January 21, 1986

Docket Nos. 50-321/366

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LICENSEE: Georgia Power Company

FACILITIES: Hatch Units 1 and 2

SUBJECT: SUMMARY OF DECEMBER 13, 1985 MEETING WITH GEORGIA POWER COMPANY ON A SAFE END-TO-NOZZLE WELD REPAIR PLAN

A meeting with Georgia Power Company (GPC) representatives was held in Bethesda, Maryland on December 13, 1985 to allow GPC and its consultants to describe to the staff, a contingency plan for repairing safe end-to-nozzle welds. The plan involves the use of the "temper bead" repair technique. GPC consultants described the development work that had been performed on this repair technique. The agenda for the meeting and discussion slides as well as a list of meeting attendees is enclosed.

Original signed by/

George Rivenbark, Project Manager
BWR Project Directorate #2
Division of BWR Licensing

Enclosures:
As stated

cc w/enclosure:
See next page

DBL:PD#2
SNorris:rc
01/17/86

DBL:PD#2
GRivenbark
01/21/86

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PDR ADOCK 05000321
P PDR

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Georgia Power Company

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Chairman
Appling County Commissioners
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Meeting Attendance List

Georgia Power Company - Hatch Plant

December 13, 1985

Name	Affiliation
G. Rivenbark	NRC-BWR/DL
P. Riccardella	Structural Integrity Associates
J. D. Heidt	GPC/NSL
J.A.Edwards	GPC/NSL
W. J. Childs	EPRI
L. T.Gucwa	GPC
P. P. Norris	GPC - Plant Hatch
W. Hazelton	NRC - BWR DL
W. Koo	NRC - BWR DL

CONTINGENCY PLAN FOR
REPAIR WELDING OF
NOZZLE-TO-SAFE END WELDS
GEORGIA POWER COMPANY
PLANT HATCH
DECEMBER 13, 1985

- INTRODUCTION - L. GUCWA
- DEVELOPMENT PROGRAM - W. CHILDS
- DEVELOPMENT DETAILS
  - METALLURGICAL/MOCK UP - P. NORRIS
  - ANALYTICAL DETAILS - P. RICCARDELLA
- CONCLUSION - L.T. GUCWA

CONTINGENCY PLAN FOR TEMPER BEAD WELD OVERLAY OF SAFE-END TO NOZZLE WELDS

PREPARED BY

GEORGIA POWER COMPANY
AND
STRUCTURAL INTEGRITY ASSOCIATES

PARTIALLY FUNDED BY

ELECTRIC POWER RESEARCH INSTITUTE

DECEMBER 13, 1985

INTRODUCTION

- CONTINGENCY PLANNING FOR REPAIR OF POTENTIAL IGSCC FLAWS IN SAFE-END TO INLET NOZZLE WELDS

- TRADITIONALLY, TWO ALTERNATIVES FOR REPAIR

  - REPAIR/REPLACE AND PWHT
  - TEMPER BEAD REPAIR USING SMAW

- CURRENT PROGRAM FOCUSED ON DEVELOPMENT OF A THIRD ALTERNATIVE:

  - TEMPER BEAD, INCONEL 82 WELD OVERLAY REPAIR USING MACHINE GTAW

  - PROGRAM PARTIALLY FUNDED BY EPRI FOR GENERIC USE - EPRI REPORT WILL BE ISSUED.

COMPARISON OF ALTERNATIVES

- PWHT:
  - COSTLY AND DIFFICULT PROCESS TO IMPLEMENT ON OPERATING PLANT VESSEL
  - LONG OUTAGE, HIGH EXPOSURE
  - POTENTIAL FOR INTRODUCING HIGH RESIDUAL STRESSES ELSEWHERE IN VESSEL IF IMPROPERLY DONE
  - APPLICABLE PRIMARILY TO REPLACEMENT PROGRAM
  - EXPERIENCE OF OTHER UTILITIES SUPPORTS ABOVE
- TEMPER BEAD REPAIR USING SMAW:
  - PERFORMED LOCALLY AT PILGRIM DURING N2 SAFE-END REPLACEMENT
  - ASME SECTION XI PROCEDURE CURRENTLY IN PLACE
  - DIFFICULT PROCESS TO CONTROL SINCE MANUAL PROCESS
  - ALMOST EXCLUSIVELY USED WITH REPLACEMENT
  - MANUAL SMAW OVERLAY WOULD HAVE HIGH MAN-REM IMPACT AT SAFE-END LOCATION

COMPARISON OF ALTERNATIVES
(CONTINUED)

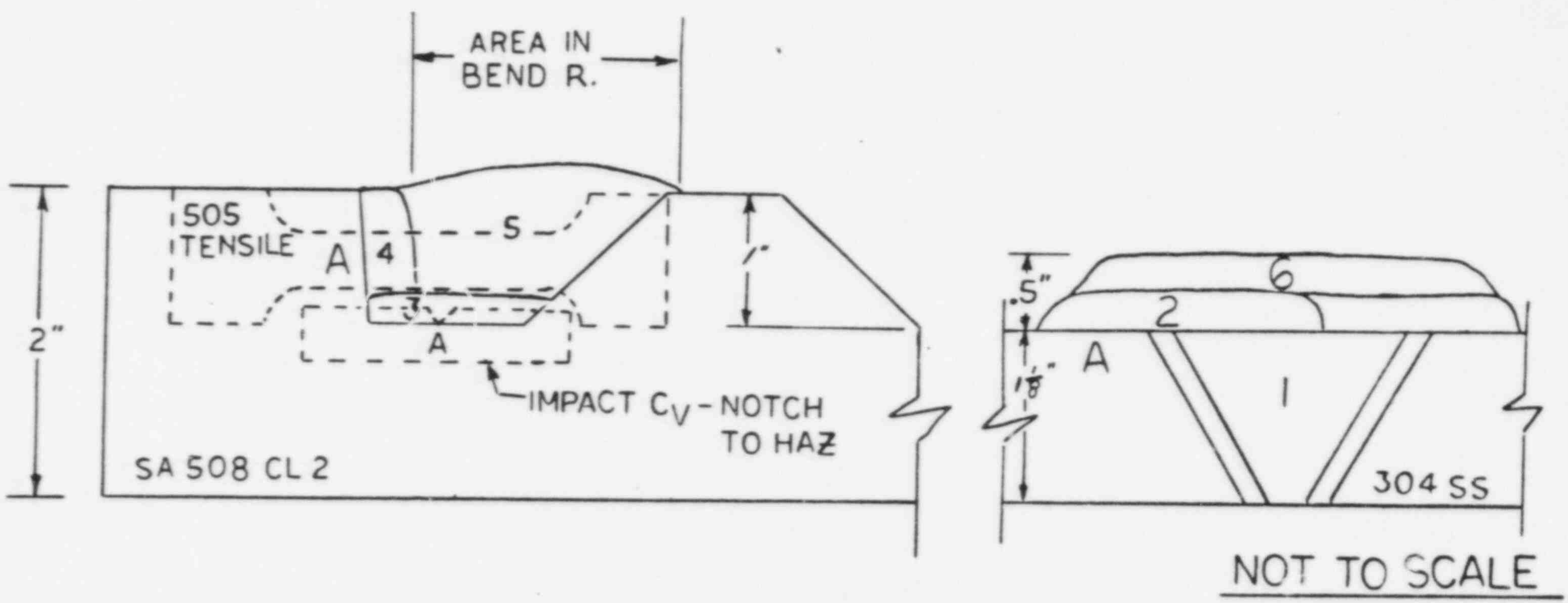
- TEMPER BEAD/WELD OVERLAY USING GTAW:
  - PARAMETERS DEVELOPED BY B & W IN EPRI PROGRAM TO GIVE PROPER TEMPERING
  - RECENTLY APPROVED SECTION XI CODE CASE INCORPORATES THESE RESULTS
  - PROPOSED OVERLAY PROCEDURE MEETS INTENT OF CODE CASE (TEMPERED P3 MATERIAL)
  - CAN BE SHOWN EFFECTIVE FOR AT LEAST ONE FUEL CYCLE (PROBABLY SEVERAL)
  - ALLOWS PLANNING OF ORDERLY PIPE REPLACEMENT IF NECESSARY
  - MINIMUM IMPACT ON OUTAGE LENGTH

1. NOZZLE TO SAFEND WELD-INCONEL BUTTER AND BUTT WELD

2-4. THREE LAYER TEMPER BEAD WELD

5-6. OVERLAY AND GROOVE COMPLETED WITH WATER BACKING

A. LOCATION OF MICROHARDNESS SURVEY



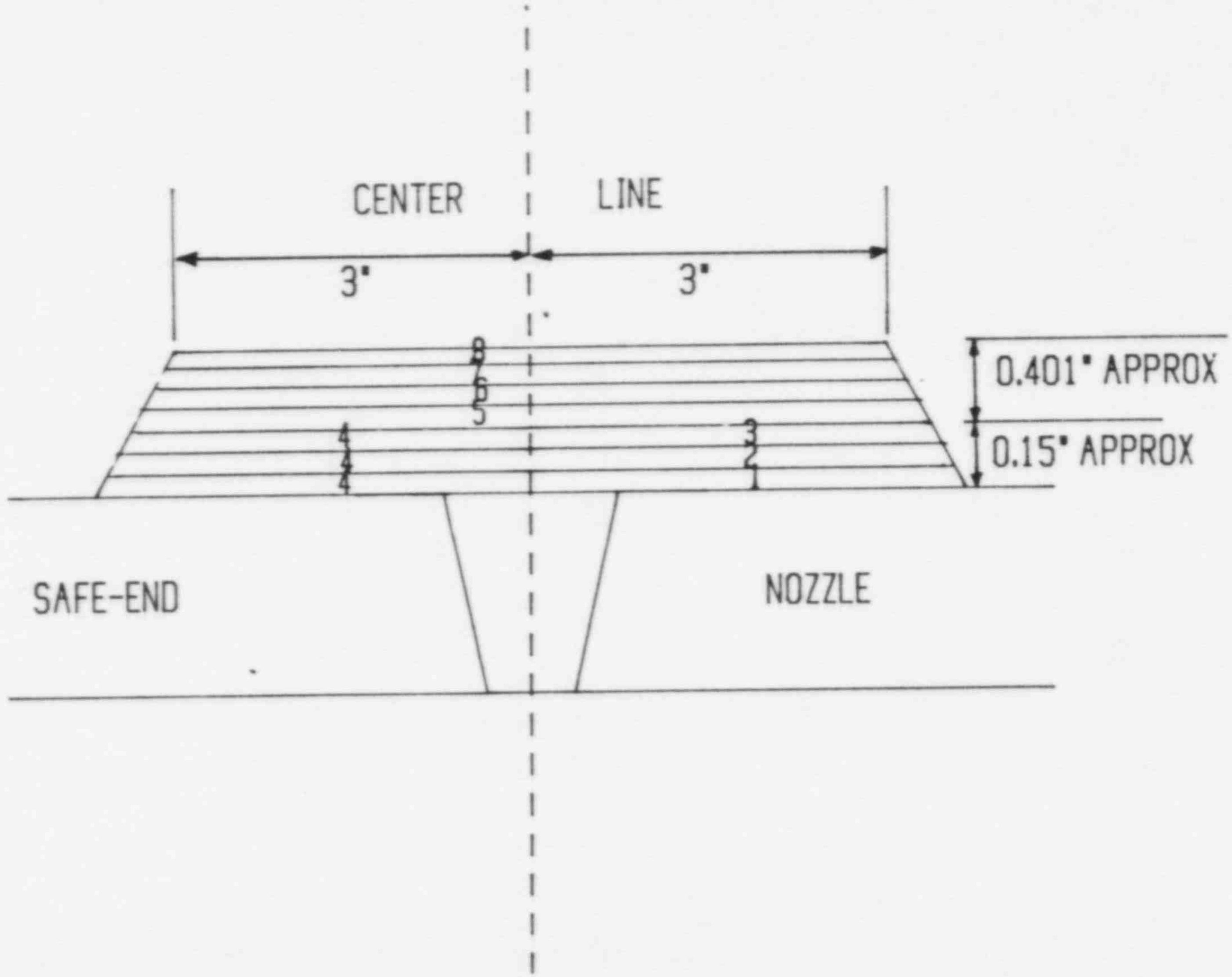
NOZZLE/SAFEND OVERLAY WELD PROCEDURE QUALIFICATION

SEQUENCE OF OPERATION (OVERLAY MOCK-UP AND GROOVE)

TEMPER BEAD (NOTE 1)

1. PREHEAT TO 350°F-HOLD 1/2 HOUR
2. DEPOSIT FIRST TEMPER BEAD LAYER (AS SHOWN ON SKETCH)
3. DEPOSIT SECOND TEMPER BEAD LAYER
4. DEPOSIT THIRD TEMPER BEAD LAYER
   - REPEAT STEPS 2 THROUGH 4 FOR THREE AREAS AS SHOWN ON SKETCH
5. HOLD PREHEAT TO POSTHEAT
6. POSTHEAT 450-500°F FOR 3 HOURS-SLOW COOL
7. FILL MOCK UP WITH WATER, FLOW APPROX 3 GPM
8. WELD BALANCE OF OVERLAY AND GROOVE WITH PARAMETERS FROM STEP 3 (SECOND TEMPER BEAD LAYER) WITH PREHEAT-INTERPASS 70-110°F

NOTE 1 - NOZZLE AND BUTTER ON NOZZLE WERE HEAT TREATED AT 1150°F ± 25°F FOR 20 HOURS TO SIMULATE AS-INSTALLED CONDITION OF VESSEL



OVERLAY DIMENSIONS AND WELDING SEQUENCE

WELDING PARAMETERS

Modified Procedure F from EPRI NP-3614, Volume 2, July, 1984

	Layer 1	Layer 2	Layer 3	Layer 4	Layer 5+
Current (A)	180	200	220	180	200
Voltage (V)	11	11	11	11	11
Wire Feed (ipm)	39	59	65	39	59
Travel (ipm)	8.5	7	6	8.5	7
Bead Overlap (%)	50	50	50	50	50
Preheat (^{o}F)	300	300	300	300	300
Max. Interpass (^{o}F)	500	500	500	500	500
Jules/in	14,000	18,900	14,200	14,000	18,900
				(Water Backed)	

Wire Diameter -- 0.035 Inch

Shielding Gas -- AR 18 CFH

Electrode -- 2% Thoria Tungsten; 5/32-Inch Diameter;
2-1/2-Inch Total Stick-out (With Long Gas Cup);
Tip: 22.5^{o} Included Angle

NOTES:

1. NO LAYER 3 PARAMETERS ON STAINLESS STEEL SIDE OF WELD

2. PREHEAT (250-350^{o}F) ON FIRST 3 LAYERS AND POST WELD BAKING (450-550^{o}F) AFTERWARDS

3. PIPE FILLED WITH WATER AFTER FIRST 3 LAYERS

CHARPY "V" TEST RESULTS 40°F

CV	FT-LB	%SHEAR	LATERAL EXPANSION
A	67	60%	56 MILS
B	88	70%	66 MILS
C	69	50%	51 MILS

BEND TEST NOTE - 7 BEVEL FUSION LINE IS NOT SUITABLE FOR SIDE BEND TEST BECAUSE THE BASE METAL AND WELD METAL DIFFER MARKEDLY IN BENDING PROPERTIES. BOTTOM OF GROOVE HAZ IS REPRESENTED IN THE SIDE BEND SIMILAR TO AN ASME SECTION IX QW-161.5 LONGITUDINAL BEND TEST.

TENSILE TEST RESULTS:

TWO SAMPLES (93.2 KSI, 92.8 KSI)
BOTH FAILED IN BASE METAL

Hardness Values*: Match Overlay Weld

Sample #0-5 OVERLAY HAZ IN A508 CL 2

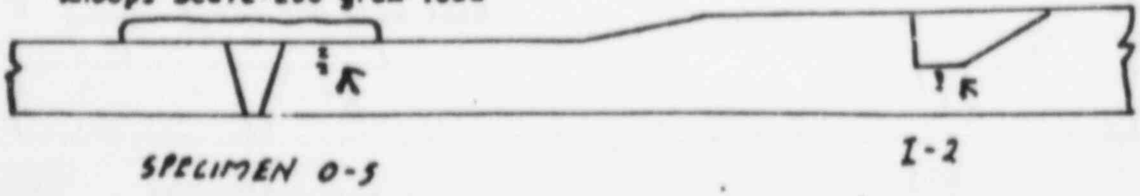
Distance from Weld Fusion Line	Row 1	Row 2	
100 μm	315	302	
300	302	290	
500	296	290	
800	305	292	Base Metal 227
1000	290	279	
1200	266	256	
1400	248	243	
1600	246	229	
1800	231	---	

Sample #I-2 . GROOVE WELD HAZ AT ROOT

area beside weld

Distance from Weld Fusion Line	Row 1	Row 2	
100 m	349	351	
300	330	340	
500	319	332	Base Metal 228
700	364	329	
900	332	351	
1100	334	312	
1300	285	287	
1500	248	259	
1700	---	---	

* Knoops Scale-200 gram load



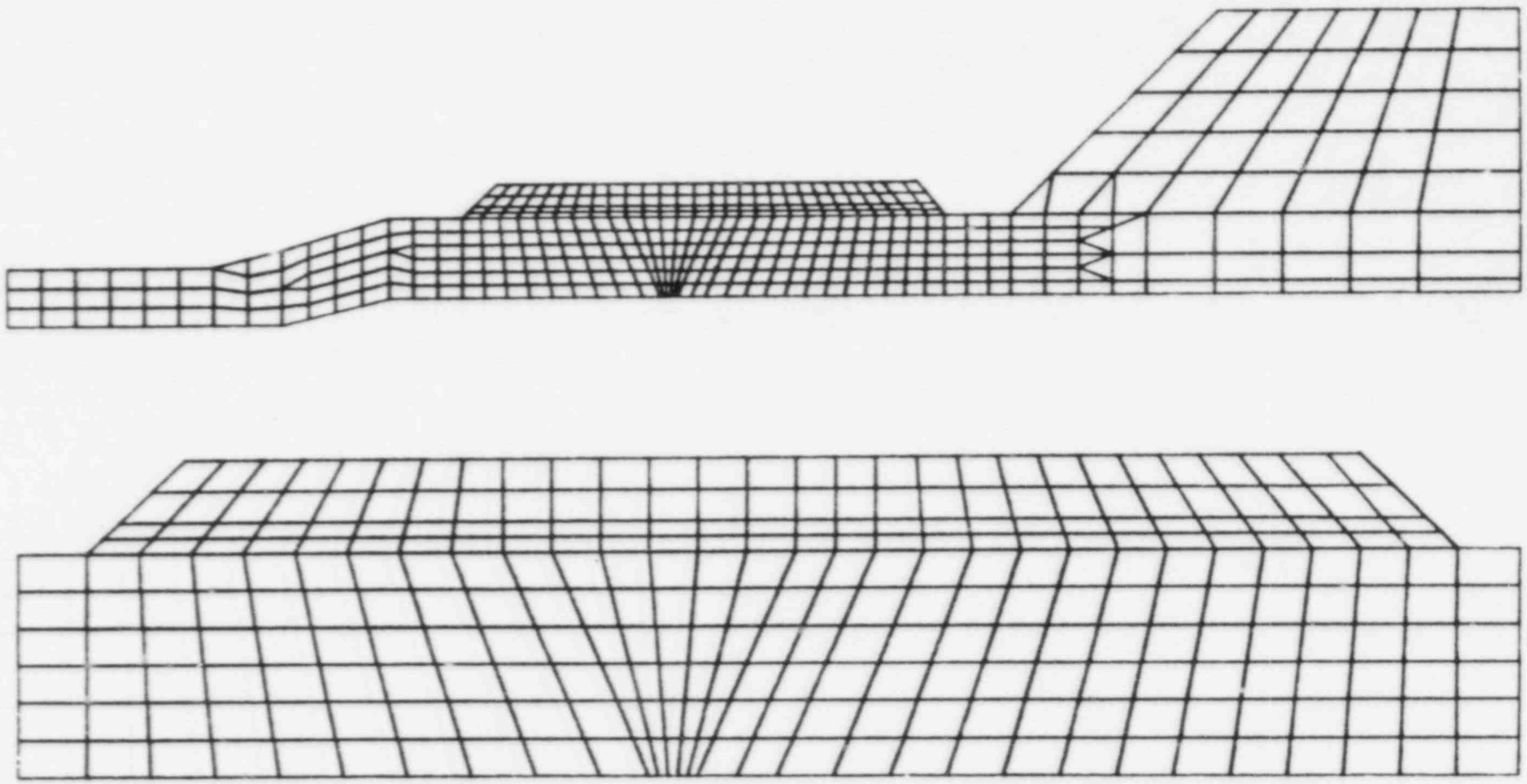
ANALYSES PERFORMED TO QUALIFY PROPOSED OVERLAY PROCEDURE

- RESIDUAL STRESS ANALYSIS
  - SIMULATED BUTT WELD RESIDUAL STRESSES IN WELDS-2 FINITE ELEMENT MODEL
  - TEMPER BEAD OVERLAY PROCESS PRODUCES COMPRESSIVE STRESSES FOR SIGNIFICANT PORTION OF PIPE WALL

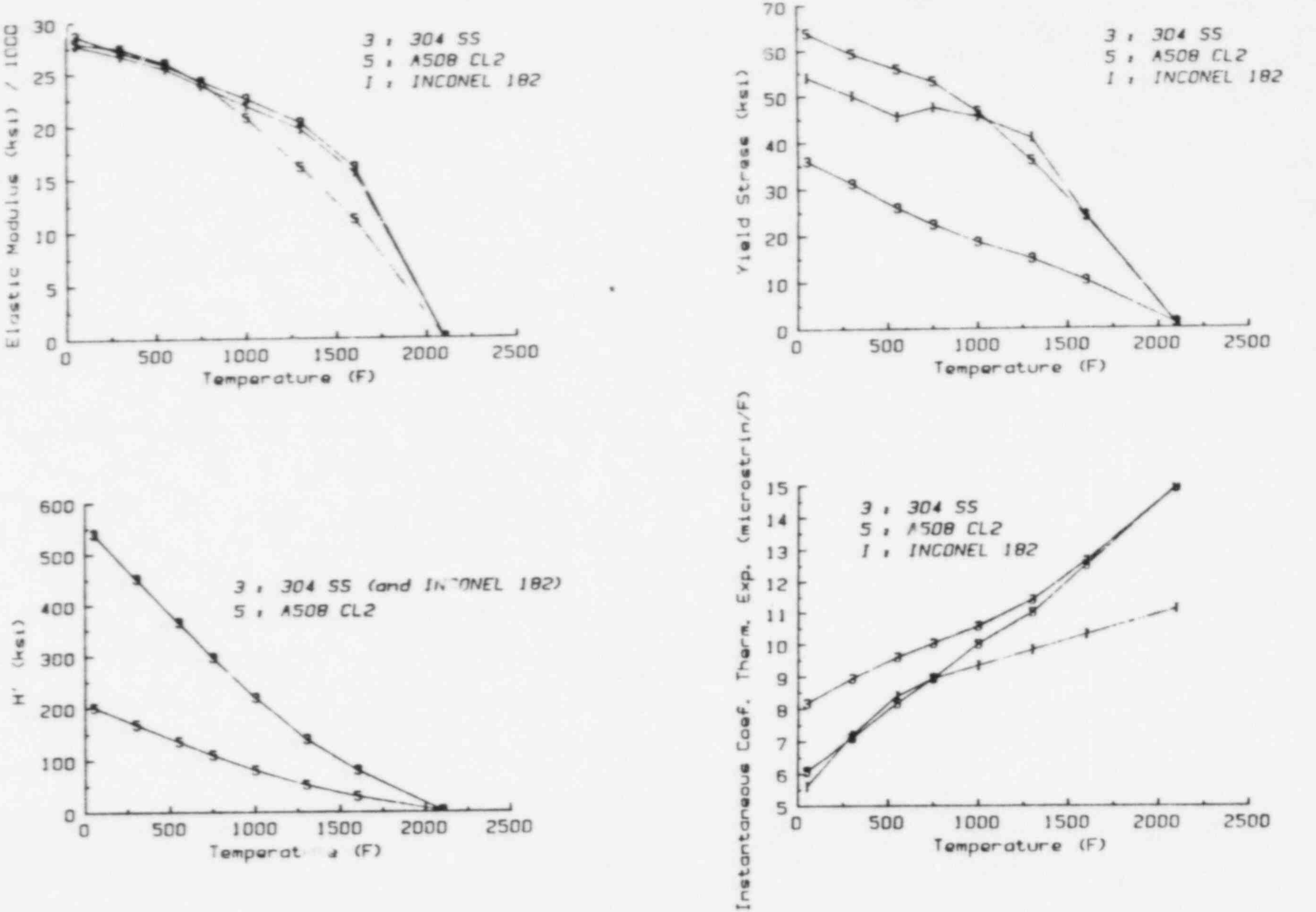
- CRACK GROWTH ANALYSIS
  - CORRELATION BASED UPON LIMITED EPRI DATA FOR CREVICED INCONEL SAMPLES IN AGGRESSIVE ENVIRONMENT

    $DA/DT = 1.08 \times 10^{-8} K^{2.26}$

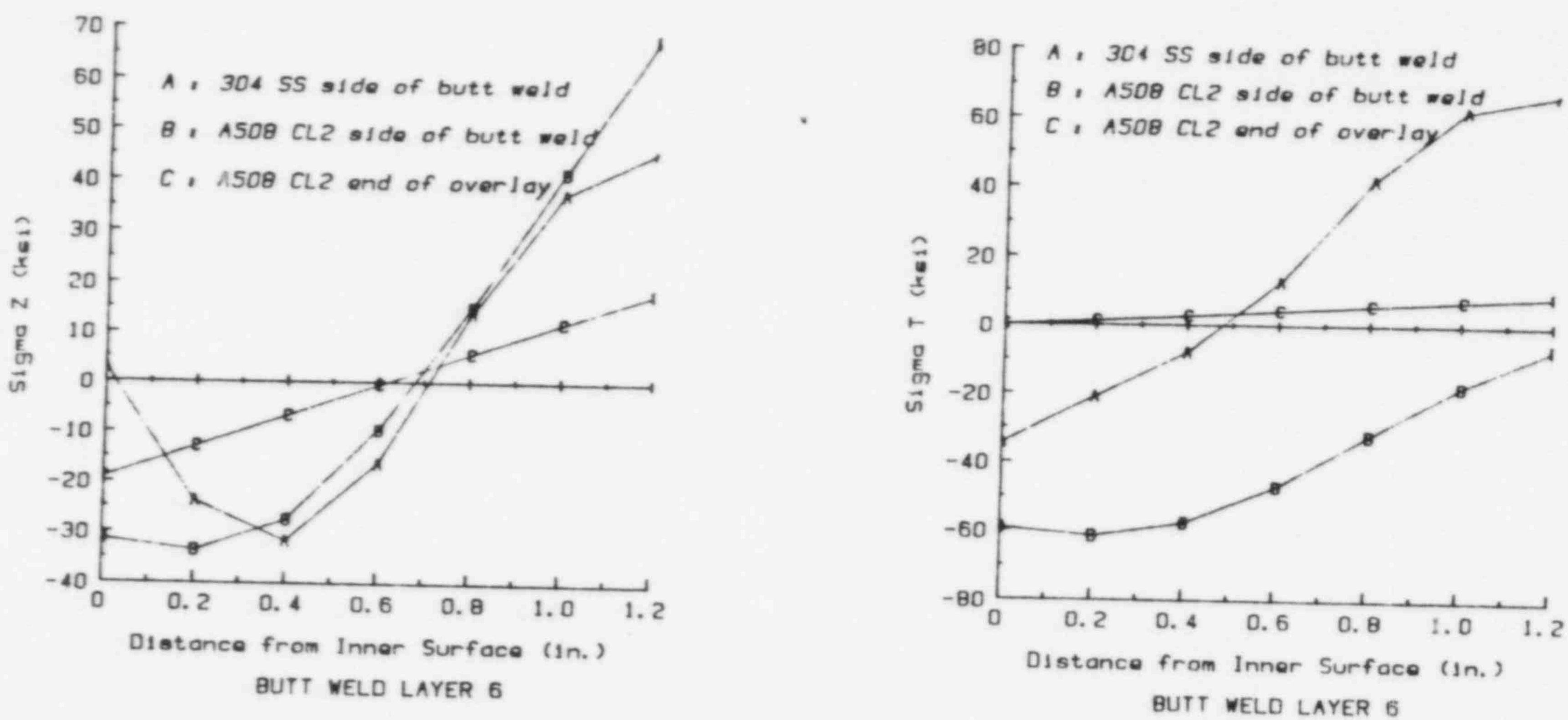
  - CRACK GROWTH RESULTS SHOW AT LEAST ONE FUEL CYCLE OF REPAIR LIFE



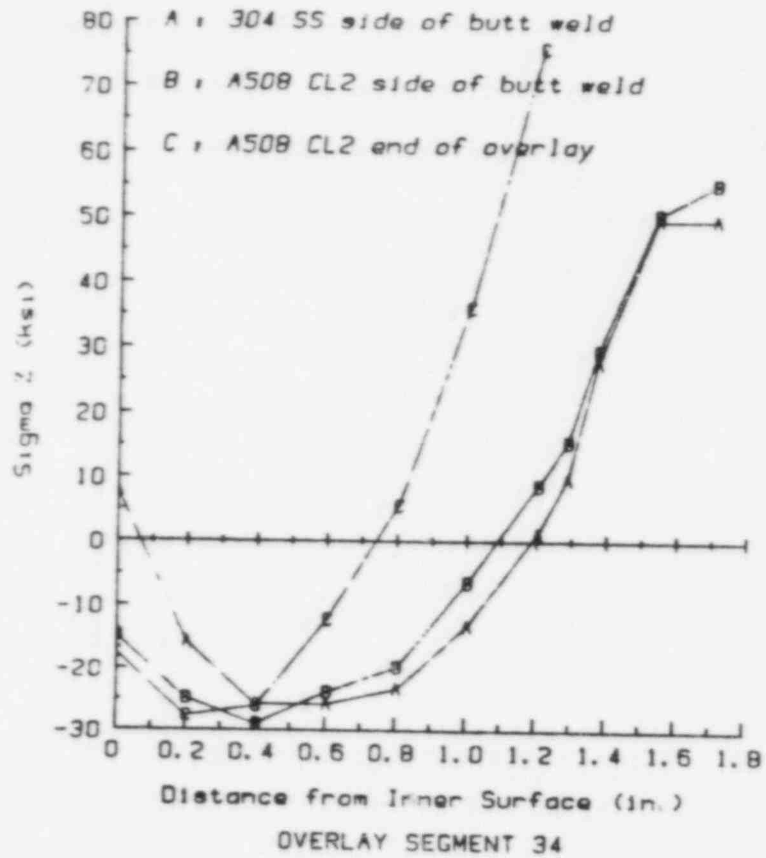
FINITE ELEMENT MODEL USED FOR RESIDUAL STRESS EVALUATION

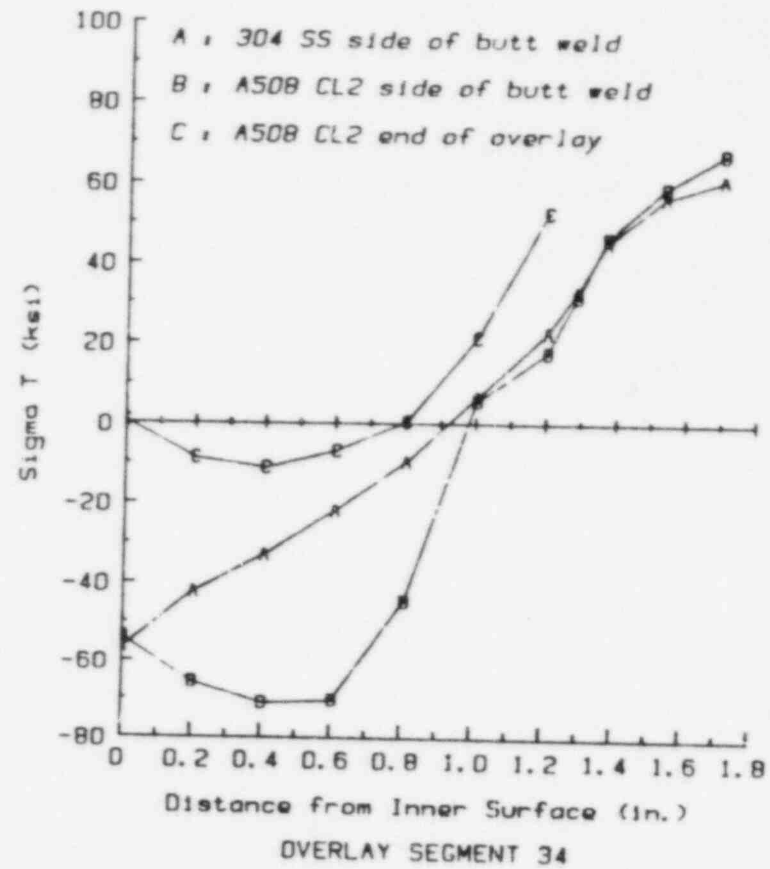


MATERIAL PROPERTIES USED IN FINITE ELEMENT RESIDUAL STRESS EVALUATION

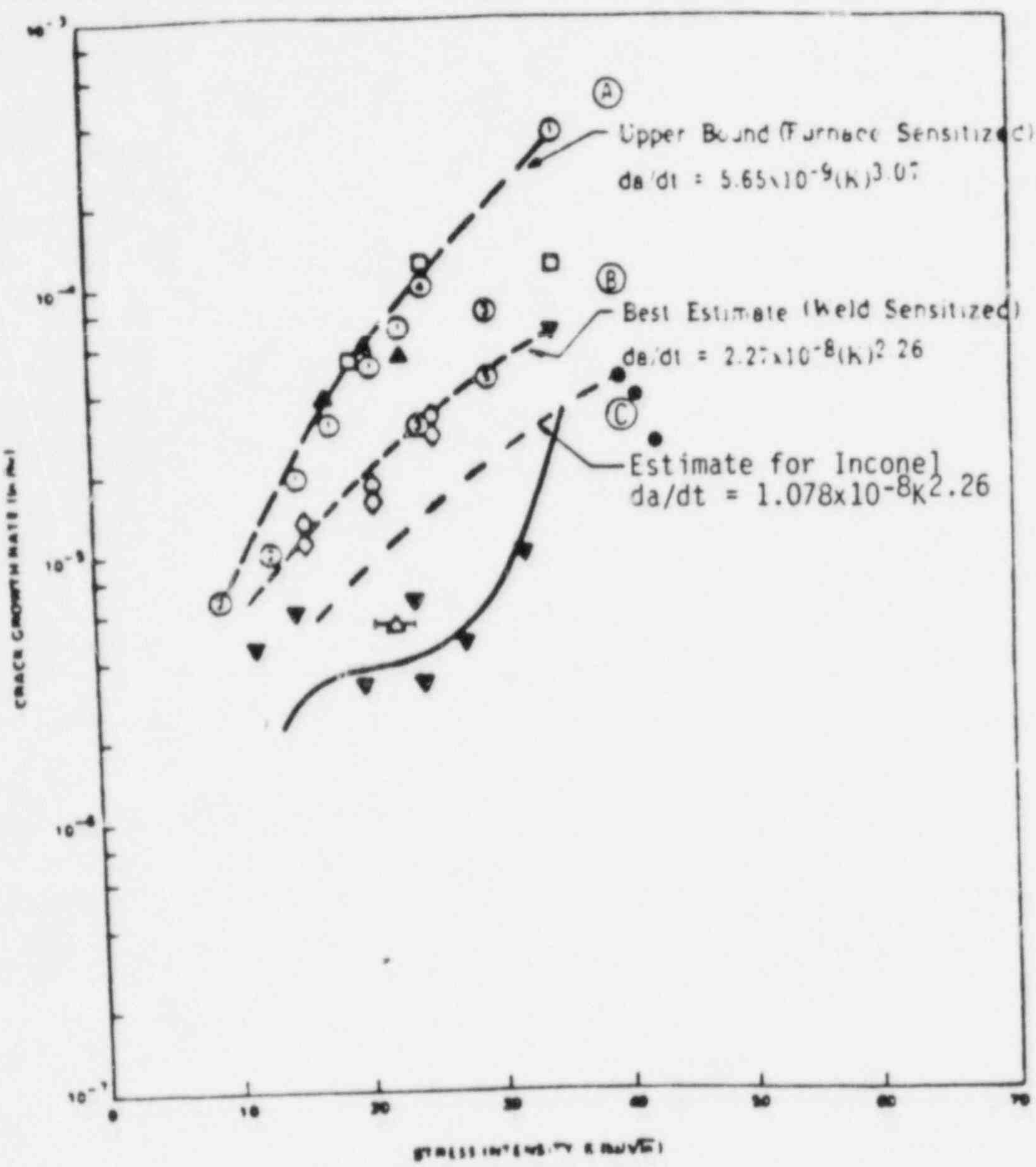


FINITE ELEMENT RESULTS - RESIDUAL STRESSES AFTER BUTT WELD



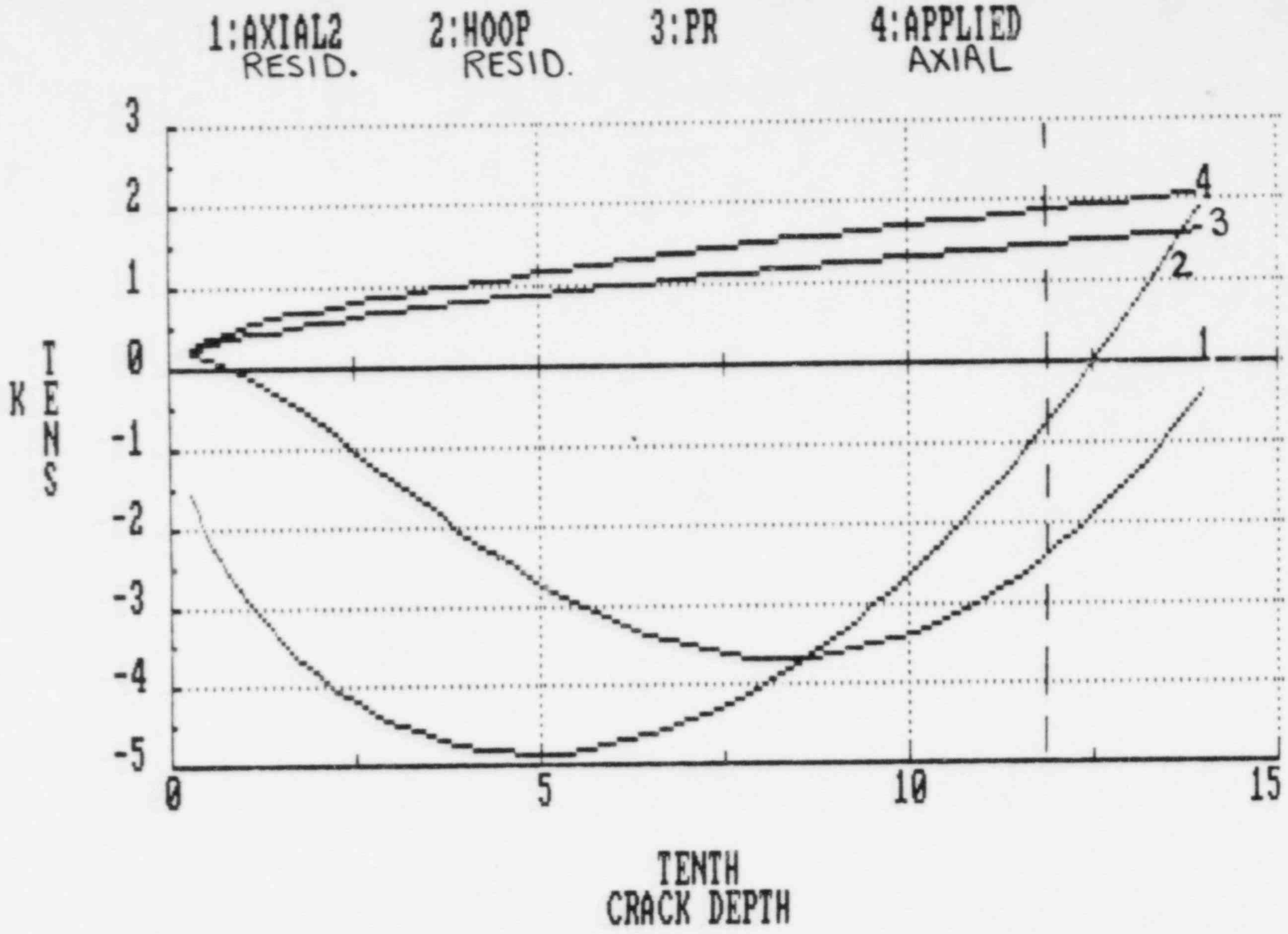


FINITE ELEMENT RESULTS - RESIDUAL STRESSES AFTER WELD OVERLAY



Crack Growth Rate Curves to be Used in Flaw Evaluation Analysis and Supporting Data (From EPRI NP-2472)

● Inconel at 288°C in 7ppm O_2, 1ppm H_2SO_4 (EPRI-1566-2, Interim Report)


1:AXIAL2 RESID.
2:HOOP RESID.
3:PR
4:APPLIED AXIAL
K TENS
3
2
1
0
-1
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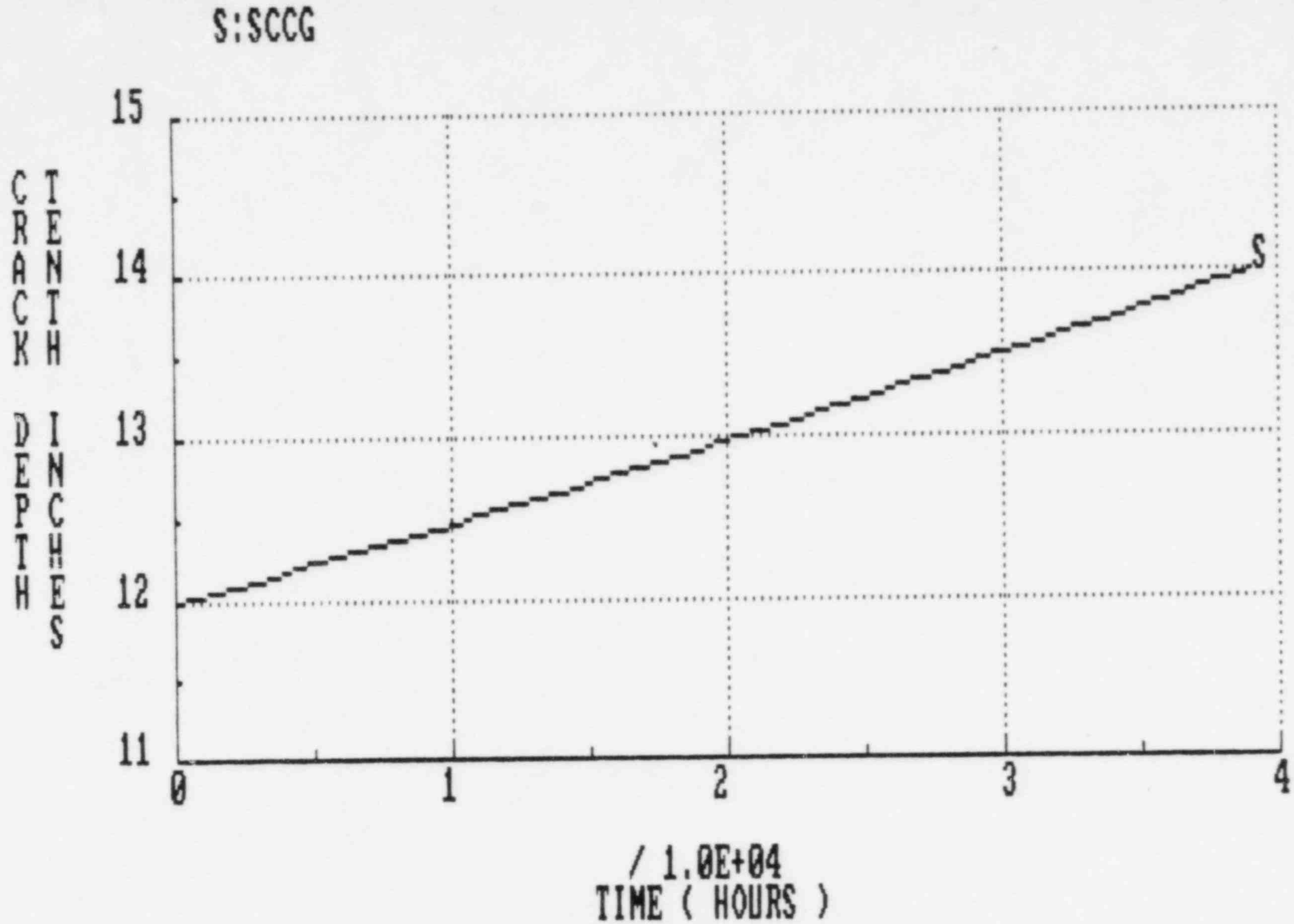
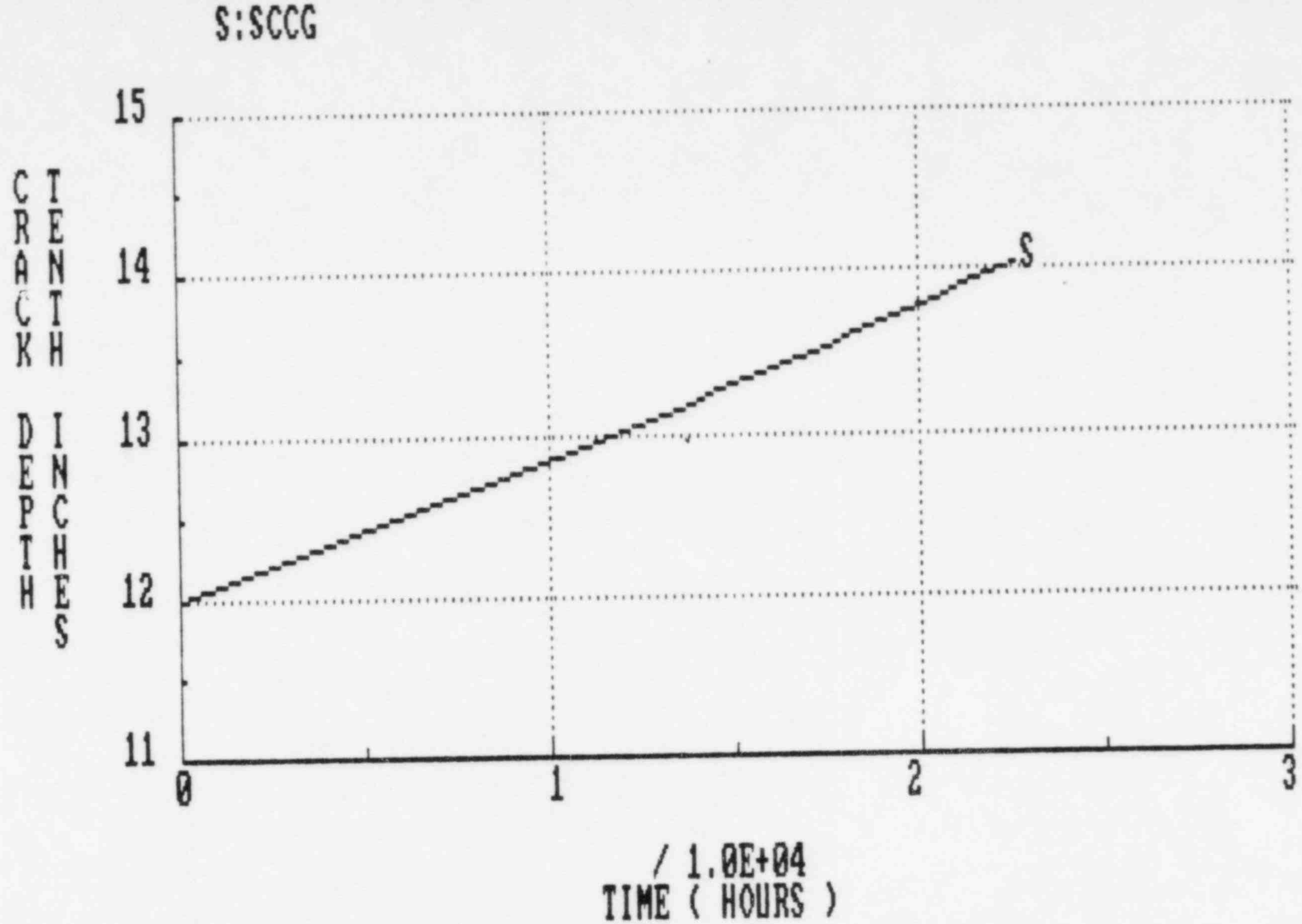
TENTH CRACK DEPTH
1
2
3
4

MODEL 0



AXIAL CRACK WITH NO RESIDUAL STRESS



CIRCUMFERENTIAL CRACK GROWTH WITH NO RESIDUAL STRESS

RESULTS/CONCLUSIONS

- A CONTINGENCY REPAIR PROCEDURE IS BEING DEVELOPED AND QUALIFIED FOR INCONEL- 82 WELD OVERLAY REPAIR OF NOZZLE TO SAFE-END WELDS.

- PROCEDURE USES GTAW TEMPER BEAD PROCESS SIMILAR TO THAT DEVELOPED UNDER EPRI SPONSORED PROGRAM AND RECENTLY APPROVED SECTION XI CODE CASE.

- METALLURGICAL TESTING SHOWS THAT HEAT AFFECTED ZONE IS TEMPERED WITHOUT PWHT, AND IS CONSISTENT WITH THE RESULTS OF ABOVE EPRI PROGRAM/CODE CASE.

- ANALYSIS SHOWS THAT:
  - RESIDUAL STRESSES ARE HIGHLY FAVORABLE (SIMILAR TO CONVENTIONAL OVERLAYS)
  - CRACK GROWTH IN INCONEL- 82 OVERLAY MATERIAL ACCEPTABLE FOR AT LEAST ONE FUEL CYCLE UNDER WORST CASE ASSUMPTIONS.