Materials Reliability Program: Screening, Categorization, and Ranking of Babcock & Wilcox–Designed Pressurized Water Reactor Internals Component Items and Welds (MRP-189, Revision 3)

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All or a portion of the requirements of the EPRI Nuclear Quality Assurance Program apply to this product.

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THE FOLLOWING ORGANIZATION, UNDER CONTRACT TO EPRI, PREPARED THIS REPORT:

Framatome, Inc.

NOTE

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PRODUCT DESCRIPTION

The Electric Power Research Institute (EPRI) Materials Reliability Program (MRP) Reactor Internals (RI) Focus Group (now part of the Internals and Internals Technical Advisory Committee) has been conducting studies to develop technical bases to support aging management of pressurized water reactor (PWR) internals of Babcock & Wilcox (B&W), Combustion Engineering and Westinghouse designs, with particular attention to utility license renewal commitments, for a subsequent license renewal (SLR) period. This component item screening and categorization report is the first of a series of reports prepared to provide a basis for developing generic PWR internals inspection and evaluation (I&E) guidelines for utility applications. Related EPRI reports include *Materials Reliability Program: Framework and Strategies for Managing Aging Effects in PWR Internals (MRP-134)* (1008203), *Materials Reliability Program: Inspection and Flaw Evaluation Strategies for Managing Aging Effects in PWR Internals (MRP-153)* (1012082), and *Materials Reliability Program: PWR Internals Material Aging Degradation Mechanism Screening and Threshold Values (MRP-175, Revision 1)* (3002010268).

This report describes the process and results of categorizing B&W-designed PWR internals component items and welds for use in SLR. These categorization results are a key element in an overall strategy for managing the effects of aging in PWR internals. Revision 0 addressed internals components but not welds used during construction and fabrication of assemblies. Revision 1 included welds associated with internals components. Revision 2 updated the categorization results to account for results obtained from a detailed records search for screening parameters and evaluations performed through May 2014. Revision 3 (the current report) provides preliminary categorization results for use in SLR.

Background

Management of aging effects—such as loss of material, reduction in fracture toughness, or cracking—depends on the demonstrated capability to detect, evaluate, and potentially correct conditions that could affect system, structure, or component function. A framework for implementing an aging management program for PWR internals component items and using inspections and flaw tolerance evaluations to manage age-related degradation issues has been developed and is documented in MRP-134 and MRP-153. The important elements of this framework are as follows:

- Screening, categorizing, and ranking PWR internals component items and welds for susceptibility to and significance of age-related degradation mechanisms
- Performing engineering evaluations and assessments of PWR internals component items and welds to define a safe and cost-effective aging management in-service I&E method and strategy

This report shows the screening and categorization process for SLR. A failure modes, effects, and criticality analysis (FMECA) was performed to identify combinations of internals component items and welds and age-related degradation mechanisms that potentially result in degradation leading to significant risk (safety and/or economic). The FMECA process included a review of B&W-designed PWR internals components and a review and endorsement of MRP-189, Revision 0 screening results by an AREVA (now Framatome) multidisciplined RI expert panel. Revision 1 of this report documented a preliminary categorization based on the state of knowledge in 2009, including welds. Final groupings were determined in MRP-231 following additional engineering evaluation and assessment in MRP-229. The groupings were submitted for United States (US) Nuclear Regulatory Commission (NRC) review and approval in MRP-227, culminating in MRP-227-A in 2011 (with 2012 erratum). Revision 2 of this report updated the screening and preliminary categorization results to account for results obtained from a detailed records search for screening parameters and evaluations performed through May 2014. The groupings were submitted for US NRC review and approval in MRP-227, culminating in a safety evaluation report to MRP-227, Revision 1 in 2019. Revision 3 (the current report) provides categorization results for SLR.

Objectives

This report describes screening, categorizing, and ranking of B&W-designed PWR internals component items and welds for susceptibility to and significance of age-related degradation mechanisms for SLR. These results can be used to support development of an inspection strategy for managing the effects of potential age-related degradation mechanisms known for PWR internals for SLR.

Approach

The principal investigators first summarized B&W-designed PWR internals component items and welds and available screening parameter values such as material, stress, temperature, and neutron exposure for SLR. Subsequently, an initial screening of component items and welds for susceptibility to and significance of potential age-related degradation was performed. These results were used as inputs for a FMECA to further screen and categorize component items and welds with regard to safety and economic risk. Each component item was preliminarily categorized into one of the three main categories (Category A, B, or C) presented in MRP-134.

Results

Following the categorization process detailed in this report, the majority of B&W-designed PWR internals component and weld items fall into Category A or Category B. Those that fall into Category C for both safety and economic concerns are the plenum cover assembly weldment rib pads, plenum cover assembly support flange, plenum cover assembly support ring, core support shield (CSS) assembly cylinder (including top and bottom flanges and circumferential flange welds), CSS assembly upper core barrel bolts (original and replacement), core barrel assembly cylinder and top flange (including center and top flange circumferential seam welds), core barrel assembly former plates, core barrel assembly baffle-to-baffle bolts/screws (internal and external) and baffle-to-former bolts/screws/special shoulder screws, core barrel assembly core barrel-to-former plate cap screws, lower grid assembly shock pad bolts (Three Mile Island Unit 1 only), and lower grid assembly lower grid rib section.

Applications, Value, and Use

The research described herein screens, categorizes, and ranks B&W-designed PWR internals components based on susceptibility to and significance of age-related degradation mechanisms. This is in support of developing and updating the PWR internals I&E guidelines.

Keywords

Aging management
B&W design
Categorization
Degradation mechanism
Failure modes, effects, and criticality analysis (FMECA)
License renewal
Screening criteria
Subsequent license renewal

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ABSTRACT

The purpose of this report is to perform a preliminary categorization of the pressurized water reactor (PWR) internals component items and welds of the Babcock & Wilcox (B&W) design for use in subsequent license renewal inspection and evaluation guideline development. This report is a key element in an overall strategy for managing the effects of aging in PWR internals using knowledge of internals design, materials, and material properties and applying screening criteria for known age-related degradation mechanisms. Note that this report is not applicable to flexible operations.

The work summarized in this report was divided into several subtasks. The first was to compile the B&W-designed PWR internals component items and welds. The potential PWR internals age-related degradation mechanisms and the screening criteria used in this report are described in detail in *Materials Reliability Program: PWR Internals Material Aging Degradation Mechanism Screening and Threshold Values (MRP-175, Revision 1)* (3002010268) and were used for an initial screening of each of the B&W-designed PWR internals component items and welds. A failure modes, effects, and criticality analysis (FMECA) was then performed to identify combinations of component items and welds and age-related degradation mechanisms that potentially result in degradation leading to significant risk (safety and/or economic). The final subtask consisted of using the initial screening results and the FMECA results to separate the B&W-designed PWR internals component items and welds into the three main categories (Category A, Category B, and Category C) presented in *Materials Reliability Program: Framework and Strategies for Managing Aging Effects in PWR Internals (MRP-134)* (1008203).

The identified Category C component and weld items (for both safety and economic concerns) in B&W-designed PWR internals are the plenum cover assembly weldment rib pads, plenum cover assembly support flange, plenum cover assembly support ring, core support shield (CSS) assembly cylinder (including top and bottom flanges and circumferential flange welds), CSS assembly upper core barrel bolts (original and replacement), core barrel assembly cylinder and top flange (including center and top flange circumferential seam welds), core barrel assembly former plates, core barrel assembly baffle-to-baffle bolts/screws (internal and external) and baffle-to-former bolts/screws/special shoulder screws, core barrel assembly core barrel-to-former plate cap screws, lower grid assembly shock pad bolts (Three Mile Island Unit 1 only), and lower grid assembly lower grid rib section.

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