

November 22, 2006

Mr. Christopher M. Crane, President
and Chief Nuclear Officer
Exelon Generation Company, LLC
4300 Winfield Road
Warrenville, IL 60555

SUBJECT: BYRON STATION, UNIT NOS. 1 AND 2 AND BRAIDWOOD STATION UNIT
NOS. 1 AND 2 - EXEMPTION FROM THE REQUIREMENTS OF 10 CFR
PART 50, APPENDIX G (TAC NOS. MC8697, MC8698, MC8699, AND MC8700)

Dear Mr. Crane:

The Commission has approved the enclosed exemption from specific requirements of Title 10 of the *Code of Federal Regulations* (10 CFR), Part 50, Appendix G, for Byron Station, Unit Nos. 1 and 2, and the Braidwood Station, Unit Nos. 1 and 2. This action is in response to your application dated October 3, 2005, which requested an exemption from the aforementioned regulations. The exemption allows the use of WCAP-16143-P in calculating certain reactor pressure vessel pressure-temperature limits in lieu of 10 CFR Part 50, Appendix G, paragraph IV.A.2.c.

A copy of the exemption is enclosed. The exemption has been forwarded to the Office of the Federal Register for publication.

Sincerely,

/RA/

Robert F. Kuntz, Project Manager
Plant Licensing Branch III-2
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket Nos. STN 50-454, STN 50-455,
STN 50-456 and STN 50-457

Enclosure:
Exemption

cc w/enclosure: See next page

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Byron/Braidwood Stations

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

EXELON GENERATION COMPANY, LLC

BYRON STATION, UNIT NOS. 1 AND 2

BRAIDWOOD STATION, UNIT NOS. 1 AND 2

DOCKET NOS. STN 50-454, STN 50-455, STN 50-456 AND STN 50-457

EXEMPTION

1.0 BACKGROUND

Exelon Generation Company, LLC (EGC, or the licensee) is the holder of Facility Operating Licenses NPF-37, NPF-66, NPF-72, and NPF-77, which authorize operation of Byron Station, Unit Nos. 1 and 2 (Byron), and Braidwood Station, Unit Nos. 1 and 2 (Braidwood), respectively. The licenses provide, among other things, that the facilities are subject to all rules, regulations, and orders of the Nuclear Regulatory Commission (NRC, the Commission) now or hereafter in effect.

The Byron facility consists of two pressurized-water reactors located in Ogle County in Illinois. The Braidwood facility consists of two pressurized-water reactors located in Will County in Illinois.

2.0 REQUEST/ACTION

Title 10 of the *Code of Federal Regulations* (10 CFR), Part 50, Appendix G, requires that pressure-temperature (P-T) limits be established for reactor pressure vessels (RPVs) during normal operating and hydrostatic or leak rate testing conditions. Specifically, 10 CFR Part 50, Appendix G states, “[t]he minimum temperature requirements...pertain to the controlling material, which is either the material in the closure flange or the material in the

beltline region with the highest reference temperature...[T]he minimum temperature requirements and the controlling material depend on the operating condition (i.e., hydrostatic pressure and leak tests, or normal operation including anticipated operational occurrences), the vessel pressure, whether fuel is in the vessel, and whether the core is critical. The metal temperature of the controlling material, in the region of the controlling material which has the least favorable combination of stress and temperature, must exceed the appropriate minimum temperature requirement for the condition and pressure of the vessel specified in Table 1 [of 10 CFR Part 50, Appendix G].” Footnote 2 to Table 1 of 10 CFR Part 50, Appendix G, specifies that RPV minimum temperature requirements related to RPV closure flange considerations shall be based on “[t]he highest reference temperature of the material in the closure flange region that is highly stressed by bolt preload.”

In order to conform to certain provisions of proposed amendments that would modify the Byron and Braidwood Technical Specifications (TS) to revise the pressure-temperature limits report (PTLR) methodology for each unit, EGC requested in its application dated October 3, 2005, that the NRC staff exempt Byron and Braidwood from the specific requirements of 10 CFR Part 50, Appendix G, as they pertain to the establishment of minimum temperature requirements, for all modes of operation addressed by 10 CFR Part 50, Appendix G, based on the material properties of the material of the RPV closure flange region that is highly stressed by the bolt preload. The requirements from which EGC requested that Byron and Braidwood be exempted shall be referred to, for the purpose of this exemption as, “those requirements related to the application of footnote (2) to Table 1 of 10 CFR Part 50, Appendix G.”

EGC’s technical basis was submitted to the NRC by letter dated October 3, 2005, which included as an attachment Westinghouse Report WCAP-16143-P, “Reactor Closure Head/Vessel Flange Requirements Evaluation for Byron/Braidwood Units 1 and 2.” WCAP-16143-P included a fracture mechanics analysis of postulated flaws in the Byron and

Braidwood RPV closure flange regions under boltup, 100 °F/hr heatup, 100 °F/hr cooldown, and steady-state conditions, with the heatup and cooldown transients being modeled in accordance with what would be permissible using P-T limit curves based on Byron and Braidwood beltline materials. Westinghouse performed finite element modeling to calculate the stresses present at critical locations within the flange region and determined that the 100 °F/hr heatup transient was the most severe condition, with the upper head-to-flange weld being the most limiting location. With these stresses, Westinghouse calculated the applied stress intensity ($K_{I \text{ applied}}$) for semi-elliptical, outside diameter initiated, surface breaking flaws with an aspect ratio (length vs. depth) of 6:1, and with depths ranging from 0 to 90 percent of the thickness of the component wall. The $K_{I \text{ applied}}$ values were calculated in accordance with the American Society of Mechanical Engineers *Boiler and Pressure Vessel Code* (ASME Code) Section XI, Appendix G, Subparagraph G-2220 requirements for the analysis of flange locations. Westinghouse then compared these $K_{I \text{ applied}}$ values to ASME Code lower-bound static crack initiation fracture toughness (K_{IC}) values determined from the nil-ductility transition reference temperature (RT_{NDT}) values for the Byron and Braidwood RPV closure flange materials. Westinghouse also provided an assessment of the potential for changes in the material RT_{NDT} values for the Byron and Braidwood RPV closure flange materials due to thermal aging resulting from exposure to the RPV operating environment.

The use of ASME Code K_{IC} as the material property for the fracture mechanics analysis represents the most significant change between the analysis provided in WCAP-16143-P and the analysis that was performed as the basis for establishing the minimum temperature requirements in 10 CFR Part 50, Appendix G. The minimum temperature requirements related to footnote 2 to Table 1 of 10 CFR Part 50, Appendix G were incorporated into the *Code of Federal Regulations* in the early 1980s and were based on analyses that used ASME Code lower-bound crack arrest/dynamic test fracture toughness (K_{IA}) as the parameter for

characterizing a material's ability to resist crack initiation and propagation. The use of ASME Code K_{IA} is always conservative with respect to the use of ASME Code K_{IC} for fracture mechanics evaluations, and its use in the evaluations that established the requirements in 10 CFR Part 50, Appendix G was justified based on the limited knowledge of RPV material behavior that was available in the early 1980s. However, the use of ASME Code K_{IC} is more consistent with the actual physical processes that would govern flaw initiation under conditions of normal RPV operation, including RPV heatup, cooldown, and hydrostatic and leak testing. Based on its current understanding of the behavior of RPV materials, the NRC staff has routinely approved the use of ASME Code K_{IC} by licensees as the basis for evaluating RPV beltline materials; licensees have previously demonstrated compliance with the intent of 10 CFR Part 50, Appendix G through the use of the ASME Code, first as Code Cases N-640 and N-641, and now via ASME Code, Section XI, Appendix G, which has been revised to use K_{IC} in lieu of K_{IA} .

The minimum K_{IC} value given in the ASME Code for RPV steel, regardless of the material RT_{NDT} value or temperature, is 33.2 ksi \sqrt{in} . This value represents the "lower shelf" of the ASME Code K_{IC} curve. Based on information in WCAP-16143-P, it is apparent that the $K_{I\text{ applied}}$ for any flaw up to 1/4 of the wall thickness (1/4 T) at the limiting location (refer to WCAP-16143-P, Figure 4-2), would not exceed 33.2 ksi \sqrt{in} (even taking into account the NRC staff's consideration of ASME Code structural factors) until between 1 and 2 hours into the 100 °F/hr heatup transient. The temperature at the tip of postulated flaws up to 1/4 T size would be adequate at that time to ensure that the limiting Byron and Braidwood flange materials would exhibit fracture toughness properties in excess of ASME Code "lower shelf" behavior.

The NRC staff has determined that the analysis provided in WCAP-16143-P has demonstrated, for the most limiting transient addressed by 10 CFR Part 50, Appendix G, that the combination of factors that would have to exist for brittle failure to occur (high stresses in

the RPV flange region along with low temperature at the metal of the flange region) can not exist simultaneously, and based on consideration of Byron and Braidwood's beltline materials, the structural integrity of the Byron and Braidwood RPV closure flange materials will not be challenged by facility operation in accordance with P-T limit curves. Therefore, the more conservative minimum temperature requirements related to footnote 2 to Table 1 of 10 CFR Part 50, Appendix G are not necessary to meet the underlying intent of 10 CFR Part 50, Appendix G, to protect the Byron and Braidwood RPVs from brittle failure during normal operation under both core critical and core non-critical conditions and RPV hydrostatic and leak test conditions.

3.0 DISCUSSION

Pursuant to 10 CFR 50.12, the Commission may, upon application by any interested person or upon its own initiative, grant exemptions from the requirements of 10 CFR Part 50, when (1) the exemptions are authorized by law, will not present an undue risk to public health or safety, and are consistent with the common defense and security; and (2) when special circumstances are present. Special circumstances are present whenever, according to 10 CFR 50.12(a)(2):

- (i) Application of the regulation in the particular circumstances conflicts with other rules or requirements of the Commission; or
- (ii) Application of the regulation in the particular circumstances would not serve the underlying purpose of the rule or is not necessary to achieve the underlying purpose of the rule; or
- (iii) Compliance would result in undue hardship or other costs that are significantly in excess of those contemplated when the regulation was adopted, or that are significantly in excess of those incurred by others similarly situated; or

(iv) The exemption would result in benefit to the public health and safety that compensates for any decrease in safety that may result from the grant of the exemption;

or

(v) The exemption would provide only temporary relief from the applicable regulation and the licensee or applicant has made good faith efforts to comply with the regulation;

or

(vi) There is present any other material circumstance not considered when the regulation was adopted for which it would be in the public interest to grant an exemption.

If such condition is relied on exclusively for satisfying paragraph (a)(2) of this section, the exemption may not be granted until the Executive Director for Operations has consulted with the Commission.

The NRC staff finds that special circumstances exist pursuant to 10 CFR 50.12(a)(2)(ii) in that the application of the regulation is not necessary to achieve the underlying purpose of the rule. As stated in Section 2.0 above, the more conservative minimum temperature requirements related to footnote 2 to Table 1 of 10 CFR Part 50, Appendix G are not necessary to meet the underlying intent of 10 CFR Part 50, Appendix G, to protect the Byron and Braidwood RPVs from brittle failure during normal operation under both core critical and core non-critical conditions and RPV hydrostatic and leak test conditions.

Authorized by Law

This exemption would allow the use of an alternative methodology in calculating the RPV P-T limits for Byron and Braidwood in lieu of 10 CFR Part 50, Appendix G, paragraph IV.A.2.c. As stated above, 10 CFR 50.12 allows the NRC to grant exemptions from the requirement of 10 CFR Part 50. Furthermore, Section 50.60(b) to 10 CFR Part 50 allows the use of alternatives to 10 CFR Part 50, Appendices G and H, when an exemption is granted by the NRC under 10 CFR 50.12. Therefore, this exemption is authorized by law.

No Undue Risk to Public Health and Safety

The underlying purpose of 10 CFR Part 50, Appendix G, paragraph IV.A.2.c, is to maintain the appropriate fracture margin in the RPV closure head region.

The proposed methodology for the Byron and Braidwood P-T limits relies, in part, on ASME Code, Section XI, Appendix G, which allows the use of the K_{IC} fracture toughness curve rather than the K_{IA} curve. P-T limits developed using the K_{IC} fracture toughness curve permit a much higher allowable pressure through the entire range of temperatures.

The benefit is negated at temperatures below $RT_{NDT} + 120^{\circ}F$ because of the additional flange requirement of 10 CFR Part 50, Appendix G. Using the K_{IC} fracture toughness curve, the analyses presented in WCAP-16143-P show that there is significant margin between the applied stress intensity factor at boltup and the material fracture toughness at cracks postulated to exist in the highest stress region of the closure head/flange region. The analyses also show that the boltup temperature requirement for Byron and Braidwood could be satisfied at $60^{\circ}F$ or higher, easily justifying boltup at ambient temperature.

Based on its review, the NRC staff finds that the results presented in WCAP-16143-P demonstrate that the 10 CFR Part 50, Appendix G RPV closure head flange requirement can be eliminated and appropriate fracture margins would still be maintained.

Based on the above, no new accident precursors are created by using an alternative methodology in calculating the RPV P-T limits; thus, the probability of postulated accidents is not increased. Also, based on the above, the consequences of postulated accidents are not increased. Therefore, there is no undue risk to public health and safety.

Consistent with Common Defense and Security

The proposed exemption would allow the use of an alternative methodology in calculating the RPV P-T limits, in lieu of 10 CFR Part 50, Appendix G, paragraph IV.A.2.c. This

change has no relation to security issues. Therefore, the common defense and security is not impacted by this exemption.

Special Circumstances

Special circumstances, in accordance with 10 CFR 50.12(a)(2), are present whenever application of the regulation in the particular circumstances would not be necessary to achieve the underlying purpose of the rule. The underlying purpose of 10 CFR Part 50, Appendix G, paragraph IV.A.2.c is to maintain the appropriate fracture margin in the RPV closure head region.

The NRC staff examined the licensee's rationale to support the exemption request and, based on its independent review of the information provided in WCAP-16143-P and in EGC's October 3, 2005, application, the NRC staff agrees that an acceptable technical basis has been established to exempt Byron and Braidwood from requirements related to the application of footnote 2 to Table 1 of 10 CFR Part 50, Appendix G. The NRC staff finds that the technical basis provided by EGC demonstrates that an adequate margin of safety against brittle failure would continue to be maintained for Byron and Braidwood RPVs without the application of those requirements related to the application of footnote 2 to Table 1 of 10 CFR Part 50, Appendix G, for normal operation under both core critical and core non-critical conditions and RPV hydrostatic and leak test conditions. The NRC staff concludes, pursuant to 10 CFR 50.12(a)(2)(ii), that the underlying purpose of 10 CFR Part 50, Appendix G will be achieved for Byron and Braidwood without the application of those requirements related to the application of footnote 2 to Table 1 of 10 CFR Part 50, Appendix G.

Therefore, since the underlying purpose of 10 CFR Part 50, Appendix G is achieved, the special circumstances required by 10 CFR 50.12(a)(2) for the granting of an exemption from those requirements related to the application of footnote 2 to Table 1 of 10 CFR Part 50, Appendix G, exist.

4.0 CONCLUSION

Accordingly, the Commission has determined that, pursuant to 10 CFR 50.12(a), the exemption is authorized by law, will not present an undue risk to the public health and safety, and is consistent with the common defense and security. Also, special circumstances are present. Therefore, the Commission hereby grants EGC an exemption from those requirements related to the application of footnote 2 to Table 1 of 10 CFR Part 50, Appendix G, for Byron and Braidwood.

Pursuant to 10 CFR 51.32, the Commission has determined that the granting of this exemption will not have a significant effect on the quality of the human environment (71 FR 57577).

This exemption is effective upon issuance.

Dated at Rockville, Maryland, this 22nd day of November 2006.

FOR THE NUCLEAR REGULATORY COMMISSION

/RA/

Catherine Haney, Director
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