 | 1.150 | 1.000 |
| | > 60 | 4.54 | 4.54 | 3.77 | | | | |
| TBVOOS SLO | ≤ 60 | 3.09 | 3.09 | 2.65 | 1.481 | 1.280 | 1.150 | 1.000 |
| | > 60 | 4.56 | 4.56 | 3.79 | | | | |

**TABLE 4-3**
**Flow Dependent MCPR Limits MCPR(F)**
**(References 2 and 12)**

| Flow (% rated) | MCPR(F) Limit |
|---|---|
| 0.0 | 1.7073 |
| 30.0 | 1.53 |
| 79.06 | 1.25 |
| 110.0 | 1.25 |

## 5.0 Linear Heat Generation Rate Limits

5.1 Technical Specification

Section 3.2.4

5.2 Description

The LHGR limit is an exposure dependent value. Table 5-1 provides the exposure dependent LHGR limit for all $UO_2$ pins for all bundles in the Cycle 14 core. Tables 5-2 and 5-3 provide the bounding exposure dependent LHGR limit for Gad rods in the Cycle 14 core. The LHGR SLO multiplier is shown in Table 5-4.

ARTS provides for power and flow-dependent thermal limit multipliers, which allow for a more reliable administration of the LHGR thermal limits. There are two sets of flow-dependent LGHR multipliers for dual-loop and single-loop operation (References 2 and 5). In addition, there are also two sets of power-dependent LHGR multipliers for use with the Turbine Bypass Valves in service and TBVOOS conditions (Reference 2). Section 7.0 contains the conditions for Turbine Bypass Valve Operability. Thermal limit monitoring must be performed with the more limiting LHGR limit resulting from the power- and flow-biased calculation. The LHGRFAC(P) curves are independent of recirculation pump trip operability (Reference 2).

**TABLE 5-1**
**Linear Heat Generation Rate Limits - $UO_2$ Rods**
**All Fuel Types**
**(Reference 8)**

| Peak Pellet Exposure (GWD/ST) | LHGR Limit (kW/ft) |
|---|---|
| 0.00 | 13.40 |
| 14.51 | 13.40 |
| 57.61 | 8.00 |
| 63.50 | 5.00 |

**TABLE 5-2**
**Linear Heat Generation Rate Limits – Gad Rods**
**Fuel Types 2530, 2882, 3035, 3038, 3041, 3273, 3274, 3275, 3272, 3040, 3042, 3039, and 2883**
**(Reference 8)**

| Peak Pellet Exposure (GWD/ST) | LHGR Limit (kW/ft) |
|---|---|
| 0.00 | 11.76 |
| 12.08 | 11.76 |
| 54.21 | 7.02 |
| 59.98 | 4.39 |

**TABLE 5-3**
**Linear Heat Generation Rate Limits – Gad Rods**
**Fuel Type 3271**
**(Reference 8)**

| Peak Pellet Exposure (GWD/ST) | LHGR Limit (kW/ft) |
|---|---|
| 0.00 | 12.00 |
| 12.17 | 12.00 |
| 54.59 | 7.16 |
| 60.39 | 4.48 |

**TABLE 5-4**
**LHGR Single Loop Operation (SLO) Multiplier**
**(Reference 2)**

| | |
|---|---|
| SLO Multiplier[1] | 0.80 |

**TABLE 5-5**
**Power Dependent LHGR Multiplier LHGRFAC(P)**
**(Reference 2)**

| EOOS Combination | Core Flow (% of rated) | Core Thermal Power (% of rated) | | | | |
|---|---|---|---|---|---|---|
| | | 0 | 25 | < 30 | ≥ 30 | 100 |
| | | LHGRFAC(P) Multiplier | | | | |
| Base | ≤ 60 | 0.485 | 0.485 | 0.490 | 0.6340 | 1.0000 |
| | > 60 | 0.434 | 0.434 | 0.473 | | |
| Base SLO | ≤ 60 | 0.485 | 0.485 | 0.490 | 0.6340 | 1.0000 |
| | > 60 | 0.434 | 0.434 | 0.473 | | |
| RPTOOS | ≤ 60 | 0.485 | 0.485 | 0.490 | 0.6340 | 1.0000 |
| | > 60 | 0.434 | 0.434 | 0.473 | | |
| RPTOOS SLO | ≤ 60 | 0.485 | 0.485 | 0.490 | 0.6340 | 1.0000 |
| | > 60 | 0.434 | 0.434 | 0.473 | | |
| TBVOOS | ≤ 60 | 0.463 | 0.463 | 0.490 | 0.6340 | 1.0000 |
| | > 60 | 0.352 | 0.352 | 0.386 | | |
| TBVOOS SLO | ≤ 60 | 0.463 | 0.463 | 0.490 | 0.6340 | 1.0000 |
| | > 60 | 0.352 | 0.352 | 0.386 | | |

[1] Applied through Table 5-6

**TABLE 5-6**
**Flow Dependent LHGR Multiplier LHGRFAC(F)**
**(References 2 and 5)**

| EOOS Combination | Core Flow (% of rated) | | | | |
|---|---|---|---|---|---|
| | 0 | 44.074 | 70 | 80 | 110 |
| | LHGRFAC(F) Multiplier | | | | |
| Dual Loop | 0.5055 | | 0.973 | 1.00 | 1.00 |
| Single Loop | 0.5055 | 0.80 | 0.80 | 0.80 | 0.80 |

## 6.0 Control Rod Block Setpoints

6.1 Technical Specification

Section 3.3.6

6.2 Description

The ARTS Rod Block Monitor provides for power-dependent RBM trips. Technical Specification Limiting Condition for Operation number 3.3.6 requires control rod block instrumentation channels to be OPERABLE with their trip setpoints consistent with the values shown in the Trip Setpoint column of Technical Specification Table 3.3.6-2. The trip setpoints/allowable values and applicable RBM signal filter time constant data are shown in Table 6-1. The Reactor Coolant System Recirculation Flow Upscale Trip is found in Table 6-2 of this COLR. These setpoints are set high enough to allow full utilization of the enhanced ICF domain up to 110% of rated core flow.

**TABLE 6-1**
**Rod Block Monitor Setpoints[1]**
**(References 2 and 7)**

| Power Level | Nominal Trip Setpoint | Allowable Value |
|---|---|---|
| LTSP | 121.5% | 121.5% |
| ITSP | 116.5% | 116.5% |
| HTSP | 111.0% | 111.7% |
| DTSP | 5.0% | 2.0% |

**TABLE 6-2**
**Reactor Coolant System Recirculation Flow Upscale Trip**
**(Reference 7)**

| | |
|---|---|
| Nominal Trip Setpoint | 113.4% |
| Allowable Value | 115.6% |

[1] Based on a cycle-specific rated RWE MCPR limit less than or equal to the minimum cycle OLMCPR. The values provided assume the Rod Block Monitor filter time constant between 0.1 seconds and 0.55 seconds is used.

## 7.0 Turbine Bypass Valve Parameters

7.1 Technical Specification

Sections 3.7.8 and 4.7.8.c

7.2 Description

The operability requirements for the steam bypass system are found in Tables 7-1 and 7-2. If these requirements cannot be met, the MCPR, MCPR(P) and LHGRFAC(P) limits for inoperable Steam Bypass System, known as Turbine Bypass Valve Out Of Service (TBVOOS), must be used. Additional information on the operability of the turbine bypass system can be found in Reference 10.

**TABLE 7-1**
**Turbine Bypass System Response Time**
**(Reference 4)**

| | |
|---|---|
| Maximum delay time before start of bypass valve opening following generation of the turbine bypass valve flow signal | 0.11 sec |
| Maximum time after generation of a turbine bypass valve flow signal for bypass valve position to reach 80% of full flow (includes the above delay time) | 0.31 sec |

**TABLE 7-2**
**Minimum Required Bypass Valves To Maintain System Operability**
**(Reference 4)**

| Reactor Power | No. of Valves in Service |
|---|---|
| $P \geq 25\%$ | 7 |

## 8.0 Stability Protection Setpoints

8.1 Technical Specification

Section 2.2.1

8.2 Description

The Limerick 1 Cycle 14 OPRM Period Based Detection Algorithm (PBDA) Trip Setpoints for the OPRM System are found in Table 8-1. These values are based on the cycle specific analysis documented in Reference 2. The Cycle 14 OPRM PBDA trip setpoints specified in Table 8-1 require a minimum OLMCPR value of 1.34 (See Section 4.0 MCPR Limits). The setpoints provided in Table 8-1 are bounding for all modes of operation shown in Table 9-1.

**TABLE 8-1**
**OPRM PBDA Trip Setpoints**
**(Reference 2)**

| PBDA Trip Amplitude | Corresponding Maximum Confirmation Count Trip Setting |
|---|---|
| ≤1.12 | 14 |

## 9.0 Modes of Operation

**TABLE 9-1**
**Modes of Operation**
**(References 2 and 5)**

| EOOS Options | Operating Region[1] |
|---|---|
| Base, Option A or B | Yes |
| Base SLO, Option A or B | Yes |
| TBVOOS, Option A or B | Yes |
| TBVOOS SLO, Option A or B | Yes |
| RPTOOS, Option A or B | Yes |
| RPTOOS SLO, Option A or B | Yes |
| TBVOOS and RPTOOS, Option A or B | No |
| TBVOOS and RPTOOS SLO, Option A or B | No |

[1] Operating Region refers to operation on the Power to Flow map with or without FFWTR.

## 10.0 Methodology

The analytical methods used to determine the core operating limits shall be those previously reviewed and approved by the NRC, specifically those described in the following documents:

1. "General Electric Standard Application for Reactor Fuel", NEDE-24011-P-A-16, October 2007 and U.S. Supplement NEDE-24011-P-A-16-US, October 2007.

2. "Reactor Stability Detect and Suppress Solutions Licensing Basis Methodology for Reload Applications", NEDO-32465-A, Rev. 0, August 1996.

## 11.0 References

1. "Technical Specifications and Bases for Limerick Generating Station Unit 1", Docket No. 50-352, License No. NPF-39.

2. "Supplemental Reload Licensing Report for Limerick 1 Reload 13 Cycle 14", Global Nuclear Fuel Document No. 0000-0104-1095-SRLR, Revision 0, January 2010.

3. "GE14 Fuel Design Cycle-Independent Analyses for Limerick Generating Station Units 1 and 2", GE-NE-L12-00884-00-01P, March 2001.

4. "Final Resolved OPL-3 Parameters for Limerick Unit 1 Cycle 14", TODI ES0900029, December 17, 2009.

5. "ARTS Flow-Dependent Limits with TBVOOS for Peach Bottom Atomic Power Station and Limerick Generating Station", GENE Document NEDC-32847P, June 1998.

6. "General Electric Standard Application for Reactor Fuel", NEDE-24011-P-A-16, October 2007 and U.S. Supplement NEDE-24011-P-A-16-US, October 2007.

7. "GE NUMAC PRNM Setpoint Study", LE-0107, Rev. 0, May 1, 2000. Including Minor Revision 0C, April 24, 2008.

8. "Fuel Bundle Information Report for Limerick 1 Reload 13 Cycle 14", Global Nuclear Fuel Document No. 0000-0104-1095-FBIR, Revision 0, January 2010.

9. Deleted.

10. "Tech Eval Stop Valve Load Limit Documentation", Exelon Document IR 917231 Assignment 7, November 11, 2009.

11. "Reactor Stability Detect and Suppress Solutions Licensing Basis Methodology for Reload Applications", NEDO-32465-A, Rev. 0, August 1996.

12. "Removal of MCPR(F) Low Flow Correction in NEDC-32847P", GE Nuclear Energy Letter NSA-02-080, February 2002.