Exelon Generation®

T.S. 6.9.1.12

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

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

Subject: Issuance of the Core Operating Limits Report (COLR) for Unit 1 Reload 16, Cycle 17

Enclosed is a copy of the Core Operating Limits Report (COLR) for Limerick Generating Station (LGS) Unit 1 Reload 16 Cycle 17 which incorporates the revised cycle specific parameters resulting from the new configuration implemented for LGS, Unit 1.

The COLR is being submitted to the NRC in accordance with LGS, Unit 1 Technical Specification 6.9.1.12.

If you have any questions or require additional information, please contact Giuseppe Rubinaccio at 610-718-3560.

Respectfully,

Richard W. Libra
Site Vice President-Limerick Generating Station
Exelon Generation Company, LLC

Attachment: Core Operating Limits Report for Limerick Generating Station Unit 1 Reload 16, Cycle 17

cc: D. Dorman, Administrator, Region I, USNRC (w/attachments)
S. Rutenkroger, USNRC Sr. Resident Inspector, LGS (w/attachments)
R. Ennis, USNRC Project Manager for LGS (w/attachments)
R. R. Janati, PADEP-BRP (w/attachments)

CORE OPERATING LIMITS REPORT

FOR

LIMERICK GENERATING STATION

UNIT 1 RELOAD 16 CYCLE 17

Prepared By: Monica Kosciuk Jamara Stathes Date: 3/17/16
M. N. Kosciuk
T. J. Stathes
Preparer

Reviewed By: Date: 3/17/16
M. R. Holmes
Independent Reviewer

Reviewed By: Date: 3/17/16
M. Doerzbacher
Reactor Engineering

Reviewed By: Date: 3/17/16
T. R. Bement
Engineering Safety Analysis

Approved By: James Tusar Date: 03/17/2016
J. J. Tusar
Manager - BWR Design (GNF)

Station Qualified Review By: Date: 03/29/2016
L. L. Korbeil
Station Qualified Reviewer

Table of Contents

Revision History

Revision	Description
Revision 13	New issue for Cycle 17.

List of Tables

1.0 Terms and Definitions

ARTS	APRM, RBM, and Technical Specification Improvement Program
BASE	A case analyzed with Turbine Bypass System in service and Recirculation Pump Trip in service and Feedwater Temperature Reduction allowed (FFWTR includes FWHOOS or final feedwater temperature reduction) and PLUOOS allowed at any point during the cycle in Dual Loop mode.
DLO	Dual Loop Operation
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)	ARTS LHGR thermal limit flow dependent multipliers
LHGRFAC(P)	ARTS LHGR thermal limit power dependent multipliers
LTSP	Rod Block Monitor Low Trip Setpoint
MAPFAC(F)	Off-rated flow dependent MAPLHGR multiplier
MAPFAC(P)	Off-rated power dependent MAPLHGR multiplier
MAPLHGR	Maximum Average Planar Linear Heat Generation Rate
MCPR	Minimum Critical Power Ratio
MCPR(F)	Off-rated flow dependent OLMCPR multiplier

MCPR(P)	Off-rated power dependent OLMCPR multiplier
MELLLA	Maximum Extended Load Line Limit Analysis
MSIVOOS	Main Steam Isolation Valve Out of Service
OLMCPR	Operating Limit Minimum Critical Power Ratio
OOS	Out of Service
OPRM	Oscillation Power Range Monitor
PBDA	Period Based Detection Algorithm
PLUOOS	Power Load Unbalance Out of Service
PROOS	Pressure Regulator Out of Service
RBM	Rod Block Monitor
RPTOOS	Recirculation Pump Trip Out of Service
RWE	Rod Withdrawal Error
SLO	Single Loop Operation
TBSOOS	Turbine Bypass System Out of Service
TCV	Turbine Control Valve
TIPOOS	Traversing In core Probe Out of Service
TSV	Turbine Stop Valve

2.0 General Information

This report provides the following cycle-specific parameter limits for Limerick Generating Station Unit 1 Cycle 17:

- Maximum Average Planar Linear Heat Generation Rate (MAPLHGR)
- Minimum Critical Power Ratio (MCPR)
- Single Loop Operation (SLO) OLMCPR adjustment
- Off-rated OLMCPR adjustments (MCPR(P) or MCPR(F))
- Off-rated OLMCPR multipliers (Kp)
- Off-rated LHGR multipliers (LHGRFAC(P) or LHGRFAC(F))
- Rod Block Monitor (RBM) setpoints
- MAPLHGR single loop operation multiplier
- LHGR single loop operation multiplier
- Linear Heat Generation Rate (LHGR)
- Turbine Bypass Valve parameters
- Reactor Coolant System Recirculation Flow Upscale Trips
- Oscillation Power Range Monitor Period Based Detection Algorithm (OPRM PBDA) Trip Setpoints

This report is prepared in accordance with Technical Specification 6.9.1.9 of Reference 1. Preparation of this report was performed in accordance with Exelon Nuclear, Nuclear Fuels T&RM NF-AB-120-3600.

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 82.9% of rated core flow during full power operation
- Increased Core Flow (ICF) up to 110% of rated core flow
- Final Feedwater Temperature Reduction (FFWTR) up to 105.0°F during cycle extension operation
- Feedwater Heater Out of Service (FWHOOS) up to 60.0°F feedwater temperature reduction at any time during the cycle prior to cycle extension.

Further information on the cycle-specific analyses for Limerick Unit 1 Cycle 17 and the associated operating domains discussed above is available in Reference 2.

3.0 MAPLHGR Limits

3.1 Technical Specification

Section 3.2.1

3.2 Description

The limiting MAPLHGR value for the most limiting lattice (excluding natural uranium) for GNF2 fuel as a function of average planar exposure is given in Table 3-1. 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, MAPFAC(P) and MAPFAC(F) are equal to 1.0 for all power and flow conditions (Reference 2). LHGRFAC(P) and LHGRFAC(F) are addressed in Section 5.0.

Table 3-1
MAPLHGR Versus Average Planar Exposure
(Reference 2)

Average Planar Exposure (GWD/ST)	MAPLHGR Limit (kW/ft)
0.00	13.78
13.24	13.78
17.52	13.78
60.78	7.50
63.50	6.69

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

SLO Multiplier	0.80

4.0 MCPR Limits

4.1 Technical Specification

Section 3.2.3

4.2 Description

The Operating Limit MCPR (OLMCPR) for GNF2 fuel is provided in Table 4-1. These values are determined by the cycle-specific reload analyses in Reference 2 and are valid for all Cycle 17 operating domains. Table 4-1 includes treatment of these MCPR limits for all conditions listed in Section 9.0, Modes of Operation. Limerick Unit 1 Cycle 17 has a mid-cycle MCPR breakpoint, as defined in Table 4-1. The BASE, TBSOOS, RPTOOS, and PROOS MCPR limits are applicable for any TCV delay time determined by ST-2-001-800-1.

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) is sufficiently generic to apply to all operating domains. MCPR(P) and MCPR(F) are independent of Scram Time Option. In addition, there are ten sets of power dependent MCPR multipliers (Kp) for use with the BASE, TBSOOS, RPTOOS, and PROOS equipment out of service combinations, in both DLO and SLO, as well as PROOS+TBSOOS and PROOS+RPTOOS equipment out of service combinations for DLO only. The PLUOOS condition is included in the BASE MCPR(P) and MCPR(F) limits and Kp multipliers and is bounded by the TBSOOS limits and multipliers; therefore, no additional adjustments are required for PLUOOS in those operating conditions. The PLUOOS condition has not been analyzed concurrent with the RPTOOS operating condition. Operation in the PLUOOS condition concurrent with the RPTOOS condition requires core thermal power < 55% of rated (Reference 3). Section 7.0 contains the conditions for Turbine Bypass Valve Operability. MCPR(P) and MCPR(F) adjustments are provided in Tables 4-2, 4-3, and 4-4. 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.

Table 4-1
Operating Limit Minimum Critical Power Ratio (OLMCPR)
(Reference 2)

EOOS Combination	SCRAM Time Option[1]	Cycle Exposure	
		< EOR - 2677 MWd/ST	≥ EOR - 2677 MWd/ST
BASE	B	1.39[3]	1.39
	A	1.45	1.47
BASE SLO[2]	B	1.60	1.60
	A	1.60	1.60
TBSOOS	B	1.40	1.44
	A	1.49	1.53
TBSOOS SLO[2]	B	1.60	1.60
	A	1.60	1.60
RPTOOS	B	1.41	1.41
	A	1.58	1.58
RPTOOS SLO[2]	B	1.60	1.60
	A	1.62	1.62
PROOS	B	1.39[3]	1.39
	A	1.45	1.47
PROOS SLO[2]	B	1.60	1.60
	A	1.60	1.60
PROOS+TBSOOS	B	1.40	1.44
PROOS+RPTOOS	B	1.41	1.41

[1] When Tau does not equal 0 or 1, determine OLMCPR via linear interpolation. For PROOS+TBSOOS and PROOS+RPTOOS, only Option B is allowed.
[2] For single-loop operation, the MCPR operating limit is 0.04 greater than the analyzed two loop value. However, a minimum value of 1.60 for GNF2 fuel is required to obtain an OLMCPR limit set by the Single Loop Operation Recirculation Pump Seizure Event (Reference 2).
[3] Value is adjusted to obtain an OPRM amplitude setpoint of 1.12.

Table 4-2
Power Dependent MCPR Limits and Multipliers MCPR(P) and Kp
(Reference 2)

EOOS Combination	Core Flow (% of rated)	Core Thermal Power (% of Rated)						
		0	25	< 30	≥ 30	65	85	100
		Operating Limit MCPR, MCPR(P)			Operating Limit MCPR Multiplier, Kp			
BASE	≤ 60	2.52	2.52	2.42	1.340	1.131	1.067	1.000
	> 60	2.78	2.78	2.57				
BASE SLO	≤ 60	2.56	2.56	2.46	1.340	1.131	1.067	1.000
	> 60	2.82	2.82	2.61				
TBSOOS	≤ 60	3.28	3.28	2.78	1.340	1.131	1.067	1.000
	> 60	3.78	3.78	3.28				
TBSOOS SLO	≤ 60	3.32	3.32	2.82	1.340	1.131	1.067	1.000
	> 60	3.82	3.82	3.32				
RPTOOS	≤ 60	2.52	2.52	2.42	1.340	1.131	1.067	1.000
	> 60	2.78	2.78	2.57				
RPTOOS SLO	≤ 60	2.56	2.56	2.46	1.340	1.131	1.067	1.000
	> 60	2.82	2.82	2.61				
PROOS	≤ 60	2.52	2.52	2.42	1.367	1.236	1.160	1.000
	> 60	2.78	2.78	2.57				
PROOS SLO	≤ 60	2.56	2.56	2.46	1.367	1.236	1.160	1.000
	> 60	2.82	2.82	2.61				
PROOS+TBSOOS	≤ 60	3.28	3.28	2.78	1.367	1.236	1.160	1.000
	> 60	3.78	3.78	3.28				
PROOS+RPTOOS	≤ 60	2.52	2.52	2.42	1.367	1.236	1.160	1.000
	> 60	2.78	2.78	2.57				

Table 4-3
Flow Dependent MCPR Limits MCPR(F)
(Reference 2)

Flow (% rated)	MCPR(F) Limit
0.0	1.70
30.0	1.53
79.0	1.25
110.0	1.25

Table 4-4
Single Loop Operation (SLO) Flow Dependent MCPR Limits MCPR(F)
(Reference 2)

Flow (% rated)	MCPR(F) Limit
0.0	1.74
30.0	1.57
79.0	1.29
110.0	1.29

5.0 LHGR Limits

5.1 Technical Specification

Section 3.2.4

5.2 Description

The LHGR limit is the product of the exposure dependent LHGR limit (from Table 5-1 for UO_2 fuel rods and Table 5-2 for Gadolinia fuel rods) and the minimum of: the power dependent LHGR Factor, LHGRFAC(P), and the flow dependent LHGR Factor, LHGRFAC(F). For single loop operation, a multiplier is used, which is shown in Table 5-3 and applied in Table 5-5. No further Single Loop Operation multipliers need to be applied to the values in Tables 5-4 and 5-5.

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 LHGR multipliers for dual-loop and single-loop operation. In addition, there are ten sets of power dependent LHGR multipliers for use with the BASE, TBSOOS, RPTOOS, and PROOS equipment out of service combinations, in both DLO and SLO, as well as PROOS+TBSOOS and PROOS+RPTOOS equipment out of service combinations for DLO only. The PLUOOS condition is included in the BASE LHGRFAC(P) and LHGRFAC(F) multipliers and is bounded by the TBSOOS multipliers; therefore, no additional adjustments are required for PLUOOS in those operating conditions. The PLUOOS condition has <u>not</u> been analyzed concurrent with the RPTOOS operating condition. Operation in the PLUOOS condition concurrent with the RPTOOS condition requires core thermal power < 55% of rated (Reference 3). Section 7.0 contains the conditions for Turbine Bypass Valve Operability. The ARTS LHGR multipliers are shown in Tables 5-4 and 5-5 and are applicable to all operating domains. Linear interpolation should be used for points not listed in Appendix B of Reference 7.

Thermal limit monitoring must be performed with the more limiting LHGR limit resulting from the power and flow biased calculation.

Table 5-1
Linear Heat Generation Rate Limits – UO_2 Rods
(References 5 and 7)

Fuel Type	LHGR
GNF2	See Table B-1 of Reference 7

Table 5-2
Linear Heat Generation Rate Limits – Gadolinia Rods
(References 5 and 7)

Fuel Type	LHGR
GNF2	See Table B-2 of Reference 7

Table 5-3
LHGR Single Loop Operation (SLO) Multiplier
(Reference 2)

SLO Multiplier[1]	0.80

Table 5-4
Power Dependent LHGR Multiplier LHGRFAC(P)
(Reference 2)

EOOS Combination	Core Flow (% of rated)	Core Thermal Power (% of rated)						
		0	25	< 30	≥ 30	65	85	100
		LHGRFAC(P) Multiplier						
BASE	≤ 60	0.485	0.485	0.490	0.750	0.817	0.922	1.000
	> 60	0.434	0.434	0.473				
BASE SLO	≤ 60	0.485	0.485	0.490	0.750	0.817	0.922	1.000
	> 60	0.434	0.434	0.473				
TBSOOS	≤ 60	0.463	0.463	0.490	0.750	0.817	0.922	1.000
	> 60	0.352	0.352	0.386				
TBSOOS SLO	≤ 60	0.463	0.463	0.490	0.750	0.817	0.922	1.000
	> 60	0.352	0.352	0.386				
RPTOOS	≤ 60	0.485	0.485	0.490	0.750	0.817	0.922	1.000
	> 60	0.434	0.434	0.473				
RPTOOS SLO	≤ 60	0.485	0.485	0.490	0.750	0.817	0.922	1.000
	> 60	0.434	0.434	0.473				
PROOS	≤ 60	0.485	0.485	0.490	0.725	0.817	0.922	1.000
	> 60	0.434	0.434	0.473				
PROOS SLO	≤ 60	0.485	0.485	0.490	0.725	0.817	0.922	1.000
	> 60	0.434	0.434	0.473				
PROOS+TBSOOS	≤ 60	0.463	0.463	0.490	0.725	0.817	0.922	1.000
	> 60	0.352	0.352	0.386				
PROOS+RPTOOS	≤ 60	0.485	0.485	0.490	0.725	0.817	0.922	1.000
	> 60	0.434	0.434	0.473				

[1] Applied through Table 5-5

Table 5-5
Flow Dependent LHGR Multiplier LHGRFAC(F)
(Reference 2)

EOOS Combination	Core Flow (% of rated)					
	0	30	44.1	70	80	110
	LHGRFAC(F) Multiplier					
Dual Loop	0.506	0.706		0.973	1.000	1.000
Single Loop	0.506	0.706	0.800			0.800

6.0 Control Rod Block Setpoints

6.1 Technical Specification

Sections 3.1.4.3 and 3.3.6

6.2 Description

The ARTS Rod Block Monitor provides for power dependent RBM trips. Technical Specification 3.3.6 states control rod block instrumentation channels shall 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 shown in Table 6-2. 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 4)

Power Level	Analytical Limit	Allowable Value	Nominal Trip Setpoint
LTSP	123.0%	121.5%	121.5%
ITSP	118.0%	116.5%	116.5%
HTSP	113.2%	111.7%	111.0%
DTSP	No Limitation	2.0%	5.0%

Table 6-2
Reactor Coolant System Recirculation Flow Upscale Trip
(Reference 4)

Analytical Limit	N/A
Allowable Value	115.6%
Nominal Trip Setpoint	113.4%

[1] These setpoints (with Rod Block Monitor filter time constant between 0.1 seconds and 0.55 seconds) are based on a cycle-specific rated RWE MCPR limit of 1.34, which is less than the minimum cycle OLMCPR.

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 System Out Of Service (TBSOOS), must be used. Additional information on the operability of the turbine bypass system can be found in Reference 6.

Table 7-1
Turbine Bypass System Response Time
(Reference 3)

Maximum delay time before start of bypass valve opening following initial turbine inlet valve movement[1]	0.11 sec
Maximum time after initial turbine inlet valve movement[1] for bypass valve position to reach 80% of full flow (includes the above delay time)	0.31 sec

[1] First movement of any TSV or any TCV or generation of the turbine bypass valve flow signal (whichever occurs first)

Table 7-2
Minimum Required Bypass Valves To Maintain System Operability
(References 1 and 3)

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 Unit 1 Cycle 17 OPRM 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 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

9.1 Description

The allowable modes of operation are found in Table 9-1. The BASE application condition includes 1 MSIVOOS and 1 TCV/TSVOOS provided the restrictions identified in the applicable station procedures are met. Note that 1 TCV/TSVOOS is not allowed to be coincident with one or more TBVOOS. All EOOS options also support the allowance of 1 TIPOOS.

Table 9-1
Modes of Operation
(Reference 2)

EOOS Options	Operating Region[1]
BASE, Option A or B	Yes[2]
BASE SLO, Option A or B	Yes[2]
TBSOOS, Option A or B	Yes[2]
TBSOOS SLO, Option A or B	Yes[2]
RPTOOS, Option A or B	Yes[3]
RPTOOS SLO, Option A or B	Yes[3]
TBSOOS and RPTOOS, Option A or B	No
TBSOOS and RPTOOS SLO, Option A or B	No
PROOS, Option A or B	Yes[2]
PROOS SLO, Option A or B	Yes[2]
PROOS+TBSOOS, Option A	No
PROOS+TBSOOS, Option B	Yes[2]
PROOS+TBSOOS SLO, Option A or B	No
PROOS+RPTOOS, Option A	No
PROOS+RPTOOS, Option B	Yes[3]
PROOS+RPTOOS SLO, Option A or B	No

[1] Operating Region refers to operation on the Power to Flow map with or without FFWTR/FWHOOS.
[2] The PLUOOS condition is supported in this mode of operation with no power reduction required.
[3] The PLUOOS condition requires core thermal power level < 55% of rated (Reference 3).

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-22, November 2015 and U.S. Supplement NEDE-24011-P-A-22-US, November 2015.

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

11.0 References

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

2. "Supplemental Reload Licensing Report for Limerick Unit 1 Reload 16 Cycle 17", Global Nuclear Fuel Document No. 001N5161, Revision 1, February 2016.

3. "Final Resolved OPL-3 Parameters for Limerick 1 Cycle 17", Exelon TODI ES1500025, Rev. 1, October 13, 2015.

4. "GE NUMAC PRNM Setpoint Study", Exelon Design Analysis LE-0107, Rev. 2, February 23, 2012.

5. "Fuel Bundle Information Report for Limerick Unit 1 Reload 16 Cycle 17", Global Nuclear Fuel Document No. 001N5162, Revision 0, February 2016.

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

7. "GNF2 Advantage Generic Compliance with NEDE-24011-P-A (GESTAR II)," Global Nuclear Fuel Document No. NEDC-33270P, Revision 5, May 2013.