February 10, 2000

Mr. Roger A. Newton, Chairman
Westinghouse Owners Group
Wisconsin Electric Power Company
231 West Michigan
Milwaukee, Wisconsin 53201

SUBJECT: DRAFT SAFETY EVALUATION CONCERNING THE WESTINGHOUSE OWNERS GROUP LICENSE RENEWAL EVALUATION: AGING MANAGEMENT EVALUATION FOR CLASS I PIPING AND ASSOCIATED PRESSURE BOUNDARY COMPONENTS, WCAP-14575, REVISION 1, AUGUST 1996

Dear Mr. Newton:

The U.S. Nuclear Regulation Commission staff has reviewed the Westinghouse Owners Group (WOG) topical report entitled, “License Renewal Evaluation: Aging Management evaluation for Class 1 Piping and Associated Pressure Boundary Component WCAP 14575, Revision 1, August 1996" and is transmitting the draft safety evaluation (DSE) to you as an enclosure to this letter. The staff will issue a final safety evaluation upon resolution of the open items identified in the DSE.

Resolution of the open items in the DSE and satisfactory completion of the identified applicant action items will allow the staff to find that a WOG member plant that references the report in a license renewal application has satisfied the requirements of 10 CFR 54.21(a)(3) for the Class 1 Piping and Associated Pressure Boundary Component within the scope of WCAP-14575.

Once you have reviewed the DSE, the staff would like to schedule a meeting with you to discuss the findings in the DSE and the schedule for resolving the open items.

Sincerely,

/RA/

Christopher I. Grimes, Chief
License Renewal and Standardization Branch
Division of Regulatory Improvement Programs
Office of Nuclear Reactor Regulation

Project No. 686

Enclosure: DSE

cc: w/enclosure : See next page

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Project No. 686

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DRAFT SAFETY EVALUATION

BY THE OFFICE OF NUCLEAR REACTOR REGULATION

CONCERNING

WESTINGHOUSE OWNERS GROUP TOPICAL REPORT
WCAP-14575, REVISION 1

"LICENSE RENEWAL EVALUATION: AGING MANAGEMENT EVALUATION FOR CLASS 1 PIPING AND ASSOCIATED PRESSURE BOUNDARY COMPONENTS"

PROJECT NO. 686

DRAFT SAFETY EVALUATION
BY THE OFFICE OF NUCLEAR REACTOR REGULATION
CONCERNING "LICENSE RENEWAL EVALUATION:
AGING MANAGEMENT FOR CLASS I PIPING AND
ASSOCIATED PRESSURE BOUNDARY COMPONENTS"
WESTINGHOUSE OWNERS GROUP REPORT NUMBER WCAP-14575, REVISION 1

1.0 INTRODUCTION

Pursuant to Section 50.51 of Title 10 of the Code of Federal Regulations (10 CFR 50.51), licenses to operate nuclear power plants are issued by the U.S. Nuclear Regulatory Commission (NRC) for a fixed period of time not to exceed 40 years; however, these licenses may be renewed by the NRC for a fixed period of time, including a period not to exceed 20 years beyond expiration of the current operating license term. The Commission's regulations in 10 CFR Part 54 (60 FR 22461), published on May 8, 1995, set forth the requirements for the renewal of operating licenses for commercial nuclear power plants (Reference 1).

Applicants for license renewal are required by the license renewal rule to perform an integrated plant assessment (IPA). The first step of the IPA, 10 CFR 54.21(a)(1), requires the applicant to identify and list structures and components that are subject to an aging management review (AMR); 10 CFR 54.21(a)(2) requires the applicant to describe and justify the methods used in meeting the requirements of 10 CFR 54.21(a)(1); and 10 CFR 54.21(a)(3) requires that for each structure and component identified in 10 CFR 54.21(a)(1), the applicant demonstrates that the effects of aging will be adequately managed so that the intended function(s) will be maintained consistent with the current licensing basis (CLB) for the period of extended operation. Furthermore, the applicant must provide an evaluation of time-limited aging analyses (TLAAs) as required by 10 CFR 54.21(c), including a list of TLAAs, as defined in 10 CFR 54.3.

1.1 Westinghouse Owners Group Topical Report

By letter dated August 28, 1996, the Westinghouse Owners Group (WOG) submitted topical report WCAP-14575, "License Renewal Evaluation: Aging Management for Class 1 Piping and Associated Pressure Boundary Components" (Reference 2), for staff review and approval. The focus of the report is on the management of the effects of aging of Class 1 piping and associated pressure boundary components during any extended period of operation. WOG defined Class 1 piping as piping that contains primary reactor coolant. In this safety evaluation (SE), Class 1 piping is referred to as reactor coolant system (RCS) piping.

The WOG report evaluated the aging management of the RCS piping for domestic commercial nuclear power plants with a Westinghouse nuclear steam supply system (NSSS). The objectives of the topical report are to

- Identify and evaluate aging effects that degrade intended functions
- Identify and evaluate TLAAs
- Provide options, in terms of activities and program attributes, to manage the aging effects identified in the topical report

1.2 Conduct of Staff Review

The staff reviewed the report to determine whether the requirements set forth in 10 CFR 54.21(a)(3) can be met. The staff issued a request for additional information (RAI) after completing its initial review (Reference 3). WOG responded to the staff's RAI (Reference 4) and provided further clarification of its response to the RAI in a meting on July 10, 1997, with the staff.

2.0 SUMMARY OF TOPICAL REPORT

WOG topical report WCAP14575 contains a technical evaluation of the effects of aging of the Westinghouse RCS piping and associated pressure boundary components. The report was submitted to the NRC staff to demonstrate that WOG member plant owners can adequately manage the effects of aging during the period of extended operation. This evaluation applies to the plants listed in Table 1-1 of the topical report. The license renewal applicant should verify that its plant is bounded by the topical report. This is Renewal Applicant Action Item 1.

2.1 Components and Intended Functions

2.1.1 Intended Functions

Section 2.2 of the topical report identified the following intended function for the Class 1 piping and associated components, based on the requirements of 10 CFR 54.4(a):

- maintain the integrity of the reactor coolant pressure boundary.

The staff has concluded that there is an additional intended function of an associated component of the Class 1 piping, namely, the flow restrictors (see Section 3.1 of this SE).

2.1.2 Components

The report addresses the plant-specific piping and associated components of the RCS that are within the scope of the license renewal rule. The scope of the topical report includes the following categories of components:

- Class 1 piping
- Class 1 valve bodies
- reactor coolant pump (RCP) casings
- associated pressure boundary components

Section 2.0 of the topical report provides a discussion of the Class 1 piping and associated components within the scope of the rule and subject to an AMR. As discussed in Section 2.0 of the report, the associated pressure boundary components include closure bolting for the RCPs and Class 1 valves and flange bolts for the Class 1 piping.

Detailed descriptions of Class 1 piping and the associated pressure boundary components, its intended functions, and its interactions and interdependence are presented in Section 2.3 of the report. As described in the report, Class 1 piping includes large- and small-bore seamless steel pipe and fittings. For piping larger than 2 inches, butt-welded construction was used. For piping smaller than 2 inches, socket-welded or butt-welded construction was used. Exceptions include thermowells, which may use threaded connections, and safety valves and resistance temperature detector (RTD) bypass lines, which use flanged connections.

RCS piping is comprised of large seamless stainless steel pipe and fittings. The piping design specifications, in conjunction with the governing code of record, define the design and loading conditions as well as the allowable stresses.

The RCS consists of two, three, or four heat transfer loops connected in parallel to the reactor pressure vessel (RPV). Each reactor coolant loop (RCL) contains an RCP and a steam generator (SG). In addition, the RCS includes a pressurizer (PZR), a pressure relief tank, interconnecting piping, and instrumentation necessary for operational control. During operation, RCPs circulate pressurized fluid through the RPV and RCL. The fluid, which serves as a coolant, moderator, and solvent for boric acid, is heated as it passes through the nuclear core. The fluid in each loop flows from the RPV through the hot leg and into the SG, where heat is transferred to the steam supply system for electrical power generation. The fluid flows from the SG to the RCP in the crossover leg and then is pumped back into the RPV in the cold leg. The hot legs, crossover legs, and cold legs of the loop comprise the RCL piping. The RPV, SG, and PZR safe-end nozzle weld to the RCS piping is a similar metal weld and is included in the scope of this evaluation because the stainless steel (piping) to carbon steel (equipment) bimetallic weld is part of the equipment design and analysis.

On the basis of the intended functions previously set forth, the Class 1 portions of the auxiliary piping systems that were identified in the report as being within the scope of license renewal and requiring AMR are described below. It was also noted in the report that each plant may have additional specific commitments to NRC to increase or decrease the scope of license renewal.

- PZR surge line from one RCL hot leg to the PZR vessel inlet/outlet nozzle

- PZR spray lines from the reactor coolant cold legs, including the PZR spray scoop, to the spray nozzle on the PZR vessel

- RTD bypass lines, including RTD scoops, direct immersion RTDs, and the RTD manifolds

- Loop bypass lines

- PZR safety and relief lines from nozzles on top of the PZR vessel up to and through the power-operated PZR relief valves and PZR safety valves

- Class 1 portions of seal injection water and labyrinth differential pressure lines to or from the RCP inside the reactor building

- Reactor vessel head vent lines

- Charging line and alternate charging line from the Class 1 system isolation valves up to the branch connections on the RCL

- Letdown line and excess letdown line from the branch connections on the RCL to the

- Class 1 system isolation valve
- Residual heat removal (RHR) lines to or from the RCLs up to the designated Class 1 check valve or isolation valve
- High-head and low-head safety injection lines from the Class 1 check valve to the RCLs
- Accumulator lines from the designated Class 1 check valve to the RCLs
- Loop fill, loop drain, sample (including the sample scoop), and instrumentation lines to or from the designated Class1 isolation valve to or from the RCLs
- Auxiliary spray line from the Class 1 isolation valve to the PZR spray line header
- Sample lines from the PZR to the Class 1 isolation valve
- Boron injection lines from the designated Class 1 check valve to the RCL

The following associated pressure boundary components of Class 1 piping that are within the scope of license renewal and are subject to AMR were also identified:

NOZZLES AND SPECIAL NOZZLE ITEMS

In all of the lines previously described, the nozzle from the Class 1 component is considered part of the Class 1 component. For example, the reactor vessel head vent nozzle is part of the RPV, and the PZR surge nozzle on the hot leg is part of the hot leg. The nozzles that are included are as follows:

- Wide-range thermowells (Class 1 with no fluid system safety class interface)
- RTD fast-response thermowells with and without scoop (Class 1 with no fluid system safety class interface)
- Sample scoop and PZR spray scoop
- Three-inch and larger nozzle with thermal sleeve
- Two-inch and smaller nozzle with thermal sleeve
- Three-inch and larger nozzle without thermal sleeve
- Two-inch and smaller nozzle without thermal sleeve
- Forty-five-degree accumulator nozzles

Where installed, the thermal sleeve, thermowells, and scoop are considered in the design analysis of the nozzle

BRANCH LINE RESTRICTORS

The scope of this report only addresses the Class 1 portion of the instrument connections and branch lines. Several instrument connections and some branch lines of the RCS are equipped with 3/8-inch-diameter flow restrictors. These restrictors limit the maximum flow through a broken line to a value below the makeup capability of the chemical and volume control system (CVCS). By providing the flow restrictions, the safety classification of the lines is downgraded from Safety Class 1 to Safety Class 2.

The staff has concluded that in addition to the pressure boundary function, the flow restrictors have an additional function, and that the effects of aging must be adequately managed so that every intended function of the component will be maintained (see Section 3.1 of this SE).

VALVES

The aging effect of the pressure boundary valve body is considered in this evaluation. The valve types include check valves, manual valves, pneumatic valves (air-operated valve), motor-operated block valves, solenoid-operated valves, and safety valves. The evaluation considers the effects of aging on the pressure boundary functions associated with the valve bodies consistent with the requirements of 10 CFR 54.21(a)(1)(i).

Valve bodies and bonnets that form part of the pressure boundary are classified as long-lived passive components and their pressure-retaining function will be addressed in this evaluation. Valve operators, discs, and seats are classified as active components and thus are not considered in this evaluation. The functions of valve operators, discs, and seats are periodically tested to ensure their functions are maintained.

<u>PZR Safety Valves</u>: The PZR safety valves are of the totally enclosed pop type and are spring-loaded and self-actuating with backpressure compensation features. These valves provide overpressure protection for the RCS and are sized to limit system pressure to below 110 percent of the system design pressure. In addition, these valves are set to the system design pressure, which is typically 110 percent of the operating pressure. The boundary between the piping and the safety valve is a flanged connection.

<u>Power-Operated Relief Valve (Air-Operated Valve)</u>: The power-operated (pneumatic) relief valve (PORV) limits system pressure during large system transients. The valves are operated automatically from a pressure-sensing system or manually from the control room. The valves are designed to limit PZR pressure to a value below the high-pressure trip setpoint for all design transients up to and including the design percentage step load decrease, with steam dump but without reactor trip. The valves are also used with the cold overpressure mitigation system to control pressure during cooldown. PORVs have two valves in parallel to ensure that either can perform the relief function.

<u>Head Vent Valves</u>: The solenoid-operated reactor head vent valves are used to remove non condensable gases or steam from the reactor vessel head to mitigate potential inadequate core cooling events or impaired natural circulation resulting from the accumulation of non condensable gases.

<u>Motor-Operated Block Valves</u>: Motor-operated block valves are installed on lines where it is possible to have flow out of the RCS, such as RHR suction, letdown, and PORVs. The typical

valve arrangement consists of two valves in series that stop flow by closing either valve. These valves provide a pressure boundary to prevent the flow of fluid out of the RCS.

Check Valves - Interconnecting Systems: Interconnecting system check valves are used to allow flow of fluid from systems required to operate in support of plant operations or an emergency situation and to prevent the backflow of reactor coolant into the support system. The check valves serve as a boundary by preventing flow out of the system.

Loop Stop Valves: Some RCL designs include loop isolation stop valves to isolate the RCLs, SG, and RCP from the RPV. During normal operation, these valves are in the open position. Although some plants have these valves, none are currently licensed to operate with the SG and RCP out of service.

THERMAL BARRIER AND RCP SEALS

The aging effect of the pressure boundary RCP casing is considered in this evaluation. In addition to the RCP casing's being a part of the Class 1 pressure boundary, the tubes of the thermal barrier heat exchanger within the RCP are considered to be part of the pressure boundary. The aging processes affecting stainless steel tubes are essentially the same as the balance of the Class 1 piping and are discussed in that context in this report.

RCP seals are also part of the pressure boundary. RCP seals are designed to leak during all operations. During normal operations, Class 1 seal water injection lines inject approximately 8 gallons per minute (gpm) into the No.1 seal area. This flow splits, with 5 gpm going into the RCS and 3 gpm bypassing and cooling the No. 1 seals. In the event charging flow is lost and the thermal barrier heat exchanger is functioning, the seal will leak cool water at 3 gpm. However, this leak will be reactor coolant water rather than charging water. The 3 gpm is within the normal reactor coolant makeup capacity. If both the charging flow and the component cooling flow are lost, the 3-gpm leakage will be hot water that will have a deleterious effect on the RCP seals. These combinations of RCP seal flow configurations are considered operating modes and not aging effects, and thus were not discussed further in the report. However, because RCP seals perform a pressure boundary function they were considered in the WOG's AMR and evaluated by the staff in Section 3.1 of this report.

2.2 Effects of Aging

Section 2.6 of the topical report lists the following aging effects that WOG considers potentially significant for the RCS piping and associated components:

- Fatigue-related cracking for fatigue-sensitive items
- Cracking and material degradation due to corrosion/stress-corrosion cracking
- Cracking due to irradiation embrittlement
- Thermal aging-related cracking of austenitic steel static castings
- Material wastage due to erosion and erosion/corrosion

- Material loss caused by wear of the RCP and Class 1 valve closure elements

- Loss of bolt preload due to creep or stress relaxation of bolted RCP and Class 1 valve closures

The staff notes that cracking is not caused by either irradiation embrittlement or thermal aging. Rather, these mechanisms cause a reduction in the fracture toughness of the material.

Section 3.0 of the topical report describes the AMR. The WOG review included operating experience of the RCS piping relating to the effects of aging. A summary of the identified potential aging effects is provided in Table 3.17 of the report. The table lists the following as potential effects of aging for the specific RCS piping components:

Component	Potential Effects of Aging
Piping	Fatigue cracking Thermal aging of cast stainless steel Loss of material from corrosion and wear
Valve bodies	Fatigue cracking Thermal aging of cast stainless steel Loss of material from corrosion and wear
RCP casings	Thermal aging of cast stainless steel Loss of material from corrosion and wear
Closures, flanges, and bolting	Fatigue cracking (flange, flange bolts, and RCP closure) Loss of material from corrosion and wear Loss of bolting preload

2.3 Aging Management Programs

Section 3.4 of the topical report identifies the following aging effects that need a specific aging management program (AMP) to manage these aging effects during an extended period of operation:

- Fatigue-related cracking for fatigue-sensitive items

- Thermal aging-related cracking of austenitic stainless steel castings

- Material loss caused by wear of RCP and Class 1 valve closure elements

- Loss of bolt preload due to stress relaxation of bolted RCP and Class 1 valve closures

Section 4.0 of the topical report describes the options for managing these aging effects during an extended period of operation. The report lists seven proposed AMPs. Two of these rely on existing programs:

- AMP for wear of enclosures (AMP-3.1) relies on the American Society of Mechanical Engineers Boiler and Pressure Code (ASME Code) Section XI in-service inspection (ISI)

- AMP for stress relaxation of bolts (AMP-3.2) relies on the ASME Code Section XI Class 1 ISI, supplemented by plant commitments in response to NRC Generic Letter (GL) 88-05 (Reference 5) on boric acid corrosion

Three of the proposed AMPs (AMP 3.3 through AMP 3.5) address fatigue-sensitive components. The remaining proposed programs (AMP-3.6 and AMP-3.7) address thermal aging of stainless steel castings.

2.4 Time-Limited Aging Analyses

Section 2.5 of the topical report identifies the following TLAAs that are applicable to the piping and associated components:

- Fatigue

- Leak-before-break evaluations

Section 3.0 of the report presents WOG's proposed AMPs to address each TLAA. The license renewal applicant should provide a summary description of the programs and evaluations of TLAAs in the FSAR supplement. This is Renewal Applicant Action Item 2.

3.0 STAFF EVALUATION

The staff reviewed the topical report and additional information submitted by WOG to determine if it demonstrated that the effects of aging on the RCS piping covered by the report will be adequately managed so that the components' intended functions will be maintained consistent with the CLB for the period of extended operation in accordance with 10 CFR 54.21(a)(3). This is the last step in the IPA described in 10 CFR 54.21(a).

Besides the IPA, Part 54 requires an evaluation of TLAAs in accordance with 10 CFR 54.21(c). The staff reviewed the topical report and additional information submitted by WOG to determine if the TLAAs covered by the report were evaluated for license renewal in accordance with 10 CFR 54.21(c)(1).

3.1 Components and Intended Functions

The staff reviewed Sections 1.0 and 2.0 of the subject topical report to determine whether there is reasonable assurance that the Class 1 piping and associated pressure boundary components and supporting structures within the scope of license renewal, and subject to AMR, have been identified in accordance with the requirements of 10 CFR 54.4 and 10 CFR 54.21(a)(1). This evaluation was accomplished as discussed below.

As part of the evaluation, the staff determined whether the applicant had properly identified the systems, structures, and components within the scope of license renewal and subject to an AMR, pursuant to 10 CFR 54.4(a) and 10 CFR 54.21(a)(1). The staff reviewed portions of a representative updated final safety analysis report (the UFSAR for Calvert Cliffs) for the Class 1 piping and associated pressure boundary components and compared the information in the UFSAR with the information in the report to identify those portions that the report did not identify as being within the scope of license renewal and subject to an AMR. The staff then reviewed structures and components that were identified as not being within the scope of license renewal. The staff requested that the WOG provide additional information and/or clarifications for a selected number of these structures and components to verify the following:

(1) that these structures and components do not have any of the intended functions delineated under 10 CFR 54.4(a), and

(2) for those structures and components that have an applicable intended function(s), verify that they either perform this function(s) with moving parts or a change in configuration or properties, or that they are subject to replacement based on a qualified life or specified time period, as described in 10 CFR 54.21(a)(1).

The staff also reviewed the UFSAR for any functions delineated under 10 CFR 54.4 (a) that were not identified as intended functions by the WOG to verify that all the systems, structures, and components having an intended function(s) were considered within the scope of the rule.

After completing its initial review, the staff issued RAIs regarding the Class 1 piping and associated pressure boundary components. In a conference call on June 25, 1999, (see WOG letter dated July 19, 1999, documenting the call), the WOG provided the staff with its responses to those RAIs.

In RAI 1, the staff requested the WOG to clarify items from Section 2.3.2.2, "Branch Line Restrictors" of the report. These items are discussed below.

The staff questioned whether the Class 2 pipes and the flow restrictors in Class 2 pipes should be within the AMR. The response from WOG was that WCAP-14575 covers only Class 1 piping and those flow restrictors installed in Class 1 piping. Class 2 piping and flow restrictors installed in Class 2 piping are not included in this report and are evaluated for AMR in a separate report.

The report has listed only one intended function for flow restrictors, which is the pressure boundary function, in accordance with 10 CFR 54.4(a)(1)(i). However, the report also indicates that the 3/8-inch flow restrictors are relied upon to limit mass flow rate during postulated breaks. The staff requested WOG to explain why one of the intended functions of flow restrictors, which is to prevent or mitigate the consequences of design-basis accidents, was not identified as an intended function in accordance with 10 CFR 54.4(a)(1)(iii). The rule requires the applicant to demonstrate that the effects of aging will be adequately managed so that all the intended functions of a component will be maintained consistent with the CLB for the period of extended operation. Therefore, any structure and component that meet any of the scoping criteria under 10 CFR 54.4, that performs an applicable intended function(s) without moving parts or without a change in configuration or properties, and that are not subject to replacement based on qualified life or specified time period should be identified and listed in the report. WOG responded that the report states that "restrictors limit the maximum flow through a broken line to a value below the makeup capability of the CVCS." Therefore, any line break downstream of a flow restrictor would not be a design-basis accident, because of this design feature. WOG therefore concluded that the absence of a design-basis accident eliminated 10 CFR 54.4(a)(1)(iii) as a reason for including this flow restrictor function as an intended function. However, after discussions with the staff, the WOG modified Section 2.3.2.2 and the "summary" sections of the report. The WOG identified "limit flow due to a downstream break to a value less than the normal RCS makeup capability" as an applicable intended function for the flow restrictors. (This is an element of Open Item 1.) The WOG further stated that because the flow restrictor forms an integral part of the piping where it is installed, subsequent discussion of aging effects and aging management for the piping is applicable also to the flow restrictors.

In its report, Section 2.3.2.4, "Thermal Barrier and RCP Seals," the WOG states that " the RCP seals are a replaceable component and, as such, are exempt from license renewal." The staff disagrees with this conclusion. As allowed by the rule under 10 CFR 54.21(a)(1)(ii), structures and components can be excluded from AMR if they are replaced based on qualified life or specified time period. Therefore, for the staff to concur with the generic exclusion of RCP seals from an AMR, the WOG needs to provide a description, if appropriate, of a replacement program that is based on the qualified life or specified time period for these components.

In response to the staff's request for additional information (RAI 2), the WOG stated that RCP seals are a highly visible and closely monitored element of the RCS. Unlike other parts of the system, they do not maintain a pressure boundary but rather allow controlled leakage, which is acknowledged in plant technical specifications. This leakoff is closely monitored in the control room, and a high leakoff flow is alarmed as an abnormal condition requiring corrective action. Certain parts of the RCP seal "package" (e.g., backup seals) are subject to wear, and these parts are frequently replaced, as are installed o-rings. The main RCP seal is routinely inspected during plant outages on the basis of the manufacturer's recommendations and is replaced on the basis of either the results of that inspection or on leakoff performance during operation. The RCP seal was never intended to be a long-lived (life of the plant) component, although the specific time period for replacement of the seals will vary between plants, depending on individual operating practices and experience. The usual period ranges between 3 and 6 fuel cycles of operation. Although the WOGs description of the RCP seal replacement activities did not include a qualified life or specified time period, it did include a description of a replacement program based on performance and condition monitoring activities that provide reasonable assurance that the intended function of the RCP seals will be maintained in the period of extended operation. In the SOC, 60 FR 22478, the Commission allows an applicant to provide a site-specific justification for the use of performance and condition monitoring to provide the necessary reasonable assurance. Although the staff cannot generically exclude RCP seals from an AMR for all applicable Westinghouse plants, an applicant can submit a description of its performance and condition monitoring activities for RCP seals to exclude these components from an AMR. In general, if an applicant's program consists of the performance and condition monitoring activities described above, and the plant operating experience demonstrates the effectiveness of these activities, the staff will consider excluding these components from an AMR.

On the basis of the staff's review of the information provided in Sections 1.0 and 2.0 of the subject topical report, the supporting information in the UFSAR, and WOG's response to the staff's RAIs, the staff did not find, with the exception of the items previously discussed, any omissions in the report and, therefore, concludes that there is reasonable assurance that the report adequately identified those portions of the Class 1 piping and associated pressure boundary components that fall within the scope of license renewal and are subject to an AMR in accordance with 10 CFR 54.4(a) and 10 CFR 54.21(a)(1).

3.2 Effects of Aging

As indicated in Section 2.2 of this SE, the effects of aging evaluated in WCAP-14575 are as follows:

- Fatigue-related cracking
- Corrosion/stress-corrosion cracking
- Reduction of fracture toughness (irradiation embrittlement and thermal aging of cast stainless steel)
- Loss of material (erosion, erosion/corrosion, and wear)
- Loss of bolting preload (creep and stress relaxation of mechanical closures)

Westinghouse reviewed these effects of aging for their specific applicability to the RCS piping, valve bodies, RCPs, and bolting. After reviewing the report and published aging research results, the staff agrees that WOG's report properly identified the potential aging effects for the RCS piping components. A discussion of the specific aging effects on the various RCS components follows.

Westinghouse reviewed information from operating experience of the RCS piping relating to the effects of aging. Although the effects of aging were correctly identified by Westinghouse, the staff found that generic communications were not discussed in the report, for example, Bulletin 82-02 on bolting and GL 85-20 on thermal sleeves. In its response to RAI 5, Westinghouse indicated that Section 3.1 of the report would be revised to describe the process used by WOG to review generic communications. Also, it stated that an updated review would be performed to capture any additional items that occurred, or were missed, since the original review was performed. At this time, this updated version is not available and thus was not reviewed by the staff (Open Item 2).

3.2.1 Fatigue

The report indicates and the staff agrees that degradation sustained from the effects of fatigue was determined to be potentially significant for the fatigue-sensitive Class 1 piping and piping components, the Class 1 valve bodies greater than 4-inch nominal pipe schedule, and the RCP pressure boundary closure components. This determination has its basis in analysis, test, and experience. WOG proposed programs to manage fatigue-sensitive components during the period of extended operation. The staff's assessment of these programs is contained in Section 3.3.2 of this SE.

3.2.2 Corrosion/Stress Corrosion

The topical report indicates that operating experience has shown that general corrosion and stress corrosion are not a concern for primary loop materials used in Westinghouse NSSSs.

NSSS components are fabricated from austenitic stainless steel. The staff agrees with the WOG assessment that austenitic stainless steel is not susceptible to corrosion and stress corrosion in pressurized water reactor (PWR) primary coolant. However, austenitic stainless steel is susceptible to stress-corrosion cracking if the outside surface of the material comes in contact with halogens. Therefore, applicants for license renewal must provide a description of all insulation used on austenitic stainless steel NSSS piping to ensure the piping is not susceptible to stress-corrosion cracking from halogens. This is Renewal Applicant Action Item 3.

The topical report identifies wastage of external surfaces caused by the leakage of borated water as a concern for RCS components. Degradation sustained from the effects of corrosion was determined to be potentially significant near the bolted or flanged connections that may be subject to boric acid corrosion from leaking primary coolant. WOG indicated that this could be managed by the existing ISI program. The staff's assessment of this program is contained in Section 3.3.1 of this SE.

3.2.3 Loss of Material

The report indicates that the effect of erosion is not considered significant for the Class 1 piping and associated components on the basis of the following considerations:

- The fluid flow velocity is relatively low in the Class 1 piping and components.
- The water is filtered before injection into the primary system.
- The operating pressure of a PWR precludes cavitation erosion.
- The inside diameter of the primary loop is 100-percent machined or ground.

The staff agrees with the WOG assessment that erosion is not significant for Class 1 piping and associated components.

Mechanical wear affects RCP and Class 1 valve bolted closure elements, such as closure flanges and bolting, because of relative motion caused by loss of bolt preload or by infrequent disassembly and reassembly. WOG indicated that this concern could be managed by the existing ISI program. The staff's assessment of this program is contained in Section 3.3.1 of this SE.

3.2.4 Reduction of Fracture Toughness

The topical report indicates that thermal aging-related cracking of austenitic steel castings are aging effects that WOG considers potentially significant for the RCS piping and associated components. However, thermal aging does not cause cracking, it causes a reduction in fracture toughness of the material. As discussed below, the reduction in fracture toughness results in a reduction in the critical flaw size that could lead to component failure. WOG should revise the topical report, accordingly (Open Item 3).

The report indicates that irradiation embrittlement is not a concern for the RCS piping components because the expected neutron fluence is much less than the threshold level at which changes in properties of the materials would occur. The staff agrees with this conclusion.

The staff concurs with Westinghouse that thermal aging is a potential aging effect on cast austenitic stainless steel (CASS) components. The thermal aging effect is a reduction in fracture toughness of CASS components. This reduced fracture toughness causes a reduction in the critical flaw size for the component, which is defined as the size flaw that could lead to failure. The staff agrees with Westinghouse that welds in the primary loop also thermally age but usually respond more slowly because of low ferrite. WOG proposed programs to manage the effects of thermal aging of CASS components during the period of extended operation. The staff's assessment of these programs is contained in Section 3.3.3 of this SE.

3.2.5 <u>Loss of Closure Integrity</u>

The report indicates that creep is not a concern for austenitic alloys below 1000 °F. The staff agrees with this conclusion. However, the report does indicate that loss of preload can occur from stress relaxation on the RCP and Class 1 valve bolted closures. WOG indicated that this could be managed by the existing ISI program. The staff assessment of this program is contained in Section 3.3.1 of this SE.

3.3 <u>Aging Management Programs</u>

Table 4-1 of the report lists the six attributes that form the basis for the existing and additional AMPs. These attributes include the scope of the program, the surveillance techniques used to detect aging effects, the frequency of the surveillance, the acceptance criteria to determine when corrective actions are necessary, the corrective actions, and confirmation techniques. WOG indicated, in Section 4.0 of the topical report, that the plant-specific details of the AMPs will be developed during the preparation of license renewal applications and that all six attributes may not be necessary for an AMP. Therefore, applicants for license renewal will be responsible for describing the plant-specific attributes of each AMP. This is Renewal Applicant Action
Item 4.

WOG evaluated existing programs and found them adequate, with a few exceptions, in managing the effects of aging so that the intended function of the RCS piping components will be maintained consistent with the CLB for any period of extended operation. As described in Section 2.3, the existing programs include ASME Code Section XI ISI programs and licensee commitments in response to NRC generic communications. These existing programs are used to address wear of closures and stress relaxation of bolts. WOG proposed additional programs to address fatigue and thermal aging.

The staff reviewed the existing and additional programs and concluded that WOG should provide a new evaluation of CASS components to the criteria in Electric Power Research Institute (EPRI) TR-106092 with additional criteria discussed in Section 3.3.3 of this SE (see Open Item 4). The staff believes that WOG should propose to perform additional inspection of small-bore RCS piping, that is, less than the 4-inch-size, for license renewal. These additional examinations would provide assurance that the potential for cracking of small-bore RCS piping is adequately managed during the period of extended operation (Open Item 5).

3.3.1 Wear of Closures and Stress Relaxation of Bolts

WOG relies on existing ASME Code Section XI ISI to manage wear and stress relaxation for the RCP and Class 1 valve bolted closure elements. The elements of these programs are shown in Tables 4-2 and 4-3 of the topical report. The topical report describes the ASME Code Section XI Class 1 ISI program “Examination Categories B-G-1, B-G-2, and B-P,” the response to GL 88-05, including pump and valve inservice testing, as necessary to manage the effects of aging of the RCS bolted closure elements during the period of extended operation to maintain the reactor coolant pressure boundary.

ASME Code Section XI "Examination Category B-P" covers system leakage and hydrostatic tests. "Examination Categories B-G-1 and B-G-2" are as follows:

“Examination Category”	Component description	Size (Inches)	Examination
B-G-1	Pressure-retaining bolting	≥ 2	Volumetric Visual “VT-1” of associated surfaces
B-G-2	Pressure-retaining bolting	<2	Visual “VT-1” of pump and valve studs and bolts

These examinations and tests are carried out at each inspection interval of the plant's ISI program or at each refueling outage in the case of system leakage tests. Valve bolting examination is limited to bolting on valves that are selected for examination under Examination Category B-M-2. "Visual VT-1" examination is conducted to determine the condition of the component or surface examined, including such conditions as cracks, wear, corrosion, erosion, or physical damage on the surfaces of the components. Flaws detected in "Examination Categories B-G-1 and B-G-2" may be acceptable for continued service if they meet the acceptance standards in IWB-3517.

AMP-3.1 is applicable to wear of bolted closures. The staff finds the ASME Code Section XI examination proposed by WOG adequate in managing potential wear of bolted closures because the closure surfaces and bolts will be examined when the closures are disassembled for inspections. Mechanical closure integrity can also be monitored through "Examination Category B-P" system leakage and hydrostatic tests.

AMP-3.2 is applicable to loss of preload by stress relaxation. The program relies on ASME Code Section XI in-service examinations and tests supplemented by the boric acid wastage surveillance programs implemented by licensees in response to NRC GL 88-05 as necessary in managing the potential loss of material of low-alloy steel bolting during the period of extended operation. The staff finds the ASME Code Section XI examination and tests supplemented by programs committed to by licensees in response to GL 88-05 to be acceptable for managing the aging effect of loss of material for low-alloy steel bolting within the scope of this report during the period of extended operation.

3.3.2 Fatigue

WOG presented three AMPs for fatigue. AMP-3.3 covers ASME Code Class 1 piping, valve bodies 6 inches and larger, and RCP closure fatigue-sensitive locations. AMP-3.4 covers fatigue- sensitive RCS piping designed to United States of America Standard (USAS) B31.1. AMP-3.5 covers valve bodies 6 inches and larger and the RCP closure. WOG presented several options to manage fatigue for each program. The staff's evaluation of these options is discussed below.

WOG evaluated the RCS components and summarized the fatigue-sensitive locations in Table 4-4 of the report. For the fatigue-sensitive locations identified in Table 4-4, WOG proposed an AMP. According to WOG, the objectives of the fatigue management program are to

(1) Maintain the CLB for fatigue for the current license renewal terms by justifying that existing fatigue analyses are valid or by extending the period of evaluation of the analyses so they remain valid or

(2) Justify that the effects of fatigue will be adequately managed for the license renewal term if the applicant cannot or chooses not to justify or extend the existing fatigue analyses.

WOG proposed AMP-3.3 for the ASME Code Class 1 components and AMPs 3.4 and 3.5 for USAS B31.1 designs. For each AMP, WOG proposed several options to meet the above objectives. In addition to program scope, each AMP specifies surveillance techniques (parameters monitored), monitoring frequency, acceptance criteria, corrective actions, and confirmation techniques. The AMPs present four alternatives for demonstrating the adequacy of the components for the extended period of operation. These alternatives are discussed in Section 4.2.1 of the topical report.

The first alternative for Class 1 components (Step 1A of the proposed program) involves demonstrating that the CLB analysis will remain valid through the period of extended operation by ensuring that the number of transients assumed in the design is not exceeded during the period of extended operation or recalculating the fatigue usage using operating experience. The first alternative for USAS B31.1 designs (Step 1B of the proposed program) involves assessing the thermal stresses during the period of extended operation. The process is described in Section 4.2.1.2 of the topical report. The process for evaluating USAS B31.1 designs involves several steps. The steps provide the following alternatives to qualify the component : (1) demonstrate that the design basis cycles of transient operation will not be exceeded during the period of extended operation, or (2) demonstrate the expansion stresses meet a reduced stress limit to account for a projected 50% increase in number of transient cycles, or (3) perform detailed analysis of the component for the period of extended operation considering design or actual operating cycles to demonstrate that either the USAS B31.1 expansion stress limits will not be exceeded or the ASME Class 1 fatigue limits will not be exceeded. The staff finds that the options specified in the first alternative provide acceptable methods for meeting the requirements of 10 CFR 54.21(c)(1).

The second alternative (Step 2 of the proposed program) allows the component to be included in an existing or enhanced ASME Code Section XI ISI program with ISI procedures adequate to detect flaw sizes that can be shown to not propagate to failure between inspection intervals. In RAI 2a, the staff requested that WOG discuss how this alternative provides assurance that the licensing basis criteria has been met at a facility. In response to the RAI, WOG proposed to modify the topical report to provide an additional discussion of this alternative. This alternative would allow the CLB fatigue cumulative usage factor (CUF) to be exceeded during the period of extended operation. The staff has not endorsed this position on a generic basis at this time. An applicant wishing to pursue this alternative would have to obtain staff review and approval on a case-by-case basis.

The third alternative (Step 3) provides for an augmented inspection program to determine the acceptability of the components for the period of extended operation. The alternative allows for the use of a flaw tolerance evaluation or a leak-before-break analysis to demonstrate the adequacy of the components. In RAI 2b, the staff requested that WOG discuss how this alternative provides assurance that the licensing basis criteria has been met at a facility. In response to the RAI, WOG proposed to modify the topical report to provide an additional discussion of this alternative. This alternative would allow the licensing basis CUF to be exceeded during the period of extended operation. The staff has not endorsed these positions at this time. The staff notes that the WOG reference to a leak-before-break analysis only involves the use of the analysis methodology. The staff would not approve the use of leak-before-break methodology to eliminate postulated pipe breaks under General Design Criterion (GDC) 4 for locations where the CLB CUF may be exceeded during plant operation. An applicant wishing to pursue the third alternative would have to obtain staff review and approval on a case-by-case basis.

The fourth alternative (Step 4) is to replace the component if the licensing basis fatigue criteria cannot be met during the period of extended operation. The staff finds that this alternative satisfies the requirements of 10 CFR 54.21(c)(1)(iii).

3.3.3 Thermal Aging of CASS Components

A recent EPRI report provides a framework for effective management of thermal aging of CASS components (Ref. 6), with appropriate modifications. This framework consists of a susceptibility screening process and an examination (ISI) flaw evaluation process. The susceptibility screening process is used to determine which CASS components are potentially susceptible to thermal aging and hence require additional evaluation or examination.

Susceptibility Screening Method

Determination of the susceptibility of CASS components to thermal aging can use a screening method based upon the Molybdenum (Mo) content, casting method, and δ-ferrite content. (Alternatively, components can be assumed as “potentially susceptible” without considering such screening.) Specific acceptable screening criteria are outlined in Table 1 and are applicable to all primary pressure boundary components constructed from SA-351 Grade CF3, CF3A, CF8, CF8A, CF3M, CF3MA, or CF8M, with service conditions above 250 °C (482 °F). The δ-ferrite content of the component can be determined from measurements or calculations. Note that calculations of δ-ferrite should use Hull’s equivalent factors or a method producing an equivalent level of accuracy (±6% deviation between measured and calculated values).

The significance of finding a particular component not susceptible or potentially susceptible is described below for each component type. The examination requirements for each component type are given in Table 2. In addition, acceptable flaw evaluation procedures are described.

Table 1: CASS Thermal Aging Susceptibility Screening Criteria

Mo Content (Wt. %)	Casting Method	δ-Ferrite Level	Susceptibility Determination
High (2.0 to 3.0)	Static	≤ 14 %	Not susceptible
		> 14 %	Potentially susceptible
	Centrifugal	≤ 20 %	Not susceptible
		> 20%	Potentially susceptible
Low (0.5 max.)	Static	≤ 20 %	Not susceptible
		> 20 %	Potentially susceptible
	Centrifugal	ALL	Not susceptible

Table 2: Examination Requirements for CASS Components

Component	Grouping	Not Susceptible	Potentially Susceptible
Piping (Base Metal)	NPS ≥ 4 in.	None	Inspection or evaluation
	NPS < 4 in.	None	Inspection or evaluation
Valve Bodies (Base Metal)	NPS ≥ 4 in.	ASME Code Section XI requirements	ASME Code Section XI requirements
	NPS < 4 in.	ASME Code Section XI requirements	ASME Code Section XI requirements
Pump Casings (Base Metal)	NPS ≥ 4 in.	ASME Code Section XI requirements	ASME Code Section XI requirements

	NPS < 4 in.	ASME Code Section XI requirements	ASME Code Section XI requirements

Current Inspection Requirements

Current inspection requirements in Table IWB-2500-1 of Section XI of the ASME Code for CASS components are as follows:

- Piping (Category B-J): Volumetric and surface examination of pressure-retaining welds for NPS ≥ 4 in.; surface examination of pressure-retaining welds for NPS < 4 in.

- Valve bodies (Categories B-M-1 and B-M-2): Visual VT-3 examination of internal surfaces and volumetric examination of pressure-retaining welds for NPS ≥ 4 in.; surface examination of pressure-retaining welds for NPS < 4 in.

- Pump casings (Categories B-L-1 and B-L-2): Visual VT-3 examination of internal surfaces and volumetric examination of welds

As described in Table 2, these requirements are sufficient in some cases for management of thermal aging even for components "potentially susceptible" to thermal aging, notably RCP casing and valve bodies. However, in the case of piping base metal the current ASME Code Section XI requirements may not be adequate and additional evaluation or examination is warranted as follows:

Piping (Base Metal)

Since the base metal of piping does not receive periodic inspection in accordance with Section XI of the ASME Code, the susceptibility of piping constructed from CASS should be assessed for each heat of material. Alternatively, an assumption of "potentially susceptible" can be assumed for each heat or specific heats.

If a particular heat is found to be "not susceptible," no additional inspections or evaluations are required because the material has adequate toughness.

If a particular heat is found or assumed to be "potentially susceptible" and subject to plausible degradation (e.g., thermal fatigue), aging management can be accomplished through volumetric examination or plant/component-specific flaw tolerance evaluation. The volumetric examination, using a method capable of detecting flaws in CASS components, should be performed on the base material of each heat, with the scope of the inspection covering the portions determined to be limiting from the standpoint of applied stress level, operating time, and environmental considerations. Alternatively, a plant-specific or component-specific flaw tolerance evaluation, using specific geometry and stress information, can be used to demonstrate that the thermally embrittled material has adequate toughness.

Valve Bodies and Pump Casings

Valve bodies and pump casings are adequately covered by existing inspection requirements in Section XI of the ASME Code, including the alternative requirements of ASME Code Case N-481 for pump casings. Screening for susceptibility to thermal aging is not required during the period of extended operation because the potential reduction in fracture toughness of these components should not have a significant impact on critical flaw sizes. Accordingly, the current ASME Code inspection requirements are sufficient.

AMP-3.7 provides aging management for RCP casings through the demonstration of compliance with Code Case N-481. The one-time fracture mechanics evaluation, specified in this AMP, must incorporate bounding material properties for the end of the period of extended operation.

Volumetric Examination

Current volumetric examination methods are not adequate for reliable detection of cracks in CASS components. If an acceptable method for volumetric examination of CASS components is developed, the performance of the equipment and techniques should be demonstrated through a program consistent with ASME Code, Section XI, Appendix VIII.

Flaw Evaluation

Flaws detected in CASS components should be evaluated in accordance with the applicable procedures of IWB-3500 in Section XI of the ASME Code. If the δ-ferrite content does not exceed 25 percent, then flaw evaluation would be in accordance with the principles associated with IWB-3640 procedures for submerged arc welds (SAWs), disregarding the ASME Code restriction of 20 percent in IWB-3641(b)(1). If the CASS material is "potentially susceptible" and the δ-ferrite content exceeds 25 percent, then flaw evaluation would be on a case-by-case basis using fracture toughness data supplied by the licensee, such as that published by Jayet-Gendrot, et al (Reference 7).

WOG should address thermal-aging issues in accordance with the staff comments above, and revise AMP-3.7 as appropriate (Open Item 4).

3.4 Time-Limited Aging Analyses

TLAAs are defined in 10 CFR 54.3 as those licensee calculations and analyses that

1. involve systems, structures, and components within the scope of license renewal, as stated in 10 CFR 54.4(a);

2. consider the effects of aging;

3. involve time-limited assumptions defined by the current operating term, for example, 40 years

4. were determined to be relevant in making a safety determination;

5. involve conclusions or provide the bases for conclusions related to the capability of the system, structure or component to perform its intended functions, as stated in 10 CFR 54.4(b); and

6. are contained or incorporated by reference in the CLB.

Section 54.21(c)(1) requires the applicant to demonstrate that

1. the analyses remain valid for the period of extended operation;

2. the analyses have been projected to the end of the period of extended operation; or

3. the effects of aging on the intended functions(s) will be adequately managed for the period of extended operation.

The TLAAs evaluated in WCAP-14575 for the Class 1 piping are

1. Fatigue of metallic components
2. Leak-before-break evaluations.

3.4.1 Fatigue (Including Environmentally Assisted Fatigue)

Section 3.3 of WCAP-14575 describes the fatigue evaluation methodology for the RCS piping and associated components. The methodology depends on the component type and its design code. The design requirements are discussed in Sections 2.4.6, 2.4.7,and 3.2 of the topical report. The specific design criteria are discussed below.

Piping

Section III of the ASME Code was used for plants designed since 1971. USAS B31.7 was used for plants designed between 1969 and 1971. The design criterion for these codes involves calculating a specific quantity called the CUF. The fatigue damage caused by each thermal or pressure transient depends on the magnitude of the change in the stresses in the component caused by the transient. The CUF sums the fatigue resulting from each transient. The design criterion requires that the CUF not exceed 1.0. USAS B31.1 was used for plants designed before 1969. USAS B31.1 does not require an explicit fatigue analysis of local thermal stresses resulting from operational transients. Instead, the criterion requires a reduction in the allowable bending stress range if the number of full-range cycles of bending stress exceeds the value specified in the Code.

Valves

Section III of the ASME Code was used for plants designed since 1971. The Draft ASME Pump and Valve Code was used for plants designed between 1969 and 1971. The design criterion for these did not require a fatigue evaluation of valves 4 inches or less. A fatigue evaluation was required for larger size valves. Before 1969, valves were covered by USAS B31.1, which did not require a fatigue analysis of valves.

RCP Casings

According to WOG, detailed fatigue analyses of RCP casings were not required because the ASME Code conditions specified in NB-3222.4(d)(1) through (6) were met. The ASME Code does not require an explicit fatigue analysis if these limits are satisfied.

RCP parts other than the casings are discussed in Section 3.3.5 of the report. According to WOG, some of the seal injection and component cooling water nozzles have high fatigue usage factors and are, consequently, considered fatigue-sensitive areas.

WOG indicated that Westinghouse maintains a generic fatigue database for the Class 1 piping systems that have been evaluated for fatigue. WOG increased the calculated CUF for each component in these systems by a factor of 1.5 to account for 60 years of design cycles. If the subsequent CUF was less than 1.0, WOG considered the component not to be fatigue-sensitive. The results of these evaluations are summarized in Tables 3-2 through 3-16. For the remaining components, either a further analysis is necessary or the component needs an AMP. WOG did not evaluate all valve bodies and RCPs. As a consequence, WOG identified these components as requiring a plant-specific evaluation. Therefore, applicants for license renewal should perform additional fatigue evaluations or propose an AMP to address these remaining components. This is Renewal Applicant Action Item 5.

Section 3.1.2 of the topical report contains a discussion of environmentally assisted fatigue of metal components. Current test data indicate that the design fatigue curves of the ASME Code may not be conservative for nuclear power plant primary system environments. The ASME fatigue curves were developed from laboratory specimens tested in air at room temperature. The current test data indicate there could be a significant reduction in the fatigue life of metal components in a reactor primary system environment. The staff addressed the issue of environmentally assisted fatigue in Generic Safety Issue (GSI) 166, “Adequacy of Fatigue Life of Metal Components.” The staff’s recommendations are contained in SECY-95-245. In SECY-95-245, the staff did not recommend the backfit of new environmental fatigue curves to operating plants. This recommendation was based, in part, on conservatism identified in the existing fatigue analyses and on a risk assessment considering a 40-year plant design life.

A further assessment was performed under GSI-190, “Fatigue Evaluation of Metal Components for 60-Year Plant Life.” In SECY-95-245, the staff indicated that it would consider whether license renewal applicants need to evaluate a sample of components with high-fatigue usage factors, using the latest available environmental fatigue data. The staff further indicated that if the GSI has not been resolved before the issuance of a renewed license, the applicant should submit its technical rationale for concluding the effects of fatigue are adequately managed for the extended period or until the resolution of the GSI becomes available (60 FR 22484, May 8, 1995). The staff recommendation for the closure of GSI-190 is contained in a December 26, 1999, memorandum from Ashok Thadani to William Travers. The staff recommended that licensees address the effects of the coolant environment on component fatigue life as aging management programs are formulated in support of license renewal. The evaluation of a sample of components with high-fatigue usage factors using the latest available environmental fatigue data is an acceptable method to address the effects of the coolant environment on component fatigue life.

Section 4.2.1 of the topical report contains further discussion of environmental effects on the fatigue life of components. In RAI 2c, the staff requested WOG to clarify the method by which the staff’s recommendation is addressed by the AMP. In response, WOG indicated that the report will be modified to incorporate the revised proposed industry position on fatigue. This revised position considers environmental effects for an extended period of operation. The staff has not yet endorsed the industry position on fatigue (References 8, 9, 10). Therefore, a renewal applicant will be required to address the GSI-190 closure recommendation on a case-by-case basis until the staff endorses the industry position. This is Renewal Applicant Action Item 6.

3.4.2 <u>Leak-Before-Break Evaluations</u>

In Section 3.3.7 of the topical report, WOG indicated that leak-before-break (LBB) evaluations have been incorporated into the current licensing basis (CLB) for most Westinghouse plants. These evaluations followed, in general, the recommendations and criteria proposed in NUREG-1061, Volume 3 (Reference 11), and have been applied to both the main coolant loop piping as well as the Class 1 auxiliary lines at some plants. WOG proposed AMP-3.6 to reevaluate the LBB status of those CASS piping components that had been previously approved for LBB during the current licensing period. According to WOG, the LBB limiting locations must be based on appropriate material properties for base and weld metals, including any long-term material degradation effects such as thermal aging embrittlement. Therefore, WOG proposed AMP-3.6 to address the impact of thermal aging embrittlement on the LBB evaluations for the period of extended operation. Previously, in Section 3.3.3, the staff identified Open Item 4 regarding the thermal aging embrittlement evaluation.

The staff has reviewed AMP-3.6 and has concluded that it is, in general, an acceptable proposal for confirming the LBB status of CASS components through the period of extended operation. However, two items from Table 4-9 on AMP-3.6 require revision. First, in order to maintain conformance with the NRC staff's guidance in NUREG-1061, Volume 3, an additional assessment of the margin on the loads is required. This is addressed as item (i) in Section 5.2 of NUREG-1061, Volume 3.

Second, the corrective actions proposed in Table 4-9 in the event that the acceptance criteria are exceeded are not sufficient to reestablish its LBB status. If the CASS component is repaired or replaced per ASME Code, Section XI IWB-4000 or IWB-7000, a new LBB analysis based on the material properties of the repaired or replaced component (and accounting for its thermal aging through the period of extended operation, as appropriate), is required to confirm the applicability of LBB. The inservice examination/flaw evaluation option is, per the basis on which the NRC staff has approved LBB in the past, insufficient to reestablish LBB approval. The WOG should revise AMP-3.6, accordingly (Open Item 6).

4.0 CONCLUSIONS

The staff has reviewed the WOG topical report (Reference 6) and additional information submitted by WOG. On the basis of its review, the staff concludes that the WOG topical report provides an acceptable demonstration that the aging effects of RCS components within the scope of this topical report will be adequately managed for the WOG license renewal member plants, with the exception of the noted renewal applicant action items, so that there is reasonable assurance that the RCS components will perform their intended functions in accordance with the CLB. The staff also concludes that upon completion of the renewal applicant action items set forth in Section 4.1 herein, the WOG topical report provides an acceptable evaluation of TLAAs for the RCS components in the WOG license renewal member plants for the period of extended operation.

Any WOG member plant may reference this topical report in a license renewal application (LRA) to satisfy the requirements of (1) 10 CFR 54.21(a)(3) for demonstrating that the effects of aging on the RCS components within the scope of this topical report will be adequately managed and (2) 10 CFR 54.21(c)(1) for demonstrating that appropriate findings be made regarding evaluation of TLAAs for the RCS components for the period of extended operation. The staff also concludes that upon completion of the renewal applicant action items set forth in Section 4.1 herein, and resolution of the open items set forth in Section 4.2, referencing this topical report in an LRA and summarizing in a final safety analysis report (FSAR) supplement the AMPs and the TLAA evaluations contained in this topical report will provide the staff with sufficient information to make the necessary findings required by Sections 54.29(a)(1) and (a)(2) for components within the scope of this topical report.

4.1 Renewal Applicant Action Items

The following are license renewal applicant action items to be addressed in the plant-specific LRA when incorporating the WOG topical report in a renewal application:

1 The license renewal applicant is to verify that its plant is bounded by the topical report. Further, the renewal applicant is to commit to programs described as necessary in the topical report to manage the effects of aging during the period of extended operation on the functionality of the reactor coolant system piping. Applicants for license renewal will be responsible for describing any such commitments and identifying how such commitments will be controlled. Any deviations from the AMPs within this topical report described as necessary to manage the effects of aging during the period of extended operation and to maintain the functionality of the reactor coolant system piping and associated pressure boundary components or other information presented in the report, such as materials of construction, will have to be identified by the renewal applicant and evaluated on a plant-specific basis in accordance with 10 CFR 54.21(a)(3) and (c)(1).

2 Summary description of the programs and evaluation of TLAAs are to be provided in the license renewal FSAR supplement in accordance with 10 CFR 54.21(d).

3 Applicants must provide a description of all insulation used on austenitic stainless steel NSSS piping to ensure the piping is not susceptible to stress-corrosion cracking from halogens.

4 The license renewal applicant should describe how each plant-specific AMP addresses the following 10 elements: (1) scope of the program, (2) preventive actions, (3) parameters monitored or inspected, (4) detection of aging effects, (5) monitoring and trending, (6) acceptance criteria, (7) corrective actions, (8) confirmation process, (9) administrative controls, and (10) operating experience.

5 The license renewal applicant should perform additional fatigue evaluation or propose an AMP to address the components labeled I-M and I-RA in Tables 3-2 through 3-16 of WCAP-14575.

6 The staff recommendation for the closure of GSI-190 “Fatigue Evaluation of Metal Components for 60-Year Plant Life” is contained in a December 26, 1999, memorandum from Ashok Thadani to William Travers. The license renewal applicant should address the effects of the coolant environment on component fatigue life as aging management programs are formulated in support of license renewal. The evaluation of a sample of components with high-fatigue usage factors using the latest available environmental fatigue data is an acceptable method to address the effects of the coolant environment on component fatigue life.

4.2 Topical Report Open Items

1. WOG should complete the specific revisions to the subject topical report that it has committed to perform in response to the staff’s RAIs discussed in Section 3.1 of the safety evaluation. As described by WOG in its letter to the staff, dated July 19, 1999, these planned modifications are limited to Section 2.3.2.2, “Branch Line Restrictors”; Section 2.3.2.4, “Thermal Barrier and RCP Seals”; and the “summary” sections of the topical report.

2. WOG should complete the updated review of generic communications and revise Section 3.1 of the topical report to describe the process used by WOG to perform the review and to capture any additional items not identified by the original review.

3. The topical report indicates that thermal aging-related cracking of austenitic steel castings is an aging effect that the WOG considers potentially significant for the RCS piping and associated components. Thermal aging does not cause cracking , it causes a reduction in the fracture toughness of the material. The reduction in fracture toughness of the material results in a reduction in the critical flaw size that could lead to component failure. WOG should revise the topical report, accordingly.

4. Components that have delta ferrite levels below the susceptibility screening criteria have adequate fracture toughness and do not require supplemental inspection. As a result of thermal embrittlement, components that have delta ferrite levels exceeding the screening criterion may not have adequate fracture toughness and do require additional evaluation or examination. WOG should address thermal-aging issues in accordance with the staff's comments in Section 3.3.3 of this evaluation.

5. WOG should propose to perform additional inspection of small-bore RCS piping, that is, less than 4-inch-size piping, for license renewal to provide assurance that potential cracking of small-bore RCS piping is adequately managed during the period of extended operation.

6. WOG should revise AMP-3.6 to include an assessment of the margin on loads in conformance with the staff guidance provided in Reference 11. In addition, AMP-3.6 should be revised to indicate If the CASS component is repaired or replaced per ASME Code, Section XI IWB-4000 or IWB-7000, a new LBB analysis based on the material properties of the repaired or replaced component (and accounting for its thermal aging through the period of extended operation, as appropriate), is required to confirm the applicability of LBB. The inservice examination/flaw evaluation option is, per the basis on which the NRC staff has approved LBB in the past, insufficient to reestablish LBB approval.

5.0 REFERENCES

1. 10 CFR Part 54, "Requirements for Renewal of Operating Licenses for Nuclear Power Plants," Federal Register, Vol. 60, No. 88, pp. 22461-22495, May 8, 1995.

2. WCAP-14575, "License Renewal Evaluation: Aging Management for Class 1 Piping and Associated Pressure Boundary Components," August 1996.

3. Letter, P. T. Kuo, NRC, to R. A. Newton, WOG, April 18, 1997, Request for Additional Information on WOG Technical Report WCAP-14575.

4. Letter, R. A. Newton, WOG, to NRC, July 13, 1997, Response to NRC Request for Additional Information on WOG Generic Technical Report WCAP-14575.

5. Generic Letter 88-05, "Boric Acid Corrosion of Carbon Steel Reactor Pressure Boundary Components in PWR Plants," March 17, 1988.

6. EPRI Technical Report TR-106092, "Evaluation of Thermal Aging Embrittlement for Cast Austenitic Stainless Steel Components in LWR Reactor Coolant Systems," Electric Power Research Institute, September 1997.

7. S. Jayet-Gendrot, P. Ould, and T. Meylogan, "Fracture Toughness Assessment of In-Service Aged Primary Circuit Elbows Using Mini C(T) Specimens Taken from Outer Skin," Fatigue and Fracture Mechanics in Pressure Vessels and Piping, PVP-Vol 304, ASME, 1996, pg 163-169.

8. Letter, C. I. Grimes, NRC, to D. J. Walters, WOG, "Request for Additional Information (RAI) Regarding the Industry's Evaluation of Fatigue Effects for License Renewal," November 2, 1998.

9. Letter, D. J. Walters, WOG, to C. I. Grimes, NRC, responding to the NRC RAIs concerning the evaluation of fatigue effects for license renewal, April 8, 1999.

10. Letter, C. I. Grimes, NRC, to D. J. Walters, WOG, giving NRC staff comments regarding the industry response to the NRC RAIs on the evaluation of fatigue effects for license renewal, August 6, 1999.

11. Report of the U. S. Nuclear Regulatory Commission Piping Review Committee, "Evaluation of Potential Pipe Breaks," Volume 3, NUREG-1061, November 1984.

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