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



October 7, 2005

LTR: BYRON 2005-0119 File: 1.10.0101

United States Nuclear Regulatory Commission Attention: 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 13 Core Operating Limits Report

In accordance with Technical Specification 5.6.5, "Core Operating Limits Report (COLR)," we are submitting the Unit 2 Cycle 13 COLR revision 0.

Should you have any questions concerning these reports, please contact William Grundmann, Regulatory Assurance Manager, at (815) 406-2800.

Respectfully,

Styphen E. Kurymshi

Stephen E Kuczynski Site Vice President Byron Nuclear Generating Station

Attachment: 1) Byron Station Unit 2 Cycle 13 COLR, revision 0

SEK/JL/rah

ATTACHMENT 1

Byron Station Unit 2 Cycle 13 Core Operating Limits Report Revision 0

1.0 CORE OPERATING LIMITS REPORT

This Core Operating Limits Report (COLR) for Byron Station Unit 2 Cycle 13 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 (MTC)
- 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) Pressure, Temperature, and Flow Departure from Nucleate Boiling (DNB) Limits
- LCO 3.9.1 Boron Concentration

The portions of the Technical Requirements Manual affected by this report are listed below:

TRM TLCO 3.1.b Boration Flow Paths - Operating TRM TLCO 3.1.d Charging Pumps - Operating TRM TLCO 3.1.f Borated Water Sources - Operating TRM TLCO 3.1.g Position Indication System - Shutdown TRM TLCO 3.1.h Shutdown Margin (SDM) – MODE 1 and MODE 2 with keff ≥ 1.0 TRM TLCO 3.1.i Shutdown Margin (SDM) - MODE 5 TRM TLCO 3.1.j Shutdown and Control Rods TRM TLCO 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 Safety Limits (SLs) (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 limit for MODE 5 is:

2.2.2 SDM shall be greater than or equal to 1.3% $\Delta k/k$ (LCO 3.1.1, LCO 3.3.9; TRM TLCOs 3.1.i and 3.1.j).

2.3 Moderator Temperature Coefficient (MTC) (LCO 3.1.3)

The Moderator Temperature Coefficient (MTC) limits are:

- 2.3.1 The BOL/ARO/HZP-MTC upper limit shall be +1.68 x $10^{-5} \Delta k/k/^{\circ}F$.
- 2.3.2 The EOL/ARO/HFP-MTC lower limit shall be -4.6 x $10^{-4} \Delta k/k/^{\circ}F$.
- 2.3.3 The EOL/ARO/HFP-MTC Surveillance limit at 300 ppm shall be -3.7 x $10^{-4} \Delta k/k/^{\circ}F$.
- 2.3.4 The EOL/ARO/HFP-MTC Surveillance limit at 60 ppm shall be -4.3 x 10⁻⁴ Δk/k/°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 Shutdown Bank Insertion Limits (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, with Bank A greater than or equal to 224 steps, 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 the following overlap limits as a function of park position:

| Park Position (step) | Overlap Limit (step) |
|----------------------|----------------------|
| 231 | 115 |





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

2.6.1 Total Peaking Factor:

$$F_Q(Z) \le \frac{F_Q^{RTP}}{0.5} x K(Z) \text{ for } P \le 0.5$$

$$F_Q(Z) \le \frac{F_Q^{RTP}}{P} x K(Z) \text{ for } P > 0.5$$

where: P = the ratio of THERMAL POWER to RATED THERMAL POWER

$$F_{Q}^{HTP} = 2.60$$

K(Z) is provided in Figure 2.6.1.

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 Table 2.6.2.a.

The normal operation W(Z) values have been determined at burnups of 150, 6000, 14000, and 20000 MWD/MTU.

Table 2.6.2.b shows the $F_Q^C(z)$ penalty factors that are greater than 2% per 31 Effective Full Power Days (EFPD). These values shall be used to increase the $F_Q^W(z)$ as per Surveillance Requirement 3.2.1.2. A 2% penalty factor shall be used at all cycle burnups that are outside the range of Table 2.6.2.b.

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

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

where:

 U_{qu} = Base F_Q measurement uncertainty = 1.05 when PDMS is inoperable (U_{qu} is defined by PDMS when OPERABLE.) 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





| | | I able 2.6.2.a | | |
|--------------------|----------------------|--|----------------------|---------|
| | W (Ton and Botto) | (Z) versus Core Hei m 15% Excluded pe | ght r WCAP-10216) | |
| Hoight | 150 | 6000 | 14000 | 20000 |
| (feet) | MWD/MTU | MWD/MTU | MWD/MTU | MWD/MTU |
| 0.00 (core bottom) | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| 0.20 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| 0.40 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| 0.60 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| 0.80 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| 1,00 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| 1.40 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| 1.60 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| 1.80 | 1.2061 | 1.2169 | 1.2897 | 1.2720 |
| 2.00 | 1.2002 | 1.1986 | 1.2759 | 1.2600 |
| 2.40 | 1.1784 | 1.1604 | 1.2443 | 1.2277 |
| 2.60 | 1.1646 | 1.1431 | 1.2266 | 1.2091 |
| 2.80 | 1.1600 | 1.1399 | 1.2108 | 1,1915 |
| 3.00 | 1.1561 | 1.1370 | 1.2011 | 1.1780 |
| 3.20 | 1 1443 | 1.1323 | 1.1906 | 1.1770 |
| 3.60 | 1.1374 | 1.1218 | 1.1796 | 1.1720 |
| 3.80 | 1.1315 | 1.1170 | 1.1758 | 1.1680 |
| 4.00 | 1.1269 | 1,1144 | 1.1716 | 1.1654 |
| 4.20 | 1.1243 | 1.1115 | 1.1658 | 1.1780 |
| 4.40 | 1.1221 | 1,1096 | 1.1596 | 1.1887 |
| 4.60 | 1.1186 | 1.1055 | 1.1509 | 1.1990 |
| 5.00 | 1.1116 | 1.0993 | 1.1444 | 1.2117 |
| 5.20 | 1.1062 | 1.0954 | 1.1450 | 1.2139 |
| 5.40 | 1,1016 | 1.0925 | 1.1455 | 1.2148 |
| 5.60 | 1.1043 | 1.0981 | 1.1441 | 1.2123 |
| 5.80 | 1.1129 | 1.1037 | 1.1528 | 1.2228 |
| 6.00 | 1.1220 | 1 1119 | 1.1044 | 1.2304 |
| 6.40 | 1.1562 | 1.1214 | 1.1807 | 1.2538 |
| 6.60 | 1.1700 | 1.1352 | 1.1864 | 1.2576 |
| 6.80 | 1.1827 | 1.1481 | 1.1901 | 1.2594 |
| 7.00 | 1.1935 | 1.1590 | 1.1909 | 1.2583 |
| 7.20 | 1.2024 | 1.1681 | 1.1899 | 1.2523 |
| 7.40 | 1 2123 | 1 1921 | 1.1827 | 1.2455 |
| 7.80 | 1.2153 | 1.2060 | 1.1778 | 1.2214 |
| 8.00 | 1.2154 | 1.2190 | 1.1699 | 1.2095 |
| 8.20 | 1.2106 | 1.2305 | 1.1609 | 1.1931 |
| 8.40 | 1.2115 | 1.2438 | 1.1530 | 1.1812 |
| 8.80 | 1.2140 | 1 2839 | 1 1485 | 1.1702 |
| 9.00 | 1.2200 | 1.2720 | 1.1507 | 1.1578 |
| 9.20 | 1.2230 | 1.2771 | 1.1509 | 1.1485 |
| 9.40 | 1.2270 | 1.2888 | 1.1520 | 1.1460 |
| 9.60 | 1.2320 | 1.3018 | 1.1523 | 1.1920 |
| 9.80 | 1.2450 | 1.3140 | 1.1660 | 1.2310 |
| 10.00 | 1.2010 | 1.3262 | 1.1940 | 1.2070 |
| 10.40 | 1.0000 | 1,0000 | 1.0000 | 1.0000 |
| 10.60 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| 10.80 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| 11.00 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| 11.20 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| 11.40 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| 11,60 | 1.0000 | 1.0000 | 1,0000 | 1,0000 |
| FI.OV | 1.0000 | 1.0000 | 1.0000 | 1.0000 |

Note: W(Z) values at 20000 MWD/MTU may be applied to cycle burnups greater than 20000 MWD/MTU to prevent W(Z) function extrapolation

| Table 2.6.2.b | | | | |
|---|---------------------------------------|--|--|--|
| Penalty Factors in Excess of 2% per 31 EFPD | | | | |
| Cycle Burnup (MWD/MTU) | Penalty Factor F ^C o(z) | | | |
| 840 | 1.0200 | | | |
| 1012 | 1.0220 | | | |
| 1185 | 1.0248 | | | |
| 1357 | 1.0266 | | | |
| 1530 | 1.0280 | | | |
| 1702 | 1.0292 | | | |
| 1875 | 1.0309 | | | |
| 2047 | 1.0332 | | | |
| 2220 | 1.0338 | | | |
| 2392 | 1.0340 | | | |
| 2565 | 1.0342 | | | |
| 2737 | 1.0344 | | | |
| 2910 | 1.0342 | | | |
| 3082 | 1.0335 | | | |
| 3255 | 1.0320 | | | |
| 3427 | 1.0300 | | | |
| 3600 | 1.0271 | | | |
| 3772 | 1.0233 | | | |
| 3945 | 1.0200 | | | |

Notes:

Linear interpolation is adequate for intermediate cycle burnups.

All cycle burnups outside the range of the table shall use a 2% penalty factor for compliance with the 3.2.1.2 Surveillance Requirements.

2.7 Nuclear Enthalpy Rise Hot Channel Factor (F^{N}_{AH}) (LCO 3.2.2)

2.7.1
$$F_{\Delta H}^{N} \leq F_{\Delta H}^{RTP} [1.0 + PF_{\Delta H} (1.0 - P)]$$

where: P = the ratio of THERMAL POWER to RATED THERMAL POWER $F_{\Delta H}^{RTP} = 1.70$ PF_{AH} = 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 $F^{N}_{\Delta H}$ shall be calculated by the following formula:

 $U_{F\Delta H} = U_{F\Delta Hm}$

where:

 $U_{F\Delta Hm}$ = Base $F^{N}_{\Delta H}$ measurement uncertainty = 1.04

2.7.3 PDMS Alarms:

 $\begin{array}{l} {\sf F}^{\sf N}_{{}_{\Delta}{\sf H}} \text{ Warning Setpoint} \geq 2\% \text{ of } {\sf F}^{\sf N}_{{}_{\Delta}{\sf H}} \text{ Margin } \\ {\sf F}^{\sf N}_{{}_{\Delta}{\sf H}} \text{ Alarm Setpoint} \geq 0\% \text{ of } {\sf F}^{\sf N}_{{}_{\Delta}{\sf H}} \text{ Margin } \end{array}$

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 $\text{DNBR}_{\text{APSL}} \ge 1.536$

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





- 2.10 <u>Reactor Trip System (RTS) Instrumentation</u> (LCO 3.3.1) Overtemperature ∆T Setpoint Parameter Values
 - 2.10.1 The Overtemperature ΔT reactor trip setpoint K₁ shall be equal to 1.325.
 - 2.10.2 The Overtemperature ΔT reactor trip setpoint T_{avg} coefficient K₂ shall be equal to 0.0297 / °F.
 - 2.10.3 The Overtemperature ∆T reactor trip setpoint pressure coefficient K₃ shall be equal to 0.00181 / psi.
 - 2.10.4 The nominal T_{ava} at RTP (indicated) T' shall be less than or equal to 588.0 °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 -18% ΔI .
 - 2.10.14 The f₁ (Δ I) "positive" slope shall be +3.47% / % Δ I.
 - 2.10.15 The $f_1(\Delta I)$ "negative" slope shall be -2.61% / % ΔI .

- 2.11 <u>Reactor Trip System (RTS) Instrumentation</u> (LCO 3.3.1) Overpower ∆T Setpoint Parameter Values
 - 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 ΔT reactor trip setpoint T_{avg} rate/lag coefficient K₅ 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 Tavo at RTP (indicated) T" shall be less than or equal to 588.0 °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 .

- 2.12 <u>Reactor Coolant System (RCS) Pressure, Temperature, and Flow Departure from Nucleate</u> <u>Boiling (DNB) Limits</u> (LCO 3.4.1)
 - 2.12.1 The pressurizer pressure shall be greater than or equal to 2209 psig.
 - 2.12.2 The RCS average temperature (Tavg) shall be less than or equal to 593.1 °F.
 - 2.12.3 The RCS total flow rate shall be greater than or equal to 386,000 gpm.

2.13 Boron Concentration

- 2.13.1 The refueling boron concentration shall be greater than or equal to the value given in the Table below (LCO 3.9.1). The reported value also bounds the end-of-cycle requirements for the previous cycle.
- 2.13.2 To maintain keff ≤ 0.987 with all shutdown and control rods fully withdrawn in MODES 3, 4, or 5 (TRM TLCO 3.1.g Required Action B.2 and TRM TLCO 3.1.k.2), the Reactor Coolant System boron concentration shall be greater than or equal to the values given in the Table below.

| COLR Section | Conditions | Boron Concentration (ppm) |
|-----------------|---------------------------------|------------------------------|
| 2.13.1 | Refueling | 1728 |
| 2.13.2 | a) prior to initial criticality | 1790 |
| 2.13.2 | b) all other times in core life | 1995 |