



Aging management of reactor coolant system piping for license renewal

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ABSTRACT

The U. S. Nuclear Regulatory Commission (USNRC) has reviewed the Babcock and Wilcox Owners Group (B&WOG) topical report addressing the reactor coolant system (RCS) piping for license renewal. The USNRC staff found that, in general, the existing plant programs are adequate for managing the effects of aging of the RCS piping components. However, there are a few situations where additional aging management programs would be necessary for license renewal.

1. INTRODUCTION

Licenses to operate nuclear power plants in the United States are issued by the USNRC for a fixed period of time not to exceed 40 years. However, these licenses may be renewed by the USNRC for an additional period not to exceed 20 years. The revised license renewal rule sets forth the requirements for the renewal of operating licenses for commercial nuclear power plants [1]. Applicants for license renewal are required to perform an assessment for certain important plant structures and components to ensure that the effects of aging will be adequately managed so that their intended functions will be maintained for the period of extended operation.

The B&WOG submitted topical report BAW-2243, "Demonstration of the Management of Aging Effects for the Reactor Coolant System Piping," [2] for USNRC staff review and approval. The topical report evaluated the aging management of the RCS piping for license renewal for their Generic License Renewal Program (GLRP) member plants. The purpose of the topical report is to provide a technical evaluation of the effects of aging on the RCS piping and demonstrate that the aging effects for the RCS piping are adequately managed for the period of extended operation associated with license renewal.

The USNRC has reviewed and approved the B&WOG topical report which is the first technical assessment of aging management of a plant component for license renewal in accordance with the revised license renewal rule [1]. This

paper provides an overview of the review performed and identifies those existing programs and the new programs accepted for the period of extended operation.

2. RCS PIPING COMPONENTS AND INTENDED FUNCTIONS

Babcock and Wilcox (B&W) plants are 2-loop pressurized water reactors (PWRs). The RCS components within the scope of the B&WOG topical report are piping components of the RCS within the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code Section XI inservice inspection (ISI) program for Class 1 components [3]. The RCS piping components addressed in the topical report are piping, valve bodies, and bolting.

Figure 1 provides a schematic of the B&W RCS piping within the scope of the topical report [2]. The piping size ranges from the 91 cm (36 in) hot leg to the 1 cm (1/2 in) instrumentation, vent, drain, and sampling lines. All bolting within the scope of the topical report are less than 5 cm (2 in) in diameter. The B&W plant hot leg and cold leg piping are fabricated from carbon steel internally clad with stainless steel. The remaining piping is generally fabricated from stainless steel. The valve bodies are generally fabricated from stainless steel. The bolting is fabricated from low-alloy steel and stainless steel. There are also Alloy 600 safe-ends.

The intended function of the RCS piping components is the maintenance of the structural integrity of the reactor coolant pressure boundary under normal, upset, emergency, and faulted conditions, in accordance with the plant's current licensing basis.

3. APPLICABLE AGING EFFECTS

The B&WOG reviewed relevant plant-specific and industry-wide operating experience of the RCS piping components relating to aging. They identified cracking, boric acid corrosion of carbon steel and low-alloy steel, thermal aging embrittlement of cast stainless steel, and loss of bolting preload as applicable aging effects. Table 1 summarizes the applicable aging effects described in the B&WOG topical report that need to be managed for license renewal for the RCS piping components in the B&WOG GLRP member plants.

The B&WOG also indicated that fatigue needs to be managed for license renewal. However, they indicated that fatigue is outside the scope of the topical report and will be evaluated on a plant-specific basis for license renewal under the "time-limited aging analysis" provision of the license renewal rule [1].

4. AGING MANAGEMENT PROGRAMS FOR LICENSE RENEWAL

There are existing aging management programs for the RCS piping components and they are:

ASME Section XI Class 1 ISI [3] - Plants have ISI programs on 10-year intervals based on the ASME Section XI Code. The Class 1 ISI program is described in Subsection IWB of Section XI and is divided into "Examination Categories." The B&WOG will also implement the mandatory Appendices VII and VIII of ASME Section XI for license renewal.

Response to Generic Letter 88-05 [4] - PWR licensees have responded to the USNRC's generic letter describing their programs for mitigating the effects of boric acid corrosion of external surfaces of carbon steel reactor coolant pressure boundary components.

Program evaluated in Generic Letter 85-20 [5] - B&W plants are implementing a B&WOG task force developed program to manage potential cracking of the B&W high pressure injection nozzle thermal sleeves.

Information resulting from Information Notice 90-10 [6] - PWR licensees have evaluated the information on the potential for primary water stress corrosion cracking of Alloy 600 materials and have considered actions, as appropriate.

Response to Bulletin 82-02 [7] - PWR licensees have responded to the USNRC's bulletin describing their maintenance procedures for threaded fasteners in the components of the reactor coolant pressure boundary.

Technical specification RCS leakage limits - Plant technical specifications contain surveillance requirements to monitor and trend RCS leakage, specific limits for identified and unidentified RCS leakage, and no leakage from the reactor coolant pressure boundary.

The B&WOG topical report relied on these existing aging management programs to continue to manage aging of the RCS piping components for the period of extended operation.

The USNRC staff reviewed the specific applicable aging effects against the specific elements of the existing aging management programs. The USNRC staff found that, in general, the existing plant programs are adequate for managing the effects of aging of the RCS piping components to ensure that the intended function of the RCS piping components would be maintained for license renewal. However, there are a few situations where additional aging management programs would be necessary for license renewal. These augmented/new programs are:

Augmented inspection of Alloy 82/182 clad hot leg segment - In B&W plants, a 24 cm (9-1/2 in) flow meter section of the hot leg is internally clad with Alloy 82/182. Operating experience shows that Alloy 82/182 material may be susceptible to cracking. Cracking of the cladding could potentially lead to underlying base metal degradation. To manage the potential cracking of the Alloy 82/182 cladding for license renewal, the B&WOG will perform a one-time volumetric (ultrasonic) inspection of the Alloy 82/182 clad flow meter section of the hot leg at or near the end of the current license term. This one-time inspection could be performed by the B&WOG at only one selected

site if the B&WOG justifies that the inspection results bound all B&WOG GLRP member plants.

Augmented inspection of small bore piping - For RCS piping less than 10 cm (4 in), the ASME Section XI ISI is based on a surface examination of the piping outside surface and leakage detection under "Examination Category B-P." For RCS piping less than or equal to 2.5 cm (1 in), the ASME Section XI ISI program is based solely on leakage detection. A volumetric inspection can usually detect significant cracking originating from the inside surface. However, a crack originating from the inside surface of a pipe but has not penetrated through the pipe wall can not be detected by either surface examination of the outside surface or leakage test. Piping with a part-through wall crack and therefore, not leaking, may not have the structural integrity to ensure the reactor coolant pressure boundary function of the piping components for all design loads. Cracked, but not leaking, piping could fail during a design loading condition such as a seismic event. Further, aging could be a common cause of degradation of piping in a similar service environment. Thus, the B&WOG will perform additional sample inspections of small bore, that is, less than 10 cm (4 in), piping for license renewal.

New program to manage loss of toughness of cast stainless steel - Valve bodies fabricated from cast stainless steel may be subject to thermal aging resulting in a loss of fracture toughness. However, there is currently no procedures in ASME Section XI to evaluate flaws in cast stainless steel materials. The B&WOG compared the lower-bound toughness property for aged cast stainless steel recently developed at the Argonne National Laboratory [8] with the toughness used in evaluating submerged arc welds (SAWs) in IWB-3640 of ASME Section XI and found them to be similar. Thus, the B&WOG will use the SAW procedures in ASME Section XI to evaluate flaws found in valve bodies fabricated from cast stainless steel for license renewal.

Table 2 summarizes the aging management programs for license renewal described in the B&WOG topical report for the RCS piping components in the B&WOG GLRP member plants.

5. CONCLUSIONS

The USNRC has reviewed and approved the B&WOG topical report which is the first technical assessment of aging management of a plant component for license renewal in accordance with the revised license renewal rule [1]. The B&WOG topical report addresses the aging management of the RCS piping for license renewal for the B&WOG GLRP member plants [2]. The scope of the topical report covers the piping components of the RCS within the ASME Section XI ISI program for Class 1 components, that is, the RCS piping, valve bodies, and bolting. The intended function of the RCS piping components is to maintain the structural integrity of the reactor coolant pressure boundary under normal, upset, emergency, and faulted conditions.

The USNRC staff found that, in general, the existing plant programs are adequate for managing the effects of aging of the RCS piping components for license renewal. However, there are a few situations where additional aging management programs would be necessary for license renewal and they are: augmented inspection of the Alloy 82/182 clad flow meter section of the hot leg, augmented inspection of small bore piping, and a new program to manage loss of toughness of cast stainless steel materials. Also, fatigue is outside the scope of the B&WOG topical report and will be evaluated on a plant-specific basis for license renewal. On this basis, the USNRC staff concluded that the B&WOG topical report describes acceptable programs to manage the effects of aging so that the intended function of the RCS piping components of B&WOG GLRP member plants will be maintained consistent with the plant's current licensing basis for the period of extended operation.

6. REFERENCES

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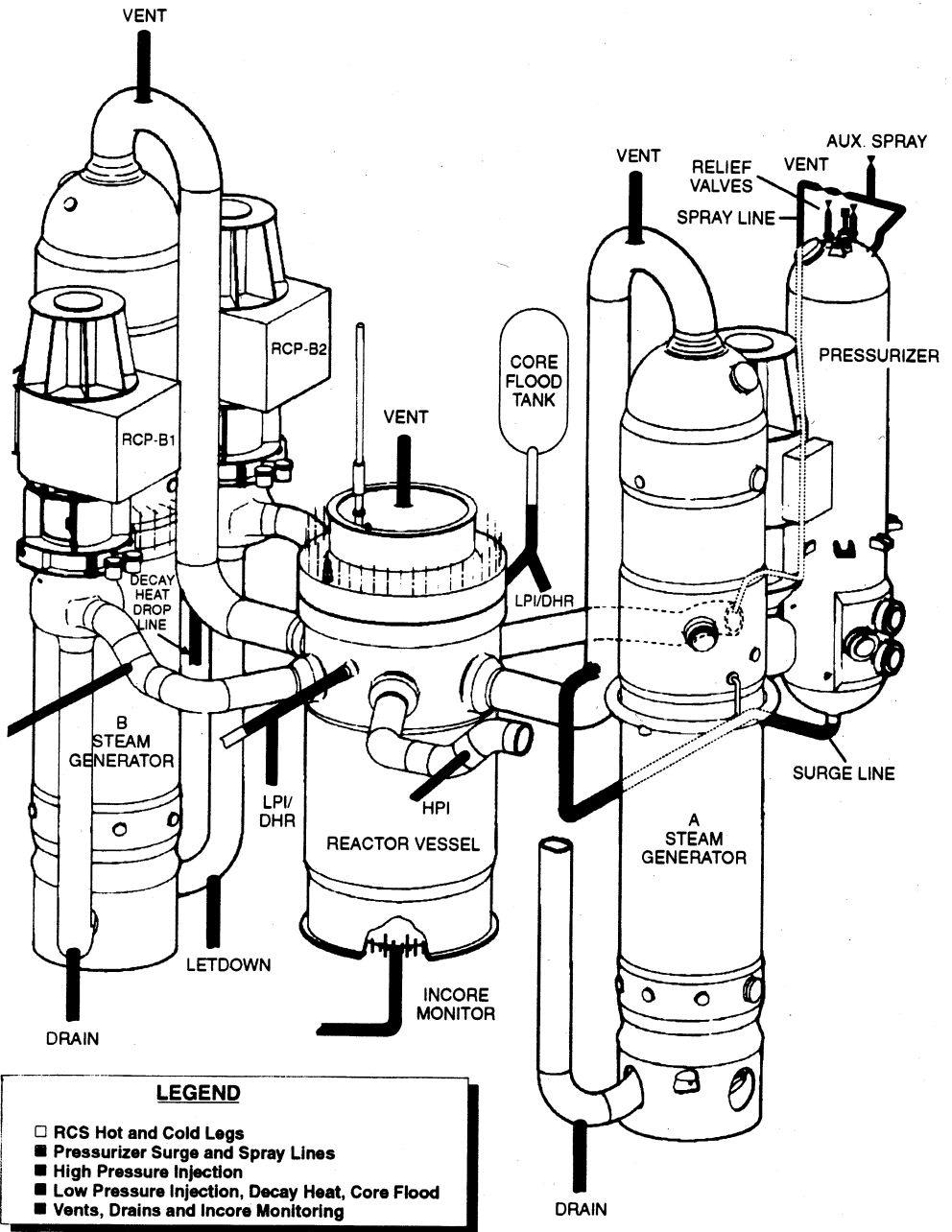


FIGURE 1 B&W REACTOR COOLANT SYSTEM PIPING [2]

TABLE 1 APPLICABLE AGING EFFECTS FOR B&W RCS PIPING COMPONENTS

<u>Component</u>	<u>Applicable Aging Effect</u>
Piping	Cracking Loss of material (carbon steel external surface)
Valve bodies	Cracking Loss of fracture toughness (cast stainless steel) Loss of material (carbon steel external surface)
Bolting	Cracking Loss of bolting preload Loss of material (low-alloy steel)

TABLE 2 AGING MANAGEMENT PROGRAMS FOR B&W RCS PIPING COMPONENTS FOR LICENSE RENEWAL

<u>Component</u>	<u>Aging Management Program for Renewal</u>
Piping	ASME Section XI "Examination Categories B-F, B-J, and B-P" Response to Generic Letter 88-05 on boric acid corrosion Program evaluated in Generic Letter 85-20 on thermal sleeve cracking Information resulting from Information Notice 90-10 on Alloy 600 Technical specification RCS leakage limits Augmented inspection of Alloy 82/182 clad hot leg segment Augmented inspection of small bore piping
Valve bodies	ASME Section XI "Examination Categories B-M-1, B-M-2, and B-P" Response to Generic Letter 88-05 on boric acid corrosion Technical specification RCS leakage limits New program to manage loss of toughness of cast stainless steel
Bolting	ASME Section XI "Examination Categories B-G-2 and B-P" Response to Generic Letter 88-05 on boric acid corrosion Response to Bulletin 82-02 on bolting degradation Technical specification RCS leakage limits

