Exelon Generation Company, LLC Byron Station 4450 North Cerman Church Road Byron, IL 61010–9794 www.exeloncorp.com



April 18, 2001

LTR: BYRON 2001-0067 File: 2.01.0700

United States Nuclear Regulatory Commission ATTN: Document Control Desk Washington, DC 20555-0001

> Byron Station Unit 2 Facility Operating License No. NPF-66 NRC Docket No. STN 50-455

Subject: Byron Station Unit 2 Cycle 10 Core Operating Limits Report

In accordance with Technical Specification 5.6.5, "Core Operating Limits Report (COLR)," Item d., we are submitting the COLR for Byron Station Unit 2, Cycle 10.

Should you have any questions concerning this report, please contact P. Reister, Regulatory Assurance Manager, at (815) 234-5441, extension 2280.

Respectfully,

Richard P. Lopriofe Site Vice President Byron Nuclear Generating Station

Attachment: Byron Station Unit 2 Cycle 10 COLR

RPL/JL/keh/dpk

cc: Regional Administrator – NRC Region III NRC Senior Resident Inspector – Byron Station

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ATTACHMENT

Byron Station Unit 2 Cycle 10 Core Operating Limits Report

DG01-000187

SAFETY RELATED Originating Organization TO NON-SAFETY RELATED Nuclear Fuel Management Rei Management ation Byron Unit 2 Cycle 10 Generic ation Byron Unit 2 Cycle 10 Core Operating Limits Report in ITS Format and W(z) Function 34 ian L. Manges Byron Witt 2 Cycle 10 Core Operating Limits Report in ITS Format and W(z) Function 34 ian L. Manges Byron Witt 2 Cycle 10 Core Operating Limits Report in ITS Format and W(z) Function 34 ivewer Review're's Signature Date 34 ''M Supervisor NFM Supervisor Signature Date atus of Information: Engineering Judgement 24 ethod and Schedule of Verification for Unverified TODIs:	
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ecification 5.6.5. Please provide NFM (Brian Manges) with a copy of Byron Station's comp bmittal to the NRC.	Eycle 10 operation from 0 Upon completion of the Planission pursuant to Technic deted Plant Review and COI
purce of Information:	
01CB-G-034 (CAC-01-77), "Byron Unit 2 Cycle 10 COLR Data for 3411 MWt Operation", 01CB-G-040 (CAC-01-82), "DNBR Limits for COLR", dated March 15, 2001	dated March 12 ,2001

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1.0 CORE OPERATING LIMITS REPORT

This Core Operating Limits Report (COLR) for Byron Station Unit 2 Cycle 10 has been prepared in accordance with the requirements of Technical Specification 5.6.5 (ITS).

The Technical Specifications affected by this report are listed below:

SL	2.1.1	Reactor Core Safety Limits (SLs)					
LCO	3.1.1	Shutdown Margin (SDM)					
LCO	3.1.3	Moderator Temperature Coefficient					
LCO	3.1.4	Rod Group Alignment Limits					
LCO	3.1.5	Shutdown Bank Insertion Limits					
LCO	3.1.6	Control Bank Insertion Limits					
LCO	3.1.8	Physics Tests Exceptions – Mode 2					
LCO	3.2.1	Heat Flux Hot Channel Factor ($F_{q}(Z)$)					
LCO	3.2.2	Nuclear Enthalpy Rise Hot Channel Factor $(F^{N}_{\Delta H})$					
LCO	3.2.3	Axial Flux Difference (AFD)					
LCO	3.2.5	Departure from Nucleate Boiling Ratio (DNBR)					
LCO	3.3.1	Reactor Trip System (RTS) Instrumentation					
LCO	3.3.9	Boron Dilution Protection System (BDPS)					
LCO	3.4.1	Reactor Coolant System (RCS) DNB Parameters					
LCO	3.9.1	Boron Concentration					
The portions of the Technical Requirements Manual affected by this report are listed below:							
TRM T	LCO 3.1	.b Boration Flow Paths - Operating					
TRM T	LCO 3.1	.d Charging Pumps - Operating					
TRM T	LCO 3.1	.f Borated Water Sources - Operating					
TRM T	LCO 3.1	.g Position Indication System – Shutdown					
TRM T	LCO 3.1	.h Shutdown Margin (SDM) – MODE 1 and MODE 2 with keff \ge 1.0					
TRM TLCO 3.1.i		.i Shutdown Margin (SDM) – MODE 5					
TRM T	'LCO 3.1	.j Shutdown and Control Rods					
TRM T	LCO 3.1	.k Position Indication System – Shutdown (Special Test Exception)					

2.0 OPERATING LIMITS

The cycle-specific parameter limits for the specifications listed in Section 1.0 are presented in the following subsections. These limits are applicable for the entire cycle unless otherwise identified. These limits have been developed using the NRC-approved methodologies specified in Technical Specification 5.6.5.

- 2.1 Reactor Core Limits (SL 2.1.1)
 - 2.1.1 In Modes 1 and 2, the combination of Thermal Power, Reactor Coolant System (RCS) highest loop average temperature, and pressurizer pressure shall not exceed the limits specified in Figure 2.1.1.



Figure 2.1.1: Reactor Core Limits

2.2 Shutdown Margin (SDM)

The SDM limit for MODES 1, 2, 3, and 4 is:

2.2.1 The SDM shall be greater than or equal to 1.3% Δk/k (LCOs 3.1.1, 3.1.4, 3.1.5, 3.1.6, 3.1.8, 3.3.9; TRM TLCOs 3.1.b, 3.1.d, 3.1.f, 3.1.h, and 3.1.j).

The SDM limits for MODE 5 are:

- 2.2.2.1 SDM shall be greater than or equal to 1.0% $\Delta k/k$ (LCO 3.1.1).
- 2.2.2.2 SDM shall be greater than or equal to 1.3% ∆k/k (LCO 3.3.9; TRM TLCO 3.1.i and 3.1.j).
- 2.3 Moderator Temperature Coefficient (LCO 3.1.3)

The Moderator Temperature Coefficient (MTC) limits are:

- 2.3.1 The BOL/ARO/HZP-MTC upper limit shall be +2.0 x $10^{-5} \Delta k/k/^{\circ}F$.
- 2.3.2 The EOL/ARO/HFP-MTC lower limit shall be -4.1 x $10^{-4} \Delta k/k/^{\circ}F$.
- 2.3.3 The EOL/ARO/HFP-MTC Surveillance limit at 300 ppm shall be less negative than or equal to $-3.2 \times 10^{-4} \Delta k/k/^{\circ}$ F.
- where: BOL stands for Beginning of Cycle Life ARO stands for All Rods Out HZP stands for Hot Zero Thermal Power EOL stands for End of Cycle Life HFP stands for Hot Full Thermal Power
- 2.4 <u>Shutdown Bank Insertion Limit</u> (LCO 3.1.5)
 - 2.4.1 All shutdown banks shall be fully withdrawn to at least 224 steps.
- 2.5 Control Bank Insertion Limits (LCO 3.1.6)
 - 2.5.1 The control banks shall be limited in physical insertion as shown in Figure 2.5.1.
 - 2.5.2 Each control bank shall be considered fully withdrawn from the core at greater than or equal to 224 steps.
 - 2.5.3 The control banks shall be operated in sequence by withdrawal of Bank A, Bank B, Bank C and Bank D. The control banks shall be sequenced in reverse order upon insertion.
 - 2.5.4 Each control bank not fully withdrawn from the core shall be operated with a 110 step overlap limit.

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CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 2 CYCLE 10

2.6 Heat Flux Hot Channel Factor (F₀(Z)) (LCO 3.2.1)

2.6.1

$$F_{Q}(Z) \leq \frac{F_{Q}^{RTP}}{0.5} xK(Z) \text{ for } P \leq 0.5$$

 $F_Q(Z) \le \frac{F_Q^{RTP}}{P} xK(Z)$ for P > 0.5where: P = the ratio of THERMAL POWER to RATED THERMAL POWER

$$F_0^{RTP} = 2.60$$

K(Z) for assembly average burnup > 4000 MWD/MTU is provided in Figure 2.6.1. K(Z) for assembly average burnup \leq 4000 MWD/MTU is provided in Figure 2.6.1.a.

2.6.2 W(Z) Values:

a) When PDMS is OPERABLE, W(Z) = 1.00000 for all axial points.

b) When PDMS is Inoperable, W(Z) is provided in Figures 2.6.2.a through 2.6.2.c

The normal operation W(Z) values have been determined at burnups of 150, 1950 and 4000 MWD/MTU.

For this cycle, the $F_{\alpha}^{c}(z)$ penalty factors are equal to 2% per 31 Effective Full Power Days (EFPD). These values shall be used to increase the $F_{\alpha}^{w}(z)$ as per Surveillance Requirement 3.2.1.2. The 2% penalty factor shall be used at all cycle burnups.

Multiplication Factor = 1.02

2.6.3 Uncertainty:

The uncertainty, $U_{FQ},$ to be applied to the Heat Flux Hot Channel Factor $F_Q(Z$) shall be calculated by the following formula

$$U_{FQ} = U_{qu} \bullet U_{\epsilon}$$

where:

 U_{qu} = Base FQ measurement uncertainty = 1.05 when PDMS is Inoperable U_{e} = Engineering uncertainty factor = 1.03

2.6.4 PDMS Alarms:

 $F_Q(Z)$ Warning Setpoint $\ge 2\%$ of $F_Q(Z)$ Margin $F_Q(Z)$ Alarm Setpoint $\ge 0\%$ of $F_Q(Z)$ Margin



Figure 2.6.1: K(Z) - Normalized $F_Q(Z)$ as a Function of Core Height (Assembly BU > 4000 MWD/MTU) Figure 2.6.1.a: K(Z) - Normalized $F_Q(Z)$ as a Function of



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Height	MAX W(Z)
Feet	4 0000
0.00	1.0000
0.20	1.0000
0.40	1.0000
0.60	1.0000
0.80	1.0000
1.00	1.0000
1.20	1.0000
1.40	1.0000
1.00	1 1640
2.00	1 1725
2.00	1.1754
2 40	1.1674
2.60	1.1551
2.80	1.1438
3.00	1.1318
3.20	1.1202
3.40	1.1111
3.60	1.1150
3.80	1.1207
4.00	1.1246
4.20	1.1295
4.40	1.1314
4.60	1.1335
4.80	1.1346
5.00	1.1338
5.20	1.1311
5.40	1.1284
5.60	1.1304
5.80	1.1449
6.00	1.1009
6.40	1 1893
6.60	1,2020
6.80	1.2128
7.00	1.2216
7.20	1.2284
7.40	1.2353
7.60	1.2410
7.80	1.2459
8.00	1.2506
8.20	1.2523
8.40	1.2585
8.60	1.2624
8.80	1.2657
9.00	1.2684
9.20	1.28/1
9.40	1.3085
9.60	1.3203
9.00	1 3538
10.00	1 3532
10.20	1 0000
10.40	1 0000
10.00	1 0000
11 00	1.0000
11 20	1.0000
11 40	1.0000
11.60	1.0000
11.80	1.0000
12.00	1.0000



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10000 Figure 2.6 2.6 10000 Summary of W(2) Function at 1950 MWD/MTU (Top and Bottom 15% Excluded per WCAP-10216) 1000 10000 1000 10000 1000 10000 1000 10000 1000 10000 1000 10000 1000 10000 1000 10000 1000 10000 1200 10000 1200 1187 2200 1187 2200 1187 2200 1187 2200 1187 2200 1187 2200 1183 1001 10000 1002 10000 1003 10000 1004 10000 1105 10000 1201 10000 1202 10000 1203 10000 1204 10000 1205 10000 1206 10000 1201 10000 1202 100000 10000 10000 <th>Height Feet</th> <th>MAX W(Z)</th> <th></th> <th></th> <th></th> <th></th> <th></th> <th></th> <th>Byro</th> <th>on U</th> <th>Init 2</th> <th>Сус</th> <th>le 10</th> <th>)</th> <th></th> <th></th> <th></th> <th></th> <th></th> <th></th> <th></th>	Height Feet	MAX W(Z)							Byro	on U	Init 2	Сус	le 10)							
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11.80 1.0000 12.00 1.0000	11 60	1,0000							C	:OR	EHE	IGH	I (F	EET,)						
12.00 1.0000	11.80	1.0000	! 																		
	12.00	1.0000																			

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Height	MAX W(Z)
Feet	
0.00	1.0000
0.20	1.0000
0.40	1.0000
0.60	1.0000
1.00	1.0000
1.00	1.0000
1.20	1.0000
1.60	1.0000
1.80	1.2245
2.00	1.2102
2.20	1.1919
2.40	1.1776
2.60	1.1593
2.80	1.1440
3.00	1.1287
3.20	1.1134
3.40	1.0989
3.00	1.0913
3.00 4.00	1.0300
4 20	1.0871
4.40	1.0850
4.60	1.0829
4.80	1.0798
5.00	1.0767
5.20	1.0726
5.40	1.0709
5.60	1.0800
5.80	1.08/2
6.00	1.1012
6.20	1 1374
6.60	1 1581
6.80	1.1768
7.00	1.1936
7.20	1.2093
7.40	1.2224
7.60	1.2357
7.80	1.2479
8.00	1.2564
8.20	1.2548
8.40	1.2701
0.00 8.80	1 2779
0.00 9.00	1 2923
9.20	1.3166
9.40	1.3374
9.60	1.3598
9.80	1.3758
10.00	1.3880
10.20	1.4063
10.40	1.0000
10.60	1.0000
10.80	1.0000
11.00	1.0000
11.20	1.0000
11.40	1.0000
11.60	1.0000
11.80	1.0000
12.00	1.0000



- 2.7 Nuclear Enthalpy Rise Hot Channel Factor $(F^{N}_{\Delta H})$ (LCO 3.2.2)
 - 2.7.1 $F_{AH}^{N} \leq F_{AH}^{RTP}[1.0 + PF_{\Delta H}(1.0 P)]$

where: P = the ratio of THERMAL POWER to RATED THERMAL POWER $F_{\Delta H}^{RTP} = 1.70$ $PF_{\Delta H} = 0.3$

2.7.2 Uncertainty when PDMS is inoperable

The uncertainty, $U_{F\Delta H}$, to be applied to the Nuclear Enthalpy Rise Hot Channel Factor $F_{\Delta H}^{N}$ shall be calculated by the following formula:

 $U_{FAH} = U_{FAHm}$

where:

 U_{EAHm} = Base F^{N}_{AH} measurement uncertainty = 1.04

2.7.3 PDMS Alarms:

 $F^{N}_{\Delta H}$ Warning Setpoint $\geq 2\%$ of $F^{N}_{\Delta H}$ Margin $F^{N}_{\Delta H}$ Alarm Setpoint $\geq 0\%$ of $F^{N}_{\Delta H}$ Margin

- 2.8 Axial Flux Difference (AFD) (LCO 3.2.3)
 - 2.8.1 When PDMS is Inoperable, the AXIAL FLUX DIFFERENCE (AFD) Acceptable Operation Limits are provided in Figure 2.8.1 or the latest valid PDMS Surveillance Report, whichever is more conservative.
 - 2.8.2 When PDMS is OPERABLE, no AFD Acceptable Operation Limits are applicable.
- 2.9 Departure from Nucleate Boiling Ratio (DNBR) (LCO 3.2.5)
 - 2.9.1 $DNBR_{APSL} \ge 1.572$

The Axial Power Shape Limiting DNBR (DNBR_{APSL}) is applicable with THERMAL POWER \geq 50% RTP when PDMS is OPERABLE.

2.9.2 PDMS Alarms:

DNBR Warning Setpoint $\ge 2\%$ of DNBR Margin DNBR Alarm Setpoint $\ge 0\%$ of DNBR Margin



Axial Flux Difference Limits with PDIVIS Inoperable



- 2.10 Reactor Trip System Overtemperature ∆T Setpoint Parameter Values (LCO 3.3.1)
 - 2.10.1 The Overtemperature ΔT reactor trip setpoint K₁ shall be equal to 1.325.
 - 2.10.2 The Overtemperature ∆T reactor trip setpoint T_{avg} coefficient K₂ shall be equal to 0.0297 / °F.
 - 2.10.3 The Overtemperature ΔT reactor trip setpoint pressure coefficient K₃ shall be equal to 0.00181 / psig.
 - 2.10.4 The nominal T_{avg} at RTP (indicated) T' shall be less than or equal to 588.4 °F.
 - 2.10.5 The nominal RCS operating pressure (indicated) P' shall be equal to 2235 psig.
 - 2.10.6 The measured reactor vessel ΔT lead/lag time constant τ_1 shall be equal to 8 sec.
 - 2.10.7 The measured reactor vessel ΔT lead/lag time constant τ_2 shall be equal to 3 sec.
 - 2.10.8 The measured reactor vessel ΔT lag time constant τ_3 shall be less than or equal to 2 sec.
 - 2.10.9 The measured reactor vessel average temperature lead/lag time constant τ_4 shall be equal to 33 sec.
 - 2.10.10 The measured reactor vessel average temperature lead/lag time constant τ_5 shall be equal to 4 sec.
 - 2.10.11 The measured reactor vessel average temperature lag time constant τ_6 shall be less than or equal to 2 sec.
 - 2.10.12 The $f_1(\Delta I)$ "positive" breakpoint shall be +10% ΔI .
 - 2.10.13 The $f_1(\Delta I)$ "negative" breakpoint shall be -24% ΔI .
 - 2.10.14 The $f_1(\Delta I)$ "positive" slope shall be +4.11% / % ΔI .
 - 2.10.15 The $f_1(\Delta I)$ "negative" slope shall be -3.35% / % ΔI .

- 2.11 <u>Reactor Trip System Overpower ∆T Setpoint Parameter Values</u> (LCO 3.3.1)
 - 2.11.1 The Overpower ΔT reactor trip setpoint K₄ shall be equal to 1.072.
 - 2.11.2 The Overpower ΔT reactor trip setpoint T_{avg} rate/lag coefficient K₅ shall be equal to 0.02 / °F for increasing T_{avg} .
 - 2.11.3 The Overpower ∆T reactor trip setpoint T_{avg} rate/lag coefficient K_s shall be equal to 0 / °F for decreasing T_{avg}.
 - 2.11.4 The Overpower ΔT reactor trip setpoint T_{avg} heatup coefficient K₆ shall be equal to 0.00245 / °F when T > T".
 - 2.11.5 The Overpower ΔT reactor trip setpoint T_{avg} heatup coefficient K₆ shall be equal to 0 / °F when T \leq T".
 - 2.11.6 The nominal T_{avg} at RTP (indicated) T" shall be less than or equal to 588.4 °F.
 - 2.11.7 The measured reactor vessel ΔT lead/lag time constant τ_1 shall be equal to 8 sec.
 - 2.11.8 The measured reactor vessel ΔT lead/lag time constant τ_2 shall be equal to 3 sec.
 - 2.11.9 The measured reactor vessel ΔT lag time constant τ_3 shall be less than or equal to 2 sec.
 - 2.11.10 The measured reactor vessel average temperature lag time constant τ_6 shall be less than or equal to 2 sec.
 - 2.11.11 The measured reactor vessel average temperature rate/lag time constant τ_7 shall be equal to 10 sec.
 - 2.11.12 The $f_2(\Delta I)$ "positive" breakpoint shall be 0 for all ΔI .
 - 2.11.13 The $f_2(\Delta I)$ "negative" breakpoint shall be 0 for all ΔI .
 - 2.11.14 The $f_2(\Delta I)$ "positive" slope shall be 0 for all ΔI .
 - 2.11.15 The $f_2(\Delta I)$ "negative" slope shall be 0 for all ΔI .

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CORE OPERATING LIMITS REPORT (COLR) for BYRON UNIT 2 CYCLE 10

2.12 Reactor Coolant System (RCS) DNB Parameter Limits (LCO 3.4.1)

2.12.1 The pressurizer pressure shall be greater than or equal to 2219 psig.

2.12.2 The RCS average temperature (T_{avo}) shall be less than or equal to 591.2 °F.

2.12.3 The RCS total flow rate shall be greater than or equal to 371,400 gpm.

- 2.13 Boron Concentration
 - 2.13.1 The refueling boron concentration shall be greater than or equal to 2000 ppm (LCO 3.9.1).
 - 2.13.2 The Reactor Coolant System boron concentration shall be greater than or equal to 1705 ppm prior to initial criticality of Cycle 10, and greater than or equal to 1864 ppm at all other times in core life, to maintain adequate shutdown margin for MODES 3, 4, and 5 during performance of rod drop time measurements and during the surveillance of Digital Rod Position Indication (DRPI) for OPERABILITY (TLCO 3.1.g and TLCO 3.1.k)