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

ENCLOSURE 1

SAFETY EVALUATION OF
GEORGIA POWER COMPANY'S
FRACTURE MECHANICS ANALYSIS

EDWIN I. HATCH NUCLEAR PLANT, UNIT 1

Introduction

In a letter from J. T. Beckham, Jr. to J.F. Stolz dated September 19, 1984 the Georgia Power Company (the licensee) submitted for staff review a fracture mechanics analysis. The licensee indicates that the analysis demonstrates that the low flow feedwater controller is in compliance with NUREG-0619 as amended by NRC Generic Letter 81-11 and is acceptable for continued use. The analysis predicts for the forty year life of the Edwin I. Hatch Nuclear Plant, Unit 1 (EIHNP-1), the amount of fatigue growth that would occur for postulated cracks in the plant's reactor vessel feedwater nozzles. The analysis was performed by General Electric (GE) and is contained in GE Report NEDE-30238, "Edwin I. Hatch Nuclear Power Station, Unit 1, Feedwater Nozzle Fracture Mechanics Analysis to Show Compliance with NUREG-0619."

In the period 1974 thru 1980 inspection of the feedwater nozzle/sparger systems disclosed some degree of cracking in the bore and inner radius of reactor vessel feedwater nozzles in 18 of the 23 commercially operated boiling water reactor (BWR) plants in the United States. The staff reviewed this issue as part of Generic Technical Activity A-10. The staff's review and recommendations are contained in NUREG-0619, "BWR Feedwater Nozzle and Control Rod Drive Return Line Nozzle Cracking," November 1980.

In NUREG-0619 the staff concluded that crack initiation in feedwater nozzles was caused by high-cycle thermal fatigue. From analyses and experience in repairing feedwater nozzles, it is known that high-cycle thermal fatigue cracks propagate to a depth of about 0.25 inch before the cyclic thermal stress amplitude attenuates to an insignificant level. Analyses also indicate that stainless steel cladding contributes to high-cycle thermal fatigue crack initiation.

The staff concluded that propagation of the small (high-cycle thermal fatigue) cracks could result from low frequency but high amplitude stresses, which are caused by the intermittent flow of cold feedwater into the vessel during startup and shutdown and during hot standby conditions when feed -water is added to maintain reactor water level. The frequency and magnitude of the stresses depend to a large degree on whether such additions are modu-lated smoothly or are made by an on-off flow control system.

The staff's position in NUREG-0619 was that improvements should include nozzle clad removal, installation of improved-design spargers and system changes. The system changes include a low-flow controller having the six characteristics described in Section 3.4.4.3 of GE Report NEDE-21821-A, "Boiling Water Reactor Feedwater Nozzle/Sparger Final Report" and rerouting of the reactor water clean-up system (RWCS) to all feedwater nozzles. As a result of comments received from GE and others, the staff in Generic Letter 81-11 dated February 20, 1981 clarified its position relative to installation of low-flow controllers. The staff indicates in this letter that continued use of existing controllers is acceptable, provided a plant-specific fracture mechanics analysis or application of the analysis already existing in Section 4 of NEDE-21821-A do not result in the growth of a crack to greater than one inch during the forty year life of the plant.

The licensee has removed the nozzle clad, installed improved-design spargers, rerouted the RWCS to all feedwater nozzles in the reactor vessel at EIHNP-1 and provided the staff with a fracture mechanics analysis (NEDE-30238), which the licensee indicates will permit them to utilize the existing low flow feed-water controller during the forty year life of the unit. The staff reviewed the fracture mechanics analysis contained in NEDE-30238 and evaluated the licensee's conclusions regarding the use of the existing low flow feedwater controller.

Discussion

According to NUREG-0619 the amount of crack growth in a feedwater nozzle is dependent upon the amount of crack growth resulting from high cycle thermal stresses and low frequency high amplitude stresses during startup, shutdown and hot standby conditions.

The GE fracture mechanics fatigue analysis in NEDE-30238 assumes the existence of a .25 inch deep flaw at both the feedwater nozzle bore and inner radius. Since stresses from high-cycle thermal fatigue attenuate to an insignificant level at 0.25 inches, a .25 inch deep flaw would conservatively estimate the amount of crack growth from high-cycle thermal fatigue stresses.

The amount of crack growth from low cycle stresses was evaluated for a 35.5 year period. This is the period of the time remaining for the plant's license (40 years) after removal of the clad and existing cracks, which were completed on the EIHNP-1 feedwater nozzles in 1979. To project the cyclic and thermal transient conditions for the remainder of the plant's life, the licensee recorded the number of thermal cycles, feedwater flow and temperature for startups, shutdowns and scrams to the hot standby condition during the period from 1979 thru 1982 (4 years). The total number of events and cycles were extrapolated to a period of 35.5 years.

Finite element computer codes were used to develop thermal and pressure stresses acting on the feedwater nozzle during startup, shutdown and scram conditions. Heat transfer coefficients were taken from GE Report NEDE-21821-A. In Section 4 of NEDE 21821-A, GE performed a finite element analysis with nozzle and sparger similar to that in EIHNP-1. The peak thermal and pressure stresses resulting from the finite element analysis in Section 4 of NEDE-21821-A and in NEDE-30238 are in relative agreement.

The thermal and pressure stresses were converted to stress intensity factors using the methods reported in Section 4 of NEDE-21821-A. The stress intensity factors were then used to predict the amount of crack growth. The amount of crack growth per cycle was calculated using the fatigue crack growth data for low alloy steels from Section XI of the ASME Code and "best fit" curves developed by GE in Section 4 of NEDE-21821-A.

Based upon the amount of events, cycles and thermal conditions projected to occur in the remaining life (35.5 years) of EIHNP-1, and using Section XI of the ASME Code and "best fit" crack growth relationships, the amount of fatigue crack growth in the feedwater nozzles at the end of the plant's life were predicted to be less than one inch.

Evaluation of NEDE-30238

The fracture mechanics analysis in NEDE-30238 is capable of predicting the amount of crack propagation resulting from fatigue in the EIHNP-1 reactor vessel feedwater nozzles because:

(a) the initial crack size from high cycle fatigue was conservatively predicted;

(b) the methods of predicting crack growth resulting from high amplitude low cycle fatigue is similar to the method in Section 4 of NEDE-21821-A;

(c) the finite element calculations in NEDE-30238 and Section 4 of NEDE-21821-A, are in relative agreement; and

(d) the methods and calculations in Section 4 of NEDE-21821-A have been previously reviewed by the staff and are considered acceptable.

Conclusion

Based on the amplitude and number of thermal transients (startup, shutdown and scram) events predicted to occur in the remaining life of EIHNP-1, the amount of crack growth in the reactor vessel feedwater nozzles should not be greater than one inch. Hence, the existing low flow controller is in compliance with the requirements of NUREG-0619 as amended by Generic Letter 81-11 and is acceptable for continued use in EIHNP-1.

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