TVA

Tennessee Valley Authority, Post Office Box 2000, Soddy-Daisy, Tennessee 37379-2000

Robert A. Fenech
Vice President, Sequoyah Nuclear Plant

April 1, 1993

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D.C. 20555

Gentlemen:

In the Matter of	)	Docket Nos. 50-327
Tennessee Valley Authority	)	50-328

SEQUOYAH NUCLEAR PLANT (SQN) - ADDITIONAL INFORMATION FOR TECHNICAL SPECIFICATION (TS) CHANGE 92-16, DELETION OF TS SURVEILLANCE REQUIREMENT (SR) 4.4.10.b - SUPPLEMENTAL EXAM OF REACTOR VESSEL NOZZLES

Reference: TVA letter to NRC dated January 8, 1993, "Sequoyah Nuclear Plant (SQN) - Technical Specification (TS) Change 92-16 - Deletion of TS Surveillance Requirement (SR) 4.4.10.b - Supplemental Exam of Reactor Vessel Nozzles"

A meeting between TVA and NRC staff representatives was held in December 1992 to discuss TVA's TS Change 92-16 that would contain justification for deleting an SR associated with examination of SQN's reactor vessel nozzles for underclad cracking. TVA submitted to NRC TS Change 92-16 by the referenced letter. Information was subsequently requested by NRC that was provided by TVA to assist and support the NRC evaluation of TS Change 92-16.

In an effort to resolve additional NRC staff questions regarding proposed TS Change 92-16, a demonstration of current ultrasonic testing (UT) technology and sensitivities for detection of reactor pressure vessel (RPV) nozzle bore underclad cold cracking was conducted at Southwest Research Institute's (TVA's contractor) facilities in San Antonio, Texas, on March 23, 1993. NRC's Nuclear Reactor Regulation (NRR), Materials and Chemistry Branch Metallurgical Engineer, Donald Naujack, and NRR Contractor, John Gieske, were in attendance at the subject meeting. The information presented at the meeting is enclosed.

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With the demonstrated UT detection capability and its ability to meet the sensitivity requirements of SR 4.4.10.b, the following exam scope of the SQN Unit 1 RPV nozzles is being planned for the Unit 1 Cycle 6 refueling outage. The scope of the exam will be the standard 10-year American Society of Mechanical Engineers Section XI scope of the nozzle inside radius of all eight reactor nozzles. Additional examinations are planned for the Unit 1, Loop 1, outlet nozzle adjacent to the safe-end region, where four indications of underclad cold cracks were identified during the 1980 exam, and the Unit 1, Loop 2, inlet nozzle bore region, where 21 indications of underclad cold cracks were identified during the 1980 exam.

Indications of underclad cold cracks with amplitudes 20 percent of the distance amplitude curve (DAC) and greater will be further examined for size and length. Indications of underclad cold cracks with amplitudes less than 20 percent of the DAC will be assessed for disposition. The ultrasonic test sensitivity being applied during the Unit 1 Cycle 6 refueling outage will have the equivalent ability to discriminate underclad cold cracks at 20 percent of the DAC limits based on the demonstrated received signal from the 2-millimeter flat-bottom hole used for calibration in 1980.

As currently required in SR 4.4.10.b, the results of these Unit 1 exams will be reported to the NRC.

Additional underclad cold crack exams are not applicable to SQN Unit 2 because no underclad cold cracks were identified during the 1980 exams as a result of the manufacturing differences. TVA plans to conduct Section XI required exams of the SQN Unit 2 vessel nozzles. Results of the Unit 2 exams will be provided with the normal Unit 2 Cycle 6 inservice inspection report.

TVA requests confirmation from NRC as to the acceptability of the approach outlined above, as soon as possible, to support the ongoing Unit 1 Cycle 6 refueling outage.

Please direct questions concerning this issue to D. V. Goodin at (615) 843-7734.

Sincerely,

Robert A. Fenech

Robert A. Fenech

Enclosure
cc: See page 3

cc (Enclosure):

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Region II
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ENCLOSURE

TENNESSEE VALLEY AUTHORITY

INFORMATION PRESENTED TO NRC

AT THE SOUTHWEST RESEARCH

INSTITUTE FACILITY

SAN ANTONIO, TEXAS

MARCH 23, 1993

AGENDA

Opening Remarks/Background Discussion	-	D. Goetcheus, TVA
Program Introduction	-	G. Lagleder, SwRI
Review of Current SwRI Techniques	-	C. Barrera, SwRI
Results of Parametric Study	-	G. Lagleder, SwRI
PaR Device Demonstration	-	C. Barrera, SwRI
EDAS Demonstration	-	H. Diaz, SwRI
Technical Approach	-	R. Bentley, TVA
Closing Remarks	-	D. Goetcheus, TVA

PROGRAM INTRODUCTION

- Underclad flaws detected preservice and determined to be acceptable per ASME standards

- Baseline calibration procedures much more sensitive than typical ASME/RG1.150 procedures

- TVA has committed to determine if the flaws have grown under service conditions

PROGRAM OBJECTIVES

With a set of actual underclad crack specimens:

- Evaluate flaw response differences between baseline procedures and ASME/RG1.150 procedures

- Determine whether ASME/RG1.150 procedures can detect underclad flaws similar to those detected preservice

- Identify the differences in flaw sizing capabilities between the baseline procedures and current procedures

PROGRAM TASKS

- Analyze baseline data
- Obtain manual detection and sizing data on flaw set using baseline procedures
- Obtain automated detection and sizing data on flaw set using ASME/RG1.150 procedures

SwRI CURRENT

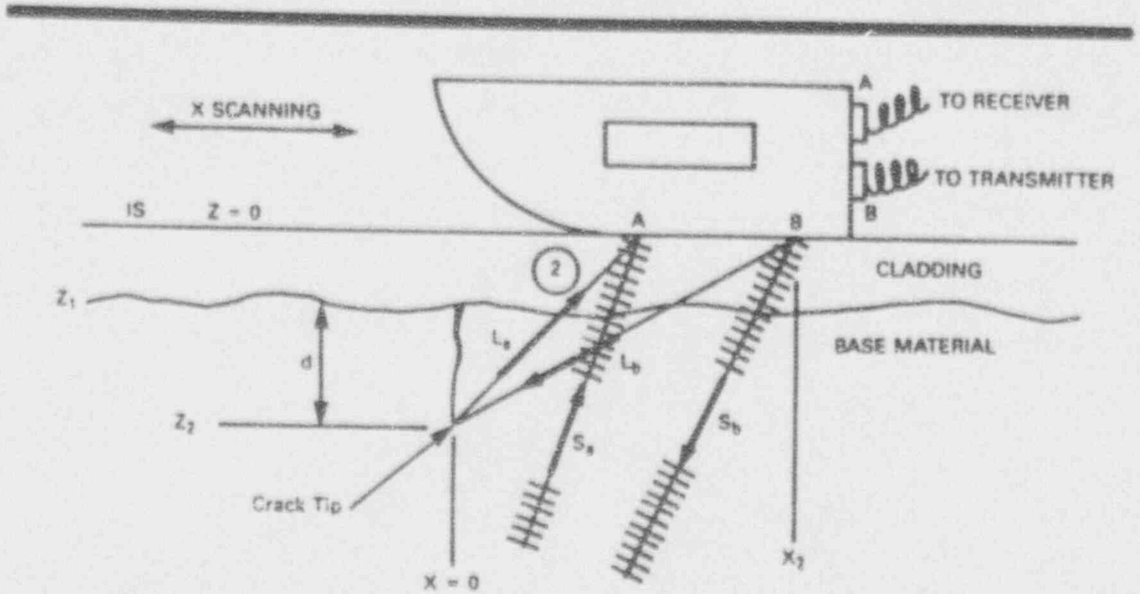
APPROACH TO

DETECTION OF

NEAR-SURFACE FLAWS

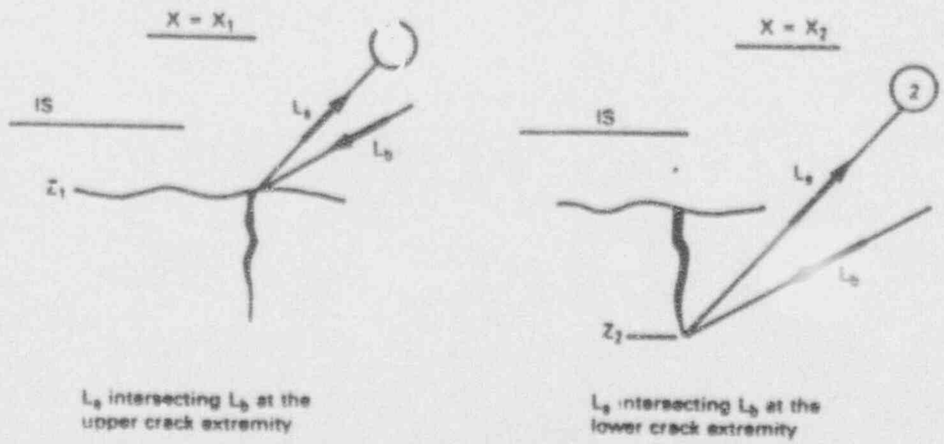
50/70 EXAMINATION METHOD

- NRC Regulatory Guide 1.150 requires the capability to effectively detect near-surface defects/flaws
- Prior to the 50/70, SwRI utilized a 70-degree refracted longitudinal, dual-element search unit
- As multibeam technology advanced, the 70-degree longitudinal dual search units were replaced by the 50/70 search units



INTERACTION OF THE TRANSMITTED L WAVE WITH AN UNDERCLAD CRACK

(A)



THE TWO MOST READILY OBSERVED PULSES

(B)

50/70 DESCRIPTION

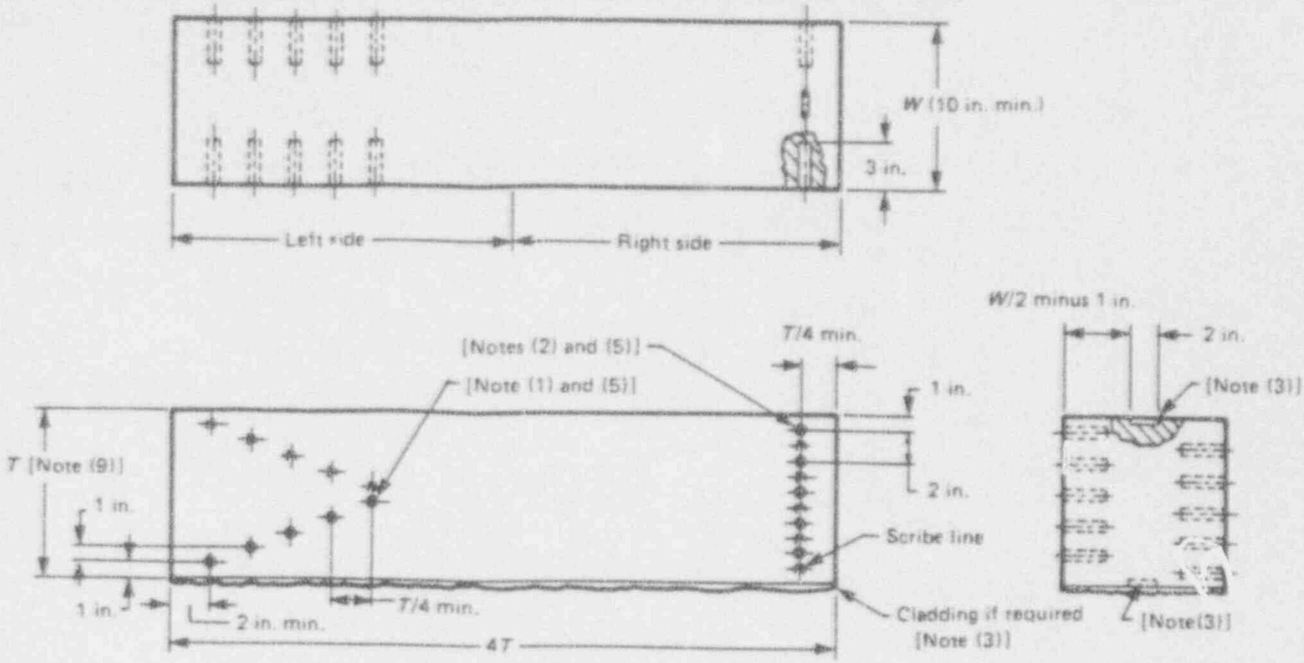
- Tandem search unit
- Multibeam/multimode
- Uses the longitudinal modes for performing examinations
- Used to examine in four directions
- Used for vessel wall (inner 1/4t) and nozzle bore near-surface examinations
- Used for nozzle butt weld (lower 1/3) examinations from the inside surface
- Used in video mode for detection

50/70 ADVANTAGES

- Relatively easy to perform distance amplitude calbrations
- Distance (depth) calibration allows for easy location of flaw depth
- Amplitude calibration is no more complicated than "standard" ASME DAC calibrations
- Due to the echo-dynamics, when scanning is performed in "beam component" direction, small flaws can be easily observed on a CRT even when "noise" or "lift-off" is present
- The 50/70 tandem search unit allows examination of a longer beam path than the "side by side" conventional 70-degree longitudinal dual search units
- Scan overlap with a 50/70 search unit is not as small as with a 70-degree longitudinal dual search unit
- When using the same calibration sensitivity, the 50/70 search unit will detect flaws at a higher amplitude than the 70-degree longitudinal dual search unit

50/70 CALIBRATION

- Distance calibration performed in depth rather than metal path
- Depth calibration is performed using side-drilled holes at various depths starting at the clad-base metal interface
- Depth of calibration is usually limited to 3-1/2 inches
- DAC curves for amplitude calibration are constructed the same way as any angle-beam DAC curve
- Side-drilled hole reflectors should be in accordance with Figure IWA-2232-1 of ASME Section XI



NOTES:

(1) Holes shall be drilled and reamed to 5/16 in. diameter and positioned at 1 in. intervals through the calibration block thickness as shown on the left side of Fig. IWA-2232-1. The five side-drilled holes positioned below center thickness are located on the near side; the five holes positioned above center thickness are located on the far side.

(2) Holes shall be drilled and reamed as shown in the right side of drawing but located on a scribe line at 1 in. intervals positioned through the thickness. The holes shall be alternated side to side as shown so that the distance between any two holes is 2 in. (top and bottom holes are 1 in. from the surface).

(3) One notch on top and one on the bottom as shown, each 2 in. long by 1/4 in. wide by 2%*T* deep. If the block is cladded, the through clad notch shall be 2% deep into the base metal. Notches shall be installed using flat end mills or other suitable means achieving the same notch profile.

(4) The tolerance for hole diameters shall be ± 1/32 in. Notch depth tolerance shall be +10 and -20%. The tolerance on hole location through the thickness and on depth shall be ± 1/8 in.

(5) For calibration blocks 4 in. and less in thickness, the dimensions shown are changed to:
   (a) width *W* shall be 2*T* or 6 in., whichever is less;
   (b) three side-drilled holes (min.) shall be installed at *T*/4 (max.) locations with hole diameter at 3/16 in., 1 1/2 in. deep.

(6) Calibration at DAC curves obtained using the block shall include all side-drilled holes representing the weld thickness to be examined.

(7) The surface notches and surface notch response calibration are optional.

(8) Inner near surface (clad-base metal interface) reflectors shall be installed as follows:
   (a) a 1/8 in. (max.) diameter side-drilled hole (SDH) shall be placed at the clad base metal interface to establish the reference level;
   (b) at least two additional in. (max.) SDH shall be installed at 1/2 in. increments (max.) to establish metal path calibration, and;
   (c) alternatively, for examinations conducted from the clad surface, a separate clad block may be used containing the reflectors in this Note, (a) and (b). Block thickness shall be 2 in. (min.).

(9) Calibration block thickness shall equal or exceed the maximum weld thickness to be examined.

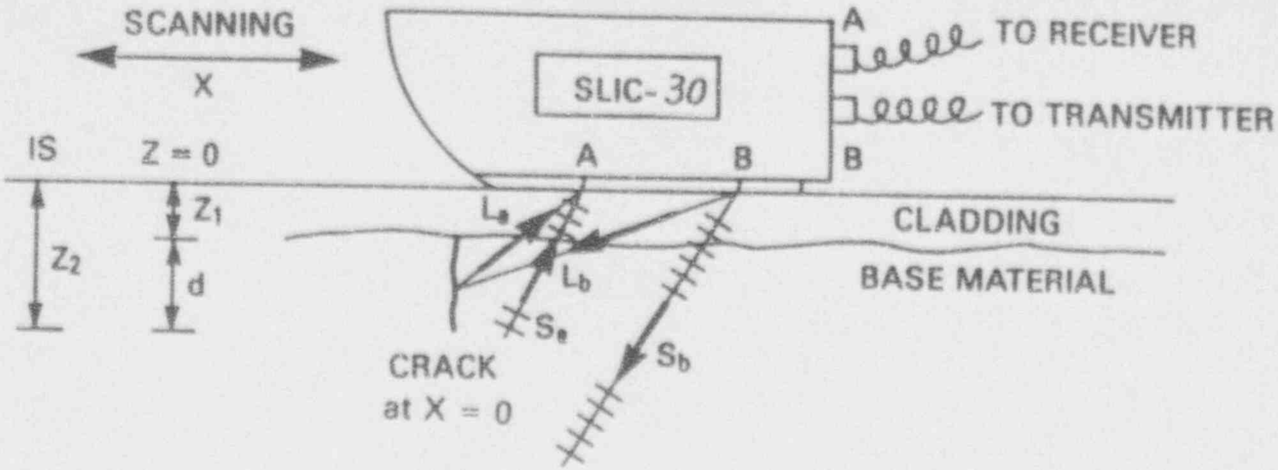
FIG. IWA-2232-1 ALTERNATIVE CALIBRATION BLOCK

SwRI CURRENT APPROACH TO SIZING OF NEAR-SURFACE FLAWS

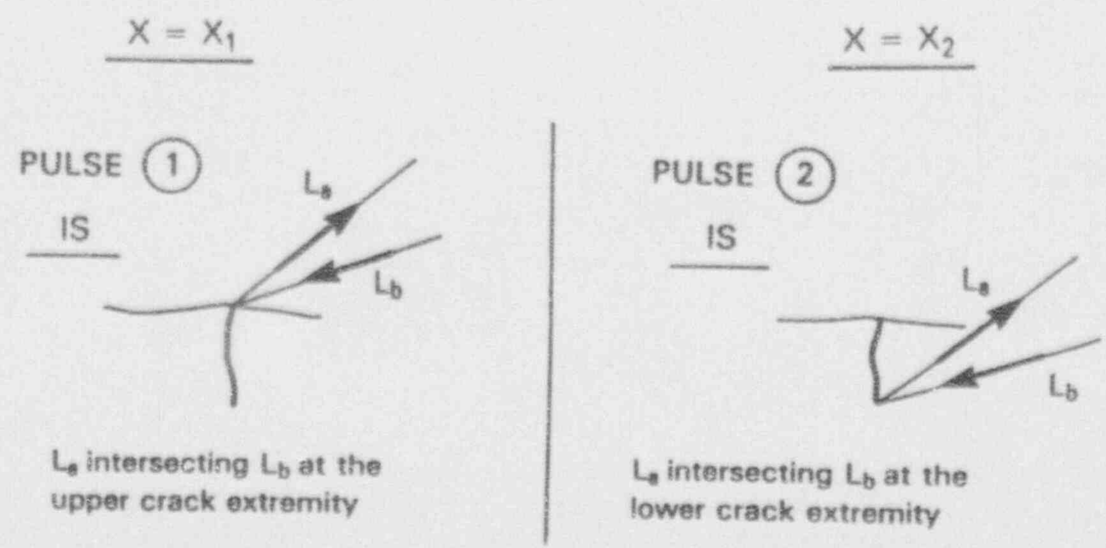
SHEAR LONGITUDINAL INVESTIGATION AND CHARACTERIZATION (SLIC) METHODS

- More accurate than conventional ASME Code sizing
- Prior to the SLIC technology, SwRI utilized high angle shear or longitudinal, single element search units

SLIC-30



(a) Transmitted (L_b, S_b) and received (L_a, S_a) beams.



(b) Two pulses returned by an underclad crack.

SLIC(S) DESCRIPTION

- Tandem search units
- Multibeam/multimodes
- Varying angles with each type of SLIC search unit
- SLIC search units complement each other
- Applicable SLIC depth ranges overlap each other
- Used in RF mode for sizing

SLIC TYPES AND ADVANTAGES

- SLIC 30
    - 10L and 60L
    - Narrow echo-dynamics
    - Performs similar to zero degree
    - 0" - 1.0" (applicable depth range)
- SLIC 40
    - 50L and 70L
    - Broad echo-dynamics
    - Performs similar to 45 degrees
    - 0" - 2.0" (applicable depth range)
- SLIC 50
    - 40S and 60L
    - Broad echo-dynamics for lower flaw tip
    - Narrow echo-dynamics for upper flaw tip
    - 0" - 1.0" (applicable depth range)
    - Does not lend itself to small radius
    - Excellent for underclad cracking

SLIC TYPES AND ADVANTAGES (CONT'D)

- SLIC 45
  - 10L and 60S
  - Broad echo-dynamics
  - Performs similar to zero degree
  - Excellent for surface connected flaws
  - Applicable for top of flaw location only
- SLIC 25/35 and 15/20
  - Applicable for deeper flaws

MULTIBEAM CALIBRATION

- Distance calibration performed in depth rather than metal path
- Depth calibration is performed using side-drilled holes at various depths
- Depth of calibration is usually limited to type of SLIC

Underclad Cracking Test Block Actual Flaw Sizes

Block Identification	Flaw Length (in.)	Flaw Depth (in.)	Aspect Ratio
W–A–1	1.25	.23	5.4 : 1
W–A–2	.65	.11	6.0 : 1
W–A–3	1.63	.31	5.3 : 1
W–B–1	1.25	.23	5.4 : 1
W–B–2	.65	.11	6.0 : 1
W–B–3	1.63	.31	5.3 : 1
PS–1	.25	.11	2.3 : 1
PS–2	.58	.25	2.3 : 1
PS–3	.76	.33	2.3 : 1
Appendix VIII – 1A	1.43	.14	10.2 : 1
Appendix VIII – 1B	1.95	.14	13.9 : 1
Appendix VIII – 2A	1.93	.68	2.8 : 1
Appendix VIII – 2B	1.98	.68	2.9 : 1

AVERAGE MAXIMUM FLAW AMPLITUDE (PERCENT OF DAC)

BLOCK IDENTIFICATION	FLAW LENGTH/DEPTH (IN.)	MANUAL PSI TECHNIQUE	AUTOMATED ASME/RG 1.150 TECHNIQUE
W-A-1	1.25/.23	566	35
W-A-2	.65/.11	631	37.5
W-A-3	1.63/.31	669	48.5
W-B-1	1.25/.23	318	25.5
W-B-2	.65/.11	238	46
W-B-3	1.63/.31	355	37
PS-1	.25/.11	596	24.5
PS-2	.58/.25	450	26
PS-3	.76/.33	358	22.5
1A	1.43/.14	312	28.5
1B	1.95/.14	362	34
2A	1.93/.68	197	39
2B	1.98/.68	262	28.5
SQ-54*	2 mm FBH	100	20

* 2 mm end-drilled, flat-bottomed hole sensitivity compared to the ASME 1/8" diameter side-drilled hole sensitivity (manually). Data acquired with a flat shoe on a curved surface.

SwRI AUTOMATED INSTRUMENT CALIBRATION RECORD

Sheet No.: 145002

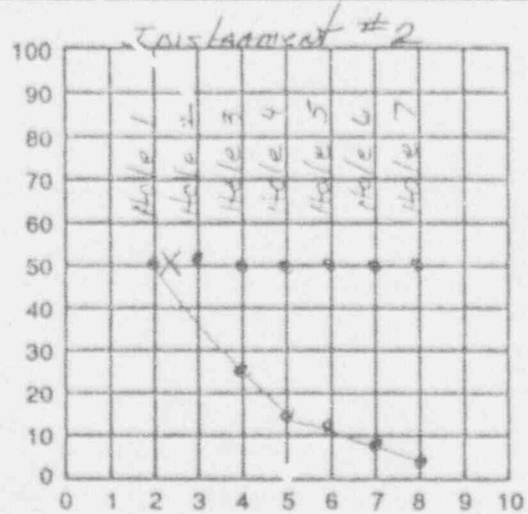
SwRI Project No.: 17-5339	Site: SwRI - Sequoyah Demo	Date (Day-Mo-Yr.) 17 MAR 93	Time: (24 Hr. Clock) 1440
Examiner (Signature) [signature] / SNT Level: II	Examiner: [signature] Date: 18 MAR Time: 0716 / SNT Level: II	Procedure No.: SEE REMARKS Rev.: Chg.: ICN:	

Search Unit

Serial No.	4055
Size	.25 X .5
Frequency (MHz)	2.25
Nominal Angle	50-70
Measured Angle	NR
Brand	SwRI

Instrument Settings

DAC Course dB	20
DAC Fine dB	9
Scan Course dB	N/A
Scan Fine dB	N/A
Frequency	2.25
Horizontal Delay	055
Material Cal.	← 50n
Range/Sec./Div.	2NS
Damping	A
Rep. Rate	1.0
Filter	N/A
Trim	TDC
Preamp/Norm	Preamp
Couplant	H_2O



X - END DRILLED FLAT BOTTOM HOLE (SQ-54)

Reflectors: Notches ☐ Holes ☑ Axial ☐ Circ. ☐ Other ☐

10 Screen Divisions = AR Inches of Metal DEPTH

Mode: Longitudinal ☐ Shear ☐ Multi-Beam ☑

Transmission: Through ☑ Normal ☐

Jack Used: R ☐ T ☐ Both ☑

Ultrasonic Instrument:

Sonic MK II ☐ SwRI MK II A ☑ Other ☐

Serial #	171123
Pulser Gain/Can No. / Strap No.	35
Initial Basic Cal. Block Temp. °F	N/A
Pyrometer Serial No.	

Search Unit Cables

Exam/Cal	Number	Type	Length	Channel
EXAM	2/3-4	RG62/RG174	253'/22"	2
N/A	N/A	N/A	N/A	N/A

Remote Cable Calibration

Signal	Amplitude	Distance	Screen Div.	Course Gain	Fine Gain
Calibration Cable	N/A				
Examination Cable					

TCG / Instrument Function Checks

Signal	Amplitude	Distance	Screen Div.	Course Gain	Fine Gain
	N/A				

TCG Settings

DAC/TCG Channel	Marker Gain	Marker Freq.	DAC Span	DAC Delay
1	80	2.25	5 X.5	0

References

Basic Cal. Block(s)	SQ-45
Aux Cal. Block(s)	N/A
Linearity Sht. No. (s).	N/A
Beam Spread Sht. No.	N/A
EDAS Cal. Sht. / Set	139001

Reviewed By: [signature] SNT Level: III Date: 23 Mar 93

SwRI FORM No. NDTR 17-145 (Rev. 3/92)

Instrument Function Check

Date	Time	Initials		Date	Time	Initials

Calibration Verification

Date	Time	Temp °F	Initials	Initials		Date	Time	Temp °F	Initials	Initials
18MAR	0716		RR							
19MAR	0840		R							
20MAR	0700		R							
20MAR	1425		R							
21MAR	0915		RR							
21MAR	1220		RR							
22MAR	0840		RR							
22MAR	1625		RR							
23MAR	1221		RR							

Examination No.(s): 1 DEMO THRU 6 DEMO

Remarks: Referenced Procedure SEQ Att 15, Rev 0, Dev 0 for Guidance.
+14dB TO BRING ~~ED FBH~~ RR END DRILLED FLAT BOTTOM HOLE REFLECTOR TO
100% OF ~~[illegible]~~ RR ASME DAC.

MANUAL –VS– AUTOMATED FLAW LENGTH SIZING

BLOCK IDENTIFICATION	ACTUAL LENGTH (IN.)	PSI TECHNIQUE* ERROR	SwRI TECHNIQUE** ERROR
W–A–1	1.25	−0.22	−0.23
W–A–2	0.65	0.82	0.55
W–A–3	1.63	0.86	−0.13
W–B–1	1.25	−0.35	−0.55
W–B–2	0.65	0.82	0.45
W–B–3	1.63	−0.03	−0.24
PS–1	0.25	0.25	0.10
PS–2	0.58	0.48	0.32
PS–3	0.76	0.64	0.14
1A	1.43	−0.06	−0.26
1B	1.95	−0.02	−0.35
2A	1.93	−0.43	−0.83
2B	1.98	0.20	0.02
	MEAN ERROR	0.23	−0.08
	VARIANCE	0.193	0.144

* Lengths taken at 1/4 max. amplitude.

** Lengths taken at 1/2 max. amplitude.

MANUAL ESTIMATED –VS– AUTOMATED FLAW DEPTH (THRU–WALL) SIZING

BLOCK IDENTIFICATION	ACTUAL DEPTH (IN.)	PSI TECHNIQUE* ERROR	SLIC TECHNIQUE ERROR
W–A–1	0.23	0.11	0.01
W–A–2	0.11	0.38	0.08
W–A–3	0.31	0.52	0.05
W–B–1	0.23	0.00	0.02
W–B–2	0.11	0.19	0.23
W–B–3	0.31	0.02	0.09
PS–1	0.11	0.05	0.03
PS–2	0.25	0.10	0.10
PS–3	0.33	0.13	0.09
1A	0.14	0.31	0.05
1B	0.14	0.50	0.03
2A	0.68	–0.18	0.06
2B	0.68	0.04	–0.05
	MEAN ERROR	0.17	0.06
	VARIANCE	0.039	0.004

* Estimated by using length divided by three.

CONCLUSIONS

- ASME/RG1.150 techniques are capable of detecting underclad flaws as small as .25 long x .11 deep
- Current sizing methods can improve sizing capabilities over estimates used during the baseline examinations

DATA CORRELATION

A direct correlation between the baseline data and upcoming ISI data may prove to be very difficult because:

- Manual indication location methods are inherently more error prone than automated methods
- Manual search unit manipulation allows optimization of signal amplitude better than automated equipment

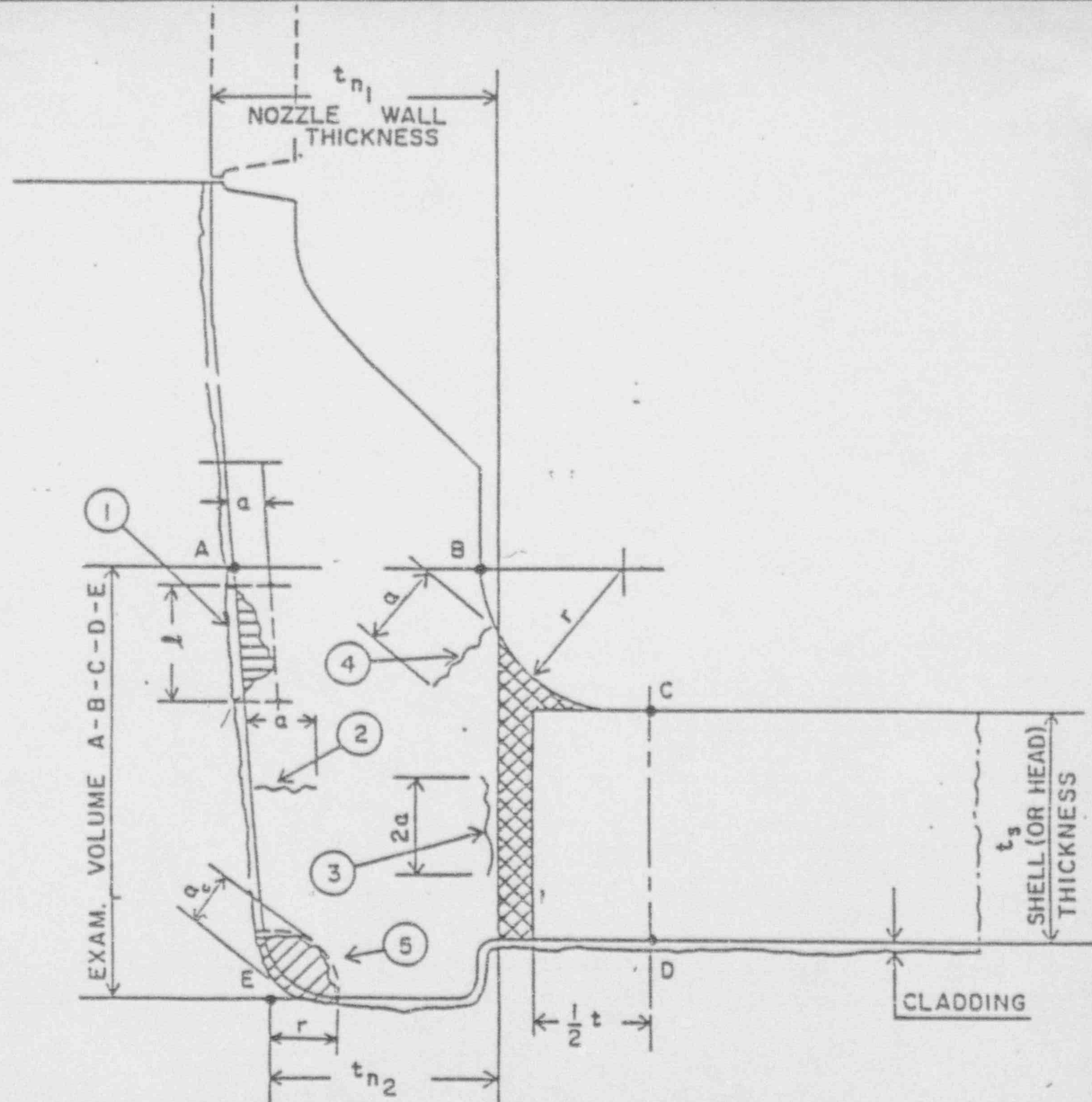
FLAW DETECTION

Flaw detection/discrimination capabilities are enhanced with automated data acquisition equipment because:

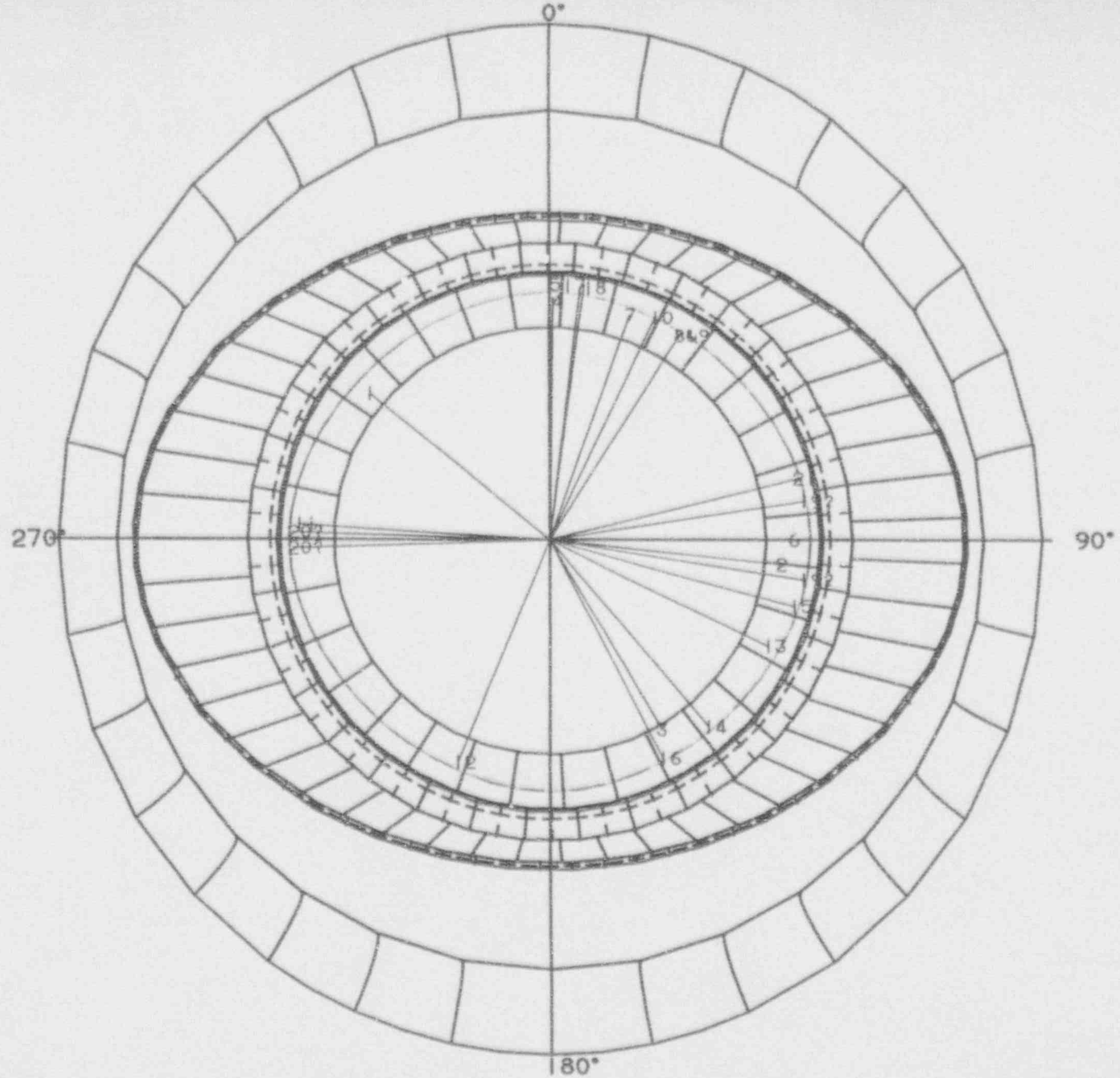
- Signal patterns are more easily discerned
- Flaw location information can be easily integrated with signal response information

NOZZLE BORE EXAMINATION GOAL

Determine if any of the larger flaws have grown during service

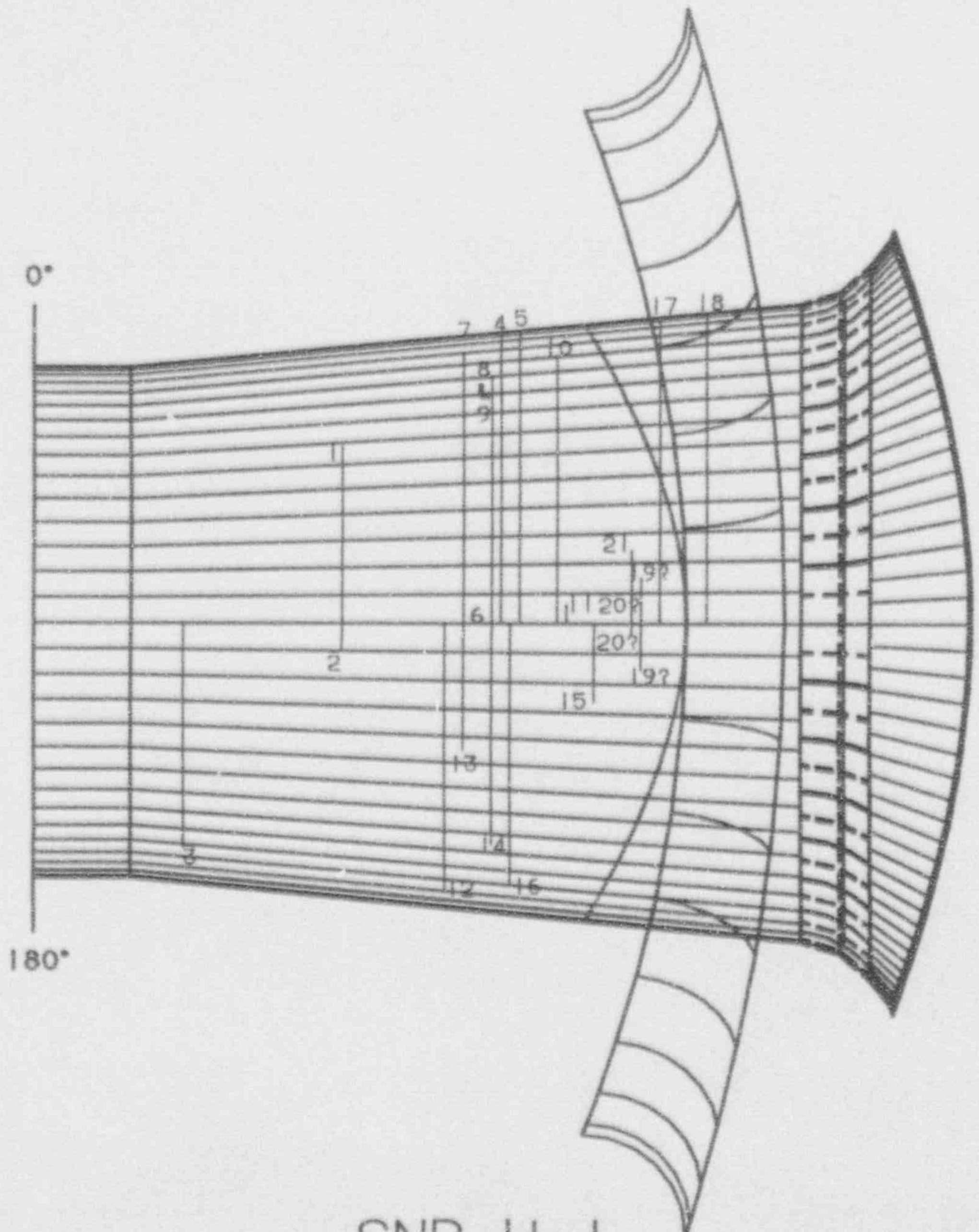


t_{n_1}
NOZZLE WALL THICKNESS
A
B
C
D
E
1
2
3
4
5
a
a
a
2a
a_c
ℓ
r
r
t_{n_2}
$\frac{1}{2}$ t
t_s
SHELL (OR HEAD) THICKNESS
CLADDING
EXAM. VOLUME A-B-C-D-E

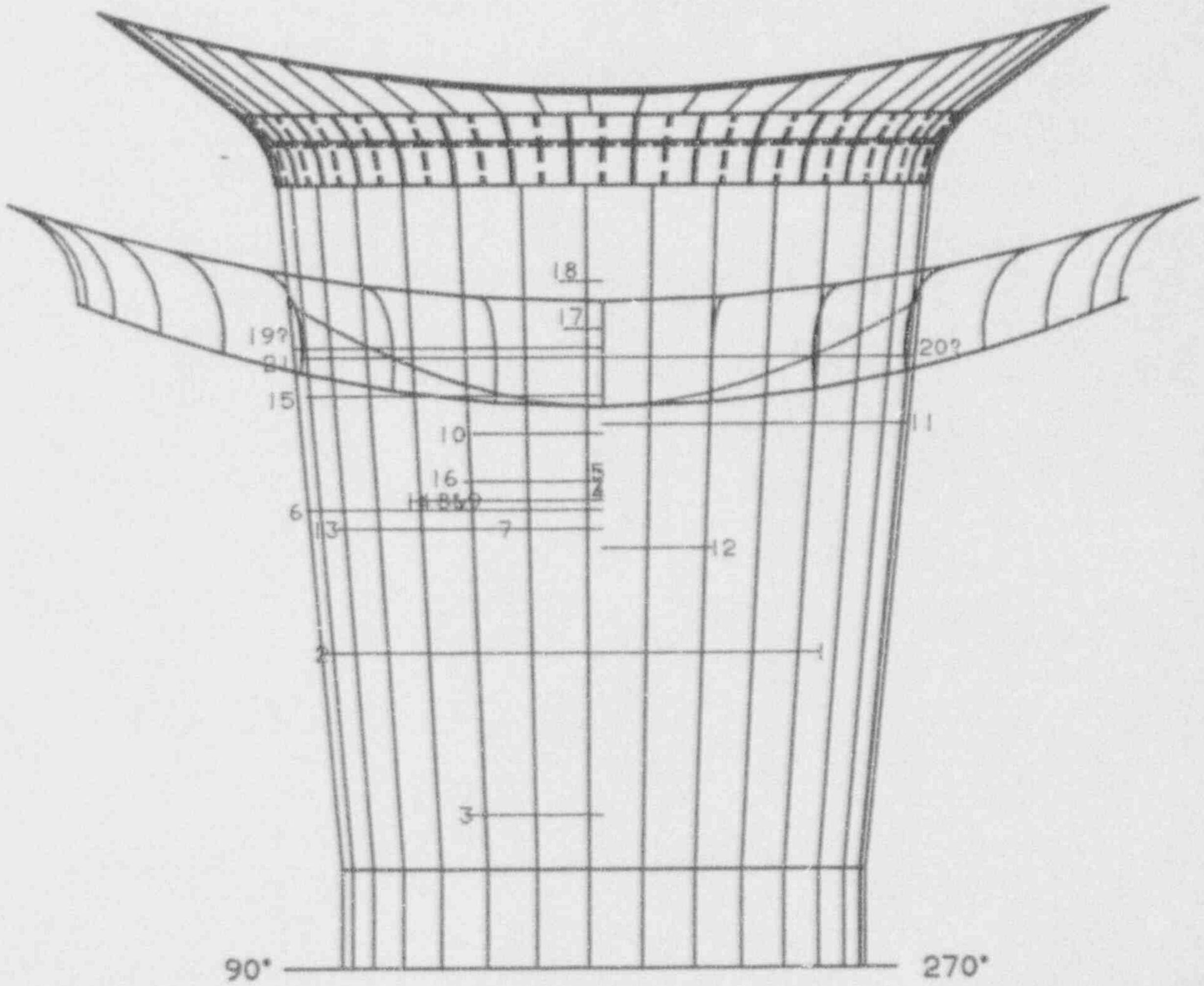


SNP U-1
COLD LEG LOOP 2

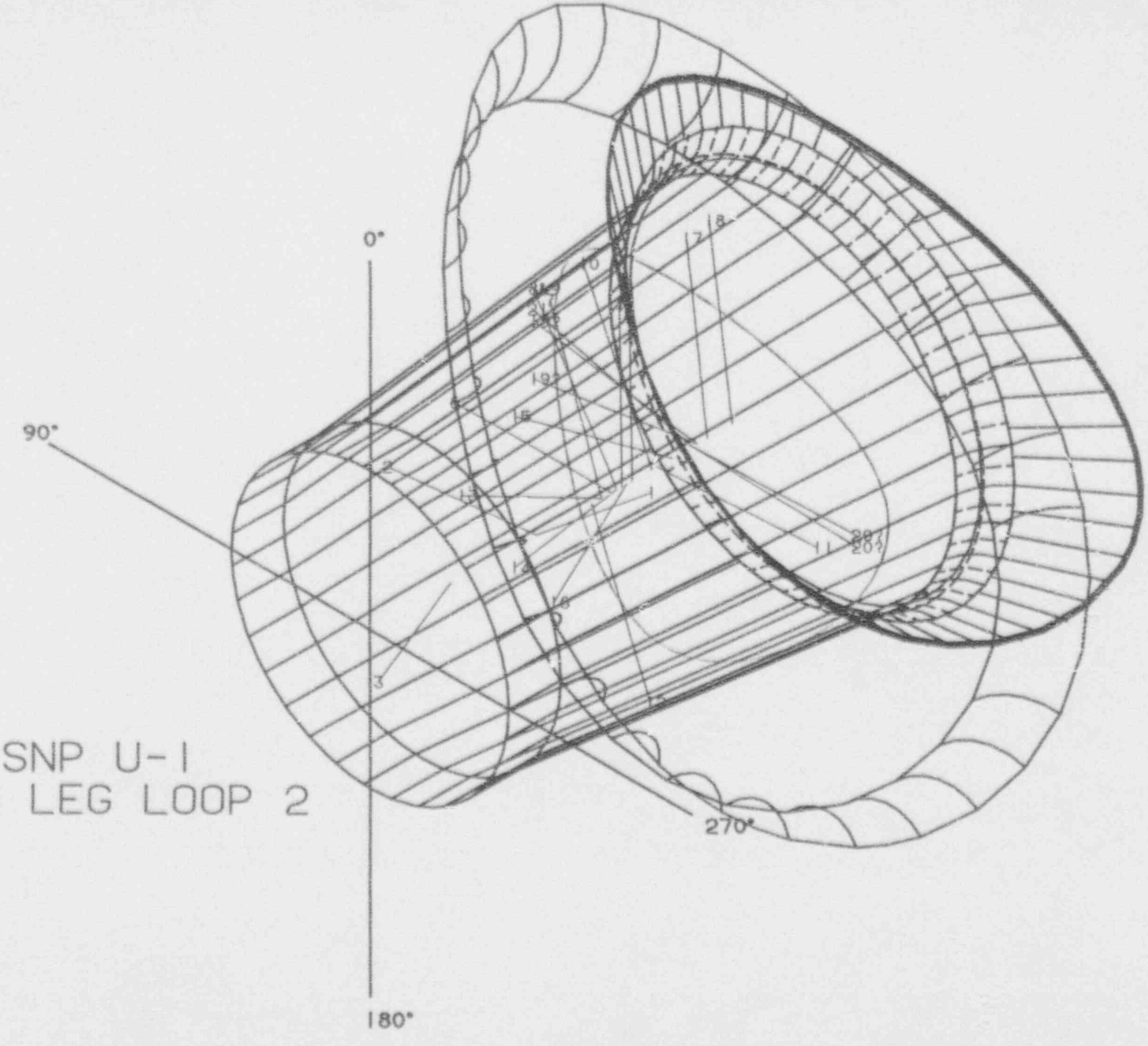
COMMENT=
GROUP=AA45 SUBGRP=SPCPRJ SCALE= 0.1000 DRAWID=PLT CLD SMALL 13-17 LIST FILE=93077 13.06
DATE= 3/18/93 TIME=13.20 ACCESS=NONE FMT=
LOGON ID=@KBB9CI
PLOT= 1



SNP U-1
COLD LEG LOOP 2



SNP U-1
COLD LEG LOOP 2



SNP U-1
COLD LEG LOOP 2