August 7, 2000

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

SUBJECT: DRAFT SAFETY EVALUATION CONCERNING THE WESTINGHOUSE OWNERS GROUP LICENSE RENEWAL EVALUATION: AGING MANAGEMENT EVALUATION FOR PRESSURIZERS, WCAP–14574, REVISION 0, JULY 1996

Dear Mr. Newton:

The U.S. Nuclear Regulatory Commission staff has reviewed the Westinghouse Owners Group (WOG) topical report entitled, “License Renewal Evaluation: Aging Management Evaluation for Pressurizers, WCAP-14574, Revision 0, July 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 pressurizers within the scope of WCAP–14574.

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/encl: See next page

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Project No. 686

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BY THE OFFICE OF NUCLEAR REACTOR REGULATION

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WCAP–14574

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PROJECT NO. 686

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 July 3, 1996, the Westinghouse Owners Group (WOG) submitted topical report WCAP–14574, “License Renewal Evaluation: Aging Management Evaluation for Pressurizers” (Reference 2), for staff review and approval. The focus of the report is on the management of the effects of aging of pressurizers and their components during any extended period of operation.

The WOG report evaluated the aging management of the pressurizers for domestic commercial nuclear power plants with a Westinghouse nuclear steam supply system. 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. On January 14, 1997, the staff issued a request for additional information (RAI) after completing its initial review of WCAP–14574. WOG responded to the staff's RAI on May 30, 1997. This safety evaluation includes the staff's assessments of WOG's response to the individual items in the RAI.

2.0 SUMMARY OF TOPICAL REPORT

2.1 Report Overview

WCAP–14574 is broken down into the following Chapters (Sections):

- Chapter 1.0, Introduction
- Chapter 2.0, Identification of Time-Limited Aging Analyses and Aging Effects
- Chapter 3.0, Aging Management Review
- Chapter 4.0, Aging Management Activities and Program Attributes
- Chapter 5.0, Summary and Conclusion

WCAP–14574 is applicable to the evaluation of pressurizers in all domestic Westinghouse facilities; these facilities are provided in Table 1–1 of WCAP–14574. The report contains a generic overview of the methods to manage the effects of age-related degradation of pressurizers in Westinghouse-designed reactors so that the intended safety and safe shutdown functions of the systems, structures, and components (SSCs) in the pressurizer will be maintained for the period of extended operation.

The report also identified those aging management programs (AMPs) and TLAAs, as defined in 10 CFR 54.3, that are applicable to these reactor components.

2.2 Components and Intended Functions

In Chapter 1.0 of the WCAP, WOG defined SSC as subject to an aging management review if the SSC: "(1) perform an intended safety function, (2) perform an intended safety function in a passive manner, or (3) have a long structural life." In Chapter 1.0, WOG states that the pressurizer and its subcomponents are within the scope of the license renewal rule.

In Section 2.1 of the WCAP, WOG states that the pressurizer is part of the reactor coolant system (RCS), and that the intended function of the pressurizer for the plant is to maintain the reactor coolant pressure boundary as defined in 10 CFR 54.4(a)(1)(i).

WOG also indicated that the pressurizer serves to limit to an allowable range those pressure changes that are caused by reactor coolant thermal expansion and contraction during normal plant load changes. However, WOG indicated that this is a secondary power generation function for the pressurizer and did not identify this function as covered under the scope of 10 CFR Part 54.

Table 1–2 of WCAP–14574 lists the pressurizer components that are covered under the scope of the report. Section 2.2 of the report states that the pressurizer is a long-lived, passive component of the RCS, and identifies the subcomponents in the pressurizer that specifically serve to support the pressure boundary function of the pressurizer; these components are also identified in Table 2–1 of the WCAP. Table 2–1 of the report then breaks down these components into those that fall within the scope of license renewal and those that do not. The pressurizer components that are considered by WOG to fall within the scope of license renewal are:

- Pressurizer shell and upper and lower heads.
- Pressurizer support skirt and flange.
- Surge nozzle (including surge nozzle thermal sleeve and safe-end, but excluding the surge nozzle retaining basket).
- Spray nozzle (including the thermal sleeve and safe-end, but excluding the spray head, spray head coupling, and spray head locking bar).
- Relief nozzle (including the safe-end).
- Instrument nozzles.
- Heater well nozzles.
- Immersion heaters.
- Seismic lugs and valve support bracket lugs.
- Manway and its subcomponents (including the manway cover, cover bolts and studs, and pad gasket seating surface, but excluding the manway gasket).

The pressurizer vessel nozzles include the attached safe-ends and weld material between the safe-ends and the nozzles. The pressurizer components that are not considered by WOG to fall within the scope of license renewal include: manway gasket, surge nozzle retaining basket, heater support plates, heater support plate brackets, heater support plate bracket bolts, spray head, spray head locking bar, and spray head coupling. WOG states that these components do not serve the function of maintaining the integrity of the primary pressure boundary and therefore do not fall within the scope of license renewal.

Section 2.3 of the WCAP summarized how the subcomponents identified in Table 2–1 were fabricated and constructed in the plant design. Section 2.4 of the WCAP prescribed applicable engineering and design data that are applicable to the designs of Westinghouse-designed pressurizers. The staff's evaluation of WOG's discussion of the pressurizer components and their associated safety and safe-shutdown functions is addressed in Subsection 3.1 of the Evaluation Section (Section 3.0) of this Safety Evaluation Report (SER).

2.3 Effects of Aging

2.3.1 Identification of the Effects of Aging

Section 2.7 of the WCAP defines aging as the time-dependent degradation of a material or component, that results in a decrease in the ability of the material or component to perform its intended design function. The section identifies the age-related degradation mechanisms for the pressurizer and its components in the following categories:

- Fatigue.
- Corrosion/stress corrosion cracking/primary water stress corrosion cracking (PWSCC).
- Irradiation embrittlement.
- Thermal aging.
- Erosion and erosion-corrosion (e.g., flow-assisted corrosion).
- Degradation by wear.
- Creep and stress relaxation.

2.3.2 Review of Aging Effects Operating Experience

Section 2.6 of WCAP summarizes WOG's review of the operating experience that has affected the structural integrity of pressurizers in the nuclear industry in the past. Briefly, the report identifies the following operating experience and aging history applicable to industry pressurizers:

- Fatigue in the lower head and surge nozzles from reactor coolant insurge and outsurge transients.

- Primary stress corrosion cracking of Alloy 600 materials in the primary system.

- Cracking of pressurizer vessel cladding (e.g., the Haddam Neck issue).

- Instrument nozzle cracking.

In addition, WOG also identified the following maintenance issues that have affected pressurizer components:

- Damage to immersion heater ceramic seals and elements.
- Leaking at the manway gasket seal.

Details of WOG's assessment of applicable industry experience are provided in Sections 2.6.1 through 2.6.7 of WCAP–14574. The staff's evaluation of WOG's identification of the applicable aging effects for the pressurizer components and WOG's assessment of the industry experience is contained in Subsection 3.2 to the Staff Evaluation section (Section 3.0) of this SER.

2.4 Aging Management Programs

In Chapter 3.0 of WCAP–14754, WOG identifies the basis for determining whether programs are necessary to manage each of the aging mechanisms identified in Section 2.7 of the report. WOG described the aging mechanism and then evaluated whether the aging mechanism is applicable to the pressurizer subcomponents, and whether it would be necessary for a WOG member to implement an AMP to control the aging mechanism during the extended period of licensed operation. WOG defines an aging effect for a pressurizer component as significant if, when allowed to continue without an effective management program, the capability of the component to perform its intended function during the extended period of operation would be compromised. WOG assessed the effects of potentially significant aging mechanisms in terms of the capability of the following licensee-implemented programs to manage the aging effects during the period of extended operation:

- Maintenance programs.
- Inservice inspection programs.
- Surveillance and testing programs.
- Programs for conducting analytical assessments of aging effects.

The following subsections to Chapter 3.0 of the WCAP present the details of WOG's assessments of potentially significant aging mechanisms and their resulting effects on the pressurizer components:

- Section 3.1 - Assessment of potentially significant effects by fatigue

- Section 3.2 - Assessment of potentially significant effects from corrosion or stress corrosion cracking

- Section 3.3 - Assessment of potentially significant effects by irradiation embrittlement

- Section 3.4 - Assessment of potentially significant effects from thermal aging

- Section 3.5 - Assessment of potentially significant effects by erosion and erosion/corrosion

- Section 3.6 - Assessment of potentially significant effects by wear

- Section 3.7 - Assessment of potentially significant effects from creep or stress relaxation

Table 3.2 and Section 3.9 to Chapter 3.0 of the WCAP summarize the conclusions from WOG's aging effect evaluations. WOG concluded that most of the potential aging affects identified in Section 2.7 of the WCAP and discussed in Sections 3.1 through 3.7 of the WCAP will have little or no impact on the intended function of maintaining the structural integrity of the reactor coolant pressure boundary (RCPB). Of these effects, WOG identified the only aging mechanisms that have the potential to impact the pressurizer components and the structural integrity of the RCPB as:

- Fatigue of the upper portion of the pressurizer shell, the spray nozzle, the manway bolts, the seismic support lugs, the lower head (due to insurge/outsurge transients), the heater wells (due to insurge/outsurge transients), the surge nozzle, and the support skirt and flange.

- Stress corrosion cracking (SCC) of potentially sensitized stainless steel safe-ends and stainless steel weld metal.

- PWSCC of Inconel 82/182 weld metal in pressurizer safety, relief, spray, and surge nozzles.

Thus, WOG identified stress corrosion cracking and fatigue as the only potential aging degradation mechanisms that could affect the pressurizer pressure boundary. In accordance with 10 CFR 54.21(a)(1), WOG also identified and listed in Table 2–1 of the report the subcomponents within the pressurizer pressure boundary that may experience fatigue damage during the period of extended operation, thus requiring aging management. A summary of specific programs for managing the effects of aging during the period of extended operation to maintain the functionality of the pressurizer components is provided in Chapter 4.0 of the report. Generic program attributes are shown in Table 4.1 of the report, applicable to specific AMPs. The report states that plant-specific details will be developed during the preparation of license renewal applications. Section 4.1 of the report provides the recommended WOG aging management activities and program attributes for managing SCC and PWSCC of Westinghouse-designed pressurizer subcomponents during the extended operating term. Section 4.2 of the report provides WOG aging management activities and program attributes for managing fatigue of the subcomponents during the extended operating term; this program is discussed further in the subsections to Section 2.4 that follow.

2.4.1 Aging Management Programs for Managing Stress Corrosion Cracking

Section 4.1 and AMP–2.1 (Table 4–2) provide descriptions and summaries of WOG-proposed program activities and attributes to manage SCC in pressurizer components that have been identified as being susceptible to SCC. The staff’s evaluation of Section 4.1 and AMP–2.1 is given in Section 3.3.2.2 of this SER.

2.4.2 Additional Activities and Program Attributes for Management of Fatigue

The following AMPs have been proposed in Section 4.2 of the report to manage fatigue of pressurizer subcomponents.

2.4.2.1 Aging Management Program 2.2

AMP–2.2 (Table 4–3) is applicable to subcomponents for which the adequacy of the CLB fatigue design basis through the license renewal term will be demonstrated, in accordance with 10 CFR 54.21(c)(1)(i), by showing that the TLAAs of these subcomponents remain valid for the period of extended operation. The TLAAs will be reevaluated, on a one-time basis, by removing excess conservatism from the fatigue calculations and demonstrating acceptable fatigue usage for the license renewal period. The table identifies the pressurizer shell, the manway bolts, and the seismic support lugs as subcomponents for which the AMP would be applicable. The fatigue evaluation will be based on an acceptable cumulative usage factor (CUF) criterion (or equivalent) for the life of the plant, including the license renewal period. This CUF criterion was not specified.

2.4.2.2 Aging Management Program 2.3

AMP–2.3 (Table 4–4) is intended for those subcomponents subjected to transient cycling, such as the insurge/outsurge and other transients. Fatigue will be managed by reevaluation of the TLAAs. The reevaluation will be based on transient cycle monitoring and modifying operating procedures during plant operation of the subcomponents for the license renewal period. The approach is based on reducing conservatisms in the TLAAs and using actual operating cycle counts, including those due to insurge/outsurge and other transients. This AMP is intended for the following subcomponents: the spray nozzle and safe-end, the support skirt and flange, the lower head, the heater well, and the surge nozzle and safe-end. The acceptance criterion consists of an (unspecified) acceptable CUF (or equivalent) for plant life, including the license renewal period. Alternatively, if the TLAAs cannot show acceptable usage for the license renewal period, the fatigue adequacy will be met by implementing a repair or replacement program of the subcomponents, per American Society for Mechanical Engineers (ASME), Section XI, IWA–4000, or IWA–7000. Such a program may also be implemented where economically justified.

2.4.2.3 Proposed Industry Position on Fatigue Evaluation for License Renewal

WOG has also proposed an industry initiative, *Proposed Industry Position on Fatigue Evaluation for License Renewal*, as an alternative fatigue AMP for WOG pressurizers. This position was proposed as a broad-based general approach to fatigue management and as an acceptable alternative to the NRC position on fatigue, which addresses the concerns of Generic Safety Issue-166 (GSI), *Adequacy of Fatigue Life of Metal Components*, as noted in SECY 95–245 *Completion of the Fatigue Action Plan*.

The position initially determines if the current and projected transients are within the CLB by comparing the current and projected transients with the CLB design transients. If the current and projected transients are within the CLB design transients, the effects of fatigue are considered adequately managed by demonstrating that the CLB fatigue evaluation is valid for the license renewal period.

If it is found that the current and projected transients are not within the design transients, the position offers the following options:

- Determine if the existing inservice inspection (ISI) programs can manage the effects of fatigue for the license renewal term.

- Determine if augmented ISI programs will manage the effects of fatigue for the license renewal term in accessible locations, considering the flaw tolerance approach plus local inspection procedures, as described in the nonmandatory Section XI Appendix for evaluation of fatigue in operating plants. This option will therefore require staff approval on a case-by-case basis.

- Recalculate Class 1 fatigue usage for license renewal term transients by removing actual and perceived conservatisms from the fatigue calculations and using realistic operational transients, and show that the CLB acceptance criteria are met for the life of the plant, including the license renewal period.

- Repair or replace the subcomponent.

The position also specifies that the flaw tolerance and the fatigue usage recalculations should consider appropriate environmental factors on fatigue crack initiation or growth, consistent with criteria to be established by the NRC for license renewal.

2.4.2.4 Environmental Effects on Fatigue

The report assesses the potential impact of environmental effects on WOG pressurizers, using the Pressure Vessel Research Council (PVRC) approach for environmental effects on fatigue. This approach consists of specifying certain multiplicative factors applied to the ASME design fatigue curves, and a number of screening criteria that indicate when environmental effects will not be significant. These criteria are listed in Table 4–6 of the report and are applicable to carbon and low-alloy steels only. However, the report concludes that, based on an evaluation of PVRC data for stainless steel, these criteria are also applicable to the pressurizer materials in contact with the water, stainless steel, and Inconel. The report also concludes that, based on the PVRC data, it does not appear that environmental effects on fatigue will be a significant issue for WOG pressurizers.

2.5 Time-Limited Aging Analyses

Section 2.5 of WCAP–14574 discusses WOG's assessment of TLAAs that are required to be reevaluated for the pressurizer components during proposed extended operating terms. WOG defines TLAAs to be licensee calculations that:

- Involve the effects of aging.

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

- Involve SSC within the scope of license renewal.

- Involve conclusions or provide the basis for conclusions related to the capability of the SSC to perform intended functions.

- Were determined to be relevant by the licensee in making a safety determination.

- Are contained or incorporated by reference in the current licensing basis.

WOG definitions for TLAAs are consistent with those defined in 10 CFR 54.3. Of the aging mechanisms identified in Section 2.7 of the WCAP, WOG identified that the only mechanism that meets all six TLAA definition criteria is fatigue. WOG's TLAA for fatigue in the pressurizer components is further discussed in the subsections to 2.5 below.

2.5.1 Overview of the TLAA for Fatigue

In accordance with 10 CFR 54.3, WOG identified the CLB fatigue analyses of pressurizer subcomponents under ASME Section III Service Level A and B transient conditions as TLAAs.

WOG pressurizers are analyzed in accordance with the rules for Class 1 components in the ASME Boiler and Pressure Vessel Code, Section III, (ASME Section III) Subsection NB, subject to various combinations of internal pressure, dead weight, and other sustained loads, and thermal, seismic, and other transient loads during normal, upset, and test plant operating conditions. These analyses are also based on the current ASME Section III fatigue design curves, and are subject to the ASME Section III Class 1 design limit (fatigue CUF $\leq$ 1.0, over the operating life of the plant).

Tables 2–5 and 2–8 of the report show representative WOG Service Level A, B, and Test transient cyclic conditions over a 40-year operating term, typical of WOG design specifications. Representative external load combinations are shown in Table 2–9 of the report.

Table 2–10 of the report lists representative calculated fatigue design CUFs of 15 pressurizer subcomponents identified as subject to potential fatigue degradation, based on the representative transient loading conditions described in Westinghouse system standards and design specifications. Based on a 40-year operating period, the design CUFs of these subcomponents were shown to be less than 1.0, in accordance with the CLBs of the plants. By using linear extrapolation of the CUFs to 1.0 as a screening method, under the same representative design conditions, WOG determined that six subcomponents would attain the design CUF of 1.0 prior to 60 years of operation, without any additional evaluation or management. These subcomponents, and their projected fatigue service life (in years), were identified as follows: the pressurizer shell (44 years), the spray nozzle (49 years), the manway bolts (46 years), the seismic support lugs (41 years), the surge nozzle (42 years), and the support skirt and flange (skirt-to-lower-head weld, 54 years).

In a letter dated May 6, 1997, the staff requested that the CUFs be reevaluated by considering environmental effects on the design fatigue curves. In a letter dated May 30, 1997, WOG identified the following additional components that will attain a design CUF of 1.0 prior to 60 years of operation: the lower head (42 years), the safety and relief nozzle (53 years), and the instrument nozzles (51 years). The staff discussion of WOG's May 30, 1997, response is in Section 3.3.1.2 of this SER.

2.5.2 Transient Loading not Included in the Current Licensing Basis

2.5.2.1 Insurge and Outsurge Transients

One of the postulated transient conditions in the design basis analysis of WOG pressurizers is based on the assumption that surge line flows resulted only from operation of the pressurizer spray line. It was also assumed that spray actuation resulted in flow from the pressurizer into the surge line and eventually to the RCS hot leg.

In Sections 2.6.1 and 3.8.4, “Pressurizer Insurge and Outsurge Transients,” of the report, WOG identified thermal transients currently being experienced in WOG pressurizers, consisting of rapid reactor coolant insurge and outsurge events in the lower head and the surge nozzle. These insurges and outsurges are flows into and out of the pressurizer and the hot leg through the surge line.

During plant heatup and cooldown, the temperature difference between the hot leg and the pressurizer can exceed 300°F, and the thermal loading resulting from the inflow or outflow occurs at a rapid rate (approaching a step change). These transients were not considered in the design basis of WOG pressurizers. WOG therefore concluded that, when insurge/outsurge thermal transients are included in the fatigue analysis of the lower head and the heater well, a CUF > 1.0 will be attained in less than 60 years. No projected fatigue service years for these subcomponents were given in the report. As stated above, the lower head was also identified as fatigue sensitive because of the environmental effects on the design fatigue curves.

Section 2.6.1 of the report describes WOG’s program, “Mitigation and Evaluation of Thermal Transients Caused by Insurges and Outsurges,” MUHP–5060/5061/5062, initiated to address this issue. The main objective of this program is to develop and evaluate generic operational strategies to mitigate or eliminate the effects of these transients. The program was scheduled to be completed by the second quarter of 1997. In a letter dated May 6, 1997, the staff requested additional information and background on the program. WOG stated that a final report describing options for modified operations to mitigate pressurizer insurge/outsurge events, and associated design transients, was anticipated to be issued by WOG by the end of 1997. WOG has not provided additional information regarding this program.

2.5.2.2 Additional Non-Design Basis Transients

Section 3.8.3 of the report stated that additional operating transients had been imposed on pressurizer subcomponents in some plants that had been operating for some time. These transients were classified into two categories:

> Off normal transients: These are random transients that were not part of the design-basis transients. The effects of these transients were evaluated on a case-by-case basis for plants where they have been discovered by comparing to technical specification heatup and cooldown limits. The time-temperature history for these transients was not provided and the evaluations were not reported.
>
> Additional transients: Some older plants added design transients specified for newer plants. The examples quoted in the report pertain to cold overpressure mitigation system transients. The report does not identify these older plants, nor has it provided information regarding the inclusion of these transients in the plant heat transfer, stress, and fatigue design calculations.

3.0 STAFF EVALUATION

The staff reviewed the report and additional information submitted by WOG to determine if it demonstrated that the effects of aging of the pressurizer components covered by this report will be adequately managed so that applicants can refer to the report as the basis for indicating that the intended function(s) will be maintained during the extended operating period consistent with the CLB and the requirements of 10 CFR 54.21(a)(3). This is the last step in the IPA described in 10 CFR 54.21(a). In addition to the IPA, Part 54 requires an evaluation of TLAAs in accordance with 10 CFR 54.21(c). WOG's method for addressing aging of pressurizer subcomponents is summarized in the items listed below:

(1) WOG identification of pressurizer subcomponents and their intended functions.

(2) WOG identification of the aging mechanisms and TLAAs that are applicable to Westinghouse-designed pressurizers as a whole.

(3) WOG assessment of whether the identified aging mechanisms and TLAAs are sufficiently significant to warrant an AMP.

(4) WOG assessment of the attributes that are necessary to be incorporated into programs for managing aging mechanisms that have been identified by WOG as being significant enough to affect the intended functions of the pressurizer components during the term of extended operation.

The staff's assessment of Item (1) above is provided in Section 3.1 of this SER. The staff's assessment of Item (2) above is provided in Section 3.2 of this SER. The staff's assessment of Items (3) and (4) is provided in Section 3.3 of this SER.

Furthermore, on January 14, 1997, the staff requested additional information from WOG in regard to the contents of WCAP–14574. WOG responded to these requests for additional information by letter dated May 30, 1997. The staff's evaluation in Sections 3.1, 3.2, and 3.3 of this SER addresses the staff's assessment of WOG's responses to these RAIs.

3.1 Components and Intended Functions

Detailed descriptions of all applicable Westinghouse-designed pressurizers, including their dimensions and components, are listed and summarized in Section 2.3 of the report as well as in Table 1–2 and Figure 1–1 of the report. As described in the report, the pressurizer is part of the RCS and is located inside containment. The RCS pressure control system consists of the pressurizer vessel equipped with electric heaters, safety valves, relief valves, spray system, interconnecting piping, and instrumentation. In operation, the pressurizer contains water and steam maintained at the desired saturation temperature and pressure by the electric heaters and the spray system. The chemical and volume control system maintains the desired water level in the pressurizer during steady-state operation.

During normal operation, the external electrical network imposes load changes on the plant turbine generator. These load changes cause temperature changes in the RCS. Since the RCS, which controls the reactor coolant temperature, does not respond instantaneously during a load transient, the pressure control system is designed to absorb the reactor coolant volume surges and limit pressure variations during the initial transient period prior to an effective response by the RCS. During volume insurges that cause pressure increases, the spray system injects subcooled water into the pressurizer steam volume to condense steam and prevent further pressure increases. During volume outsurges that cause pressure decreases, flashing of saturated water in the pressurizer and the generation of steam by immersion heater operation maintains the pressure above a minimum value fixed by reactor core heat transfer design and safety requirements. Self-actuated safety valves are provided to accommodate large volume insurges beyond the pressure-limiting capacity of the pressurizer and spray system. The safety valves are capable of handling the most severe volume insurge transient.

In addition, power-operated relief valves are set to open at a slightly lower pressure to minimize use of the safety valves.

In Section 2.2 of the topical report, WOG identified the following intended function for the pressurizer and system components based on the requirements of 10 CFR 54.4(a):

- To maintain the reactor coolant pressure boundary [as defined in 10 CFR 54.4(a)(1)(i)].

Based on the intended function set forth above, WOG identified the following structures and components of the pressurizer that were identified in the report to be within the scope of license renewal, and that would require an aging management review: lower head, surge nozzle, surge nozzle safe-end, surge nozzle thermal sleeve, heater well nozzle, immersion heaters, support skirt and flange, shell, seismic lugs, valve support bracket lugs, instrument nozzles, upper head, spray nozzle, spray nozzle safe-end, spray nozzle thermal sleeve, safety and relief nozzle, safety and relief nozzle safe-end, manway cover, manway cover bolts/studs, and manway pad gasket seating surface.

The report also identified components of the pressurizer that do not fall under the scope of license renewal and do not require an AMR. These components include the manway gasket, the surge nozzle retaining basket, heater support plates, heater support plate brackets, heater support plate bracket bolts, spray head locking bar, spray head, and spray head coupling. The manway gasket is not part of the pressure boundary and is a replaceable component, therefore, it is not subject to AMR. The surge nozzle retaining basket, heater support plates, heater support plate bracket, heater support plate bracket bolts, spray head locking bar, spray head, and spray head coupling are not within the scope of license renewal because they do not act as a pressure boundary for the reactor coolant.

The staff reviewed Sections 1.0 and 2.0 of the subject topical report to determine whether the WOG had properly identified the SSCs 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). To accomplish this, the staff reviewed portions of representative updated final safety analysis reports (i.e., the UFSARs for Surry and Calvert Cliffs) for the pressurizer and compared the information in the UFSARs with the scoping information in the WOG report. The review of Surry's UFSAR was added to the evaluation because it has a Westinghouse-designed pressurizer. Since no applicant with a Westinghouse-designed pressurizer has submitted an FSAR update for license renewal, the staff also reviewed the Calvert Cliffs UFSAR because the UFSAR was updated for license renewal, the plant design is "similar" to those designed by Westinghouse, and the scoping methodology had been reviewed by staff. The staff then reviewed structures and components outside the portion identified in the report, and as described below, requested WOG to provide additional information and/or clarifications for a selected number of structures and components to verify that (1) they do not have any intended functions as delineated in 10 CFR 54.4(a) and if they do, to verify that (2) they are either active components, or 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 UFSARs for any safety-related system functions that were not identified as intended functions in the report to verify that all structures and components having intended functions were not omitted from consideration within the scope of the rule.

After completing the initial review, the staff requested WOG to verify whether any of the applicable plants rely on the RCS pressure control function of the pressurizer to prevent or mitigate the consequences of design-basis events. This additional information from WOG was requested to verify that components such as the spray head, which sprays subcooled water inside the pressurizer to control RCS pressure, were appropriately excluded from the AMR. In a conference call on June 25, 1999, WOG confirmed that none of the applicable plants rely on the RCS pressure control function of the pressurizer to prevent or mitigate the consequences of design-basis events, and therefore the passive and long-lived components (e.g., spray head) that perform the pressure control function, but do not perform the pressure boundary function, need not be within the scope of license renewal, nor be subject to an AMR according to the regulations. The staff agrees with this conclusion.

In RAI Item No. 9, the staff informed WOG that 10 CFR 54.21(a)(1)(ii) requires structures and components not subject to replacement based on a qualified life or specified time period to be subject to an AMP. With respect to this requirement, the staff inquired whether the pressurizer manway gaskets were among those components that fall within the scope of 10 CFR 54.21(a)(1)(ii), and whether a program would be needed to manage aging of the gaskets. In its response to the RAI, WOG stated that the manway gaskets were not within the scope of license renewal. WOG indicated that the pressurizer manway gaskets are required to be replaced every time the manway is opened, but also indicated that failure of the gaskets between periods of maintenance could result in leakage from the gasket. However, the gaskets are not defined as pressure boundary components. The staff's assessment of whether an AMP is necessary to manage leakage from the manway gaskets is discussed in Section 3.3.2.1 of this report.

On the basis of the staff's review of the information provided in Sections 1.0 and 2.0 of the report, the supporting information in the UFSARs, and WOG's response to the staff's RAI as discussed above, the staff did not find any omissions in the report. Therefore, the staff concludes that there is reasonable assurance that the report adequately identified those portions of the pressurizer and its associated (supporting) structures and 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

In Section 2.7 to Chapter 2.0 of the WCAP, WOG identifies that age-related degradation (aging) mechanisms for the pressurizer and its subcomponents may be grouped into the following general categories: (1) fatigue, (2) corrosion, stress corrosion cracking, and primary water stress corrosion cracking, (3) irradiation embrittlement, (4) thermal aging, (5) erosion and erosion/corrosion (flow-assisted corrosion), (6) degradation by wear, and (7) creep and stress relaxation. In Chapter 3.0 of the report, WOG follows up by presenting a general assessment of each aging mechanism. This assessment is accomplished by: (1) providing a general description of the aging mechanism, (2) conducting an evaluation of the aging mechanism as it relates to the pressurizer and its components, and (3) making a final determination as to whether the aging mechanism needs to be managed for any of the pressurizer subcomponents. A discussion of the specific aging effects and various pressurizer components that may be affected by the aging effects is provided below.

3.2.1 Evaluation of WOG's Aging Assessment for the Effects of Fatigue

WOG performed an initial screening, based on simple extrapolation, of 15 pressurizer subcomponents with CLB fatigue analyses. Six of these were identified where the CUFs can be expected to exceed the ASME Section III criterion of 1.0 prior to the end of the extended period of operation.

The report indicates that the seismic support lugs in the upper portion of the pressurizer have the shortest projected fatigue service life, 41 years. Likewise, the shell has a projected fatigue service life of 44 years. This has been attributed to thermal stresses in the pressurizer shell at the location of the support lugs, resulting from spray impingement on the shell. The report states that this condition is not as severe as originally analyzed, and that a reanalysis would show a considerable reduction in fatigue usage. The projected fatigue service life of the spray nozzle is 49 years, and is attributed to alternating thermal conditions caused by cycling between a saturated steam and subcooled water environments. The manway bolts also have a projected fatigue service life of 46 years, attributed to differential movements of the pad and cover during heatup and cooldown, which were analyzed with conservative assumptions. The report states that a new analysis of the bolts with more appropriate boundary conditions would reduce the calculated fatigue usage. It also states that another option would be replacement at regular intervals. The staff finds that replacing bolts is an acceptable option because the new bolts would not have accumulated fatigue usage.

In the lower portion of the pressurizer, the report indicates that the surge nozzle has a projected fatigue service life of 42 years. This was attributed to thermal loading caused by insurge and outsurge thermal shocks due to stratification in the surge line during plant operation. Likewise the skirt-to-lower-head weld in the support skirt and flange has a projected fatigue service life of 54 years. The report states that a new analysis of this weld, using appropriate boundary conditions, would reduce the calculated fatigue usage.

The CLB fatigue usage calculations were based on the ASME Section III design fatigue curves that did not consider environmental effects. By letter dated January 14, 1997, the staff requested that WOG reevaluate the initial screening of the subcomponents, based on the consideration of environmental effects on the design fatigue curves. By letter dated May 30, 1997, WOG reevaluated the usage factors of those subcomponents that were initially found to have a projected fatigue service life greater than 60 years. The reevaluation showed that three additional subcomponents would have a projected fatigue life less than 60 years. The projected fatigue life for the safety and relief nozzles, located in the upper portion of the pressurizer, is 53 years. The projected fatigue life for the lower head is 42 years, and the projected fatigue life for the instrument nozzles, located in the lower portion of the pressurizer, is 51 years. WOG did not reevaluate those subcomponents that had initially been shown to have projected fatigue lives less than 60 years, since these had already been identified as such.

WOG's reevaluation was based on the results of fatigue calculations reported in NUREG/CR–6260 for the surge line hot nozzle safe-end of an older vintage Westinghouse plant, based on revised interim fatigue design curves proposed in NUREG/CR–5999. WOG's reevaluation was based on a multiplicative factor of 4.7 (NUREG/CR–6260). By letter dated May 30, 1999, WOG also reported the result of the fatigue evaluation at the same location, but using the environmental factor approach (to the ASME Section III design fatigue curves) of Electric Power Research Institute (EPRI) Topical Report TR–105759. This evaluation showed a fatigue usage factor that was approximately 10% of the NUREG/CR–6260 fatigue usage factor. The purpose of this was to demonstrate that the extrapolated CUFs are very conservative.

The staff concurs that some of the procedures and assumptions on which the fatigue calculations are based may be excessively conservative. However, no quantitative assessment of this conservatism was provided. The staff therefore considers the CUFs provided in WCAP–14574 by Westinghouse as the projected CUFs of the subcomponents.

3.2.2 Evaluation of WOG's Aging Assessment for the Effects of Corrosion

In Section 3.2 of WCAP–14574, WOG defines corrosion to be degradation of a material as a result of chemical or electrochemical reaction with its environment. In this section, WOG identifies the following forms of corrosion that may be applicable to the pressurizer:

- General corrosion and boric acid corrosion of ferritic pressurizer components.
- Pitting and crevice corrosion.
- SCC, including intergranular stress corrosion cracking (IGSCC) and PWSCC.

3.2.2.1 General Corrosion, Pitting, Crevice Corrosion, and Boric Acid Corrosion of Ferritic Pressurizer Components

In Section 3.2 of the WCAP, WOG defines general corrosion as a uniform attack of a material of fabrication over its entire surface. WOG states general corrosion results from an electrochemical reaction on the surface of a metal. WOG describes general corrosion as a general thinning of the material, usually at a slow degradation rate. WOG states that general thinning can be managed by allowing sufficient excess material to be present in the design to accommodate the expected degree of material loss over the serviceable life of the component. WOG also states that more localized forms of corrosive attack, such as pitting, crevice corrosion, or SCC, may be more difficult to manage. In Section 3.2.2 of the report, WOG states that the Westinghouse pressurizers are designed with austenitic stainless steel claddings that provide considerable corrosion resistance to the ferritic regions of the pressurizer. In general, this is true; however, in the second sentence of the second paragraph of Section 3.2.2 of the report, WOG qualifies this assertion by stating that:

> "This resistance extends to crevice regions, where an aggressive environment has the potential to cause localized corrosion, even for film forming materials."

In Section 3.2.2 of the report, WOG proceeds to identify that the only creviced geometries that are present in Westinghouse-designed pressurizers are the tight-gapped regions between the heater sheath and the heater well, the surge nozzle and its thermal sleeve, and the spray nozzle and its thermal sleeve. WOG states that hydrogen overpressure in the RCS minimizes the adverse effects of oxygen in the coolant and provides adequate protection against crevice corrosion in creviced geometries on the internal surfaces of the pressurizer. While the staff concurs that hydrogen overpressure can mitigate the aggressive corrosive effect of oxygen in creviced geometries on the internal pressurizer surfaces, applicants for license renewal will have to provide a basis (statement) in their plant-specific applications as to how their water chemistry control programs will provide for a sufficient level of hydrogen overpressure to manage general corrosion of the internal surfaces of their pressurizer. **(Renewal Applicant Action Item 3.2.2.1–1**)

In Section 3.2.2 of the report, WOG states that corrosive wastage of the external ferritic surfaces of the pressurizer or ferritic bolting materials may result if the primary coolant, which normally contains borated water, leaks out onto the external surfaces of the pressurizer. In this section, WOG identifies current activities to manage boric acid corrosion in Westinghouse-designed pressurizers. This include programs and other activities to monitor for boric acid corrosion consistent with the staff position in Generic Letter 88–05, *Boric Acid Corrosion of Carbon Steel Reactor Pressure Boundary Components*. WOG states that the boric acid monitoring and control programs have the following program attributes:

- Determination of principal locations where coolant leakage less than the allowable technical specification limits could result in degradation of the pressure boundary by boric acid corrosion.

- Visual examinations that are integrated into the VT–2 examinations conducted during system leakage tests.

- Corrective actions to prevent recurrences of this form of corrosion.

WOG then refers to the definition in ASME Code, Section XI, Paragraph IWA–2212 for VT–2 type visual examinations, and to the provisions in Paragraph IWB–3522.1 regarding primary coolant (borated water) leakage. The staff finds that the criteria in GL 88–05 and the Section XI requirements for conducting system leak tests and VT–2 type visual examinations of the pressurizer pressure boundary are acceptable programs for managing boric acid corrosion of the external, ferritic surfaces and components of the pressurizer. However, the report fails to refer to the actual provisions in the ASME Code, Section XI, that require mandatory system leak tests of the pressurizer pressure boundary. These requirements are contained in Paragraph IWB–2500 and Category B–P of Table IWB–2500–1 of ASME Code, Section XI. The report needs to be revised to refer to the appropriate Code requirement for this discussion to be acceptable **(Open Item 3.2.2.1–1).**

3.2.2.2 Stress Corrosion Cracking

In Section 3.2.1 of the report, WOG identifies SCC as a form of localized corrosive attack that may occur when an applied stress, an environmentally aggressive environment, and a susceptible material are present in combination with one another. In this section WOG identifies three forms of SCC: (1) IGSCC, (2) PWSCC, and (3) transgranular stress corrosion cracking (TGSCC). WOG identified that TGSCC results from the presence of aggressive chemical species (e.g., caustics or chlorides) in the reactor coolant, especially if the species are coupled with a highly oxygenated coolant and applied stresses approaching yield strength levels.

In Section 3.2.2 of the report, WOG concluded that leaking primary coolant provides an aggressive environment that could affect the structural integrity of the pressurizer bolting materials made from quenched and tempered low-alloy steels (e.g., SA 193 Grade B7 Alloy 4140 Steels). However, WOG also concluded that, consistent with the analysis in EPRI Report NP–5769, SCC should not be a concern for the pressurizer closure bolting if the yield strength of the steels is held below 150 ksi. WOG stated that the material specification requires SA–193, Grade B7 bolting materials with a minimum yield strength of 105 ksi. The staff concurs that the potential to develop SCC in the bolting materials will be minimized if the yield strength of the material is held to less than 150 ksi, or the hardness is less than 32 on the Rockwell C hardness scale. However, the staff concludes that conformance with the minimum yield strength criteria in ASME Specification SA–193, Grade B7 does not in itself preclude a quenched and tempered low-alloy steel from developing SCC, especially if the acceptable yield strength is greater than 150 ksi. To take credit for the criteria in EPRI Report NP–5769, the license renewal applicant needs to state that the yield strengths for the quenched and tempered low-alloy steel bolting materials (e.g., SA–193, Grade B7 materials) are within the range of 105–150 ksi **(Renewal Applicant Action Item 3.2.2.3.2–1)**.

In Section 3.2.2 of the report, WOG also discussed the potential for austenitic stainless steel pressurizer components to develop IGSCC in the extended operating periods. WOG concluded that three factors must be present for a material to have the potential to develop IGSCC: the material must be susceptible to IGSCC, the material must be subjected to a stress approaching or greater than the yield strength of the material, and the material must be subjected to an aggressively corrosive (oxidizing) environment. WOG identified that in the absence of any of these three conditions, IGSCC will not occur; however, WOG also noted that intergranular attack (IGA) is possible even with the absence of an applied stress. Both of these forms of attack induce cracking at the boundaries between the grains that comprise the material (grain boundaries). Since industry experience has shown that austenitic stainless steel materials have the potential to be susceptible to IGSCC, WOG concluded that those austenitic stainless steel components in the pressurizer in contact with the primary coolant have the potential to develop IGSCC. The staff concurs with this conclusion because the pressurizer is in contact with primary coolant and has the potential to develop IGSCC.

In its assessment in Section 3.2.2 of the report, WOG listed Westinghouse standard practices that are used to minimize the potential for austenitic stainless steel primary pressure boundary components to develop IGSCC and IGA. These practices include:

- Minimizing the time that austenitic stainless steel materials used in the components are subjected to temperatures in the sensitization range (900–1700°F).

- Controlling heat input during welding.

- Controlling the chemical environment of the primary coolant, particularly with regard to the levels of dissolved oxygen, chlorides, and other halides in the coolant.

- Ensuring that austenitic stainless steel materials for use in Westinghouse-designed nuclear plants will be procured to meet the IGA tests in ASTM Standard Practice A262.

In Section 3.2.2 of the report, WOG identified that the Westinghouse pressurizer subcomponents that are susceptible to SCC are the safe-end connections to the safety, relief, spray, and surge nozzles. WOG identified that these safe-ends in all Westinghouse pressurizers are fabricated from either Type 316 or 316L stainless steel, which provides better resistance to SCC than does Type 304 stainless steel. WOG identified that the concern for SCC in the safe-ends typically focuses on whether the safe-ends have been post-weld heat treated, which might promote sensitization of the safe-ends. WOG also evaluated the potential for Inconel pressurizer components to develop PWSCC during proposed extended operating terms. WOG has stated that with the exception of some of the components using Alloy 82/182 weld material for their pressure-retaining welds, no component in a Westinghouse-designed pressurizer is fabricated from Inconel 600-type materials (Alloy 600-type materials). The pressurizer heads and shells, surge nozzle, relief nozzle, and spray nozzle are fabricated from either carbon or magnesium-molybdenum steel materials; these pressurizer components are clad on their internal surfaces with either E309L or E308L stainless steel materials. However, WOG also identified that, for those safe-ends that were welded with Alloy 82/182 (Inconel 82/182) filler materials, the nozzles were first buttered with Inconel 182 filler metal and post-weld heat treated. The safe-ends were then welded to the buttered layers using Inconel 82 without subsequent post-weld heat treatments (PWHT). In Section 4.1 of the report, WOG proposed that aging programs are necessary to manage IGSCC of austenitic stainless steel pressurizer nozzles and PWSCC of Inconel 82/182 filler metals used in welding these nozzles to ferritic piping safe-ends. The staff concurs that aging management programs are necessary for these components. The staff's assessment of WOG's AMP for these components is contained in Section 3.3.2.2 of this SER.

In RAI Item No. 12, the staff informed WOG that age-related degradation has occurred in pressurized water reactor (PWR) designed thermal sleeves. In the RAI, the staff requested an evaluation of all relevant operating experience regarding age-related degradation of pressurizer thermal sleeves, and a discussion of whether the operating experience was germane to the evaluation of the pressurizer thermal sleeves as provided in the content of WCAP–14574. In its response to the RAI, WOG indicated that no age-related degradation has occurred in the thermal sleeves for Westinghouse-designed surge-line nozzles and safety nozzles. The staff concurs with this assessment. The staff therefore considers the issue of thermal sleeve cracking in Westinghouse-designed pressurizer surge-line and safety nozzles to be closed.

3.2.3 Evaluation of WOG's Aging Assessment for the Effects of Irradiation Embrittlement

In Sections 3.3.1 and 3.3.2 of the report, WOG identified materials that have the potential to undergo changes in their microstructures and material properties when exposed to significant levels of neutron or gamma irradiation. Specifically, WOG identified that materials may undergo a significant loss in ductility or fracture toughness when exposed to neutron irradiation. However, WOG concluded that the pressurizer components in Westinghouse-designed pressurizers would not be subject to any loss of fracture toughness because the neutron fluences in the pressurizer are less than the neutron embrittlement thresholds of $1X10^{-20}$ n/cm^2 [sic] for neutrons with kinetic energies $\geq$ 0.1 MeV or $1X10^{-17}$ n/cm^2 [sic] for neutrons with kinetic energies $\geq$ 1.0 MeV.

The staff concurs with the argument that the neutron radiation and gamma radiation fields in the pressurizers are significantly lower than those in the reactor vessels. However, the threshold for irradiation embrittlement for neutrons with kinetic energies in excess of 1.0 MeV should be $1X10^{17}$ n/cm^2 (as opposed to $1X10^{-17}$ n/cm^2). This is the threshold neutron fluence for implementing surveillance programs that are designed to monitor for the effects of irradiation embrittlement. WOG needs to amend the report to cite the correct "positive" exponents for the threshold values if WOG's arguments for neutron irradiation are to remain valid **(Open Item 3.2.3–1).**

3.2.4 Evaluation of WOG's Aging Assessment for the Effects of Thermal Aging

In Section 3.4.1 of the WCAP, WOG assessed the potential for the pressurizer components to become embrittled from thermal aging. WOG identified that thermal aging is a process in which the microstructures and properties of a material change as a result of being exposed to elevated temperatures for an extended period of time. WOG stated that while there are many forms of thermal aging, the only thermal aging mechanism that is applicable to the pressurizer components is thermal aging of two-phase, austenitic-ferritic cast stainless steel material. In this section, WOG stated that exposure to the elevated temperatures for a prolonged period has the potential to induce complex phase changes in the ferritic phase of the steel that result in a reduced fracture toughness for the material. WOG identified that the spray head internal to the pressurizer is the only pressurizer component that is fabricated from two-phase, austenitic-ferritic cast stainless steel material, and that therefore the spray head is the only pressurizer component that has the potential of being susceptible to thermal aging embrittlement.

In RAI Item No. 5, the staff informed WOG that page 14 of WCAP–14574 states that the surge line nozzles are fabricated from carbon steel, but that page 4–12 of Nuclear Utility Management and Resources Council (NUMARC) Report 90–07 states that the nozzles are fabricated from cast stainless steel. In the RAI the staff requested that WOG clarify the basis for this discrepancy. In its reply to RAI Item No. 5, WOG stated that contrary to the statements in the NUMARC report, Westinghouse pressurizers do not have any pressure boundary nozzles, including surge line nozzles, fabricated from cast stainless steel. WOG stated that the surge nozzles for Westinghouse pressurizers are either integrally cast with the lower head, or a separate forged nozzle is welded to the head for those units where a fabricated head is used. Those units using integrally cast nozzles, the WOG noted that nozzles are fabricated from ASME SA–216, Grade WCC carbon steel. WOG indicated that for pressurizers designed with fabricated heads, the surge line nozzles were forged from SA–508, Class 2a steel, and welded to heads fabricated from SA 533, Grade A, Class 2 low-alloy carbon steel plate materials. WOG's response to RAI Item No. 5, when taken in context with the content of the report, indicates that the spray heads in the Westinghouse pressurizers are the only subcomponents that have the potential to degrade from thermal embrittlement. Since the pressurizer nozzles are not fabricated from two phase austenitic-ferritic cast stainless steels, Westinghouse applicants do not have to monitor and assess their pressurizer nozzles for evidence of thermal aging during a proposed extended operating term for their facility. Since the spray heads are not within the scope of license renewal (see discussion in SER Section 2.2), they are not subject to aging management review. This resolves the issue identified in RAI Item No. 5.

3.2.5 Evaluation of WOG's Aging Assessment for the Effects of Erosion and Flow-Assisted Corrosion (Erosion/Corrosion)

In Sections 3.5.1 and 3.5.2 of the WCAP, WOG assessed the potential for the pressurizer components to degrade by either erosion or flow-assisted corrosion (sometimes called erosion/corrosion). In these sections WOG identified erosion as a mechanical degradation process in which the material wears away as a result of mechanical action by a fluid or particulate matter on the surface of the metal, and flow-assisted corrosion (erosion/corrosion) as a process in which components wear away as the result of the combined effects of erosion and corrosion. WOG identified that carbon steel materials and low-alloy steel materials are the materials of fabrication that are most susceptible to flow-assisted corrosion, and that nickel-based steels, higher alloy steels, and austenitic stainless steels are considered resistant to the effects of erosion and flow-assisted corrosion in a PWR environment. In Sections 3.5.1 and 3.5.2, WOG identified that only the process of erosion is considered to be a potential aging mechanism for the pressurizer. WOG reached this conclusion because, of all the pressurizer subcomponents, the only components in contact with the reactor coolant are those fabricated from austenitic stainless steel. Since only austenitic stainless materials in the pressurizer are in contact with reactor coolant and austenitic materials are not subject to flow-assisted corrosion, the WOG discussion of flow-assisted corrosion is acceptable and the only remaining issue is erosion, which is discussed below.

In Section 3.5.2, WOG concluded that these subcomponents have a low probability of degrading by erosion because the components are subjected to relatively low fluid flow velocities, and because the coolant is filtered prior to being injected into the primary system, thus minimizing the potential for particulate materials to erode the metal surfaces of the components. WOG proceeds to state that the following pressurizer components are exposed to primary coolant fluid flows that have the potential to result in erosion of the components:

- Surge nozzle thermal sleeve.
- Spray nozzle thermal sleeve.
- Surge nozzle retaining basket.
- Spray head.
- Spray head coupling.
- Surge nozzle safe-end.
- Spray nozzle safe-end.

WOG then states that only one component, the spray head, has the potential to degrade from the process of erosion. The staff considers the discussion in Section 3.5.2 to be extremely confusing in that it appears WOG is making three different conclusions that conflict with one another:

(1) That fluid flow velocity and particulate conditions are not sufficient in the pressurizer to consider that erosion is a plausible degradation mechanism that could affect the integrity of the subcomponents in the pressurizer.

(2) That seven components in the pressurizer (refer to the list above) are exposed to fluid flows that have the potential to result in erosion of the components.

(3) That only one component in the pressurizer (the spray head) is exposed to a fluid flow that has the potential to result in erosion of the component.

WOG should state why erosion is not plausible or does not require aging management for the surge nozzle thermal sleeve, spray nozzle thermal sleeve, surge nozzle safe-end, and spray nozzle safe-end. If erosion is plausible, then an AMP is required **(Open Item No. 3.2.5–1)**.

3.2.6 Evaluation of WOG's Aging Assessment for the Effects of Degradation by Wear

In Sections 3.6.1 and 3.6.2 of the report, WOG defined wear as the removal or plastic displacement of material as the result of mechanical contact and motion of two surfaces against each other. WOG identified that, in general, the pressurizer components are not susceptible to wear; however, WOG did identify that the potential existed for some wear to occur at the heater well to support plate interface, resulting in the thinning of the sheath wall, and subsequently in electrical failure. However, WOG also stated that if such wearing did occur, the wear would not affect the ability of the pressurizer to maintain the structural integrity of the pressure boundary because the pressurizer is designed with a redundant boundary at the heater connection. The staff concurs with this assessment because the pressurizer is designed with a redundant boundary at the heater connection and wear would not affect the ability of the pressurizer to meet its pressure boundary function.

3.2.7 Evaluation of WOG's Aging Assessment for the Effects of Creep and Stress Relaxation

3.2.7.1 Creep

In Sections 3.7.1 and 3.7.2 of the report, WOG defined creep as a plastic deformation process that occurs at elevated temperatures over time. WOG identified that the stress levels to initiate creep are typically below the stress associated with the material's elastic limit, and that the deformation occurs on constant strain. WOG has stated that creep is not a concern for austenitic alloys below 1000°F, nor for low-alloy steels below 800°F. WOG also stated that the maximum temperature experienced by the pressurizer component is 680°F. WOG, therefore, concluded that creep is not a significant aging mechanism for any pressurizer component. The staff concurs with this assessment.

3.2.7.2 Stress Relaxation

In Sections 3.7.1 and 3.7.2 of the report, WOG identified stress relaxation as a process in which a loaded (stressed) material may undergo a reduction in applied stress over time. WOG stated that stress relaxation is a process similar to creep, but which occurs under conditions where the elastic strain is replaced with plastic strain. WOG identified two contributors to stress relaxation: (1) elevated temperatures, and (2) neutron irradiation. WOG also identified the manway bolted connections as the only pressurizer components that could be impacted by the mechanism of stress relaxation. These bolts are preloaded when secured. WOG identified that the loss of preload could contribute to two age-related degradation methods in the manway's bolted connections:

- Excessive loss of preload or variability in preload could result in leakage through the bolted connection.

- If excessive loss of preload continues without correction, the potential exists for cyclic loads to be imposed on the bolts, which could increase the fatigue usage factor for the bolts.

WOG has stated that the neutron levels in the pressurizer are not high enough to be a potential contributor to any stress relaxation of the bolting materials. WOG identified that the loss of preload occurs at a decreasing rate over time, and that the majority of the loss of preload would occur within the first year of the time when the bolts are secured. WOG also stated that any cyclic loading amplitudes resulting from a loss of preload on the bolts would have to be large or of a long duration to result in detectable leakage from the manway mating surfaces. WOG therefore concluded that leakage through the bolted connections is the plausible aging effect for the bolting materials. The staff concurs with this assessment.

3.3 Assessment of Aging Management Activities and Program Attributes

In Chapter 4.0 of the report, WOG provided its options to manage aging effects during proposed extended operating periods for Westinghouse-designed nuclear power facilities. 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. This report predates the "Draft Standard Review Plan for Review of License Renewal Applications for Nuclear Power Plants," which identified the 10 elements that are to be reviewed by the staff. WOG indicated, in Section 4.0 of the topical report, that the report only presents program attributes for the AMPs, and that the plant-specific details of the AMPs will be developed during the preparation of license renewal applications. Therefore, applicants for license renewal will be responsible for describing the plant-specific attributes of each AMP. **This is Renewal Applicant Action Item 3.3–1**.

3.3.1 Aging Management for Fatigue

3.3.1.1 Aging Management Programs

To manage the fatigue of the pressurizer subcomponents, WOG has proposed to implement two AMPs, or an industry-initiated program labeled “Proposed Industry Position on Fatigue Evaluation for License Renewal” (the Position). This initiative was under development in 1997. Attributes of these programs are described in Section 2.4.2 of this report.

The staff has evaluated the attributes of WOG’s AMPs and finds them acceptable, on a generic basis, except for one. The acceptance attribute in AMPs 2.2 and 2.3 is an “acceptable cumulative usage factor (or equivalent).” Neither the CUF nor “equivalent” were defined. The staff, therefore, will require that applicants for license renewal provide a detailed description of the aging management programs for the pressurizer components and define the CUFs for these components in accordance with the ASME Section III Class 1 criterion (CUF≤1.0), consistent with the current licensing basis (CLB) or as revised in the license renewal application.

The ASME Section III Class 1 fatigue analyses are based on the assumption that the transients used in the design of Class 1 piping reflect actual plant operating conditions. The CLB fatigue design basis of WOG pressurizers typically does not include recently discovered additional insurge/outsurge transients and other operational transients discussed above. In addition, it also does not account for environmental effects on the ASME Section III design fatigue curves.

WOG has stated that plant-specific details will be developed during the preparation of the license renewal applications. The following information regarding the reevaluated TLAAs should be provided in plant-specific license renewal applications:

(1) The applicant should provided a detailed description and basis for the reduction of conservatism.

(2) The applicant should describe the thermal cyclic transients that form the basis of the reevaluated TLAAs. These should include the following, as applicable:

a. Insurge/outsurge transients.
b. Other transients.
c. Surge line nozzle transient loads.

(3) The CUFs of all subcomponents should be shown to be ≤ 1.0 for the extended period of operation, accounting for environmental effects on the design fatigue curves and considering the reduction in conservatism.

In RAI Item No. 1.b, the staff requested that WOG provide a more detailed description of the program for addressing the effects of insurge-outsurge transients on CUFs, as provided in Report No. MUHP–5060/5061/5062 and described in Section 2.6.1 of WCAP–14574. In its response to the RAI, WOG stated that the proposed industry position, in part, addresses potential reconstitution of pressurizer lower head and surge nozzle thermal transients that may result from plant-specific application of the WOG program on insurge-outsurge transients mitigation. WOG also stated that this issue is not directly related to NRC Bulletin 88–11.

WOG stated that it anticipated that the insurge-outsurge report describing options for modified operations to mitigate insurge-outsurge transients, and associated design transients, would be finalized by the end of 1997. To date, WOG has not provided additional information regarding this program. WOG stated that WOG-member utilities could use the criteria in the report to determine the significance, if any, of the insurge-outsurge issue at their plants, and the opportunity to implement modified operating procedures to mitigate such transients, if deemed necessary. The issue of including the effects of insurge-outsurge transients in the TLAAs for fatigue has not been addressed.

In the resolution of Generic Safety Issue (GSI) 190, *Fatigue Evaluation of Metal Components for 60-Year Plant Life*, (NRC memorandum dated December 26, 1999, from A. C. Thadani, RES, to W. Travers, EDO), the staff concluded that during the license renewal period, the increase in risk from fatigue failure for metal components because of environmental effects on the ASME Class 1 fatigue curves, is negligible, and therefore no NRC generic regulatory action is required. The effects of the coolant environment on fatigue is discussed in more detail in Section 3.3.1.4 of this report. The non-design basis transients, including the insurge/outsurge transients, were outside the scope of GSI-190 and, therefore, not addressed.

License renewal applicants should, therefore, identify the TLAAs for the pressurizer components, define the associated CUF and, in accordance with 10 CFR 54.21(c)(1), demonstrate that the TLAAs meet the CLB fatigue design criterion, CUF $\leq$1.0, for the extended period of operation, including the insurge/outsurge and other transient loads not included in the CLB which are appropriate to such an extended TLAA, as described in the WOG report "Mitigation and Evaluation of Thermal Transients Caused by Insurges and Outsurges," MUHP–5060/5061/5062, and considering the effects of the coolant environment on critical fatigue locations. (**Renewal Applicant Action Item 3.3.1.1–1)**.

3.3.1.2 Proposed Industry Position on Fatigue Evaluation for License Renewal

Step 1 of the proposed Industry Position, as specifically applied by WOG to WOG pressurizers, consists of determining if the current and projected transients for the license renewal term are encompassed within the CLB. The purpose of this step is to identify the actual or projected operational transients occurring during the license renewal period, and to verify that they fall within the CLB design-basis transients. WOG stated that the effects of fatigue will be considered to be adequately managed if an applicant can demonstrate that the CLB fatigue evaluations are valid for the license renewal period. If the existing design basis transients cannot be shown to account for the transients postulated to occur for the license renewal term, the position provides alternatives in the following three additional steps, depending on the results of the comparison made in this step.

Step 2 of the Industry Position consists of determining if the subcomponent is, or can be, included in the existing ISI program, and if these programs can manage the effects of fatigue for the license renewal term. For the pressurizer, the applicable plant-specific ASME Section XI ISI program would be used and would be applicable only to those pressurizer subcomponents accessible for ISI. The various examination categories are listed in Section XI, Table IWB–2500–1. Examination Category B–F requires volumetric and surface examinations for welds of nozzles with connected piping greater than four inches in diameter, and surface examination only for welds of nozzles with connected piping less than four inches in diameter.

Since evidence of excessive fatigue damage will manifest itself by fatigue crack initiation and/or growth, the position expects that the volumetric and/or surface examinations at the frequencies specified in ASME Section XI IWB–2400 will be sufficient to manage the effects of significant fatigue damage for the license renewal period.

This step of the Position refers to the ISI of ASME Section III Class 1 piping that is four inches in diameter or less. In contacts with ASME and industry representatives, the staff has expressed a concern about the effectiveness of the ASME Section XI required inspections in identifying cracks caused by fatigue or other degradation mechanisms, if present, in piping less than four inches in diameter. It is obvious that cracks in the inner weld surface cannot be detected by surface examination of the outer surface exclusively. The staff is currently interacting with ASME and industry to develop an appropriate approach to resolve this concern. No consensus has been reached on such an approach. The staff has not endorsed the position that uses volumetric examination to permit continuing operation of piping and components where the CUF has been determined to exceed the ASME Section III CUF criterion.

Step 3 of the Industry Position is provided if the subcomponent is not, or cannot, be included in an adequate ISI program. It consists of evaluating the subcomponent for the license renewal term based on an augmented ISI program, considering the flaw tolerance approach of the ASME Section XI non–mandatory Appendix for evaluation of fatigue in operating plants. As stated in the report, implementation of this option is subject to staff approval of this non–mandatory Appendix. As an alternative, this step offers the option of recalculating the cummulative fatigue usage for the license renewal term, based on refining the fatigue calculations by eliminating perceived conservatisms from the fatigue analysis. The Industry Position also recommends that both flaw tolerance and fatigue usage calculations should consider appropriate environmental factors on fatigue crack initiation or growth. As stated in the report, this should be done consistent with a generic NRC position on fatigue for license renewal. The Industry Position does not address the environmental effects on fatigue crack initiation and growth.

Step 3 also states that the existing ISI program to manage the fatigue effects for the license renewal term will include future risk-based considerations. In RAI Item No. 2, the staff requested that the ISI program be based on the 1989 Edition of ASME Section XI, and that any deviation from this standard be reviewed and endorsed by the staff. In the response to RAI Item No. 2, WOG agreed to include risk-based considerations as endorsed by the staff, and that reference in the position will be made to the 1989 Edition of ASME Section XI. This resolves the issue identified in RAI Item No. 2.

Step 3 also states that, based on published results of the status of PVRC activities regarding environmental effects on fatigue, and the expected PWR water chemistry, it does not appear that environmental effects will be a significant issue for WOG pressurizers. In RAI Item No. 4, the staff indicated that the published results of the PVRC had not been endorsed by the staff, and requested elimination of reference to these results (Reference 17 of the WOG report). In a letter dated May 30, 1997, WOG responded that, to provide WOG utilities with a complete status of activities related to environmental effects on fatigue, it would not delete the reference to the report. However, it would add the following sentence: “It is noted that, at the time of this writing, the NRC staff has not endorsed the results in Reference 17. Any plant-specific evaluations of environmental effects on fatigue should be performed in accordance with a methodology endorsed by the NRC staff at the time of the evaluation." The staff finds this acceptable because WOG has indicated that any plant-specific evaluation of fatigue environmental effects should be performed using a methodology endorsed by the staff. This resolves RAI Item No. 4.

WOG stated that plant-specific details on the WOG position on environmental effects on fatigue related to the Industry Position will be provided during the preparation of the license renewal applications. The staff has reviewed the steps in the WOG position, under development at the time of the submittal of the WOG report, and has determined that there is insufficient information to assess the quality and scope of the WOG position in actual application. The staff, therefore, cannot endorse the generic application of the proposed Industry Position to WOG pressurizers. The staff will, however, consider approval of the WOG position on a case-by-case basis only as part of a plant-specific license renewal application.

Step 4 of the Industry Position consists of repairing or replacing the subcomponents, per ASME Section XI, Subsections IWA–4000 and IWA–7000. The staff finds this an acceptable option.

3.3.1.3 Aging Management for Pressurizer Thermal Sleeves

The staff requested information regarding age-related degradation of the thermal sleeves in the surge and spray nozzles. In response, WOG stated in a letter dated May 30, 1997, that thermal sleeve degradation has usually occurred in sleeves exposed to a cross-flow environment, causing flow-induced vibration of the sleeves. The sleeves in the surge and spray nozzles do not experience cross-flow velocities, so they are not subjected to flow-induced vibration. The staff concurs with this assessment and finds it reasonable and acceptable. This resolves RAI Item No. 12.

3.3.1.4 Environmental Effects on ASME Section III Fatigue Design Curves

In 1993, the NRC staff expressed concerns regarding adverse environmental effects on the ASME Section III fatigue design curves and the fatigue qualification of ASME Section III Class 1 piping and reactor coolant pressure boundary components. These concerns were based on test data that had recently become available (NUREG/CR–5999) which indicates there could be a significant reduction in the fatigue life of metal components in a reactor primary system environment. To resolve these concerns, the staff established a fatigue action plan (FAP) under which the Idaho National Environmental Engineering Laboratory performed evaluations of selected components at seven operating plants (NUREG/CR–6260), using interim fatigue curves proposed by the Argonne National Laboratory (ANL) (NUREG/CR–5999) to account for environmental effects. The closure of the FAP was documented in NRC Policy Issue SECY–95–245, *Completion of the Fatigue Action Plan*.

The staff also evaluated these concerns under GSI–166, *Adequacy of Fatigue Life of Metal Components.* This GSI was intended to resolve this issue for plants with a design life of 40 years and plants considering a license renewal extension to 60 years. Based on the results of the FAP, the staff concluded that the environmental effects on plants within the first forty years of life were not significant and no immediate staff or licensee action was required. The staff based its conclusions on available transient monitoring records, certain conservatism identified in the existing fatigue analyses methodologies, and an RES risk assessment based on a 40-year plant life. However, the issue of environmental effects on the design fatigue curves for plants seeking to extend their operating licenses to 60 years was not resolved. The staff therefore established GSI–190, *Fatigue Evaluation of Metal Components for 60-Year Plant Life,* to address this issue separately.

In SECY–95–245, the staff proposed that license renewal applicants evaluate a sample of components with high-fatigue usage factors, using the latest available environmental fatigue data developed by ANL. This would provide an acceptable technical basis for addressing this issue (60 FR 22484, May 8, 1995) for the extended period of operation, or until a resolution of GSI–190 became available. In a memorandum dated December 26, 1999, regarding the closure of GSI–190, the staff recommended that licensees address the effects of the coolant environment on component fatigue as AMPs 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 coolant environment on component fatigue life.

WOG has adopted in this topical report the industry position on environmental effects on fatigue. Environmental effects on the ASME Section III fatigue curves in this proposed industry position are considered based on recommendations by the PVRC. In this industry position, operational screening criteria have been specified that serve to indicate that the environmental effects issue will not be significant. Otherwise, factors have been developed to modify the existing ASME Section III design fatigue curves, and thus account for environmental effects on these curves. Subsequent evaluation of environmental fatigue data by ANL has resulted in the development of revised environmental fatigue curves (SECY 95–245), and the identification by the staff of open issues regarding this industry proposal by letter dated August 6, 1999. Further issues were also raised at a meeting between the staff and the industry (letter dated May 17, 1999). The staff has not endorsed the PVRC approach to account for environmental effects on fatigue, and has therefore not endorsed the industry position as a resolution to GSI–190. In accordance with the closure of GSI–190, the staff will require that license renewal applicants address management of the environmental effects on the fatigue damage to the pressurizer subcomponents (see Renewal Applicant Action Item 3.3.1.1–1 in Section 3.3.1.1 of this report).

3.3.2 Aging Management for Forms of Corrosion

3.3.2.1 General Corrosion and Boric Acid Corrosion of Ferritic Pressurizer Components

In Section 3.2.3 of the WCAP, WOG concluded that no AMP is necessary to manage general forms of corrosion on the pressurizer materials. WOG's basis for the claim provided in Section 3.2.2 of the report. WOG's basis for this is that the cladding to the pressurizer naturally forms a passive protective oxide layer, which protects the internal surfaces of the pressurizer against effects of general corrosion. WOG also stated that hydrogen overpressure in the RCS typically mitigates the effects of oxygen in creviced geometries on the internal surfaces of the pressurizer. WOG therefore concluded that general corrosion is not significant for the internal surfaces of Westinghouse-designed pressurizers and that no further evaluations of general corrosion are necessary. While the staff concurs that hydrogen overpressure can mitigate the aggressive corrosive effect of oxygen in creviced geometries on the internal pressurizer surfaces, applicants for license renewal will have to provide a basis (statement) in their plant-specific applications about how their water chemistry control programs will provide for a sufficient level of hydrogen overpressure to manage general corrosion of the internal surfaces of their pressurizer **(Renewal Applicant Action Item 3.3.2.1–1).**

In Section 3.2.3 of the WCAP, WOG also concluded that an AMP is not necessary to manage boric acid corrosion of the external surfaces of ferritic and low-alloy steel pressurizer components. WOG's basis for this conclusion is that any primary water leakage (borated water leakage) would be detected well before the time when leaking borated water or boric acid residues could effectively waste (corrode) away the ferritic or low-alloy pressurizer materials.

On January 14, 1997, the staff issued a series of RAIs to WOG for resolution. In RAI Item No. 8, the staff disagreed with WOG's conclusions that (1) boric acid corrosion would not affect any components in the pressurizer, and (2) no AMP is necessary to control boric acid leakage. The staff stated that WOG appears to be relying on a program to mitigate the effects of boric acid corrosion so as to conclude that boric acid corrosion is not an aging effect. In the RAI, the staff requested that WOG revise the report to include an AMP for boric acid corrosion, or provide a justification for why a boric acid management program is not needed. On May 30, 1997, WOG replied and stated that the "staff has misinterpreted WOG's position on boric acid corrosion," and that "WOG's position is that external pressurizer components may be affected by boric acid leakage." However, in the reply to the RAI, WOG stated that "effects resulting from boric acid leakage, an event that causes degradation, are managed by [the] current activities described in Paragraph 3 of Section 3.2.2," of the report. WOG also stated its position that "an event management program limits degradation and precludes aging from occurring." WOG stated that it would amend the report to provide further descriptions of the programs described in Section 3.2.2 of the WOG report.

The staff concludes that the reply to RAI Item No. 8 does not resolve the issue of whether an AMP is necessary to control boric acid leakage and corrosion of pressurizer components. The staff's position is that WOG should credit the programs listed in Paragraph 3 of Section 3.2.2 of the WCAP as being sufficient to manage the effects of boric acid corrosion. Therefore, applicants for license renewal must provide sufficient details in their LRAs about how their GL 88–05 programs and inservice inspection programs will be sufficient to manage the corrosive effects of boric acid leakage on their pressurizer components during the proposed extended operating terms for their facilities **(Renewal Applicant Action Item 3.3.2.1–2).**

In RAI Item No. 9, the staff, in part, inquired whether an AMP was necessary to manage leakage out of the pressurizer manway gaskets. In its response to RAI Item No. 9, WOG indicated that postulated leakage from the manway gaskets is considered to be an event-driven mechanism, not an aging degradation mechanism. In making this statement, WOG identified that the boric acid leakage program and ISI programs described in Section 3.2.2 of the WCAP can be used to manage the effects of any postulated leakage from the gaskets. Manway gaskets are not considered by the ASME Code to be primary pressure boundary components. The manway gaskets, therefore, are not considered to fall under the scope of license renewal because they do not serve the function of maintaining the primary pressure boundary during extended operating terms. However, any leakage from the manway gaskets can be appropriately controlled by the applicant's boric acid monitoring and control programs. The staff considers this to be a reasonable approach to controlling leakage from the gaskets, which may occur between maintenance periods for the pressurizer. This resolves RAI Item No. 9.

In RAI Item No. 10, the staff requested a description of (1) the potential for corrosion of the bolt holes in the carbon steel manway cover, and (2) the potential for corrosion of the manway cover at the interface between the cover and the manway gasket. The staff informed WOG that an AMP for the bolted manway connections was necessary to ensure against cracking and loss of preload, and then requested that WOG either revise the report to include an AMP for the bolted connections in the pressurizer or provide a justification for not including it. In its response to RAI Item No. 10, WOG indicated that it did not consider boric acid corrosion of the bolt holes and manway covers to be an age related degradation mechanism that needed an AMP, and that instead, it was an event-driven effect. In making this conclusion, WOG stated that this event can be managed by the event management program in Section 3.2.2. of the report. Again, the staff's position is that the report should credit the programs listed in Paragraph 3 of Section 3.2.2 to the WOG report as being sufficient to manage the effects of boric acid corrosion. The issues identified in RAI Item No. 10 are similar to the issue for RAI Item No. 8. Therefore, the applicant's response to **Renewal Applicant Action Item 3.3.2.1–2** must be sufficient to resolve how the plant-specific GL 88–05 programs and inservice inspection programs will be sufficient to manage boric acid leakage through bolted manway connections and to preclude boric acid corrosion of the manway bolts and covers.

3.3.2.2 Aging Management Programs for Stress Corrosion Cracking, Including Programs for IGSCC of Austenitic Stainless Steel Pressurizer Components, PWSCC of Inconel Pressurizer Components, and Manway Covers

In Section 3.2.2 of the report, WOG concluded that the safe-ends of the surge, instrument, and relief nozzles are the only pressurizer components that are fabricated from austenitic stainless steel, subject to high stresses, and in contact with the primary coolant. In this section WOG also stated that, to date, there has not been any operating experience that indicated the presence of IGSCC or IGA in austenitic stainless steel pressure boundary components in the pressurizer. In spite of the lack of IGSCC industry experience for these components, WOG recommended that AMPs be proposed for controlling IGSCC of the austenitic stainless steel pressurizer nozzles and PWSCC of dissimilar metal nozzle-to-safe-end weld filler metals. In this section, WOG identified that the programs may include the following optional attributes:

- Review of industry experience, developments from ongoing laboratory studies of PWSCC of Inconel 82/182 filler metals, and developments from ongoing research activities on alternative weld consumables (e.g., on Inconel 52/152 filler materials).

- Crediting plant-specific ISI programs for examinations of dissimilar nozzle-to-safe-end welds and adjacent HAZ/base metal in accordance with inspection and frequency criteria in Category B–F of Table IWB–2500–1 to Section XI of the ASME Code, and crediting the evaluation criteria of Paragraph IWB–3514 for assessing flaws in these components if flaw indications are detected during the examinations of the nozzle-to-safe-end welds.

WOG program attributes for controlling IGSCC/PWSCC in the pressurizer nozzles and safe-ends, and for verifying that the pressurizer can perform its intended safety function during the license renewal period, are incomplete. In RAI Item No. 6, the staff took issue with the omission by WOG to identify IGSCC as an age-related degradation mechanism for the shell/heads, spray line nozzle, valve nozzle, manway, instrumentation nozzle, surge line nozzle, and support skirt of the pressurizer. The staff stated that it considered AMPs for these components to be necessary because: (1) high levels of oxygen could be introduced into the primary coolant during cooldown conditions as a result of efforts to control crud bursts; (2) high levels of oxygen may be introduced into the primary coolant during shutdown operations as a result of exposing the reactor coolant system to the outside air; (3) the pressurizer cladding may have regions of low delta ferrite that have been sensitized during PWHT, and thus be susceptible to IGSCC; and (4) ASME Section XI requires inspections of the pressurizer welds and weld regions.

In its response to the RAI, WOG replied that, to date, neither PWSCC nor IGSCC has been a problem in these pressurizer components, and that currently there is no need for an AMP for these components. The WOG position is based on the following:

(1) Implementation of industry practices during the fabrication of Westinghouse-designed pressurizers to limit the degree of sensitization of the austenitic stainless steel portions of these components, including the practice of limiting the heat input during welding;

(2) The industry practice of controlling the dissolved oxygen content of the reactor coolant to less than 0.10 ppm during power operations or times when the reactor coolant temperature is greater than 200°F; and

(3) The practice of limiting the amount of Inconel or Alloy 600 materials used in Westinghouse-designed pressurizers and using Inconel 82/182 filler metals only.

The staff considers that the lack of industry experience is not an acceptable basis for concluding that IGSCC/PWSCC will not occur in the pressurizer nozzle components during a proposed extended operating period for a WOG member facility, especially when there have been cases of pressurizer instrumentation nozzle cracking in the industry (e.g., cracking in two of the Type 316 stainless steel instrumentation nozzles at Surry Unit 1). With the exception of those nozzles that are integrally cast with the pressurizer shell or heads, the staff considers the surge, spray, relief, and instrumentation nozzles to be penetrations that are welded to pressurizer shells or heads using partial- or full- penetration welds. The welding of these components may create highly stressed regions in the weld and adjacent base metal areas; the staff considers these areas to be potentially susceptible to SCC.

As invoked by the requirements of 10 CFR 50.55a, PWR licensees are required by Table IWB–2500–1 to Section XI of the ASME Code to perform the following inspections of pressurizer nozzle components:

- Items B3.30 and B3.40 of Examination Category B–D, volumetric examinations of full-penetration nozzle-to-vessel welds and nozzle inside radii.

- Item B5.40 of Examination Category B–F, volumetric and surface examinations of nozzle-to-safe-end butt welds greater than 4 inches in nominal pipe size.

- Items B5.50 of Examination Category B–F, surface examinations of nozzle-to-safe-end butt welds less than 4 inches in nominal pipe size, and B5.60 of Examination Category B–F, surface examinations of nozzle-to-safe-end socket welds.

- Item B15.20 of Examination Category B–P, system leak tests and VT–2 type visual examinations of the pressurizer pressure boundary.

- Item B15.30 of Examination Category B–P, system hydrostatic tests and VT–2 type visual examinations of the pressurizer pressure boundary.

The manway covers are pressure boundary components that are secured in place with 1.875 inch-diameter, quenched, and tempered low-alloy steel bolts (such as Alloy 4140 steels, SA–193 Grade B7 materials). The staff considers that these bolting materials may be susceptible to SCC if the yield strength for the materials is greater than 150 ksi or if the Rockwell C hardness is greater than 32 (**Renewal Applicant Action Item 3.2.2.3.2–1**). Table IWB–2500–1 to Section XI of the ASME Code requires the following inspections of the manway bolting materials:

- Item B7.20 of Examination Category B–G–2, visual VT–1 surface examinations of the bolts, studs, and nuts in the pressurizer primary pressure boundary.

In 1995/1996, IGSCC- and TGSCC- type cracking were reported in two of the instrumentation nozzles welded to the pressurizer of the Surry Unit 1 nuclear plant (letters dated October 9, 1995, and February 23, 1996). This event provides definite evidence that the potential exists for SCC-type cracking to initiate in the penetration nozzles of Westinghouse-designed pressurizer vessels. The staff concludes that WOG should have determined that AMPs are necessary to control and manage the potential for SCC to occur in welded pressurizer penetration nozzles and manway bolting materials, and that WOG should have recommended that applicants for license renewal could credit their administrative primary coolant chemistry control programs, ASME Code ISI programs for the pressurizers, and plant-specific 10 CFR Part 50, Appendix B, quality assurance programs as the bases for managing the phenomena of PWSCC/IGSCC of these pressurizer components. These programs are already implemented by licensees at their facilities. The staff concludes that the report needs to be revised to extend AMP–2–1 to the pressurizer penetration nozzles, to the nozzle-to-vessel welds, and to the manway bolting materials, and to include the appropriate Code requirements among the program attributes listed in Table 4–1 and summarized in the text in Section 4.1 of the report. Therefore, the issue identified in RAI Item No. 6 remains open (refer to **Open Item 3.3.2.2–1)**. In addition, applicants for license renewal must provide sufficient details in their license renewal applications (LRAs) about how their primary coolant chemistry control programs, ISI programs, and 10 CFR Part 50, Appendix B, quality assurance programs will be sufficient to manage the potential for SCC to occur in the pressurizer nozzle components and bolted manway covers during the proposed extended operating terms for their facilities **(Renewal Applicant Action Item 3.3.2.2–1).**

In RAI Item No. 7, the staff disagreed with WOG's conclusion that an AMP for the cladding of the pressurizer is not needed. In the RAI, the staff informed WOG that it believed that cracks in the clad could propagate into the base metal, and that the cladding should be included among the components to be addressed by an AMP for stress corrosion cracking. In this RAI, the staff stated that an acceptable program to demonstrate the integrity of the cladding could be a one-time license renewal inspection of the cladding and any attachment welds to the cladding.

In its response to RAI Item No. 7, WOG stated that an AMP is not necessary because the circumferential cracking discovered in the Haddam Neck pressurizer cladding was the result of an isolated, plant-specific event, and not caused by an age-related degradation mechanism. In its response, WOG stated that the following paragraph would be added to the report to clarify this position:

> "In 1990, the Connecticut Yankee Atomic Power Company (CYAPCO) discovered and reported a 10- to 20-inch-wide band of crack-like indications in the Haddam Neck pressurizer cladding. The cracking extended 360° around the circumference of the pressurizer and was located about 1 to 2 feet below the normal water level [letter dated May 30, 1997, and SECY 95–245]. Nondestructive examination investigations established that at least some of the indications penetrated the cladding to the cladding-ferritic base metal interface. Review of plant operating records revealed that the same band of indications had been reported as early as 1970. The indications may have been caused by a spray of cold water from the spray nozzle onto the cladding during a low water-level transient, which the plant operating records show occurred prior to the 1970 inspection that first discovered the indications. Alternatively, the indications may have been present during initial start-up. Whatever the cause of the indications, they have been dormant since at least 1970. This has been confirmed by inspections subsequent to the 1990 inspections using a more accurate inspection technique. Therefore, the crack-like indications were not caused by an aging-related degradation process such as fatigue or stress corrosion cracking. This condition has recently been reviewed to the satisfaction of the USNRC. On the basis that this condition is unique to the Haddam Neck pressurizer, and that it is not an aging-related form of degradation, it is not considered further in this generic evaluation."

The staff has noted that WOG's proposed wording is simply a restatement of the information provided in Section 2.6.3 of the WCAP. In the evaluation of the cracks in the cladding of the Haddam Neck pressurizer, the staff concurred with the conclusions in the Northeast Utilities safety evaluations that the flaw indications in the cladding were acceptable under ASME Section XI, and that the Haddam Neck Unit would be acceptable for continued operation. However, in its SERs of the event, the staff did not come to a definitive conclusion as to what was the source of the cracking. The staff therefore concludes that the paragraph on page 2.6.3 of the report does not provide a sufficient basis for concluding that the cracking in the Haddam Neck pressurizer cladding was solely the result of a one-time operational pressurizer level transient, in that the paragraph does not:

(1) Provide sufficient details about where and when the cracking in the cladding occurred.

(2) Provide sufficient details about the operational event that is presumed to have initiated the cracking in the cladding.

(3) Provide sufficient details about the inspections performed in 1970 that would support WOG's conclusions that the cracks in the pressurizer cladding have been dormant.

(4) Provide a reference or summary of any NRC inspection report or safety evaluation report that supported and concurred with the conclusion that the cracking in the cladding was not the result of thermal fatigue or SCC.

The staff therefore concludes that WCAP–14574 does not contain enough information to conclude that the cracking in the Haddam Neck pressurizer cladding was not the result of thermal fatigue or SCC. SCC is not a concern for crack propagation into the ferritic base metal or weld metal beneath the cladding due to the water chemistry controls used in PWRs. The staff therefore concludes that applicants must propose an AMP to verify whether or not thermal fatigue-induced cracking has propagated through the clad into the ferritic base metal or weld metal beneath the clad **(Renewal Applicant Action Item 3.3.2.2–2).**

In RAI Item No. 11, the staff requested identification of those components that are welded to the inside cladding of the pressurizer vessel, and a discussion of whether aging management programs are necessary to monitor for cracking in these welds. In its reply to the RAI, WOG identified that the following internal Type 304 stainless steel supports are welded to the pressurizer cladding using E308 or E308L filler material: spray head coupling, upper heater support plate bracket, lower heater support plate bracket, surge nozzle retaining basket, and heater welds. WOG identified that of these components, the spray head coupling is welded using a full penetration weld, the upper and lower heat support brackets are welded using 0.5-inch fillet welds, and the surge nozzle retaining basket is welded to the cladding using a 0.25-inch fillet weld. WOG also stated that procedural control of weld-process heat input, and fit-up thicknesses, as well as testing of the welds following the methods of ASTM A262 Practice E, have prevented the sensitization that could render the weld materials and heat-affected zones susceptible to IGSCC. WOG therefore maintained that an AMP for these components was not necessary because there have been no generic cracking incidents of the component welds to date. In addition, in Section 3.1 of this SER, the staff concluded that these components are not within the scope of license renewal as defined in 10 CFR 54.4. However, the staff is concerned that IGSCC in the heat-affected zones of these welds could grow as a result of thermal fatigue into the adjacent pressure boundary during the license renewal term. The staff considers that these welds will not require aging management in the extended operating periods if applicants can provide a reasonable justification that sensitization has not occurred in these welds during the fabrication of these components. Therefore, applicants for license renewal must provide a discussion of how the implementation of their plant-specific procedures and quality assurance requirements, if any, for the welding and testing of these austenitic stainless steel components provides reasonable assurance that sensitization has not occurred in these welds and their associated heat-affected zones. In addition, the staff requests that applicants for license renewal identify whether these welds fall into Item B8.20 of Section XI Examination Category B–H, Integral Attachments for Vessels, and if applicable, whether the applicants have performed the mandatory volumetric or surface examinations of these welds during the ISI inspection intervals referenced in the examination category (**Renewal Applicant Action Item 3.3.2.2–3**). The information provided by WOG and the Renewal Applicant Action Item resolve the issue identified in RAI Item No. 11.

3.3.3 Aging Management for the Effects of Irradiation Embrittlement

In Section 3.3.3, WOG concluded that no surveillance programs would be needed to monitor for radiation-induced embrittlement of the pressurizer components, because the neutron and irradiation fields within the pressurizer are not high enough to induce radiation embrittlement of the pressurizer components. Pending the corrections to Section 3.3.2 of the report (refer to Open Item No. 3.2.3–1), the staff concurs with this conclusion. The staff therefore concludes that no AMP or TLAA surveillance program is necessary to monitor for radiation embrittlement of the pressurizer components.

3.3.4 Aging Management for the Effects of Thermal Embrittlement

In Section 2.3.2, WOG indicated that the spray heads in Westinghouse-designed pressurizers were fabricated from ASTM A296 Grade CF8M duplex stainless steels and that the spray heads are secured in place with a locking bar welded to the upper head cladding and the spray head. In Section 3.4.2 of the report, WOG identified that the spray head is the only pressurizer component that could be susceptible to thermal aging embrittlement. However, WOG concluded that any postulated thermal aging of the spray head would not have any significant effect on the safety function of the pressurizer because it is a low-stressed component and is located internally to the pressurizer shell and heads. WOG therefore concluded that no further thermal aging assessment of the spray head need be performed, and that no AMP was needed for the spray heads in Westinghouse-designed plants.

In Section 3.1 of this SER, the staff concurred with WOG's determination that the spray heads in Westinghouse-designed pressurizers are not within the scope of license renewal. The staff therefore concludes that an AMP is not necessary to control thermal aging in Westinghouse pressurizer spray heads.

3.3.5 Aging Management for the Effects of Erosion and Erosion/Corrosion

The staff cannot determine whether an aging management program is necessary for managing erosion in the pressurizer until WOG provides a clearer assessment of erosion (Refer to Open Item No. 3.2.5–1). The WOG response to Open Item No. 3.2.5–1 will be used to determine whether an such AMP is necessary.

3.3.6 Aging Management for the Effects of Wear

In the report, WOG did not identify any pressurizer pressure boundary components that have the potential to be affected by wear. The staff concurs with WOG's assessment, and concludes that no aging management programs are necessary to manage wear in the pressurizer components.

3.3.7 Aging Management for the Effects of Creep and Stress Relaxation

3.3.7.1 Aging Management for Creep

In Section 3.7.2 of the report, WOG concluded that creep is not a significant aging mechanism for any pressurizer component, because the operating temperatures for the pressurizer were not significantly high to be a factor that could induce creep. WOG therefore concluded that aging management programs were not necessary to monitor for and control the effects of creep in the pressurizer components. The staff concurs with this assessment.

3.3.7.2 Aging Management for Stress Relaxation

In Section 3.7.2 of the report, WOG concluded that leakage from the bolted connections of the pressurizer manways is the only aging effect that could result from stress relaxation of the bolted connections. In the report, however, WOG stated, that the magnitude of the bolt preloads is intended to compensate for some loss of preload. WOG also stated that operating history supports the premise that stress relaxation is not an aging effect that needs to be addressed by pressurizer AMPs. WOG has concluded that stress relaxation of the bolted manway connections is plausible, yet WOG is relying on a lack of industry experience as the basis for claiming that management of this aging effect is not necessary. The staff concludes that a lack of operating experience is not a sufficient basis for concluding that aging management is not necessary for aging effects considered to be plausible by the industry **(Open Item 3.3.7.2–1)**.

In Section 3.3.2.1 of this report, the staff concluded that WOG must credit the programs listed in Paragraph 3 of Section 3.2.2 to the WCAP as being sufficient to manage the effects of boric acid corrosion **(Open Item 3.3.2.1–1)**. In addition, the staff concluded that applicants for license renewal must provide sufficient details in their LRAs as to how their GL 88–05 programs and inservice inspection programs will be sufficient to manage the corrosive effects of boric acid leakage on their pressurizer components during the proposed extended operating terms for their facilities **(Renewal Applicant Action Item 3.3.2.1–2).** The staff concludes that the response of WOG to Open Item 3.3.2.1–1 and the license renewal applications to **Renewal Applicant Action Item 3.3.2.1–2** should be comprehensive enough to show how the boric acid control programs (e.g., GL 88–05 Programs) and ISI programs will be sufficient to address the issue of stress relaxation in the bolted connections for the pressurizer manway.

4.0 CONCLUSIONS

4.1 Conclusion for Aging Management Programs for Fatigue

(1) Extrapolation of the current design fatigue usage factors from 40 to 60 years indicates that the pressurizer's intended function cannot be assured for the license renewal period, even for those subcomponents determined in the report to have a CUF less than 1.0, for the following reasons:

- The CLB design-basis fatigue analyses of WOG pressurizer subcomponents do not include transient loading conditions such as additional insurge/outsurge and other transients not included in the CLB.

- The design-basis fatigue analyses do not account for environmental effects on the ASME Section III design fatigue curves.

(2) Except for concerns expressed in the staff's evaluation in Section 3.3.1.1 of this SER, the topical report forms an acceptable generic framework for WOG pressurizer fatigue management programs for the extended period of operation. However, applicants for license renewal will be required to provide plant-specific details of these programs. These should therefore be provided in plant-specific applications. These items are identified in the Renewal Applicant Action Items listed for the management of fatigue (refer to Section 6.1 of this SER).

4.2 Conclusion for Aging Management for Other Forms of Age-related Degradation

1. In general, the report forms an acceptable framework for managing the effects of thermal embrittlement, wear, and creep in Westinghouse-designed pressurizer components.

2. The report does not form an acceptable framework for managing the effects of erosion and erosion/corrosion in Westinghouse-designed pressurizer components. WOG needs to state why erosion is not plausible or does not require aging management for the pressurizer components that are listed in Section 3.5.2 of the report. (Refer to Open Item No. 3.2.5–1 that is listed in Section 5.2 of this SER.)

3. WOG concludes that stress relaxation is a plausible aging effect that can occur in bolted pressurizer manway closures; however, due to a lack of detrimental operating experience, it does not consider this effect to be one that requires aging management during extended operating terms. Lack of detrimental experience is not a sufficient basis for concluding that aging management is not necessary for aging effects considered plausible by the industry. The staff therefore concludes that the report, in its current form, does not form an acceptable framework for managing the effects of stress relaxation.

4. The report, in its current form, also does not form an acceptable framework for managing the effects of corrosion in Westinghouse-designed pressurizer components, in that:

    a. WOG concludes that boric-acid corrosion is not an aging effect that needs to be managed for Westinghouse plants. The staff does not agree. Stress relaxation of bolting could lead to loosening of the bolted connections and leakage, and result in boric-acid induced corrosion of the bolting. Pressurizer manway gaskets have historically experienced such leakage. On this basis, the staff concludes that boric-acid induced corrosion is an applicable aging effect for bolted connections in the pressurizer, and needs to be managed during proposed extended operating terms for Westinghouse PWRs.

    b. WOG has proposed that aging management is necessary to control the effects of IGSCC of austenitic stainless steel safe-ends to penetration nozzles in the pressurizer designs and the effects of PWSCC of Alloy 82/182 filler metals used in the safe-end-to-nozzle welds for these components, yet WOG does not consider that aging management is necessary to control IGSCC/PWSCC in the portions of the nozzles penetrating the pressurizer vessels. The IGSCC and TGSCC that have been reported in the penetration portions of the instrumentation nozzles at the Surry Nuclear Plant are indications that SCC-type cracking can occur in the nozzle-to-shell welds of welded pressurizer penetration nozzles.

        The staff concludes that WOG needs to revise the discussion in Section 4.1 of the report (e.g., AMP–2.1) to extend the scope of the program to the penetration nozzles that are welded to the pressurizer shells or heads and to the bolting materials in the pressurizer manways.

5. The staff cannot accept the contents of WCAP–14574 as written. Section 5.0 of this SER provides a list of open items that need to be addressed and resolved if the staff is to accept the report for use or reference by license renewal applicants. Section 6.0 to this SER provides a list of Renewal Applicant Action Items that will need to be addressed by applicants seeking license renewal for their nuclear units.

5.0 OPEN ITEMS NEEDING RESOLUTION BY WOG

5.1 Open Item for Aging Management Programs for Fatigue

Open Item 3.3.1.1–1 The report should show the specific approach that WOG will use to include insurge/outsurge and other off-normal and additional transients in the fatigue TLAAs.

5.2 Open Items for Aging Management Programs for Other Aging Effects

Open Item 3.2.2.1–1. The staff finds that the criteria in GL 88–05 and the Section XI requirements for conducting system leak tests and VT–2 type visual examinations of the pressurizer pressure boundary are acceptable programs for managing boric acid corrosion of the external, ferritic surfaces and components of the pressurizer. However, the report fails to refer to the actual provisions in the ASME Code, Section XI that require mandatory system leak tests of the pressurizer boundary. These requirements are contained in Paragraph IWB–2500 and Category B–P of Table IWB–2500–1. The report needs to be revised to refer to the appropriate Code inspection requirements for this discussion to be acceptable.

Open Item 3.2.3–1. In Sections 3.3.1 and 3.3.2 of the report, WOG concluded that the components in Westinghouse-designed pressurizers would not be subject to any loss of fracture toughness because the neutron fluences in the pressurizer are less than the neutron embrittlement thresholds of $1X10^{-20}$ n/cm^2 [sic] for neutrons with kinetic energies $\geq$ 0.1 MeV or $1X10^{-17}$ n/cm^2 [sic] for neutrons with kinetic energies $\geq$ 1.0 MeV. While the staff concurs with the argument that the neutron radiation and gamma radiation fields in the pressurizers are significantly lower than those in the reactor vessels, they are certainly greater than the threshold values cited by WOG. For neutrons with kinetic energies in excess of 1.0 MeV, 10 CFR Part 50, Appendix H, refers to a neutron fluence threshold of $1X10^{17}$ n/cm^2 (as opposed to $1X10^{-17}$ n/cm^2) as being the basis for implementing surveillance programs that are designed to monitor for the effects of irradiation embrittlement. WOG needs to amend the report to cite the correct “positive” exponents for the threshold values if WOG’s arguments for neutron irradiation are to remain valid.

Open Item No. 3.2.5–1. The staff considers the discussion in Section 3.5.2 to be extremely confusing in that it appears WOG is making three different conclusions that conflict with one another:

a. That fluid flow velocity and particulate conditions are not sufficient in the pressurizer to consider that erosion is a plausible degradation mechanism that could affect the integrity of the subcomponents in the pressurizer.

b. That seven components in the pressurizer (refer to the list above) are exposed to fluid flows that have the potential to result in erosion of the components.

c. That only one component in the pressurizer (the spray head) is exposed to a fluid flow that has the potential to result in erosion of the component.

WOG should state why erosion is not plausible for the surge nozzle thermal sleeve, spray nozzle thermal sleeve, surge nozzle safe-end, and spray nozzle safe-end. If erosion is plausible, then an AMP is required.

Open Item 3.3.2.2–1. The staff concludes that WOG should have determined that an AMP is necessary to control and manage the potential for SCC to occur in welded pressurizer penetration nozzles and manway bolting materials, and should have recommended that a licensee could credit the following programs as the basis for managing the phenomena of PWSCC/IGSCC of the pressurizer components: (1) the primary coolant chemistry control program; (2) the ISI program for the pressurizers; and (3) the plant-specific quality assurance program as it pertains to assuring that previous welding activities on welds in the pressurizer have been controlled in accordance with the pertinent requirements of 10 CFR Part 50, Appendix B, and with the pertinent welding requirements of the ASME Code for Class 1 systems. The programs are already implemented by licensees at their facilities. The staff concludes that the report needs to be revised to extend AMP–2–1 to the pressurizer penetration nozzles, to the nozzle-to-vessel welds, and to the manway bolting materials, and to include the appropriate Code requirements among the program attributes listed in Table 4–1 and summarized in the text in Section 4.1 of the report.

Open Item 3.3.7.2–1. In Section 3.7.2 of the report, WOG concluded that leakage from the bolted connections of the pressurizer manways is a plausible aging effect that could result from stress relaxation of the bolted connections. In the report however, WOG stated, that the magnitude of the bolt preloads is intended to compensate for some loss of preload. WOG also stated that operating history supports the premise that stress relaxation is not an aging effect that needs to be addressed by pressurizer AMPs.

The staff concludes that a lack of operating experience is not a sufficient basis for concluding that aging management is not necessary for aging effects considered to be plausible by the industry. Therefore, WOG should propose programs that will detect stress relaxation of pressurizer manway bolting.

6.0 RENEWAL APPLICANT ACTION ITEMS

6.1 Renewal Applicant Action Items for the Management of Fatigue

The following items should be included in plant-specific license renewal applications:

Renewal Applicant Action Item 3.3.1.1–1. License renewal applicants should identify the TLAAs for the pressurizer components, define the associated CUF and, in accordance with 10 CFR 54.21(c)(1), demonstrate that the TLAAs meet the CLB fatigue design criterion, CUF $\leq$1.0, for the extended period of operation, including the insurge/outsurge and other transient loads not included in the CLB which are appropriate to such an extended TLAA, as described in the WOG report "Mitigation and Evaluation of Thermal Transients Caused by Insurges and Outsurges," MUHP–5060/5061/5062, and considering the effects of the coolant environment on critical fatigue locations.

6.2 Renewal Applicant Action Items for Aging Management Programs of Other Aging Effects

Renewal Applicant Action Item 3.2.2.3.2–1. The staff concurs that the potential to develop SCC in the bolting materials will be minimized if the yield strength of the material is held to less than 150 ksi, or the hardness is less than 32 on the Rockwell C hardness scale; however, the staff concludes that conformance with the minimum yield strength criteria in ASME Specification SA–193 Grade B7 does not in itself preclude a quenched and tempered low-alloy steel from developing SCC, especially if the acceptable yield strength is greater than 150 ksi. To take credit for the criteria in EPRI Report NP–5769, the applicant needs to state that the acceptable yield strengths for the quenched and tempered low-alloy steel bolting materials (e.g., SA–193, Grade B7 materials) are in the range of 105–150 ksi.

Renewal Applicant Action Item 3.2.2.1–1. In the report, WOG concluded that general corrosion is nonsignificant for the internal surfaces of Westinghouse-designed pressurizers and that no further evaluations of general corrosion are necessary. While the staff concurs that hydrogen overpressure can mitigate the aggressive corrosive effect of oxygen in creviced geometries on the internal pressurizer surfaces, applicants for license renewal will have to provide a basis (statement) in their plant-specific applications about how their water chemistry control programs will provide for a sufficient level of hydrogen overpressure to manage general corrosion of the internal surfaces of their pressurizer.

Renewal Applicant Action Item 3.3–1. Applicants for license renewal must describe how each plant-specific AMP addresses the following 10 elements: (1) scope of the program, (2) preventive action, (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.

Renewal Applicant Action Item 3.3.2.1–2. Applicants for license renewal must provide sufficient details in their LRAs about how their GL 88–05 programs and ISI programs will be sufficient to manage the corrosive effects of boric acid leakage on their pressurizer components during the proposed extended operating terms for their facilities, including postulated leakage from the pressurizer nozzles, pressurizer nozzle-to-vessel welds, pressurizer nozzle-to-safe end welds, and pressurizer manway bolting materials.

Renewal Applicant Action Item 3.3.2.2–1. Applicants for license renewal must provide sufficient details in their LRAs as to how their primary coolant chemistry control programs, ISI programs, and 10 CFR Part 50, Appendix B, quality assurance programs will be sufficient to manage the potential for SCC to occur in the pressurizer nozzle components and bolted manway covers during the proposed extended operating terms for their facilities**.**

Renewal Applicant Action Item 3.3.2.2–2. Applicants must propose an AMP to verify whether or not thermal fatigue-induced cracking has propagated through the clad into the ferritic base metal or weld metal beneath the clad.

Renewal Applicant Action Item 3.3.2.2–3. The staff is concerned that IGSCC in the heat-affected zones of 304 stainless steel supports that are welded to the pressurizer cladding could grow as a result of thermal fatigue into the adjacent pressure boundary during the license renewal term. The staff considers that these welds will not require aging management in the extended operating periods if applicants can provide a reasonable justification that sensitization has not occurred in these welds during the fabrication of these components. Therefore, applicants for license renewal must provide a discussion of how the implementation of their plant-specific procedures and quality assurance requirements, if any, for the welding and testing of these austenitic stainless steel components provides reasonable assurance that sensitization has not occurred in these welds and their associated heat-affected zones. In addition, the staff requests that applicants for license renewal identify whether these welds fall into Item B8.20 of Section XI Examination Category B–H, Integral Attachments for Vessels, and if applicable, whether the applicants have performed the mandatory volumetric or surface examinations of these welds during the ISI intervals referenced in the examination category.

7.0 REFERENCES

1. Part 54 to Title 10, *Code of Federal Regulations*, “Requirements for Renewal of Operating Licenses for Nuclear Power Plants.”

2. Letter dated July 3, 1996, from Westinghouse Owners Group to the U.S. Nuclear Regulatory Commission Document Control Desk, submittal of Westinghouse Energy Systems Topical Report WCAP–14574, “License Renewal Evaluation: Aging Management Evaluation for Pressurizers.”

3. WCAP–14574, “License Renewal Evaluation: Aging Management Evaluation for Pressurizers,” July 1996.

4. Letter dated January 14, 1997, from S.C. Flanders, U.S. Nuclear Regulatory Commission, to R.A. Newton, Chairman, LCM/LR Working Group, Westinghouse Owners Group, “Request for Additional Information Regarding the Westinghouse Owners Group Topical Report WCAP–14574 (TAC No. M96110).”

5. Letter dated May 6, 1997, from R.J. Prato, U.S. NRC, to the Westinghouse Owners Group, with enclosed Request for Additional Information on WOG Generic Technical Report WCAP–14574.

6. Letter dated May 30, 1997, from R.A. Newton, Chairman, LCM/LR Working Group, Westinghouse Owners Group, to the U.S. Nuclear Regulatory Commission Document Control Desk, “Westinghouse Owners Group Response to NRC Request for Additional Information on WOG Generic Technical Report WCAP–14574,” License Renewal Evaluation: Aging Management for Pressurizers“.

7. SECY 95–245 *Completion of the Fatigue Action Plan,* September 25, 1997.

8. NUREG/CR–6260, *Application of NUREG/CR–5999 Interim Fatigue Curves to Selected Nuclear Power Plant Components,* 1995.

9. NUREG/CR–5999, *Interim Fatigue Design Curves for Carbon, Low Alloy and Austenitic Stainless Steels in LWR Environments*, 1993.

10. EPRI TR–105759, *An Environmental Factor Approach to Account for Reactor Water Effects in Light Water Reactor Pressure Vessel and Piping Fatigue Evaluations*, December 1995.

11. Letter dated August 6, 1999, from C.I. Grimes, Director, License Renewal and Environmental Branch, Division of Reactor Program Management, U.S. Nuclear Regulatory Commission, to D.J. Walters, Nuclear Energy Institute (NEI), with enclosed Assessment of NEI Letters.

12. Meeting between the U.S. NRC staff and the Nuclear Energy Institute held on May 17, 1999, in Rockville, Maryland.

13. Letter dated October 9, 1995, from D.A. Christian, Station Manager, Surry Power Station, to the U.S. Nuclear Regulatory Commission Document Control Desk, submittal of Virginia Electric Power Company Licensee Event Report No. 50–280/95–007–00

14. Letter dated February 23, 1996, from D.A. Christian, Station Manager, Surry Power Station, to the U.S. Nuclear Regulatory Commission Document Control Desk, submittal of Virginia Electric Power Company Licensee Event Report 50–280/95–007–01.

15. Letter dated June 29, 1990, from E.J. Mroczka, Senior Vice President, Northeast Utilities, to the U.S. Nuclear Regulatory Commission Document Control Desk, ‘’Haddam Neck Plant, Structural Evaluation of Pressurizer Indications.”

16. Letter dated March 24, 1992, from J.F. Opeka – Executive Vice President, Northeast Utilities, to the U.S. Nuclear Regulatory Commission Document Control Desk, “Haddam Neck Plant, Pressurizer Examination Results.”

17. Letter dated February 12, 1993, from J.F. Opeka – Executive Vice President, Northeast Utilities, to the U.S. Nuclear Regulatory Commission Document Control Desk, “Haddam Neck Plant, Pressurizer Examination Results.”

18. Letter dated August 3, 1990, from Alan Wang, Project Manager, Project Directorate I–4, Division of Reactor Projects I/II, Office of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission, to E.J. Mroczka, Senior Vice President, Northeast Utilities, “Haddam Neck Plant - Evaluation of Cracks and Flaw Indications in the Haddam Neck Pressurizer . . .”

19. Letter dated July 12, 1994, from J.F. Stolz, Director, Project Directorate I–4, Division of Reactor Projects I/II, Office of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission, to J.F. Opeka, Executive Vice President, Northeast Utilities, “Haddam Neck Plant - Pressurizer Examination Results. . .”

20. Memorandum dated December 26, 1999, from Ashok C. Thadani to William D. Travers, Closure of Generic Safety Issue 190, *Fatigue Evaluation of Metal Components for 60-Year Plant life.*