May 9, 2000

Mr. Oliver D. Kingsley, President
Nuclear Generation Group
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Executive Towers West III
1400 Opus Place, Suite 500
Downers Grove, IL 60515

SUBJECT: BYRON - REVIEW OF REVISED PRESSURE TEMPERATURE LIMITS REPORT (TAC NOS. MA6449 AND MA6450)

Dear Mr. Kingsley:

By letter dated July 12, 1999, Commonwealth Edison Company submitted its revised Pressure Temperature Limits Report (PTLR) for Byron Station, Units 1 and 2. The submittal revised the following information in the PTLR: (1) new fluence based on fluence analyses using ENDF/B-VI cross sections, (2) new chemistry factor (CF) for the limiting beltline material based on recent surveillance data in which all measured shifts for the reference temperature, RT_{NDT}, have been revised using computer curve fitting of the Charpy curves, and (3) an increase in the applicability of the heatup and cooldown curves from 12 to 16 effective full power years.

We have completed our review of the report and concluded that the application of the methodology discussed in the PTLR and the results obtained from it, are acceptable. The safety evaluation that addresses the technical basis for these conclusions is enclosed.

Sincerely,

/RA/

George F. Dick, Jr., Sr. Project Manager, Section 2
Project Directorate III
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket Nos. STN 50-454, STN 50-455

Enclosure: Safety Evaluation

cc w/encl: See next page

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO PRESSURE TEMPERATURE LIMIT REPORT

COMMONWEALTH EDISON COMPANY

BYRON STATION, UNITS 1 AND 2

DOCKET NOS. STN 50-454 AND STN 50-455

1.0 INTRODUCTION

By letter dated July 12, 1999 (Reference 1), Commonwealth Edison Company (ComEd, the licensee) submitted its revised pressure temperature limits report (PTLR) for Byron Station, Units 1 and 2, in accordance with Technical Specification (TS) 5.6.6, “Reactor Coolant System Pressure and Temperature Limits Report.” The submittal revised the following information in the PTLR: (1) new fluence based on fluence analyses using ENDF/B-VI cross sections, (2) new chemistry factor (CF) for the limiting beltline material based on surveillance data including data from WCAP-15123 (Reference 2) for Unit 1 and data from WCAP-15176 (Reference 3) for Unit 2, in which all measured shifts for the reference nil ductility temperature, RT_{NDT}, have been revised using computer curve fitting (CVGRAPH Version 4.1) of the Charpy curves, and (3) the heatup and cooldown curves recalculated from 12 effective full power years (EFPYs) to 16 EFPYs. The current PTLR, which contains the pressure temperature (P-T) limits based on Appendix G of the 1996 edition of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (Code) and the use of Code Case 514 on low temperature overpressure protection (LTOP), was approved by the NRC staff in a safety evaluation dated January 21, 1998 (Reference 4).

2.0 BACKGROUND

The Commission has provided guidance for the contents of TS in its "Final Policy Statement on Technical Specifications Improvements for Nuclear Power Reactors" (Final Policy Statement), 58 FR 39132, dated July 22, 1993. To date, the NRC has approved several PTLR applications, including that from the licensee, and has concluded that the removal of LTOP curves and P-T limit curves from plant TSs to other licensee-controlled documents is consistent with the criteria of the final policy statement. Currently, the P-T limit curves for Byron, Units 1 and 2, are contained in the PTLR. This current methodology approved for calculating P-T limits in this PTLR is the methodology contained in Appendix G of the 1996 edition of the ASME Code. The proposed revision of the PTLR updates the P-T limit curves for both Byron units using:
(1) revised chemistry data based on an extensive review of existing beltline material records,

and (2) revised CF based on existing and new surveillance data for the limiting beltline material. Although the P-T limits methodology remains the same, the adequacy of the P-T limits is dependent upon the adjusted reference temperature (ART) calculation for the limiting beltline material. Although prior approval of the changes is not required unless there is an unreviewed safety question, the NRC reviews the licensees' submittals in order to continue to monitor status of the structural integrity of the reactor vessel.

3.0 EVALUATION

3.1 Reactor Vessel Fluence Values

The staff reviewed the pressure vessel fluence values used in the evaluation of the pressure vessel material properties which define the P-T limit curves and the associated LTOP setpoints and enable temperature.

The methodology used to evaluate the new fluence data and associated changes in pressure vessel material properties is presented in Reference 1. The methodology is based on the material properties used for the evaluation of the P-T curves in WCAP-15124 and WCAP-15178 for Units 1 and 2, respectively (References 5 and 6). In turn, the fluence values for the estimation of the material properties were taken from the analysis of Unit 1 surveillance capsule W reported in WCAP-15123 and the analysis of Unit 2 surveillance capsule X reported in WCAP-15176.

3.1.1 Dosimetry

The standard dosimeter set of Cu-63(n, α), Fe-54(n, p), Ni-58(n, p), U-238(n, f), Np-237(n, f) and Co-59(n, θ) was used. The source term for the capsule irradiation was derived from the monthly power output for each unit to the end of cycle when the capsule was removed (NUREG-0020, "Licensed Operating Reactors"). The dosimeter specific activity was measured using Li-drifted Germanium gamma spectrometer following the appropriate American Society for Testing and Materials (ASTM) procedures. Previously measured capsules were recalculated to account for cross section changes.

3.1.2 Analysis

The analytical tool used in the analysis is the DORT two-dimensional neutron transport code (Reference 7) using the BUGLE-96 cross-section library. The code is used in the forward and adjoint modes. Two dimensional (r, θ) and (r, x) calculations were performed.

For the conversion of the measured dosimeter activities to neutron fluxes at the location of the dosimeters, the licensee estimated an energy neutron spectrum at the center of the capsule. The dosimeter reaction and the transport cross-sections were derived from the latest (ENDF/B-VI) files. The capsule spectra were adjusted using a code not approved by the NRC. However, the calculated activities were named "best estimate" and compared to the corresponding calculated values. The comparison indicated that the calculated and the best-estimate values were in good to excellent agreement. The fluence values used for the

determination of the material properties are those estimated through the calculation. This is in accordance with staff recommendations.

3.2 Pressure-Temperature Limit Curves

Appendix G to Title 10 of the Code of Federal Regulations, Part 50 (10 CFR Part 50) defines P-T limit curves for heatup, cooldown, LTOP, and inservice leak and hydrostatic testing. Each curve defines an acceptable region for normal operation. The curves are used for operational guidance during heatup and cooldown maneuvering. Since the change to the current P-T limits methodology is limited to the ART calculations based on revised chemistry data and revised CF for the limiting beltline material, the staff focused its evaluation on the revised ART for the limiting beltline material of each unit. To be consistent, the material data for both Byron units in NRC's reactor vessel integrity database (RVID) have also been updated according to the latest information reported in the submittal.

3.2.1 ART for the Limiting Beltline Material of Unit 1

The licensee revised the best estimate chemistry for the intermediate shell forging (Heat 5P-5933) to 0.04 percent Cu and 0.74 percent Ni based on additional chemistry data from two surveillance specimens from Capsule W of Unit 1. This material is also the limiting beltline material for Unit 1. The revision was documented in the submitted PTLR for Unit 1 and in WCAP-15124. The best estimate chemistry for the middle circumferential weld that was fabricated with weld wire heat 442002 was also revised. Since the limiting beltline material for Unit 2 was fabricated with weld wire of the same heat, detailed evaluation will be given later in Section 3.2.2.

The CF of 30.3 degrees Fahrenheit for the limiting material was calculated using six surveillance data (3 tangential and 3 axial). Report WCAP-15183, (Reference 8) concluded that two of the six surveillance data are not credible per the criterion of Regulatory Guide (RG) 1.99, Revision 2 (Reference 9). However, since the calculated CF is more conservative than that based on the Table of RG 1.99, Revision 2, the staff agrees that the licensee may use the CF of 30.3 degrees Fahrenheit and a full margin for the proposed and future P-T limits and PTS evaluations. Based on this CF, a full margin of 34 degrees Fahrenheit, an initial RT_{NDT} of 40 degrees Fahrenheit, and revised fluence for 16 EFPY of 0.591×10^{19} at the quarter thickness (1/4T) and 0.213×10^{19} at 3/4T of the RPV wall, the licensee calculated the ART to be 100 degrees Fahrenheit at 1/4T and 92 degrees Fahrenheit at 3/4T. These ART values are consistent with those in RVID if the fluence of 32 EFPY in RVID were adjusted appropriately, and are therefore acceptable.

3.2.2 ART for the Limiting Beltline Material of Unit 2

The licensee revised the best estimate chemistry for the middle circumferential weld (Heat 442002) to 0.04 percent Cu and 0.63 percent Ni based on additional chemistry data from two surveillance specimens from Capsule W of Unit 1 and two Charpy specimens from Capsule X of Unit 2. This material is the limiting beltline material for Unit 2. The revision was documented in the submitted PTLR for Unit 2 and in WCAP-15178. The revised chemistry data for the limiting material also reflected the exclusion, through misidentification, of two data points, which

were determined to have been included in the previous chemistry data evaluation. This was concluded in a Babcock and Wilcox Owners' Group (B&WOG) report (Reference 10). This report documented an extensive weld records review conducted recently by the B&WOG.

The CF of 65.9 degrees Fahrenheit for the limiting material was calculated using all six surveillance data, three from Unit 1 and three from Unit 2, as reported in WCAP-15178. All six surveillance data were evaluated and determined to be credible in WCAP-15180 (Reference 11). It should be noted that, in WCAP-15180, the CF was mistakenly reported as 32.7 degrees Fahrenheit without applying the ratio procedure. This mistake was corrected in WCAP-15178. Based on the correct CF of 65.9 degrees Fahrenheit, a half margin of 28 degrees Fahrenheit, an initial RT_{NDT} of 10 degrees Fahrenheit, and revised fluence for 16 EFPY of 0.592×10^{19} at 1/4T and 0.214×10^{19} at 3/4T of the RPV wall, the licensee calculated the ART to be 94 degrees Fahrenheit at 1/4T and 77 degrees Fahrenheit at 3/4T. These ART values are consistent with those in RVID if the fluence of 32 EFPY in RVID were adjusted appropriately and are, therefore, acceptable.

Another revision was made to the chemistry data of the lower shell forging, which was updated to 0.06 percent Cu and 0.73 percent Ni considering additional data from two Charpy specimens from Capsule X of Unit 2. The PTLR for Unit 2 still reported the unrevised chemistry data for the lower shell forging. However, there is no impact on the proposed P-T limits because the proposed P-T limits were calculated using the best-estimate chemistry from WCAP-15178, which evaluated all beltline materials using the revised chemistry data.

3.2.3 P-T Limit Curves for Both Units

The next step in generating P-T limits is to calculate the fracture toughness, K_{IR}, based on the ART values determined previously and to equate this K_{IR}, to the applied stress intensity factor due to pressure, K_{Ip}, and the applied stress intensity factor due to thermal loading, K_{It}, with specific safety factors for different operating conditions. The licensee employed the 1996 ASME Appendix G methodology for this portion of the analysis in the current PTLR and continued to employ the same methodology for the proposed PTLR. Nonetheless, the staff has performed calculations to verify the validity of the P-T limit curves and confirmed that the proposed P-T limit curves (at 16 EFPY) for heatup, cooldown, and inservice leak hydrostatic tests meet the beltline material requirements in Appendix G of 10 CFR Part 50. This verification was made after the staff included the difference between the RCS coolant temperature and the wall metal temperature in these curves.

3.2.4 Pressurized Thermal Shock (PTS) Evaluations for Both Units

The licensee performed PTS evaluations for both units using the latest RPV materials information upon which the proposed P-T limits for both units are based. The staff compared the licensee's RT_{PTS} values at 32 EFPY for both units to those in the RVID and concluded that they are consistent and are below the screening criteria. Therefore, the licensee has demonstrated that both Byron units satisfy the fracture toughness requirements of 10 CFR 50.61. The staff would like to point out that the latest RT_{PTS} values for both units are available in the proposed P-T limits submittal (Reference 1), which supersede the PTS

evaluations reported in WCAP-15125 (Reference 12) for Unit 1 and WCAP-15177 (Reference 13) for Unit 2.

3.3 LTOP Analyses

3.3.1 Minimum Enable Temperature

Per the licensee's approved PTLR methodology, the minimum allowed enable temperature is the larger of either RT_{NDT} + 50 degrees Fahrenheit + E_{inst} + delta-$T_{¼-t}$ or 200 degrees Fahrenheit. In this calculation, E_{inst} refers to instrument error while delta-$T_{¼-t}$ refers to the temperature difference between the reactor coolant and the metal at a distance one-fourth of the vessel wall thickness from the inside surface in the beltline region. The values for E_{inst} and delta-$T_{¼-t}$ that were provided in the submittals for the PTLR methodology are 15.0 degrees Fahrenheit and 29.254 degrees Fahrenheit, respectively.

The licensee proposed a LTOP system enable temperature of $\geq$350 degrees Fahrenheit for both units. Based on vessel material data, instrumentation uncertainties, and delta-$T_{¼-t}$, the minimum allowed enable temperature for each of the units is 200 degrees Fahrenheit. During a conference call with the staff on November 30, 1999, the licensee confirmed that the E_{inst} and delta-$T_{¼-t}$ values have not changed since the approval of the PTLR methodology. Accordingly, for the above values, the LTOP enable temperatures included in the licensee's revised PTLRs (i.e., $\geq$350 degrees Fahrenheit) are conservative with respect to the minimum LTOP enable temperatures allowed by the licensee's approved PTLR methodology and, therefore, acceptable.

3.3.2 LTOP PORV Setpoints

Per the licensee's approved PTLR methodology, the pressure limits utilized in the calculation of the LTOP system power operated relief valve (PORV) lift setpoints are the lower of either 110 percent of the steady state pressure limit at the corresponding temperature or 800 psig. The staff compared the values of the limits provided in the revised PTLRs to the values that were submitted in support of the PTLR methodology for the temperature range of interest (i.e, 60 degrees Fahrenheit $\leq T \leq$350 degrees Fahrenheit for both units). The staff determined that, with the exception of the pressure limit at 60 degrees Fahrenheit for Unit 1, these values have not changed. The pressure limit at 60 degrees Fahrenheit for Unit 1 has decreased since approval of the PTLR methodology. To address this change, the licensee increased the minimum temperature for pressurization of the Unit 1 PTLR from 60 degrees Fahrenheit to 65 degrees Fahrenheit. This ensures that the reactor vessel will not be pressurized and, therefore, eliminates the need for the LTOP system below 65 degrees Fahrenheit. At 65 degrees Fahrenheit the pressure limit in the revised PTLR is the same as the pressure limit that was presented in the submittals for the PTLR methodology. In addition, the staff compared the PORV lift setpoint curves in the revised PTLRs to the values in the submittals for the PTLR methodology and found that those have not changed. During the November 30, 1999, conference call, the licensee confirmed the staff's determinations regarding the pressure limit values and PORV lift setpoints (i.e., that they have not changed) for the LTOP region (i.e., 65 degrees Fahrenheit $\leq T \leq$350 degrees Fahrenheit for Unit 1 and 60 degrees Fahrenheit

$\leq$T $\leq$350 degrees Fahrenheit for Unit 2). The licensee also confirmed that no plant modifications have been implemented that would have affected the LTOP analyses.

4.0 CONCLUSIONS

As a result of its review of the licensee's PTLR, for Byron Station, Units 1 and 2, the staff concluded that the application of the methodology and the results from the application are acceptable. The new fluence using ENDF/B-VI cross-sections is about 10 percent lower than the current estimated fluence.

The licensee continued to use the 1996 ASME Appendix G methodology to generate the P-T limits in the proposed PTLR. Consequently, the staff's review focused on the new CF for the limiting beltline material for both Units. The staff concluded that the licensee's CF evaluation based on surveillance data and the associated credibility evaluation meet the intent of RG 1.99, Revision 2. Hence, the P-T limit curves in the PTLR are acceptable for 16 EFPY of operation and satisfy Appendix G to 10 CFR Part 50 and 1996 Appendix G to Section XI of the ASME Code.

The staff reviewed the changes the licensee made to address the decrease in the pressure limit at 60 degrees Fahrenheit and found them to be consistent with the licensee's PTLR methodology and, therefore, acceptable. Furthermore, because the limits in the revised LTOP region have not changed, and because no plant modifications affecting LTOP analyses were implemented, the staff concluded that the PORV setpoints included in the licensee's revised PTLRs are acceptable. Other parameters dealing with mitigation of LTOP events (e.g., RHR relief valve setpoints and vent areas) are also acceptable for the same reasons.

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Dated: May 9, 2000

5.0 REFERENCES

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2. Westinghouse Electric Company, “Analysis of Capsule W from Commonwealth Edison Company Byron Unit 1 Reactor Vessel Radiation Surveillance Program,” WCAP-15123, January 1999.

3. Westinghouse Electric Company, “Analysis of Capsule X from Commonwealth Edison Company Byron Unit 2 Reactor Vessel Radiation Surveillance Program,” WCAP-15176, March 1999.

4. NRC, “Byron Station, Units 1 and 2, and Braidwood Station, Units 1 and 2, Acceptance for Referencing of Pressure Temperature Limits Report,” January 21, 1998.

5. Westinghouse Electric Company, “Byron Unit 1 Heatup and Cooldown Limit Curves for Normal Operation,” WCAP-15124, November 1998.

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7. DOORS 3.1, “One, Two- and Three-Dimensional Discrete Ordinates Neutron/Photon Transport Code System, Version 3.1" RSICC computer code collection CCC-650,” August 1996.

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10. Babcock and Wilcox Owners Group Report, “Byron and Braidwood RV Weld Chemistry and Initial RT_{NDT},” October 5, 1998.

11. Commonwealth Edison Company, “Surveillance Program Credibility Evaluation, Byron, Unit 2,” WCAP-15180, June 1999.

12. WCAP-15125, “Evaluation of Pressurized Thermal Shock for Byron, Unit 1,” November 1998.

13. WCAP-15177, “Evaluation of Pressurized Thermal Shock for Byron, Unit 2,” June 1999.