



Michael P. Gallagher
Vice President, License Renewal
Exelon Nuclear
200 Exelon Way
Kennett Square, PA 19348
610 765 5958 Office
610 765 5956 Fax
www.exeloncorp.com
michaelp.gallagher@exeloncorp.com

10 CFR 50
10 CFR 51
10 CFR 54

RS-14-221

July 25, 2014

U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, DC 20555-0001

Braidwood Station, Units 1 and 2
Facility Operating License Nos. NPF-72 and NPF-77
NRC Docket Nos. STN 50-456 and STN 50-457

Byron Station, Units 1 and 2
Facility Operating License Nos. NPF-37 and NPF-66
NRC Docket Nos. STN 50-454 and STN 50-455

Subject: Response to NRC Request for Additional Information, Set 36, dated June 26, 2014, related to the Braidwood Station, Units 1 and 2, and Byron Station, Units 1 and 2, License Renewal Application

References: 1. Letter from Michael P. Gallagher, Exelon Generation Company LLC (Exelon) to NRC Document Control Desk, dated May 29, 2013, "Application for Renewed Operating Licenses."

2. Letter from Lindsay R. Robinson, US NRC to Michael P. Gallagher, Exelon, dated June 26, 2014, "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)"

In Reference 1, Exelon Generation Company, LLC (Exelon) submitted the License Renewal Application (LRA) for the Byron Station, Units 1 and 2, and Braidwood Station, Units 1 and 2 (BBS). In Reference 2, the NRC requested additional information to support staff review of the LRA.

Enclosure A contains the response to this request for additional information.

Enclosure B contains an update to the section of the LRA affected by the response.

There are no new or revised regulatory commitments contained in this letter.

If you have any questions, please contact Mr. Al Fulvio, Manager, Exelon License Renewal, at 610-765-5936.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on 7-25-2014

Respectfully,



Michael P. Gallagher
Vice President - License Renewal Projects
Exelon Generation Company, LLC

Enclosures: A. Response to Request for Additional Information
B. Update to affected LRA sections

cc: Regional Administrator – NRC Region III
NRC Project Manager (Safety Review), NRR-DLR
NRC Project Manager (Environmental Review), NRR-DLR
NRC Senior Resident Inspector, Braidwood Station
NRC Senior Resident Inspector, Byron Station
NRC Project Manager, NRR-DORL-Braidwood and Byron Stations
Illinois Emergency Management Agency - Division of Nuclear Safety

Enclosure A

Byron and Braidwood Stations (BBS), Units 1 and 2

License Renewal Application

Response to Request for Additional Information

RAI 3.1.2.3.4-1a

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 measurable, 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.

Issue:

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.

Request:

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.

Exelon Response:

1. Byron and Braidwood Unit 1 steam generators tube support lattice bar attachment components are castings fabricated from SA-351 CF3M CASS material, which include various hardware fittings (i.e., end connections, centre connections, and link bars). The following tables provide material compositions for each lot used to fabricate these components. These values were documented in the original Certified Material Test Reports (CMTRs) or Commercial Grade Dedications (CGDs) for these components. Also documented in the tables are the maximum ferrite content values calculated in accordance with NUREG/CR-4513, "Estimation of Fracture Toughness of Cast Stainless Steels During Thermal Aging in LWR Systems, U.S. Nuclear Regulatory Commission", Revision 1, August 1994, using Hull's equivalent factors.

Table 1, Material composition and calculated ferrite content for Byron Unit 1 steam generator tube support lattice bar attachment components made of SA-351 CF3M

Component	Cr (%)	Mo (%)	Si (%)	Ni (%)	Mn (%)	C (%)	N (%)	Ferrite Content (%)
Link Bar	18.2	2.4	1.13	10.8	0.95	0.017	0.04 (1)	9.05
End Connection	18.0	2.44	1.12	10.6	0.98	0.018	0.04 (1)	9.19
Centre Connection	18.2	2.45	1.21	10.8	1.00	0.025	0.04 (1)	8.59

Table 2, Material composition and calculated ferrite content for Braidwood Unit 1 steam generator tube support lattice bar attachment components made of SA-351 CF3M

Component	Cr (%)	Mo (%)	Si (%)	Ni (%)	Mn (%)	C (%)	N (%)	Ferrite Content (%)
Link Bar	18.1	2.49	1.29	10.7	1.00	0.029	0.04 (1)	8.55
End Connection	18.2	2.69	1.40	10.8	0.93	0.023	0.04 (1)	10.25
Centre Connection	17.6	2.6	1.80	11.2	0.92	0.022	0.04 (1)	7.00

Note 1 (Applies to Tables 1 and 2) – The concentration of N was not available in the CMTRs and CGDs. Therefore in accordance with the guidance in NUREG/CR-4513, Revision 1, Section 3.2.1; the concentration of N was assumed to be 0.04%.

The Byron and Braidwood Unit 1 steam generator tube support lattice bar attachment components do not contain niobium.

The original CMTRs and CGDs for the material lots which were used to fabricate the Byron and Braidwood Unit 1 steam generator tube support lattice bar attachment components do not indicate whether these parts were fabricated by static or centrifugal fabrication methods.

NUREG-1801, Revision 2, Section XI.M12, "Thermal Aging Embrittlement of Cast Austenitic Stainless Steel (CASS)" documents the following screening criteria.

"Static-cast high-molybdenum steels with $\leq 14\%$ ferrite and centrifugal-cast high-molybdenum steels with $\leq 20\%$ ferrite are not susceptible [to thermal embrittlement]."

The ferrite content values, documented in the above tables, are less than both of these criteria. Therefore, the Byron and Braidwood (BBS) Unit 1 steam generator tube support lattice bar attachment components made from SA-351 CF3M cast austenitic stainless steel are not susceptible to loss of fracture toughness due to thermal aging embrittlement.

- a) As discussed above, the BBS Unit 1 steam generator tube support lattice bar attachment components made from SA-351 CF3M CASS have ferrite content less than the screening criteria. There are no other BBS Unit 1 Steam Generator System components made from CASS. Therefore, the aging effect of loss of fracture toughness due to thermal aging embrittlement of CASS materials and a potential for non-ductile failure is not applicable to the BBS Unit 1 Steam Generator system at any temperature for which the steam generators were designed.
- b) As discussed above, the BBS Unit 1 steam generator tube support lattice bar attachment components made from SA-351 CF3M cast austenitic stainless steel are not susceptible to thermal aging embrittlement. Therefore, the loss of fracture toughness due to thermal aging embrittlement is not applicable and will not challenge the ability of these components to perform their intended safety function during normal operation, transient, and accident conditions, nor result in the generation of loose parts that could adversely affect the performance of other parts of the steam generator or downstream components. Therefore, examinations to manage loss of fracture toughness due to thermal aging embrittlement are not required for these components.

LRA Table 3.1.2-4 is revised as shown in Enclosure B to remove this aging effect. LRA component type Steam Generators (Internal Supports and Structures) include the end connection and centre connection components. LRA component type Steam Generators (Tube Support Plates and U-Bend Supports) includes the link bar components.

Enclosure B

Byron and Braidwood Stations, Units 1 and 2

License Renewal Application (LRA)

Update to affected LRA Sections as a result of the following RAI:

RAI 3.1.2.3.4-1a

Note: To facilitate understanding, the original LRA pages have been repeated in this Enclosure, with revisions indicated. Existing LRA text is shown in normal font. Changes are highlighted with ***bolded italics*** for inserted text and ~~strikethroughs~~ for deleted text.

Enclosure B

LRA Table 3.1.2-4 on page 3.1-104 is revised as shown below to remove this aging effect of loss of fracture toughness due to thermal aging embrittlement. Existing text from the LRA is shown in normal font. Inserted text is highlighted by ***bolded italics***.

Table 3.1.2-4 Steam Generators (Continued)

Component Type	Intended Function	Material	Environment	Aging Effect Requiring Management	Aging Management Programs	NUREG-1801 Item	Table 1 Item	Notes
Steam Generators (Internal Supports and Structures)	Structural Support	Cast Austenitic Stainless Steel (CASS) - (Byron Unit 1 and Braidwood Unit 1 only)	Treated Water > 482 F (External)	Cracking	Steam Generators (B.2.1.10)	IV.D1.RP-384	3.1.1-71	B, 3
					Water Chemistry (B.2.1.2)	IV.D1.RP-384	3.1.1-71	A, 3

LRA Table 3.1.2-4 on page 3.1-105 is revised as shown below to remove this aging effect of loss of fracture toughness due to thermal aging embrittlement. Existing text from the LRA is shown in normal font. Deletions are shown with ~~strikethroughs~~.

Table 3.1.2-4 Steam Generators (Continued)

Component Type	Intended Function	Material	Environment	Aging Effect Requiring Management	Aging Management Programs	NUREG-1801 Item	Table 1 Item	Notes
Steam Generators (Internal Supports and Structures)	Structural Support	Cast Austenitic Stainless Steel (CASS) - (Byron Unit 1 and Braidwood Unit 1 only)	Treated Water > 482 F (External)	Loss of Fracture Toughness	Steam Generators (B.2.1.10)			H, 3
				Loss of Material	Steam Generators (B.2.1.10)	IV.D1.RP-225	3.1.1-76	B
						IV.D1.RP-226	3.1.1-71	B
Water Chemistry (B.2.1.2)	IV.D1.RP-226	3.1.1-71	A					

LRA Table 3.1.2-4 on page 3.1-114 is revised as shown below to remove this aging effect of loss of fracture toughness due to thermal aging embrittlement. Existing text from the LRA is shown in normal font. Inserted text is highlighted by ***bolded italics***, deletions are shown with ~~strikethroughs~~.

Table 3.1.2-4 Steam Generators (Continued)

Component Type	Intended Function	Material	Environment	Aging Effect Requiring Management	Aging Management Programs	NUREG-1801 Item	Table 1 Item	Notes
Steam Generators (Tube Support Plates and U-Bend Supports)	Structural Support	Cast Austenitic Stainless Steel (CASS) - (Byron Unit 1 and Braidwood Unit 1 only)	Treated Water > 482 F (External)	Cracking	Steam Generators (B.2.1.10)	IV.D1.RP-384	3.1.1-71	B, 3
					Water Chemistry (B.2.1.2)	IV.D1.RP-384	3.1.1-71	A, 3
				Loss of Fracture Toughness	Steam Generators (B.2.1.10)			H, 3
				Loss of Material	Steam Generators (B.2.1.10)	IV.D1.RP-225	3.1.1-76	B
						IV.D1.RP-226	3.1.1-71	B

The Plant Specific Note 3 following LRA Table 3.1.2-4 is revised as shown below to remove this aging effect of loss of fracture toughness due to thermal aging embrittlement. Existing text from the LRA, as modified by subsequent submittals, is shown in normal font. Inserted text is highlighted by ***bolded italics***; deletions are shown with ~~strikethroughs~~.

3. ~~The Steam Generators (B.2.1.10) program inspection activities include periodic visual inspection of the steam generator secondary side internal components and eddy current testing of the steam generator tubes. The steam generator CASS components are non-pressure retaining, do not perform an intended function at low temperatures, and are not subjected to loads that would result in a non-ductile failure at low temperatures. No additional inspection activities are required to manage the loss of fracture toughness due to thermal aging embrittlement.~~ ***The steam generator tube support lattice bar attachment components, fabricated from SA-351 CF3M cast austenitic stainless steel (CASS), are not Class 1 pressure boundary components. Therefore, these components are not included in the Thermal Aging Embrittlement of Cast Austenitic Stainless Steel (CASS) (B.2.1.6) program. Additionally, the steam generator tube support lattice bar attachment components were determined not to be susceptible to loss of fracture toughness due to thermal aging embrittlement based on ferrite content.***