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

June 26, 2014

Mr. Michael P. Gallagher
Vice President, License Renewal Projects
Exelon Generation Company, LLC
200 Exelon Way
Kennett Square, PA 19348

SUBJECT: REQUEST FOR ADDITIONAL INFORMATION FOR THE REVIEW OF THE BYRON STATION, UNITS 1 AND 2, AND BRAIDWOOD STATION, UNITS 1 AND 2, LICENSE RENEWAL APPLICATION, SET 36 (TAC NOS. MF1879, MF1880, MF1881, AND MF1882)

Dear Mr. Gallagher:

By letter dated May 29, 2013, Exelon Generation Company, LLC, submitted an application pursuant to Title 10 of the *Code of Federal Regulations* Part 54, to renew the operating licenses NPF-37, NPF-66, NPF-72, and NPF-77 for Byron Station, Units 1 and 2, and Braidwood Station, Units 1 and 2, respectively, for review by the U.S. Nuclear Regulatory Commission (NRC or the staff). The staff is reviewing the information contained in the license renewal application and has identified, in the enclosure, areas where additional information is needed to complete the review.

These requests for additional information were discussed with John Hufnagel, and a mutually agreeable date for the response is within 30 days from the date of this letter. If you have any questions, please contact me at 301-415-4115 or e-mail Lindsay.Robinson@nrc.gov.

Sincerely,

/RA John Daily for/

Lindsay R. Robinson, Project Manager
Projects Branch 1
Division of License Renewal
Office of Nuclear Reactor Regulation

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

Enclosure:
Request for Additional Information

cc w/encl: Listserv

June 26, 2014

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Vice President, License Renewal Projects
Exelon Generation Company, LLC
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ADAMS Accession No.: ML14176A090 *concurred via email

OFFICE	LA:DLR*	PM:RPB1:DLR	BC:RPB1:DLR	PM:RPB1:DLR
NAME	YEdmonds	LRobinson	YDiazSanabria	LRobinson (JDaily for)
DATE	6/25/14	6/25/14	6/26/14	6/26/14

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Letter to M.P. Gallagher from Lindsay R. Robinson dated June 26, 2014

SUBJECT: REQUEST FOR ADDITIONAL INFORMATION FOR THE REVIEW OF THE BYRON STATION, UNITS 1 AND 2, AND BRAIDWOOD STATION, UNITS 1 AND 2, LICENSE RENEWAL APPLICATION, SET 36 (TAC NOS. MF1879, MF1880, MF1881, AND MF1882)

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BYRON STATION, UNITS 1 AND 2,
AND BRAIDWOOD STATION, UNITS 1 AND 2,
LICENSE RENEWAL APPLICATION
REQUEST FOR ADDITIONAL INFORMATION, SET 36
(TAC NOS. MF1879, MF1880, MF1881, MF1882)

RAI 3.1.2.3.4-1a

Applicability:

Byron Station (Byron) and Braidwood Station (Braidwood), Unit 1

Background:

By letter date May 12, 2014, the applicant responded to request for additional information (RAI) 3.1.2.3.4-1 which addressed loss of fracture toughness in Byron and Braidwood, Unit 1 steam generator internal structural supports. In its response, the applicant revised license renewal application Table 3.1.2-4 by deleting the aging management review (AMR) line item which manages loss of fracture toughness for Byron and Braidwood, Unit 1 steam generator tube support lattice bar attachment components made of cast austenitic stainless steel (CASS). The deleted AMR line item indicated that these CASS components are exposed to treated water greater than 482 degrees Fahrenheit and may experience loss of fracture toughness due to thermal aging embrittlement. Byron and Braidwood manage both by the Steam Generators program.

The applicant further stated that loss of fracture toughness due to thermal aging embrittlement is not applicable to these steam generator CASS internal components (i.e., internal supports and structures and tube support plates and U-bend supports). The applicant reviewed the Grimes' letter to Walters on License Renewal Issue No. 98-0030, "Thermal Aging Embrittlement of Cast Stainless Steel Components," dated May 19, 2000, (ADAMS Accession Number ML003717179) and provided the following justification for excluding the steam generator tube support lattice bar attachment components, fabricated from SA-351 CF3M CASS, from being susceptible to thermal aging embrittlement.

The concern associated with thermal aging embrittlement is the reduction in fracture toughness of a component at low temperatures (i.e., room temperature) and the potential for non-ductile failure at low temperatures. The material properties at high temperature are not affected. Therefore, fracture of a CASS component is not expected at low temperatures. Since the loading on the CASS components at low temperature is negligible, the possibility that loss of fracture toughness would render the component incapable of performing its function without showing any visual evidence of cracking, deformation, or damage is also negligible.

The staff reviewed the Grimes' letter, dated May 19, 2000, and notes that it states that aging of CASS at reactor operating temperatures of 280-350 degrees Celsius (536-662 degrees Fahrenheit) can lead to changes in the mechanical properties of these materials, depending on the characteristics of the material and the environment to which the component is exposed.

The effects of thermal aging on materials include increases in the tensile strength, hardness, and Charpy impact energy transition temperature, as well as decreases in ductility, fracture toughness, and impact strength.

Further, NUREG/CR-6923, “Expert Panel Report on Proactive Materials Degradation Assessment” February 2007, states that:

> Thermal aging of CASS at boiling water reactor and pressurized water reactor operating temperatures is characterized by an increase in hardness and tensile strength and a decrease in ductility, impact strength and toughness. In addition, the "brittle-ductile" transition temperature increases **and the upper shelf decreases** (emphasis added).

The upper shelf decrease described in NUREG/CR-6923 relates directly to behavior of CASS at operating temperatures, contrary to the assertion in the RAI response that the concerns with thermal aging embrittlement only apply at low temperatures.

As cited in the Grimes’ letter, thermal aging of CASS results in reduced toughness, which means that the aged CASS component can tolerate smaller flaw sizes. Since the toughness of CASS is not directly measureable, the Grimes’ letter and the Generic Aging Lessons Learned (GALL) Report cite that thermal aging of CASS can be appropriately managed by inspections to demonstrate that flaws of a potentially critical size are not present in the CASS component.

In addition, GALL Report aging management program (AMP) XI.M12 states that for high-molybdenum content steels (SA-351 Grades CF3M, CF3MA, and CF8M or other steels with 2.0 to 3.0 wt. percent Mo), static-cast steels with >14 percent ferrite and centrifugal-cast steels with >20 percent ferrite are potentially susceptible to thermal embrittlement. Static-cast high-molybdenum steels with ≤14 percent ferrite and centrifugal-cast high-molybdenum steels with ≤20 percent ferrite are not susceptible.

<u>Issue</u>:

Thermal aging embrittlement of CASS may result in reduction in fracture toughness of a component at operating conditions (i.e., 536-662 degrees Fahrenheit), contrary to the assertion in the RAI response that it only applies at low temperatures. The reduction in fracture toughness of CASS requires adequate aging management.

<u>Request</u>:

1. Please provide the composition, ferrite content, and the fabrication method to determine if the SA-351 CF3M CASS components are susceptible to thermal aging embrittlement in accordance with the guidance of AMP XI.M12. If so,

    a) Justify the assertion in the response to RAI 3.1.2.3.4-1 that the concern associated with thermal aging embrittlement is a reduction in fracture toughness and a potential for non-ductile failure at low temperatures (i.e., room temperature).

    b) Discuss how the proposed examinations will be adequate to provide assurance that the CASS components will not have flaws that could either (a) challenge the ability of the component to perform its intended safety function during normal operation, transient, and accident conditions; or (b) result in the generation of loose parts that could adversely affect the performance of other parts of the steam generator or downstream components.