



Materials Reliability Program: Pressurized Water Reactor Internals Inspection and Evaluation Guidelines (MRP-227, Revision 2-NP)

2021 TECHNICAL REPORT



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EPRI Project Manager
K. Amberge



3420 Hillview Avenue
Palo Alto, CA 94304-1338
USA

PO Box 10412
Palo Alto, CA 94303-0813
USA

800.313.3774
650.855.2121

askepri@epri.com

www.epri.com

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MRP and PWROG Joint Reactor Internals Planning Team

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The following organizations, under contract to the Electric Power Research Institute (EPRI), prepared this report:

MRP and PWROG Joint Reactor Internals Planning Team:

Heather Malikowski, Chair	Exelon Nuclear
Tim Wells	Southern Nuclear Operating Co.
Rachel Doss	Duke Energy
Derek Simpson	America Electric Power
Steve Skubey	Wolf Creek Nuclear Operating Co.
Tim Hanna	Dominion Generation
Chris Koehler	Xcel Energy
Tom Malota	Arizona Public Service Co.
Mike Hoehn II	Ameren
Brian Burgos	EPRI Sr. Program Manager
Kyle Amberge	EPRI Technical Executive
Steve Fyfitch	Framatome Inc.
Sarah Davidsaver	Framatome Inc.
Ryan Hosler	Framatome Inc.
Bryan Wilson	Westinghouse Electric Co., LLC
Joshua McKinley	Westinghouse Electric Co., LLC
Taylor Zindren	Westinghouse Electric Co., LLC

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Report Summary

The Electric Power Research Institute (EPRI) Materials Reliability Program (MRP) developed inspection and evaluation (I&E) guidelines for managing the long-term aging of reactor vessel internal components of pressurized water reactors (PWRs). Specifically, the guidelines are applicable to PWR internals structural components; they do not address fuel assemblies, reactivity control assemblies, or welded attachments to the reactor vessel. Revision 2 of this report updated the aging management guidelines for relevant operating experience and to address subsequent license renewal (SLR) operation. Revision 2 also added two new appendices to expand the options available to implementing utilities. These appendices include guidance on the implementation of alternate aging management approaches (other than inspection and evaluation) and guidance on showing continued applicability of the I&E guidelines for a plant using flexible operation for certain nuclear steam supply system (NSSS) designs.

Background

Demonstrating that the effects of aging degradation in PWR internals are adequately managed is essential for maintaining a healthy fleet and ensuring continued functionality of PWR internals. As a work product of the MRP, these I&E guidelines are intended to support that demonstration, with requirements for various inspections to detect effects of aging degradation. The program to develop and maintain these guidelines is organized around a framework and strategy for managing effects of aging in PWR internals and is supported by a substantial database of material data and evaluation results. The goal of this development was primarily to support license renewal for the first and subsequent periods of extended operation. The requirements contained in this document are applicable to Babcock & Wilcox (B&W), Combustion Engineering (CE), and Westinghouse NSSS “Generation II” PWR designs in the United States, where construction began prior to 2007.

Objectives

- To provide generic I&E guidelines for each PWR design for use by individual plant owners in developing engineering programs to manage aging in PWR internals
- To evaluate PWR internals for all three PWR designs currently operating in the United States and internationally, and to make recommendations for aging management actions specific to each component
- To support the industry in preparing PWR internals aging management programs to satisfy license renewal commitments
- To provide guidance for implementation of alternate aging management strategies and determination of guideline applicability at plants using flexible operation

Approach

An experienced team consisting of utility and NSSS vendors and EPRI experts, representing a broad spectrum of reactor design, operations, inspection, and materials expertise, worked on the project. The team developed screening criteria with susceptibility levels for the eight postulated aging mechanisms relevant to PWR internals and their effects and updated those screening criteria based on the latest research and the need to extend operation for SLR. Initial component screening and categorization were completed using susceptibility levels and a failure modes, effects, and criticality analysis to identify the relative ranking of components. The team also completed engineering evaluations and safety assessments of degradation for components and assemblies of components. Aging management strategy development, combining results of the engineering evaluations and safety assessments with component accessibility, operating experience, existing evaluations, and prior examination results, was completed to determine the appropriate aging management methodology, baseline examination timing, and the need for and the timing of subsequent inspections. Inputs such as accumulated neutron radiation dose were updated for all these engineering evaluations and safety assessments to address SLR operation. Revision 2 of this report also included alternate aging management strategy guidance and flexible operation applicability guidance.

Results

One “mandatory” and four “needed” Nuclear Energy Institute (NEI) 03-08 implementation requirements have been developed. These requirements provide the framework and details for individual utility engineering programs for managing aging in reactor internal components and the development of AMPs to support license renewal.

Applications, Value, and Use

The guidelines are based on a broad set of assumptions about plant operation, which, with some exceptions, encompass the range of current plant conditions for the U.S. fleet of PWRs. The aging management strategies reports (MRP-231 and MRP-232) provide the basis for these guidelines. The functional evaluations that support the guidelines were based on representative configurations and operational histories, which were generally conservative, but not necessarily bounding in every parameter. These assumptions are a conservative representation of U.S. PWR operating plants, all of which implemented low-leakage core-loading patterns early in their operating life. The recommendations are thus applicable to all U.S. PWR operating plants as of November 2017 for the three designs identified. These guidelines are also considered applicable to plants that have replaced components or component assemblies; however, alternatives can be technically justified, as described in Appendix C. The inspection standard for PWR internals (MRP-228) is the companion document to these I&E guidelines, and it provides examination requirement standards for components listed in these guidelines.

Keywords

Aging management
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Reactor internals
Subsequent license renewal

