Exelon Generation®

Clinton Power Station
8401 Power Road
Clinton, IL 61727

U-604284
June 16, 2016

U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, D.C. 20555-0001

Clinton Power Station, Unit 1
Facility Operating License No. NPF-62
NRC Docket No. 50-461

Subject: Submittal of the Core Operating Limits Report for Clinton Power Station, Unit 1, Cycle 17, Revision 11

In accordance with Technical Specification 5.6.5, Core Operating Limits Report (COLR), Item d., Exelon Generation Company (EGC), LLC is submitting Revision 11 of the COLR for Clinton Power Station, Unit 1, Cycle 17.

Should you have any questions concerning this report, please contact Mr. Dale Shelton at (217) 937-2800.

Respectfully,

Theodore R. Stoner
Site Vice President
Clinton Power Station

DRA/cas

Attachment: Core Operating Limits Report for Clinton Power Station Unit 1, Cycle 17, Revision 11

cc: NRC Regional Administrator, Region III
NRC Senior Resident Inspector - Clinton Power Station

A001
NRR

ATTACHMENT
Core Operating Limits Report for Clinton Power Station Unit 1, Cycle 17, Revision 11

CORE OPERATING LIMITS REPORT

FOR

CLINTON POWER STATION UNIT 1 CYCLE 17

Prepared By:	Dale M. Bradish	Date: 04/28/2016
Reviewed By:	RE Reviewer – Christian Small	Date: 4/29/16
Reviewed By:	ESA Reviewer – Andy M. Olson	Date: 04/29/16
Reviewed By:	Independent Reviewer – Chad D. Burns	Date: 4/29/2016
Approved By:	NF Manager – James J. Tusar	Date: 05/09/2016
Station Qualified Reviewer By:		Date: 5/12/16

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Revision History

Revision	Description
Rev. 11	First issuance for Cycle 17.

List of Tables

1.0 Terms and Definitions

Base Case	A case analyzed with two (2) Safety-Relief Valves Out-of-Service (OOS), one (1) Turbine Control Valve stuck closed, one (1) Turbine Stop Valve stuck closed, one (1) Turbine Bypass Valve OOS, and up to a 50°F feedwater temperature reduction (FWTR includes feedwater heater OOS or final feedwater temperature reduction) at any point in the cycle operation in Dual Loop mode (Reference 3).
Coastdown	The reactor condition where thermal power gradually decreases due to fuel depletion while the following conditions are met: 1) all operable control rods are fully withdrawn and 2) all cycle extension techniques have been exhausted including FFWTR and ICF.
Design NORMAL Temperature	Nominal operating temperature for Clinton is 430°F at rated power.
DLO	Dual Reactor Recirculation Loop Operation
EOOS	Equipment Out of Service
FFWTR	Final Feedwater Temperature Reduction
FWHOOS	Feedwater Heaters Out of Service
ICF	Increased Core Flow
LHGR	Linear Heat Generation Rate
LHGRFAC(F)	LHGR thermal limit flow dependent multipliers
LHGRFAC(P)	LHGR thermal limit power dependent multipliers
Loss of 'FULL' Feedwater Heating	±10 °F outside design NORMAL temperature, meaning changes in feedwater temperature greater than 10 °F and less than or equal to 50 °F. This condition may also be referred to as Asymmetric Feedwater Temperature Operation or AFTO.
MAPLHGR	Maximum Average Planar Linear Heat Generation Rate
MCPR	Minimum Critical Power Ratio
MCPR(F)	MCPR thermal limit flow dependent adjustments and multipliers
MCPR(P)	MCPR thermal limit power dependent adjustments and multipliers
MELLLA	Maximum Extended Load Line Limit Analysis
MSIV	Main Steam Isolation Valve

OLMCPR	Operating Limit Minimum Critical Power Ratio
OPRM	Oscillation Power Range Monitor
PBDA	Period Based Detection Algorithm
PLUOOS	Power Load Unbalance Out of Service
PROOS	Pressure Regulator Out of Service
SLO	Single Reactor Recirculation Loop Operation
SRVOOS	Safety Relief Valve Out of Service
TBVOOS	Turbine Bypass Valve(s) Out of Service – valves are not credited for fast opening or for normal pressure control
TBSOOS	Turbine Bypass System Out of Service
TCV	Turbine Control Valve
TSV	Turbine Stop Valve

2.0 General Information

This report is prepared in accordance with Technical Specification 5.6.5 of Reference 1. Power and flow dependent limits and multipliers are listed for various power and flow levels. Linear interpolation is to be used to find intermediate values.

These values have been determined using NRC-approved methodologies presented in Section 10 and are established such that all applicable limits of the plant safety analysis are met.

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 99% of rated core flow during full power operation
- Increased Core Flow (ICF) up to 107% of rated core flow
- Final Feedwater Temperature Reduction (FFWTR) up to 50°F during cycle extension operation
- Feedwater Heater Out of Service (FWHOOS) up to 50°F feedwater temperature reduction at any time during the cycle prior to cycle extension.

Equipment out of service conditions are as defined in Section 1 and Section 9.

3.0 MAPLHGR Limits

3.0 Technical Specification Reference:

Sections 3.2.1 and 3.4.1.

3.1 Description:

Table 3-1 is used to determine the maximum average planar linear heat generation rate (MAPLHGR) limit. Limits listed in Table 3-1 are for dual reactor recirculation loop operation (DLO).

For single reactor recirculation loop operation (SLO), the MAPLHGR limits given in Table 3-1 must be multiplied by a SLO MAPLHGR multiplier provided in Table 3-2.

For Loss of 'FULL' Feedwater Heating (±10 °F outside design NORMAL temperature, meaning changes in feedwater temperature greater than 10 °F and less than or equal to 50 °F), the MAPLHGR limits given in Table 3-1 must be multiplied by a LHGR multiplier provided in Table 3-3. This multiplier accounts for potential feedwater riser flow asymmetries (Reference 7).

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

Avg. Planar Exposure (GWd/ST)	MAPLHGR Limit (kW/ft)
0.00	13.78
17.15	13.78
60.78	6.87
63.50	5.50

[1] Linear interpolation should be used for points not listed in the table.

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

Fuel Type	MAPLHGR SLO Multiplier
All Fuel Types	0.760

Table 3-3
MAPLHGR Multiplier for Loss of 'FULL' Feedwater Heating
(Reference 7)

Fuel Type	MAPLHGR Multiplier
All Fuel Types	0.990

4.0 MCPR Limits

4.0 Technical Specification Reference:

Sections 3.2.2, 3.4.1, and 3.7.6.

4.1 Description:

The various MCPR limits are described below.

4.1.1 Manual Flow Control MCPR Limits

The Operating Limit MCPR (OLMCPR) is determined from either Section 4.1.1.1 or 4.1.1.2, whichever is greater at any given power and flow condition.

4.1.1.1 Power-Dependent MCPR

For operation less than 33.3% core thermal power, the MCPR(P) as a function of core thermal power is determined from Table 4-2 or Table 4-3 depending on plant conditions.

For operation at greater than or equal to 33.3% core thermal power, the OLMCPR as a function of core thermal power is determined by multiplying the applicable rated condition OLMCPR limit shown in Table 4-1 by the applicable MCPR multiplier K(P) given in Table 4-2 or Table 4-3.

4.1.1.2 Flow-Dependent MCPR

Tables 4-4 through 4-7 give the MCPR(F) as a function of flow based on the applicable plant condition. The limits for dual loop operation are listed in Tables 4-4 and 4-6. The limits for single loop operation are listed in Tables 4-5 and 4-7. The MCPR(F) determined from these tables is the flow dependent OLMCPR.

4.1.2 Automatic Flow Control MCPR Limits

Automatic Flow Control MCPR Limits are not provided.

4.1.3 Option A and Option B

Option A and Option B refer to use of scram speeds for establishing MCPR operating limits.

Option A scram speed is the BWR/6 Technical Specification scram speed. The Technical Specification scram speeds must be met to utilize the Option A MCPR limits. Cycle-specific reload analyses performed by GNF for Option A MCPR limits utilized a 20% core average insertion time of 0.516 seconds (Reference 6).

To utilize the MCPR limits for the Option B scram speed, the cycle average scram insertion time for 20% insertion must satisfy equation 2 in Reference 5 Section 4. If the cycle average scram insertion time does not meet the Option B criteria, the appropriate MCPR value may be determined from a linear interpolation between the Option A and B limits as specified by equation 4 in Reference 5 Section 4.

4.1.4 Recirculation Flow Control Valve Settings

The cycle was analyzed with a maximum core flow runout of 109%; therefore the recirculation flow control valve must be set to maintain core flow less than 109% (92.105 Mlb/hr) for all runout events (Reference 3).

Table 4-1
Operating Limit Minimum Critical Power Ratio
(Reference 3)

EOOS Combination	Option A All Exposures	Option B All Exposures
Base Case DLO	1.40	1.30
Base Case SLO[1]	1.43	1.33
PROOS/PLUOOS DLO	1.40	1.36
PROOS/PLUOOS SLO[1]	1.43	1.39
Two or More TBVOOS DLO	1.44	1.34
Two or More TBVOOS SLO[1]	1.47	1.37

Notes for Table 4-1:

1. SLO Option A(B) OLMCPR is the transient DLO Option A(B) OLMCPR plus 0.03.

Table 4-2
Power Dependent MCPR Limits MCPR(P) and Multipliers K(P) for Base Case and Two or More TBVOOS[1, 2]
(Reference 3)

EOOS Combination	Core Flow (% of Rated)	Core Thermal Power (%)								
		0.0	21.6	<33.3	≥33.3	≤43.3	>43.3	≤70.0	>70.0	100.0
		MCPR(P)			K(P)					
Base Case DLO Option A/B	≤ 50	2.31	2.31	2.10	1.617	1.590	1.313	1.212	1.163	1.000
	> 50	2.46	2.46	2.17						
Base Case SLO Option A/B	≤ 50	2.34	2.34	2.13	1.617	1.590	1.313	1.212	1.163	1.000
	> 50	2.49	2.49	2.20						
Two or More TBVOOS DLO Option A/B	≤ 50	2.31	2.31	2.10	1.617	1.590	1.329	1.212	1.163	1.000
	> 50	2.46	2.46	2.17						
Two or More TBVOOS SLO Option A/B	≤ 50	2.34	2.34	2.13	1.617	1.590	1.329	1.212	1.163	1.000
	> 50	2.49	2.49	2.20						

Notes for Table 4-2:

1. Values are interpolated between relevant power levels.
2. Allowable EOOS conditions are listed in Section 9.0.

Table 4-3
Power Dependent MCPR Limits MCPR(P) and Multipliers K(P) for PROOS/PLUOOS[1,2]
(Reference 3)

EOOS Combination	Core Flow (% of Rated)	Core Thermal Power (%)								
		0.0	21.6	<33.3	≥33.3	43.3	60	≤85.0	>85.0	100.0
		MCPR(P)			K(P)					
PROOS/PLUOOS DLO Option A/B	≤ 50	2.31	2.31	2.10	1.617	1.590	1.436	1.309	1.090	1.000
	> 50	2.46	2.46	2.17						
PROOS/PLUOOS SLO Option A/B	≤ 50	2.34	2.34	2.13	1.617	1.590	1.436	1.309	1.090	1.000
	> 50	2.49	2.49	2.20						

Notes for Table 4-3:

1. Values are interpolated between relevant power levels.
2. Allowable EOOS conditions are listed in Section 9.0.

Table 4-4
Dual Loop Operation (DLO) Flow Dependent MCPR Limits MCPR(F) for Base Case or PROOS/PLUOOS[1]
(Reference 3)

Core Flow (% rated)	MCPR(F)
0.0	1.88
25.0	1.70
84.1	1.27
109.0	1.27

Table 4-5
Single Loop Operation (SLO) Flow Dependent MCPR Limits MCPR(F) for Base Case or PROOS/PLUOOS[1]
(Reference 3)

Core Flow (% rated)	MCPR(F)
0.0	1.91
25.0	1.73
84.1	1.30
109.0	1.30

[1] Linear interpolation should be used for points not listed in the table.

Table 4-6
Dual Loop Operation (DLO) Flow Dependent MCPR Limits MCPR(F) for Two or More TBVOOS[1]
(Reference 3)

Core Flow (% rated)	MCPR(F)
0.0	2.04
25.0	1.85
100.0	1.27
109.0	1.27

Table 4-7
Single Loop Operation (SLO) Flow Dependent MCPR Limits MCPR(F) for Two or More TBVOOS[1]
(Reference 3)

Core Flow (% rated)	MCPR(F)
0.0	2.07
25.0	1.88
100.0	1.30
109.0	1.30

[1] Linear interpolation should be used for points not listed in the table.

5.0 Linear Heat Generation Rate Limits

5.1 Technical Specification Reference:

Section 3.2.3, 3.4.1, and 3.7.6.

5.2 Description:

The linear heat generation rate (LHGR) limit is the product of the exposure dependent LHGR limit (from Table 5-1 for UO2 fuel rods and Table 5-2 for Gadolinia fuel rods) and the minimum of: the power dependent LHGR Factor, LHGRFAC(P), the flow dependent LHGR Factor, LHGRFAC(F), or the single loop operation (SLO) multiplication factor if applicable. The LHGRFAC(P) is determined from Table 5-3. The LHGRFAC(F) is determined from Tables 5-4 and 5-5, depending on plant conditions. The SLO multiplication factor can be found in Table 5-6. Tables 5-1 and 5-2 are the LHGR limit as a function of peak pellet exposure.

For Loss of 'FULL' Feedwater Heating (±10 °F outside design NORMAL temperature, meaning changes in feedwater temperature greater than 10 °F and less than or equal to 50 °F), LHGRFAC(P) is determined from Table 5-7 and LHGRFAC(F) is determined from Tables 5-8 and 5-9, depending on plant conditions. Concurrent operation with SLO and reduced feedwater heating has not been evaluated and thus is not a valid operating mode. (Reference 8)

Table 5-1
Linear Heat Generation Rate Limits for UO_2 Rods[1]
(References 4 and 9)

Fuel Type	LHGR Limit
GNF2	See Table B-1 of Reference 9

Table 5-2
Linear Heat Generation Rate Limits for Gad Rods[1]
(References 4 and 9)

Fuel Type	LHGR Limit
GNF2	See Table B-2 of Reference 9

[1] Linear interpolation should be used for points not listed in the table.

Table 5-3
Power Dependent LHGR Multipliers LHGRFAC(P)[1]
(Reference 3)

EOOS Combination	Core Flow (% of Rated)	Core Thermal Power (%)										
		0.0	21.6	<33.3	≥33.3	40.0	43.3	<60.0	≥60.0	<85.0	≥85.0	100.0
		LHGRFAC(P)										
Base Case DLO/SLO	≤ 50	0.634	0.634	0.689	0.651	-	0.684	-	-	-	-	1.000
	> 50	0.572	0.572	0.600								
PROOS/PLUOOS DLO/SLO	≤ 50	0.560	0.560	0.560	0.560	0.560	-	0.709	0.749	0.868	0.906	1.000
	> 50	0.560	0.560	0.560								
Two or More TBVOOS DLO/SLO	≤ 50	0.634	0.634	0.689	0.651	-	0.684	-	-	-	-	1.000
	> 50	0.572	0.572	0.600								

Notes for Table 5-3:

1. Linear interpolation should be used for points not listed in the table.

Table 5-4
Flow Dependent LHGR Multipliers LHGRFAC(F) for Base Case or PROOS/PLUOOS[1]
(Reference 3)

Core Flow (% rated)	LHGRFAC(F)
0.0	0.442
25.0	0.612
30.0	0.646
82.2	1.000
109.0	1.000

Table 5-5
Flow Dependent LHGR Multipliers LHGRFAC(F) for Two or More TBVOOS[1]
(Reference 3)

Core Flow (% rated)	LHGRFAC(F)
0.0	0.140
25.0	0.365
30.0	0.410
40.0	0.500
50.0	0.630
80.0	0.860
98.3	1.000
109.0	1.000

Table 5-6
LHGR Single Loop Operation (SLO) Reduction Factor
(Reference 3)

Fuel Type	LHGR SLO Multiplier
All Fuel Types	0.760

[1] Linear interpolation should be used for points not listed in the table.

Table 5-7
Power Dependent LHGR Multipliers LHGRFAC(P)
(Loss of 'FULL' Feedwater Heating)[1,2]
(Reference 3)

EOOS Combination	Core Flow (% of Rated)	Core Thermal Power (%)										
		0.0	21.6	<33.3	≥33.3	40.0	43.3	<60.0	≥60.0	<85.0	≥85.0	100.0
		LHGRFAC(P)										
Base Case DLO	≤ 50	0.628	0.628	0.682	0.644	-	0.677	-	-	-	-	0.990
	> 50	0.566	0.566	0.594								
PROOS/PLUOOS DLO	≤ 50	0.554	0.554	0.554	0.554	0.554	-	0.702	0.742	0.859	0.897	0.990
	> 50	0.554	0.554	0.554								
Two or More TBVOOS DLO	≤ 50	0.628	0.628	0.682	0.644	-	0.677	-	-	-	-	0.990
	> 50	0.566	0.566	0.594								

Notes for Table 5-7:

1. Linear interpolation should be used for points not listed in the table.
2. Concurrent operation with SLO and reduced feedwater heating has not been evaluated and thus is not a valid operating mode (Reference 8).

Table 5-8
Flow Dependent LHGR Multipliers LHGRFAC(F) for Base Case or PROOS/PLUOOS
(Loss of 'FULL' Feedwater Heating)[1]
(Reference 3)

Core Flow (% rated)	LHGRFAC(F)
0.0	0.438
25.0	0.606
30.0	0.640
82.2	0.990
109.0	0.990

Table 5-9
Flow Dependent LHGR Multipliers LHGRFAC(F) for Two or More TBVOOS
(Loss of 'FULL' Feedwater Heating)[1]
(Reference 3)

Core Flow (% rated)	LHGRFAC(F)
0.0	0.139
25.0	0.361
30.0	0.406
40.0	0.495
50.0	0.624
80.0	0.851
98.3	0.990
109.0	0.990

[1] Linear interpolation should be used for points not listed in the table.

6.0 Reactor Protection System (RPS) Instrumentation

6.1 Technical Specification Reference:

Section 3.3.1.1

6.2 Description:

The Average Power Range Monitor (APRM) flow biased simulated thermal power-high time constant, shall be between 5.4 seconds and 6.6 seconds (Reference 6).

7.0 Turbine Bypass System Parameters

7.1 Technical Specification Reference:

Section 3.7.6

7.2 Description:

The operability requirements for the Main Turbine Bypass System are governed by Technical Specification 3.7.6. If the requirements of LCO 3.7.6 cannot be met, the appropriate reactor thermal power, minimum critical power ratio (MCPR), and linear heat generation rate (LHGR) limits must be used to comply with the assumptions in the design basis transient analysis.

Table 7-1 provides the reactor thermal power limitations for an inoperable Main Turbine Bypass System as specified in Technical Specification LCO 3.7.6. The MCPR and LHGR limits for one TBVOOS are included in the Base Case, as identified in Table 9-1. The MCPR and LHGR limits for two or more TBVOOS are provided in Sections 4 and 5.

Table 7-1
Reactor Power Limitation – Turbine Bypass Valves Out of Service
(References 2, 3, and 10)

Turbine Bypass System Status	Maximum Reactor Thermal Power (% Rated)
One Turbine Bypass Valve Out of Service	100.0
Two or More Turbine Bypass Valves Out of Service	100.0

8.0 Stability Protection Setpoints

8.1 Technical Specification Reference:

Section 3.3.1.3

8.2 Description:

The OPRM Period Based Detection Algorithm (PBDA) Trip Setpoint for the OPRM System for use in Technical Specification 3.3.1.3 is found in Table 8-1. This value is based on the cycle specific analysis documented in Reference 3.

Stability-based OLMCPR is non-limiting for the PBDA setpoint in Table 8-1.

Table 8-1
OPRM PBDA Trip Setpoint
(Valid for All Conditions)
(Reference 3)

PBDA Trip Amplitude	Corresponding Maximum Confirmation Count Trip Setting
1.12	14

9.0 Modes of Operation

The Allowed Modes of Operation with combinations of Equipment Out-of-Service (EOOS) are as described below in Table 9-1:

Table 9-1
Modes of Operation
(Reference 3)

	Operating Region				
EOOS Options[2]	**Standard**	**MELLLA**	**ICF**	**FFWTR[1]**	**Coastdown**
Base Case DLO[3]	Yes	Yes	Yes	Yes	Yes
Base Case SLO[1,3]	Yes	No	No	No	Yes
PROOS/PLUOOS DLO[3,5]	Yes	Yes	Yes	Yes	Yes
PROOS/PLUOOS SLO[1,3,5]	Yes	No	No	No	Yes
Two or More TBVOOS DLO[4]	Yes	Yes	Yes	Yes	Yes
Two or More TBVOOS SLO[1,4]	Yes	No	No	No	Yes

Notes:

1. Concurrent operation with SLO and Loss of 'FULL' Feedwater Heating (±10 °F outside design NORMAL temperature, meaning changes in feedwater temperature greater than 10 °F and less than or equal to 50 °F). MELLLA, ICF, or FFWTR has not been evaluated and thus is not a valid operating mode. (Reference 8)

2. A single Main Steam Isolation Valve (MSIV) out of service is supported at or below 75% power. (Reference 3)

3. Includes 2 SRVOOS, 1 TCV stuck closed, 1 TSV stuck closed, 1 TBVOOS, and up to a 50°F feedwater temperature reduction (FWTR includes feedwater heater OOS or final feedwater temperature reduction) at any point in cycle operation in Dual Loop mode.

4. Includes 2 SRVOOS and up to a 50°F feedwater temperature reduction (FWTR includes feedwater heater OOS or final feedwater temperature reduction) at any point in cycle operation in Dual Loop mode.

5. Concurrent operation with either or both of PROOS + PLUOOS is allowed.

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. Global Nuclear Fuel Document, "General Electric Standard Application for Reactor Fuel", NEDE-24011-P-A-22-US, November 2015 and U.S. Supplement NEDE-24011-P-A-22-US, November 2015.

11.0 References

1. Nuclear Regulatory Commission, Technical Specifications for Clinton Power Station Unit 1, Docket No. 50-461, License No. NPF-62.

2. GE Hitachi Nuclear Energy Report, 0000-0086-4634-R2-P Revision 1, "Clinton Power Station One Bypass Out of Service or Turbine Bypass System Out of Service Analysis – Final", July 2010.

3. Global Nuclear Fuel Document, 002N6802 Revision 0, "Supplemental Reload Licensing Report for Clinton Unit 1 Reload 16 Cycle 17", March 2016.

4. Global Nuclear Fuel Document, 002N6803 Revision 0, "Fuel Bundle Information Report for Clinton Unit 1 Reload 16 Cycle 17", March 2016.

5. General Electric Document, GE-NE-0000-0000-7456-01P, "Option B Scram Times For Clinton Power Station", February 2002.

6. Exelon Transmittal of Design Information, TODI ES1500028 Revision 0, "Clinton Unit 1 Cycle 17 Final Resolved OPL-3 Parameters", November 24, 2015.

7. GE Hitachi Nuclear Energy Letter, CFL-EXN-LH1-12-059, "Affirmation of the Clinton Power Station Unit 1 MAPLHGR Reduction for Feedwater Riser Flow Asymmetry", April 25, 2012.

8. General Electric Document, GE-NE-0000-0026-1857-R1 Revision 1, "Evaluation of Operation With Equipment Out-Of-Service for the Clinton Power Station", June 28, 2004.

9. Global Nuclear Fuel Document, NEDC-33270P, Rev. 5, "GNF2 Advantage Generic Compliance with NEDE-24011-PA (GESTAR-II)", May 2013.

10. GE Hitachi Nuclear Energy Report, 003N4558-R0, "Removal of TBSOOS Power Restriction for Clinton", March 10, 2016.