

## ATTACHMENT 1

GE REPORT GE-NE-523-24-0293

Fracture Mechanics Evaluation of the Indication  
in Weld NG-D-18 in the Recirculation System  
in the Oyster Creek Nuclear Plant

GE-NE-523-24-0293  
DRF 137-0010-6  
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FRACTURE MECHANICS EVALUATION OF THE INDICATION  
IN WELD NG-D-18 IN THE RECIRCULATION SYSTEM  
IN THE OYSTER CREEK NUCLEAR PLANT

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Date: 2/19/93

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### OBJECTIVE

Weld NG-D-18 in the recirculation system has been subjected to the Induction Heat Stress Improvement (IHSI) process. During the refueling outage 13R, the weld was examined ultrasonically. Two circumferential indications (one with an axial component) and one axial indication were discovered during this inspection. A subsequent UT examination during the December 1992 outage (14R) showed that these indications remained essentially unchanged confirming the absence of crack growth. However, a new circumferential indication (0.22 in. depth and 0.2 in. length) was found during this inspection. At the request of the NRC the new indication was evaluated without taking credit for IHSI (i.e., using as welded residual stresses). The purpose of this report is to document the fracture mechanics analysis of the indication to evaluate acceptability for continued operation for the next 18 months using the criteria of IWB-3600, Section XI, ASME Code 1992 edition.

### METHODOLOGY AND ASSUMPTIONS

The evaluation is performed using the criteria of IWB-3600 and Appendix C of Section XI, ASME Code [1]. The crack growth analysis is performed using the crack growth relationship recommended in NUREG 0313 [2]:  $da/dt = 3.59 \times 10^{-8} K_I^{2.161}$  where  $da/dt$  is in inches/hour and  $K_I$  is the sustained stress intensity factor in ksi/in. The NRC crack growth rate curve for weld sensitized material was used, but for  $K$  levels below 8 ksi/in a constant growth rate of  $3.2 \times 10^{-6}$  in/hour was conservatively used. Residual stresses were consistent with the data in NUREG-0313 for large diameter piping.

The analysis was performed using the stress intensity formulation of Raju & Newman [3] since the indication was relatively short and could be characterized as a semicircular surface indication. Crack growth analysis was performed using steps of 100 hours with the  $K$  values updated at each step. Flaw acceptance evaluation was performed using the methodology of Appendix C for flux welds with the appropriate  $Z$  factors for shielded metal arc weldment.

### INPUTS

Weld NG-D-18 is a pipe to pipe weldment with outside diameter of 36 inches and minimum thickness of 0.982 in. The UT measured thickness is higher, but for the present analysis, the minimum thickness value is conservatively used. Other stresses are as follows [4]:

Axial Pressure Stress ( $P_m$ )	=	7.95 ksi
Dead Weight	=	0.525 ksi
Thermal	=	0.288 ksi
Seismic	=	1.256 ksi

The seismic stress is assumed to be OBE stress. Also, because of the small seismic stress compared to other stresses e.g., pressure and dead weight combined, the Level B condition is limiting. The weldment is made of shielded metal arc weld material.

## RESULTS

Because of the small crack length and the resulting use of semicircular flaw geometry, the applied stress intensity factor is small and the resulting crack growth was small. Starting with an initial flaw of 0.22 in. depth, the final depth at the end of 12,000 hours (or one fuel cycle) at temperature was predicted to be 0.258 in. The allowable flaw size i.e., combination of flaw depth and length, per Appendix C and IWB-3600 is shown in the flaw evaluation diagram (Figure 1). The initial flaw size and the predicted final size after 12,000 hours is also shown in the Figure. It is seen that the final flaw size is well within the allowable size per IWB-3600 for SMAW material.

An additional analysis performed assuming a bounding 360° crack in the crack growth analysis also showed that the flaw indication is acceptable after 12,000 hours of operation.

## CONCLUSIONS

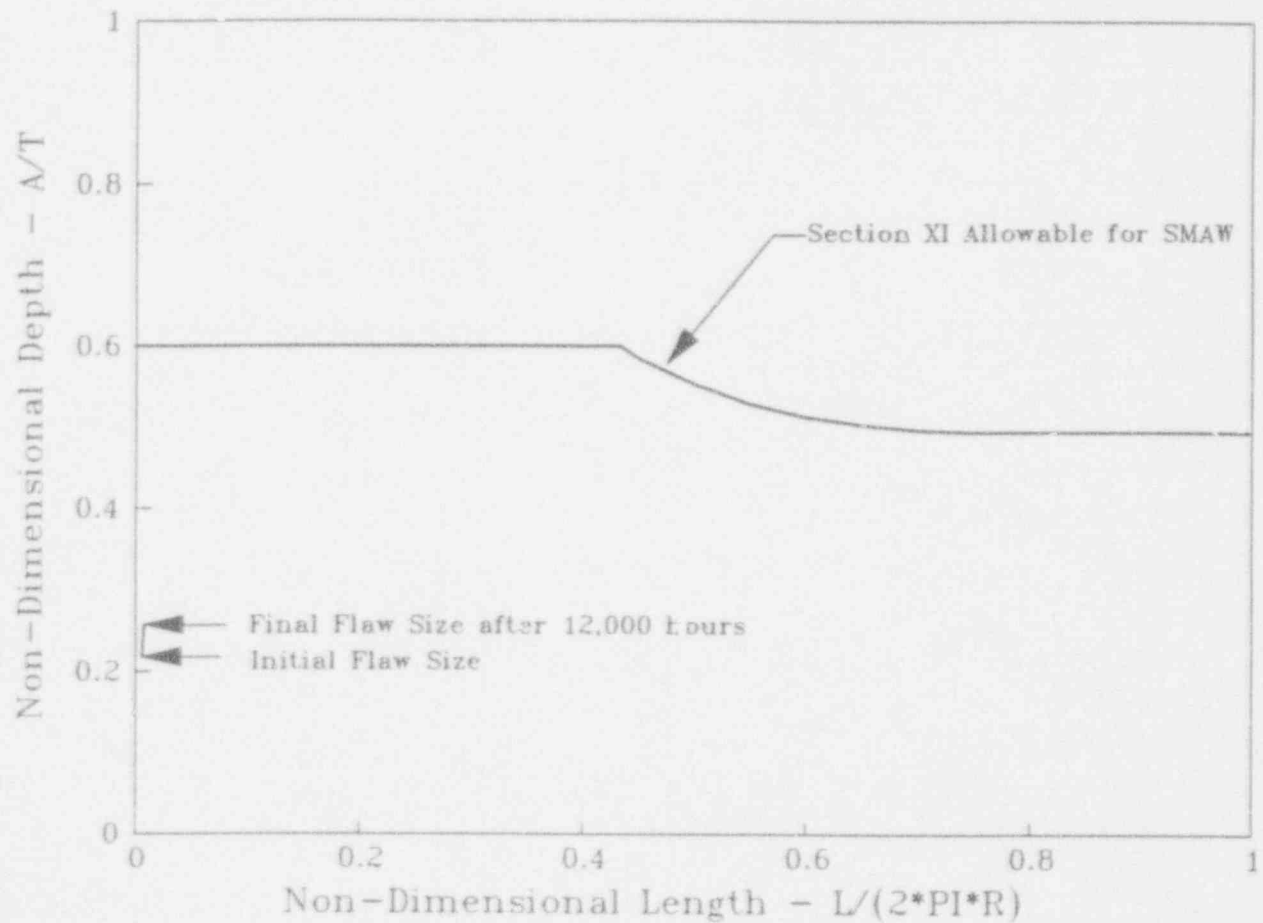
The fracture mechanics analysis performed for the flaw indication in weld NG-D-18 shows that continued operation without repair can be justified for over 12,000 hours and that the criteria of IWB-3600 and Appendix C of Section XI, ASME are fully satisfied.

## REFERENCES

- 1) ASME Boiler and Pressure Vessel Code - Section XI, Appendix C, "Evaluation of Flaws in Austenitic Piping," The American Society of Mechanical Engineers, N.Y., N.Y., 1989.
- 2) W.S. Hazelton and W.H. Koo, "Technical Report on Material Selection and Processing Guidelines for BWR Coolant Pressure Boundary Piping," U.S. Nuclear Regulatory Commission, Washington, Washington, DC, January 1988, (NUREG-0313, Rev. 2).
- 3) I.S. Raju and J.C. Newman, Jr., "Stress Intensity Factor Influence Coefficients for Internal and External Surface Cracks in Cylinders in "Aspects of Fracture Mechanics in Pressure Vessels and Piping"," ASME PVP Publication, Vol. 58, 1982.
- 4) Letter from S. Leshnoff (GPUN) to S. Ranganath (GENE) Dated 02.02/93 on "ASME Section XI IWB-3640 Analysis of NG-D-18 Indications," followed by Letter Dated 02/04/93 on the Same Subject.

FIGURE 1

# Flaw Evaluation Diagram for Weld NG-D-18 Using Raju-Newman K Calculation



ATTACHMENT 2

GE EXAMINATION SUMMARY SHEET

Report No. R-005  
Weld NG-D-18 in the Recirculation System



GE Nuclear Energy

## EXAMINATION SUMMARY SHEET

REPORT NO.:

R-005

PROJECT: OYSTER CREEK UNIT 1  
GPIS1

PROCEDURE: GE-UT-208

REV: 1

FRR: OC14R-02

REV.1

N/A

SYSTEM: RECIRCULATION

MINOR #

92-0164

GE-UT-104

REV: 1

FRR: OC14R-07

N/A

N/A

WELD NO.: NG-D-18

CONFIGURATION: PIPE TO PIPE

PG 3

OF

N/A

REV: N/A

FRR: N/A

N/A

N/A

EXAMINER: D. WALTER/KIEFFER LEVEL: II/II

NDE METHOD:

☐ MT☐ PT☒ UT☐ VY

EXAMINER: BOB BONNIWELL LEVEL: III

☒ CIRCUMFERENTIAL

EXAMINER: PAUL JOHNSON LEVEL: II

WELD TYPE:

☐ LONGITUDINAL☐ OTHER N/A

DATA SHEET NO.(S): D-011, D-012, D-013

N/A

N/A

CAL SHEET NO.(S): C-010, C-011

N/A

N/A

DURING THE ULTRASONIC EXAMINATION OF THE ABOVE REFERENCED WELD, THREE (3) INDICATIONS ASSOCIATED WITH IQSQC AND ONE (1) AXIAL COMPONENT WERE RECORDED BY THE SMART 2000 SYSTEM UTILIZING 45° SHEAR AND 60° REFRACTED LONGITUDINAL WAVE SEARCH UNITS. THE INDICATIONS HAVE THE FOLLOWING PARAMETERS:

IND #	DIST. FROM "L" REF.	TOTAL LENGTH	THRU-WALL DIMENSION	REMAINING LIGAMENT	SIDE OF WELD	TYPE OF REFLECTOR	SEARCH UNIT(S)	THRU-WALL %
1	83.6"	3.0"	.18"	.96"	UPST	CIRC/PLANAR	45°S/60°RL	16%
2	77.8"	.5"	.16"	.96"	UPST	CIRC/PLANAR	45°S/60°RL	14%
3	56.1"	.25"	N/A	N/A	UPST	AXIAL COMP. OF IND. #1	45°S	"
4	AXIAL INDICATION REPORTED IN 1991 @ 70" COULD NOT BE CONFIRMED DURING THIS EXAMINATION							
* 5	48.4"	.3"	.22"	.90"	UPST	CIRC/PLANAR	45°S/60°RL	18%

\* NEW INDICATION - PREVIOUSLY DISPOSITIONED AS ROOT GEOMETRY IN 1991.

\*\* THRU-WALL DIMENSION COULD NOT BE DETERMINED AND IS CONSIDERED TO BE LESS THAN .10".

SUBSEQUENT RELOOKS AND FLAW SIZING PERFORMED MANUALLY. SIZING WAS PERFORMED USING THE TIP DIFFRACTION METHOD (AATT). MANUAL INDICATION CHARACTERIZATION AND LOCATION CONFIRMED SMART 2000 DATA RESULTS.

REALIZING THAT "L" DIMENSIONS OF THE RECORDED INDICATIONS HAVE SHIFTED COUNTERCLOCKWISE, AS COMPARED TO PREVIOUS 1991 DATA, IT HAS BEEN DETERMINED THAT INDICATIONS #1, 2, & 3 ARE THE SAME INDICATIONS PREVIOUSLY REPORTED IN 1991, AND DISPLAY NO INCREASE IN LENGTH OR THRU-WALL DIMENSION. BASED UPON THE CLOSE PROXIMITY OF THE RECORDED INDICATIONS, PREVIOUS DATA, AND CORRELATION OF THE UNCRACKED WELD LENGTHS, IT IS CONCLUDED THAT SEARCH UNIT ZERO POSITIONS OF 1991 AND 1992 EXAMINATIONS HAVE BEEN PLACED AT DIFFERENT LOCATIONS NEAR THE "V" STAMP WHICH IS USED AS A REFERENCE POINT FOR ZERO POSITION. INCONSISTANT ALIGNMENT OF THE SEARCH UNIT OVER THE REFERENCE MARK, LIMITED ACCESS TO DIRECTLY VIEW THE REFERENCE MARK AND SEARCH UNIT WHILE ALIGNING ZERO POSITION, OR INADVERTANT PLACEMENT ON NEARBY REFERENCE MARKS IN THE SAME LOCATION ARE PROBABLE CAUSES.

INDICATION #4, AFTER MANUAL RELOOKS, COULD NOT BE CONFIRMED DURING THIS EXAMINATION. INDICATION #5 WAS NOT PREVIOUSLY RECORDED AS IQSQC, HOWEVER IT WAS SUSPECT AND DISPOSITIONED AS ROOT GEOMETRY IN 1991 DATA.

IN ADDITION TO THE RECORDED REPORTABLE INDICATIONS, THE FOLLOWING NON-RELEVANT AND GEOMETRIC INDICATIONS WERE RECORDED: THE 45° SHEAR WAVE RECORDED REDIRECTED SHEAR, ROOT AND COUNTERBORE GEOMETRY, AND NON-RELEVANT INDICATIONS. THE 60° RL RECORDED SHEAR COMPONENT, ACOUSTIC INTERFACE, AND NON-RELEVANT INDICATIONS.

INDICATIONS DETERMINED FROM LOCATION, SIGNAL CHARACTERISTICS, MOD PROFILING, RADIOGRAPHS, AND PREVIOUS DATA. TWO DIRECTIONAL COVERAGE WAS OBTAINED FROM BOTH SIDES OF THE WELD. CATEGORY B-J, ITEM B4.5, ASME SECTION XI, 1986 EDITION, NO ADDENDA. EXAM # 02724

☒ EXAM COMPLETE☐ PARTIALLY EXAMINED (EXPLAIN IN COMMENTS)☐ EXAM COMPLETE IN COMBINATION WITH DATA SHEETS BELOW

ADDITIONAL DATA SHEETS: N/A

COMPARED TO: ☐ PSI ☒ SI REPORT NO.(S): R-291 (1991) ☐ NO CHANGE

NO. OF RECORDABLE INDICATIONS: 7

RWP NO.: 92-1335

EXAMINATION RESULTS: ☐ ACCEPTABLE☒ UNACCEPTABLE

NO. OF REPORTABLE INDICATIONS: 4

TOTAL DOSE

723 MAN REM

DATA ANALYSIS BY

LEVEL

12-17-92  
DATE

REVIEWED BY

LEVEL

12-17-92  
DATE

REVIEWED BY

TITLE

DATE

PAGE: 1 OF 27

FORM UT-00 REV 1