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

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

NORTHERN STATES POWER COMPANY

PRAIRIE ISLAND NUCLEAR GENERATING PLANT UNIT 1

DOCKET NO. 50-282

1.0 INTRODUCTION

On June 17, 1991, Northern States Power (NSP) Company requested to modify the gaps on whip restraints on the pressurizer surge line at Prairie Island Unit 1 (PI-1). The request was based on the leak-before-break (LBB) analysis (Reference 1) of the surge pipe as permitted by General Design Criteria 4 (GDC-4) of Appendix A to 10 CFR Part 50.

This request stems from NSP's response to NRC Bulletin 88-11, "Pressurizer Surge Line Thermal Stratification." Operating experiences in some PWRs have shown that a large temperature differential (as much as 320°F) between the pressurizer and hot leg coupled with a low flow rate of one to five gallons per minute (GPM) in the surge line cause the pipe to expand and to contact the whip restraints. This contact may restrict pipe movement and cause pipe stresses to exceed the allowables of the ASME Code, Section III. Bulletin 88-11 requires licensees to take action to assure the structural integrity of the surge line considering the occurrence of thermal stratification.

To satisfy Bulletin 88-11, NSP has performed thermal stratification analysis for the surge line at PI-1 (Reference 2). The analysis shows that the surge line will satisfy Bulletin 88-11 only if the whip restraints are removed. However, without the whip restraints, the surge line will not comply with GDC-4 unless NSP can show, by analyses, that the probability of piping rupture is extremely low. Therefore, NSP submitted, for NRC approval, the LBB analysis of the surge line to comply with GDC-4. The licensee commits to remove the shims on whip restraints during the 1992 refueling outage to comply with Bulletin 88-11. Only at that time can the licensee take credit for LBB on the surge line.

2.0 DISCUSSION

General Design Criteria 4 allows the use of the LBB analysis to eliminate the dynamic effects of postulated pipe ruptures in high energy piping from the design basis in nuclear power units. The NRC permits licensees with approved LBB analysis to remove pipe whip restraints and jet impingement barriers. The acceptance criteria for the LBB analysis are defined in NUREG-1061 (Reference 3) and draft Standard Review Plan (SRP) 3.6.3, and are summarized, in part, as follows:

The LBB analysis should provide materials data on materials specifications, age-related degradation such as thermal aging, and materials limitations. The piping materials must be free from brittle cleavage-type failure over the full range of the system operating temperature.

The analysis should consider the forces and moments due to pressure, deadweight, thermal expansion, operating basis earthquake, and safe shutdown earthquake (SSE). The analysis should identify location(s) at which the highest stresses are coincident with the poorest material properties for base metals, weldments, and safe ends.

The analysis should postulate a through-wall flaw at the highest stressed locations. The flaw size should be large enough so that any leakage is assured of being detected with at least a margin of 10 using the minimum installed leak detection capability when the pipe is subjected to normal operational loads.

The analysis should show that the postulated leakage flaw is stable under faulted conditions (normal plus SSE loads). The leakage flaw should also be stable under larger loads at least 1.4 times the normal plus SSE loads. However, the margin of 1.4 may be reduced to 1.0 if the individual normal and SSE loads are summed absolutely.

Under normal plus SSE loads, the safety margin should be at least a factor of two between the leakage-size flaw and the critical-size flaw to account for the uncertainties inherent in the analyses and leakage detection capability.

The analysis should provide operating experience to show that the pipe will not experience stress corrosion cracking, fatigue, or water hammer. The operating history should include system operational procedures; system or component modification; water chemistry parameters, limits, and controls; resistance of piping material to various forms of stress corrosion; and performance of the pipe under cyclic loadings.

3.0 EVALUATION

The pressurizer surge line at PI-1 has nominal diameter of 10.75 inches (schedule 140) with a minimum wall thickness of 0.875 inch. The piping material is austenitic wrought stainless steel A-376/TP316 and A-403/WP316. The welds are made of shield metal arc welding.

Northern States Power Company used forces and moments of pressure, deadweight, seismic, and thermal expansion in the flaw stability analysis to assess margins for a postulated pipe rupture at the faulted condition. The highest stress node is located at the weld joint between the pressurizer nozzle and surge line. The next highest stress node is located at the weld joint between the hot leg and surge line.

Northern States Power Company stated that PI-1 has leak detection systems for the reactor coolant pressure boundary that satisfy the guidelines of Regulatory Guide 1.45 such that a leakage of one gallon per minute (GPM) in one hour can be detected. The calculated leak rate through the postulated flaw is large relative to the staff's required sensitivity of the plant's leak detection systems. The licensee used a margin of 10 on leakage in calculating the leakage crack size. This is consistent with the LBB criteria in NUREG-1061.

The licensee provided material properties of the surge lines from the Certified Materials Test Report and ASME Code. The licensee used the ASME Code minimum tensile properties and the lower-bound stress-strain properties in the flaw stability evaluations. For the leakage rate calculations, the average stress-strain properties were used.

The licensee showed that the postulated leakage flaw is stable under normal plus SSE loads. In the stability analysis, the normal loads and faulted loads were summed algebraically and absolutely. The safety margin in terms of applied loads was shown to comply with NUREG-1061.

The licensee showed that the margin between the leakage-size flaw and the critical size flaw exceeds and satisfies the acceptable value of 2 for all the load cases except load case B/G. Load case B/G postulates that the unit is in a forced cooldown resulting from a leak at operating temperatures with a maximum stratification temperature (320°F) during a safe shutdown earthquake. The margin for load case B/G was calculated to be 1.8 using the ASME Code specified materials properties; however, the margin was 2.1 when actual properties based on the Certified Materials Test Reports were used. The staff finds the margin of 2.1 acceptable because it exceeds the allowable. The staff concludes that NSP has satisfied the acceptable margin on crack size.

The licensee provided operating history of thermal transients for different modes of operation, including number of cycles and temperature differentials in the surge line. The licensee used thermal transients to evaluate thermal fatigue in the surge line. The fatigue analysis showed that the fatigue usage factors are within the ASME Code allowable of 1.0 and the fatigue crack growth at end of 40 years is acceptable. There has not been any stress corrosion cracking or water hammer problems reported in the PI-1 surge line.

The staff reviewed NSP's proposed measures that will be implemented to meet Bulletin 88-11 during the 1992 outage. The staff judges that the surge line with the proposed modifications will satisfy Bulletin 88-11 and the LBB technology can be applied to justify the removal of whip restraints.

4.0 CONCLUSION

The NRC staff has performed independent flaw stability calculations to evaluate the licensee's LBB analysis of the pressurizer surge piping at Prairie Island Unit 1. The staff concludes that the licensee's LBB

analysis is consistent with the criteria in NUREG-1061, Volume 3, and, therefore, the analysis complies with GDC-4. Thus, the probability of large pipe breaks occurring in the pressurizer surge line is sufficiently low such that dynamic effects associated with postulated pipe breaks need not be a design basis.

The staff conclusion is conditioned on the licensee's commitment to remove the shims or modify the gaps of the whip restraints to allow the surge line to satisfy NRC Bulletin 88-11. Only at that time can the licensee take credit for leak-before-break on the surge line.

5.0 REFERENCES

1.0 WCAP-12877, "Technical Justification for Eliminating Pressurizer Surge Line Rupture as the Structural Design Basis for Prairie Island Unit 1," Westinghouse Electric Corporation, March 1991 (Proprietary).

2.0 WCAP-12839, "Structural Evaluation of the Prairie Island Unit 1 Pressurizer Surge Line, Considering the Effects of Thermal Stratification," Westinghouse Electric Corporation, March 1991 (Proprietary).

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

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