SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION FOR THE PROPOSED ALTERNATIVE FOR THE USE OF ENCODED PHASED ARRAY ULTRASONIC EXAMINATION TECHNIQUES IN LIEU OF RADIOGRAPHY BRAIDWOOD STATION, UNITS 1 AND 2, BYRON STATION, UNITS 1 AND 2, CALVERT CLIFFS NUCLEAR POWER PLANT, UNITS 1 AND 2, CLINTON POWER STATION, UNIT 1, DRESDEN NUCLEAR POWER STATION, UNITS 2 AND 3, LASALLE COUNTY STATION, UNITS 1 AND 2, LIMERICK GENERATING STATION, UNITS 1 AND 2, NINE MILE POINT NUCLEAR STATION, UNITS 1 AND 2, PEACH BOTTOM ATOMIC POWER STATION, UNITS 2 AND 3, QUAD CITIES NUCLEAR POWER STATION, UNITS 1 AND 2, R. E. GINNA NUCLEAR POWER PLANT, AND THREE MILE ISLAND NUCLEAR STATION, UNIT 1

EXELON GENERATION COMPANY, LLC

DOCKET NOS.: 50-456, 50-457, 50-454, 50-455, 50-317, 50-318, 50-461, 50-237, 50-249, 50-373, 50-374, 50-352, 50-353, 50-220, 50-410, 50-277, 50-278, 50-254, 50-265, 50-244, AND 50-289

1.0 INTRODUCTION

By letter dated November 2, 2016 and amended by letter dated March 13, 2017, (Agencywide Documents Access and Management System (ADAMS) Accession No. ML16307A253 and ML17072A385 respectively), Exelon Generation Company, LLC (the licensee), submitted alternative request "Proposed Alternative For the Use of Encoded Phased Array Ultrasonic Examination Techniques in Lieu of Radiography" (UT-RR) to request relief from the requirements of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (Code) Section XI, Paragraphs IWA-4221 and IWA-4540(a)(2). ASME Code Section XI, Paragraphs IWA-4221 and IWA-4540(a)(2) requires the use of Section III paragraph NC-5200 for repaired and replaced components, which in turn specifies the use of radiographic examinations. The licensee is proposing to use Phased Array Ultrasonic Testing (PAUT) as an alternative to the required radiographic testing.

Specifically, pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) 50.55a(z)(1), the licensee requested to use the proposed alternative on the basis that the alternative would provide an acceptable level of quality and safety.

2.0 REGULATORY EVALUATION

The Relief Request "Proposed Alternative For the Use of Encoded Phased Array Ultrasonic Examination Techniques in Lieu of Radiography" 10 CFR 50.55a(a)(z)(1), which covers requests for alternatives on the basis that the proposed alternative would provide an acceptable level of quality and safety.

10 CFR 50.55a(g)(4) states, in part, that in a boiling or pressurized water-cooled nuclear power facility, components that are classified as ASME Code Class 1, Class 2, and Class 3 must meet the requirements set forth in ASME Code Section XI. Additionally, 10 CFR 50.55a(b)(2)(xx)(B)

ENCLOSURE

requires that the Nondestructive Examination (NDE) provision in IWA-4540(a)(2) of the 2002 Addenda of Section XI must be applied when performing system leakage tests after repair and replacement activities performed by welding or brazing on a pressure retaining boundary.

The licensee has requested relief from the requirements of ASME Code Section XI paragraph IWA-4221 and IWA-4540(a)(2). Section XI section IWA-4200 covers repair/replacement activities, and paragraph IWA-4221 requires that when the licensee replaces an existing item, the replacement shall meet the requirements of the Construction Code to which the original item was constructed. IWA-4540(a)(2) of the 2002 Addenda of Section XI requires that the NDE method and acceptance criteria of the 1992 Edition or later of Section III be met prior to return to service in order to perform a system leakage test in lieu of a system hydrostatic test.

Title 10 CFR 50.55a(z) states, in part, that alternatives to the requirements of 10 CFR 50.55a(b)-(h) may be used, when authorized by the U.S. Nuclear Regulatory Commission (NRC), if (1) the proposed alternatives would provide an acceptable level of quality and safety or (2) compliance with the specified requirements would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

Based on the above, and subject to the following technical evaluation, the NRC staff finds that regulatory authority exists for the licensee to request and the Commission to authorize the alternative requested by the licensee.

3.0 TECHNICAL EVALUATION

3.1 The Licensee's Relief Request

ASME Code Components Affected

UT-RR covers ASME Code, Section XI, ferritic piping butt welds requiring radiography during repair/replacement activities at the nuclear power reactors listed in Table 1.

ASME Code Requirement

10 CFR 50.55a(b)(2)(xx)(B) requires that "The NDE provision in IWA-4540(a)(2) of the 2002 Addenda of Section XI must be applied when performing system leakage tests after repair and replacement activities performed by welding or brazing on a pressure retaining boundary using the 2003 Addenda through the latest edition and addenda incorporated by reference in paragraph (a)(1)(ii) of this section." IWA-4540(a)(2) of the 2002 Addenda of Section XI requires that the NDE method and acceptance criteria of the 1992 Edition or later of Section III be met prior to return to service in order to perform a system leakage test in lieu of a system hydrostatic test.

Additionally, ASME Section XI paragraph IWA-4221 requires the owner to use the requirements of the construction code for repair/replacement activities. The examination requirements for ASME Section III, circumferential butt welds are contained in the ASME Code, Section III, Subarticle NB-5200, NC-5200 and ND-5200. The acceptance standards for radiographic examination are specified in Subarticle NB-5300, NC-5300 and ND-5300.

ASME Codes of Record

The Editions and addenda for each nuclear power reactor covered by UT-RR are described in Table 1.

Table 1: ASME Code Section XI Codes of Record for Plants covered by UT-RR

Reactor	Section XI Edition
Braidwood Station, Units 1 and 2	2001 Edition, through 2003 Addenda
Byron Station, Units 1 and 2	2007 Edition, through 2008 Addenda
Calvert Cliffs Nuclear Power Plant, Units 1 and 2	2004 Edition
Clinton Power Station, Unit 1	2004 Edition
Dresden Nuclear Power Station, Units 2 and 3	2007 Edition, through 2008 Addenda
LaSalle Units 1 and 2	2007 Edition, through 2008 Addenda
Limerick Generating Station, Units 1 and 2	2007 Edition, through 2008 Addenda
Nine Mile Point Nuclear Station, Unit 1	2004 Edition
Nine Mile Point Nuclear Station, Unit 2	2004 Edition
Peach Bottom Atomic Power Station, Units 2 and 3	2001 Edition, through 2003 Addenda
Quad Cities Nuclear Power Station, Units 1 and 2	2007 Edition, through 2008 Addenda
R. E. Ginna Nuclear Power Plant	2004 Edition
Three Mile Island Nuclear Station, Unit 1	2004 Edition

Proposed Alternative

The licensee is proposing the use of encoded PAUT in lieu of the ASME code-required RT examinations for ferritic piping repair/replacement welds. The proposed alternative qualification program are based on ASME Code Case N-831, with some small changes in wording for clarification. ASME Code case N-831 was approved by the ASME Standards committee on September 27, 2016.

The encoded PAUT procedures, equipment, and personnel will be qualified using performance demonstration testing. The flaw acceptance standards for the PAUT tests will consider all flaws to be planar and use evaluated against the preservice acceptance standards of ASME Section XI, IWB-3400, IWC-3400, or IWD-3400 for ASME Code Class 1, 2, or 3 welds, respectively.

Basis for Use

The basis for UT-RR is that encoded PAUT is equivalent to or superior for detecting and sizing planar flaws as compared to the required radiographic examination. The examination procedure and personnel performing examinations are qualified via performance demonstration testing using representative piping conditions and flaws that demonstrate the ability to detect and size flaws that are both acceptable and unacceptable to the defined acceptance standards.

Ultrasonic testing techniques are being used throughout the nuclear industry for examination of dissimilar metal welds and overlaid welds, as well as other applications including ASME B31.1 piping replacements.

Duration of Proposed Alternative

The licensee is requesting that this proposed alternative be applied for the duration of the ten-year inservice inspection intervals for each of the facilities as described in Table 2.

Table 2: Interval start and scheduled end dates for plants covered by UT-RR

Plant	Interval	Start	End
Braidwood Station, Unit 1	Third	July 29, 2008	July 28, 2018
Braidwood Station, Unit 2	Third	October 17, 2008	October 16, 2018
Byron Station, Units 1 and 2	Fourth	July 16, 2016	July 15, 2025
Calvert Cliffs Nuclear Power Plant, Units 1 and 2	Fourth	October 10, 2009	June 30, 2019
Clinton Power Station, Unit 1	Third	July 1, 2010	June 30, 2020
Dresden Nuclear Power Station, Units 2 and 3	Fifth	January 20, 2013	January 19, 2023
LaSalle Units 1 and 2	Fourth	October 1, 2017	September 30, 2027
Limerick Generating Station, Units 1 and 2	Fourth	February 1, 2017	January 31, 2027
Nine Mile Point Nuclear Station, Unit 1	Fourth	August 23, 2009	August 22, 2019
Nine Mile Point Nuclear Station, Unit 2	Third	April 5, 2008	June 15, 2018
Peach Bottom Atomic Power Station, Units 2 and 3	Fourth	November 5, 2008	December 31, 2018
Quad Cities Nuclear Power Station, Units 1 and 2	Fifth	April 2, 2013	April 1, 2023
R. E. Ginna Nuclear Power Plant	Fifth	January 1, 2010	December 31, 2019
Three Mile Island Nuclear Station, Unit 1	Fourth	April 20, 2011	April 19, 2022

3.2 Staff Evaluation

The licensee is proposing to use encoded PAUT in lieu of radiographic testing in UT-RR for repair and replacement activities in 21 nuclear power reactors for the remainder of their current 10-year inspection intervals. Ultrasonic testing, like radiographic testing, is a volumetric inspection technique that is commonly used to inspect welds in nuclear power plants and in other industries. Ultrasonic examinations are not equivalent to radiographic examinations as they use different physical mechanisms to detect and characterize discontinuities. These differences in physical mechanisms result in several key differences in sensitivity and discrimination capability.

The NRC staff has been assessing the effectiveness of the use of ultrasound in lieu of radiography since 2009, including literature reviews, detailed evaluations of previous relief requests and proposed alternatives, and confirmatory experimental work to validate the findings. An assessment of the use of UT in lieu of RT by the NRC is described in the 2015 NUREG/CR-7204 “Applying Ultrasonic Testing In Lieu of Radiography for Volumetric Examination of Carbon Steel Piping” (ADAMS Accession No. ML15253A674). This report included evaluation on the

use of UT in lieu of RT for welded pipes and plates with thicknesses ranging from 0.844 inches to 2.2 inches thick.

One conclusion from NUREG/CR-7204 is:

> "Considering overall detections/non-detections for the piping specimens, as well as the Navy plates, it appears that phased array ultrasonic inspection (PA-UT), based on the techniques applied in this study, provides an equally effective examination for identifying the presence of fabrication flaws in carbon steel welds. The PA-UT parameters applied were shown to be more effective for planar flaws, but slightly less effective for small volumetric flaws, than RT."

Based on this research the NRC staff finds that there is a sufficient technical basis for the use of UT in lieu of RT for ferritic steel welds. Given that UT in lieu of RT can be effective, the NRC staff worked to determine if the proposed alternative applies UT in a way that provides reasonable assurance of finding structurally-significant flaws.

Important aspects of this proposed alternative include:

The examination volume shall include 100% of the weld volume and the weld- to-base-metal interface.

The electronic data files for the PAUT examinations will be stored as archival-quality records. In addition, hard copy prints of the data will also be included as part of the PAUT examination records to allow viewing without the use of hardware or software.

Ultrasonic examination procedures shall be qualified by using either a blind or a non-blind performance demonstration using a minimum of 30 flaws covering a range of sizes, positions, orientations, and types of fabrication flaws. The demonstration set shall include specimens to represent the minimum and maximum diameter and thickness covered by the procedure.

The flaw through-wall heights for the performance demonstration testing shall be based on the applicable acceptance standards for volumetric examination in accordance with IWB-3400, IWC-3400 or IWD-3400. At least 30% of the flaws shall be classified as acceptable planar flaws, with the smallest flaws being at least 50% of the maximum allowable size based on the applicable a/l aspect ratio for the flaw.

Ultrasonic examination personnel shall demonstrate their capability to detect and size flaws by performance demonstration using the qualified procedure. The demonstration specimen set shall contain at least 10 flaws covering a range of sizes, positions, orientations, and types of fabrication flaws.

All flaws detected using angle-beam ultrasonic inspections will be treated as planar flaws and will be evaluated against the preservice acceptance standards of ASME Section XI, IWB-3400, IWC-3400, or IWD-3400 for ASME Code Class 1, 2, or 3 welds, respectively.

A significant change from the use of Section III radiography requirements is the use of Section XI flaw acceptance standards as opposed to Section III NB-5330, NC-5330, and ND-5330 flaw acceptance standards. Section III acceptance standards require the inspector to detect and determine the type of flaw (e.g. Porosity, lack of fusion, slag, incomplete penetration). While

radiography is effective at discerning between different flaw types, it is less capable than UT at detecting planar flaws such as cracks and lack-of-fusion defects. While ASME Section XI, IWB-3400, IWC-3400, and IWD-3400 allow larger flaws than Section III NB-5330, NC-5330, and ND-5300 the use of ASME Section XI acceptance standards has proven effective for piping welds for in-service inspections. The NRC staff finds that the use of ASME Section XI acceptance standards is appropriate for the proposed alternative, as the proposed alternative is for repair/replacement activities, not new plant construction, and the favorable industry experience with ASME Section XI.

Based on the inspection and qualification requirements described in UT-RR and the results of NUEG/CR-7204, there is reasonable assurance that the encoded phased array UT qualified as proposed by the licensee will provide an adequate level of quality and safety.

4.0 CONCLUSION

As set forth above, the NRC staff concludes that the licensee's proposed alternative to use ultrasonic testing in lieu of radiographic testing using encoded phased array examinations provides reasonable assurance of structural integrity and leak tightness of Class 1 and 2 ferritic piping welds. Thus, ultrasonic testing using the procedure described in the submittals of the subject welds would provide an adequate level of quality and safety. Accordingly, the NRC staff concludes that the licensee has adequately addressed all of the regulatory requirements set forth in 10 CFR 50.55a(z)(1). Therefore, the NRC staff authorizes relief request "Proposed Alternative For the Use of Encoded Phased Array Ultrasonic Examination Techniques in Lieu of Radiography" for the 21 nuclear power facilities described in Table 2 for the remainder of the 10-year inservice inspection intervals given in Table 2.

All other requirements of the ASME Code for which relief has not been specifically requested remain applicable, including third-party review by the Authorized Nuclear Inservice Inspector.