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To:	Poehler, Jeffrey; Hardies, Robert
Cc:	NATOUR Tammy (AREVA); Fyfitch, Stephen; Holonich, Joseph; Malikowski, Heather M:(GenCo-Nuc)
Subject:	[External_Sender] Distribution of AREVA-16-02248: Transmittal of Final AREVA Customer Service Bulletin No. 16-02 Regarding Recent BFB NDE OE to the Operating B&W-designed 177-FA Units
Date:	Monday, July 18, 2016 4:34:29 PM
Attachments:	PA-MSC-1473 Baffle Bolt Customer Service Bulletin.pdf

Jeff and Bob,

See attached the AREVA Baffle Bolt Customer Service Bulletin for you use.

Please let me know if you have any questions.

Regards,

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CUSTOMER SERVICE BULLETIN NO. 16-02

DATE: 07/14/16

SUBJECT: Relevance of Recent Baffle-to-Former Bolt Degradation at Westinghouse-designed 4-Loop Units and Its Impact on B&W-designed 177-FA RV Internals Operability

AREVA CONTRACT(S): All Operating B&W 177-FA Units

PRODUCT OR SERVICE: RV Internals Baffle-to-Former and Baffle-to-Baffle Bolts

CUSTOMER PURCHASE ORDER(S): N/A

DESCRIPTION: Recent operating experience (OE) obtained during baffle-to-former bolt (BFB) non-destructive examinations at two Westinghouse-designed 4-loop units has identified a significant number of BFB failures. This Customer Service Bulletin is being issued to provide the preliminary evaluations performed by AREVA Inc. of the relevance of the observed OE conditions to the operating B&W-designed 177-FA units. In addition, a preliminary evaluation by AREVA Inc. relative to the risk to safety and operability has also been performed and provided herein.

RECOMMENDATION: Since the root cause(s) of the failures is yet unknown, it is not known if such degradation is unique to the Westinghouse-designed units or if it affects the B&W-designed 177-FA units. However, based on the currently available information, AREVA Inc. believes that the OE is limited at this time to a subset of design and operating conditions for the Westinghouse operating units and not an immediate risk to the safety and operability of the B&W-designed 177-FA units. Until further evaluation and assessment of the current issue is completed through the PWROG (i.e., PA-MSC-1473) and the industry BFB Focus Group, it is recommended that the B&W-designed 177-FA units continue to follow the BFB, baffle-to-baffle bolt (BBB), and BFB and BBB locking devices/locking weld inspection guidelines of MRP-227 and implement any future MRP guidance changes. In addition, it is also recommended that the B&W-designed 177-FA units maintain increased awareness of telltale signs of BFB and BBB degradation through continuation of the following existing activities: a) evaluating reactor coolant radioactivity levels during the fuel cycle, b) performing loose parts monitoring and foreign object search and removal (FOSAR) examinations as part of normal refueling activities, and, c) performing visual examinations of the peripheral fuel assemblies currently identified for assessment of fuel performance. Additional details are provided in the attachment.

☐ SPECIFICALLY APPLICABLE ☒ INFORMATION ONLY

AREVA NP INC. CONTACT: Steve Fyfitch TELEPHONE NO.: 412-264-1610

ATTACHMENTS: Attachment 1 – Evaluation of Recent Baffle-to-Former Bolt Degradation at Westinghouse-designed 4-Loop Units and Its Impact to B&W-designed 177-FA RV Internals Operability

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Background

In March 2016, visual and ultrasonic examination of the BFBs at Indian Point Unit 2 identified 31 visually failed bolts and 182 bolts that exhibited ultrasonic testing (UT) indications of possible flaws. In April 2016, Salem Unit 1 found 18 visually failed bolts and 139 bolts that exhibited UT indications of possible flaws.

In addition, the following OE has been observed at several other Westinghouse-designed 2-loop and 4-loop units with similar design characteristics:

- In 2014, ultrasonic examination of the BFBs at Prairie Island Unit 1 identified 40 BFBs with indications of possible flaws.
- In 2013, ultrasonic examination of the BFBs at Prairie Island Unit 2 identified 75 BFBs with indications of possible flaws.
- In 2010, a visual examination of the BFBs at D.C. Cook Unit 2 identified 18 degraded bolt locations (i.e., missing lock tabs, bolt heads, or both). Ultrasonic examination was not performed because a reliable technique was not considered to be available. During replacement activities, a total of 42 degraded bolts were discovered.
- In 1999, UT examinations of the BFBs at R.E. Ginna identified 59 bolts with crack-like indications and 17 suspect bolts. It is noted that the UT technique at the time had a relatively high false positive rate. A replacement campaign was performed and a limited replacement of Type 316CW bolts were installed. In 2011, UT examination of a number of original and replacement bolts was performed and one original bolt was identified with a crack-like indication.
- In 1999, UT examinations of the BFBs at Point Beach Unit 2 identified 55 bolts with crack-like indications and 29 suspect bolts. It is noted that the UT technique at the time had a relatively high false positive rate. A replacement campaign was performed and Type 316CW bolts were installed in a pattern acceptable per a Westinghouse NRC-approved methodology. In 2014, UT examination of both the remaining original and replacement bolts was performed and 15 additional original bolts were identified with crack-like indications.

Common characteristics associated with each of these Westinghouse-designed units include:

- 2-loop or 4-loop downflow (or, converted to upflow) units (generally a relatively large pressure differential across the baffle plates in the downflow configuration)

  (Note: the 2-loop designs have more BFBs per square inch of baffle plate and therefore a lower primary stress than the 4-loop design.)
- Type 347 solution annealed stainless steel BFBs
- Internal hex head BFBs

Examinations Completed at Other Westinghouse-designed Units

The following examinations of BFBs at Westinghouse-designed 3-loop units have also been completed to date:

- In 2013, UT examinations of the BFBs at H.B. Robinson Unit 2 identified nine bolts with indications. An additional 12 bolts could not be examined due to an inability to adequately couple to the bolt head.
- In 2011, UT examinations of the BFBs at Surry Unit 2 identified two bolts with crack-like indications.
- In 2010, visual and UT examinations of the BFBs at Surry Unit 1 identified one bolt as likely failed, two bolts as uninspectable, and one bolt with a missing lock bar weld.

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Common characteristics associated with each of these Westinghouse-designed units include:

- 3-loop downflow units (generally a relatively large pressure differential across the baffle plates in the downflow configuration)

  (Note: the 3-loop designs have more BFBs per square inch of baffle plate and therefore a lower primary stress than the 4-loop design.)
- Type 347 solution annealed stainless steel BFBs
- External hex head design BFBs

Examinations Completed at B&W-designed 177-FA Units

The following examinations of BFBs and BBBs have been completed to date:

- In April 2014, visual examinations of the BBB locking devices/locking welds and both visual and UT examinations of the BFBs and their locking devices/locking welds were completed at ONS-3. One BFB was identified with crack-like indications and one BFB was uninspectable due to the UT probe not seating properly. No reportable indications were identified during the visual examination of the BFB and internal BBB locking devices/locking welds.
- In October 2013, visual examinations of the BBB locking devices/locking welds and both visual and UT examinations of the BFBs and their locking devices/locking welds were completed at ONS-2. One BFB was uninspectable due to the UT probe not seating properly. No reportable indications were identified during the visual examination of the BFB and internal BBB locking devices/locking welds.
- In October 2012, visual examinations of the BBB locking devices/locking welds and both visual and UT examinations of the BFBs and their locking devices/locking welds were completed at ONS-1. Four BFBs were identified as uninspectable due to large welds on the locking bars interfering with the UT probe. No reportable indications were identified during the visual examination of the BFB and internal BBB locking devices/locking welds.
- In November 2005, visual examinations of the BBB bolts and locking devices/welds and both visual and UT examinations of the BFBs were completed at CR-3. No reportable indications in BFBs and their locking devices/welds were identified. However, the BBB bolt and locking devices/welds visual examination revealed the following observations:
  - Four bolt heads protruding beyond the baffle plate surface
  - One locking ring and lower attachment weld missing
  - One locking ring with excessive weld material
  - Two locking rings not welded to the baffle plate on one side
  - One BBB improperly captured on locking ring peaks rather than valleys

Common characteristics of the B&W-designed 177-FA units include:

- Upflow design with numerous flow holes and slots in both baffle and former plates (small pressure differential across the baffle plates)
- Type 304 solution annealed stainless steel BBBs and BFBs
- BFB designs are special shoulder screws with flat head, button head cap screws with internal socket, or flat hex head cap screws
- BBB designs are either 12-point head screws or internal hex (socket) head cap screws (a.k.a., internal hex head bolts)

[Note: Technically, all of the fasteners utilized in the core barrel region for all vendor designs are screws (i.e., threaded into blind holes with no nuts). Nevertheless, both terms are used interchangeably by the industry. The bolt design, bolt length, head fabrication process, and head-to-shank stress concentration factor are all believed to have an effect on IASCC crack initiation, but the exact correlation is currently unknown.]

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Preliminary Evaluation of the Relevance of Westinghouse-designed BFB OE to B&W-designed 177-FA BFBs and BBBs

BFBs and BBBs, regardless of the RV internals design, are potentially susceptible to irradiation-assisted stress corrosion cracking (IASCC), as detailed in various documents that have been prepared for the nuclear industry (e.g., MRP-227-A and MRP-175). IASCC occurs when there is a combination of irradiation, susceptible material, an aggressive environment, and an applied tensile stress. At present, interactions among these variables have not adequately been quantified and no primary IASCC controlling mechanism has been identified; therefore, a thorough understanding of the IASCC mechanism in PWRs remains hypothetical.

The two primary factors affecting IASCC susceptibility are believed to be accumulated fluence and stress. Irradiation increases the IASCC susceptibility of Type 300-series stainless steel alloys and has been observed in stainless steel materials with accumulated fluence levels as low as 3 dpa. IASCC is therefore believed to be the main degradation mechanism driving the observed conditions for each of the above bolt failures.

In addition, comparing the OE between the Westinghouse-designed units and the B&W-designed units, several key stress drivers for IASCC appear to exist at the Westinghouse-designed units that do not exist at the B&W-designed units. These are: 1) higher applied stresses due to the pressure differential inherent in the downflow configuration at the applicable Westinghouse-designed units, and 2) bolting installation and design characteristics that appear to be more susceptible to cracking (i.e., bolt length, initial bolt torque levels, the fabrication process associated with an internal hex head design, and potentially higher stress concentration factors in the head-to-shank area). However, sufficient information is currently not available to AREVA Inc. to adequately quantify these stress drivers.

Preliminary Evaluation of the Observed OE to the Risk to Operability and Safety for B&W-designed 177-FA Units

At present, there have been four BFB UT examinations performed at the B&W-designed units (CR-3, ONS-1, ONS-2, and ONS-3). Given that only one bolt out of the 3,456 BFBs examined to date in the B&W-designed RV internals has shown crack-like indications, it is concluded that there is a very high probability that this was a random failure and not an indication of an active degradation mechanism (i.e., IASCC) having initiated. Both the core barrel-to-former bolts (CBFBs) and BFBs have the function of maintaining structural integrity of the baffle and former portion of the structural assembly and thus of maintaining flow geometry during normal operation. For faulted events, structural analyses performed previously indicate that only a small number of the CBFBs and BFBs are needed to restrain the baffle so that a coolable core geometry is maintained for safety considerations. Therefore, it is concluded to be very unlikely that a failure rate leading to an unacceptable BFB configuration could occur before performing the next MRP-227 examination (i.e., the initial or subsequent, whichever is relevant) at any of the operating B&W-designed 177-FA units. As such, given that each of the B&W-designed 177-FA units are designed and operate in a similar fashion, the risk of observing OE similar to that seen at the Westinghouse-designed units to date is low.

Currently, the B&W units are performing visual inspections of peripheral fuel assemblies in the slots (12 FAs) in support of fuel performance assessments. In addition, units using fuel assemblies that have operated on the core periphery for one cycle and are being reinserted into the core in a subsequent cycle are required to visually inspect those assemblies for grid or rod damage. Therefore, the B&W units, as a group, are actively inspecting both the slot fuel assemblies and a number of additional peripheral fuel assemblies such that current fuel performance inspection plans represent a reasonable and sufficient number of peripheral fuel assemblies to observe BFB or BBB interaction.

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Further, loose parts monitoring and examinations (i.e., foreign object search and removal, or FOSAR) and reactor coolant radioactivity level evaluations (i.e., radiochemistry monitoring) are already in place.

AREVA Inc. recommends maintaining loose parts monitoring efforts and the FOSAR outage activities; fuel cycle radiochemistry monitoring; and, currently planned visual fuel performance related inspections of peripheral fuel assemblies. These efforts are deemed adequate for the current interim period until such time as additional evaluations and assessments planned through the PWROG (i.e., PA-MSC-1473) and the industry BFB Focus Group initiatives are completed and additional guidance is provided.

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