Docket File

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

June 27, 1990

Docket No. 50-410

LICENSEE: Niagara Mohawk Power Corporation

FACILITY: Nine Mile Point Nuclear Station, Unit 2

SUBJECT: MEETING MINUTES REGARDING THE JUNE 19, 1991, MEETING TO DISCUSS THE UPCOMING MID-CYCLE INSPECTION AND POSSIBLE REPAIR OF THE HPCS NOZZLE AT NINE MILE POINT 2.

A meeting was held in the NRC One White Flint North Office in Rockville, Maryland, with Niagara Mohawk Power Corporation (NMPC) and NRC staff representatives to discuss the planned inspections, fracture mechanics analysis, and possible repairs of the HPCS nozzle at Nine Mile Point 2 during the upcoming mid-cycle inspection. Enclosure 1 is a list of the meeting attendees. The handout material used by the licensee during the meeting is attached as Enclosure 2.

By letter dated December 28, 1990, NMPC submitted for NRC staff review and approval a fracture mechanics evaluation of a flaw that had been detected in the weld (KC-32) joining the HPCS nozzle safe end to the safe end extension. The flaw had been detected by a scheduled ultrasonic inservice inspection during the plant's first refueling outage. After subjecting the weld to a Mechanical Stress Improvement Process, the licensee determined the flaw to be 41% of wall thickness and to extend 11.3% of the wall circumference. The NRC staff reviewed the licensee's submittal and requested the licensee commit to performing a mid-cycle inspection of the subject weld. By letter dated January 7, 1991, the licensee committed to perform the requested mid-cycle inspection between the beginning of the fifth and end of the tenth month of the second refueling cycle. The NRC staff's safety evaluation of the licensee's analysis concluded that the Nine Mile Point 2 reactor pressure vessel was acceptable for service without excavation and weld repair of the flaw in weld KC-32 provided the flaw would be ultrasonically reexamined during the committed mid-cycle inspection. The NRC staff's safety evaluation also recommended that the licensee submit for staff review and approval, a revised fracture mechanics analysis performed in accordance with recommendations contained in the safety evaluation. A further recommendation was to consider using radiographic examination techniques for examination of weld KC-32 during the mid-cycle inspection.

The licensee requested this meeting to update the NRC staff on the status of the revised analysis and to inform the staff that attempts to perform radiographic examination of weld KC-32 did not produce radiographs of acceptable quality and therefore this technique will not be used during the

mid-cycle inspection. During the meeting, the licensee committed to submit a revised fracture mechanics analysis by June 28, 1991. The NRC staff agreed to promptly review this revised analysis as well as the proposed repair plan submitted on June 10, 1991. It was agreed that if any significant growth (to be defined by NMPC and agreed to by the NRC staff) of this flaw is detected during the mid-cycle inspection, further evaluation will be required as well as a probable repair. However, if the NRC staff determines the revised analysis to be submitted on June 28, 1991, is acceptable and there is no significant growth of the flaw, the plant may resume and continue operation without repairing the weld (KC-32) until the next refueling outage when the weld will be reinspected.

Donald S. Brinkman

Donald S. Brinkman, Senior Project Manager
Project Directorate I-1
Division of Reactor Projects - I/II
Office of Nuclear Reactor Regulation

Enclosures:
1. List of Attendees
2. Licensee Handout Material

cc w/enclosures:
See next page

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Niagara Mohawk Power Corporation

Nine Mile Point Nuclear Station
Unit 2

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ENCLOSURE 1

ATTENDANCE LIST

June 19, 1991 Meeting With Niagara Mohawk Power Corporation to Discuss Upcoming Mid-cycle Inspection and Possible Repair of HPCS Nozzle at Nine Mile Point 2

Name	Position	Organization
Donald S. Brinkman	Senior Project Manager	NRC/NRR/PDI-1
Robert A. Capra	Project Director	NRC/NRR/PDI-1
C. Y. Cheng	Chief, Mat and Chem Eng. Br.	NRR/DET/EMCB
W. David Baker	Licensing-Program Director	Niagara Mohawk
John Tsao	Materials Engineer	NRR/DET/EMCB
Richard B. Abbott	NMPC Mgr. Unit 2 Eng.	NMPC
W. A. Koo	Materials Engineer	NRR/DET/EMCB
Tom Fay	NMPC - Licensing	NMPC
M. Banic	Materials Engineer	NRR/DET/EMCB
John Swenszkowski	NMPC - QA/NDE Group Lead	NMPC
Christopher A. Boen	Materials Co-op	NRC/Rgn I
H. Kaplan	Reactor Inspector	NRC/Rgn I
Robert Hermann	Chief, Met Sect	NRC/NRR/DET
W. S. Fingrutd	GE - Sr. Welding Spec.	GE
Sam Ranganath	Manager, Mat, Mon & Stru Anal	GE-NE
Carl Terry	VP - Nuclear Engineering	NMPC
Martin J. McCormick, Jr.	Plant Manager NMP2	NMPC
Shashi Dhar	Mech Engineer NMP2	NMPC
Robert Deuvall	Supervisor Mech Eng NMP2	NMPC
Daniele Oudinot	Project Engineer	NRC/NRR/PDI-1

ENCLOSURE 2

NIAGARA MOHAWK POWER CORPORATION

HPCS CORE SPRAY NOZZLE MEETING AGENDA

JUNE 19, 1991

		SPEAKERS
I.	INTRODUCTION/PURPOSE	R. ABBOTT
II.	BACKGROUND INFORMATION	S. DHAR
III.	FRACTURE MECHANICS ANALYSIS	M. BADLANI (SMC O'DONNELL, INC.)
IV.	UNCERTAINTY IN FLAW SIZING UTILIZING UT TECHNIQUES	J. SWENSZKOWSKI
V.	UTILIZATION OF RT TECHNIQUE FOR EXAMINATION PURPOSES	J. SWENSZKOWSKI
VI.	CONTINGENCY REPAIR PLAN	S. RANGANATH (GENERAL ELECTRIC)
VII.	SUMMARY	R. ABBOTT

BACKGROUND INFORMATION OF HPCS NOZZLE KC-32 FLAW

(A) IN-SERVICE INSPECTION OF HIGH PRESSURE CORE SPRAY NOZZLE SAFE END TO SAFE END EXTENSION WELD KC-32 PERFORMED IN OCTOBER 1990 REVEALED A FLAW THAT EXCEEDED THE ASME CODE ACCEPTANCE STANDARDS.

(B) SINCE THE FLAW HAD PROPAGATED TO ALLOY 182, WHICH IS SUSCEPTIBLE TO IGSCC, NMPC ELECTED TO UTILIZE MECHANICAL STRESS IMPROVEMENT (MSIP) AS A MEANS OF MITIGATING CRACK GROWTH DUE TO IGSCC BY IMPROVING THE RESIDUAL STRESS DISTRIBUTION AROUND THE TIP OF THE FLAW.

(C) POST MSIP, THE WELD WAS RE-INSPECTED. THE RE-INSPECTION INDICATED THAT THE FLAW DEPTH WAS 0.35 INCHES (41% OF WALL THICKNESS) AND 3.4 INCHES (11.3% OF CIRCUMFERENCE) IN LENGTH.

(D) NMPC PERFORMED A FRACTURE MECHANICS ANALYSIS TO SUPPLEMENT MSIP. THE FRACTURE MECHANICS ANALYSIS DISREGARDED BENEFIT OF MSIP. THE THROUGH WALL RESIDUAL WELD STRESS DISTRIBUTION REPORTED IN NUREG-0313, REVISION 2, WAS UTILIZED WHICH SHOWED THE FLAW TO GROW FROM A DEPTH OF 41% TO A DEPTH OF 59% IN ONE FUEL CYCLE OF OPERATION (12,000 HOURS).

(E) NRC SAFETY EVALUATION OF FRACTURE MECHANICS ANALYSIS FOR KC-32 REQUIRED NMPC TO:

- PERFORM A MID-CYCLE INSPECTION OF NOZZLE WELD KC-32 (BETWEEN THE 5TH AND 10TH MONTH OF THIS CYCLE).

- RESUBMIT FRACTURE MECHANICS ANALYSIS BASED ON MID-CYCLE INSPECTION WHICH WOULD:

  (i) ASSESS WELD RESIDUAL STRESSES IN 10" DIAMETER PIPE.

  (ii) ADDRESS UNCERTAINTY IN FLAW SIZING RESULTING FROM ULTRASONIC EXAMINATION.

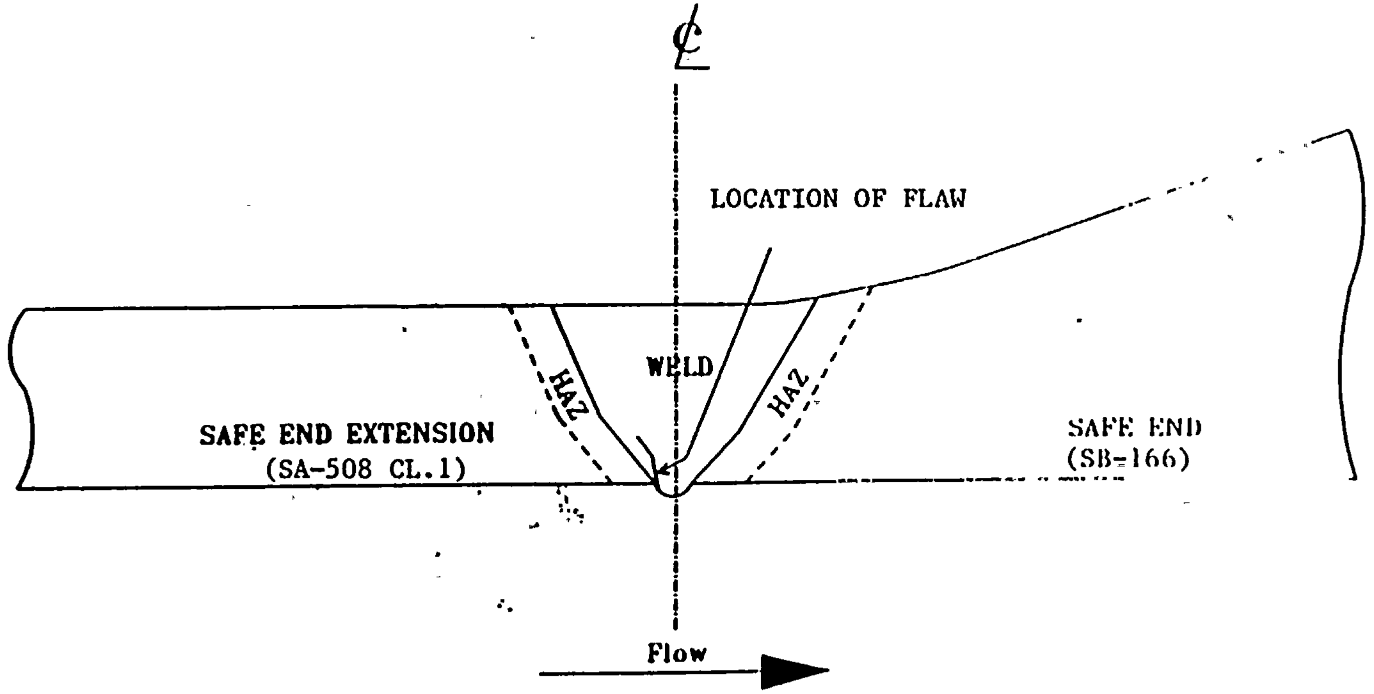


Figure - Nine Mile Point 2 - Core Spray Nozzle
Safe-End to Safe-End Extension Weld

NIAGARA MOHAWK POWER CORPORATION

NINE MILE POINT UNIT 2

CRACK GROWTH EVALUATION

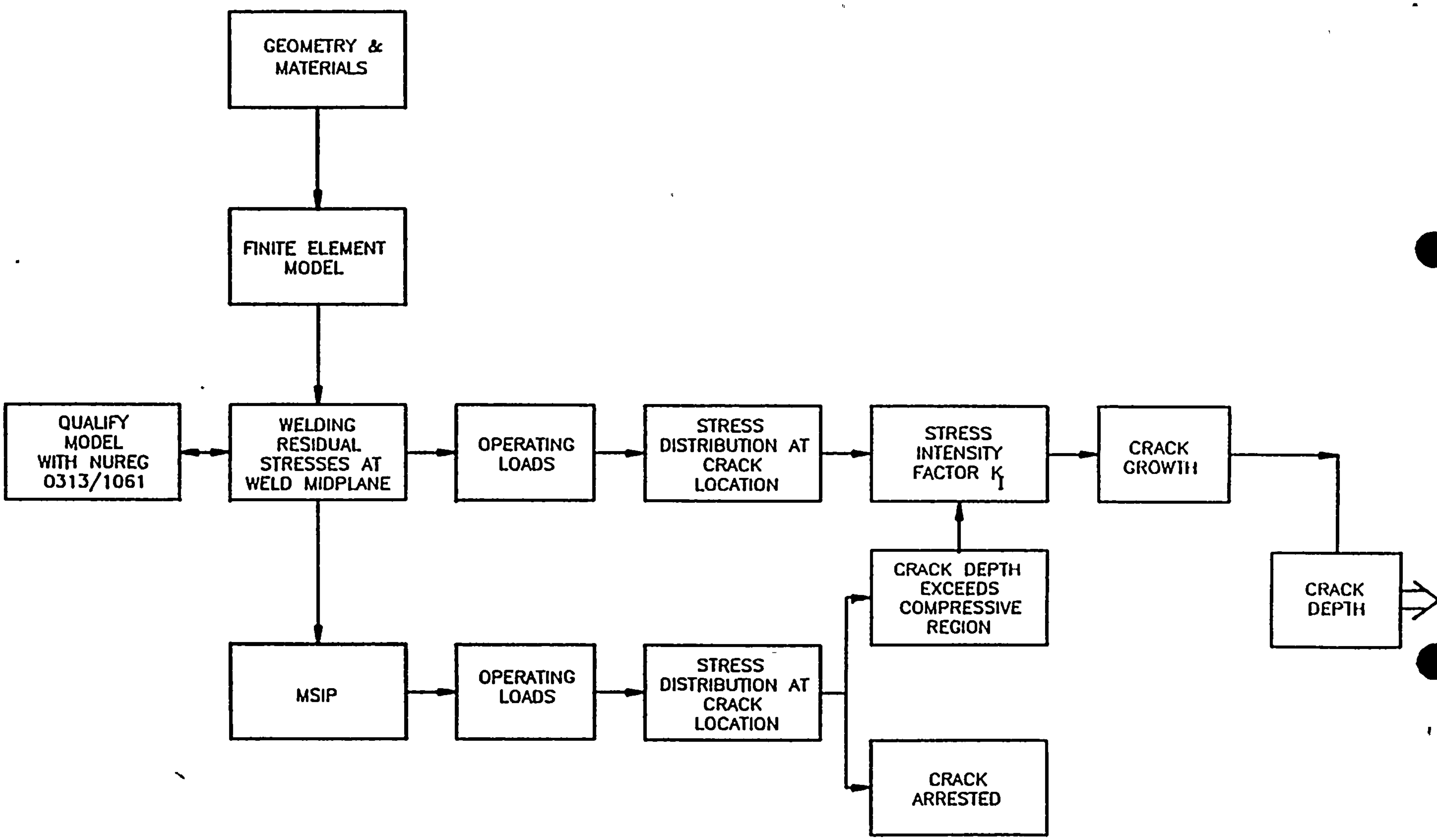
FOR

CORE SPRAY SAFE-END-TO-EXTENSION WELDMENT

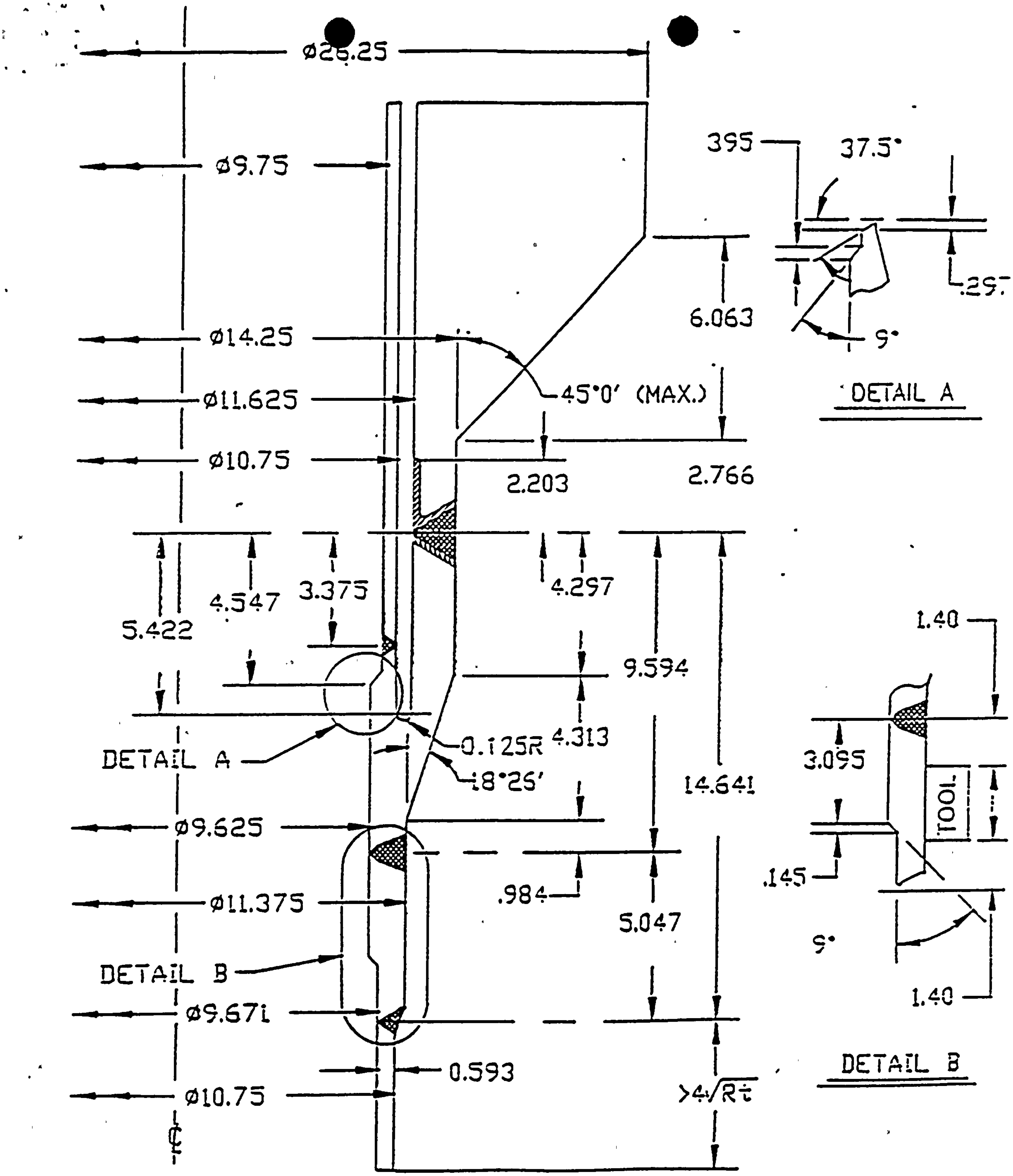
PRESENTED TO

UNITED STATES NUCLEAR REGULATORY COMMISSION

JUNE 1991



ANALYSIS FLOW CHART



CORE SPRAY NOZZLE GEOMETRY

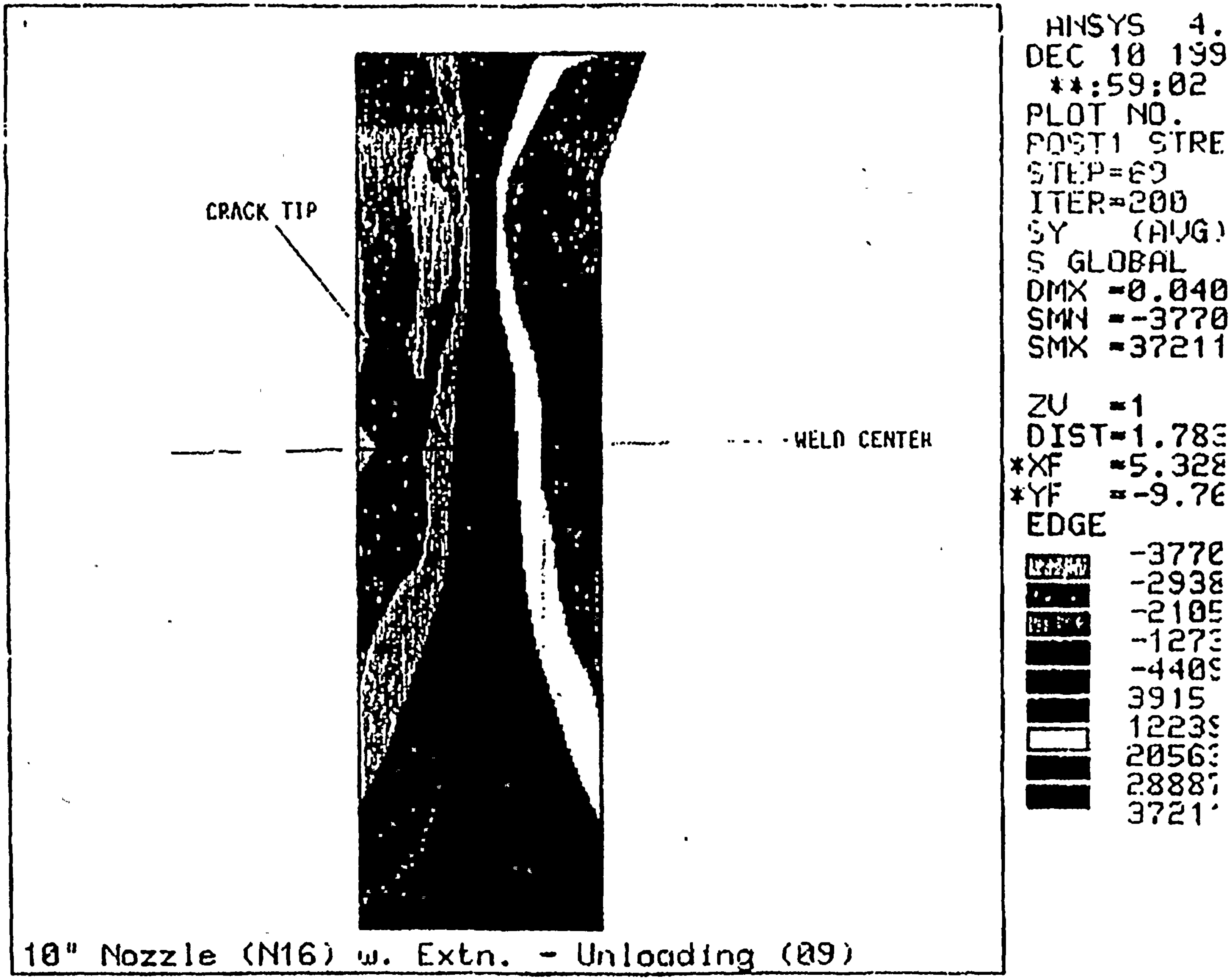


FIGURE 3.7 POST MSIP AXIAL STRESSES IN THE SAFE-END-TO-EXTENSION WELD (0.780% CONTRACTION)

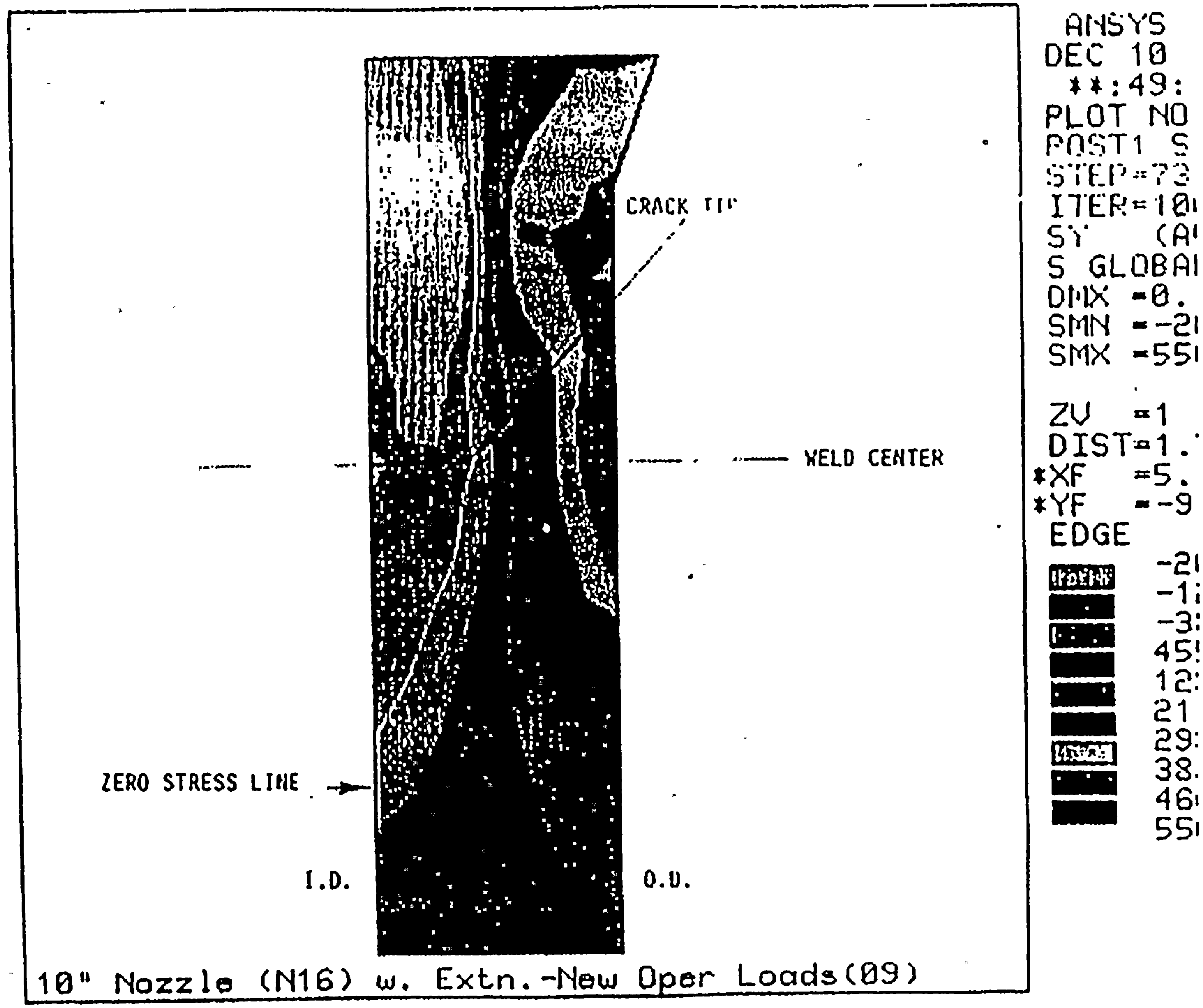
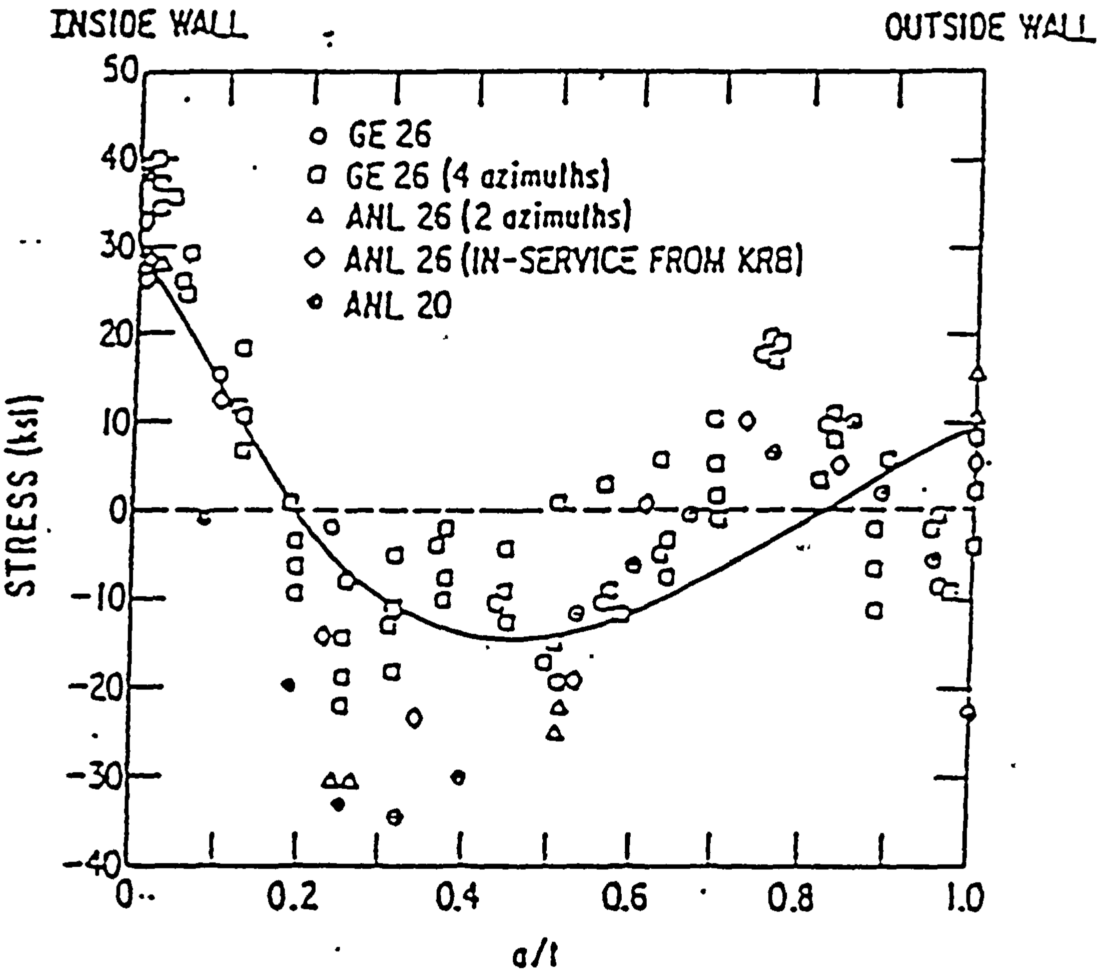
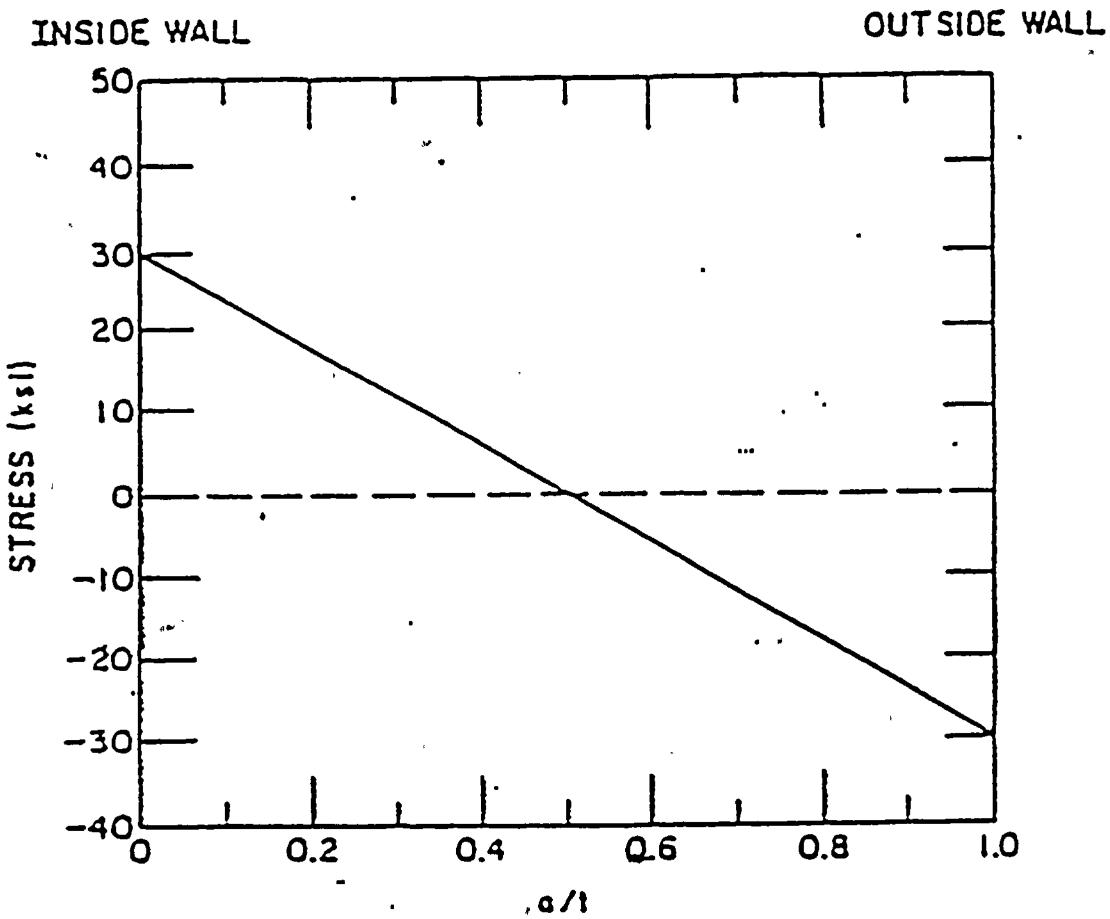


FIGURE 3.11 POST MSIP AXIAL STRESSES WITH OPERATING LOADS INCLUDED FOR THE SAFE-END-TO-EXTENSION WELD (0.788% CONTRACTION)



THROUGH-WALL DISTRIBUTION OF AXIAL RESIDUAL
STRESS FROM NUREG-0313



ASSUMED THROUGH-WALL WELDING RESIDUAL STRESS DISTRIBUTION IN SMALL-DIAMETER WELDMENTS (<12 in.).

(FROM NUREG-1061)

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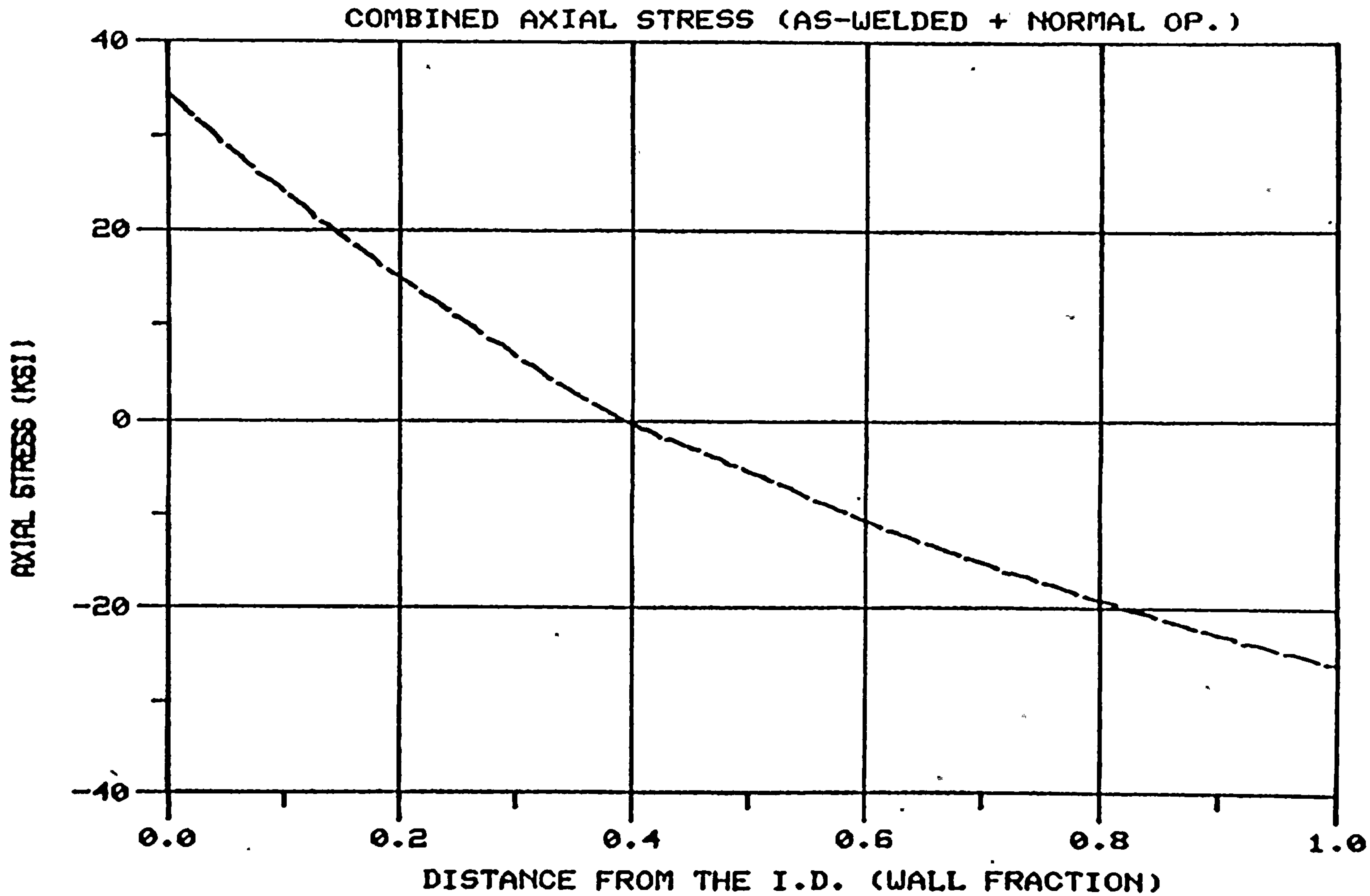
Pittsburgh, Pennsylvania



COMBINED AXIAL STRESS DISTRIBUTION AT OPERATING CONDITIONS

PROPRIETARY

SMC O'DONNELL INC.

STRESS INTENSITY FACTOR

Stress Profile represented by third degree polynomial

$$\sigma_0 = A_0 + A_1X + A_2X^2 + A_3X^3$$

Stress Intensity Factor [Reference: Dedhia and Harris,

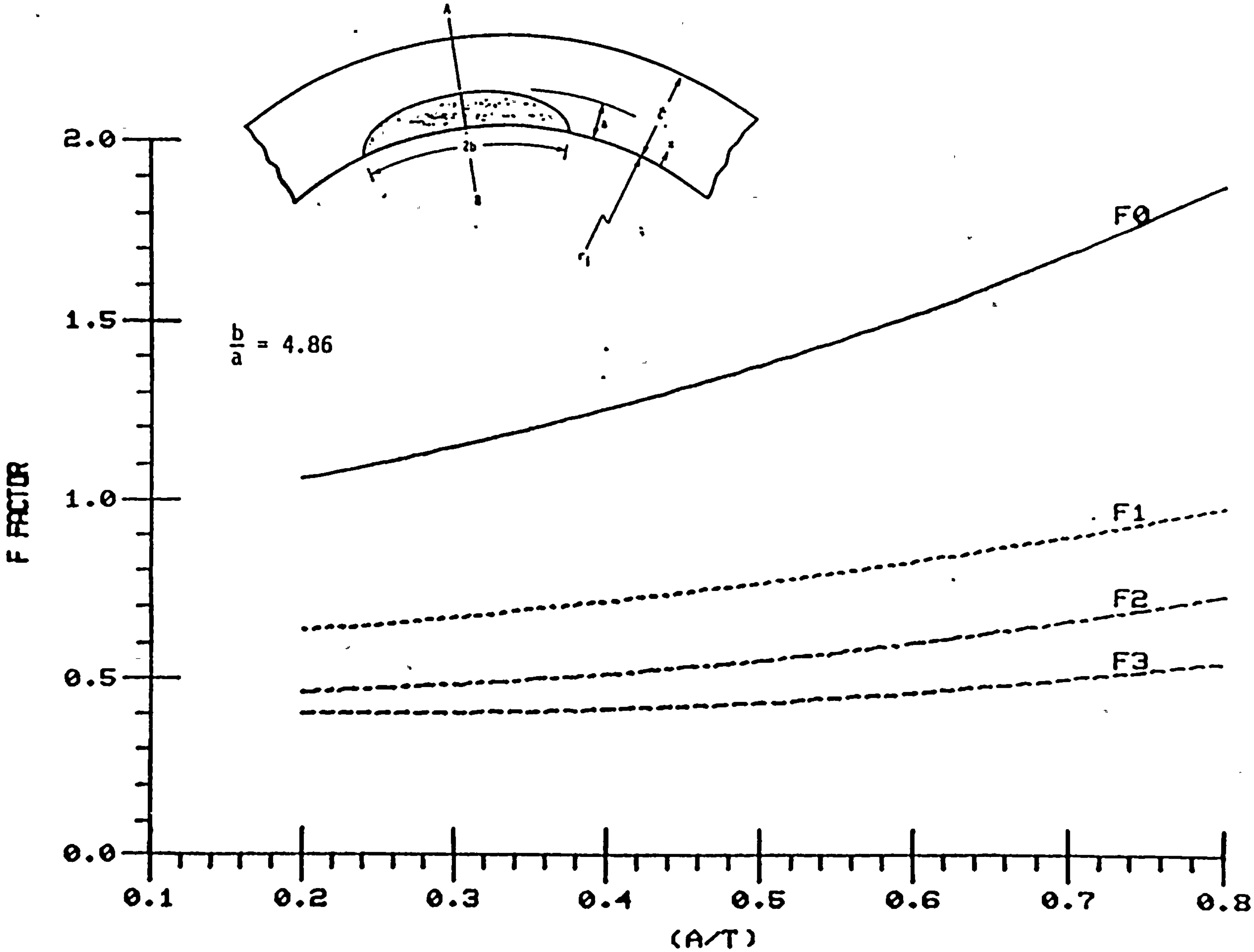
PVP Vol. 95, 1983]

$$K_1 = \sqrt{\pi a}\left[A_0F_0 + aA_1F_1 + a^2A_2F_2 + a^3A_3F_3\right]$$

A_0, A_1, A_2 and A_3 = coefficients of the polynomial expression representing the stress profile $\sigma(x)$ in the uncracked section

a = crack depth, and

F_0, F_1, F_2 and F_3 = Influence function factors



INFLUENCE FUNCTIONS FOR POWER STRESSES

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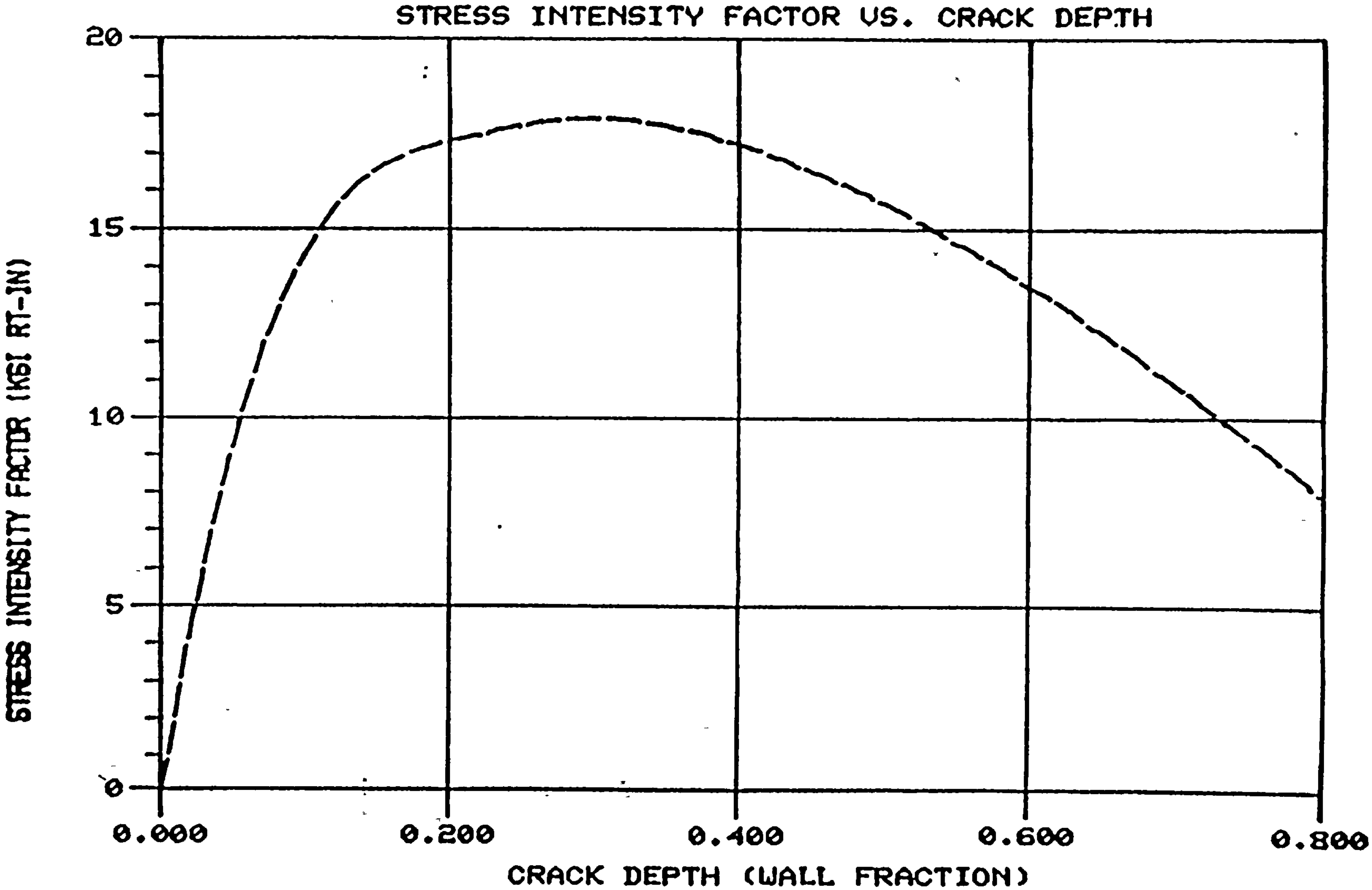
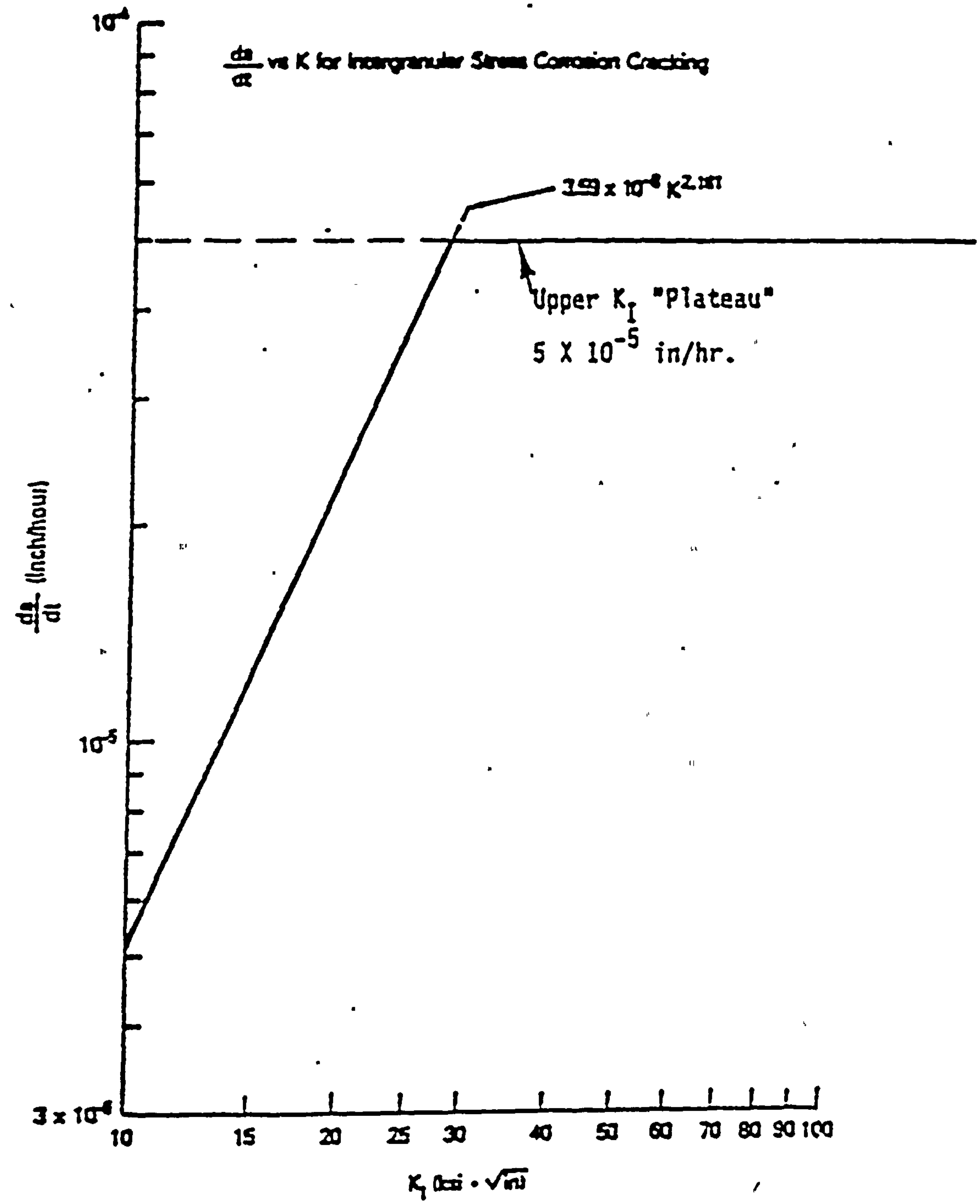


STRESS INTENSITY FACTOR VERSUS CRACK DEPTH FOR OPERATING CONDITIONS INCLUDING AS-WELDED STRESS



COMPOSITE CRACK GROWTH RELATIONSHIP
USED IN THE EVALUATION

CRACK GROWTH ASSESSMENT

MONTH ENDING	TIME (hrs)	CRACK DEPTH (% Wall)	CRACK LENGTH* % Circumference
	0	41.18	11.2
May 91	2920	46.59	12.7
June 91	3650	47.85	13.0
July 91	4380	49.08	13.3
August 91	5110	50.27	13.7
Sept 91	5840	51.43	14.0
Oct 91	6570	52.55	14.3
Nov 91	7300	53.63	14.6
Feb 92	9700	56.95	15.5

Threshold K_1 = 28.5 ksi$\sqrt{in}$ Plateau Growth Rate = 5.0×10^{-5} in/hr.

*Assuming length grows in same ratio as depth.

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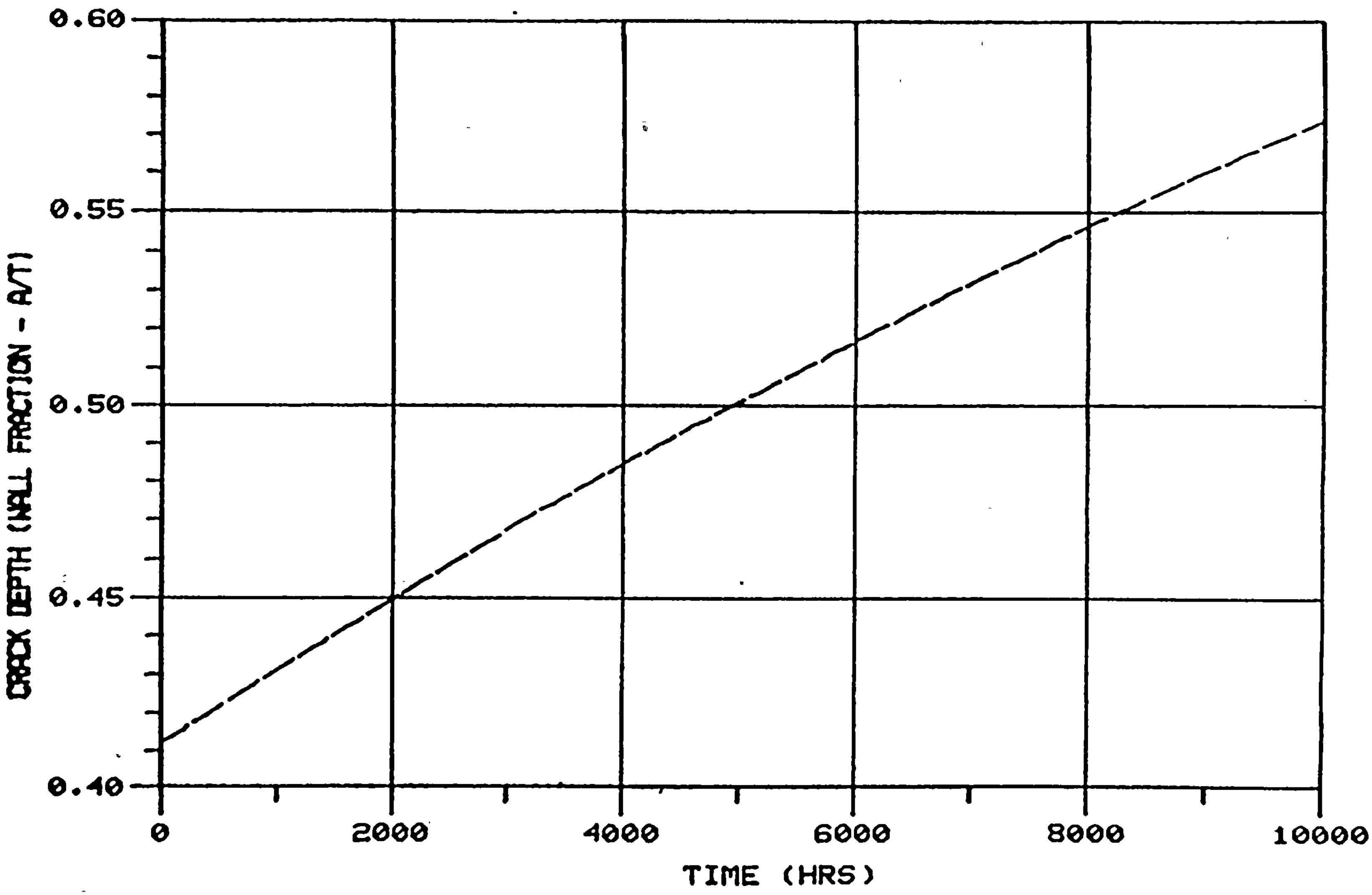
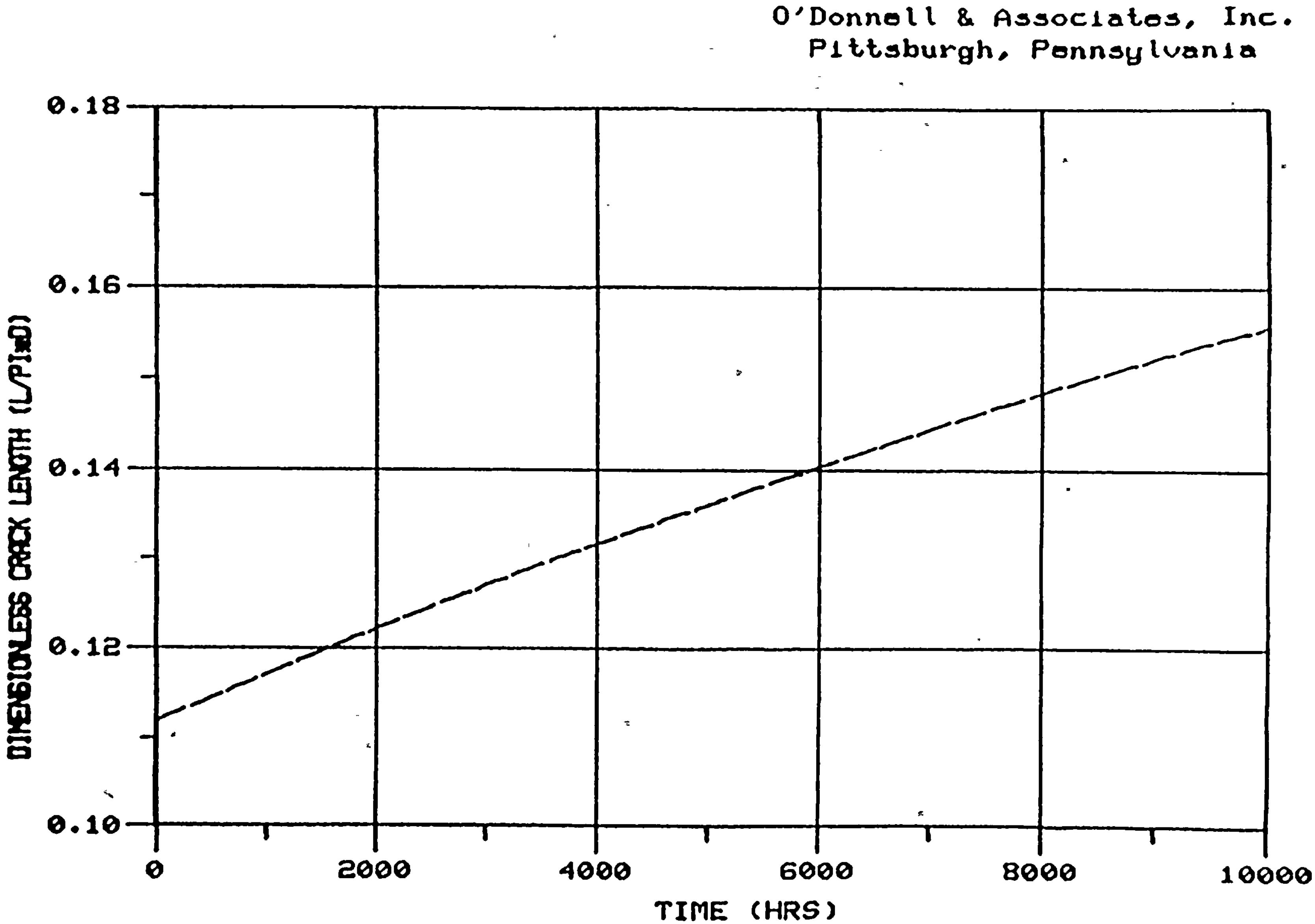
Pittsburgh, Pennsylvania



CRACK DEPTH AS A FUNCTION OF OPERATING TIME



CRACK LENGTH AS A FUNCTION OF OPERATING TIME

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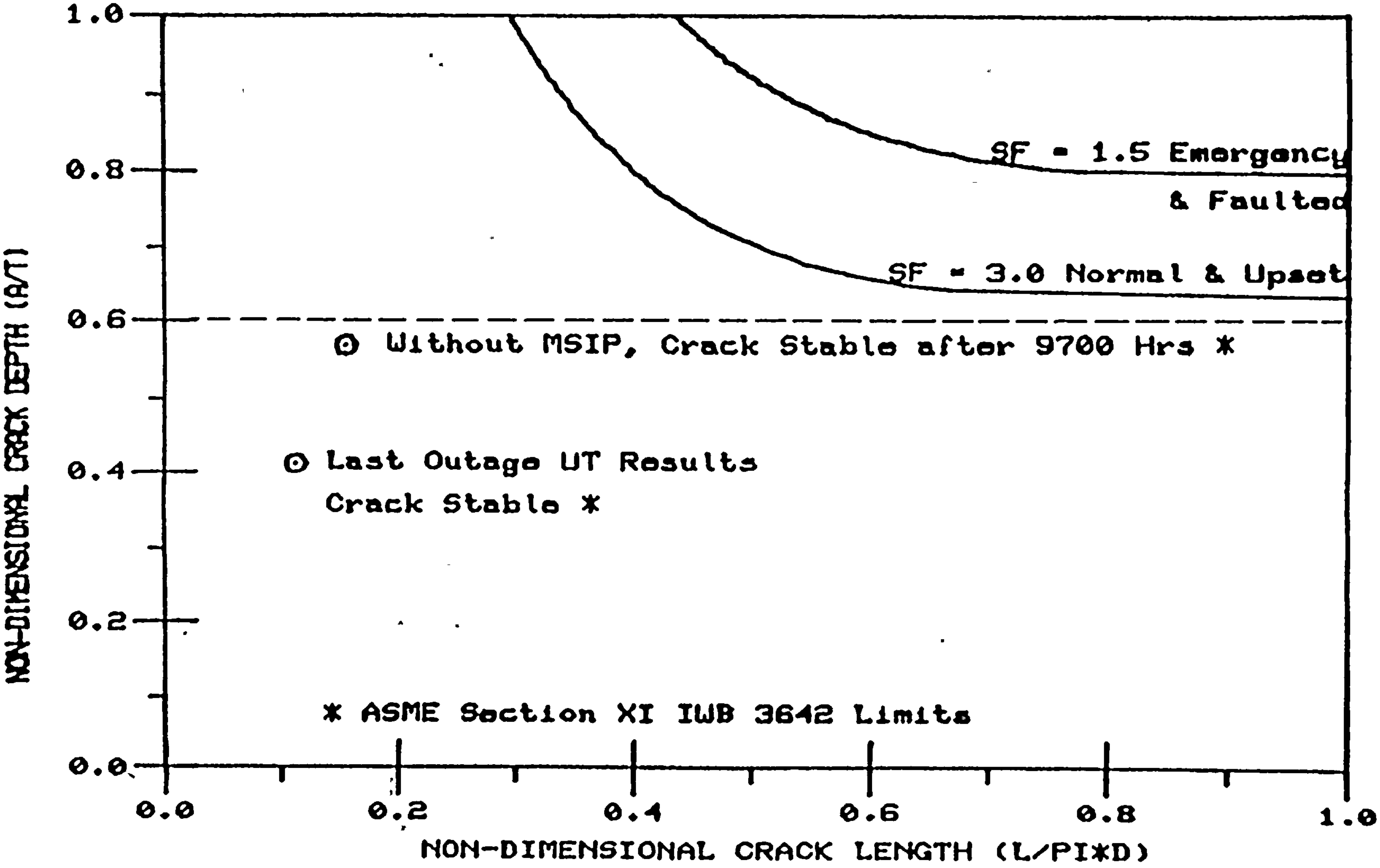


FAILURE ANALYSIS DIAGRAM

CONCLUSIONS

- ANALYSIS BASED ON THE ACTUAL POST-MSIP DISTRIBUTION CORRESPONDING TO FIELD MEASURED PIPE CONTRACTION INDICATES THAT THE CRACK REMAINS IN THE COMPRESSIVE REGION.

- FOR THE HYPOTHETICAL CASE WITHOUT MSIP, FRACTURE MECHANICS EVALUATION BASED ON A CONSERVATIVE LINEAR AS-WELDED RESIDUAL STRESS, PREDICTS A CRACK DEPTH LESS THAN 57% OF THE WALL THICKNESS AFTER ONE FUEL CYCLE.

- PREDICTED CRACK DEPTH AFTER ONE CYCLE MEETS THE ASME CODE SECTION XI LIMIT AND THE CRACK REMAINS IN THE STABLE REGIME.

- ANALYSIS RESULTS RECONFIRM THAT SAFE OPERATION CAN BE CONTINUED THROUGH THE CURRENT CYCLE.

UT UNCERTAINTY

- U.T. EXAMINATIONS WERE PERFORMED TO ASME SECTION XI CODE, WITH ENHANCEMENTS ENDORSED BY THE EPRI NDE CENTER.

- EPRI REQUIRES THAT THE TECHNIQUES EMPLOYED (PROCEDURE, EQUIPMENT, AND PERSONNEL) BE QUALIFIED BY DEMONSTRATION, ON SAMPLES WITH DEFECTS OF KNOWN QUANTITIES AND QUALITIES.

- ALL UT EXAMINATIONS PERFORMED ON THIS WELD WERE BY PROCEDURE, EQUIPMENT, AND PERSONNEL THAT HAD BEEN QUALIFIED AT THE EPRI NDE CENTER.

UT UNCERTAINTY

- AUTOMATED UT EXAMINATION IDENTIFIED THE INDICATION.

- FOUR (4) DIFFERENT MANUAL UT TECHNIQUES WERE UTILIZED TO SIZE THE INDICATION. THE RESULTS WERE ALL CONSISTENT WITH EACH OTHER AND SUPPORTED THE AUTOMATED EXAM.

- AFTER A MODIFICATION ON AN ADDITIONAL AREA OF THIS SYSTEM BOTH AUTOMATED AND MANUAL UT EXAMINATIONS WERE REPERFORMED. THE RESULTS WERE ALSO CONSISTENT WITH THE PREVIOUSLY PERFORMED SIZING.

UT UNCERTAINTY

- UT UNCERTAINTY SHOULD NOT BE A FACTOR AS THE TECHNIQUES THAT WERE EMPLOYED ARE STATE OF THE ART AND HAVE BEEN PROVEN BY DEMONSTRATION TO ACCURATELY MEASURE THE SIZES OF KNOWN DEFECTS.

FEASIBILITY OF RADIOGRAPHY ON HPCS INDICATION

- A WATER FILLED MOCK-UP OF THE NOZZLE WAS RADIOGRAPHED IN THE SHOP USING APPROXIMATELY A 70 CURIE IR 192 SOURCE.
- RESULTS INDICATED THAT BY USING A STRONGER SOURCE MEANINGFUL RESULTS COULD POSSIBLY BE OBTAINED.
- A 200 CURIE SOURCE OF IR 192 WAS OBTAINED AND RADIOGRAPHY WAS ATTEMPTED ON THE AREA CONTAINING THE INDICATION.
- RESULTS OF THE RADIOGRAPHS WERE INCONCLUSIVE (RADIOGRAPHS WERE NOT OF READABLE QUALITY).
- ADDITIONAL RADIOGRAPHS WERE ATTEMPTED USING DIFFERENT SPEED FILMS AND WITH VARYING THE SOURCE ANGLE.

FEASIBILITY OF RADIOGRAPHY ON HPCS INDICATION

- THESE ALSO DID NOT PRODUCE RADIOGRAPHS OF ACCEPTABLE QUALITY.
- TO PURSUE FURTHER RADIOGRAPHY ON THIS WELD WOULD RESULT IN UNNECESSARY EXPOSURE TO PERSONNEL AND NOT YIELD ANY MEANINGFUL INFORMATION.

WELD OVERLAY DESIGN BASIS FOR NINE MILE POINT 2 CORE SPRAY NOZZLE SAFE END TO SAFE END EXTENSION WELD

PRESENTED BY

SAM RANGANATH
GE NUCLEAR ENERGY
SAN JOSE, CALIFORNIA

OVERLAY DESIGN BASIS

- O THICKNESS BASED ON IWB-3640 AND APPENDIX C OF SECTION XI

  - CONSIDERS PRESSURE, WEIGHT AND SEISMIC INERTIA LOADING

  - NO CREDIT TAKEN FOR REMAINING PIPE CROSS-SECTION, THUS INDEPENDENT OF CRACK SIZE

- O MINIMUM LENGTH IS $\sqrt{RT}$

  - LENGTH GENERALLY GREATER FOR UT INSPECTABILITY

- O SHRINKAGE ANALYSIS ASSURES STRESSES ELSEWHERE IN THE PIPING SYSTEM ARE WITHIN ALLOWABLE VALUES

  - SYSTEM WELDS WITH INDICATIONS NEED TO BE REEVALUATED

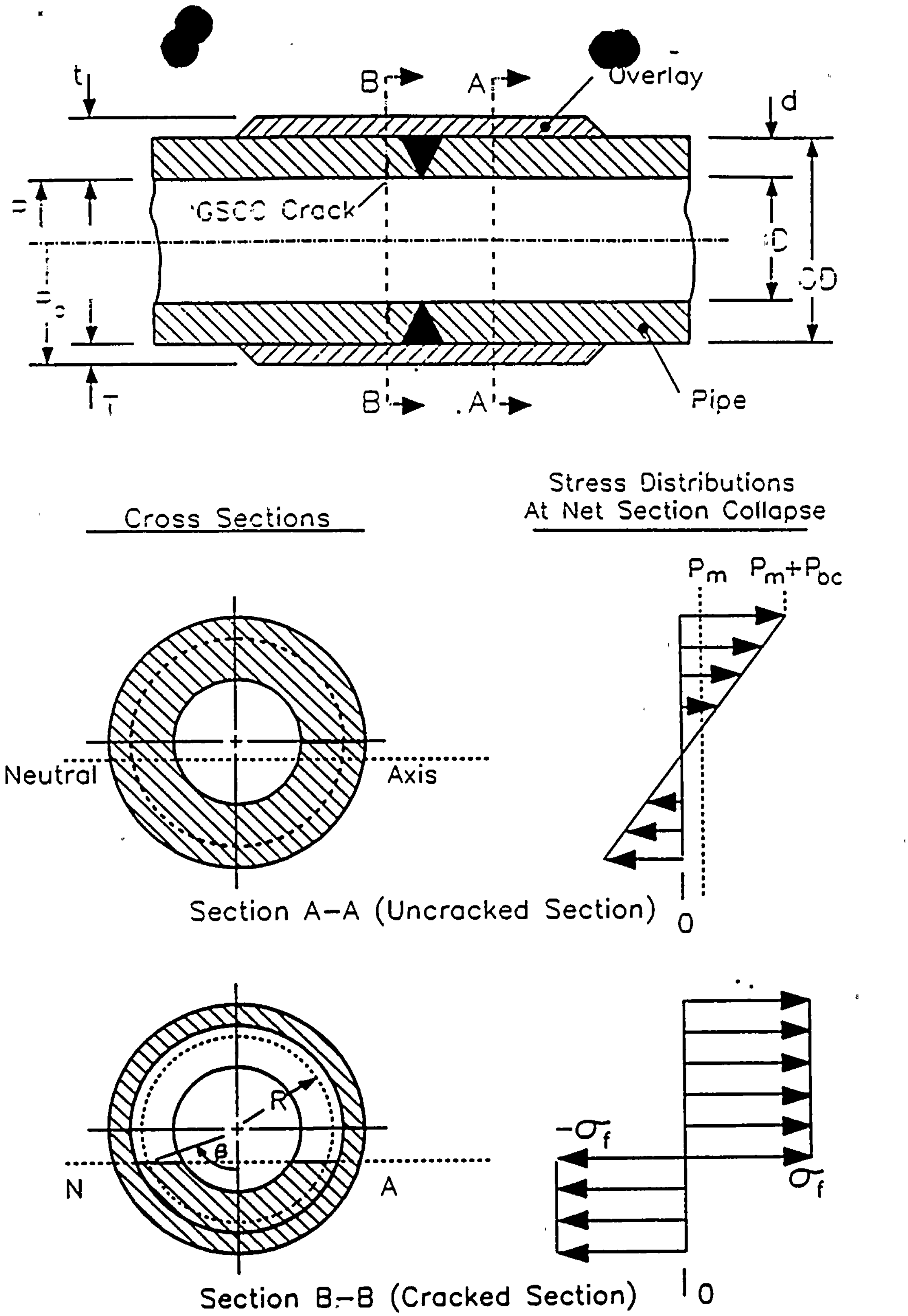
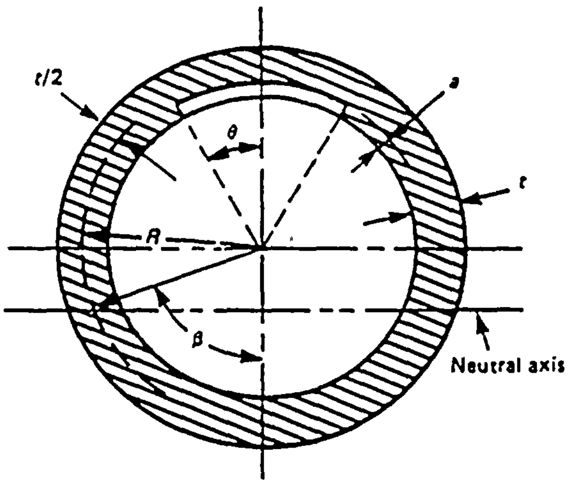


Figure 2 - Weld Overlay Stress Distributions at Net-Section Collapse

THICKNESS DESIGN FOR A FULL STRUCTURAL OVERLAY



$$P'_b = \frac{6S_m}{\pi}\left(2 - \frac{a}{t}\right)\sin\beta$$

$$\beta = \frac{\pi}{2 - \frac{a}{t}}\left(1 - \frac{a}{t} - \frac{P_m}{3S_m}\right)$$

$$P'_b = SF(P_m + P_b) - P_m$$

WELD OVERLAY THICKNESS = (t - a)

Table 1 - Weld Overlay Thickness Calculation Summary

PLANT ID: NINE MILE POINT 2

WELD ID: SAFE-END TO SAFE-END EXT

PIPE THICKNESS = 0.88 INCH

PIPE DIAMETER = 11.38 INCH

PRIMARY STRESSES:

PRESSURE	=	3.66 KSI
DEAD WEIGHT MEMBRANE	=	0.27 KSI
DEAD WEIGHT BENDING	=	2.98 KSI
SEISMIC MEMBRANE	=	0.58 KSI
SEISMIC BENDING	=	4.13 KSI
SM WELD MATERIAL	=	23.30 KSI
SM PIPE MATERIAL	=	23.30 KSI

WOT	T / T+WOT	PM (KSI)	PB (KSI) REMOTE	PB (KSI) WOT	PM+PB (REMOTE)	PM+PB/3 (WOT)
0.255	0.774	3.595	5.333	23.556	8.928	9.050

PRIMARY STRESSES:

PM = 3.595

PM+PB = 8.928

MINIMUM REQUIRED WELD OVERLAY THICKNESS = 0.255 INCH

MINIMUM REQUIRED WELD OVERLAY WIDTH = 2.2 INCH

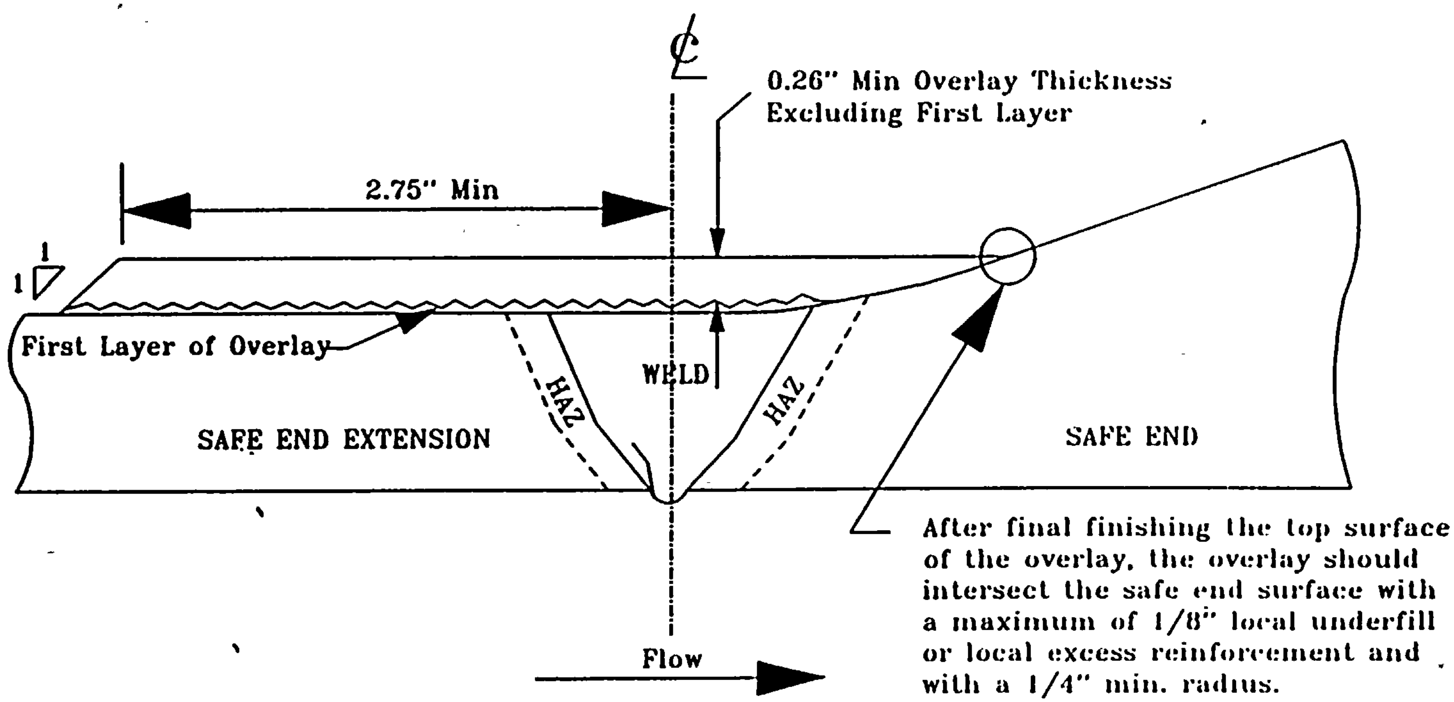
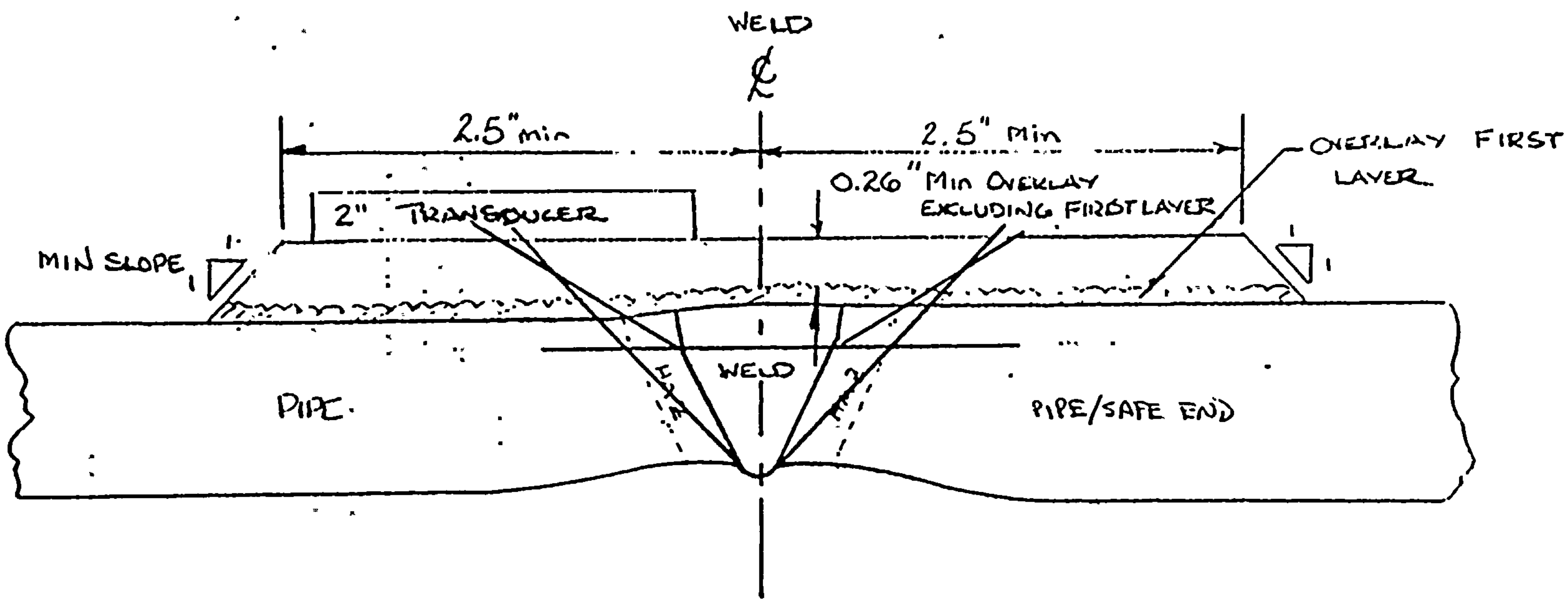


Figure 1 - Nine Mile Point 2 - Core Spray Nozzle
Safe-End to Safe-End Extension Weld

EXAMPLE OF HOW A WELD OVERLAY IS EXAMINED
REQUIRED WIDTH OF OVERLAY



CONCLUSION

THE FULL STRUCTURAL WELD OVERLAY FOR THE NMP 2 CORE SPRAY NOZZLE SAFE END TO SAFE END EXTENSION WELD, MEETS ALL CODE, NRC AND UT INSPECTABILITY CRITERIA

SUMMARY

NMPC ACTIONS

- SUBMIT REVISED FRACTURE MECHANICS ANALYSIS TO NRC BY JUNE 28 FOR APPROVAL
- PERFORM MID-CYCLE UT INSPECTION OF WELD KC-32
- EVALUATE UT RESULTS WITH RESPECT TO THE RESULTS OF REVISED FRACTURE MECHANICS ANALYSIS.

  THE FOLLOWING CRITERIA WILL BE UTILIZED:

  (i) IF FLAW LENGTH AND DEPTH FOR THE PERIOD OF EVALUATION IS WITHIN ALLOWABLE LIMITS AS ESTABLISHED BY THE ANALYSIS, NO FURTHER ACTION WILL BE TAKEN UNTIL THE REFUELING OUTAGE.

  (ii) IF FLAW LENGTH FOR THE PERIOD OF EVALUATION EXCEEDS ALLOWABLE LIMITS AS ESTABLISHED BY THE ANALYSIS BUT DEPTH REMAINS WITHIN THE LIMITS ESTABLISHED, A REVISED FRACTURE MECHANICS ANALYSIS WILL BE SUBMITTED TO NRC FOR ACCEPTANCE PRIOR TO STARTUP.

  (iii) IF FLAW DEPTH FOR THE PERIOD OF EVALUATION EXCEEDS ALLOWABLE LIMITS AS ESTABLISHED BY THE ANALYSIS, NMPC SHALL PERFORM REPAIR OF THE KC-32 WELD.

NRC ACTIONS

- REVIEW AND APPROVE REVISED FRACTURE MECHANICS ANALYSIS
- APPROVE ASME XI REPAIR PLAN SUBMITTED ON JUNE 10, 1991

mid-cycle inspection. During the meeting, the licensee committed to submit a revised fracture mechanics analysis by June 28, 1991. The NRC staff agreed to promptly review this revised analysis as well as the proposed repair plan submitted on June 10, 1991. It was agreed that if any significant growth (to be defined by NMPC and agreed to by the NRC staff) of this flaw is detected during the mid-cycle inspection, further evaluation will be required as well as a probable repair. However, if the NRC staff determines the revised analysis to be submitted on June 28, 1991, is acceptable and there is no significant growth of the flaw, the plant may resume and continue operation without repairing the weld (KC-32) until the next refueling outage when the weld will be reinspected.

Original Signed By:

Donald S. Brinkman, Senior Project Manager
Project Directorate I-1
Division of Reactor Projects - I/II
Office of Nuclear Reactor Regulation

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1. List of Attendees
2. Licensee Handout Material

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DBrinkman	CVogan
OGC	EJordan
NRC Participants	ACRS (10)
CCowgill	

OFC	:PDI-1:LA	:PDI-1:PM	:PDI-1:D	:	:
NAME	:CVogan CV	:DBrinkman:ln DSB	:RACapra RC	:	:
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