ENERGY NORTHWEST

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U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
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Subject: **COLUMBIA GENERATING STATION, DOCKET NO 50-397**
CYCLE 20 CORE OPERATING LIMITS REPORT (COLR), REVISION 0

Dear Sir or Madam:

In accordance with the Columbia Generating Station Technical Specifications (TS) 5.6.3.d, Energy Northwest herewith submits the Cycle 20 COLR, Revision 0. The operating limits in the COLR were developed in accordance with the requirements of TS 5.6.3.a, b, and c. The changes to the COLR have been reviewed by the Columbia Generating Station Plant Operations Committee.

No new regulatory commitments are made in this letter. Should you have any questions or desire additional information regarding this matter, please contact me at (509) 377-6105.

Respectfully,

Gregory V. Cullen

GV Cullen
Manager, Regulatory Programs

Enclosure: COLR 09-20 Revision 0

cc: EE Collins – NRC RIV
NJ DiFrancesco – NRC NRR
NRC Sr. Resident Inspector – 988C (2)
WA Horin – Winston & Strawn
RN Sherman – BPA/1399

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NRR

COLR 09-20 Revision 0

Columbia Generating Station

Cycle 20

Core Operating Limits Report

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1.0 Introduction and Summary

This report provides the **Average Planar Linear Heat Generation Rate (APLHGR)** limits, the **Minimum Critical Power Ratio (MCPR)** limits, the **Linear Heat Generation Rate (LHGR)** limits and the **Oscillation Power Range Monitor (OPRM) Instrumentation** limits for Columbia Generating Station Cycle 20 as required by Technical Specification 5.6.3. As required by Technical Specification 5.6.3, these limits were determined using NRC-approved methodology and are established so that all applicable limits of the plant safety analysis are met. LOCA analyses were performed with methodologies that result in Single Loop Operation (SLO) APLHGR limits as well as Two Loop Operation (TLO) APLHGR limits. The APLHGR and LHGR limits for ATRIUM-10 fuel given in this report are documented in Reference 6.1. The APLHGR and LHGR limits for GE14 fuel given in this report are documented in References 6.4 and 6.5, respectively. The full power MCPR limits for all Cycle 20 fuel types (GE14 as well as ATRIUM-10 fuel) are documented in Reference 6.4. The power and flow dependent MCPR limits are documented in Reference 6.6. The basis for the OPRM Instrumentation limits is documented in References 6.3 and 6.4.

The MCPR limit is the maximum of (a) the applicable exposure dependent, full power MCPR limit, (b) the applicable power dependent MCPR limit, and (c) the applicable flow dependent MCPR limit specified in this report. This stipulation assures that the safety limit MCPR will not be violated during steady-state operation and anticipated operational occurrences throughout the Columbia Generating Station operating regime. Full power MCPR limits are specified to define operating limits at rated power and flow. Power dependent MCPR limits are specified to define operating limits at other than rated power conditions. A flow dependent MCPR is specified to define operating limits at other than rated flow conditions. The flow dependent MCPR limit, set by the limiting Recirculation Flow Increase event, provides bounding protection for all events at reduced flow.

The reload licensing analyses for this cycle provide operating limits for Extended Load Line Limit Analysis (ELLLA) operation which extends the power and flow operating regime for Columbia Generating Station up to the 108% rod line which at full power corresponds to 88% of rated flow. The MCPR limits defined in this report are applicable up to 100% of rated thermal power along and below the 108% rod line. The minimum flow for operation at rated power is 88% of rated flow; the maximum is 106%.

The specific topical report revisions and supplements which describe the methodology utilized in this cycle specific analysis are shown in Table 1.1.

Table 1.1

Columbia Generating Station
Reference Topical Reports

1. XN-NF-81-58(P)(A) Revision 2 and Supplements 1 and 2, *RODEX2 Fuel Rod Thermal-Mechanical Response Evaluation Model*, Exxon Nuclear Company, March 1984.

2. XN-NF-85-67(P)(A) Revision 1, *Generic Mechanical Design for Exxon Nuclear Jet Pump BWR Reload Fuel*, Exxon Nuclear Company, September 1986.

3. EMF-85-74(P) Revision 0 Supplement 1(P)(A) and Supplement 2(P)(A), *RODEX2A (BWR) Fuel Rod Thermal-Mechanical Evaluation Model*, Siemens Power Corporation, February 1998.

4. ANF-89-98(P)(A) Revision 1 and Supplement 1, *Generic Mechanical Design Criteria for BWR Fuel Designs*, Advanced Nuclear Fuels Corporation, May 1995.

5. EMF-2361(P)(A) Revision 0, *EXEM BWR-2000 ECCS Evaluation Model*, Framatome ANP, May 2001.

6. EMF-2292(P)(A) Revision 0, *ATRIUM™–10: Appendix K Spray Heat Transfer Coefficients*, Siemens Power Corporation, September 2000.

7. NEDO-32465-A, *BWR Owners' Group Reactor Stability Detect and Suppress Solutions Licensing Basis Methodology and Reload Applications*, August 1996.

8. NEDC-33419P, *GEXL97 Correlation Applicable to ATRIUM-10 Fuel*, Revision 0, June 2008.

9. NEDE-24011-P-A and NEDE-24011-P-A-US, *General Electric Standard Application for Reactor Fuel (GESTAR II) and Supplement for the United States*, Revision 16, October 2007.

2.0 Average Planar Linear Heat Generation Rate (APLHGR) Limits for Use in Technical Specification 3.2.1

The APLHGRs for use in Technical Specification 3.2.1, as a function of Average Planar Exposure, shall not exceed the limits shown in the following tables. APLHGR limits for single loop operation for GE14 fuel are obtained by applying a 1.00 multiplier to the two loop operation APLHGR limits. APLHGR limits for single loop operation for ATRIUM-10 fuel are obtained by applying a 0.90 multiplier to the two loop operation APLHGR limits.

a. Table 2.1 – GE14 Reload Fuel

b. Table 2.2 – ATRIUM-10 Reload Fuel

Table 2.1

Maximum Average Planar Linear Heat Generation Rate (MAPLHGR)
Versus Average Planar Exposure
GE14 Reload Fuel

Average Planar Exposure		MAPLHGR Limit
GWd/MTU	GWd/ST	kW/ft
0.00	0.00	12.82
16.00	14.51	12.82
21.10	19.14	12.82
63.50	57.61	8.00
70.00	63.50	5.00

Table 2.2

Maximum Average Planar Linear Heat Generation Rate (MAPLHGR)
Versus Average Planar Exposure
ATRIUM-10 Reload Fuel

Average Planar Exposure (MWd/MTU)	TLO MAPLHGR (kW/ft)
0	12.5
15000	12.5
67000	7.3

3.0 Minimum Critical Power Ratio (MCPR) Limit for Use in Technical Specification 3.2.2

The MCPR limit for use in Technical Specification 3.2.2 shall be greater than or equal to the bounding limits determined from Table 3.1 through Table 3.6. Supporting information for the MCPR limits is provided in Table 3.1-1 through Table 3.1-2.

The MCPR safety limit for Cycle 20 is 1.09 for two loop operation (TLO) and 1.10 for single loop operation (SLO). The power and flow dependent MCPR limits for SLO require a 0.01 adder to the TLO MCPR limits due to the difference in the MCPR safety limit.

Table 3.1

Columbia Generating Station
Two Loop Operation[1]
MCPR Operating Limits

Appl. Cond.	Exposure Range[2]	Option A	Option B[3]
		All Fuel	All Fuel
1	**Equipment In Service**		
	Full Power Limits (BOC to MOC)	1.38[4]	1.38[4]
	Full Power Limits (MOC to EOC)	1.42	1.39
	Flow Dependent Limits[5]	Table 3.6	
	Power Dependent Limits[6]	Table 3.2	
2	**EOC RPT Out of Service (RPTOOS)**		
	Full Power Limits (BOC to MOC)	1.47	1.38[4]
	Full Power Limits (MOC to EOC)	1.63	1.46
	Flow Dependent Limits[5]	Table 3.6	
	Power Dependent Limits[6]	Table 3.3	
3	**Turbine Bypass Valve Out of Service (TBVOOS)**		
	Full Power Limits (BOC to MOC)	1.39	1.38[4]
	Full Power Limits (MOC to EOC)	1.47	1.44
	Flow Dependent Limits[5]	Table 3.6	
	Power Dependent Limits[6]	Table 3.4	
4	**TBVOOS and RPTOOS**		
	Full Power Limits (BOC to MOC)	1.52	1.41
	Full Power Limits (MOC to EOC)	1.67	1.50
	Flow Dependent Limits[5]	Table 3.6	
	Power Dependent Limits[6]	Table 3.5	

Notes for Table 3.1

Note 1: For Single Loop Operation (SLO), the SLMCPR increases by 0.01. This 0.01 increase must also be applied to the Two Loop Operation (TLO) MCPR Operating Limit, when the limit is not set by Stability, to obtain the SLO Operating Limit. Note 4 identifies which limits are set by Stability.

Note 2: The cycle exposure range designation is defined in Table 3.1-1. End of Rated (EOR) is defined as the cycle exposure corresponding to all rods out, 100% power, 100% flow and normal feedwater temperature. The limits are applicable for normal feedwater temperature, feedwater heaters out of service, final feedwater temperature reduction and coastdown.

Table 3.1-1 Cycle Exposure Range Designation

Name	Exposure Range
BOC to MOC	≤ EOR-3938 MWd/MTU (3572 MWd/ST)
MOC to EOC	> EOR-3938 MWd/MTU (3572 MWd/ST)

Note 3: The NRC has concluded that a statistical approach (Option B) may be used for pressurization events analyzed with ODYN (References 6.7 and 6.8). In order to take credit for conservatism in the scram speed performance, it must be demonstrated that there is insufficient reason to reject the plant-specific scram speed as being within the distribution assumed in the statistical analysis.

The procedure described below determines the full power MCPR limit based on the scram times of SR 3.2.2.2 or the Stability based MCPR limit, whichever is greater. If the scram speed distribution is not within the assumed distribution, the MCPR for pressurization events must be re-established based on an interpolation between the applicable limits for Option A (scram times of LCO 3.1.4, "Control Rod Scram Times") and Option B (realistic scram times) analyses.

The surveillance information for the fuel cycle is the number of active control rods measured for each surveillance test (the first test is at the BOC and is denoted N_1; the i^{th} test denoted N_i) and the average scram time to Notch 39 for the active rods measured in test i denoted τ_i.

The equation used to calculate the overall average of all the scram data generated to date in the cycle is:

$$\tau_{ave} = \frac{\sum_{i=1}^{n} N_i \tau_i}{\sum_{i=1}^{n} N_i} \quad (1)$$

where:

n = number of surveillance tests performed to date in the cycle;

$\sum_{i=1}^{n} N_i$ = total number of active rods measured to date in the cycle; and

$\sum_{i=1}^{n} N_i \tau_i$ = sum of the scram time to Notch 39 of all active rods measured to date in the cycle to comply with the Technical Specification surveillance requirements.

The average scram time, τ_{ave}, is tested against the analysis mean using the following equation:

$$\tau_{ave} \leq \tau_B \quad (2)$$

where:

$$\tau_B = \mu + 1.65 \sqrt{\left(\frac{N_1}{\sum_{i=1}^{n} N_i} \right)} \sigma \quad (3)$$

μ = 0.672 seconds (mean scram time to Notch 39 used in the Option B analysis)

σ = 0.016 seconds (standard deviation of μ)

N_1 = total number of active rods measured at BOC to comply with the Technical Specification surveillance requirements.

If the cycle average scram time satisfies the Equation 2 criterion, continued plant operation under the ODYN Option B MCPR for pressurization events is permitted. If not, the MCPR for pressurization events must be re-established, based on a linear interpolation between the Option B and Option A MCPRs.

The equation to establish the new operating limit is given below:

$$OLMCPR_{New} = MAX\left(MCPR_{Option\,B} + \frac{\tau_{ave} - \tau_B}{\tau_A - \tau_B} \Delta MCPR, MCPR_{Stability} \right) \quad (4)$$

where:

τ_{ave} and τ_B =	defined in Equations 1 and 3, respectively
τ_A =	0.866 seconds (the Technical Specification limit on core average scram time to Notch 39)
$\Delta MCPR$ =	$MCPR_{Option\ A}$ - $MCPR_{Option\ B}$ (the difference between the MCPR calculated using Option A and that using Option B for pressurization events from Table 3.1-2)
$MCPR_{Option\ A}$ =	the limiting pressurization event Option A MCPR
$MCPR_{Option\ B}$ =	the limiting pressurization event Option B MCPR
$MCPR_{Stability}$ =	1.38 (the MCPR set by Stability)

Table 3.1 cannot be used with Equation 4 for interpolation between Option A and Option B MCPR limits because in some instances, Stability sets the OLMCPR. Table 3.1-2 provides the limiting pressurization event MCPR values for use with Equation 4.

Table 3.1-2

Two–Loop Operation Full Power MCPR Limits for Pressurization Events

Appl. Cond.	Exposure Range	Option A	Option B
		All Fuel	All Fuel
1	**Equipment In Service**		
	BOC to MOC	1.33	1.30
	MOC to EOC	1.42	1.39
2	**EOC RPT Out of Service (RPTOOS)**		
	BOC to MOC	1.47	1.36
	MOC to EOC	1.63	1.46
3	**Turbine Bypass Valve Out of Service (TBVOOS)**		
	BOC to MOC	1.39	1.36
	MOC to EOC	1.47	1.44
4	**TBVOOS and RPTOOS**		
	BOC to MOC	1.52	1.41
	MOC to EOC	1.67	1.50

Note 4: The Full Power MCPR Operating Limit is set by Stability, and therefore the Option A and Option B values in Table 3.1 cannot be directly used to interpolate between Option A and Option B Full Power MCPR Operating Limits. See Note 3 for guidance.

Note 5: Flow dependent MCPR limits are applicable to TLO and require the SLO 0.01 adder when operating in SLO.

Note 6: Power dependent MCPR limits are provided for core thermal powers greater than or equal to 25% of rated power at all core flows. The power dependent MCPR limits for core thermal powers less than 30% of rated power are subdivided by core flow. Limits are provided for core flows greater than 50% of rated flow and less than or equal to 50% of rated flow. A step change in the power dependent MCPR limits occurs at 30% of rated power because direct scrams on turbine throttle valve closure and turbine governor valve fast closure are automatically bypassed below 30% of rated power and not applicable per Technical Specification 3.3.1.1.

The power dependent MCPR limits in Tables 3.2 through 3.5 are provided as Kp multipliers above the direct scram bypass power level (Pbypass) and as absolute MCPRp limits below Pbypass. MCPRp limits above Pbypass are determined through the following equation: MCPRp = Kp × OLMCPR(Full Power Limit). Power dependent MCPR limits are applicable to TLO and require the SLO 0.01 adder when operating in SLO.

Table 3.2
Columbia Generating Station
Application Group 1: Equipment In Service
TLO Power Dependent MCPR Limits
All Fuel Types

Limits for Power < 30.0%		
Power (%)	**Limit for Flow > 50.0%** *MCPRp*	**Limit for Flow ≤ 50.0%** *MCPRp*
25.0	2.24	2.24
30.0	2.15	2.15

Limits for Power ≥ 30.0%	
Power (%)	**Limit** *Kp*
30.0	1.483
45.0	1.280
60.0	1.150
85.0	1.072
100.0	1.000

Table 3.3
Columbia Generating Station
Application Group 2: EOC RPT Out of Service (RPTOOS)
TLO Power Dependent MCPR Limits
All Fuel Types

Limits for Power < 30.0%		
Power (%)	**Limit for Flow > 50.0%** *MCPRp*	**Limit for Flow ≤ 50.0%** *MCPRp*
25.0	2.24	2.24
30.0	2.15	2.15

Limits for Power ≥ 30.0%	
Power (%)	**Limit** *Kp*
30.0	1.483
45.0	1.280
60.0	1.150
85.0	1.072
100.0	1.000

Table 3.4
Columbia Generating Station
Application Group 3: Turbine Bypass Valve Out of Service (TBVOOS)
TLO Power Dependent MCPR Limits
All Fuel Types

Limits for Power < 30.0%		
Power (%)	**Limit for Flow > 50.0%** *MCPRp*	**Limit for Flow ≤ 50.0%** *MCPRp*
25.0	3.28	3.12
30.0	2.89	2.69

Limits for Power ≥ 30.0%	
Power (%)	**Limit** *Kp*
30.0	1.483
45.0	1.280
60.0	1.150
85.0	1.072
100.0	1.000

Table 3.5
Columbia Generating Station
Application Group 4: TBVOOS and RPTOOS
TLO Power Dependent MCPR Limits
All Fuel Types

Limits for Power < 30.0%		
Power (%)	**Limit for Flow > 50.0%** *MCPRp*	**Limit for Flow ≤ 50.0%** *MCPRp*
25.0	3.28	3.12
30.0	2.89	2.69

Limits for Power ≥ 30.0%	
Power (%)	**Limit** *Kp*
30.0	1.483
45.0	1.280
60.0	1.150
85.0	1.072
100.0	1.000

Table 3.6
Columbia Generating Station
All Application Groups
TLO Flow Dependent MCPR Limits
All Fuel Types

Flow (%)	Limit *MCPRf*
0.0	1.85
30.0	1.65
90.0	1.25
108.5	1.25

4.0 Linear Heat Generation Rate (LHGR) Limits for Use in Technical Specification 3.2.3

The LHGRs for use in Technical Specification 3.2.3 are given as a function of nodal pellet exposure for both the GE14 and ATRIUM-10 fuel. The LHGRs shall not exceed the limits shown in the following:

a. Fuel Bundle Information Report (Reference 6.5) for GE14 Reload Fuel

b. Table 4.1 for ATRIUM-10 Reload Fuel

Table 4.1

Linear Heat Generation Rate (LHGR)
Versus Pellet Exposure
ATRIUM-10 Reload Fuel

Pellet Exposure (MWd/MTU)	LHGR (kW/ft)
0	13.4
18900	13.4
74400	7.1

5.0 Oscillation Power Range Monitor (OPRM) Instrumentation Limits for Use in LCO 3.3.1.3

The OPRM instrumentation limits for use in LCO 3.3.1.3 shall not exceed the following:

Function	Trip Setpoint
Period Based Detection Algorithm (PBDA)	
Amplitude Setpoint: Sp	1.11 Peak/Average
Confirmation Count Setpoint: N2	14

6.0 References

6.1 ANP-2602 Revision 0, "Columbia Generating Station Cycle 19 Reload Analysis," AREVA NP, March 2007.

6.2 EMF-3172(P) Revision 1, "Columbia Generating Station LOCA-ECCS Analysis MAPLHGR Limit for ATRIUM™-10 Fuel," Framatome ANP, June 2005.

6.3 NE-02-00-03, Revision 0, "Oscillation Power Range Monitor (OPRM) Trip Setpoints," Energy Northwest, June 17, 2000.

6.4 0000-0098-0322-SRLR, "Supplemental Reload Licensing Report for Columbia Reload 19 Cycle 20," Revision 0, March 2009.

6.5 0000-0098-0322-FBIR, "Fuel Bundle Information Report for Columbia Reload 19 Cycle 20," Revision 1, April 2009.

6.6 GEH-0000-0075-4920-R1, "GE14 Fuel Design Cycle-Independent Analyses for Energy Northwest Columbia Generating Station," Revision 1, March 2009.

6.7 NEDO-24154 and NEDE-24154-P, "Qualification of the One-Dimensional Core Transient Model for Boiling Water Reactors", Volumes 1, 2 and 3, August 1986.

6.8 Letter JSC-005-86 (MFN-003-86), J. S. Charnley (GE) to H. N. Berkow (NRC), "Revised Supplementary Information Regarding Amendment 11 to GE Licensing Topical Report NEDE-24011-P-A", January 16, 1986.