Attachment 2

Core Operating Limits Report, Reload 16, Cycle 17, Revision 5
(Non-Proprietary Version)

CORE OPERATING LIMITS REPORT

FOR

Hope Creek Generating Station Unit 1

RELOAD 16, CYCLE 17

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1.0 Terms and Definitions

APLHGR	Average Planar Linear Heat Generation Rate
ARTS	APRM and RBM Technical Specification Analysis
BSP	Backup Stability Protection
COLR	Core Operating Limits Report
ECCS	Emergency Core Cooling Systems
EOC	End-of-Cycle
EOC-RPT	End-of-Cycle Recirculation Pump Trip
FFWTR	Final Feedwater Temperature Reduction
FWHOOS	Feedwater Heater Out of Service
GNF-A	Global Nuclear Fuel – Americas, LLC
ITA	Isotope Test Assembly
LCO	Limiting Condition for Operation
LHGR	Linear Heat Generation Rate
$LHGRFAC_f$	ARTS LHGR thermal limit flow dependent adjustments and multipliers
$LHGRFAC_p$	ARTS LHGR thermal limit power dependent adjustments and multipliers
MCPR	Minimum Critical Power Ratio
$MCPR_p$	ARTS MCPR thermal limit power dependent adjustments and multipliers
$MCPR_f$	ARTS MCPR thermal limit flow dependent adjustments and multipliers
OPRM	Oscillation Power Range Monitor
SLMCPR	Safety Limit Minimum Critical Power Ratio
SLO	Single Recirculation Loop Operation
TLO	Two Recirculation Loop Operation

2.0 References

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

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

3. Facility Operating License No. NPF-57, PSEG Nuclear LLC, Hope Creek Generating Station, Docket No. 50-354.

4. Final Safety Evaluation by the Office of Nuclear Reactor Regulation, "Applicability of GE Methods to Expanded Operating Domains," NEDC-33173P, July 2009.

5. GE14 Compliance with Amendment 22 of NEDE-24011-P-A (GESTAR II), NEDC-32868P, Revision 3, April 2009.

6. "Supplemental Reload Licensing Report for Hope Creek Unit 1 Reload 16 Cycle 17," Global Nuclear Fuel Document No. 0000-0105-6621-SRLR, Revision 0, July 2010.

7. "Fuel Bundle Information Report for Hope Creek Unit 1 Reload 16 Cycle 17," Global Nuclear Fuel Document No. 0000-0105-6621-FBIR, Revision 0, July 2010.

8. "Option B Licensing Basis & Cycle-Independent Transient Evaluation for Implementation of the Technical Specification Improvement Program (TSIP) Scram Speed," Global Nuclear Fuel Document No. 0000-0119-7785, Revision 0, October 2010.

9. "Core Operating Limits Report for Hope Creek Generating Station Unit 1 Reload 15, Cycle 16," COLR Hope Creek 1 Revision 3.

3.0 General Information

This revision of the Core Operating Limits Report provides the core operating limits for Hope Creek Generating Station Unit 1 Cycle 17 operation. Revision 5 of the Core Operating Limits Report was performed to include the surveillance requirement value of rated core flow for the OPRM enabled region as required by Hope Creek License Amendment 190 (Reference 3). Revision 5 also introduces a precautions and limitations section to clearly define applicable or allowable plant configurations for the application of the limits contained within the Core Operating Limits Report. Additional editorial changes were made for ease of use of the document.

This report provides information relative to OPRM setpoints, OPRM surveillance requirements, and backup stability protection regions, single recirculation loop operation, and core average scram speed. The power distribution limits presented here correspond to the core thermal limits for Average Planar Linear Heat Generation Rate (APLHGR), Minimum Critical Power Ratio (MCPR), and Linear Heat Generation Rate (LHGR). Finally, this report provides references to the most recent revision of the implemented approved methodology.

These operating limit values have been determined using NRC approved methods contained in GESTAR-II (Reference 1) and NEDO-32465-A Reactor Stability Detect and Suppress Solutions Licensing Basis Methodology for Reload Applications (Reference 2). These operating limit values also include limitations where required by the NRC Safety Evaluation Report for Hope Creek License Amendment Number 174, Extended Power Uprate (Reference 3) for the use of GE Licensing Topical Report NEDC-33173P, Applicability of GE Methods to Expanded Operating Domains (Reference 4). In addition, the LHGR limits contained within are based upon the GE Report, GE14 Compliance with Amendment 22 of NEDE-24011-P-A (GESTAR II), NEDC-32868P, Revision 3, April 2009 (Reference 5). Revision 3 of the GE14 Compliance report updates the report to include a specific LHGR limit curve to be used by plants referencing NEDC-33173P.

The following sections contain operating limit values for both the GE14 fuel design and the GE14i Isotope Test Assemblies (GE14i ITAs). The limits for the GE14i ITAs were determined using the methods and limitations described in the NRC Safety Evaluation Report for Hope Creek License Amendment Number 184 (Reference 3). The operating limit values apply to both GE14 and GE14i ITAs, unless specific values are provided for the GE14i ITAs. The limitations and penalties for the GE14 fuel design discussed in the previous paragraph also apply to the GE14i ITAs.

The method of calculating core average scram speed, τ, is provided in Option B Licensing Basis & Cycle-Independent Transient Evaluation for Implementation of the Technical Specification Improvement Program (TSIP) Scram Speed (Reference 8).

These operating limits are established such that all applicable fuel thermal-mechanical, core thermal-hydraulic, ECCS, and nuclear limits such as shutdown margin, and transient and accident analysis limits are met.

Various sections of the Hope Creek Technical Specifications reference this COLR. Those sections are listed in Section 5 of this document. Hope Creek Technical Specification 6.9.1.9 also requires that this report, including any mid-cycle revisions, shall be provided upon issuance to the NRC.

4.0 Precautions and Limitations

This document is specific to Hope Creek Generating Station Unit 1 Cycle 17 and shall not be applicable to any other core or cycle design. This report is applicable for Cycle 17 operating from the date of issuance through the end of cycle including consideration of a power coastdown to a core thermal power that shall not go below 40% rated core thermal power. End of full power capability is reached when 100% rated power can no longer be maintained by increasing core flow (up to 105% of rated core flow), at allowable feedwater temperatures, in the all-rods-out configuration. Operation beyond the end of full power capability is defined as power coastdown operation which includes an operating assumption that vessel dome pressure will decrease during the power coastdown period as steam flow decreases (maintaining constant vessel dome pressure during the power coastdown period was not generically considered by GESTAR-II for determining the operating limit LCO values described above).

The limits provided in this document do not support FFWTR/FWHOOS conditions.

5.0 Technical Specifications that Reference the COLR

The following Hope Creek Technical Specifications reference this COLR:

Technical Specification	Title
2.1	Safety Limits
3/4.2.1	Average Planar Linear Heat Generation Rate
3/4.2.3	Minimum Critical Power Ratio
3/4.2.4	Linear Heat Generation Rate
3/4.3.11	Oscillation Power Range Monitor
3/4.4.1	Recirculation System Recirculation Loops
6.9.1.9	Administrative Controls, Core Operating Limits Report

5.1 Average Planar Linear Heat Generation Rate

LIMITING CONDITION FOR OPERATION

All AVERAGE PLANAR LINEAR HEAT GENERATION RATES (APLHGRs) shall be less than or equal to the limits specified in Table 5.1-1 for two recirculation loop operation (TLO).

When the Technical Specification 3.4.1.1 Action statement a.1.d is entered from that section's Limiting Condition for Operation, reduce the APLHGR limits to the values specified in Table 5.1-1 for single recirculation loop operation (SLO).

Linear interpolation shall be used to determine APLHGR limits as a function of exposure for intermediate values in Table 5.1-1.

TABLE 5.1-1 APLHGR Data for GE14 and GE14i ITAs

Average Planar Exposure		APLHGR Limit (kW/ft)	
MWd/MTU	MWd/STU	TLO	SLO
0.00	0.000	12.82	10.26
16000	14510	12.82	10.26
21090	19130	12.82	10.26
63500	57610	8.00	6.40
70000	63500	5.00	4.00

5.2 Minimum Critical Power Ratio

LIMITING CONDITION FOR OPERATION

The MINIMUM CRITICAL POWER RATIO (MCPR) shall be equal to or greater than the MCPR limit computed from the following steps:

1. Determine τ as defined in Appendix A.

> NOTE
> The SLO operating condition MCPR values in Tables 5.2-1, 5.2-2, 5.2-4, and 5.2-5 implement the increase in the MCPR Safety Limit to meet the requirements of Technical Specification 3.4.1.1 ACTION statement a.1.c.

2. Linearly interpolate a MCPR value as a function of τ from the MCPR value at τ=0 and MCPR value at τ=1 as specified in Table 5.2-1 and Table 5.2-2 for the appropriate condition. Repeat for each fuel type.

3. For the power dependent MCPR adjustment, when thermal power is ≥ 24% rated core thermal power, determine a K_p value by linearly interpolating a K_p value as a function of core rated thermal power from Table 5.2-3. Multiply the MCPR value obtained from Step 2 by the K_p value to determine the power dependent MCPR limit for each fuel type.

   When core thermal power is < 24% rated thermal power, no thermal limits are required.

4. For the flow dependent MCPR adjustment, determine the appropriate flow dependent MCPR limit by linearly interpolating between the MCPR limits as a function of rated core flow using the information in Table 5.2-4 (GE14) and Table 5.2-5 (GE14i ITAs).

5. Choose the most limiting (highest value) of the power and flow dependent MCPR limits determined in Steps 3 and 4 as the value for the MCPR limit for the Limiting Condition for Operation for each fuel type.

Note that the MCPR limit is a function of core average scram speed (τ), cycle exposure, core thermal power, total core flow, EOC-RPT operability, the number of reactor coolant recirculation loops in operation, and main turbine bypass operability.

EOC-RPT system operability is defined by Hope Creek Technical Specification 3.3.4.2.

Reactor coolant recirculation loop operation is defined by Hope Creek Technical Specification 3.4.1.1.

Main Turbine Bypass operability is defined by Hope Creek Technical Specification 3.7.7.

TABLE 5.2-1 MCPR Operating Limits Cycle Exposure ≤ 9450 MWd/MTU (≤ 8573 MWd/STU)

Main Turbine Bypass Operable			
Operating Condition	Scram Speed Option	GE14	GE14i ITAs
TLO-EOC-RPT Operable	A	1.49	1.56
	B	1.38	1.45
TLO-EOC-RPT Inoperable	A	1.51	1.58
	B	1.40	1.47
SLO-EOC-RPT Operable	A	1.51	1.58
	B	1.40	1.47
SLO-EOC-RPT Inoperable	A	1.53	1.60
	B	1.42	1.49

Scram Speed Option A τ=1, Scram Speed Option B τ=0
TLO = Two Recirculation Loop Operation
SLO = Single Recirculation Loop Operation

TABLE 5.2-2 MCPR Operating Limits Cycle Exposure > 9450 MWd/MTU (>8573 MWd/STU)

Main Turbine Bypass Operable			
Operating Condition	Scram Speed Option	GE14	GE14i ITAs
TLO-EOC-RPT Operable	A	1.60	1.67
	B	1.43	1.50
TLO-EOC-RPT Inoperable	A	1.62	1.69
	B	1.45	1.52
SLO-EOC-RPT Operable	A	1.62	1.69
	B	1.45	1.52
SLO-EOC-RPT Inoperable	A	1.64	1.71
	B	1.47	1.54

Scram Speed Option A τ=1, Scram Speed Option B τ=0
TLO = Two Recirculation Loop Operation
SLO = Single Recirculation Loop Operation

TABLE 5.2-3 Power Dependent MCPR Multiplier (K_p) Data

Operating Condition	Core Thermal Power (% of Rated)			
	24	45	60	≥100
	MCPR Multiplier K_p			
TLO	1.561	1.280	1.150	1.000
SLO	1.561	1.280	1.150	1.000

K_p is linearly interpolated between core thermal power entries.
The K_p multiplier is the same for both GE14 and GE14i ITAs.
TLO = Two Recirculation Loop Operation
SLO = Single Recirculation Loop Operation

TABLE 5.2-4 Flow Dependent MCPR Limit ($MCPR_f$) for GE14

Operating Condition	Core Flow (% of Rated)			
	30	60	89.2	105
	MCPR Limit			
TLO	1.55		1.20	1.20
SLO	1.57	1.39		

$MCPR_f$ is linearly interpolated between core flow entries.
TLO = Two Recirculation Loop Operation
SLO = Single Recirculation Loop Operation

TABLE 5.2-5 Flow Dependent MCPR Limit ($MCPR_f$) for GE14i ITAs

Operating Condition	Core Flow (% of Rated)			
	30	60	89.2	105
	MCPR Limit			
TLO	1.62		1.27	1.27
SLO	1.64	1.46		

$MCPR_f$ is linearly interpolated between core flow entries.
TLO = Two Recirculation Loop Operation
SLO = Single Recirculation Loop Operation

5.3 Linear Heat Generation Rate

LIMITING CONDITION FOR OPERATION

The LINEAR HEAT GENERATION RATE (LHGR) shall not exceed the limit computed from the following steps:

> NOTE
> The steps performed in 1 through 6 below should be repeated for both UO_2 and gadolinia bearing fuel rods in each bundle type.

1. Determine the exposure dependent LHGR limit using linear interpolation between the table values in Appendix B.

> NOTE
> For two recirculation loop operation (TLO) utilize steps 1, 2, 3, and 6 to determine the LCO LHGR limits.
>
> When the Technical Specification 3.4.1.1 ACTION statement a.1.e is entered from that section's Limiting Condition for Operation (LCO), utilize steps 1, 4, 5, and 6 to determine the LCO LHGR limits for single recirculation loop operation (SLO).

2. For the power dependent LHGR adjustment for TLO, determine a $LHGRFAC_p$ value by linearly interpolating a $LHGRFAC_p$ value as a function of rated core thermal power from the TLO entries in Table 5.3-1. Multiply the LHGR values obtained from Step 1 by the $LHGRFAC_p$ value to determine the power dependent LHGR limit.

3. For the flow dependent LHGR adjustment for TLO, determine a $LHGRFAC_f$ value by linearly interpolating a $LHGRFAC_f$ value as a function of rated core flow from the TLO entries in Table 5.3-2. Multiply the LHGR values obtained from Step 1 by the $LHGRFAC_f$ value to determine the flow dependent LHGR limit.

4. For the power dependent LHGR adjustment for SLO, determine a $LHGRFAC_p$ value by linearly interpolating a $LHGRFAC_p$ value as a function of rated core thermal power from the SLO entries in Table 5.3-1. Multiply the LHGR values obtained from Step 1 by the $LHGRFAC_p$ value to determine the power dependent LHGR limit.

5. For the flow dependent LHGR adjustment for SLO, determine a $LHGRFAC_f$ value by linearly interpolating a $LHGRFAC_f$ value as a function of rated core flow from

the SLO entries in Table 5.3-2. Multiply the LHGR values obtained from Step 1 by the $LHGRFAC_f$ value to determine the flow dependent LHGR limit.

6. Choose the most limiting (lowest value) of the power and flow dependent LHGR limits determined in Steps 2 and 3 (TLO) or 4 and 5 (SLO) as the value for the LHGR limit for the Limiting Condition for Operation.

TABLE 5.3-1 Power Dependent Linear Heat Generation Rate Multiplier ($LHGRFAC_p$)

Operating Condition	Core Thermal Power (% of Rated)		
	24	60.86	≥ 100
	$LHGRFAC_p$ Multiplier		
TLO	0.603		1.000
SLO	0.603	0.796	

$LHGRFAC_p$ is linearly interpolated between core thermal power entries.
The $LHGRFAC_p$ multiplier is the same for both GE14 and GE14i ITAs.
TLO = Two Recirculation Loop Operation
SLO = Single Recirculation Loop Operation

TABLE 5.3-2 Flow Dependent Linear Heat Generation Rate Multiplier ($LHGRFAC_f$)

Operating Condition	Core Flow (% of Rated)					
	30	50	52.7	60	82.2	105
	$LHGRFAC_f$ Multiplier					
TLO	0.500	0.782			1.000	1.000
SLO	0.500	0.782	0.800	0.800		

$LHGRFAC_f$ is linearly interpolated between core flow entries.
The $LHGRFAC_f$ multiplier is the same for both GE14 and GE14i ITAs.
TLO = Two Recirculation Loop Operation
SLO = Single Recirculation Loop Operation

5.4 OPRM Setpoints

5.4.1 1.0 Hz Corner Frequency Setpoints

LIMITING CONDITION FOR OPERATION

Four channels of the OPRM instrumentation shall be OPERABLE. Each OPRM channel period based algorithm amplitude trip setpoint (Sp) shall be less than or equal to the Allowable Value of 1.11.

Additional Information

The NRC Safety Evaluation Report, dated 12/22/04, which was issued for Hope Creek License Amendment Number 159 required that the period based algorithm amplitude trip setpoint and confirmation counts be documented in the COLR (Reference 3). Confirmation count information applicable to Cycle 17 is documented below.

For Sp = 1.11, the required minimum number of successive confirmation counts for OPRM setpoint (N2) = 14.

5.4.2 OPRM Enabled Region Core Flow Setpoint

SURVEILLANCE REQUIREMENT (4.3.11.5)

Verify OPRM is enabled when thermal power is ≥ 26.1%, as specified in Technical Specification Surveillance Requirement 4.3.11.5, and recirculation drive flow is ≤ the value corresponding to 60% of rated core flow in accordance with the Surveillance Frequency Control Program.

Appendix A: Method of Core Average Scram Speed Calculation

Method of Core Average Scram Speed, τ, Calculation

τ is defined as $$\tau = \frac{(\tau_{ave} - \tau_B)}{\tau_A - \tau_B}$$

where: $$\tau_B = 0.672 + 1.65\left[\frac{N_1}{\sum_{i=1}^{n} N_i}\right]^{1/2}(0.016) \qquad \tau_{ave} = \frac{\sum_{i=1}^{n} N_i \tau_i}{\sum_{i=1}^{n} N_i}$$

τ_A= 0.86 seconds, control rod scram insertion time limit to notch 39 per Specification 3.1.3.3

n = number of surveillance tests performed to date in cycle,

N_i = number of active control rods measured in the ith surveillance test,

τ_i = average scram time to notch 39 of all rods measured in the ith surveillance test, and

N_1 = total number of active rods measured in Specification 4.1.3.3.a or 4.1.3.3.d.

If $\tau_{ave} \leq \tau_B$, set τ = 0 to apply Option B OLMCPR.

τ shall be 1.0 (τ = 1.0) prior to performance of the initial scram time measurements for the cycle in accordance with Specification 4.1.3.3.

Appendix B: Exposure-Dependent Linear Heat Generation Rate Limits

Exposure-Dependent Linear Heat Generation Rate Limits

The LHGR limits for all fuel and rod types are considered proprietary information of the vendor. Tables B-1 through B-6 contain exposure-dependent LHGR limits. The tables are presented in pairs since the LHGR limits are presented at separate peak pellet exposures for UO_2 and gadolinia bearing fuel rods. Several of the bundle types have the same exposure-dependent LHGR limits, and the applicable bundle types are noted before each set of tables. The gadolinia fuel rod limits provided for each bundle type reflect the bounding gadolinia LHGR limit for all gadolinium concentrations occurring in that bundle type.

Tables B-1 and B-2 contain limits applicable to the GE14 bundle types that follow.

- GE14-P10CNAB400-9G6.0/6G4.0-100T-150-T6-3176
- GE14-P10CNAB400-14GZ-100T-150-T6-3006
- GE14-P10CNAB402-12G6.0/2G4.0-100T-150-T6-3312
- GE14-P10CNAB405-6G6.0/11G4.0-100T-150-T6-3313
- GE14-P10CNAB402-5G6.0/14G4.0-100T-150-T6-2758
- GE14-P10CNAB396-17GZ-100T-150-T6-3007
- GE14-P10CNAB405-15GZ-100T-150-T6-3009
- GE14-P10CNAB398-17GZ-100T-150-T6-3008

TABLE B-1: GE14 LHGR Limits – UO_2 Fuel Rods

Peak Pellet Exposure		UO_2 LHGR Limit
MWd/MTU	MWd/STU	kW/ft
[[		
		]]

TABLE B-2: GE14 LHGR Limits – Gadolinia Bearing Rods

Peak Pellet Exposure		Most Limiting Gadolinia LHGR Limit
MWd/MTU	MWd/STU	kW/ft
[[		
		]]

Tables B-3 and B-4 contain limits applicable to the GE14 bundle types that follow.

- GE14-P10CNAB393-18G4.0-100T-150-T6-2885
- GE14-P10CNAB393-18GZ-100T-150-T6-2884

TABLE B-3: GE14 LHGR Limits – UO_2 Fuel Rods

Peak Pellet Exposure		UO_2 LHGR Limit
MWd/MTU	MWd/STU	kW/ft
[[		
		]]

TABLE B-4: GE14 LHGR Limits – Gadolinia Bearing Rods

Peak Pellet Exposure		Most Limiting Gadolinia LHGR Limit
MWd/MTU	MWd/STU	kW/ft
[[		
		]]

Tables B-5 and B-6 contain limits applicable to the GE14i ITA bundle type that follows.

- GE14I-P10CCOB379-13GZ-100T-150-T6-3309

TABLE B-5: GE14i ITA LHGR Limits – UO_2 Fuel Rods

Peak Pellet Exposure		UO_2 LHGR Limit
MWd/MTU	MWd/STU	kW/ft
[[		
		]]

TABLE B-6: GE14i ITA LHGR Limits – Gadolinia Bearing Rods

Peak Pellet Exposure		Most Limiting Gadolinia LHGR Limit
MWd/MTU	MWd/STU	kW/ft
[[		
		]]

Appendix C: Backup Stability Protection

Backup Stability Protection Region Intercepts

The region boundaries for Tables C-1 and C-2 are defined using the Generic Shape Function. The endpoints given in Table C-1 below were provided in Revision 3 to the Core Operating Limits Report for Cycle 16 as the bounding values for that cycle (Reference 9). Table C-2 values reflect the cycle-specific BSP region intercepts determined for Cycle 17 (Reference 6).

TABLE C-1: BSP Region Intercepts for Cycle 16

Region Boundary Intercept	% Power	% Flow
Region 1 High Flow Control Line	62.8	45.5
Region 1 Natural Circulation Line	44.7	35.0
Region 2 High Flow Control Line	67.2	51.1
Region 2 Natural Circulation Line	32.2	36.3

TABLE C-2: BSP Region Intercepts for Cycle 17

Region Boundary Intercept	% Power	% Flow
Region 1 High Flow Control Line	58.2	40.0
Region 1 Natural Circulation Line	44.7	35.0
Region 2 High Flow Control Line	66.4	50.0
Region 2 Natural Circulation Line	32.2	36.3

Region 1 = BSP Scram Region
Region 2 = BSP Controlled Entry Region