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SUBJECT: Forwards addl info re B&W linear elastic fracture mechanics analysis, evaluating vessel shell-to-flange weld indications.

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June 24, 1986

Mr. Harold R. Denton, Director
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Attention: Mr. John F. Stolz, Project Director
PWR Project Directorate No. 6

Re: Oconee Nuclear Station
Docket Nos. 50-269, -270, -287

Dear Sir:

Recently members of the NRC Staff along with a consultant had contacted Babcock & Wilcox (B&W) with several questions relative to the Linear Elastic Fracture Mechanics Analysis that was performed by B&W to evaluate the Oconee-1 Reactor Vessel Shell-to-Flange weld indications. In response, please find attached Duke's response to the additional questions raised by your Staff.

Very truly yours,

Hal B. Tucker

Hal B. Tucker

PFG:slb

Attachment

xc: Mrs. Helen Pastis
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Duke Power Company
Oconee Nuclear Station, Unit 1
Inservice Inspection of
Reactor Vessel Shell-to-Flange Weld
Request for Additional Information

Request 1:

What is the effect of system transients in addition to the Heatup/Cooldown (HU/CD) and Inservice Leak and Hydrostatic Test (ISLHT) transients considered in the B&W analysis. Specifically, whether some large cyclic transients, although not necessarily of high stress, could be significant to flaw evaluation.

Response 1:

The flaw evaluations performed were in accordance with B&W's original stress report, which considered only the two transients (HU/CD and ISLHT) as significant in the flaw growth calculations. Review of the original stress report showed that other transients induce stresses less than the endurance limit stress, and thus do not affect the fatigue usage factor.

In order to address the question raised more specifically, the functional specification was reviewed with respect to transients with large numbers of cycles. Four transients fall into this category: 1) Power Loading/Unloading, 2) 10 percent Step Load Increase/Decrease, 3) Feed and Bleed, and 4) Miscellaneous. The temperature variation on the RV due to these transients is 20, 5, 0, and 0 degrees Fahrenheit respectively.

The effect of the most significant of these four transients, the Power Loading/Unloading transient, was evaluated. A thermal stress ($1.43E\alpha\Delta T$) of 5.7 ksi was assumed to vary linearly from the ID to the OD. This is a very conservative assumption since this stress is actually a surface stress which rapidly decays and probably has a zero value at the tips of the subsurface flaw. The transient membrane and bending stresses and cycles were input as a third transient into the FLEP (Section XI, Appendix A) flaw evaluation program. (This evaluation also includes a correction to the eccentricity as a result of recalculating the edge distance(s).)

The results of this calculation are attached for the worst case indication (ER 86-019 Indication No. 18/19 combined). A comparison of these results with and without the effect of the Power Loading/Unloading transient included, shows this transient to have an insignificant effect on the flaw evaluation.

Request 2:

Verify the e value for indications No. 18 and 19 combined.

Response 2:

The correct value is 1.85".

Request 3:

Indications No. 3 and 4 should be combined.

Response 3:

These indications were combined for evaluation as shown in the transmittal of meeting presentation material following the last Duke/B&W/NRC meeting.

Request 4:

Verify the combined length of indication No. 3 and 4. Should this be 7.61"?

Response 4:

The length dimension of indications No. 3 and 4 combined remains as reported in the last transmittal (7.4"). Since No. 3 and No. 4 were measured from separate reference points, the length of the combined indication is determined by layout on a scaled drawing.

Request 5:

Verify the S and e dimensions for indications No. 3 and 4 combined.

Response 5:

S = 3.1"   e = 1.85"

ER 86-019 Indication No. 18/19 Combined

FLAW TYPE : SUBSURFACE

INITIAL FLAW DEPTH, (A) = 1.15000 IN

INITIAL FLAW LENGTH = 4.40000 IN

WALL THICKNESS = 12.00000 IN

ECCENTRICITY OF SUBSURFACE FLAW = 1.85000 IN

CRACK TIP TEMPERATURE = 275.0 F

REFERENCE NIL DUCTILITY TEMPERATURE = 20.0 F

YIELD STRENGTH = 50.00 KSI

SCALING CONSTANT USED IN PARIS EQUATION = 0.267E-10

EXPONENT USED IN PARIS EQUATION = 3.726

MEMBRANE STRESS = 13.65 KSI

BENDING STRESS = 11.35 KSI

FATIGUE CRACK GROWTH : POINT 1 LOCATION IS CRITICAL

TRANSIENT NO.	STRESS RANGES (KSI) MEMBRANE	BENDING	NO. OF CYCLES	FLAW DEPTH (IN) INITIAL	FINAL
1	13.65	11.35	240.0	1.1500	1.1520
2	7.65	18.65	100.0	1.1520	1.1524
3	2.86	2.86	18000.0	1.1524	1.1530

FLAW SHAPE PARAMETER Q = 1.449

MEMBRANE STRESS CORRECTION FACTOR MM = 1.032

BENDING STRESS CORRECTION FACTOR MB = 0.421

STRESS INTENSITY FACTOR USING FINAL FLAW SIZE, KI = 29.83 KSI ROOT INCH

CRACK ARREST STRESS INTENSITY FACTOR, KIA = 200.00 KSI ROOT INCH

RATIO, KIA/KI = 6.70

ACCEPTANCE CRITERIA : KIA/KI MUST BE GREATER THAN 3.16

THIS FLAW IS ACCEPTABLE PER SECTION XI OF THE ASME BOILER AND PRESSURE VESSEL CODE (1977 EDITON THROUGH SUMMER 1978 ADDENDA), PROVIDED THE PRIMARY STRESS LIMITS OF NB-3000 ARE SATISFIED FOR THE FLAWED SECTION