UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RESPONSE TO BULLETIN 88-11

(PRESSURIZER SURGE LINE THERMAL STRATIFICATION)

BABCOCK & WILCOX OWNERS GROUP

1.0 INTRODUCTION

By reports BAW-2127, "Final Submittal for Nuclear Regulatory Commission Bulletin 88-11, 'Pressurizer Surge Line Thermal Stratification,'" and BAW-2127, Supplement 2, "Pressurizer Surge Line Thermal Stratification for the B&W 177-FA Nuclear Plants Summary Report, Fatigue Stress Analysis of the Surge Line Elbows," the Babcock & Wilcox Owners Group (BWOG) demonstrated the integrity of the pressurized surge line (PSL) in view of the occurrence of thermal stratification during 40-year service life as described in NRC Bulletin 88-11. The reports responded generically to the NRC concern for the following six lowered loop plants:

50-313	Arkansas Nuclear One, Unit 1
50-302	Crystal River, Unit 3
50-269/270/287	Oconee, Units 1, 2, and 3
50-289	Three Mile Island, Unit 1

2.0 EVALUATION

NRC Bulletin 88-11 required all licensees for PWR Operating Plants to take the following actions to demonstrate that the integrity of PSLs is maintained for the 40-year design life of these piping systems.

1.a Perform a visual inspection walkdown (ASME Section XI, VT-3) at the first available cold shutdown which exceeds 7 days.

1.b Perform a plant-specific or generic-bounding analysis to demonstrate that the surge line meets applicable design codes and other Final Safety Analysis Report (FSAR) and regulatory commitments for the design life of the plant. The analysis is requested within 4 months for plants in operation over 10 years and within 1 year for plants in operation less than 10 years. If the analysis does not demonstrate compliance with these requirements, submit a justification for continued operation (JCO) and implement actions 1.c and 1.d below.

1.c Obtain data on thermal stratification, thermal striping, and line deflections either by plant-specific monitoring or through collective efforts among plants with a similar surge line design. If through collective efforts, demonstrate similarity in geometry and operation.

1.d Perform detailed stress and fatigue analyses of the surge line to ensure compliance with applicable code requirements incorporating any observations from 1.a. The analysis should be based on the applicable plant-specific or referenced data and should be completed within 2 years. If the detailed analysis is unable to show compliance, submit a Justification for Continued Operation (JCO) and description of corrective actions for effecting long-term resolution.

Although not required by the Bulletin, licensees were encouraged to work collectively to address the technical concerns associated with this issue, as well as to share the PSL data and operational experience. The BWOG implemented a series of programs to address the issue of surge line stratification in B&W plants.

In a July 24, 1991, letter (J. Shea, NRC, to J. Taylor, B&W), the staff provided its safety evaluation of BAW-2127 and concluded that the BWOG methodology used to analyze and evaluate the stress and fatigue effects due to thermal stratification and thermal striping was generally acceptable, with the exception of how secondary and peak stresses in the surge line elbows were calculated. In order to resolve this issue, BWOG reevaluated the surge line elbows using elastic-plastic analysis methods and criteria given in ASME Code, Section III, Subsection NB-3228.4 as documented in B&W report BAW-2127, Supplement 2.

The B&W reevaluation was based on the alternate ASME Code criteria of Section III, Subsection NB-3228.4, "Shakedown Analysis," which allows certain stress limits to be exceeded at a specific location provided a plastic analysis demonstrates that shakedown occurs and that the deformations which occur prior to shakedown do not exceed specified limits. Using an ABAQUS finite element model of the surge line piping which was identical to the original ANSYS model, except for the use of elastic-plastic pipe elbow elements, in conjunction with bounding load histories, the B&W analysis showed all of the stress points corresponding to the stratification peaks to be acceptable. In addition, the shakedown analysis showed that the maximum accumulated local strain that occurred due to the application of the bounding load cycles was 1.07%.

However, NB-3228.4 did not provide relief from the thermal expansion stress limit of $3S_m$ given in NB-3653.6 (Equation 12) and NB-3222.3, and B&W was not able to demonstrate that the limit could be met. Because it appeared that demonstrating shakedown would satisfy the intent of this stress limit, an ASME Code inquiry to confirm this interpretation was submitted. The ASME Code Committee response confirmed that the expansion stress criterion of NB-3222.3 need not be satisfied if shakedown is demonstrated in accordance with NB-3228.4(b).

3.0 CONCLUSION

BNL has reviewed the BWOG reports BAW-2127, "Final Submittal for Nuclear Regulatory Commission Bulletin 88-11, 'Pressurizer Surge Line Thermal Stratification,'" and BAW-2127, Supplement 2, "Pressurizer Surge Line Thermal Stratification for the B&W 177-FA Nuclear Plants Summary Report, Fatigue Stress Analysis of the Surge Line Elbows," as documented in the attached Technical Evaluation Report (TER) A-3869(66). The staff has reviewed the TER and concurs with BNL that the methodology used to analyze the effects of thermal stratification and striping in the PSL is acceptable, and concludes that the B&W analyses adequately demonstrates the structural integrity of the lowered loop plant surge lines for the 40-year design life of the plant, while considering the effects of thermal stratification. Accordingly, we conclude that the results of the BWOG analysis may be used as the basis for BWOG licensees to update their plant-specific Code stress reports to demonstrate compliance with applicable Code requirements as requested in Bulletin 88-11.

However, due to the fact that an elastic-plastic analysis was necessary in performing the PSL evaluation, the staff concurs with BNL's recommendation that enhanced inservice inspections of the surge line be performed to provide additional confidence in structural integrity. The staff recommends that licensees perform volumetric examination of critical elbow components as part of future ASME Section XI inservice examinations. Examinations of elbow bodies, as well as elbow welds, should be performed to ensure that the most highly-stressed areas have not sustained damage.

Principal Contributor: T. Chan

Date: September 16, 1993

Attachment: Technical Evaluation Report