

**GUIDANCE ON THE BASELINE EXAMINATION SCHEDULE AND  
SUBSEQUENT EXAMINATION FREQUENCY FOR BAFFLE-FORMER  
BOLTS IN PRESSURIZED-WATER REACTORS WITH DOWN-FLOW  
CONFIGURATIONS**

**A Report for the Senate Committee on Environment  
and Public Works and the House Committee  
on Energy and Commerce**



**By the U.S. Nuclear Regulatory Commission**

## INTRODUCTION

The U.S. Nuclear Regulatory Commission (NRC) developed this report as required by Section 104 of the Nuclear Energy Innovation and Modernization Act, which requires the NRC to submit to the appropriate congressional committees a report explaining revisions made to guidance on the baseline examination schedule and subsequent examination frequency for baffle-former bolts (BFBs) in pressurized-water reactors (PWRs) with down-flow configurations or a report explaining why current guidance is sufficient.

## BACKGROUND

BFBs help hold together a structure of plates inside the reactor vessel in many PWR designs that directs the flow of reactor coolant through the reactor core. In the event of extensive BFB degradation, these plates could be detached under design basis accidents, which could cause localized fuel damage, potentially jeopardizing core cooling and the ability to insert some control rods that regulate the fission reaction in the reactor. BFB degradation due to irradiation-assisted stress corrosion cracking is a known issue for PWRs, and is addressed in NRC guidance for aging management. In 2016, visual and non-destructive examinations of BFBs led to the discovery of unexpected numbers of degraded BFBs in several PWRs in the United States. A specific design – the Four-loop Westinghouse reactor when operated in a “down-flow” configuration with BFBs made of a certain grade of stainless steel (Type 347) – appears to be the most susceptible to this deterioration.

After thorough reviews of the BFB degradation issue and existing agency and industry guidance, the NRC staff determined that the changes made to existing industry guidance were sufficient and that changes to existing agency guidance are not necessary.

## STATUS

### Current NRC Regulatory Basis and Guidance for BFB Examinations

NRC regulations in Title 10 of the *Code of Federal Regulations* (10 CFR), Part 50, “Domestic Licensing of Production and Utilization Facilities,” establish requirements for structures, systems and components that are important for reactor safety, including reactor pressure vessels and reactor vessel internals. Regulatory requirements regarding BFBs are also contained in 10 CFR Part 54, “Requirements for Renewal of Operating Licenses for Nuclear Power Plants,” pertaining to managing the effects of aging for reactor license renewal. These license renewal requirements are supported by NRC regulatory guidance documents, which describe acceptable actions that may be taken to manage the degradation of BFBs. The primary NRC license renewal guidance document is NUREG-1801, Revision 2, “Generic Aging Lessons Learned (GALL) Report” (Ref. 1). This document provides guidance for aging management programs for renewal of nuclear power plant operating licenses. With respect to managing the aging of BFBs (and other reactor pressure vessel internals), the GALL Report references industry guidance known as a topical report. That topical report from the Electric Power Research Institute (EPRI), entitled “Materials Reliability Program: Pressurized Water Reactor Internals Inspection and Evaluation Guidelines” (MRP-227-A) (Ref. 2), provides information concerning managing the aging of reactor pressure vessel components, including BFBs, such as recommended examination types and intervals.

## Revisions to Industry Guidance and NRC Response since 2016

Following observations of BFB degradation in 2016, the nuclear industry updated its BFB-related guidance via two letters from EPRI:

- Materials Reliability Program (MRP) 2016-022, July 27, 2016 (Ref. 3), and
- MRP 2017-011, March 23, 2017 (Ref. 4).

This updated guidance specifies accelerated schedules for examination of BFBs. The updated guidance provides different recommendations based on design variations of the plants. For the most susceptible group of plants, the updated guidance specifies that the initial examinations of the BFBs should be completed by the next scheduled refueling outage. It also places limits on the timing of subsequent examinations depending on the plant design and specific examination findings.

Also following the 2016 observations of BFB degradation, the NRC staff assessed the safety significance of the degradation using a risk-informed evaluation process to determine whether immediate regulatory action was necessary to address the degradation. The evaluation (Ref. 5) determined that it was acceptable from a regulatory and risk perspective for the BFBs in the group of PWRs most susceptible to BFB degradation to be inspected at the next scheduled refueling outage. This NRC staff determination was consistent with the updated industry guidance that was issued during the same time frame. The NRC staff also reviewed the updated industry guidance, considering the results of the staff's risk-informed evaluation. The NRC staff assessment (Ref. 6) concludes that EPRI's updated guidance, as supplemented by EPRI's responses to NRC staff questions (Ref. 7), provides an acceptable approach for aging management of BFBs.

Through Nuclear Energy Institute (NEI) document NEI 03-08, "Guideline for the Management of Materials Issues" (Ref. 8), licensees voluntarily monitor implementation of the industry guidance to ensure that materials degradation issues are managed consistently across the industry. The industry monitoring process specifies that any deviations from the guidance need to be reported to the NRC. To date, the NRC has not received any notifications of deviations.

The NRC inspection process is used by agency staff to monitor licensee corrective actions related to BFBs, including examination, replacement, and evaluation. Baseline ultrasonic examinations have been completed at all seven reactors in the most susceptible group and the two plants in the next most susceptible group in accordance with the schedule in EPRI's updated guidance. The licensees for these plants replaced all bolts for which indications of cracking were found in the ultrasonic examinations. Most of these licensees also replaced additional non-cracked bolts. Two of these nine plants completed follow-up ultrasonic examinations of all BFBs at the next refueling outage, and found only a few additional degraded original bolts and no degradation of replacement bolts, indicating that the bolt replacements appear to have been effective (Ref. 9). Baseline ultrasonic examinations have also been completed at all but one of the two-loop and three-loop down-flow plants (eight plants total).

To ensure consistency among relevant guidance documents, the industry has committed to incorporate EPRI's 2016 and 2017 updated guidance for accelerated BFB examinations into the final version of EPRI Topical Report "Materials Reliability Program: Pressurized Water Reactor Internals Inspection and Evaluations Guideline" (MRP-227, Revision 1) (Ref. 10). The NRC staff is currently reviewing this update to the MRP-227 topical report and expects, in view of its prior assessment of the EPRI 2016 and 2017 updated guidance, that the NRC-approved version of the report will be published in July 2019.

## CONCLUSION

The NRC staff has concluded that further revision to BFB guidance is not necessary. The NRC staff has reviewed EPRI's guidance related to this issue, has found it acceptable, and has verified that licensees of susceptible reactors are properly implementing this guidance. The initial BFB examinations recommended by EPRI's updated guidance have been completed for all reactors in the two groups most susceptible to BFB cracking. These examinations indicate that corrective actions appear to be effective. The NRC staff will formally document its position regarding EPRI's updated guidance in a safety evaluation of Revision 1 to MRP-227, and will continue to monitor the examination, replacement, and evaluation of BFBs through the NRC inspection process.

## References

1. NUREG-1801, Revision 2, "Generic Aging Lessons Learned (GALL) Report," Final Report, December 31, 2010 (ADAMS Accession No. ML103490041).
2. Materials Reliability Program: Pressurized Water Reactor Internals Inspection and Evaluation Guidelines (MRP-227-A), 1022863, Final Report, December 2011 (ADAMS Accession No. ML120170453) – Transmitted to the NRC by EPRI letter MRP 2011-036 dated January 9, 2012.
3. Letter from Bernie Rudell and Anne Demma to the NRC, "Transmittal of NEI-03-08 'Needed' Interim Guidance Regarding Baffle Former Bolt Inspections for Tier 1 Plants as Defined in Westinghouse NSAL 16-01," EPRI Materials Reliability Program, MRP 2016-022, July 27, 2016 (ADAMS Accession No. ML16211A054).
4. Letter from Bernie Rudell and Brian Burgos to the NRC, "Transmittal of NEI-03-08 'Needed' Interim Guidance Regarding Baffle Former Bolt Inspections for U.S. PWR Plants as Defined in Westinghouse NSAL 16-01," EPRI Materials Reliability Program, MRP 2017-011, March 23, 2017 (ADAMS Accession No. ML17087A110).
5. Degradation of Baffle-Former Bolts in Pressurized-Water Reactors - Documentation of Integrated Risk-Informed Decisionmaking Process in Accordance with NRR Office Instruction LIC-504, October 20, 2016 (ADAMS Accession No. ML16225A341).
6. Office of Nuclear Reactor Regulation Staff Assessment of Electric Power Research Institute NEI 03-08, Revision 2, "Needed" Interim Guidance Regarding Baffle-Former Bolt Inspections in Westinghouse-Design Pressurized Water Reactors, November 20, 2017 (ADAMS Accession No. ML17310A861).
7. Letter from Mike Hoehn II and Brian Burgos to the NRC, "Responses to the Questions from the U.S. Nuclear Regulatory Commission Staff on the Baffle-Former Bolt 'Needed' Guidance Transmitted in Letter MRP 2017-009," EPRI Materials Reliability Program, MRP 2017-015, July 13, 2017 (ADAMS Accession No. ML17261B149).
8. NEI 03-08, "Guideline for the Management of Materials Issues," Revision 3, Nuclear Energy Institute, February 2017 (ADAMS Accession No. ML19079A256).
9. Presentation by Kyle Amberge, Electric Power Research Institute, at the May 21-23, 2018, Annual Industry / U.S. Nuclear Regulatory Commission Materials Programs Technical Information Exchange Public Meeting – "Updated Baffle-Former-Bolting (BFB) Inspection Results in the United States," May 31, 2018 (ADAMS Accession No. ML18142A458).

10. Letter from David Czufin and Anne Demma to the NRC, "Report Transmittal: Materials Reliability Program: Pressurized Water Reactor Internals Inspection and Evaluations Guideline (MRP-227, Revision 1)," EPRI Materials Reliability Program, MRP 2015-040, December 21, 2015 (ADAMS Accession No. ML15358A046).