MRP **Materials Reliability Program**_____MRP 2021-020
(via email)

Date: November 12, 2021 Docket No. 99902021

To: U.S. Nuclear Regulatory Commission
Document Control Desk
11555 Rockville Pike
1 White Flint N; Mail Stop: 0-12-D2
ROCKVILLE, MD 20852

Subject: Transmit Electric Power Research Institute NEI 03-08 Interim Guidance MRP 2021-005 Related to B&W-Designed Core Barrels to NRC for Information

References:
1. *Meeting Summary from NRC Public Meeting on 10/12/2021 (EPID L-2019-PMP-0095), dated October 22, 2021 [ADAMS accession number ML21285A022]*

In response to NRC's request during a public meeting on 10/12/2021 (Reference 1) that EPRI provide for information only a copy of recently issued interim inspection guidance to support NRC review of PWR utility SLR applications, we are forwarding one (1) copy of the following NEI 03-08 guidance in letter MRP 2021-005:

Materials Reliability Program (MRP letter) MRP 2021-005: NEI "Needed" Interim Guidance regarding MRP-227-A and MRP-227, Revision 1-A B&W Core Barrel Cylinder Top Flange Circumferential Weld Heat-Affected Zone Inspection, dated 9/10/2021.

If you have any questions, please contact Kyle Amberge at 704-595-2039.

Sincerely,

Christopher R. Koehler, Xcel Energy
MRP RIC Chair

Robert O. McGill, EPRI
Manager Program Manager – MRP

cc: Joe Holonich, NRC
MRP RIC Members

Attachment:
Letter MRP 2021-005: NEI "Needed" Interim Guidance regarding MRP-227-A and MRP-227, Revision 1-A B&W Core Barrel Cylinder Top Flange Circumferential Weld Heat-Affected Zone Inspection, dated 9/10/2021

MRP Materials Reliability Program _____MRP 2021-005

September 10, 2021

To: MRP-Research Integration Committee Members

Subject: NEI "Needed" Interim Guidance regarding MRP-227-A and MRP-227, Revision 1-A B&W Core Barrel Cylinder Top Flange Circumferential Weld Heat-Affected Zone Inspection

References

1. Framatome Customer Service Bulletin 21-04, "Post Stress Relief Weld Repairs in the B&W Core Barrel and Impact on SCC Susceptibility," 7/21/21 (Enclosed).
2. *Materials Reliability Program: Pressurized Water Reactor Internals Inspection and Evaluation Guidelines (MRP-227-A).* EPRI, Palo Alto, CA: 2011. 1022863.
3. *Materials Reliability Program: Pressurized Water Reactor Internals Inspection and Evaluation Guidelines (MRP-227, Revision 1-A).* EPRI, Palo Alto, CA: 2019. 3002017168.
4. NEI 03-08, "Guideline for the Management of Materials Issues," Revision 4, NRC Accession Number ML20315A536.
5. *Materials Reliability Program: Inspection Standard for Pressurized Water Reactor Internals – 2020 Update (MRP-228, Rev. 4).* EPRI, Palo Alto, CA: 2020. 3002018245.
6. *Materials Reliability Program: Aging Management Strategies for B&W Pressurized Water Reactor Internals (MRP-231, Rev. 4). EPRI, Palo Alto, CA: 2021. 3002020103.*

Background

As discussed in MRP-231, Revision 4, Framatome performed an in-depth review of the Babcock & Wilcox (B&W) core barrel (CB) cylinder fabrication records to determine whether weld repairs were permissible or made following the final post-weld stress relief for the core barrel cylinder [Reference 6]. The records search concluded that there is sufficient information in the historical records to substantiate that weld repairs likely were performed at some of the units, following the final post-weld stress relief. These weld repairs invalidate the final categorization of "Category A" or "Category N" for SCC used in prior revisions of MRP-231 in support of MRP-227-A [Reference 2] or MRP-227, Revision 1-A [Reference 3] for the B&W CB cylinder top flange circumferential weld heat-affected zone (HAZ). Note that "Category A" and "Category N" component items and welds do not require inspection by MRP-227-A [Reference 2] or MRP-227, Revision 1-A [Reference 3]. Therefore, consistent with MRP-231, Revision 4, the core barrel cylinder top flange adjacent base metal (that is, HAZ) shall be the Primary item for SCC for units that had weld repairs performed in their top flange circumferential weld after the stress relief treatment.

The enclosed Framatome customer service bulletin (CSB) 21-04 [Reference 1] provides further detail on the affected plants. Consistent with the recommendations of CSB 21-04, at the next planned reactor vessel (RV) internals removal (i.e., coinciding with the next 10-year ISI examination of the RV internals), the affected B&W units should perform an inspection of the outside diameter surface of the CB top flange circumferential weld HAZ as described herein.

Purpose

The purpose of this letter is to issue Interim Guidance regarding the inspection of the CB cylinder top flange circumferential weld HAZ in the B&W RV internals design. This Interim Guidance is only applicable to B&W plants that have had weld repairs performed in their top flange circumferential weld after the stress relief treatment.

Interim Guidance

The CB cylinder top flange circumferential weld HAZ shall be the Primary item for SCC for units that had weld repairs performed on their top flange circumferential weld after the stress relief. There are no associated Expansion items.

The CB cylinder top flange circumferential weld HAZ is "Primary" because this location is screened as susceptible to SCC (as well as irradiation embrittlement), an indication could become functionally significant, and there are no other locations that could act as a leading indicator. The base metal adjacent to the weld (i.e., HAZ) is the focus because the weld metal was screened out for SCC because of the ferrite content.

This Interim Guidance is "Needed" as defined in NEI 03-08 [Reference 4].

NEI 03-08 "Needed" Interim Guidance:

Primary Item: CB Cylinder Top Flange Circumferential Weld HAZ

Applicability: B&W-designed plants that have had weld repairs performed in their top flange circumferential weld after the stress relief treatment.

Primary Item: CB cylinder top flange circumferential weld HAZ; see Figure 1

Effect (Mechanism): Cracking (SCC, IE), including detection of surface-breaking crack-like indications

Examination Method: Enhanced visual (EVT-1), volumetric (UT), or eddy current (ECT) examination

Initial Inspection: At the time of the next planned RV internals removal (i.e., coinciding with the next 10-year in-service inspection [ISI] of the RV internals)

Subsequent Inspection: During each 10-year ISI interval unless evaluation can justify otherwise (note that such an evaluation would require submittal to the NRC for approval)

Examination Coverage: 100% of the accessible outer diameter (OD) surfaces of ¾" of the adjacent base metal to the top flange circumferential weld, as defined in MRP-228 [Reference 5]. Examination coverage requires a minimum of 50% of the length of the specified surface of the weld being examined due to the potential obstruction of the upper thermal shield restraints at the top of the core barrel cylinder.

Examination Acceptance Criteria: The absence of a relevant condition (i.e., the specific relevant condition is a detectable crack-like surface indication)

Expansion Item: None.

Expansion Criteria: N/A

Evaluation Requirements: Relevant conditions should be addressed per the "Implementation Requirements" of MRP-227-A, Section 7 or MRP-227, Revision 1-A, Section 7, as applicable.

Reporting Requirements: The plant should report inspection results consistent with the "Implementation Requirements" of MRP-227-A, Section 7 or MRP-227, Revision 1-A, Section 7, as applicable.

This guidance only applies to B&W-designed PWR units, and supplements existing inspection guidance in MRP-227-A and MRP-227-Revision-1-A. The inspection recommendations detailed herein have also been incorporated into the MRP-227-Revision 2 report (EPRI product ID 3002020105). If there are any questions or concerns with this guidance, please contact the undersigned.

Implementation Date: First refueling outage with pre-planned core barrel removal after 1/1/2022.

Christopher R. Koehler, Xcel Energy
MRP RIC Chair

Robert O. McGill, EPRI
Program Manager – MRP

Enclosure: Framatome CSB-21-04, dated 7/21/2021 "*Post Stress Relief Weld Repairs in the B&W Core Barrel and Impact on SCC Susceptibility*"

Cc: MRP Internals & Integrity TAC
MRP Pressure Boundary TAC
MRP Inspection TAC

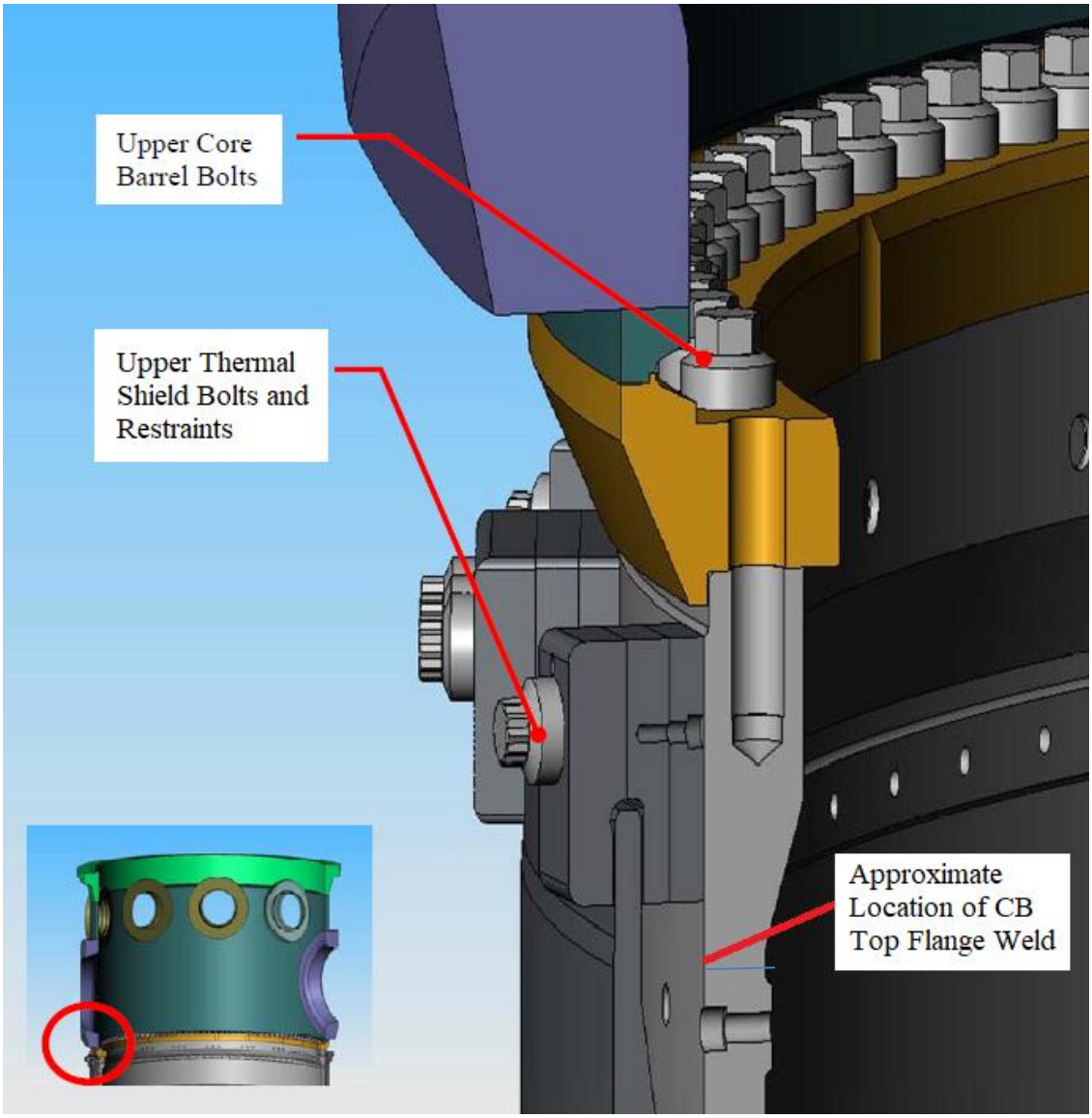

Figure 1: Location of CB Cylinder Top Flange Circumferential Weld – B&W-Designed PWRs

0504-12-F01 (Rev. 014, 03/02/2018)

CUSTOMER SERVICE BULLETIN NO. 21-04

DATE: 07/21/2021

SUBJECT: Post Stress Relief Weld Repairs in the B&W Core Barrel and Impact on SCC Susceptibility

APPLICABILITY: Arkansas Nuclear One Unit 1 and Oconee Unit 2

AFFECTED REPORT: MRP-227 Pressurized Water Reactor Internals Inspection and Evaluation Guidelines

This issue does not represent a substantial safety hazard pursuant to 10 CFR 21.

This customer service bulletin replaces CSB 20-02 in its entirety. CSB 20-02 should not be used.

Background:

This Customer Service Bulletin (CSB) replaces CSB 20-02 in its entirety. CSB 20-02 discussed concerns for stress corrosion cracking (SCC) due to post stress relief weld repairs in the Babcock and Wilcox (B&W) Core Support Shield (CSS) cylinder. Upon further review, it was determined no weld repairs were performed after the post-weld stress relief for the CSS welds of interest in ANO1, ONS 1, 2 and 3 and DB and, thus, the existing justification in MRP-231, Revision 3 [3] that the B&W CSS cylinder is “Category A” for SCC remains valid for all the domestic B&W plants. Therefore, the information in CSB 20-02 is inaccurate, and CSB 20-02 should not be used. Since the CB cylinder at some units does have post stress relief weld repairs, the CSS cylinder weld regions cannot serve as leading indicators for SCC. Therefore, the core barrel (CB) cylinder weld regions must be considered for SCC at ANO 1 and ONS 2.

Summary:

In response to the observed indications in the St. Lucie Unit 1 core support barrel, Framatome performed an in-depth review of the B&W CB cylinder fabrication records to determine if this operating experience is applicable to the B&W design [1]. As part of this records search, Framatome discovered evidence that weld repairs occurred following the post-weld stress relief of the CB cylinder circumferential welds at Arkansas Nuclear One Unit 1 (ANO-1) and Oconee Unit 2 (ONS-2). The records did not indicate any post-stress relief weld repairs in the CB cylinder circumferential welds at Oconee Unit 1, Oconee Unit 3, or Davis-Besse. This issue is addressed in Framatome CSB 21-03 for irradiation-assisted stress corrosion cracking (IASCC) susceptibility of the CB cylinder center circumferential weld [2]. The purpose of this CSB is to address the impact of post stress relief weld repairs in the CB cylinder top and bottom flange to top and bottom CB cylinder circumferential welds at ANO 1 and ONS 2, which impacts SCC susceptibility instead of IASCC susceptibility because this is a relatively low fluence region.

These weld repairs at ANO-1 and ONS-2 invalidate the existing justification in MRP-231, Revision 3 [3] that the B&W core barrel cylinder top and bottom flange welds heat affected zones (HAZ) are “Category A” for SCC. Note that “Category A” component items are defined as those for which aging effects are below the screening criteria, so that aging degradation significance is minimal and, thus, do not require inspection by MRP-227 [4].

The potential for SCC in the B&W CB cylinder top and bottom flange weld HAZ is not considered a nuclear safety concern because previous analyses (which considered rod insertion, maintaining a coolable geometry, and core bypass flow) have concluded that in the unlikely event of full CB severance, safe shutdown would still be assured. The safety consequence ranking in MRP-189 is based (in part) on the extent of fuel failures; the extent of fuel failures in a severed CB cylinder condition has not been analyzed. Therefore, based on currently available information, the ANO-1 and ONS-2 CB cylinder top flange weld HAZ would become Primary for SCC per the MRP-227 process even though this issue is not a substantial safety hazard. The CB cylinder bottom flange weld HAZ is not a concern due to a lower safety consequence and, thus, does not required inspection per the MRP-227 process. Note that the weld metal is not considered susceptible to SCC due to the ferrite content typical of austenitic stainless steel welds.

FRAMATOME INC. CONTACT:

Ryan Hosler, Materials Engineering Supervisor

ryan.hosler@framatome.com

434-832-4532

To address this issue, it is recommended that the ANO-1 and ONS-2: 1) inspect the CB cylinder top flange weld HAZ at the next planned CB pull and, if desired, 2) perform an analysis to justify that SCC at this location is not credible. These recommendations are provided in more detail at the end of this CSB.

Evaluation:

In response to the observed indications in the St. Lucie Unit 1 core support barrel, Framatome performed an in-depth review of the B&W CB cylinder fabrication records to determine if this operating experience is applicable to the B&W design [1]. The records search did not indicate any post-weld stress relief repairs in the CB cylinder vertical welds. However, Framatome discovered evidence that weld repairs occurred following the post-weld stress relief of the CB cylinder circumferential welds at ANO-1 and ONS-2. The records did not indicate any post-stress relief weld repairs in the CB cylinder circumferential welds at Oconee Unit 1, Oconee Unit 3, or Davis-Besse. This issue is addressed in Framatome CSB 21-03 for IASCC susceptibility of the CB cylinder center circumferential weld [2]. The purpose of this CSB is to address the impact of post stress relief weld repairs in the CB top and bottom flange to cylinder circumferential welds, which impact SCC susceptibility instead of IASCC susceptibility because the projected fluence is below the IASCC screening criterion of 3 dpa [5].

The records are clear that the weld repairs were in the region of the core barrel cylinder circumferential welds, but the records did not specify which circumferential weld(s). The B&W core barrel cylinder has three circumferential welds: one at the top joining the cylinder to the top flange, one in the center joining the top and bottom cylinders, and one at the bottom joining the cylinder to the bottom flange. Therefore, for the purpose of this evaluation, it is assumed that the weld repairs occurred in the CB cylinder top flange to cylinder circumferential weld. Note that the bottom circumferential weld is not a concern due to the lower consequence of failure, per MRP-189 [5].

These weld repairs at ANO-1 and ONS-2 invalidate the existing justification in MRP-231, Revision 3 [3] that the B&W CB cylinder top flange weld HAZ is “Category A” for SCC. Note that “Category A” component items are defined as those for which aging effects are below the screening criteria, so that aging degradation significance is minimal and, thus, do not require inspection by MRP-227 [4].

While the CB top flange weld HAZ screens in for SCC per the criteria in Appendix A of MRP-175 [6], SCC in the CB cylinder is unlikely. Extensive literature and operating experience support that weld residual stress alone is not expected to cause SCC in a PWR environment; instead, excessive cold-work and/or off-chemistry conditions are typically required [7]. This is consistent with the excellent operating experience with the similar component items in the Westinghouse and Combustion Engineering-designed reactor vessel internals (i.e., the upper flange weld region of the upper core barrel).

Safety Significance:

In the unlikely event of SCC resulting in full severance of the CB cylinder top flange weld, the portion of the reactor vessel internals below the failure could drop approximately ½-inch before coming to rest on the core guide lugs. By design, such an event would not impair rod insertion [8]. This event could create a ½-inch gap in the CB cylinder at the location of the severance, which would have some impact on the amount of flow bypassing the core. Bypass flow resulting from CB cylinder severance was previously considered and it was concluded that safe shutdown of the unit would still be assured [8]. Furthermore, a CB cylinder drop was previously analyzed (in this case, due to the failure of core support bolting) and found that, while such an event may result in fuel failures, the limiting event in offsite dose evaluations would remain bounding [9]. As discussed above, CB cylinder severance would not affect the integrity of the reactor coolant pressure boundary, the capability to shut down the reactor and maintain it in a safe shutdown condition, or the capability to prevent or mitigate the consequences of accidents which could result in potential offsite exposures. Therefore, in the unlikely event of SCC resulting in full severance of the CB cylinder, this would not create a substantial safety hazard per 10 CFR 21 [10].

However, the safety consequence ranking in the MRP-189 is based (in part) on the extent of fuel failures; the extent of fuel failures in a severed CB cylinder condition has not been analyzed. Therefore, based on currently available information, the B&W CB cylinder top flange weld HAZ would result in categorization as a Primary item per the MRP-227 process even though this issue would not create a substantial safety hazard per 10 CFR 21.

Recommendations:

1. At the next planned CB pull (i.e., coinciding with the next 10-year ISI examination of the RV internals), ANO-1 and ONS-2 should perform an inspection of the outside diameter surface of the CB top flange weld HAZ (i.e., ¾" on both sides of the weld). The inspection method can be EVT-1, UT, or eddy current. The examination coverage should be 100% of the accessible weld length with a minimum of 50%, due to the obstruction of the thermal shield upper restraints. Prior to the inspection, a crack growth and critical flaw size analysis should be performed to be prepared to disposition inspection findings.
2. An evaluation could be performed to justify that SCC of the CB cylinder is not a credible age-related degradation mechanism. This would be based on the available literature, operating experience, and an understanding of the fundamentals of SCC.

Recommendation 1 should be performed. If desired, Recommendation 2 could also be performed to justify not performing future inspections of the CB cylinder top flange weld HAZ for SCC. If Recommendation 2 is performed in lieu of Recommendation 1, then this should be treated as a deviation to MRP-227 and, thus, require NRC approval.

References:

1. PWROG-19029-P, Revision 1, "Review of B&W-Designed Core Barrel Information for Applicability of St. Lucie Unit 1 Operating Experience." (Framatome Proprietary)
2. Framatome Inc. CSB 21-03, "Post Stress Relief Welds Repairs in the B&W Core Barrel and Impact on IASCC Susceptibility"
3. Materials Reliability Program: Aging Management Strategies for B&W Pressurized Water Reactor Internals (MRP-231-Rev. 3). EPRI, Palo Alto, CA: 2014. 3002004284.
4. Materials Reliability Program: Pressurized Water Reactor Internals Inspection and Evaluation Guidelines (MRP-227, Revision 1-A). EPRI, Palo Alto, CA: 2019. 3002017168.
5. Materials Reliability Program: Screening, Categorization, and Ranking of Babcock & Wilcox–Designed Pressurized Water Reactor Internals Component Items and Welds (MRP-189, Revision 3). EPRI, Palo Alto, CA: 2019. 3002013218.
6. Materials Reliability Program: PWR Internals Material Aging Degradation Mechanism Screening and Threshold Values (MRP-175, Revision 1). EPRI, Palo Alto, CA: 2017. 3002010268.
7. Materials Reliability Program: Stress Corrosion Cracking of Stainless Steel Components in Primary Water Circuit Environments of Pressurized Water Reactors (MRP-236, Rev. 1). EPRI, Palo Alto, CA: 2017. 3002009967.
8. Materials Reliability Program: Updated B&W Design Information for the Issue Management Tables (MRP-157). EPRI, Palo Alto, CA: 2005. 1012132.
9. 43-1843PA-000 (BAW-1843PA), "Evaluating Internals Bolting Concerns in 177 FA Plants," 1986. (Framatome Proprietary)
10. NRC Regulation 10 CFR 21, "Reporting of Defects and Noncompliance."