UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

December 30, 2009

Mr. Charles G. Pardee
President and Chief Nuclear Officer
Exelon Nuclear
4300 Winfield Road
Warrenville, IL 60555

SUBJECT: CLINTON POWER STATION, UNIT NO. 1 - REQUEST FOR ALTERNATIVE 4215 FOR CLASS 1 REACTOR VESSEL CIRCUMFERENTIAL SHELL WELDS (TAC NO. ME0407)

Dear Mr. Pardee:

By letter to the Nuclear Regulatory Commission (NRC) dated January 16, 2009 (Agencywide Documents Access and Management System Accession No. ML090210139), Exelon Generation Company, LLC submitted Request for Alternative Number 4215 (Request No. 4215) for Clinton Power Station, Unit No. 1 (Clinton). In Request No. 4215, the licensee proposed an alternative to the examination requirements of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Section XI, for the reactor vessel (RV) circumferential shell welds at Clinton. The NRC staff reviewed and evaluated the licensee's request pursuant to the provisions of Title 10 of the *Code of Federal Regulations* (10 CFR) 50.55a(a)(3)(i).

The NRC staff has completed its review of Request No. 4215. The details of the NRC staff's review are included in the enclosed safety evaluation. Accordingly, Request No. 4215, is authorized pursuant to 10 CFR 50.55a(a)(3)(i) for the remainder of the 40-year licensed operating period at Clinton, which ends on September 29, 2026, and extends up to 32 effective full power years of facility operation, based on the NRC staff's determination that the alternative will provide an acceptable level of quality and safety at Clinton. All other requirements of the ASME Code, Section XI, for which relief has not been specifically requested and approved, remain applicable, including third party review by the Authorized Nuclear Inservice Inspector.

Sincerely,

Stephen J. Campbell, Chief
Plant Licensing Branch III-2
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-461

Enclosure:
Safety Evaluation

cc w/encl: Distribution via Listserv

UNITED STATES
NUCLEAR REGULATORY COMMISSION
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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO REQUEST FOR ALTERNATIVE NO. 4215

EXELON GENERATION COMPANY, LLC

CLINTON POWER STATION

DOCKET NO. 50-461

1.0 INTRODUCTION

By letter dated January 16, 2009 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML090210139), Exelon Generation Company, LLC (the licensee) submitted Request for Alternative Number 4215 (Request No. 4215) for Clinton Power Station, Unit No. 1 (Clinton). In Request No. 4215, the licensee proposed an alternative to the examination requirements of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Section XI, for the reactor vessel (RV) circumferential shell welds at Clinton. The Nuclear Regulatory Commission (NRC) staff reviewed and evaluated the licensee's request pursuant to the provisions of Title 10 of the *Code of Federal Regulations* (10 CFR) 50.55a(a)(3)(i).

2.0 REGULATORY REQUIREMENTS

2.1 Inservice Inspection Requirements

Inservice Inspection (ISI) of the ASME Code Class 1, 2, and 3 components is performed in accordance with Section XI of the ASME Code and applicable addenda as required by 10 CFR 50.55a(g), except where specific relief has been granted by the NRC pursuant to 10 CFR 50.55a(g)(6)(i). Section 50.55a(a)(3) of 10 CFR states that alternatives to the requirements of paragraph (g) may be used, when authorized by the NRC, if: (i) the proposed alternatives would provide an acceptable level of quality and safety or (ii) compliance with the specified requirements would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

Pursuant to 10 CFR 50.55a(g)(4), ASME Code Class 1, 2, and 3 components (including supports) shall meet the requirements, except the design and access provisions and the pre-service examination requirements, set forth in the ASME Code, Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components," to the extent practical within the limitations of design, geometry, and materials of construction of the components. The regulation requires that inservice examination of components and system pressure tests conducted during the first 10-year interval and subsequent intervals comply with the requirements in the latest edition and addenda of Section XI of the ASME Code incorporated by reference in 10 CFR 50.55a(b) 12 months prior to the start of the 120-month interval, subject to the

limitations and modifications listed therein. The applicable Code of record for the second 10-year interval ISI program at Clinton is the 1989 Edition of the ASME Code, Section XI, without addenda.

2.2 Augmented Inservice Inspection Requirements for RV Shell Welds

Section 50.55a(g)(6)(ii)(A)(2) of 10 CFR requires licensees to augment their RV examinations by implementing, as part of the ISI interval in effect on September 8, 1992, the examination requirements for RV shell welds specified in the ASME Code, Section XI, Table IWB-2500-1, Examination Category B-A, "Pressure Retaining Welds in Reactor Vessel," Item B1.10. Item B1.10 includes the volumetric examination requirements for both RV circumferential shell welds, as specified in Item B1.11, and RV longitudinal shell welds, as specified in Item B1.12. Section 50.55a(g)(6)(ii)(A)(2) of 10 CFR defines "essentially 100% examination" as covering 90 percent or more of the specified examination volume of each weld.

2.3 Additional Regulatory Guidance

2.3.1 BWRVIP-05 Report

By letter dated September 28, 1995, as supplemented by letters dated June 24 and October 29, 1996, May 16, June 4, June 13, and December 18, 1997, and January 13, 1998, the Boiling-Water Reactor Vessel and Internals Project (BWRVIP), a technical committee of the BWR Owners Group (BWROG), submitted the Electric Power Research Institute (EPRI) proprietary report TR-105697, "BWR Vessel and Internals Project, BWR Reactor Pressure Vessel Shell Weld Inspection Recommendations (BWRVIP-05)." The BWRVIP-05 report evaluates the current inspection requirements for RV shell welds in BWRs, formulates recommendations for alternative inspection requirements, and provides a technical basis for these recommended requirements. As modified, the BWRVIP-05 report proposed to reduce the scope of inspection of BWR RV welds from essentially 100 percent of all RV shell welds to examination of 100 percent of the axial (i.e., longitudinal) welds and essentially zero percent of the circumferential welds, except for the intersections of the axial and circumferential welds. In addition, the report includes proposals to provide alternatives to ASME Code, Section XI requirements for successive and additional examinations of circumferential welds, specified in paragraphs IWB-2420 and IWB-2430, respectively, of Section XI of the ASME Code.

On July 28, 1998, the NRC staff issued a Safety Evaluation Report (SER) for BWRVIP-05. This evaluation concluded that the failure frequency of RV circumferential welds in BWRs was sufficiently low to justify elimination of ISI for these welds. In addition, the evaluation concluded that the BWRVIP proposals on successive and additional examinations of circumferential welds were acceptable. The evaluation indicated that examination of the circumferential welds will be performed if axial weld examinations reveal an active degradation mechanism. The NRC staff supplemented this evaluation with an SER to the BWRVIP dated March 7, 2000 (ADAMS Accession No. ML003690281). In this SER, the NRC staff updated the interim probabilistic failure frequencies for RV axial shell welds and revised the Table 2.6-4 of the original SER to correct a typographical error in the 32 effective full power years (EFPY) Mean RT_{NDT} value cited for the limiting Chicago Bridge and Iron (CB&I) case study for circumferential welds. The correction changed the 32 EFPY Mean RT_{NDT} value for the CB&I case study from 109.5 °F to 134.9 °F.

In the BWRVIP-05 report, the BWRVIP committee concluded that the conditional probabilities of failure for BWR RV circumferential welds are orders of magnitude lower than that of the axial welds. As a part of its review of the report, the NRC conducted an independent probabilistic fracture mechanics assessment of the results presented in the BWRVIP-05 report. The NRC staff's assessment conservatively calculated the conditional failure probability values for RV axial and circumferential welds during the initial 40-year license period and at conditions approximating an 80-year vessel lifetime for a BWR nuclear plant. The weld failure frequency is calculated as the product of the frequency for the critical (limiting) transient event and the conditional probability of failure for the weld.

The NRC staff determined the conditional probability of failure for axial and circumferential welds in BWR vessels fabricated by CB&I, Combustion Engineering, and Babcock and Wilcox. The analysis identified a cold overpressure event that occurred in a foreign reactor as the limiting event for BWR RVs, with the pressure and temperature from this event used in the probabilistic fracture mechanics calculations. The NRC staff estimated that the probability for the occurrence of the limiting overpressurization transient was 1×10^{-3} per reactor year. For each of the vessel fabricators, Table 2.6-4 of the NRC staff's SER of July 28, 1998, identifies the conditional failure probabilities for the plant-specific conditions with the highest projected reference temperature (for that fabricator) through the expiration of the initial 40-year license period. Table 2.6-5 of the NRC staff's SER of July 28, 1998, identifies the conditional failure probabilities for the plant-specific conditions with the highest projected reference temperature (for that fabricator) through the expiration of an 80-year license period, which constitutes the licensing basis if two 20-year extended periods of operation would have been granted for a BWR-designed nuclear power plant.

2.3.2 Generic Letter 98-05

On November 10, 1998 (ADAMS Accession No. ML082460066), the NRC staff issued Generic Letter (GL) 98-05, "Boiling Water Reactor Licensees Use of the BWRVIP-05 Report to Request Relief from Augmented Examination Requirements on Reactor Pressure Vessel Circumferential Shell Welds." GL 98-05 states that BWR licensees may request permanent relief from the ISI requirements of 10 CFR 50.55a(g) for the volumetric examination of RV circumferential welds (ASME Code Section XI, Table IWB-2500-1, Examination Category B-A, Item No. B1.11, "Circumferential Shell Welds") by demonstrating conformance with the following safety criteria:

1. Licensees will have demonstrated that the conditional failure probability for their limiting RV circumferential welds at the expiration of the plant operating license will continue to satisfy (i.e., be less than) the limiting conditional failure probability for circumferential welds assessed in the applicable BWRVIP-05 limiting case study.

2. Licensees have implemented operator training and established procedures that limit the frequency of cold overpressure events to the amount specified in the NRC staff's July 28, 1998, SER.

In GL 98-05, the NRC staff stated that licensees applying the BWRVIP-05 criteria would need to continue performing the volumetric inspections of all RV axial shell welds that are required by the ASME Code, Section XI, Table IWB-2500-1, Inspection Category B-A, Item B1.12, and the augmented volumetric inspections of the RV axial shell welds that are required under 10 CFR 50.55a(g)(6)(ii)(A)(2). For plants that are currently licensed to operate in accordance

with their initial 40-year operating licenses, the limiting case studies are provided in Table 2.6-4 of the SER on BWRVIP-05 dated July 28, 1998. For plants that have been granted renewed licenses to operate for a 20 year extended period, the limiting case studies are provided in Table 2.6-5 of this SER. In addition to meeting the above criteria, plants granted renewed operating licenses must also demonstrate that the failure probability for their limiting axial shell welds at the end of the period of extended operation is bounded by the limiting axial weld failure frequency of 5×10^{-6} per reactor-year from Table 3 of March 7, 2000, supplemental SER on BWRVIP-05.

3.0 EVALUATION

3.1 Request No. 4215

Request No. 4215 proposed an alternative to the volumetric examination requirements for the RV circumferential shell welds that would remain in effect for the remainder of the 40-year licensed operating period at Clinton, which ends on September 29, 2026. The proposed alternative would allow for the elimination of the RV circumferential shell weld volumetric examinations required by the ASME Code, Section XI in accordance with the alternative probabilistic fracture mechanics methods discussed in the BWRVIP-05 report and GL 98-05.

3.2 Staff Evaluation

The 1989 Edition of the ASME Code, Section XI, Article IWB-2500 requires that components be examined and tested as specified in Table IWB-2500-1 of the ASME Code, Section XI. Table IWB-2500-1, Examination Category B-A, Item No. B1.11 requires a volumetric examination of the RV circumferential shell welds, with essentially 100 percent volumetric coverage of the examination volume specified in Figure IWB-2500-1 of the ASME Code, Section XI for the entire length of the weld.

Pursuant to 10 CFR 50.55a(a)(3)(i), Request 4215 proposed an alternative to the requirements of the ASME Code, Section XI, Table IWB-2500-1, Examination Category B-A, pertaining to the RV circumferential shell welds at Clinton. Specifically, the licensee requested authorization for relief from the ASME Code, Section XI volumetric examination requirements for the RV circumferential shell welds in accordance with the alternative probabilistic fracture mechanics methods discussed in the BWRVIP-05 report and with the NRC's guidelines for proposing these alternative programs, as established in GL 98-05. As part of the proposed alternative, the licensee stated that the RV axial shell welds will continue to receive ISI examinations in accordance with ASME Code, Section XI requirements. The licensee also indicated that limited examinations of the circumferential welds (approximately 2 to 3 percent of the circumferential weld length) shall be performed where the circumferential welds intersect with the axial welds. The procedures and systems used for these examinations shall be qualified such that flaws relevant to the RV integrity can be reliably detected and sized, and the personnel implementing these procedures shall be qualified in accordance with ASME Code requirements. Examinations of circumferential welds, with essentially 100 percent volumetric coverage, shall be performed if the axial weld examinations reveal an active mechanistic mode of degradation. The NRC staff determined that these proposed alternative examinations are consistent with the criteria of BWRVIP-05, as approved by the NRC, for licensees seeking relief from RV circumferential weld examination requirements.

In its submittal for Request No. 4215, the licensee provided a technical basis for relief from the ASME Code, Section XI requirements for examination of RV circumferential shell welds. The licensee based its request on the NRC's provisions for obtaining relief from these requirements in GL 98-05 and the guidelines of BWRVIP-05. The licensee cited the following acceptance criteria as the bases for evaluating the acceptability of its request:

Per the NRC SE on BWRVIP-05 dated July 28, 1998, and GL 98-05, BWR licensees may request relief from the ISI requirements of 10 CFR 50.55a(g) for volumetric examination of [RV] circumferential welds (ASME Code, Section XI, Table IWB-2500-1, Examination Category B-A, Item No. B1.11, Circumferential Shell Welds) by demonstrating the following:

1. The licensee will have demonstrated that the conditional failure probability for their limiting RV circumferential welds at the expiration of the plant operating license will continue to satisfy (i.e., be less than) the limiting conditional failure probability for circumferential welds assessed in the applicable BWRVIP-05 limiting case study.

2. The licensee has implemented operator training and established procedures that limit the frequency of cold overpressure events to the amount specified in the NRC staff's July 28, 1998, SER on BWRVIP-05.

As previously established in BWRVIP-05, the NRC SER for BWRVIP-05, and GL 98-05, the limiting conditional failure probability for each of the circumferential welds assessed in the limiting case studies from the NRC SER for BWRVIP-05 is associated with a specific mean RT_{NDT} value for that weld. This mean RT_{NDT} value was essentially derived from the conditional failure probability for each limiting case study. The limiting case studies, conditional failure probabilities, and associated mean RT_{NDT} values corresponding to a 32 EFPY operating period are listed in Table 2.6-4 of the NRC SER for BWRVIP-05. According to GL 98-05, Criterion 1 above may be met by demonstrating that the end-of-license (EOL) mean RT_{NDT} value for the limiting circumferential weld at the plant is less than that in the applicable limiting case study from Table 2.6-4 of the NRC SER for BWRVIP-05. The applicable limiting case study for Clinton is the conditional failure probability analysis for RVs manufactured by CB&I, the RV manufacturer for Clinton. The mean RT_{NDT} value for the limiting circumferential weld at the plant is equal to the initial RT_{NDT} value for the weld material prior to exposure to neutron radiation plus the projected shift in the RT_{NDT} value (ΔRT_{NDT}) resulting from exposure to neutron radiation during the licensed operating period for the plant (32 EFPY). The ΔRT_{NDT} value is calculated based on the weight percentage of copper and nickel in the weld material (wt. percent Cu and Ni) and the projected EOL neutron fluence for the limiting circumferential weld at the inside diameter of the RV.

The licensee provided its calculations for demonstrating conformance with the Criterion 1 in Table 1 of Request No. 4215. The NRC staff performed an independent calculation of the mean RT_{NDT} value for the limiting circumferential weld at Clinton through the end of the current licensed operating period (32 EFPY). This calculation confirmed that the EOL mean RT_{NDT} value for the limiting circumferential weld at Clinton was correctly calculated by the licensee and is less than the mean RT_{NDT} value corresponding to the limiting circumferential weld failure probability from Table 2.6-4 of the NRC SER for BWRVIP-05. A summary of these calculations is provided below.

RV Circumferential Weld Parameter Description	Clinton RV Limiting Circumferential Weld Parameters at 32 EFPY	32 EFPY Circumferential Weld Parameters for CB&I Case Study from Table 2.6-4 of NRC SER for BWRVIP-05
Cu%	0.10	0.10
Ni%	1.08	0.99
Chemistry Factor (CF)	135	134.1
RV Inner Diameter Fluence (10^{19} n/cm^2)	0.081	0.51
Delta RT_{NDT}	50.77	109.5
Initial RT_{NDT}	-30	-65
Mean RT_{NDT}	20.77	44.5
NRC P(F/E)	---	2.00×10^{-7}

The licensee's calculation of the mean RT_{NDT} value for the RV limiting circumferential weld at Clinton is shown in the first column of the above table. The staff independently confirmed that the licensee correctly calculated this mean RT_{NDT} value. This mean RT_{NDT} value is bounded by the corresponding 32 EFPY mean RT_{NDT} value associated with the circumferential weld conditional failure probability calculated by the NRC staff for the CB&I case study from Table 2.6-4 of the NRC SER for BWRVIP-05, as shown in the second data column of the above table. As discussed in the NRC SER for BWRVIP-05, P(F/E) represents the circumferential weld conditional failure probability calculated by the NRC for the CB&I case study. The actual weld failure frequency is determined in each instance by multiplying the P(F/E) value by the frequency of occurrence for a low temperature over-pressure event, which is 1×10^{-3} per reactor operating year. Thus, the actual weld failure frequency for the CB&I case study is 2.00×10^{-10}. This value is considered to be an acceptable bounding limit on the circumferential weld failure frequency, and the licensee's calculated mean RT_{NDT} value of 20.77 °F from the first column conclusively demonstrates that the Clinton limiting circumferential weld failure frequency at EOL will be substantially less.

Based on the above evaluation, the staff determined that the data provided by the licensee in Request 4215 adequately demonstrated that the limiting circumferential weld at Clinton will satisfy the provisions of Criterion 1 from GL 98-05 through the end of the current 40-year licensed operating period.

In its submittal for Request No. 4215, the licensee stated its bases for meeting Criterion 2 of GL 98-05 above. The licensee included a detailed description of the operational controls, system design considerations, procedural considerations, and operator training programs that are in place to minimize the possibility of a low temperature overpressurization event. The NRC staff independently reviewed these program descriptions and determined that, based on the information provided by the licensee regarding the plant's high pressure coolant injection systems, operating training programs, and plant-specific procedures, the possibility of a low temperature overpressurization event will be minimized. The staff therefore found that the licensee provided a sufficient basis in Request No. 4215 for satisfaction of Criterion 2 from GL 98-05.

Based on the above evaluation, the NRC staff determined that the licensee satisfied both of the acceptance criteria for circumferential weld examination relief from the NRC SER on BWRVIP-05 dated July 28, 1998, and GL 98-05, for the 40-year licensed operating period. Therefore, the staff found that the alternative examinations proposed by the licensee in Request 4215, including examinations of axial welds and limited examinations (approximately 2 to 3 percent) of circumferential welds at intersections with the axial welds, will provide an acceptable level of quality and safety.

4.0 CONCLUSION

The NRC staff concludes that the licensee's request to implement the provisions of BWRVIP-05 and GL 98-05 pertaining to relief from the ASME Code, Section XI examination requirements for the RV circumferential shell welds through the end of the 40-year licensed operating period will provide an acceptable level of quality and safety at Clinton. Therefore, the licensee's proposed alternative in Request 4215 is authorized pursuant to 10 CFR 50.55a(a)(3)(i) for the remainder of the 40-year licensed operating period at Clinton, which ends on September 29, 2026, and extends up to 32 EFPY of facility operation. All other requirements of the ASME Code, Section XI, for which relief has not been specifically requested and approved, remain applicable, including third party review by the Authorized Nuclear Inservice Inspector.

Principal Contributor: C. Sydnor, NRR

Date: December 30, 2009

December 30, 2009

Mr. Charles G. Pardee
President and Chief Nuclear Officer
Exelon Nuclear
4300 Winfield Road
Warrenville, IL 60555

SUBJECT: CLINTON POWER STATION, UNIT NO. 1 - REQUEST FOR ALTERNATIVE 4215 FOR CLASS 1 REACTOR VESSEL CIRCUMFERENTIAL SHELL WELDS (TAC NO. ME0407)

Dear Mr. Pardee:

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The NRC staff has completed its review of Request No. 4215. The details of the NRC staff's review are included in the enclosed safety evaluation. Accordingly, Request No. 4215, is authorized pursuant to 10 CFR 50.55a(a)(3)(i) for the remainder of the 40-year licensed operating period at Clinton, which ends on September 29, 2026, and extends up to 32 effective full power years of facility operation, based on the NRC staff's determination that the alternative will provide an acceptable level of quality and safety at Clinton. All other requirements of the ASME Code, Section XI, for which relief has not been specifically requested and approved, remain applicable, including third party review by the Authorized Nuclear Inservice Inspector.

Sincerely,
/RA/
Stephen J. Campbell, Chief
Plant Licensing Branch III-2
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-461

Enclosure:
Safety Evaluation
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