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

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO REINSPECTION UNREPARIED PIPING WELDS

CAROLINA POWER & LIGHT COMPANY

BRUNSWICK STEAM ELECTRIC PLANT, UNIT 2

DOCKET NO. 50-324

1.0 Introduction

Brunswick Unit 2 was shut down in November 1983 in accordance with the confirming order issued on August 26, 1983 to inspect all ASME Class 1 austenitic stainless steel piping that is susceptible to intergranular stress corrosion cracking (IGSCC) in the Recirculation, Residual Heat Removal (RHR) AND Reactor Water Clean-up (RWCU) systems. The results of the ultrasonic testing (UT) indicated that a total of 19 welds showed reportable linear indications. Of these, eight (8) [five (5) 12" riser welds and three (3) 6" RWCU welds] welds were overlay repaired and 11 welds [eight (8) 28" recirculation welds, two(2) 22" manifold welds and one (1) 20" RHR weld] were not repaired. Brunswick Unit 2 returned to operation in December 1983. After operating for about four months, Brunswick Unit 2 came down in April 1984 for refueling. During this refueling outage, the 11 unrepaired welds were ultrasonically reinspected by the same General Electric inspection team that had inspected the same welds during the confirming order outage, using the same ultrasonic techniques and procedures. The results of the reinspection indicated that there was no significant crack growth in the unrepaired welds. One RHR weld (2-E11-20"-A-2), reported to contain one short defect (16% in depth and 0.95 inch in length) in the 1983 inspection, was reported to be free of defects in the current 1984 reinspection. The largest increase in crack size in the 11 unrepaired welds after four-months operation was 7% in depth and 3.7 inches in length. In some unrepaired welds, the 1984 reported crack sizes were smaller than those reported in 1983. The small variations in the reported UT data between 1983 and 1984, to a large part, can be attributed to the inherent UT data scattering. The worst cracking in the unrepaired welds was reported in weld 2-B32-28"-B-5 with a maximum depth of 20% of wall thickness and a total length of 8.5% of the circumference. NUTECH performed the evaluation of the crack growth in the unrepaired welds for the licensee. The evaluation results indicated that the final crack size at the end of one 18-month fuel cycle in all the unrepaired welds will not exceed 2/3 of the limits allowed in ASME Code Section XI IWB 3640.

Evaluation

We have reviewed the licensee's submittals regarding their ultrasonic inspections and NUTECH's crack growth (IGSCC) calculations to support the continued operation of Brunswick Unit 2, with eight overlay repaired welds and 10 unrepaired defective welds, for an 18-month fuel cycle.

We reviewed the licensee's ultrasonic inspection results and the NUTECH's crack growth calculations. We agree with the licensee's conclusion that the continued operation of Brunswick Unit 2 for one 18-month refuel cycle in its present configuration is justified because the Code required safety design margin in the overlay repaired welds and unrepaired defective welds would be maintained. Our conclusion is based on the following considerations:

1. Short Cracks

   All the unrepaired defective welds and overlay repaired welds have relatively short and shallow cracks ($\leq$ 20% of wall thickness). The longest total crack length in those welds is less than 9% of the circumference. Based on limit load analysis, such short length cracks, even assumed throughwall, will not have a significant effect on the structural integrity of the weld.

2. UT Inspections

Region II of NRC has confirmed that the UT personnel performing the UT examinations for the licensee were qualified in accordance with I&E Bulletin 83-02. The qualification of UT personnel in compliance with I&E Bulletin 83-02 emphasized the demonstration of the capabilities of IGSCC detection and discrimination. Recently, training courses on UT flaw sizing were provided at EPRI NDE Center, Charlotte, North Carolina. UT personnel, to be qualified for UT flaw sizing, must pass the tests of these training courses. When UT was performed in the early stage of this refueling outage, UT personnel qualified for flaw sizing were not available. To ensure that the UT flaw sizing data, especially the crack depth reported in this outage was conservative, additional confirmatory crack depth sizing was performed on two (2) welds (2-B22-28"-B-5 and 2-B32-22"-AM-5) by personnel qualified for UT flaw sizing. The results of the confirmatory UT tests indicated that the reported crack depths on welds 2-B32-22"-AM-5 and 2-B22-28"-B-5 are conservative. We conclude that the UT examinations performed during this outage are satisfactory.

3. Crack Growth

To ensure that excessive crack growth in the unrepaired defective welds will not occur during the next fuel cycle, we performed an independent crack growth calculation. The crack growth in the unrepaired defective welds was bounded by this calculation. The stress intensity factor (K_I) was calculated based on a cylindrical model of a 28-inch diameter pipe, assuming a complete 360° circumferential crack at a depth of 20% throughwall. The crack growth rate curve used in our calculation is more conservative than that used by NUTECH, and is an upper bound of GE and EPRI crack growth data in furnace sensitized material tested in 0.2 ppm O_2 water. Our calculations showed that the initial crack depth of 20% would grow to a depth of about 47% at the end of an 18-month period as the crack is relatively short (9% of the circumference). Even if the reported initial crack depth is doubled to 40% of wall thickness, the final crack size at the end of an 18-month period is calculated to be only about 60% of the wall thickness which is still well within the new Code allowable limit (75% of wall thickness).

The cracks in the overlay repaired welds are not expected to have significant growth especially in length because of the presence of the favorable residual stress distribution as a result of heat sink welding.

4. Safety Margin

Because of the current concerns regarding the conservatism of the ASME Code Section XI IWB 3640 limits, we performed an independent limit load analysis to evaluate the safety margin that will be present in the above calculated final crack size, 60% of wall thickness at the end of an 18-month period. The length of the final crack size, conservatively assumed to follow an aspect ratio of 20, was calculated to be 15.6 inches (17.5% in circumference). In our limit load analysis, we used a reduced flow stress of 45.5 Ksi (corresponding to half of the ASME Code allowed yield stress plus tensile stress for type 316 stainless steel at a temperature of 550°F) and included the thermal stresses from the expansion and overlay shrinkages in the safety margin calculation. Our limit load calculation has shown that there is a safety factor of about 6 on the bending stresses, which includes the primary (dead weight and seismic stresses), as well as the secondary (thermal expansion and shrinkage stresses) stresses. The calculated safety margin substantially exceeds the Code required safety margin of three.

5. Leak Detection

Although the conservative calculations discussed above indicate that the cracks in the unreinforced welds will not progress to the point of leakage during the next 18 month period, and very wide margins are expected to be maintained over crack growth to the extent of compromising safety, uncertainties in crack sizing and growth rate remain. Because of these uncertainties, it is prudent to tighten the requirements for the monitoring of unidentified leakage. The licensee has agreed to implement additional monitoring to more restrictive limits on the unidentified leakage as delineated in Attachment 1 to the Generic Letter 84-11. This will provide adequate assurance that possible cracks in pipes will be detected before growing to a size that could compromise the safety of the plant.

The piping in Brunswick Unit 2 was not reinspected in accordance with Generic Letter 84-11 during the current refueling outage, because all Class 1 IGSCC susceptible piping welds were inspected only about four (4) months ago. The reinspection to Generic Letter 84-11 will be performed by the licensee during the next refueling outage. We consider that the licensee's schedule is acceptable, because it meets the intent of Generic Letter 84-11, which requires the reinspection to be performed within about two (2) years and the schedule adjusted to coincide with the next scheduled outage.

Conclusion

We conclude that the Brunswick Unit 2 can be safely returned to operation in its present configuration at least for one 18-month fuel cycle.