REACTOR PRIMARY SYSTEM INVESTIGATION

AT NINE MILE POINT NUCLEAR STATION

NIAGARA MOHAWK

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May 1, 1970

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1. INTRODUCTION AND SUMMARY

INTRODUCTION

On March 2, 1970, the station was shut down for repairs to the generator exciter reduction gear. During this outage, two small cracks were found in the west (Number 11) core spray nozzle (N6B) safe end.

Prior to this outage with the reactor at full 1,000 pound per square inch pressure, there was no detectable increase in the drywell equipment drain and floor drain pump out. With a static head of about twenty feet of water, the observed leakage at the cracks was estimated at about fifty drops per minute. An immediate investigation was started to determine the cause of the west core spray nozzle safe end failure:

1. It was first found that excessive stresses were produced at the location of failure by an inadequately designed pipe suspension system.

2. An exhaustive program of materials study on the failed safe end was initiated. Preliminary results of this study are recorded in the General Electric Report NEDM-10159 dated March 27, 1970. Further investigations are contained in this report which supercedes the previous one. These studies included dye-penetrant inspection, ultrasonic response traces, radiographic photographs, chemical tests, and metallographic photomicroscopy.

3. The Teledyne Materials Research Corporation (TMR) was employed to perform an independent study of all primary system piping arrangements in the drywell. Advance results of this study were forwarded to engineering and field personnel to initiate corrective action. The TMR study included as Section 6 of this report includes the following:

   (a) A field inspection of all primary system piping hangers and restraints.

   (b) Recalculation of all piping stresses which may exist during operation or shutdown to disclose whether any additional excessive stresses may have occurred in the primary systems.

   (c) Recommendation for redesign of any piping or piping suspension systems as required to assure acceptable stress throughout the primary systems in the drywell.

4. Dr. James G. Sylvester, an independent materials consultant, was employed to represent Niagara Mohawk in the evaluation of the materials studies.

5. Samples of the failed safe end were delivered to the Atomic Energy Commission for examination at the Battelle Northwest Laboratories, Richland, Washington.

Table I is a cross reference of primary system nomenclature used on the various reports and engineering drawings. It is published to assist in assuring positive identification of each system when reviewing these documents.

WEST CORE SPRAY SYSTEM (N6B)

The excessive stress at the west core spray nozzle safe end was the result of designing the pipe hanger and seismic restraint system for the assumed most severe case where both the reactor vessel and the core spray line were at the maximum design temperature of 575° F. In addition, the hanger loadings were set for the case with no water in the pipe. The post-failure study disclosed that the most severe unsupported pipe loading would occur with the reactor vessel heated to maximum temperature and the pipe at drywell temperature. Calculations by General Electric and TMR indicate that the stress near the point of failure was between 88,000 psi and 92,000 psi. This is about six times the stress which would normally be allowed by any piping code. Details of the stress analysis review are contained in the Teledyne Material Research Report in Section 6. The extra high stress was caused in part by an interference which caused an 11/16 inch vertical deflection limit.

Metallographic observations of the failed material reveal that the microstructure is typical of solution-treated, furnace-sensitized, austenitic stainless steel with precipitate carbides at the grain boundaries. Chemical analysis of the safe end material disclosed no abnormalities. The inner surface of the failed safe end was coated with a very thin, uniform, adherent, dark brown, matte-finish oxide layer. Chemical analysis of inner surface scrapings indicated the presence of fluorides. Throughout reactor operations prior to this outage, reactor water chlorides averaged well below 0.1 ppm.

Permission was received from the AEC to lower the reactor water below the core spray nozzle to permit replacement of the safe end without removal of reactor fuel. A new safe end assembly composed of inner and outer mating parts was obtained and welded into place. Material for the new safe end was solution treated (non-sensitized) SA 182F304L stainless steel. Restoration also required a replacement extension of the core spray nozzle thermal sleeve.

The original 12-inch core spray line fitted to the 6-inch reactor nozzle safe end through a 12" x 6" reducing elbow. This arrangement served to concentrate in the safe end any stresses resulting from forces on the 12-inch line.

TABLE I

MAJOR PRIMARY SYSTEMS

System Name	Reactor Vessel Nozzle No.	Reactor Vessel Azimuth	Drywell Penetration Number	Recirculation Loop Termination	Piping System Number	Station Operations Name	Notes
*West Core Spray	N6B	240°	X14	---	40	11 Core Spray	
*East Core Spray	N6A	60°	X13A	---	40	12 Core Spray	
*West Emergency Condenser Steam Supply	N5A	70°	X3A	---	39	11 Emergency Condenser Steam	Steam Lines Cross North
*East Emergency Condenser Steam Supply	N5B	290°	X3B	---	39	11 Emergency Condenser Steam	Of Reactor Inside Drywell
West Emergency Condenser Condensate Return	---	---	X5B	PS5	39	11 Emergency Condenser Return	Enters No. 15 Recirc. Pump Suction
East Emergency Condenser Condensate Return	---	---	X5A	PS1	39	12 Emergency Condenser Return	Enters No. 11 Recirc. Pump Suction
West Main Steam Line	N3B	270°	X2A	---	01	11 Main Steam Line	
East Main Steam Line	N3A	40°	X2B	---	01	12 Main Steam Line	
West Feedwater Line	N4C N4D	225° 315°	X4A	---	31	11 Feedwater Line	
East Feedwater Line	N4A N4B	45° 135°	X4B	---	31	12 Feedwater Line	
Shutdown Cooling Suction	---	---	X8	PS4	38	Shutdown Cooling Outlet	Enters 14 Recirc. Pump Suction
Shutdown Cooling Return	---	---	X7	PD10	38	Shutdown Cooling Inlet	Enters 15 Recirc. Pump Discharge

TABLE I

MAJOR PRIMARY SYSTEMS

System Name	Reactor Vessel Nozzle No.	Reactor Vessel Azimuth	Drywell Penetration Number	Recirculation Loop Termination	Piping System Number	Station Operations Name	Notes
Clean-Up System Suction	---	---	X9	PS1	33	Clean-Up System Outlet	Enters 11 Recirc. Pump Suction
Clean-Up System Discharge	---	---	X154	PD7	33	Clean-Up System Inlet	Enters 12 Recirc. Pump Discharge
*Control Rod Drive System Discharge	N9	270°	X174	---	44.1	Control Rod Drive Hydraulic System	
A-Recirc. Loop						11 Recirc. Loop	
*Suction PS1	N1A	42°	---	---	32	Outlet	
*Discharge PD6	N2A	0°	---	---	32	Inlet	
B-Recirc. Loop						12 Recirc. Loop	
*Suction PS2	N1B	114°	---	---	32	Outlet	
*Discharge PD7	N2B	72°	---	---	32	Inlet	
C-Recirc. Loop						13 Recirc. Loop	
*Suction PS3	N1C	186°	---	---	32	Outlet	
*Discharge PD8	N2C	144°	---	---	32	Inlet	
D-Recirc. Loop						14 Recirc. Loop	
*Suction PS4	N1D	258°	---	---	32	Outlet	
*Discharge PD9	N2D	216°	---	---	32	Inlet	
E-Recirc. Loop						15 Recirc. Loop	
*Suction PS5	N1E	330°	---	---	32	Outlet	
*Discharge PD10	N2E	288°	---	---	32	Inlet	

* Furnace Sensitized Stainless Steel

A new ell shaped pipe section was made up to replace the reducing elbow with a 6" x 6" elbow and a 4' - 4" straight section of 6-inch pipe terminating in a straight 6" x 12" increaser. The new arrangement will serve to relieve some of the stress concentration at the safe end. Maximum longitudinal stress in the new safe end with redesigned piping and hanger arrangement is calculated by TMR at 12,600 psi.

The original spring hangers on the west core spray line are being replaced with new hangers to support the full range of expected pipe loadings. In addition, an additional constant support hanger will be installed on the vertical section of 12-inch pipe about 10 feet below the core spray nozzle.

EAST CORE SPRAY SYSTEM (N6A)

The hanger design for this core spray system was essentially the same as the west core spray system. The only difference was that no collar-type seismic restrainers were installed on the east system. However, because of the weak support design, a longitudinal stress of 31,800 psi would exist at the reactor nozzle safe end during normal operation of the plant.

Dye-penetrant, ultrasonic, and radiographic inspections did not detect any cracking in the east core spray safe end; however, it was decided that this safe end should be removed, inspected, and replaced in an identical manner to the west core spray. A redesigned pipe hanger system similar to the west core spray will also be installed. With the redesigned system, maximum longitudinal stress at the nozzle safe end will be reduced to 10,900 psi.

EMERGENCY CONDENSER SYSTEM

A sample was cut from the west emergency condenser nozzle safe end N5A after indications were disclosed on dye-penetrant examination. Photo microscopy indicated intergranular attack to a maximum depth of 40 mils on the outside surface. TMR reported total longitudinal stress on the east and west emergency cooling steam line near the nozzle as 15,600 and 14,200 psi respectively. Double wall radiographs and ultrasonic probes disclosed no indication of internal cracking.

MAIN STEAM AND FEEDWATER SYSTEMS

All feedwater and main steam nozzles were examined by ultrasonic and radiographic procedures. No indications of cracking were observed. Dye penetrant examination disclosed no serious surface flaws. TMR reports no excessive stress in any of these lines.

RECIRCULATION LOOPS

All ten recirculation loop nozzles were externally examined by dye-penetrant, ultrasonic, and radiographic procedures. Ultrasonic and radiographic

indications were noted on the safe end field welds, but these were accounted for by the step in the pipe structure at this location. Various "strawberries" occurred in the dye-penetrant indicating minor surface imperfections. Photographs of these are on file along with maps of the locations. On N2A safe end the indication at 10 o'clock disappeared after a 15 mil grind. No cracks or serious pipe imperfections were observed. (Appendix B)

The TMR Corporation calculations of piping stress indicate no excessive stresses were found in these systems.

REACTOR SAFETY VALVE NOZZLES

All reactor safety valve and other head nozzles were examined for flaws by dye-penetrant and ultrasonic procedures. (Appendix B) Photographs and maps are on file at the station. No evidence of attack was observed on the inside of these nozzles although some probe grinding was done to explore surface indications. On the outside surface roughly half of these nozzles showed some evidence of shallow surface attack. Radiographs were made of the outer ring of nozzle safe ends. These show no cracking.

SHUTDOWN COOLING SYSTEM

Weight stress, expansion stress, and pressure stress were calculated for the shutdown cooling system to the first isolation valves outside the drywell. Maximum longitudinal stresses of 36,900 and 22,000 psi were found in the suction and discharge lines respectively. Dye penetrant, ultrasonic, and if indicated, radiographic examinations will be made at these locations.

CLEAN-UP SYSTEM

Weight stress, expansion stress and pressure stress calculations were made for the clean-up system to the first isolation valve outside the drywell. Maximum longitudinal stresses of 25,300 and 25,300 psi were found in the suction and discharge lines respectively. Dye penetrant and ultrasonic examinations will be made at these locations.

The stress analysis in drywell primary systems is continuing. Recommendations for hanger changes will be made by TMR as indicated in their report in Section 6.

SUMMARY

The evaluation of analytical, laboratory, and non-destructive testing work performed has resulted in the following conclusions:

1. The mechanism of failure of the core spray nozzle safe end N6B was intergranular cracking that started on the inside surface of the safe end and progressed at the leaking locations to the outside diameter.

The failure of the Nine Mile Point reactor core spray pipe was due to stress corrosion cracking of furnace sensitized 304 stainless steel. The induced stress was quite high due to a design error, and the crack initiation propagation rate was probably accentuated by the presence of a high oxygen concentration in the stagnant core spray pipe leg. Internal fluoride contamination may also have been a contributing factor.

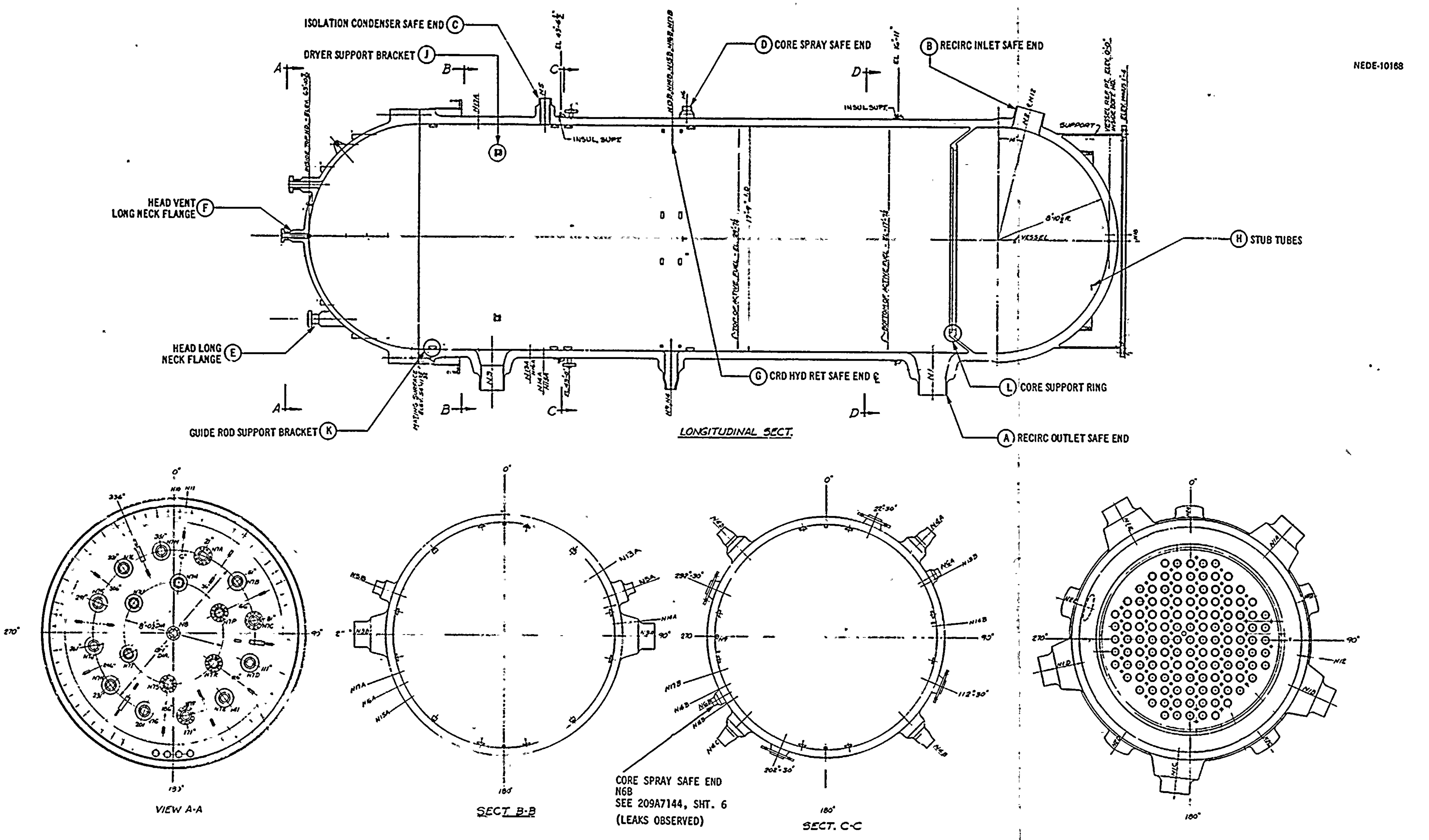
Furnace-sensitized 304 stainless steel used in Nine Mile Point is similar to that which may be found on other operating BWR's for which up to 10 years satisfactory experience exists.

Shallow transgranular and intergranular attack was found on the outside of the nozzle. Minor transgranular cracking on the o.d. could be of chemical origin or due to original forging imperfections.

2. Penetrant examination was performed on all accessible furnace sensitized stainless steel internal to the vessel, followed by sampling and metallographic examination of selected indications. There was no service induced intergranular attack on the interior accessible surfaces other than the leaking nozzle. Accessible interior surfaces included all head flange inside diameters, the inside diameters of both emergency condenser nozzle safe ends, and surfaces on the four dryer support bracket lugs and the two guide rod support brackets.

   A sample removed from the dryer support bracket showed an intergranular penetration at the root of a manufacturing defect. This may have been the result of entrapment of a corrodant pickling solution or of hot cracking during operations at the mill.

   A sample removed from the guide rod support bracket consisted of weld metal which contained interdendritic fissuring. This appears to have been caused by hot tearing during the welding process.



NOZZLE SCHEDULE

NOZZLE NUMBER	QUANTITY	SIZE	FUNCTION	AZIMUTH	ELEVATION	MATING PIPE O.D.	MATING PIPE SCH.	MATING PIPE MTL.
N1A thru N1E	5	36" to 28"	RECIRCULATION OUTLET	42°, 114°, 186°, 258°, 330°	14'-0"	28"	1.125"	SA240-TP304
N2A thru N2E	5	28"	RECIRCULATION INLET	0°, 72°, 144°, 216°, 255°	SEE LONGTDNL SECT.	28"	1.125"	SA240-TP304
N3A, N3B	2	24" SPCL	STEAM OUTLET - TURBINE	90°, 270°	49'-3"	24"	1.250"	SA212 GRB
N4A thru N4D	4	10" SPCL	FEEDWATER	45°, 155°, 225°, 315°	35'-2"	10.750"	SCH 100	SA106 GRB
N5A, N5B	2	10"	STEAM OUTLET - EMERG. CONDENS.	70°, 290°	45'-1"	10.750"	SCH 100	SA312-TP304
N6A, N6B	2	6"	CORE SPRAY	60°, 240°	34'-0"	6.625"	SCH 80	SA312-TP304
N7A thru N7U	16 PLUS 2	6"	SAFETY VALVE & INSTR.	SEE VIEW A-A	SEE LONGTDNL SECT.	—	—	—
N8	1	4"	VENT	SEE VIEW A-A	SEE LONGTDNL SECT.	—	—	—
N9	1	3" SPCL.	CONT. ROD DR. - HYD. SYS. RETURN	270°	35'-2"	3.500"	SCH. 80	SA312-TP304
	129	6" SPCL	CONTROL ROD DRIVE	SEE SECT. D-D				
	64	2" SPCL	FLUX MONITOR	SEE SECT. D-D				
N10	1	1"	HIGH PRESS. SEAL LEAK DETECT.	0°	SEE SH. 2	—	—	—
N11	1	1"	LOW PRESS. SEAL LEAK DETECT.	3°-37'	SEE SH. 2	—	—	—
N12	1	2"	CORE DIFFERENTIAL PRESS.	98°	SEE LONGTDNL SECT.	2.375"	SCH 80	SA312-TP304
N13A	1	2"	PROTECTION SYSTEM REF. COLUMN TOP	57°	46'-1"	2.375"	SCH. 80	SA312-TP304
N13B	1	1"	PROTECTION SYSTEM REF. COLUMN BOTT.	62°	35'-2"	1.315"	SCH 80	SA312-TP304
N14A	1	1"	LEVEL CONTROL REF. POT.	84°	45'-1"	1.315"	SCH. 80	SA312-TP304
N14B	1	1"	LEVEL CONTROL STATIC LEG.	82°	35'-2"	1.315"	SCH 80	SA312-TP304
N15A	1	1"	LEVEL CONTROL REF. POT.	236°	45'-1"	1.315"	SCH 80	SA312-TP304
N15B	1	1"	LEVEL CONTROL STATIC LEG	236°	35'-2"	1.315"	SCH 80	SA312-TP304
N16A	1	2"	PROTECTION SYSTEM REF. COLUMN - TOP	244°	46'-1"	2.375"	SCH 80	SA312-TP304
N16B	1	1"	PROTECTION SYSTEM REF. COLUMN - BOTT.	244°	35'-2"	1.315"	SCH 80	SA312-TP304
N17A	1	1"	WIDE RANGE LEVEL - TOP	250°	50'-5"	1.315"	SCH 80	SA312-TP304
N17B	1	1"	WIDE RANGE LEVEL - BOTT.	252°	35'-2"	1.315"	SCH. 80	SA312-TP304
N18	1	2"	DRAIN	315°	SEE LONG. SECT.	2.375"	SCH 160	SA106 GRB

SUMMARY OF FURNACE-SENSITIZED STAINLESS STEEL ATTACHED TO THE NINE MILE POINT REACTOR VESSEL

ITEM	DESCRIPTION	QUANTITY
A	RECIRCULATION OUTLET SAFE END	5
B	RECIRCULATION INLET SAFE END	5
C	ISOLATION CONDENSER SAFE END	2
D	CORE SPRAY SAFE END	2
E	HEAD SAFETY VALVE & INSTRUMENT LONG NECK FLANGE	18
F	HEAD VENT LONG NECK FLANGE	1
G	CONTROL ROD DRIVE HYDRAULIC RETURN LINE SAFE END	1
H	STUB TUBES	129
J	DRYER SUPPORT BRAKCET	4 (LUG ONLY)
K	GUIDE ROD SUPPORT BRACKET	1
L	CORE SUPPORT RING	1

FIGURE 1-1. REACTOR VESSEL DRAWING–SUMMARY OF FURNACE-SENSITIZED STAINLESS STEEL PARTS


ISOLATION CONDENSER SAFE END
DRYER SUPPORT BRACKET
HEAD VENT
LONG NECK FLANGE
CORE SPRAY SAFE END

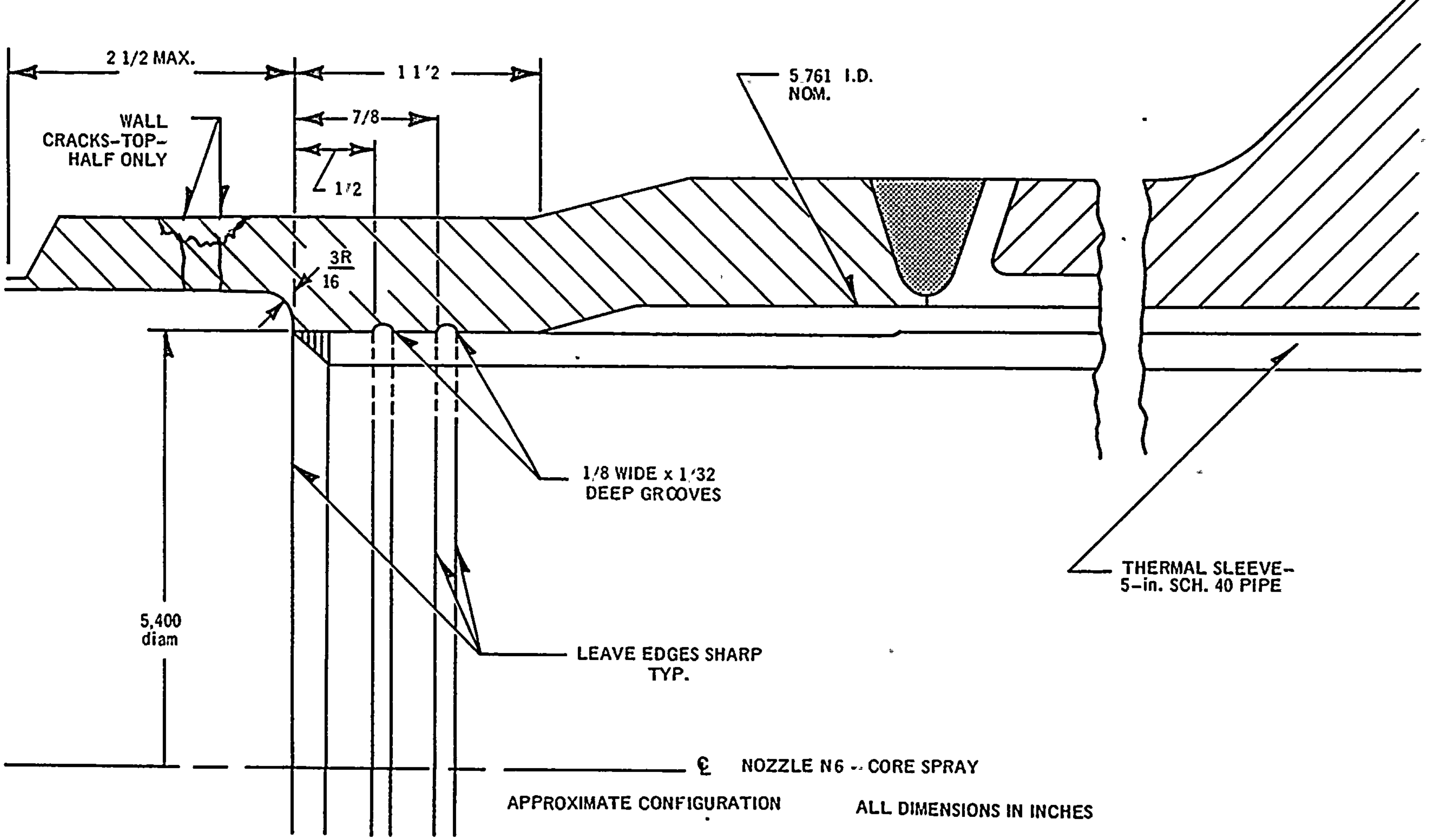


FIGURE 1-2. CROSS SECTION OF CORE SPRAY NOZZLE AND SAFE END N6B

2. BACKGROUND INFORMATION

2.1 Furnace Sensitized Stainless Steel

Intergranular attack problems were encountered on sensitized Type 304 components in the Oyster Creek and Tarapur reactor vessels. All these problems were associated with construction of the vessels prior to any operation of the reactors, and have no relation to actual operating conditions in high temperature, high purity reactor water. The Intergranular attack was entirely confined to furnace sensitized 304. No problems occurred on any annealed or "as welded" stainless steel components.

There was concern that a similar condition might exist in the Nine Mile Point reactor vessel. Therefore, extensive dye penetrant tests, metallurgical examinations, and accelerated corrosion tests were performed to evaluate the condition of the Nine Mile Point vessel. The results of these examinations were reported in the Supplements to the FSAR. No evidence of surface attack, cracking, or abnormal material was found in any of these examinations. Special precautions, which included strict cleanliness control and the use of tri-sodium phosphate in all cleaning operations, were employed to make certain that no subsequent corrosive attack would occur in the reactor vessel.

In order to re-affirm the position that normal, unattacked, furnace sensitized 304 was suitable for use in BWR reactors, a study of all available data were made. A comprehensive review of the literature, loop tests performed in simulated BWR environments, results obtained on surveillance specimens exposed in operating BWR's, and actual BWR service history all showed that furnace sensitized 304 would perform satisfactorily in high temperature, high purity BWR water.

All the examinations and tests performed in connection with the Nine Mile Point reactor vessel demonstrated that the vessel had not been corrosively attacked and contained normal 304 components which were considered suitable for service in the intended BWR environment.

2.2 Nine Mile Point Nuclear Station History

2.2.1 Reactor Pressure Vessel Summary

The pressure vessel was built by Combustion Engineering in Chattanooga, Tennessee and completed in 1966. It is constructed of A302B Alloy Steel weld clad on the i.d. with 308/309 stainless steel. The austenitic stainless steel safe ends were welded to the alloy steel nozzles prior to welding the nozzles to the shell, thus, the safe ends were furnace sensitized by subsequent post weld heat treatments given to the vessel.

The vessel was installed at the Nine Mile Point site in 1967 and internals construction completed in 1968. The system was field hydrotested late in 1968. Initial power operation was started in November 1969 and initial rated power was reached in January 1970. The station was shut down for repairs in March 1970.

Exceptional care was taken during the entire construction period to avoid surface contamination of the vessel parts by chlorides. TSP solutions were used to clean the vessel and systems to counteract any chloride contamination.

During startup and commercial operation, the vessel experienced 28 thermal cycles in excess of 50^{o}F, and 19 cycles in excess of 150^{o}F. This includes the heatup for hot functional tests.

2.2.2 Reactor Vessel History Detailed

2.2.2.1 At Shop

A review of the manufacturing practices used for the Nine Mile Point vessel revealed no significant differences between this vessel and the Oyster Creek and Tarapur vessels, except some Nine Mile Point nozzles were machined in the field.

The forged and bored stainless steel safe ends for the Nine Mile Point reactor core spray nozzles were purchased to ASME Specification SA-182 F403. They were attached to the low-alloy steel nozzles using the following fabrication sequence: the nozzle was received in the rough machined condition. The bore, inside radius, and nose of the weld prep was weld clad with stainless steel. Weld praps were machined and the safe end was fitted and tack welded to the nozzle. The root pass between the stainless steel safe end and the nozzle cladding was made at room temperature, using the GTAW process. The nozzle was preheated to $250^{\circ}F$ minimum and the weld completed using BP-85 electrodes (BP-85 is an early designation used by INCO for E Ni Cr Fe-3). The nozzle assembly was interstage tempered at $1150^{\circ}F \pm 25^{\circ}F$ for 15 minutes, and was welded to the vessel shell. The safe ends underwent several cycles of interstage tempering before the final post weld heat treatment at 1 hour per inch of wall thickness.

The vessel was hydrostatically tested on September 14, 1966, using Chattanooga tap water. Subsequent to the hydro test, the hydro caps were cut off and machining of the final weld preps on the safe ends was begun. Due to the necessity for crossing the Great Lakes before the winter freeze, the vessel was shipped incomplete on October 1, 1966, prior to completion of the final weld prep on some safe ends (See Table 2-1).

TABLE 2-1

SAFE END SUMMARY

NOZZLE	QTY.	SAFE END MATERIAL	FIELD MACHINED	SAFE END FURNACE SENSITIZED
Recir. Inlet	5	SA-336 F8M	Yes - 5 [(a)]	Yes
Recir. Outlet	5	SA-336 F8M	Yes - 4	Yes
Energy Condenser	2	SA-336 F8	Yes - 2	Yes
Core Spray	2	SA-182 F304	No	Yes
Top Head	19	SA-182 F304	No	Yes
Core ΔP	1	SA-336 F8	No	No
Instrument	8	SA-336 F8	No	No
Protection System	2	SA-336 F8	No	No
CRD Return	1	SA-336 F8	No	Yes

a. Recirc. Outlet Nozzle at 330 degrees was shipped final machined.

2.2.2.2 At Site

The vessel was sealed and filled with dry nitrogen before being placed in a covered barge. The shipping route was via the Missippi and Tennessee Rivers, the Chicago Sanitary Canal, and the Great Lakes. The vessel arrived at the site on November 8, 1966 and was stored at the site February 1967 when the Combustion Engineering crew arrived and began to machine the remaining safe end weld preps. The nitrogen purge was not in effect during the machining operation, which was completed in late April 1967. Subsequent events as the site are outlined below.

1967

May 1	Vessel moved into l[illegible]t area.
May 3	Set on soleplates. Work started on vessel internals.
Late in year	Stub tube penetrant and ultrasonic test program. All areas found free of intergranular attack

1968

September	Chemical cleaning of vessel and associated system.
Nov. 8	Field hydrotest of vessel.
Nov. 12 to 20	Additional non-destructive testing of sensitized stainless steel components and field welds of stub tubes; all areas inspected found free of intergranular attack.

2.2.2.3 Vessure Pressure and Thermal History

1969 Date	Event	Pressure Range (psi)	Temp. Range (^{o}F)
Feb.	Hand cleaned vessel with isopropyl alcohol swabs		
May 26	Hot Functional	1000	545
Oct. 2	Start Nuclear Heatup		
4	Full Pressure	~1000	545
5	Scram	1000 → 60 → 1000	545 → 290 → 545
6	Shutdown-valve repairs	1000 → 0	545 → 120
9	Plant Dedication	0 → 1000	→ 545
11	Scram	1000 → 200 → 360	→ 380 → 435
12	Scram and Cold Shutdown	→ 1000 → 50	→ 545 → 280

2.2.2.3 Vessel Pressure and Thermal History - (Continued)

1969

Date	Event	Pressure Range (psi)	Temp. Range (°F)
Oct. 13-17	Maintenance and training	0 to 100	120-330
18	Heatup	→ 1000	→ 545
19	Scram	1000 → 100	→ 330
20	Turbine rolled	100 → 550 → 1000	→ 545
21	Shutdown	→ 0	→ 120
22-29	Maintenance and training; scram	((0	120
30	Pressure Test	0 → 1000 → 0	
Nov. 1	Startup	→ 1000	→ 545
2	Cooldown and scram	1000 → 100	→ 300
3	Hot standby and scram	100 → 500 → 80 → 1000	→ 545
5	Hot standby and heatup	1000 → 400 → 1000	
6-7	Hot standby	1000 → 560	545 → 445
8	Scram	→ 100	→ 330
9	Heatup	→ 1000	→ 545
10	Scram and hot standby	1000 → 250 → 540	→ 400 → 475
11-12	Scram	550 → 40	→ 265
13	Heatup and scram	→ 950 → 80 → 500	→ 545 → 310 → 465
14	Heatup and scram	→ 960 → 240 → 970	→ 540 → 400 → 540
15-19	25% power	~ 1000	545
20	Start cold shutdown for maintenance	→ 650	→ 495
21-12/5		→ 0	→ 120
Dec. 5	Pressure test	→ 1000 → 0	120
6	Pressure test	↕ 1000 → 0	120
7	Heatup	→ 1000	→ 545
11	Hot standby and heatup	→ 450 → 1000	→ 455 → 545
14	Scram (twice)	→ 80 → 600 → 150	→ 310 → 485
15	Scram, then 50% power	→ 1000 → 500 → 1000	→ 545 → 465 → 545
20	Hot standby	→ 230 → 500	→ 395 → 465
21	Scram	→ 300 → 500	→ 415 → 465
22-23		→ 1000	→ 545
24	Manual scram	→ 40	→ 265
25-28	Hot standby	→ 500	→ 465
29	Heatup	→ 1000	→ 545
30	Manual scram	1000 → 170	→ 370
31	Heatup	→ 500 → 1000	→ 465 → 545

1970			
Jan. 1	Scram	→360	→435
2-4	Cold shutdown	→40	→265
5-9	Heatup—completed 50% power test	→1000	→545
10	Shutdown and heatup	→160→1000	→365→545
11			
12-16	Scram, then 75% power	→400→1000	→445→545
17	Hot standby	→500→240	→400
18	Heatup—rated power	→100	→545
19	Standby scram and heatup	→260→1000	→405→545
20-22		1000	→545
23	Scram, cooldown and heatup	→400→1000	→445→545
24	Shutdown	1000→80	→310
25-31	Shutdown and pressure test	20/50 and 1000	225
Feb. 1	Heatup—hot standby	→520	→470
2	Heatup	→440→1000	→455→545
3-7	Power-start 100-hr run	1000	545
8	Scram and heatup	→260→1000	→405→545
9-14		1000	545
15	Scram	→30	→250
16	Heatup and plant turnover	→1000	→545
17	Scram	→300	→420
18	Heatup	→1000	→545
20	Shutdown	→140	→355
24		→20	→230
25	Heatup	→660→140→1000	→495→355→545
26 to Mar. 2		1000	545
3	Shutdown	→20→0	→230
9		0	~90

*Converted from pressure from steam tables, or from computer printout. Computer temperatures are from thermocouples located at inlet to recirc pump No. 1

2.2.3 Core Spray System History

The west (leaker) core spray system has been operated on two occasions. After chemical cleaning, but before hydro test on 11. 8. 68, both core spray systems were tested for about 2 minutes. Source of the demineralized water for this test was the condensing storage tank. On 11. 12. 68, the vessel and systems were drained. The core spray systems were drained through the small valves on the bottom of the inside isolation valves.

Both systems remained empty until late May 1969. At this time, the hot functional test was performed, and the vessel was at full operating pressure and temperature. Reactor pressure forces water to backup through the core spray spargers, compressing the air in the system to a very small volume. This air would occupy the high points of the systems, i.e., the penetration nozzle to the reducing elbow. When the reactor was depressurized on 5. 30. 69, the compressed air would force water out of the systems as far back as the reducing elbow.

On 9. 5. 69, the west core spray system was used to supply demineralized water for leak testing of the head cavity and reactor internals pool. The east system was not used. Neither core spray system was drained at this time or subsequently. The west system would now be essentially full of water, while the east system would be empty in the reducing elbow to sparger section.

On subsequent reactor pressurizations, the air in the east system would compress to a small volume. On de-pressurizations, the air would expand and again drain the elbow to sparger section. The west system would be expected to remain essentially air free.

2.2.3 Core Spray System History - (Continued)

Both systems were checked for operability on 1.28.70 using the test loop for testing pumps and motors. The outside isolation valve is closed, test loop valve opened, and water is circulated through the test loop. The valve system is arranged so that the test loop valve cannot be opened until the outside isolation valve is closed. For checking valve operability, the pump motors are locked out. There is no circulation possible during these operability tests. The inside isolation valves, normally closed, have been actuated on other occasions for checkout of the reactor protection system, but there has been no flow through the valves on these occasions.

3. LEAKING CORE SPRAY NOZZLE SAFE END EVALUATION

A metallurgical investigation of the leaker core spray safe end was made at the Vallecitos Nuclear Center (VNC). The safe end was removed and shipped there in two sections labelled Sample 1 and Sample 3. Sample 1 was the pipe end of the piece, contained the leak and was exposed to core spray water. Sample 3 was the portion of the safe end behind the thermal sleeve. Sample 4 was a short separate section of thermal sleeve.

3.1 CONCLUSIONS FROM METALLURGICAL STUDY OF N6B

1. Cracking on the inside of the safe end was shown to be due to intergranular stress corrosion in areas of high stress in the presence of high oxygen.

2. The furnace sensitized material behaved similar to accelerated laboratory tests at high stresses in an oxygen-water environment.

3. The annealed 304 thermal sleeve material is satisfactory for continued use.

4. Intergranular attack was found on the o.d. surfaces similar to the cracking found at Oyster Creek.

5. A few isolated transgranular penetrations were found on the o.d. which are considered to be incidental to the investigation.

3.2 CONCLUSIONS FROM STRESS ANALYSIS REVIEW OF N6B

1. The N6B nozzle safe end was overstressed due to weight loading which in turn was caused by improper hanger design.

2. The N6B nozzle was further stressed due to thermal expansion interference with one of the vertical and horizontal earthquake restraints. The maximum strain caused by both of the overstress sources has been estimated to be about 2% which corresponds in this analysis to a sustained real stress of about 125% of the yield stress at temperature. This sustained tensile stress is estimated to have a total time at NMP service of approximately 2000 hours. (88,000 - 92,000 psi calculated elastic stress).

3.3 EXAMINATIONS OF NOZZLE N6B

The following examinations were performed on the leaking nozzle N6B.

1. Nondestructive testing performed at the site included liquid penetrant, radiographic, and ultrasonic examinations.

2. Sample No. 1 included a portion of the safe end, outboard of the weld to the thermal sleeve, the field weld between the safe end and pipe, and a short length of the pipe. The sample was delivered to VNC for evaluation.

   a. The sample was visually inspected, marked with a Vibratool to preserve orientation identity, and photographed in black and white and in color.

b. Surface samples were machined from the safe end for chemical analysis of halogen contaminants.

c. The sample was liquid penetrant tested and again photographed in black and white and in color to record the location and character of indications found.

d. The sample was sectioned into longitudinal strips as shown in Figure C-12, Appendix C.

e. Metallographic evaluations were performed on samples from selected circumferential locations to determine the nature and depth of PT indications and visible cracks.

f. Bend tests were performed to assess the propagation behavior of fine cracks found by PT or visual observation.

g. Tensile tests were performed on the material to determine its mechanical properties in air at room temperature and at 550° F.

h. Hardness tests were performed to evaluate the cold worked condition of the material. Hardness tests were also performed on a tensile sample to determine the relationship between tensile strain and hardness for the material.

i. Tests were performed at constant load in 550° F oxygenated water to evaluate the fracture characteristics of the material.

j. Chemical analyses were performed to verify that the material satisfied the requirements of the ASTM-specifications used.

k. Specialized metallographic techniques including X-ray diffraction, electron microprobe, and scanning electron microscope, were utilized to evaluate the nature of the crack surfaces and of deposits found in the grain boundaries.

l. Metallography was performed on the field weld to evaluate weld quality and to search for cracks.

3. Sample No. 3 included a 3-1/2 in. length of the safe end, the weld between the thermal sleeve and safe end, and a 7/8 in. length of the thermal sleeve (welded to the safe end). The sample was delivered to VNC for evaluation.

   a. The sample was visually inspected, marked with a Vibratool, and photographed in black and white and in color.

   b. Wipe samples were collected from the undisturbed safe end i.d. and o.d. surfaces and from the thermal sleeve i.d. surface. The samples were analyzed for fluoride and chloride contamination.

c. Surface samples were machined from the i.d. and o.d. of the safe end and from the i.d. surface of the thermal sleeve for chemical analysis of fluoride and chloride contaminants.

d. The safe end was sectioned to provide longitudinal strips for metallographic examination and bend testing, as shown in Figure C-13, Appendix C.

e. The thermal sleeve section attached to one of the strips was removed and analyzed to determine the level of fluoride and chloride surface contamination in the crevice.

f. Remaining parts of the safe end and thermal sleeve were ultrasonically cleaned and nondestructively tested by PT and ultrasonic methods. The results of the liquid penetrant tests were recorded photographically.

g. Metallographic samples of the safe end material were examined to determine the nature and depth of cracks existing in the material surfaces.

h. Bend tests were performed to open cracks in both the i.d. and o.d. surfaces of the safe end and thereby facilitate their evaluation.

i. Metallographic samples of the safe end material were examined to determine the depth and nature of any cracks found.

4. Sample No. 4 consisted of a 3 in. long section of the thermal sleeve.

a. The sample was visually inspected, marked with a Vibratool, and photographed.

b. Longitudinal strips were cut at the 6, 9, and 12 o'clock positions for metallographic examination.

c. Rockwell B hardness measurements were taken on the i.d. and o.d. surfaces of strips cut from the thermal sleeve.

3.4 LEAKING CORE SPRAY SAFE END N6B (Details)

A water leak was detected in this item, March 6, 1970, by following the drippage noted from a lower level in the drywell to its source. When the mirror insulation was removed, water was coming from two cracks in the safe end located at the 12 and 3 o'clock positions. The inner surface of the mirror insulation had a discoloration at each of the impingement points. Station personnel conducted a liquid penetrant (PT) examination of the safe end. General Electric personnel conducted ultrasonic (UT) and radiographic (RT) examination of the pipe end of the part in the period March 7 to 16. The results are plotted on Figures 3-1 and 3-2, respectively. The sample was cut in accordance with NMP Procedure No. 1, Rev. 1., see Appendix D, using a power hacksaw without lubricant. The severed pipe at the ell moved 3/16-inch down, 15/32-inch toward the reactor vessel, and 5/8-inch to the left of the vessel nozzle when viewed facing the vessel. An azimuthal position mark was placed on the safe end prior to cutting. Positions are designated by clock notation facing the reactor vessel with 12 o'clock at the top of the safe end. A 1-inch-wide sample (G.E. Designation No. 1A) was dry cut at a position of approximately 10:30 for the AEC. The remainder of the sample (G.E. Designation No. 1) was delivered to the Vallecitos Nuclear Center (VNC) on March 15, 1970, for investigation in accordance with the procedure outlined above.

Following removal of Sample 1, the remainder of the safe end (Sample 3) was examined by PT, RT and UT. PT results are presented in Sketch 209A7144, Sheet 6. No indications were detected by UT or RT. Samples 1 and 3 were examined at the Vallecitos Lab on both the i.d. and o.d. by liquid penetrant. The results of these examinations are presented in Figures 3-3 and 3-4, respectively.

Sample 3 was removed by cutting the thermal sleeve from the i.d. with an abrasive cutter and then cutting the safe end wall near the nozzle weld almost through with an abrasive cutter and chiseling through the remainder. (See Appendix D.)

3.4.1 Macro Observations

The outside surface of Samples No. 1 and 3, with silvery metallic in appearance and had a very thin oxide interference film, with considerable surface grinding marks. The leak at 12 o'clock was clearly visible and was surrounded by a thin, tan, tear-drop-shaped film leading toward the 9 o'clock side of the pipe. On the exterior surface the leaking crack was tight, 3/10 inch long and parallel to the pipe axis with four circumferential branches from 1/32 to 3/32 inch long. The leak at 3 o'clock was destroyed by the cutting operations at the site.

A penetrant test of the outside surface of Sample No. 1 shows large indications at the leak with some small linear indications between 12 and 2 o'clock (generally circumferential) and between 5 and 8 o'clock (generally axial) as shown in Figure 3-3.

The inside surface of Sample No. 1 was covered with a very thin, uniform, adherent, dark-brown, matte-finish oxide layer. Cracking was clearly visible on the inner surface as three distinct sets of roughly parallel, circumferential crack systems. Their course and length can be seen in Figure 3-4. As shown in the figure, the main cracking pattern was slightly skewed, being closest to the field weld at the 9 o'clock position, and farthest from the field weld at the 12 to 3 o'clock position. No cracking was observed in the bottom half of the safe end. Liquid penetrant examination outlined the cracks more clearly as shown in Figure C-10, Appendix C.

The inside surface of Sample No. 3 was also covered with a thin, uniform, adherent, dark-brown, matte-finish oxide layer. No cracks were observed by visual inspection and only a small number of PT indications were found as shown in Figure C-12, Appendix C, in the corner where the large diameter meets the conical section of the safe end. A few PT indications were found on the outside surface as shown in Figure C-12, Appendix C. No other unusual features were found.

Sample No. 4 was a 3-inch long section of the 5-inch schedule 40 thermal sleeve pipe. This sample was taken between a point beginning about 1 inch from the field weld between the thermal sleeve and safe end. Both inside and outside surfaces of the sample were covered with a dark-brown adherent oxide. The outside surface of the section of thermal sleeve had been machined throughout its length to a wall thickness of 0.200 in. (nominal wall thickness of unmachined pipe is 0.258 in.)

3.4.2 Metallographic Observations

Samples for various tests were cut from safe end Sample No. 1, as shown in Figure C-12, Appendix C. The microstructure is typical of annealed, furnace-sensitized, austenitic stainless steel with equiaxed grains outlined by precipitated carbides. The approximate grain size is 0.25 mm (approximately grain size 1) at the

inner surface, and 0.50 mm (approximately grain 00) at the outer surface. Continuous carbides have precipitated in both the grain boundaries and on twin bands. Nonmetallics are small, randomly distributed, and normal for forged material. Cold work from machining is present on both surfaces.

The location and pattern of the cracks found on the inside surface of the safe end are illustrated in Drawing 117C4602. The depths of the cracks that were measured metallographically are also shown. The deepest crack penetrations found, except for the leak, were 0.40 in. and 0.39 in. The majority of the cracks in this area ranged from 0.18 in. to 0.22 in. in depth, and were interspersed with smaller cracks having depths of 0.01 to 0.07 in. All of the cracks were found to be completely intergranular. The circumferential failure cracks are widest and longest at the inner surface, thus, supporting the conclusion that the cracking progressed from the inside toward the outside.

Several axial intergranular cracks originate internally at the circumferential crack tips and progress toward the o.d. One of these axial cracks penetrated the o.d. at 12 o'clock and caused the leak there.

There is no transgranular cracking on the inner surface. Gross plastic strain is less than 5% by metallographic determination.

Some intergranular attack is evident on the outer surface. In addition, there are occasional spots of shallow (0.005-inch deep) transgranular penetrations which could be chemically induced or due to original forging imperfections. A metallographic survey of the sample is shown on Figure C-1, Appendix C.

Metallographic evaluation of the safe end-to-pipe weld did not reveal any cracks in the weld deposit or in the heat affected zone. However, some lack of fusion between the weld root and the safe end material was found as illustrated in Figure C-2, Appendix C. The maximum depth observed for this condition was about 0.012 in. and no cracks were found near or emanating from the crevices. One crack with a depth of about 0.040 in. was found in the safe end material at about 1/4 inch from the side of the weld bead. This crack is shown in Figure C-2, Appendix C.

3.4.2.1 Thermal Sleeve, Sample No. 4

Metallographic examination of the thermal sleeve material revealed very shallow surface imperfections having a mixed intergranular-transgranular mode as shown in Figure C-6, Appendix C. These imperfections had a maximum depth of about 0.004 in., an average depth of about 0.002 in., and were fairly uniformly dispersed over the inside surface of the thermal sleeve. No imperfections were found on the machined o.d. surface of the thermal sleeve.

Tensile tests of the safe end material in air at room temperature and at 550°F, stress rupture tests at 550°F in an oxygenated water environment, hardness tests, bend tests, analyses of the chemical composition of the material, and anslyses to evaluate contaminants on the surfaces of the safe end were made.

The tensile test data for the safe end material are listed in the table below. No abnormal behavior was observed. The material is well within the specification requirements and the normal tensile property range expected.

TENSILE PROPERTIES OF N6B SAFE END MATERIAL

Specimen Clock Position	Specimen Ident.	Test Temp. (°F in air)	Strength (ksi) Ult.	Strength (ksi) Yield*	Elong. (%)	RA (%)	Fracture Mode
3:30	W	RT	83.5	39.5	77.4	77.3	Transgranular
5:30	T	RT	*–	37.4	*–	*–	Test interrupted after about 8% strain–no fracture
4:40	U	550	61.6	25.3	36.5	55.4	Transgranular

*0.2% offset

Hardness tests were performed on sections of the safe end material and on the thermal sleeve. The results of these tests are shown below.

The safe end material is within the normal commercial hardness range for this material although as shown by the annealing test it was not in the softest possible condition. The thermal sleeve material obviously has been work hardened by the rolling process at the welded end.

HARDNESS MEASUREMENT DATA FOR SAFE END AND THERMAL SLEEVE MATERIALS

Sample Description	Hardness Number, R_b I.D.	Hardness Number, R_b O.D.
Safe end, 6 o'clock	76	81
Safe end, 10 o'clock	74	82
Safe end, 12 o'clock	80	84
Safe end, after annealing 24 minutes at 1950 F, one of 4 samples	67.8	67.8
Thermal sleeve, 5:30 o'clock, in area that was rolled	97.5 96	87 86
Thermal sleeve, ~ 1-1/2 inches from rolled area		
6 o'clock	73.1	72.3
9 o'clock	73.5	74.5
12 o'clock	72.5	76

3.4.2.2 Hardness versus Strain of Sample No. 1 Material

A portion of the sample was strained in tension at room temperature with hardness measurements at the increments shown below. Note that after up to 8% strain the material is still within the hardness range for commercial material.

STRAIN (in./in.)	HARDNESS (R_b)
0	76
4	82
8	87

Constant load rupture testing was conducted on several specimens from Sample 1 in demineralized water in an autoclave. The time-to-failure data measured are shown below and are in good agreement with data obtained from other tests on similar material. All failures were intergranular.

Clock Position	O_2 Content (ppm)	Stress (ksi)	Failure Time (hr)
8:00	8	55	150
6:45	100	50	38
7:00	100	50	13
7:30	100	50	48
3:30	100	55	2.5

Bend tests were used on selected samples to assist in evaluating surface cracks. Typical results of the effect of the bend tests on the surface cracks are shown in Figures 3-3 and 3-4.

In addition to these tests, specialized techniques including electron microprobe, X-ray diffraction, and scanning electron microscopy were used to evaluate the nature of the cracking and the precipitates in the grain boundaries. Using an extraction replica technique together with X-ray diffraction two grain boundary precipitates were identified. These were M_2O_3 oxides, and $M_{23}C_6$ type carbides. Electron microprobe analysis of the cracks detected only the constituents of the stainless steel; no contaminants such as chlorine or fluorine were found. With the scanning electron microscope it was determined that there was no evidence of ductivity on the surfaces of the intergranular cracks. Approximately 50 percent ductile fracture was found in the area where the crack was extended to completion at liquid nitrogen temperatures.

The results of chemical analyses of the safe end material are tabulated in the table below. The analyses are with the specification limits and are normal for this material.

CHEMICAL ANALYSIS

	Safe End			Pipe		Field Weld	
	SA 182 F304 (c,d)	C.E. Data (a)	G.E. Data (b)	SA 376 TY 304 (c,d)	G.E. Data (b)	SA 298 TY 308 (c,d)	G.E. Data (b)
C	0.08	0.06	0.05	0.08	0.07	0.08	0.04
Mn	2.00	1.35	1.28	2.00	1.74	2.5	1.54
P	0.04	0.009	0.006	0.03	0.028	0.04	0.025
S	0.03	0.010	0.009	0.03	0.015	0.03	0.012
Si	1.00	0.36	0.29	0.75	0.53	0.90	0.42
Ni	8.0-11.0	10.7	10.5	8.0-11.0	10.8	9.0-11.0	9.9
Cr	18.0-20.0	18.9	19.2	18.0-20.0	18.7	18.0-21.0	20.4
Mo			0.06		0.33		0.32
Cu			0.06		0.10		0.06
Zn			<0.01		<0.01		<0.01

a. Mill test report - safe end heat B 1235

b. Anamet, March 1970

c. Max. unless otherwise indicated

d. 1964 applicable specification

3.5 STRESS ANALYSIS OF LEAKING CORE SPRAY NOZZLE SAFE END N6B

Several tasks have been defined in order to supplement the failure analysis of the N6B nozzle safe end.

The analysis which supports the conclusions given at the start of this section follows: (Photographs of several views of the piping loop are shown in Figure 3-5 for information).

3.5.1 Analysis of N6B Core Spray Loop

On the basis of serveral weight and flexibility analyses, performed using a variety of different assumptions, the following deductions have been reached as to the sequence of events which occurred.

> During the first cycle of vessel heatup, the elastic calculated stresses in the safe end at the core spray nozzle increased to a value of about 45,000 psi. These stresses were caused by the piping lifting off the inadequately designed suspension system. Such weight stresses should normally be limited to about 2000 psi and should not exceed 10,000 to 15,000 psi; depending upon the design code used (B31.1 or B31.7). Thus, the pipe was clearly overstressed for weight loading under any code.
>
> As the piping continued to raise, interference occurred between a shock suppressor support bracket on the core spray line and the structural steel on a seismic restraint. The elastic calculated stresses, because of this interference, increased to at least 88,000 psi.
>
> After the system deformed as described above, the stress range at the safe end during subsequent heatups was about 32,000 psi. This stress range is due primarily to the weight of the pipe being transferred to the vessel nozzle as the piping raised off its suspension system.
>
> The basis for the above deductions is contained in the following paragraphs.

The 45,000 psi stress identified above was determined as follows: The hangar at Point 703 was designed for 1/2-inch movement of the pipe in a downward direction. The actual movement at this point with a properly supported system would be slightly greater than 1 inch upward. The hangar installed with its design cold setting would support the pipe for only 1/4 to 1/2 inch upward movement. It was thus concluded that as the vessel heated up, the pipe would tend to raise up off the hanger at this point. A stress analysis was made to simulate this condition by removing this hanger. The forces, moments and stresses at the safe end for this analysis are listed in Table 3-1 as Problem 10. The stresses include the effects of thermal expansion and dead weight. The longitudinal pressure stress is not listed in the table, but is approximately 4,000 psi.

Table 3-1
SUMMARY DATA – SAFE END
WEST CORE SPRAY LINE

ΔY PT130	ΔY PT703	Problem No.	F_X (lb)	F_Y (lb)	F_Z (lb)	M_X (ft-lb)	M_Y (ft-lb)	M_Z (ft-lb)	S_e	Notes
1.298	1.044	1	158	-744	136	2880	604	-976	3199	b
1.282	0.717	4	-784	-9528	-1305	22260	-9100	-13000	28400	c
-0.001	-0.001	9	-34	-565	24	1074	-600	-217	1290	a
1.125	0.696	10	-177	-12200	1380	27800	-7680	-16100	34100	c
		12	2675	-31600	2000	60000	4400	33000	70362	c'

Notes:

a. Weight effects.

b. Thermal effects.

c. Weight plus thermal effects.

Assumptions:

1. Vessel at 546°F, piping at 135°F.

There is convincing evidence that during vessel heatup, interference occurred between a bracket on the core spray line near the elbow at Point 703 and some structural steel supporting a seismic restraint bracket. After the pipe failure was detected, the clearance between the bracket and structural steel with the system in the cold condition was measured as being 11/16 of an inch. This amount is almost exactly equal to the predicted amount of movement at this point under actual conditions. Also, it was noted that the cold setting of the hanger after the pipe failure occurred had increased from 4,320 lb. to 5,030 lb. The spring constant of this hanger is 2,160 lb/in., showing that the plastic deformation of the piping system was sufficient to cause the elbow at Point 703 to move downward approximately 0.33 inches. Two computer runs were made which allow an accurate estimate of the stress in the safe end when the pipe is restrained to move in the vertical direction.

From these runs it may be shown that each 0.1 inch deflection between the vessel nozzle and the 12 by 6 inch elbow causes a stress of about 20,000 psi in the safe end. In order to produce a permanent deformation of 0.33 inch, a total deflection of about 0.44 inch would be required. The resulting elastic calculated stress would be 88,000 psi. The longitudinal pressure stress would increase this to about 92,000 psi.

Problem 4 was run for the case in which the hanger continues to provide some support to the piping as the vessel heats up. This case reflects the condition after shakedown when there was enough deformation at Point 703 for the hanger to continue to provide some support throughout the vessel temperature cycle. As can be seen in Table 3-1, Problem 4 results in a stress in the safe end of about 28,000 psi. Longitudinal pressure stresses will increase this to 32,000 psi.

Problem 1 in Table 3-1 represents a free thermal analysis of the west side core spray piping. This analysis does not consider the weight of the pipe or any restraints acting on it. The stresses are about 3,000 psi. If the hangers were properly designed, the weight stresses in the safe end could be much less than 1,000 psi. This shows that the pipe routing is satisfactory and if the pipe were properly supported the stresses due to thermal expansion and to weight would be small.

In the west loop it is clear, after comparing the total weight the hangers were designed to carry against the total weight of the piping system, that the hangers are much too small. A distributed weight calculation (Problem 9) was made to determine proper hanger size. The hanger size indicated from the distributed weight calculation is compared with the actual hanger size in the table below.

Hanger Location	Actual Hanger Load	Required Hanger Load
Point 703	5400 lb	7500 lb
Point 612	2325 lb	6280 lb
Point 853	3700 lb	5000 lb
Point 823	-	2400 lb

Since these stresses are calculated on an elastic basis, and the maximum stresses are above the material yield strength, an elastic-plastic analysis of the 6-inch section of the pipe was performed to determine the correct stresses and strains. The elastic analysis will over-estimate the stresses and under-estimate the strains. Figure 3-7 shows the strain-deflection behavior for the 6-inch section of pipe based on the stress-strain curve shown in the inset (Figure 3-7), which is an approximation of an actual stress-strain curve at 540°F for this material.

The curve shown is for cantilever bending, with one end of the pipe restrained from rotating (at the nozzle). If both ends are restrained from rotating, then the deflection is half as great, and the load twice as great, at a given strain level. Actual end conditions in the section of 6-inch core spray piping were between these extremes. Therefore, for any known displacements absorbed in the 6-inch line, we can estimate the elastic-plastic stresses and strains which would have existed on the N6B nozzle safe end.

For example, at 40,000 psi elastic calculated stress, the elastic calculated strain is 0.16%. If 0.16% is entered in Figure 3-7, it is assumed that the elastic basis deflection is accurate for the plastic case, then we observe that the plastic strain is 0.64%. This plastic strain compares with 0.5% determined by analysis of the crack opening displacement of one of the circumferentially oriented cracks. The corresponding true plastic stress at 0.64% strain is $17,500 + 0.227 \times 0.064 \times 10^6 =$ 18,950 psi or 108% of the assumed yield point of 17,500 psi. The alternate case of the fixed-fixed 6-inch pipe produces identical results which leads to the conclusion that this elastic-plastic analysis is not sensitive to the assumed end condition.

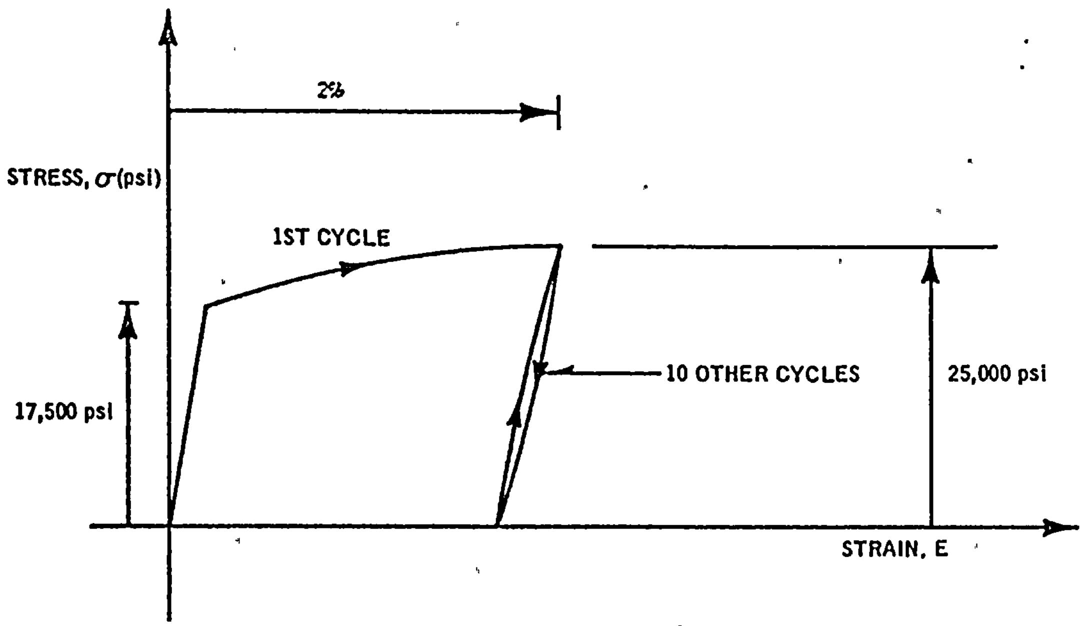
The elastic calculated stresses can be greatly in error because of large possible interference; hence, a second example is shown to indicate that the plastic stress cannot be greatly in excess of the yield strength. Suppose for example, it is assumed that instead of 0.1-inch deflection, we use 0.4-inch deflection (corresponding to 150,000 psi elastic calculated stress). In this case, by a similar procedure with Figure 3-7, it is found that the actual plastic strain becomes 1.99% while the plastic stress becomes 21,860 psi, which is 125% of the

assumed yield point. Thus the true stress resultant is nearly independent of the elastic calculated stress. Therefore, it is concluded that the failed safe end was stressed at least to about 108% of yield (true plastic stress) and about 0.64% strain. As a more realistic estimate, the plastic strain could be as high as about 2% with the plastic stress as high as 21,860 psi.

From this discussion, it can be concluded that the stress stain curve of the material at the point of the through wall cracks was approximately as in the sketch below.

That is the first loading cycle which deformed the 6-inch section of pipe, caused a peak strain of about 2% and following 10 cycles were essentially elastic. Each time the reactor was brought to temperature, the stress returned to its highest value. If the fatigue design usage is computed for this condition following the ASME III fatigue curve, it is found that only the first cycle causes any significant usage. The stress equivalent strain salt for the one cycle is $0.02 \times 25 \times 10^6/2 =$ 500,000 psi, which yields N_f = 90 cycles.

Therefore, the total fatigue usage following ASME III rules is less than 1%, and it is seen that the safe end did not fail due to exceeding the design fatigue requirements.



In addition, a study has been made of the potential effect of residual stresses in the N6B safe end due to pipe weld stresses and thermal sleeve rolling and welding stresses. It has been concluded that these residual stresses probably did not have a major effect on the circumferential cracking because the resulting axial residual stresses (perpendicular to crack direction) were largely compressive as seen in Table 3-2.

Table 3-4

STRESSES IN CORE SPRAY NOZZLE SAFE END (Inside Surface)

Based on SNAP and OMP Stress Models (Elastic)

Crack Location	Distance from End (in.)	Stresses for 1-mil Sleeve Roll-In Deformation (Radial) σ_x(ksi)	σ_θ(ksi)	Stresses for 60-mil Pipe Weld Shrinkage (Radial) σ_x(ksi)	σ_θ(ksi)	Pressure = 1000 psi Temperature = 545°F σ_x(ksi)	σ_θ(ksi)	Pipe Load M = 277 in.-kps (Problem 10) σ_x(ksi)	σ_θ(ksi)
	0	-3.2	5.2	-138.	-42.	3.4	6.9	27.6	3.2
	0.25	0.1	4.8	-169	-66	2.5	6.6	26.0	1.4
	0.50	1.8	4.0	-197	-106	1.7	6.5	24.	-0.2
	0.75	2.6	3.2	-206	-160	1.2	6.5	23.	-1.0
	1.0	2.8	2.3	-194	-214	0.9	6.6	22.5	-1.7
	1.25	2.5	1.4	-130	-270	0.8	6.7	22.9	-1.7
	1.50	2.2	0.9	- 21.3	-329	0.7	6.8	24.0	-1.3
	1.75	1.6	0.4	203.	-358	0.8	6.9	26.	-0.3
Pipe Weld	2.0	1.1	0.1	530.	-336	0.8	7.0	30.	2.

An elastic analysis was made of the non-axisymmetric loading shell discontinuity effects by use of the OMP (Kalnins) program.

Included in this analysis is the limit moment alone which could be carried on the safe end using a material yield point of 22 ksi. The actual yield stress at temperature was 25.3 ksi for the N6B safe end, and so if one subtracts 3300 psi for pressure effects, then approximately 22 ksi would be available to support the limit moment. In addition the pressure and thermal expansion effects (differential expansion between carbon steel and stainless steel) have been included in this elastic analysis. This is a purely elastic analysis and it should be remembered that all stresses above about 25.3 ksi are fictitiously high; however, the resulting plots are a convenient way of displaying the entire stress distributions which are as close to the actual stresses as can be displayed with a purely elastic analysis. The results are plotted in Figures 3-8, 3-9, 3-10 and 3-11, which show the stresses at the inner and outer surfaces, and 6 o'clock and 12 o'clock orientations of the nozzle.

3.6 ENVIRONMENT AT I.D. OF CORE SPRAY SYSTEM NOZZLE N6B SAFE END

3.6.1 Summary

The nozzle-end and the pipe-end of this part are exposed to two entirely separate environments because of the thermal sleeve barrier between them. The oxygen content of the water at the i.d. of the nozzle end follows the oxygen content of the bulk reactor water, e.g., approaches 8 ppm when the head is off and approaches 0.2 ppm when the reactor is operating. The oxygen content of the pipe end water was very high, somewhere between 300 and 25,000 ppm during the hot functional test. At the first power operation, the oxygen content in the same location was most probably 8 ppm but under the most adverse circumstances could be 580 ppm. The amount of fluoride in the core spray water was measured as less than 0.05 ppm. (Limit of detection is approximately .04 ppm.)

3.6.2 Details - Nozzle End

The nozzle end is connected directly to the reactor i.d. by an annular path 0.16 inch wide and 20 inches long. Thermal convection will occur in this area during heat up and operation because there will always be a temperature gradient through the vessel wall. Thus, bulk reactor water will be constantly flowing in the annular space and the oxygen content at the safe end will follow the variations of the bulk reactor water, 8 ppm when air saturated at shutdown and 0.2 ppm during operation.

3.6.3 Details - Pipe End

Conditions at the pipe end are vastly more complex because it is connected to the main body of the reactor by a tortuous path of 21 feet of pipe which is horizontal at the safe end, drops vertically 5 feet at the vessel i.d., curves around the i.d. for 12 feet and rises vertically 2 feet to the sparger. The safe end is at the highest part of the system and the horizontal run of about 6 feet there traps air introduced to the system.

As stated in the core spray history above, during the hot functional test, the system was back filled from the vessel. The computation in Appendix E shows that under this condition the maximum oxygen level in the water at the horizontal section could approach 2-1/2% (25,000 ppm) if all the trapped air collected there. The minimum oxygen level would be 300 ppm if it is assumed the oxygen is equally partitioned in all the water contained in the system beyond the stop valve.

After the hot functional test and before the first startup, the B core spray system was operated and was not drained. Theoretically atmospheric pressure will prevent the system from draining beyond the spray nozzles of the B system sparger even if the reactor water level were lowered below the sparger. There is no record of the water level being lowered in the interval between the B core spray operation and reactor power operation. In this case, the oxygen level will remain at 8 ppm. The only oxygen escape route is by thermal expansion of the water from the core spray system to the reactor vessel during heat up. However, all the water flowing through the safe end during this transient period will contain a minimum of 8 ppm O_2 and when equilibrium is reached, the water remaining will still contain 8 ppm O_2. Once the water has reached equilibrium and thermal expansion has stopped, thermal convection will take place only where appropriate temperature gradients exist. The sparger, header and i.d. verticals are isothermal. The vertical pipe outside the reactor is hot at the top and cold at the bottom which prevents thermal flow. The horizontal section at the safe end has continuous stirring within itself because of the thermal gradient from vessel to elbow but no net flow will occur. Thus, the oxygen content which started at 8 ppm will remain at 8 ppm. Some will tend to diffuse out and some will react with the metal but both of these processes are very slow. If by some chance, water did escape from this system and air burbled in to replace it, the maximum volume for the resulting bubble would be the horizontal run plus 3 feet of down comer. The calculation in Appendix E shows that the maximum oxygen concentration that can occur from this assumption is 580 ppm.

3.6.4 Other considerations

Fluorine content of the water was measured in the bulk reactor, below the external top elbow of the core spray system and as drippage from the leak (see Table 5-1). Essentially no fluorine was detected in the first two samples and 0.1 to 0.2 ppm was detected in the drip. It is concluded that the drip sample was contaminated by dirt from the outside of the safe end and the fluorine content of the water was negligible.

Oxygen will be formed radiolytically in the core spray system. Very limited data are available which indicate the equilibrium level could vary between 6 and 10,000 ppm, with a most probable value 10-300 ppm.

NINE MILE POINT
CORE SPRAY SAFE END
COMPOSITE RADIOGRAPH
N6B

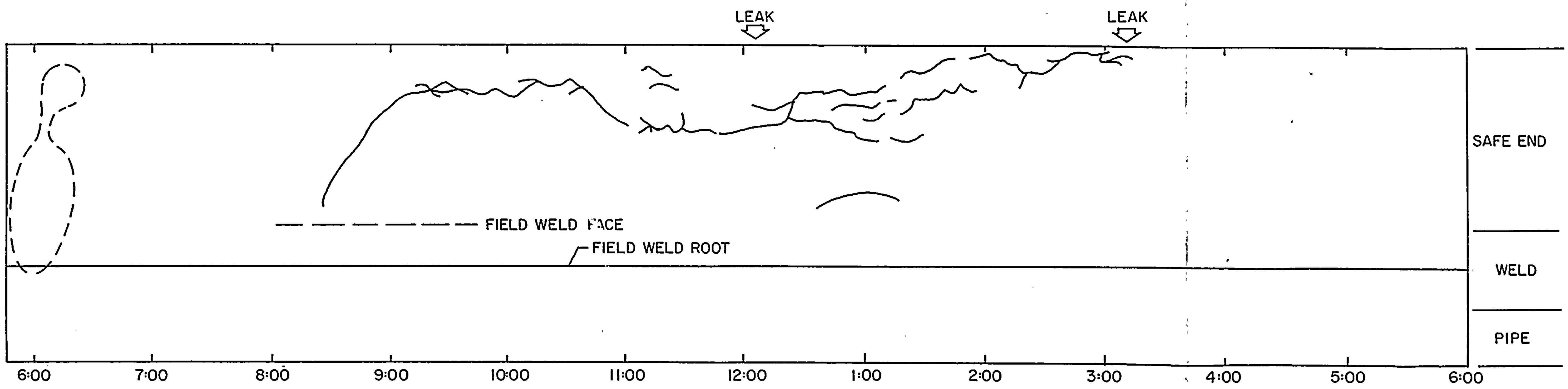


FIGURE 3-1. COMPOSITE RADIOGRAPH OF CORE SPRAY NOZZLE SAFE END N6B

[illegible]

NINE MILE POINT
CORE SPRAY SAFE END
ULTRASONIC RESPONSE SHOWING ESTIMATED FLAW LOCATION
N6B

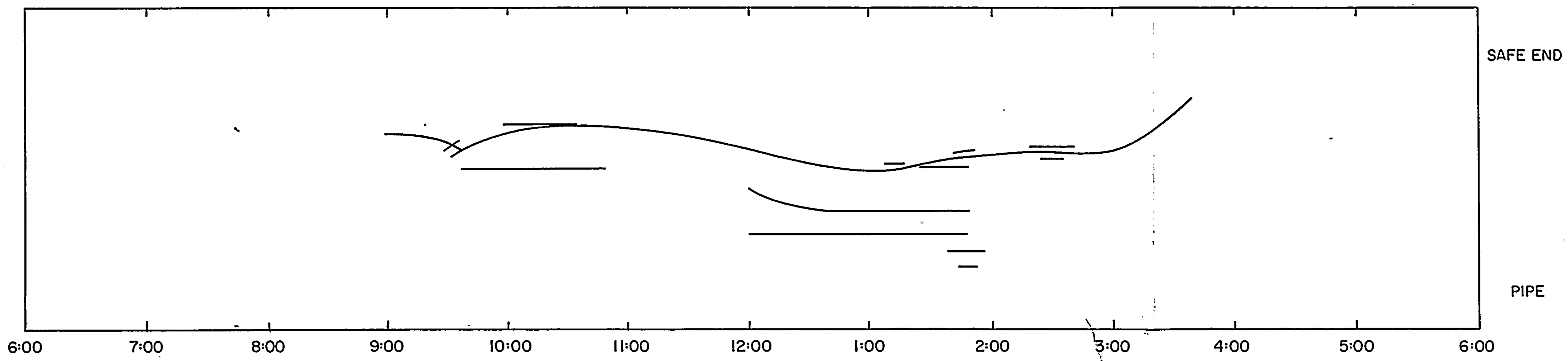


FIGURE 3-2. ULTRASONIC RESPONSE CHART
CORE SPRAY NOZZLE SAFE END N6B

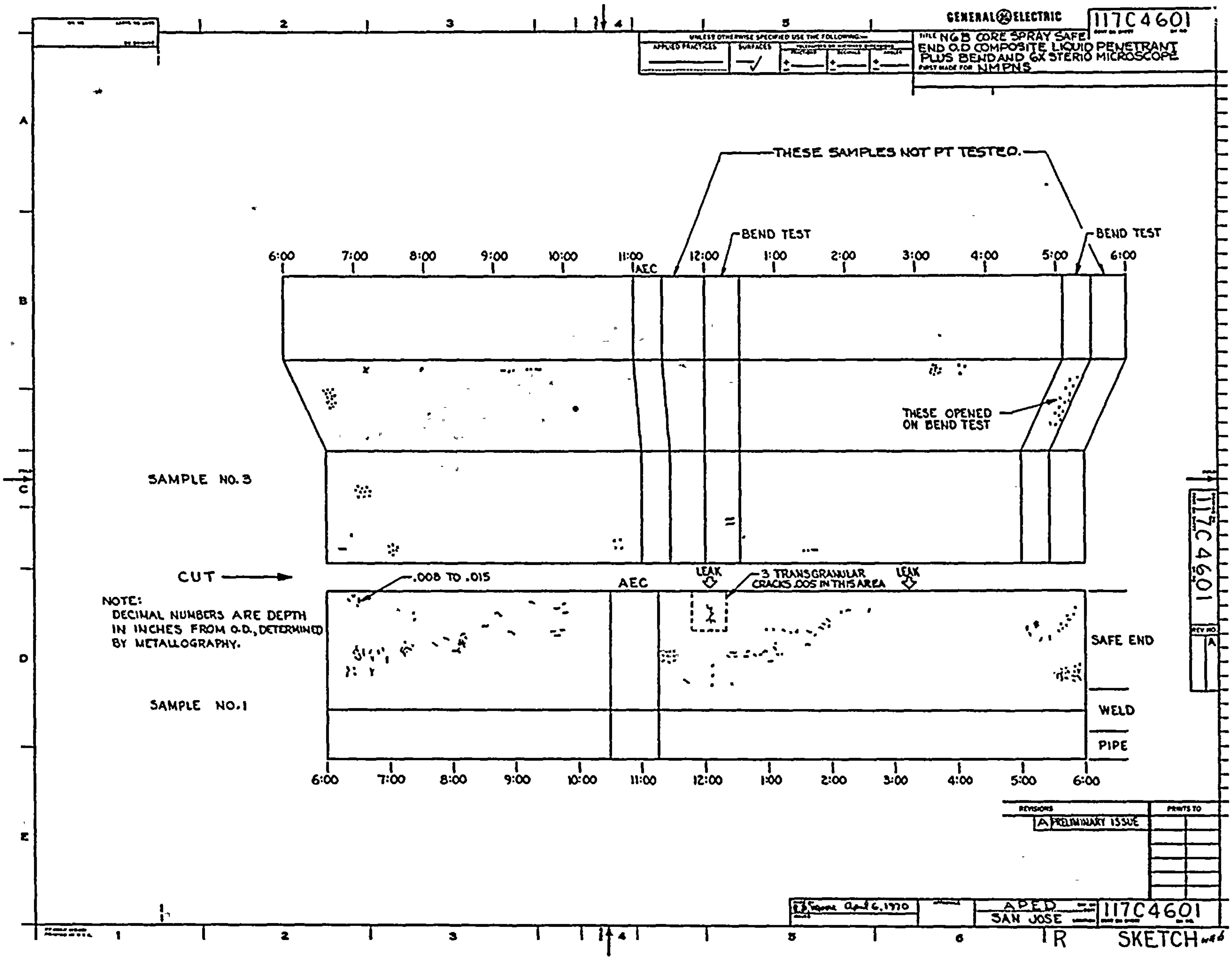


FIGURE 3-3. O.D. EXAMINATION SAFE END N6B

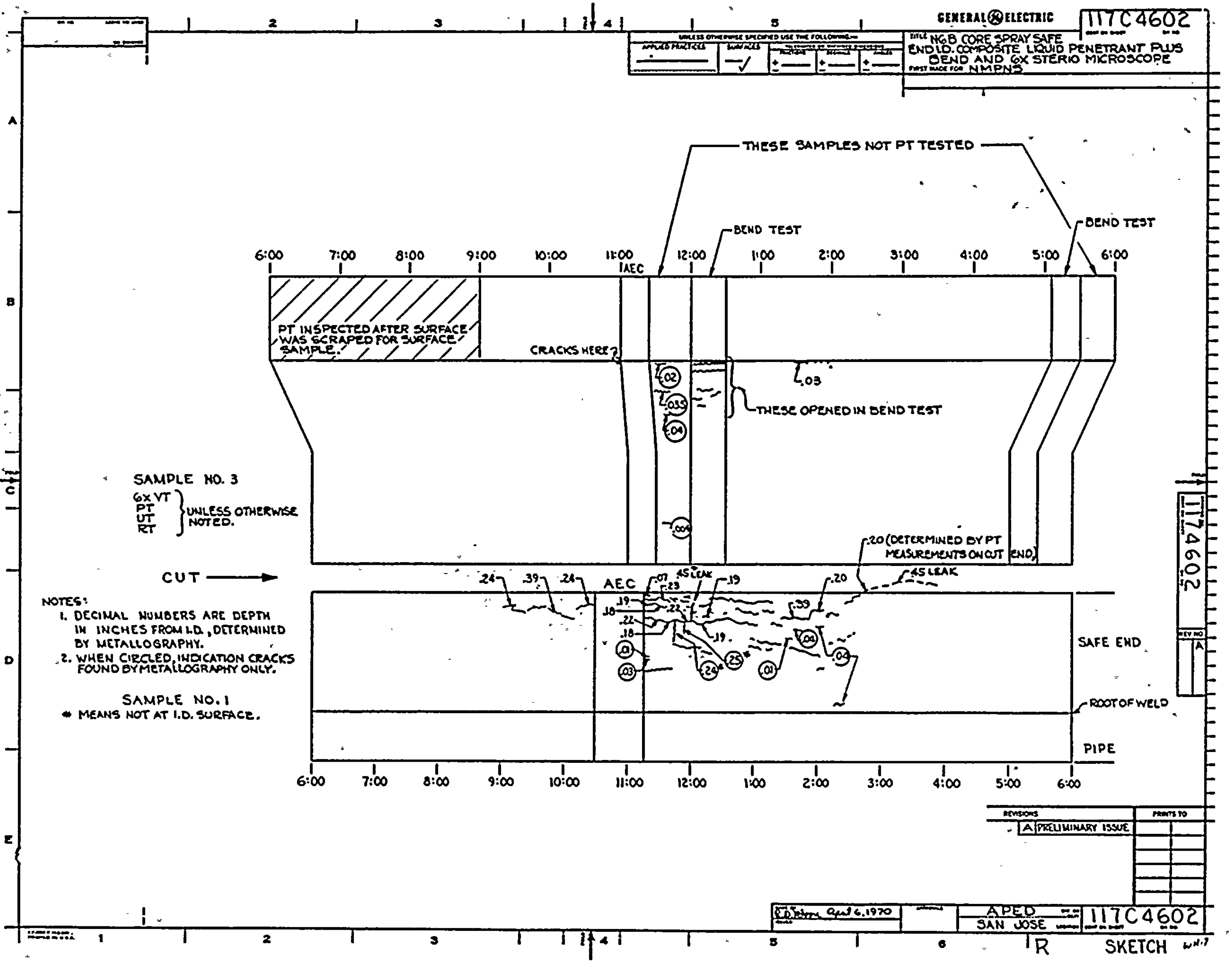
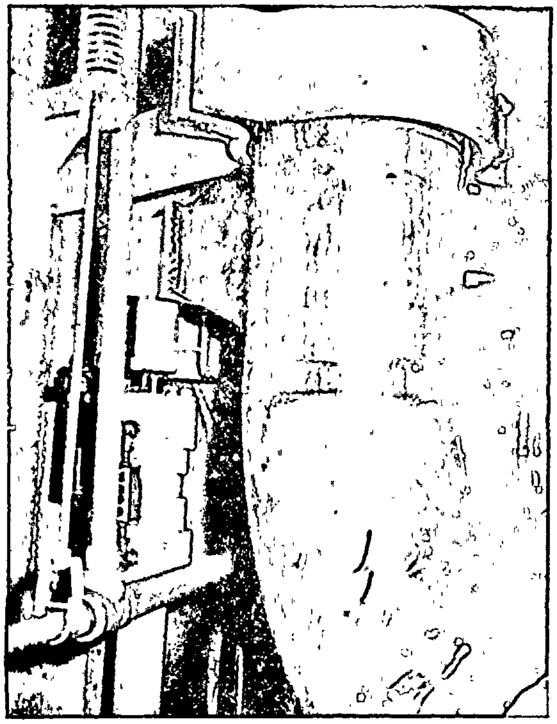
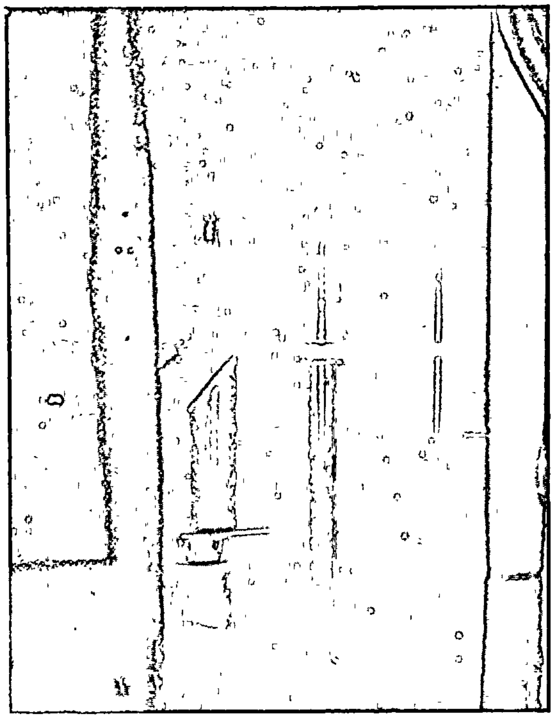


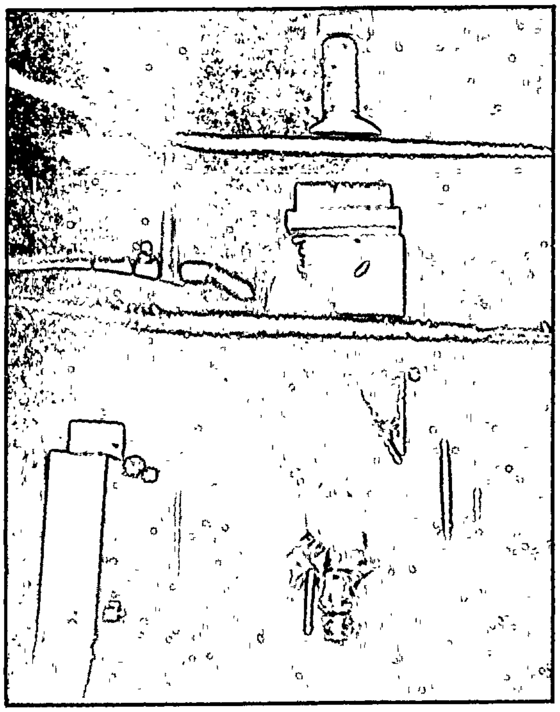
FIGURE 3-4. I.D. EXAMINATION SAFE END N6B



a. Jet Force Restraint and
Seismic Suppressor



b. Shock Suppressor



c. Seismic Restraint

FIGURE 3-5. WEST CORE SPRAY LINE

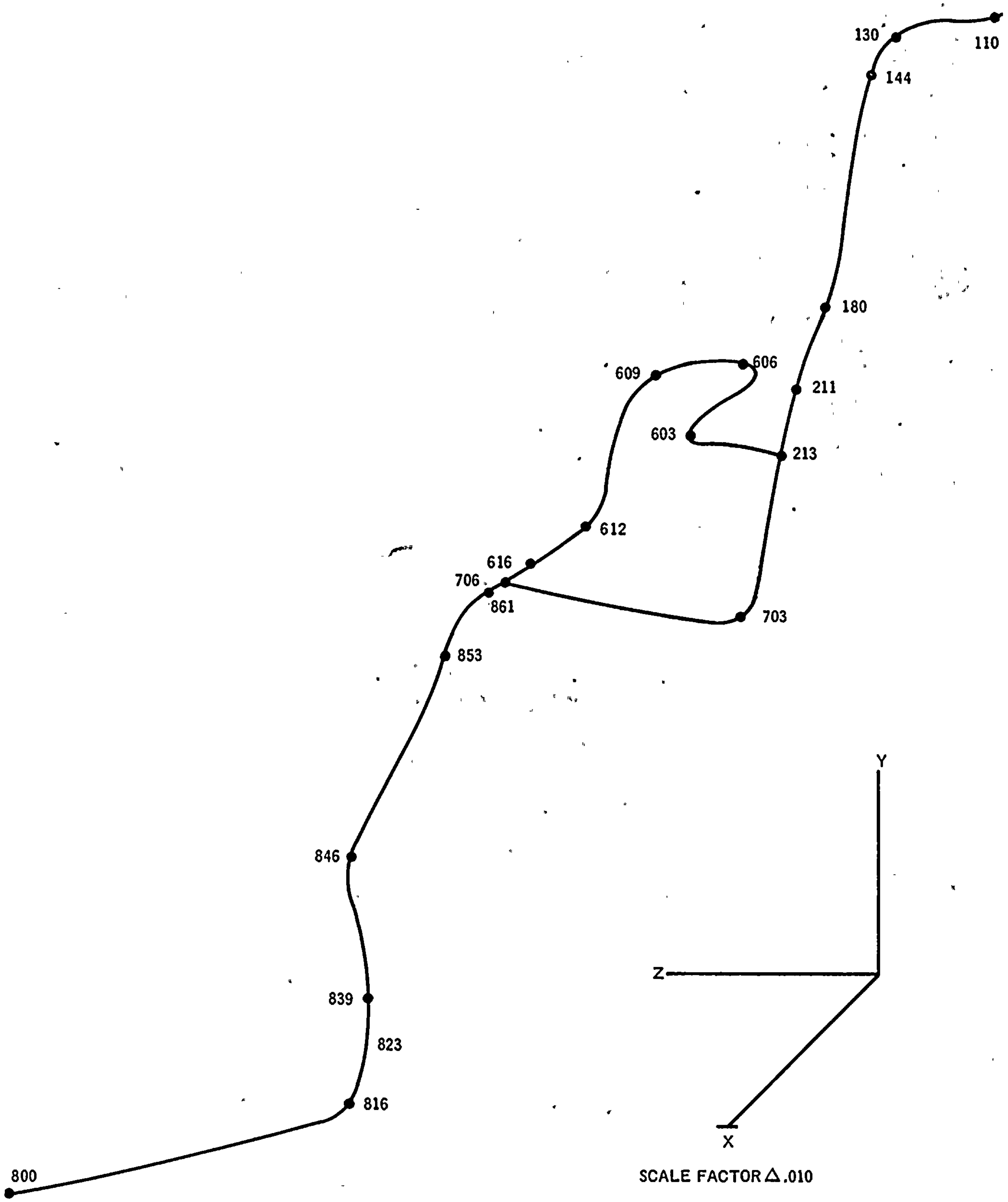


FIGURE 3-6. 135°F CORE SPRAY, 546°F VESSEL

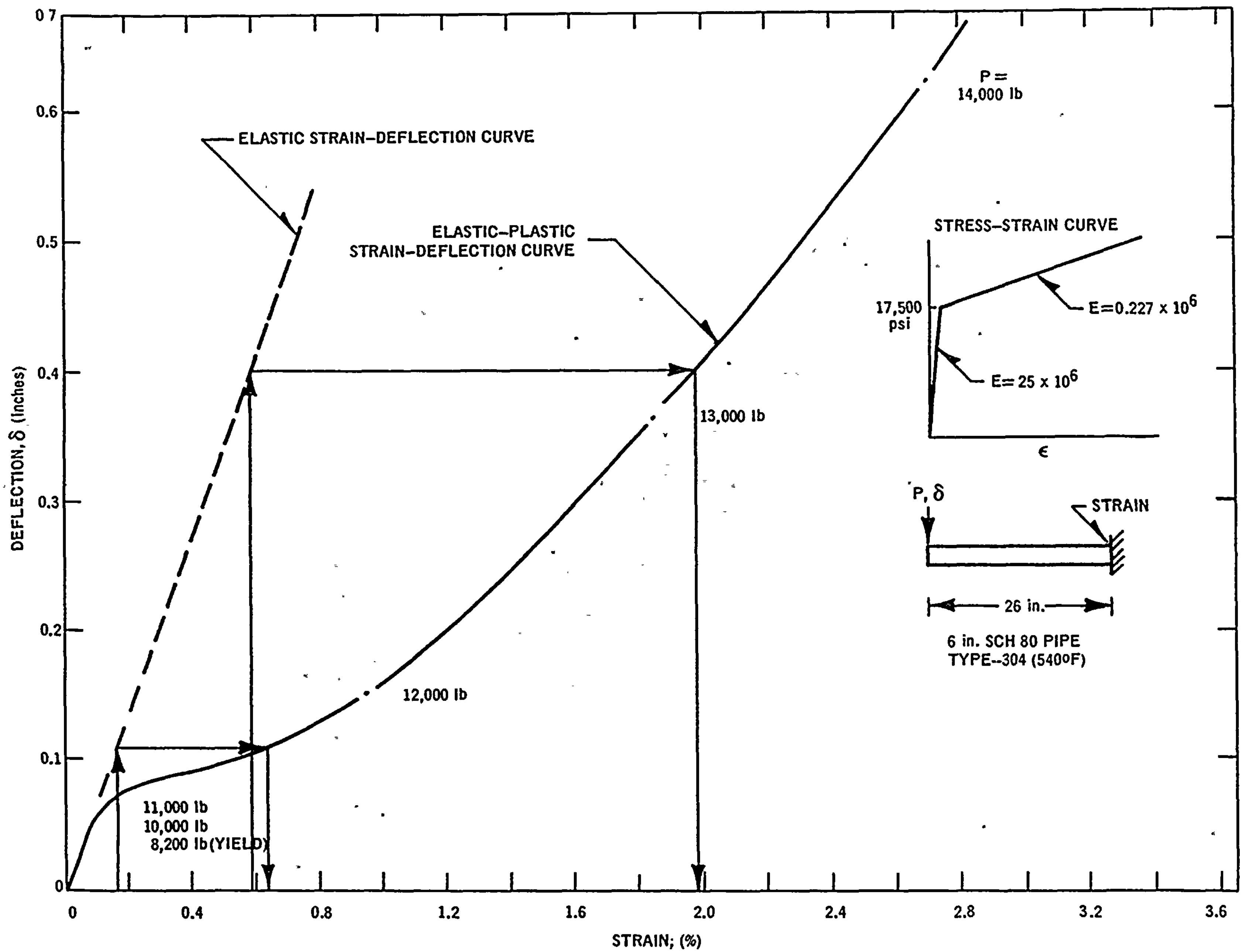


FIGURE 3-7. LOAD, STRAIN, AND DEFLECTION FOR CANTILEVER BENDING OF 6-INCH SCHEDULE 80 PIPE WITH BILINEAR STRESS-STRAIN RELATIONSHIP

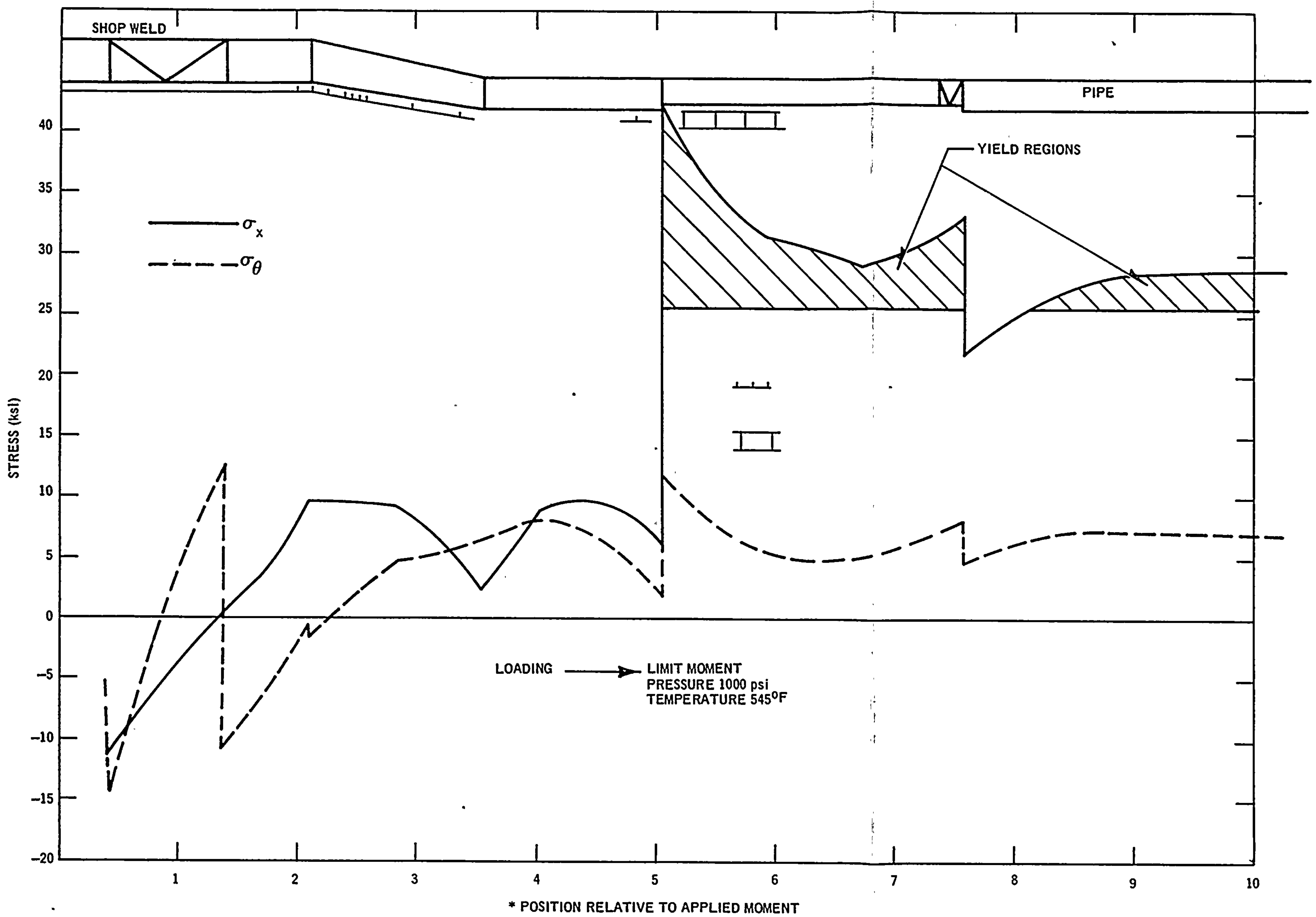


FIGURE 3-8. NINE MILE POINT N6B WEST CORE SPRAY NOZZLE–INSIDE SURFACE STRESSES 12 O'CLOCK POSITION

[illegible]

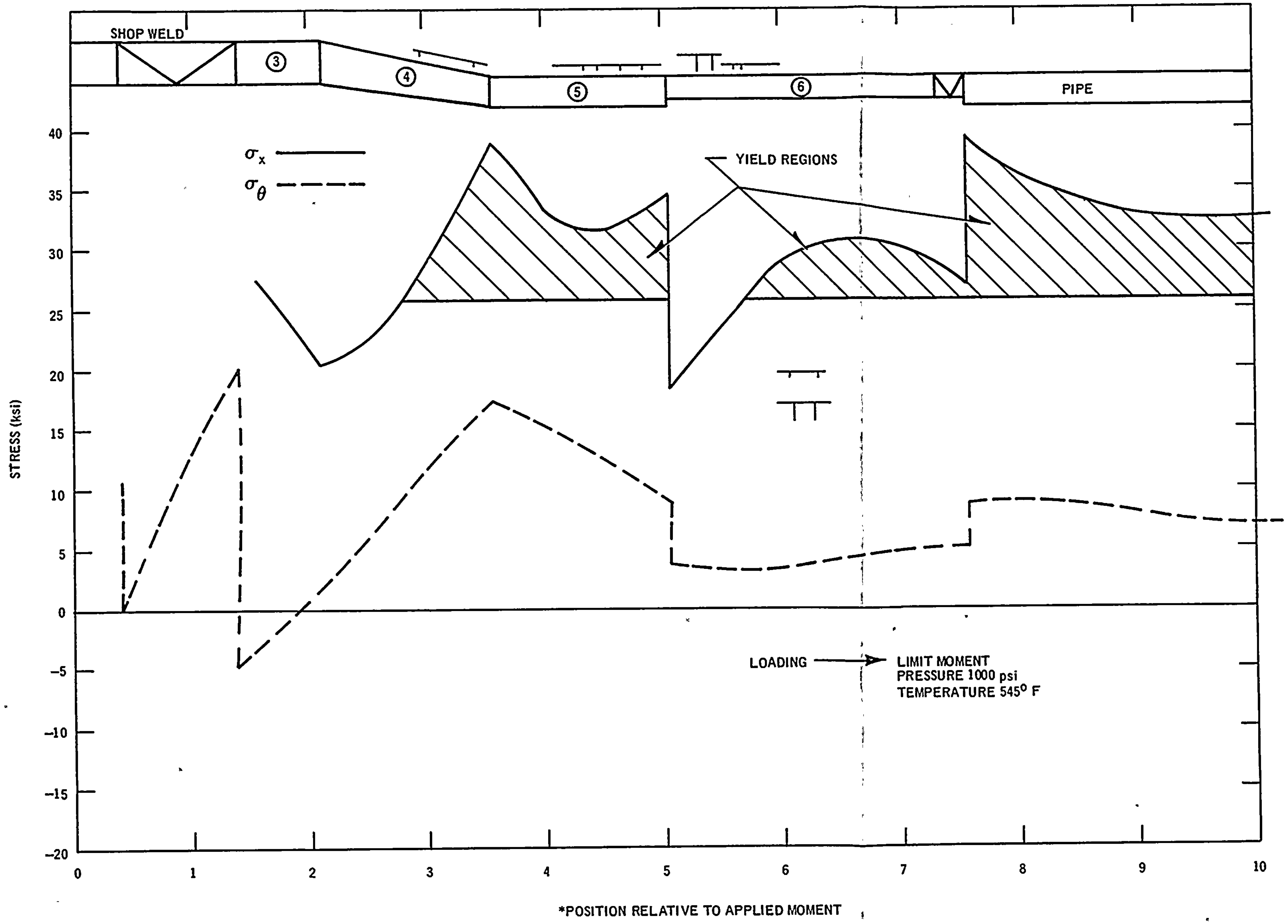


FIGURE 3-9. NINE MILE POINT N6B WEST CORE SPRAY NOZZLE–OUTSIDE SURFACE STRESSES 12 O'CLOCK POSITION

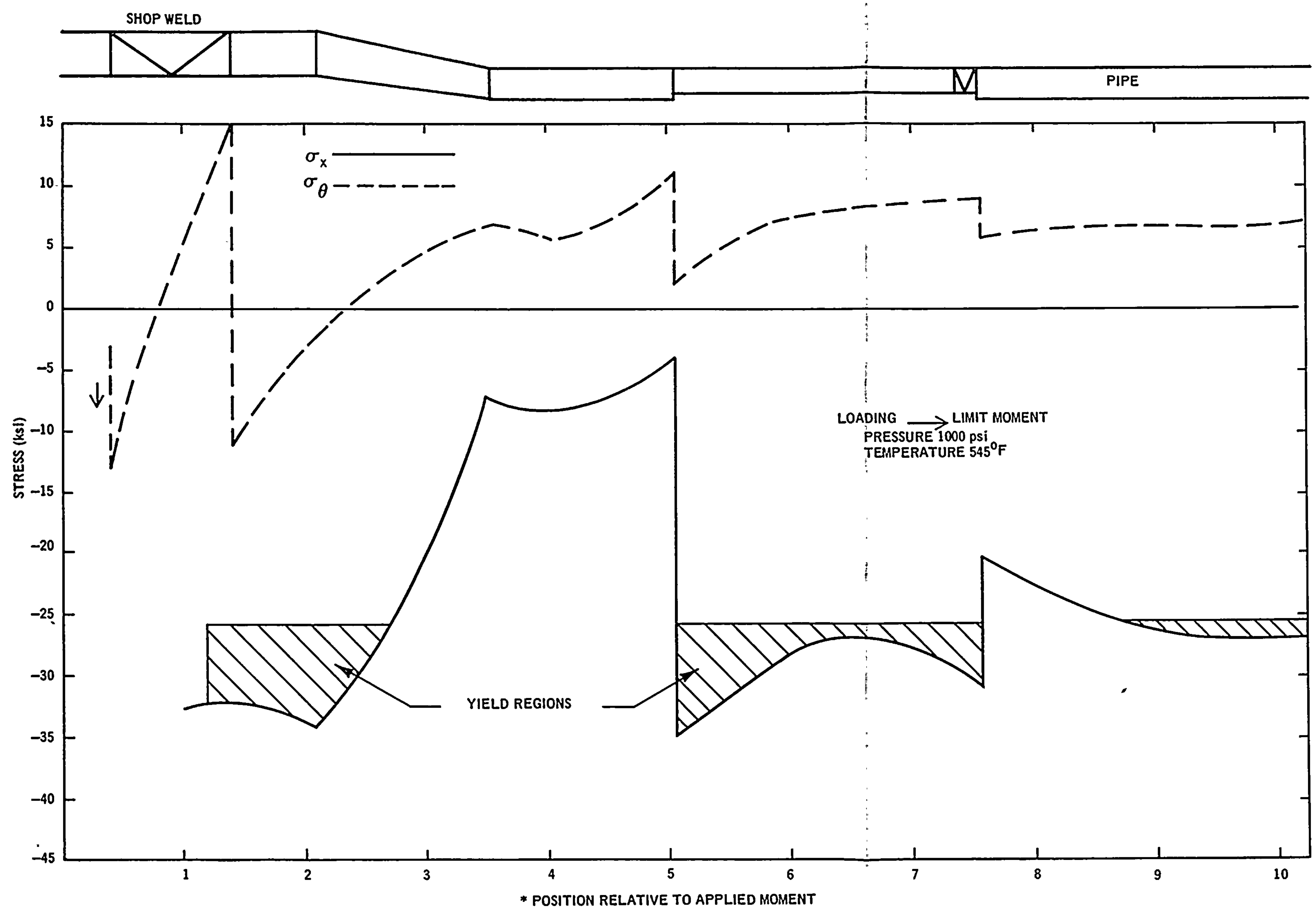


FIGURE 3-10. NINE MILE POINT N6B WEST CORE SPRAY NOZZLE–INSIDE SURFACE STRESSES 6 O'CLOCK POSITION

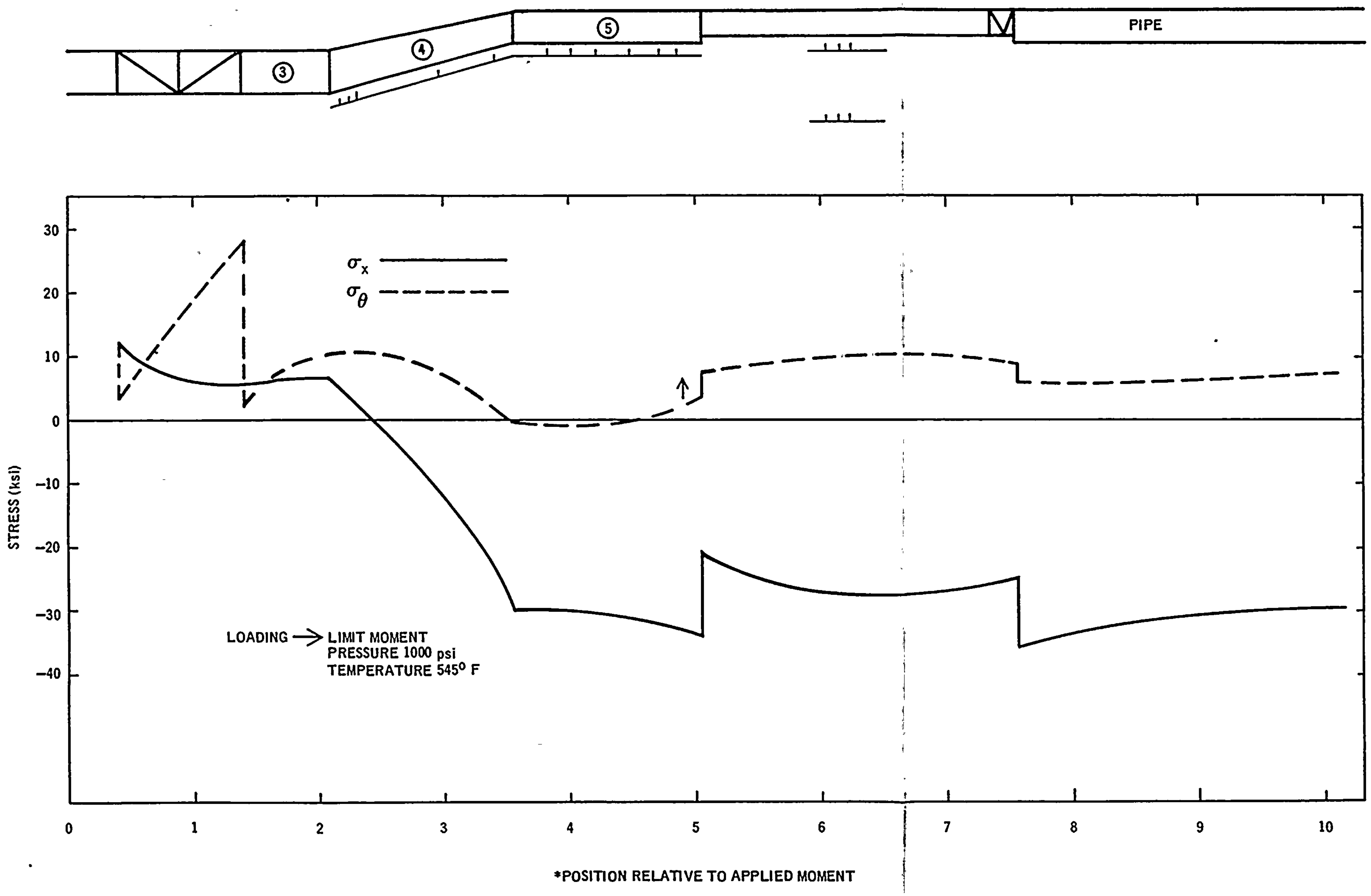


FIGURE 3-11. POSITION RELATIVE TO APPLIED MOMENT

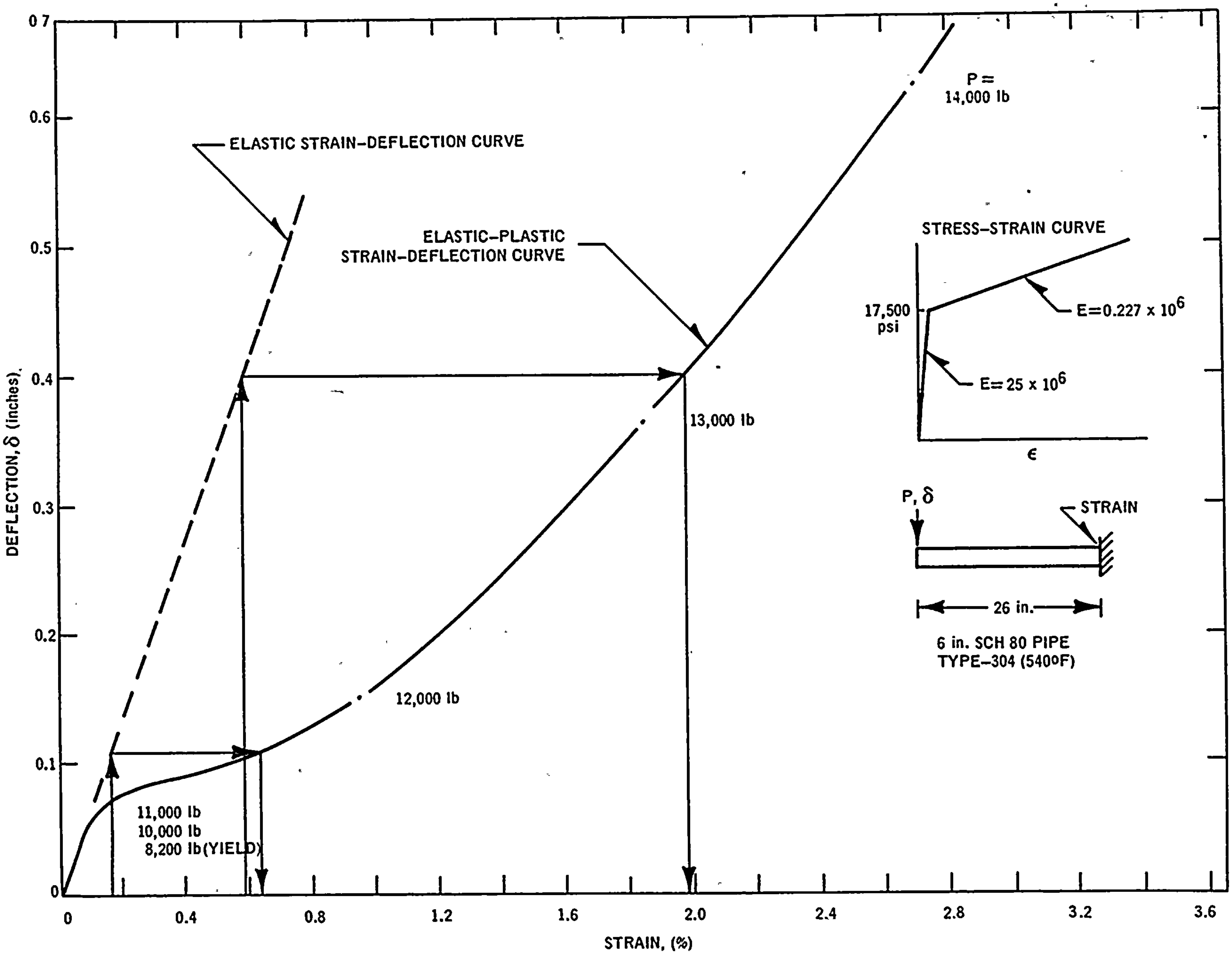


FIGURE 3-7. LOAD, STRAIN, AND DEFLECTION FOR CANTILEVER BENDING OF 6-INCH SCHEDULE 80 PIPE WITH BILINEAR STRESS-STRAIN RELATIONSHIP

[redacted]

4. INVESTIGATION OF OTHER FURNACE SENSITIZED STAINLESS STEEL-INTERIOR PRESSURE VESSEL

4.1 NONDESTRUCTIVE EXAMINATION OF ACCESSIBLE F.S.S.S. SAFE END INTERNAL SURFACES AND INTERNAL BRACKETS

4.1.1 Conclusions

No evidence of service induced corrosion was found on the internal surfaces represented by UT of all safe ends, and PT of the i.d. of 21 safe ends and of 6 brackets.

SAFE END INTERNAL SURFACES

Following the detection of intergranular cracking on the i.d. surface of Sample 3 of N6B (see Section 3), the interior surfaces of the eighteen N-7 safe ends, two N-5 safe ends and the N-9 safe end were examined using liquid penetrant procedure 21A8570 (see Appendix B), to determine if similar conditions existed on the internal surfaces of other F.S.S.S. safe ends. No indication of intergranular cracking was present.

The radiographic and untrasonic examination of all F.S.S.S. safe ends revealed no indications of intergranular attack or cracking. The ultrasonic examination did produce indications from the root of dissimilar metal shop welds on the N-1, N-2, N-7, and N-9 nozzles. See Table 1, Appendix B for details.

4.1.2 Internal Brackets

Included in the internal liquid penetrant examination were the two Guide Rod Brackets and the four Steam Dryer Support Brackets.

The examination revealed indications on both Guide Rod Brackets and three of the four Steam Dryer Support Brackets. The Guide Rod Brackets had been previously examined in November 1968 by liquid penetrant procedure PS-1 (see Appendix B) and found free of indications. The Steam Dryer Brackets had not been previously examined. The examination results for the November 1968 and the April 1970 examinations are contained in Appendix B. (The linear indication on the side of the un-sensitized S.S. collar shown on Sketch B-47 was due to abutting plate edges of the built-up collar.)

Metallurgical examination of Sample 5 from the 50 degree aximuth Steam Dryer Bracket and Sample 6 from the zero degree azimuth Guide Rod Bracket revealed (as discussed in Section 4.2) that the penetrant indications were produced by fabrication defects. Representative areas on each Steam Dryer Bracket were ground as indicated on the data sheet in Appendix B. Examination of the ground areas indicate the penetrant indications were produced by fabrication defects.

4.2 METALLURGICAL EXAMINATION OF INTERIOR BRACKETS

METALLURGICAL SAMPLE 5

Sample Number 5 was cut from the steam dryer support bracket at 50 degree aximuth as shown in Appendix C. The sample was visually inspected, photographed, liquid penetrant tested, and again photographed.

The sample was sectioned and examined metallographically to evaluate the nature and extent of the liquid penetrant indications found.

The dimensions of the sample were 2-3/4 inches long, 1 inch wide, and 0.2 inch thick. The 2-3/4 inch diameter represented the thickness of the bracket as shown in the figure. The surfaces of the sample that had been exposed to the pressure vessel atmosphere were covered with a dark grey adherent oxide film. Visual observations and liquid penetrant testing revealed a lap or fold extending about two-thirds the length of the specimen. Radiography of the specimen showed a void beneath the fold and a crack in the lip of the fold (which was detected by liquid penetrant testing); no other defects were found by nondestructive testing.

It was confirmed that the bracket material had been sensitized. A small pocket, partly filled with cutting debris, was found under the surface fold as shown in Appendix C. An intergranular penetration that extended to a depth of 0.050 inch below the surface of the sample was found at the bottom of the pocket under the fold and can be attributed either to prior pickling or to hot cracking during hot rolling. A small hole, about 4-5 mils in cross-section, was found near one end of the fold and extended from the bottom of the pocket through the 0.2 inch thickness of the sample. The source of the hole was not identified. No other unusual features were found in the sample.

METALLURGICAL SAMPLE 6

Sample Number 6 consisted of a wedge-shaped piece cut from the left side at the bottom end of the guide rod support bracket at zero degree azimuth as shown in Appendix C. The sample was visually inspected, photographed, liquid penetrant tested, and rephotographed.

The sample was sectioned into three pieces for metallographic evaluation of the nature and depth of indications found by PT.

Visual observation indicated that the surface of the sample exposed to the reactor environment has been ground or otherwise abraded before being placed in service, and was covered with a tightly adherent dark grey oxide film. Liquid penetrant testing revealed several indications as shown in Appendix C.

Metallographic sections through PT indications found in the sample revealed small hot tears in the weld deposit material, some of which extended to the surface of the sample. No intergranular attack of the type observed elsewhere in wrought

sensitized stainless steel was found. Typical examples of these hot tears are shown in Appendix C.

4.3 SUMMARY OF OTHER STRESS ANALYSES

Conclusions

1. Based on results on the best available analytical model, it is concluded that the maximum sustained service tensile stresses on the o.d. of the stub tubes occur during the shut down condition at reactor ambient temperature.

2. The relative fatigue service severity on F.S.S.S. stub tubes for two operating reactors (Dresden-1 and Big Rock Point) has been compared to the anticipated service life for the Nine Mile Point stub tubes. Based on a limited evaluation, it is believed that the D-1 fatigue service severity is greater than that projected for Nine Mile Point while for BRP the fatigue service is about the same. The D-1 reactor has operated for about nine years with no apparent difficulty in the CRD stub tube region. The early failure of the N6B safe end is somewhat anomolous with respect to this successful service experience.

3. None of the other F.S.S.S. components at Nine Mile Point are expected to experience high service stresses (above yield) comparable to the failed N6B safe end

4. Residual stresses are not considered as service stresses by any code requirement. The magnitude and sign of residual stresses are largely indeterminate and may influence stress corrosion behavior. Residual tensile stress should be considered in a qualitative sense as an extra degree of conservatism.

5. Clad overlay only on the o.d. nozzle safe ends is almost certain to induce high residual tension stresses (above nominal yield) on localized regions of the inside surface. If both the o.d. and the i.d. were clad, then the stress corrosion significance of residual stresses due to overlay procedure would disappear because there would be no furnace sensitize stainless steel exposed to reactor water.

4.3.1 East Side Core Spray Line Nine Mile Point

A stress analysis was made of the east core spray piping to determine the stress condition at the vessel nozzle. The east core spray piping is shown on Figure 4-1. This analysis shows that the suspension system of the east line, like that of the west line, is not adequate to carry the weight of the pipe. The calculated stresses from the TMR Report, Section 6, at the safe end are:

Weight Stress	22,000
Pressure Stress (Long)	3,800
Thermal Expansion	6,000

As can be seen from these results the N6A stresses are considerably lower than those of the N6B loop.

4.3.2 Other NMP F.S.S.S. Nozzle Safe End Stresses

The following is a summary of the design calculation for the recirculation piping safe ends.

APRIL 20, 1970

NINE MILE SYSTEM—RECIRC LOOP PUMP DISCHARGE 28-INCH PIPE

Combined Nozzle Forces and Moments

	lb			in.-lb		
	Axial F_x	Vertical F_y	Horiz F_z	Axial M_x	Vertical M_y	Horiz M_z
Thermal	- 362	-1,850	-4,535	387,800	1,033,000	-258,700
Weight	3,270	4,450	- 280	-145,600	- 169,900	5,930
Seismic	3,540	2,190	2,970	134,400	122,400	119,160
Total	7,172	8,490	7,785	667,800	1,325,300	383,790

M_R - Thermal = 1,133,315
M_R - Weight = 223,832
M_R - Seismic = 217,358
Z = 639.5 in.^{3}
Thermal Stress = 1,772
Weight Stress = 350
Seismic Stress = 340
Pressure Stress = 7,100

APRIL 20, 1970
NINE MILE SYSTEM—RECIRC LOOP PUMP SUCTION 28-INCH PIPE

Combined Nozzle Forces and Moments

	lb			in.-lb		
	Axial F_x	Vertical F_y	Horiz F_z	Axial M_x	Vertical M_y	Horiz M_z
Thermal	-1,610	2,800	-540	-122,600	199,200	398,000
Weight	1,190	- 3,160	-6	94,780	-125,500	13,390
Seismic	5,590	5,210	5,370	476,040	202,680	507,720
Total	8,390	11,170	5,916	693,420	527,380	919,110

M_R - Thermal = 461,645
M_R - Weight = 157,838
M_R - Seismic = 724,895
Z = 639.5 in.^{3}
Thermal Stress = 722
Weight Stress = 247
Seismic Stress = 1134
Pressure Stress = 7100

All other nozzle safe end stresses are described in the report by Teledyne Materials Research in Section 6.

The stresses on the vessel head nozzles are tabulated as follows:

Nozzle	Stresses
Head Vent Long Neck Flange	≤ 15,000 psi
Safety Valve and Inst. Long Neck Flange	≤ 15,000 psi

4.3.3 Stub Tubes

A summary of the highest stressed F.S.S.S. CRD nozzle stub tube service stresses based on Combustion Engineering calculations is shown as follows:

NEDE-10168

GENERAL ELECTRIC CO.

Nuclear Energy Division

ENGINEERING CALCULATION SHEET

DATE March 20, 70

SHOP ORDER NO.

SUBJECT BY V.R.W. SHEET 1 OF

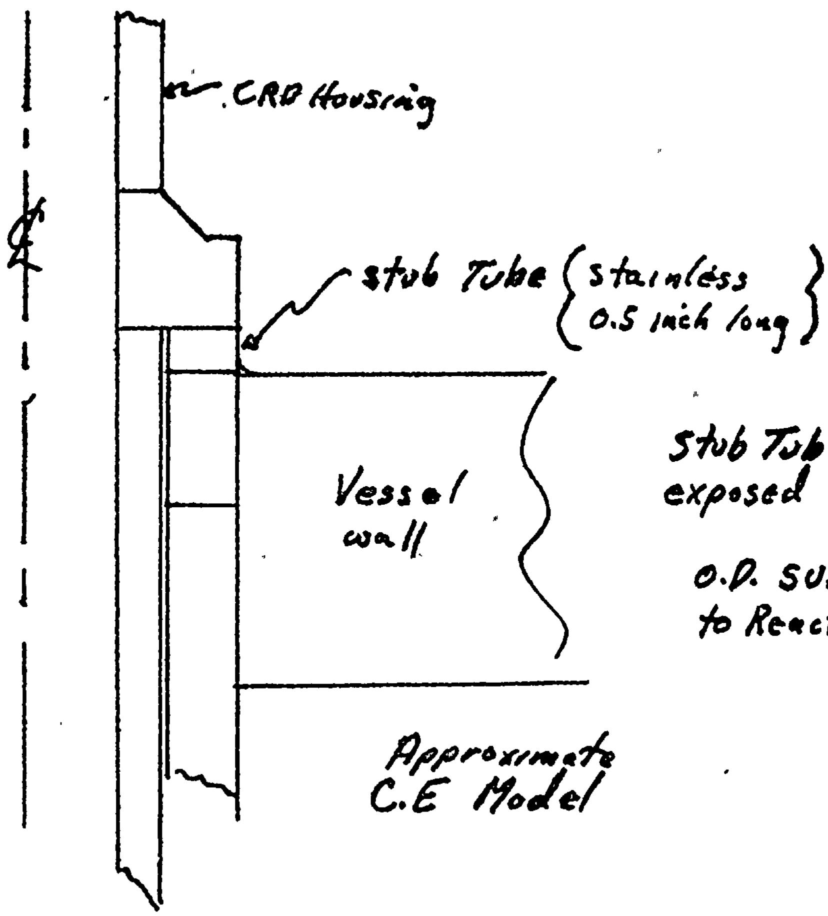
Nine Mile Point Stub Tube Stresses

Summary of

1) Primary + Secondary stress Components

2) Peak stress components

from Combustion Engry Calculations
Calc # 304 Rev 3, 8/16/68



Stub Tube I.D. surface exposed to air.

O.D. surface exposed to Reactor water.

Approximate C.E Model

Form No. ATPE 87

NEDE-10168

GENERAL ELECTRIC CO.

Nuclear Energy Division

ENGINEERING CALCULATION SHEET

DATE

SHOP ORDER NO.

SUBJECT BY SHEET 2 OF

Primary + Secondary stresses (ksi)

Condition	I.D. Surface σ_x	I.D. Surface σ_θ	O.D. Surface σ_x	O.D. Surface σ_θ
Top of Stub Tube				
1 Pressure only	-4.1	2.0	-1.5	2.8
2 End of startup	-8.4	-28.3	1.4	-25.3
3 Scram & Steady state	-4.9	-25.1	-0.9	-23.5
4 C.R.D. Isolation	-11.6	-20.5	5.8	-14.9
Bottom of Stub Tube				
1 Pressure only	-8.8	2.4	3.0	6.0
2 End of startup	29.4	-26.3	-35.6	-42.8
3 Scram steady state	19.6	-21.9	-26.0	-35.7
CRD. Isolation	16.7	-16.8	-24.9	-29.4

Form No. ATPE 87

NEDE-10168

GENERAL ELECTRIC CO.
Nuclear Energy Division
ENGINEERING CALCULATION SHEET

29

DATE

SHOP ORDER NO.

SUBJECT BY SHEET 3 OF

Peak Stresses (ksi)

Condition	I.D. surface σ_x	I.D. surface σ_θ	O.D. surface σ_x	O.D. surface σ_θ
Top of Stub Tube				
1 Pressure only	-16.1	+0.9	-1.5	+2.8
2 End of startup	-26.	-38.	-2.8	-48.6
3 Scram or steady state	-15.2	-27.7	-7.2	-44.0
4 CRD Isolation	-58.9	-43.6	9.2	-25.7
Bottom of Stub Tube				
1 Pressure only	-8.8	2.9	5.0	7.6
2 End of startup	62.	-32.3	-131.5	-99.
3 Scram or steady state	43.5	-26.6	-94.2	-75.5
4 CRD Isolation	38.9	-25.5	-82.6	-61.0

Form No. ATPE 87

These are the stresses which are directly from the elastic analysis. Since the stress ranges are considerably above the yield stress, it is necessary to consider the consequences of plastic flow and shakedown action to determine the actual plastic sustained service stresses which are expected to exist under various operating conditions. The following plots, (Figures 4-6 through 4-9) were made to estimate the direction of the stress components during various service loading conditions where account is taken of yielding to change the residual or mean stresses. It was assumed that the material yields at 22 ksi in these plots.

Notice from Figures 4-6 and 4-7 that both the top and bottom of the water-exposed side of the stub tube will exceed the tensile yield strength during the shutdown condition. Since this total accumulated shutdown condition could be 10 or 20% of the design life, this means that tensile stresses slightly in excess of yield may exist for sustained periods up to a total of 35,000 to 75,000 hours during the reactor shutdown at low temperature conditions. The condition of control rod drive isolation also produces tensile yield stresses, but this should occur for much shorter periods of time. Figures 4-8 and 4-9 indicate biaxial yielding on the i.d. surface where neither stress component alone is at the yield level, but the biaxial stress is at a yield condition, and reduces to a maximum stress of 13,000 psi during steady state operating condition which is less than 2/3 of the yield strength at 550° F.

Based upon G. E. estimates, the service loading of NMP stub tubes is approximately the same as Big Rock Point stub tubes and less than Dresden-1 stub tubes.

4.3.4 STRESSES IN NOZZLE AND VESSEL SHELL MATERIAL DURING ABNORMAL CORE SPRAY PIPE REACTION

Analysis was made of the stresses, in the core spray nozzle material that will remain as part of the vessel, that occurred as a result of the abnormal pipe reaction on nozzle N6B. The results are as follows:

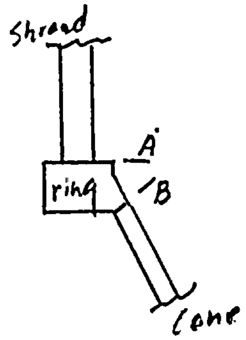
1. Maximum moment applied = 398 in-Kips

2a. Axial stress due to moment at smallest nozzle section = 22,600 psi

b. Maximum stress intensity (includes pressure and bending) = 25,400 psi
   Section III allowable: S_m = 26,700 psi
   Material yield stress = 40,000 psi

3. Increase in membrane plus bending stress in vessel shell at nozzle due to maximum moment = 830 psi

4.3.5 NMP Core Support Ring



Stress Intensities $|\sigma_1 - \sigma_3|$ ksi

Condition	B Inside	B Outside	A Inside	A Outside
Design	14.68	16.75	6.60	6.60
100% SS	15.42	15.75	6.70	7.60
100°F/hr h.u.	18.20	15.79	7.13	5.83
100°F/hr c.d.	11.61	16.34	9.46	14.54
300°F/hr	14.85	21.61	13.38	16.59
Scram A	10.10	8.53	6.11	6.45
Scram B	17.20	13.90	3.23	6.06
Bldn. C	12.26	17.92	8.88	9.15
Bldn. D	8.40	6.87	5.56	5.59
Bldn. E	9.80	17.85	12.10	14.94

Stress Components

	A Inside	A Outside	B Inside	B Outside	B Inside	B Outside
Design	- 1.65	- 1.67	- 2.02	- 4.06	12.66	12.69
100% SS	- 2.14	1.18	- 3.28	- 2.78	12.14	12.97
100°F/hr h.u.	- 3.83	0.51	- 7.76	1.74	10.44	14.05
100°F/hr c.d.	9.46	-14.54	8.80	-16.34	- 2.81	- 10.65
300°F/hr E.C.	11.51	-16.59	13.99	-21.61	- 0.86	- 11.98
Scram A	1.66	- 4.98	2.83	- 8.53	10.10	7.03
Scram B	- 3.23	- 0.09	- 5.92	- 0.12	11.28	13.78
Bldn. C	5.83	- 9.15	12.22	-17.92	12.26	3.23
Bldn. D	1.41	- 4.73	1.31	- 6.87	8.40	6.29
Bldn. E	9.86	14.74	9.80	17.36	- 2.44	- 0.49

Times

40 years = 35 X 10^5 hours (100% steady state) 12.97 ksi
100°F/hr heatup 120 X 8 hours = 9600 hours 14.05 ksi
Other times negligible at lower stress for outside at B.

Maximum tensile stress = 17.36 ksi outside at B
Condition is Blowdown E—10 hours.

4.3.6 Dryer Bracket Pads

Stress 15,750 psi.

4.3.7 Track Guide Bracket

Stress ~ 24,000 psi short time loading during shutdown conditions.

4.3.8 Evaluation of Residual Stresses Due to Weld Overlay

In order to study the possible residual stress effects of a weld overlay procedure on the o.d. of F.S.S.S. safe ends, an experiment was performed on a straight cylindrical section of pipe in which dimensional changes were recorded.

Measurements made before and after the longitudinal weld overlay on the sample pipe indicates a residual deformation in an approximate 4 lobe (8 node) pattern in alignment with the 12-6 o'clock and 9-3 o'clock position. This deformation is quite uniform along the length of the weld overlay. A representative set of measurements are as shown:

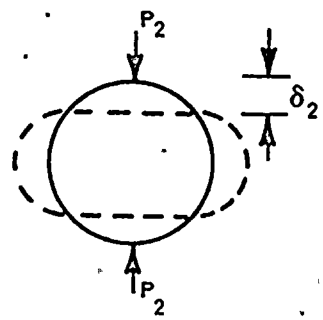
Position	Diametrical Deformation
12-6 o'clock	-0.032 inch
11-5 o'clock	-0.008 inch
10-4 o'clock	+0.008 inch
9-3 o'clock	-0.010 inch
8-2 o'clock	-0.002 inch
7-1 o'clock	-0.018 inch

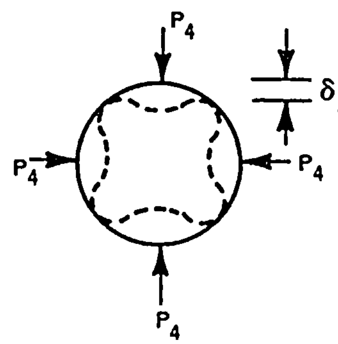
The residual stresses were estimated by analyzing a ring of unit length taken from the cylinder and loaded by point loads at 12, 3, 6, and 9 o'clock. Deformations at the 12-6 o'clock and 9-3 o'clock positions are used to evaluate the residual stresses.

From the data we get

$\delta_2 = 0.0055$ inch

$\delta_4 = 0.0105$ inch





This gives loads of

$P_2 = 2100$ lb

$P_4 = 49{,}300$ lb

Bending stresses combine at the 12 o'clock and 6 o'clock positons to give the maximum tensile stress.

Individual bending stresses at this point, calculated elastically are:

$\sigma_2 = 22{,}700$ psi

$\sigma_4 = 228{,}000$ psi

At the 9 o'clock and 3 o'clock positions the σ_2 stress will subtract from the σ_4 stress. However, the σ_4 stress is so high that there will be essentially yield stresses present at all four of the assumed point load locations.

Therefore, the longitudinal weld overlay process if applied only on the o.d. of a safe end can be expected to cause high residual tensile stresses on the interior furnace sensitized stainless steel surface.

This investigation of residual stresses is not a normal design procedure, but this has been investigated to shed further light on the consequences of any proposed welding procedure.

If both the o.d. and the i.d. were clad, then the stress corrosion significance of residual stresses due to the overlay procedure would disappear because there would be no furnace sensitized stainless steel exposed to reactor water.

4.4 INTERIOR CONDITION AND PROTECTION OF FURNACE SENSITIZED STAINLESS STEEL

Exceptional care was taken to avoid surface contamination of the interior vessel parts. During construction, personnel access was restricted, and clean clothing and shoe covers were required. In addition, TSP solutions were used to clean the vessel and systems to counteract and remove any inadvertent halide contamination. A history of the operations since the field hydrostatic test is listed below:

1968

June-July inspected all stub tubes and weld build up 59 field welds initiated.

Sept. 20-29 - Cleaned all stainless steel systems with 0.5% TSP solution in demineralized water. This included a portion of the vessel, as it was used as a tank for the TSP solution. Solution was then drained, but systems were not rinsed.

Nov. 7 - Completed filling reactor systems for hydro, using 0.05% TSP in demineralized water.

Nov. 8 - Hydro test

Nov. 12 - Draining vessel and systems

Nov. 12-20 - N.D.T. of vessel internals:

75 stub tube field welds

i.d. and o.d. recirc inlet, outlet, top head nozzles and emergency condensate nozzles. Portions of flange seal surface and shroud support ring.

Guide rod brackets

1969

Jan. 3- Filled vessel - demineralized water

Jan. 25 - Drained vessel and inspected 54 stub tube to housing field welds. Repaired two welds.

May 22 - Pressure test and heatup for hot functional, using demineralized water. After test, the vessel was partially drained.

June 13 - Filled vessel with demineralized water.

Aug. 23 - Started fuel loading.

4.5 INTERNAL ENVIRONMENT

4.5.1 Water Chemistry

The bulk reactor water is demineralized and is constantly monitored to assure that conductivity and chloride are maintained within the upper limit of 10 micromhos/cm and 1.0 ppm chloride. Experience has shown when the reactor head is off that the water equilibrates with atmospheric oxygen at about 8 ppm O_2. At operating conditions, the equilibrium point for radiolytic production of O_2 and loss through the steam is approximately 0.2 ppm in the water. During periods of hot standby the bulk water oxygen level has been measured to increase at a rate of 200 to 300 ppb per day due to oxygen added by makeup water from the condensate storage tank. The maximum hot standby time was less than 3 days. There is sufficient forced circulation in the bulk of the reactor to maintain constant oxygen concentration at all points in the vessel except as described below.

Fluorine is not monitored but measurement (Table 4-1) shows that the level is near or below the measurement capability of 0.04 ppm. Fluorine can be produced by transmutation of O_2 but the production rate is below the measurable level.

4.5.2 Stagnant Water

A review was made of the normal function of all the lines during operation to determine what lines had water flow or were stagnant. In summation, all the lines except the feedwater, main steam, control rod drive hydraulic return and the recirculation lines do not have forced flow during normal operation. These lines include the instrument nozzle lines, core spray, steam emergency condenser, core Δ P and liquid poison and all the vessel head nozzles. As covered in more detail in the section on core spray water, thermal convection as well as mechanically forced circulation can cause sufficient flow to maintain chemical equilibrium. Oxygen concentration will not exceed the equilibrium concentration in the gas phase because diffusion rates are so high. With the exception of the core spray system, oxygen levels in the several systems and nozzles will be at or near the bulk water level at all times.

4.5.3 Internal Surfaces

As noted in the section on bend test specimens, surfaces in contact with the reactorwater have accumulated a tight surface oxide and a loose coating of crud. This coating has been observed on all test specimens placed in the Dresden 1 and Humboldt plants and on internal surfaces of all General Electric reactors. Chemical analyses of surface coatings have been made as shown on Table 4-2. To date, the amount of fluorides detected has been very low and that seen on the exposed reactor surfaces compares to surfaces exposed to air contamination at random.

4.5.4 Corrosion Surveillance Bend Test Samples

4.5.4.1 Inspection at Site 4/13/70

Bend specimens which were loaded in racks and inserted in the vessel steam dryer, steam separator, and core regions were examined. Each specimen rack contained 9 bend specimens which were deflected to produce a stress calculated by the beam equation equivalent to 125% of their room temperature yield strength (on an elastic basis). These bend specimens consist of triplicate samples of Type-304 stainless steel in three metallurgical conditions as per APED Drawing No. 158B7919, Rev. O. These are: (1) rolled, annealed, and pickled ASTM A-240 plate; (2) same as condition (1) plus 12 hours furnace sensitization at 1150° F in air and cooled in still air; and (3) 304 stub tube forging material produced to ASTM A-182 forged, machined, and furnace sensitized as per condition (2).

All specimens were visually examined in their rack containers with a stereographic microscope at magnifications ranging from 14x to 60x. The majority of the examination was done at lower magnifications (20x); selected areas of the specimens were examined at 60x. No cracks or abnormalities were found on any specimen.

Steam dryer specimens - A reddish-brown crud film was uniformly distributed over the entire surface of specimens, rack and holder. In addition, isolated whitish crystalline deposits 0.001-0.003 inch in diameter were randomly distributed over the surfaces. These deposits appear to be the same as previously observed in other examinations and identified as spinel oxides. Metal under oxides was normal. No cracks or other anomalies noted.

Steam separator samples - The samples, rack and holder were uniformly covered with a reddish-brown (rust) loosely adhering crud film. It was easily removed by wiping. Microscopic examination disclosed no cracks or other abnormalities.

Core samples - The specimens, rack and holder were uniformly covered with a dark grey moderately adhering crud. No cracks or abnormalities were observed.

4.5.4.2 Inspection at VNC

Nine samples representing each material exposed at each condition were shipped to VNC for metallographic examination for cracks. No cracks or intergranular attacks were detected in these samples.

TABLE 4-1

WATER ANALYSIS

Number	Location	F Analysis (ppm)	Cl (ppm)	Activation Products
1	Reactor, Inlet to cleanup system	< 0.01	< 0.02	Yes
2	Core Spray B - drip from leak	0.1 to 0.2	–	Yes
3	Same - top of vertical pipe	< 0.05	0.04	–
4	Core spray A - hypodermic at safe end field	to be taken		
5	Core spray A - top of vertical pipe	to be taken		
6	Analytical blank	< 0.04		

TABLE 4-2
SUMMARY OF ANALYSIS — SAFE END SAMPLES
FLUORIDE RESULTS

Analysis Sample	Met. Sample	Description	Asimuthal Location	Results (μg F)	Sampling Method	Sampling Area (cm^2)
1	1	Pipe + Safe End Pipe End ID and OD	12	288	Ultrasonic crud	2050
2	1	Pipe + Safe End Pipe End ID and OD	12	332	Ultrasonic filtrate	2050
3	1	Safe End ID Pipe End	5-6	15	Machining (after UT cleaning)	12
4	3	Safe End ID Reactor End	6-10:30	26	Wipe	95
5	3	Safe End ID Reactor End	6-9	20	Machining	29
6	3	Safe End ID Crevice	5:30-6	5	Wipe	4.6
7	3	Thermal Sleeve OD Crevice	5:30-6	5	Acid	4.6
8	3	Thermal Sleeve ID	12-6	28	Wipe	50
9	3	Thermal Sleeve ID	6-9	17	Machining	21
10	3	Thermal Sleeve ID	6-9	19	Machining	21
11	3	Safe End OD	12-6	21	Wipe	240
12	3	Safe End OD Pipe End	6-9	15	Machining	26
13		Stock 304 Pipe (Sampling Blank)	—	16	Machining	33
14		Chemical Blank	—	< 0.04		

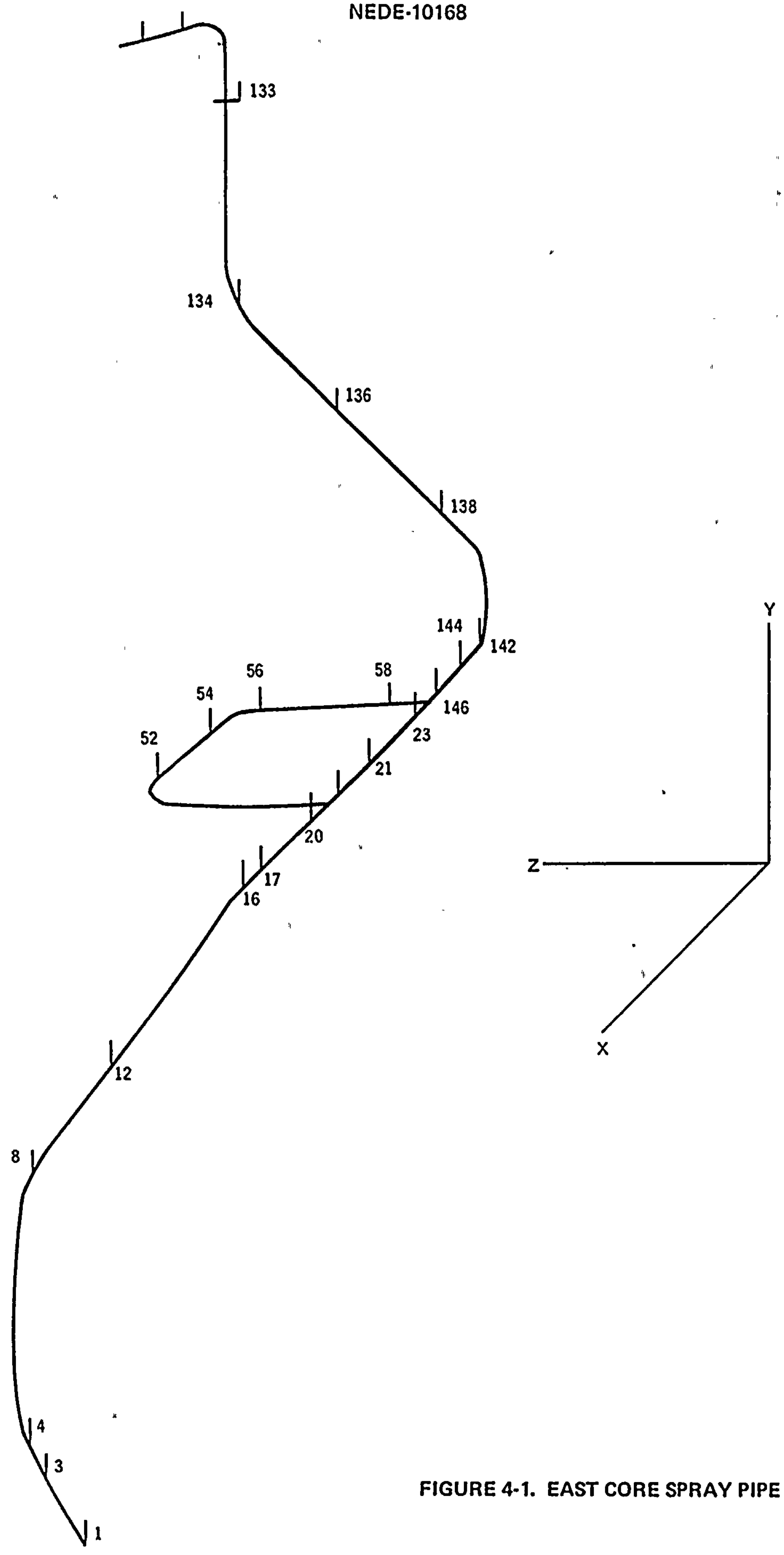


FIGURE 4-1. EAST CORE SPRAY PIPE (N5A) 195°F LINE

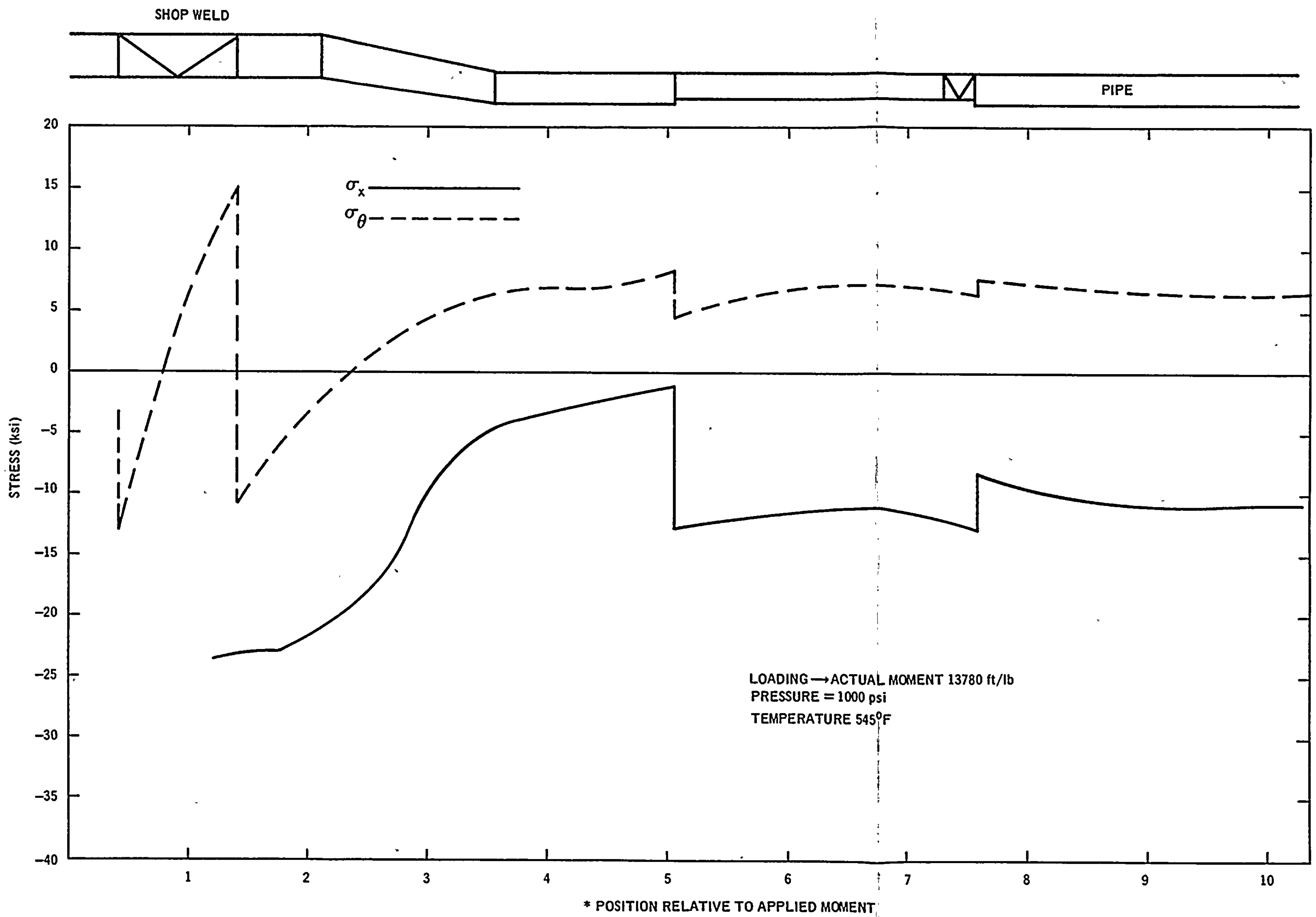


FIGURE 4-2. NINE MILE POINT N6A EAST CORE SPRAY NOZZLE–INSIDE SURFACE STRESSES 6 O'CLOCK POSITION

[illegible]

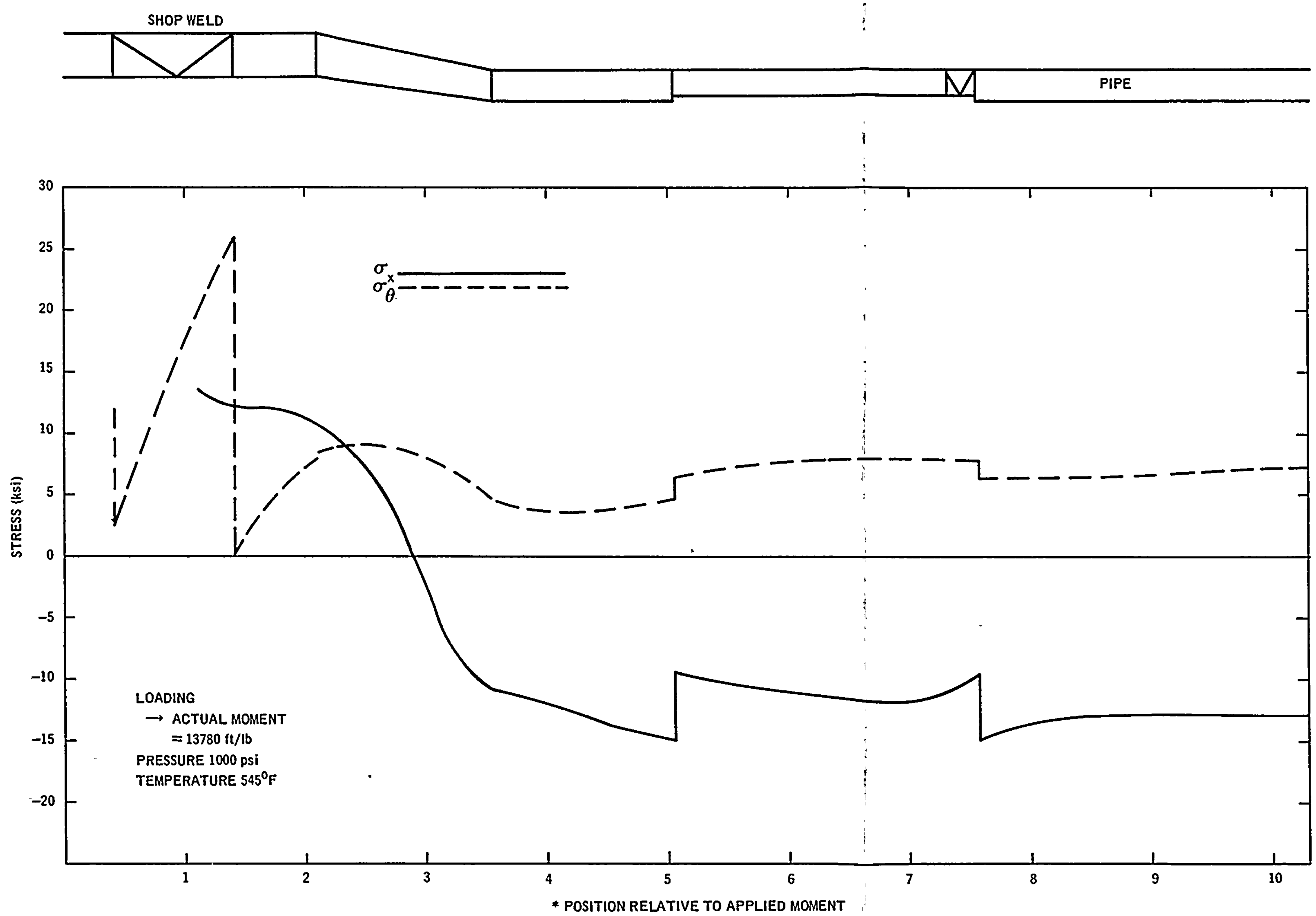


FIGURE 4-3. NINE MILE POINT N6A EAST CORE SPRAY NOZZLE–OUTSIDE SURFACE STRESSES 6 O'CLOCK POSITION

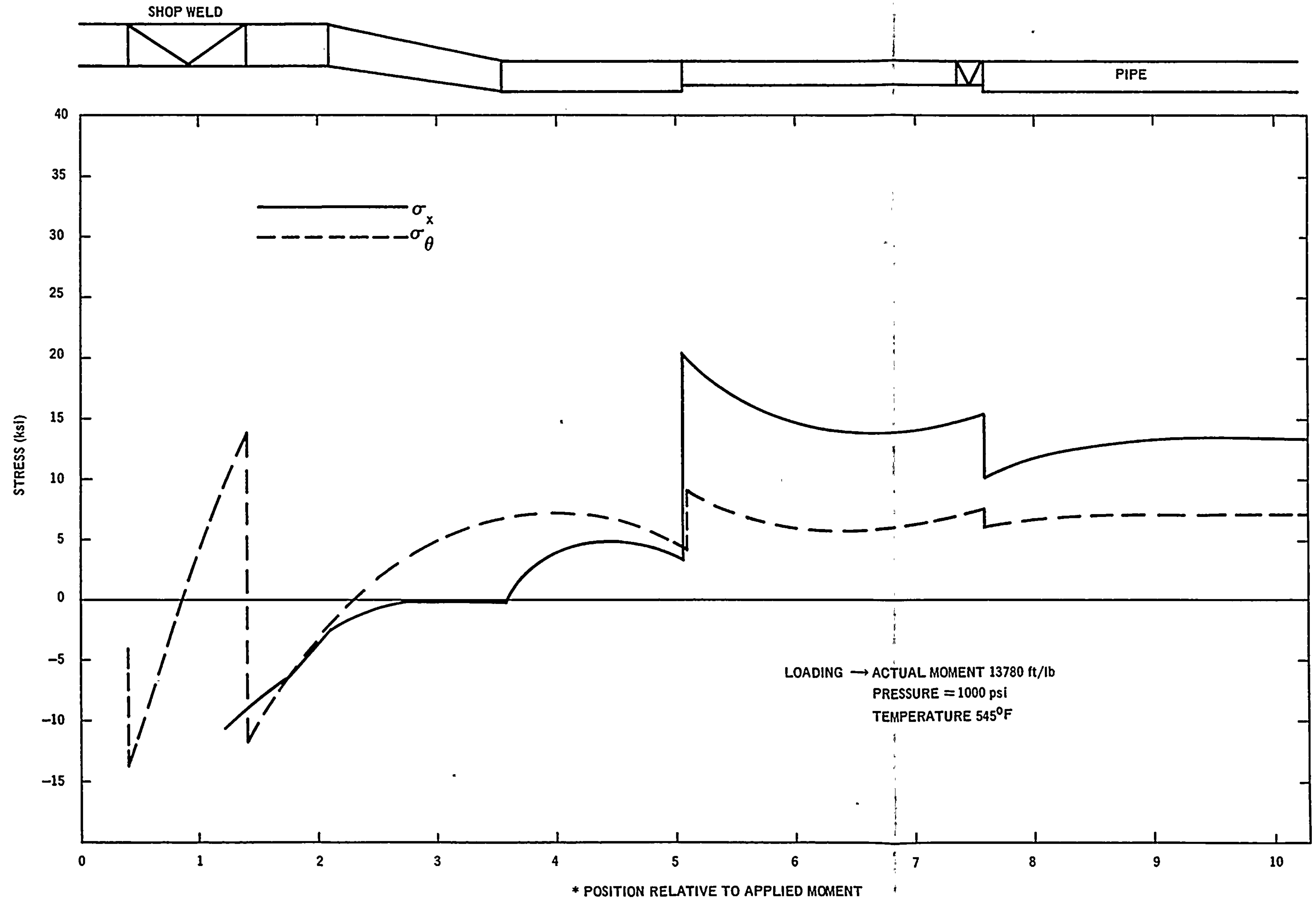


FIGURE 4-4. NINE MILE POINT N6A EAST CORE SPRAY NOZZLE–INSIDE SURFACE STRESSES 12 O'CLOCK POSITION

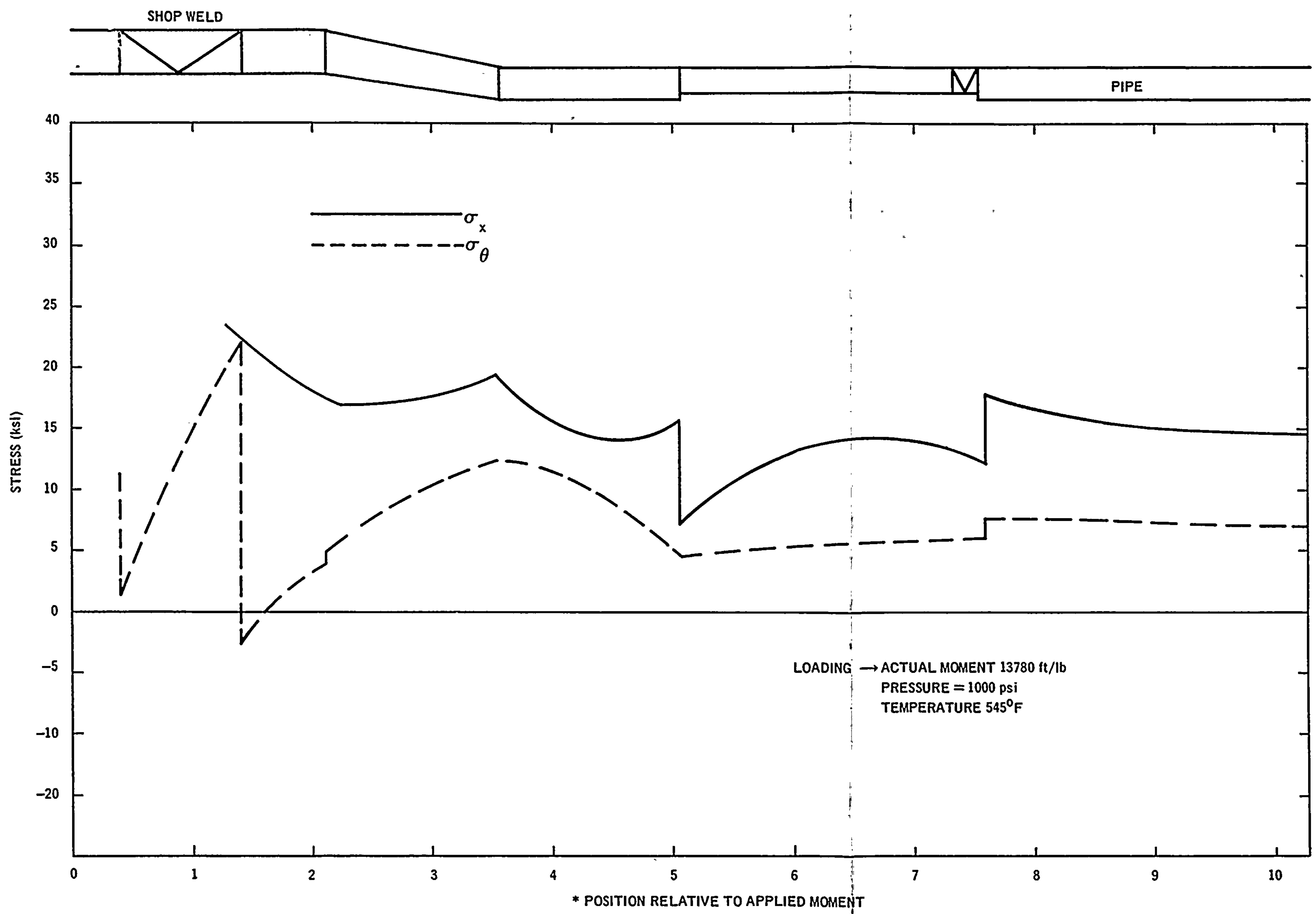


FIGURE 4-5. NINE MILE POINT N6A EAST CORE SPRAY NOZZLE—OUTSIDE SURFACE STRESSES 12 O'CLOCK POSITION

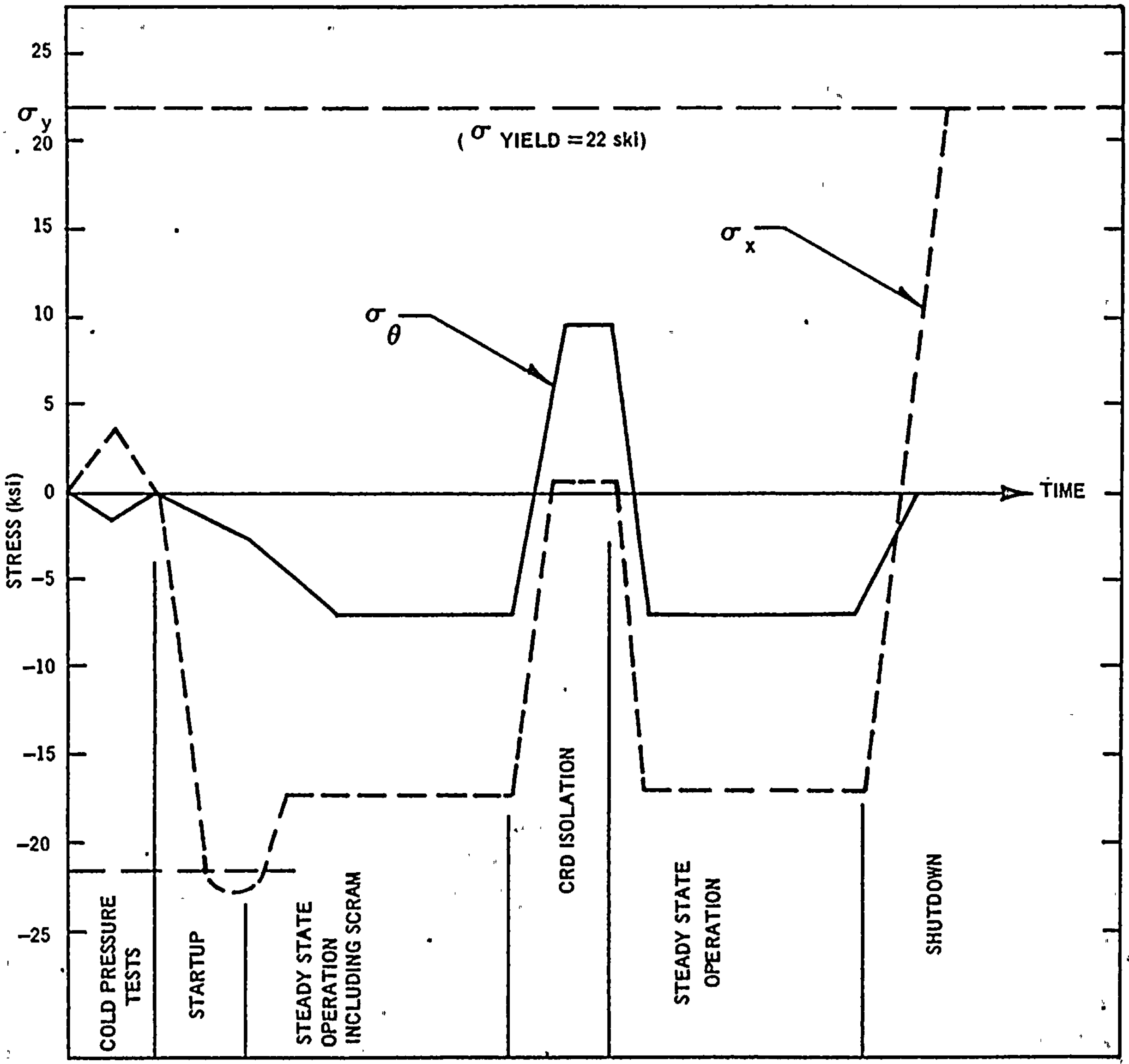


FIGURE 4-6. TOP OF STUB TUBE (O.D. SURFACE) PEAK STRESS VERSUS TIME C.E. CALCULATION VALUES ONLY

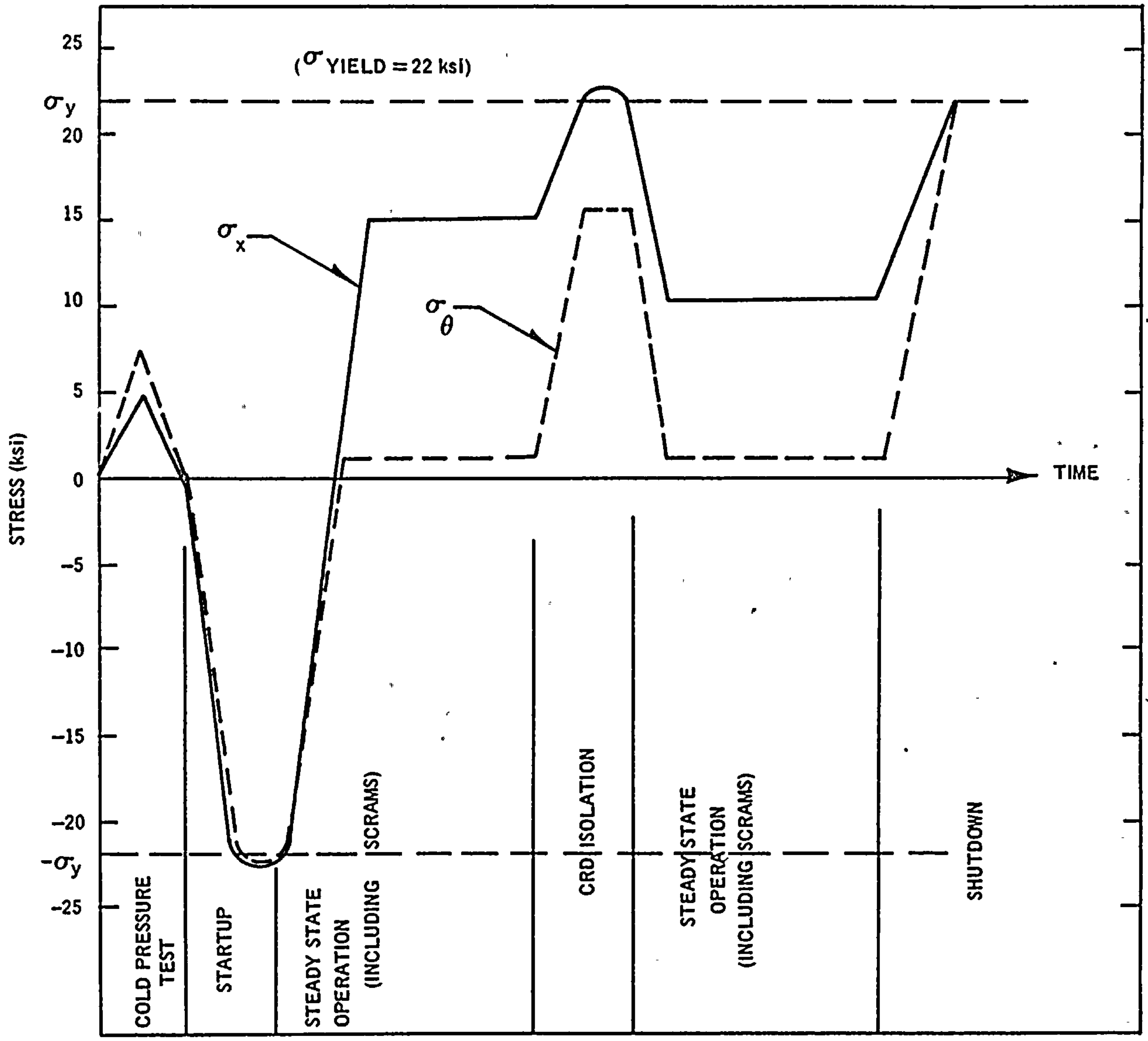


FIGURE 4-7. BOTTOM OF STUB TUBE (O.D. SURFACE)
PEAK STRESS VERSUS TIME
C.E. CALCULATION VALUES ONLY

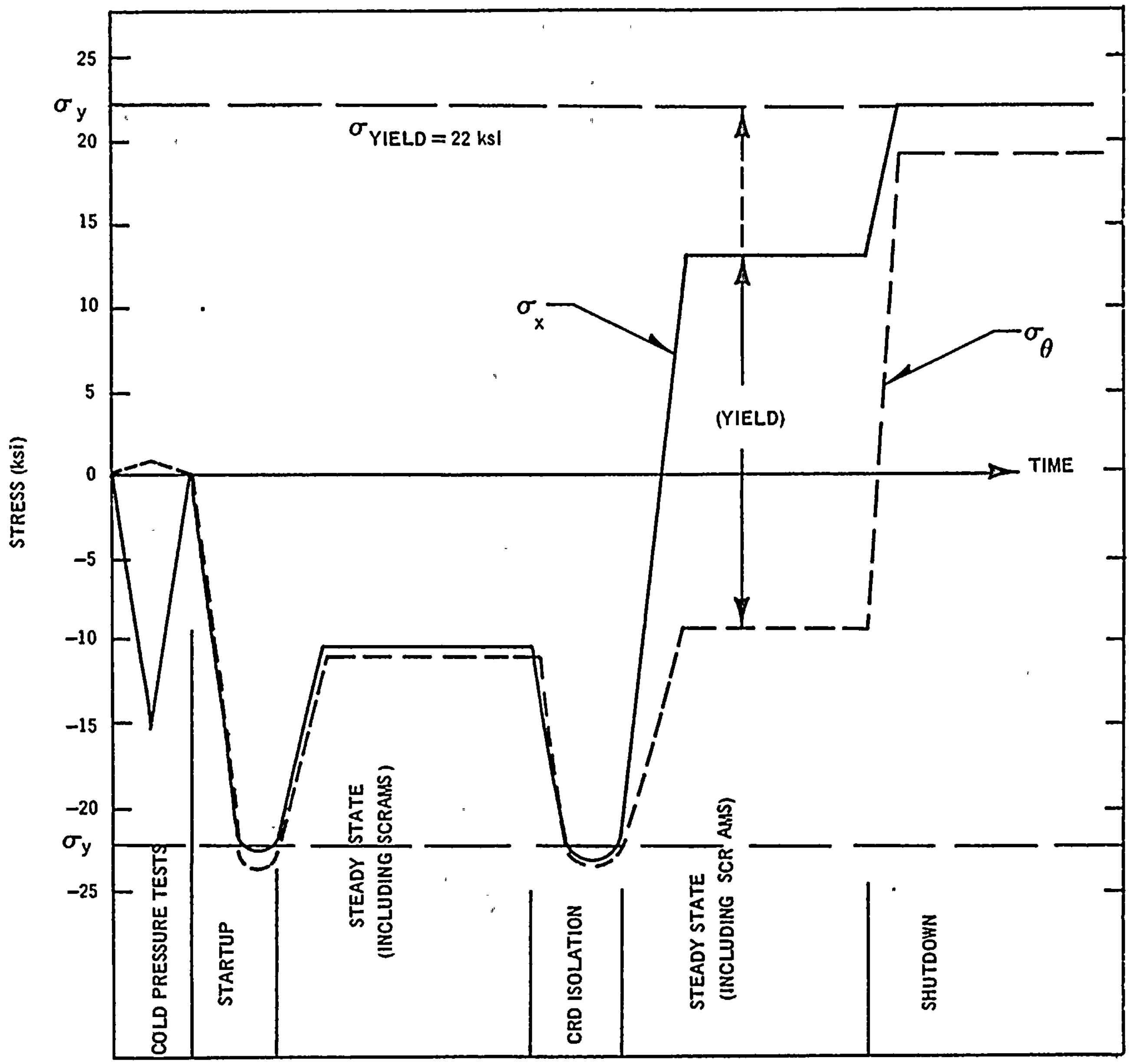
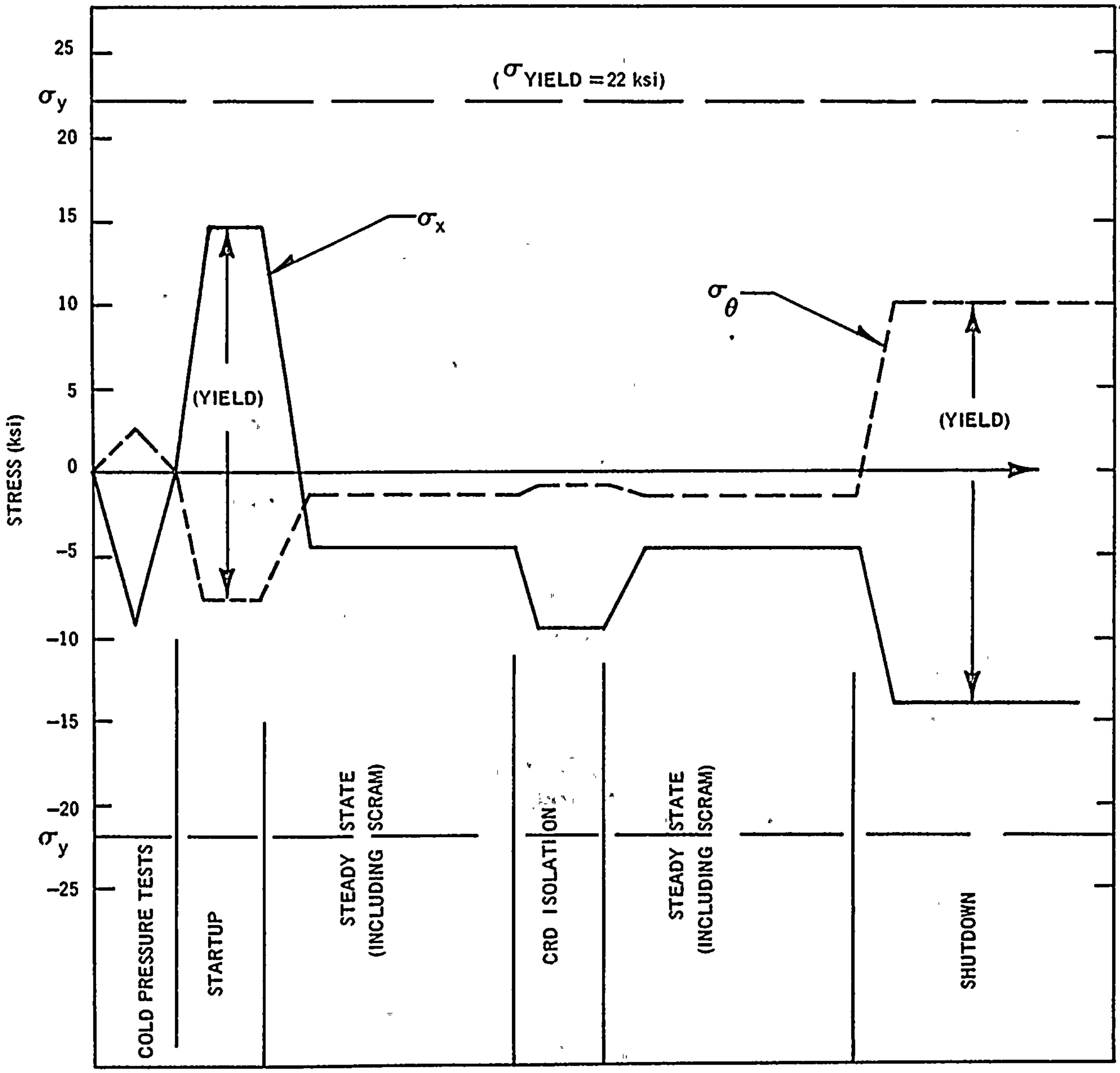


FIGURE 4-8. TOP OF STUB TUBE (I.D. SURFACE) PEAK STRESS VERSUS TIME



STRESS VALUE OF σ_x, σ_θ WILL CHANGE WITH CONTINUING CYCLES DUE TO COMBINED YIELD FAILURE

FIGURE 4-9. BOTTOM OF STUB TUBE (I.D. SURFACE) PEAK STRESS VERSUS TIME

5. INVESTIGATION OF OTHER FURNACE SENSITIZED STAINLESS STEEL-EXTERIOR OF REACTOR VESSEL

5.1 NON-DESTRUCTIVE EXAMINATION OF EXTERIOR SURFACES OF F.S.S.S. SAFE ENDS

Following the detection of the N6B safe end failure, a non-destructive examination program employing liquid penetrant, radiographic, and ultrasonic examination was initiated March 7, 1970, to determine if similar conditions existed on other F.S.S.S. safe ends.

The examination results obtained are tabulated in Table 1 of Appendix B. This table shows that the radiographic and ultrasonic examination results detected no cracking on safe end material with the exception of the failed N6B safe end. The ultrasonic examination did produce indications in the recirculation system safe end field welds as indicated in Sketch 209A7153, Sh. 1-10, Appendix B. In addition to the indications shown, indications were received from the dissimilar metal welds on all N-1, N-2, N-7, and the N-8 nozzles.

Liquid penetrant examination did disclose many indications. None of these indications were present at the conclusion of the post-hydrostatic test examination of safe ends during November 1968.

The liquid penetrant examination was performed in accordance with 21A8570, and revealed indications on the following:

Recirculation Outlet Safe Ends - 4 of 5-N1A,B,C, and D.
Recirculation Inlet Safe Ends - 2 of 5-N2A and C.
Emergency Condenser Safe Ends - 2 of 2-N5A and B.
Head Safety Valve Safe Ends - 10 of 18-N7B,E,K,M,N,P,R,S,T, and U.
Head Vent Safe End - 1 of 1-1 of 1-N-8.

Maps of the penetrant indications observed on each nozzle are shown in Sketch 209A7144, Sh. 1-13 and Sketch 209A7148, Sh. 12-18, Appendix B.

Metallurgical examination of Sample No. 2 from the N5A emergency condenser safe end revealed, (as discussed in subsection 5.2) that the penetrant indications were produced by intergranular attack of 20 to 40 mils in depth.

In contrast with the findings on the interior surfaces, the exterior surfaces have experienced a wide-spread intergranular attack, 20 to 34 safe ends, since the post-hydrostatic test examination was conducted in November 1968.

5.2 SAMPLE NO. 2 - OUTER SURFACE OF EMERGENCY CONDENSER NOZZLE SAFE END N5A

This nozzle was PT inspected on the outer surface in November 1968 and showed no indications. When inspected on the outer surface March 11, 1970, indications were detected as shown on Sketch No. 209A7144, Sh. 5.

When it was rechecked on March 23, 1970, additional indications were found adjacent to the sample locations shown above. Two samples were cut out of this area by hand hacksawing. One sample (GE Designation No. 2A) was given to the AEC, the other sample (GE Designation No. 2) was sent to Vallecitos Nuclear Center where it was photographed, penetrant tested, and sectioned at the penetrant indications for metallographic observation.

Figure C-4 (Appendix C) shows the intergranular attack to be 20 to 40 mils deep.

5.3 DRYWELL ENVIRONMENT

Since external surface indications were found by liquid penetrant examinations, the drywell environment, which contacted these surfaces since the system hydrotest, was investigated.

During construction, electric space heating was used as required. After hydrotest on 11/8/68, station personnel estimated a temperature of -70° F. and relative humidity of 15 to 50%. During operation, relative humidity is 90%, and temperature 120° F. In the temperature range of 70 to 120° F., 90% relative humidity corresponds to a dew point of 3° F. below ambient. Under these conditions, many pipes would be expected to sweat. The torus was first filled and drained in October 1968. The purpose of this operation was primarily to flush out any dirt remaining from the hand cleaning operation. The inside of the torus is not painted.

It was filled again on 2/19/69, and drained on 3/21/69 to do plumbing work on the bottom.

It was finally filled at some date prior to 5/22/69 and left in this condition.

The only water used in these fillings has been demineralized water. Conductivity of torus water is checked periodically and is consistently $<$ 5 micromho.

Water temperature is reported to be fairly constant, at around 60° F. An actual check on 4/15/70 showed 68° F. If the drywell temperature exceeds torus temperature, the torus water will act as a humidity sink and vice versa.

Water has been accidentally dumped inside the drywell on at least two occasions. During chemical cleaning, September 1967, a Dresser coupling gave way, and sprayed hot TSP solution and steam. The volume is unknown, but the flow rate was 3280 gpm. In December 1968, the water in the containment spray system pipes was dumped.

Construction work continued in the drywell between hydrotest on 11/8/68 and the hot functional test in late May 1969. All of the site crafts were represented in this period, and the work was all completed by about 5/15/69.

Before insulation was applied on the drywell piping, the piping was hand swabbed with solvent. Dirt subsequently found on pipe surfaces, under the insulation, was presumably airborne. The ventilation system would be expected to circulate dust particles. Insulation of the drywell piping was applied after hydro test, and was completed before the hot functional test in May 1969.

Samples of dirt collected at the site have been analyzed, with results as shown in Table 5-1.

These analyses indicate that appreciable quantities of both fluoride and chloride do exist in the drywell, and also in the outside air adjacent to the reactor building.

Table 5-1

ANALYSIS OF DIRT AND MIRROR INSULATION SAMPLES

Sample No.	Sample Description	Water Leached: Sample Weight (g)	Water Leached: F (ppm)	Water Leached: C (ppm)	Pyrohydrolysis: Sample Weight (g)	Pyrohydrolysis: F (ppm)	Pyrohydrolysis: Cl (ppm)	Total: F (ppm)	Total: Cl (ppm)
1	Dirt–9M–Recirc. Nozz. 15	0.266	394	216	0.300	8900	818	8900	818
2	Dirt–9M–Outside Fire Extinguisher	0.072	386	947	a	986	1015	1372	1962
3	Dirt–9M–Steam Nozz. N3A	0.100	221	445	a, b	1787	363	2008	808
4	Dirt–Chattanooga Motel window				0.192	972	844		
5	Dirt–Chattanooga Industrial				0.496	174	186		
6	Deposit–9M Insulation–over leak				0.021	1694	1860		

a. Pyrohydrolysis results based on wt. of sample water leached. Test made on residue after water leach.

b. Possible loss on pyrohydrolysis result due to oxygen-paper explosion.

SPECTROGRAPHIC DATA

Element	Sample 1 %[2]	Sample 2 %	Sample 3 %	Sample 4 %	Sample 5 %	Sample 6 %
Al	2	2	2			6
B	0.2	< 0.1	< 0.1			0.07
Ca	10	10	10			7
Cr	2	0.5	0.5			b.d.[1]
Cu	–	–	–			0.1
Fe	30	30	30			22
Mg	0.5	0.5	0.5			2
Mn	5	2	5			1
Mo	2	0.2	2			–
Ni	5	0.5	2			0.4
Pb	0.1	0.2	0.5			1.5
Si	20	20	15			15
Ti	0.5	0.5	0.5			1.0
Zn	25	20	50			45

Notes: [1] b.d. = below detectable level

[2] % = $\frac{\text{wt. of element as metal}}{\text{sum of wts of all elements}}$

5.4 PROTECTION OF EXTERIOR SAFE ENDS SINCE SYSTEM HYDRO IN FIELD

At no time have any special precautions been taken, in the sense that protective coatings were not used. Prior to application of insulation, pipe surfaces were hand swabbed with solvent.

5.5 ENVIRONMENT ON EXTERIOR SURFACES IN DRYWELL

During construction and the startup test phase moisture was noted on pipe systems in the drywell. No specific record of which lines were wet is available. The moisture levels in the drywell during operation were 90% RH, 115° F. dewpoint. All vessel nozzles operate well above 115° F. and no condensation can occur during operation. During startup some nozzles may experience condensation if the humidity remains high. No data are available but based on the normal amount of valve and pump packing leakage during shutdown, the humidity should be high. The torus water will always act as a moisture sink since its temperature is lower than drywell temperature and thus will reduce moisture levels in the drywell.

Fluoride contamination appears to be as ubiquitous as chloride contamination and there is no reason to believe that the fluoride analyses shown in Table 5-1 deviate from normal. Compared to Table 4-2, which shows internal fluoride contamination levels, it can be seen that external contamination is orders of magnitude greater than internal.

The reactor vessel paint contributes to the high zinc concentration shown in the spectrographic analyses shown on the following page. During initial heatup volatiles from painted surfaces create high smog levels in the drywell. These will condense on cold surfaces rather than hot surfaces.

The craft activities noted after the November 1968 penetrant tests are usual for any reactor construction site.

6. INSPECTION AND ANALYSIS OF PIPING SYSTEMS CONNECTED TO REACTOR VESSEL (TELEDYNE MATERIALS RESEARCH REPORT NO. E-1289)

7. CORE SPRAY NOZZLE SAFE END AND PIPE REPLACEMENT

7.1 SCOPE

The core spray nozzle safe end and piping replacement encompasses the removal, redesign, and replacement of the entire safe end of the core spray nozzle N6B. Also, included are the removal, redesign and replacement of the outer end of the core spray nozzle thermal sleeve and the removal and replacement of portions of the connecting core spray system piping. The redesign of the safe end and thermal sleeve will also apply to core spray nozzle N6A. Safe end, as used herein, is the transition piece between the connected piping and the ferritic steel core spray nozzle.

7.2 LOCATION

The location of core spray nozzle N6B and connected piping is shown on drawing 761E284. Nozzle N6A is identical to N6B and is at the same vessel elevation at a vessel azimuth of 60 degrees.

7.3 REMOVAL OF F.S.S.S. SAFE END

The removal of the F.S.S.S. safe end of core spray nozzle N6B is covered in detail in Procedure No. 1 and Procedure No. 3, and nozzle N6A is covered in Procedure No. 9, all in Appendix D. Removal of the F.S.S.S. on the N6B nozzle amounted to removing a section of pipe just beyond the nozzle in a series of controlled cutting operations that used no cutting fluids or coolants. The cutting fluids and coolants were eliminated to prevent chips and debris from being carried into the core spray system and reactor. The pipe section was removed from the middle of the horizontal run between cuts No. 1 and No. 2 shown on drawing 761E284. Interior plugs were installed in the core spray nozzle thermal sleeve and the 6-inch pipe to prevent further entry of chips and debris from subsequent operations. Drawing 922D131 of Procedure No. 3, Appendix D, shows the locations and sequence of cuts and machining operations to remove the F.S.S.S. safe end from the nozzle. To assure removal of the F.S.S.S. and leaving enough Inconel weld metal on the low alloy portion of the core spray nozzle, the Inconel stainless steel junctions were located by etching and the machining controlled to remove the F.S.S.S. and leave a maximum amount of Inconel to allow for welding on the replacement safe end.

The thermal sleeve was machined to produce a socket to receive the replacement sleeve end. The existing Inconel weld was machined to produce a weld prep for attaching the new safe end.

7.4 INTENT FOR RESTORATION TO SERVICE

The restoration intent is as follows:

1. Remove F.S.S.S. safe end entirely (done in 7.3 above).

2. The replacement material for the new safe end to be ASTM ASME SA182, F304L forging.

3. The redesigned safe end to retain a uniform wall thickness from the Inconel weld for a distance of $1.5\sqrt{RT}$ before any change of section or weld, as prescribed in the ASME Boiler and Pressure Vessel Code Section III, paragraph N-445.

4. Minimum wall thickness of replacement safe end to be sized for pressure using the more conservative Section VIII of the ASME B&PV Code.

5. That all materials, inspections of materials and welds are to conform to requirements of ASME B&PV Code Section III as a minimum.

7.5 DESIGN OF SAFE END AND SLEEVE REPLACEMENTS

Calculations for minimum wall thickness are per ASME B&PV Code Section VIII paragraph UG-27(c) (1):

$$\text{Min. } t = \frac{PR}{SE-0.6P},$$

where:

t	=	Minimum wall thickness-inches,
P	=	Design pressure=1250 psig,
R	=	Inside radius=2.919 inches,
S	=	Maximum allowable design stress = 9175 psi for SA 182 F304L at 575° F design temperature, and
E	=	Joint efficiency = 1.00.

Therefore

$$\text{Min. } t = \frac{1250\ (2.919)}{9175\ (1.00) - 0.6\ (1250)} = 0.433 \text{ inch.}$$

Actual minimum wall thickness = 0.482 inch. (Drawing 158B8464 Appendix D Procedure No. 3).

To allow venting and purging oxygenated water from the high point in the core spray system three 1/8 by 1/8-inch slots were left open between the core spray system and the vessel interior. During normal operation positive pressure inside the reactor shroud (about 6 to 7 psi) forces water back through the core spray nozzles and internal piping to the high point of the core spray system. Since the core spray admission valve is shut, the water flows through the three slots and into the interior of the vessel. With a pressure difference of 6 to 7 psi about 14 gpm of water flows through the slots thus continuously purging the high point of the core spray system. With two core spray

7.5 DESIGN OF SAFE END AND SLEEVE REPLACEMENTS (Continued)

systems, this means there will be a normal leakage that bypasses the steam separators of 28 gpm. This small amount of fluid starts out as a steam water mixture inside the shroud, but the steam condenses when the mixture flows into the pipe outside the shroud as the core spray pipe, outside the shroud but inside the vessel, is submerged in subcooled water.

During operation of the core spray system, 44 gpm flows through the three slots under a 60-psi differential pressure head.

The thermal sleeve to sleeve end replacement weld (See Drawing 922D131 Appendix D Procedure No. 3) and the sleeve end replacement to inner safe end weld each have 1.5 square inches of area to resist a design pressure difference of 150 psi across the thermal sleeve. This amounts to a stress of approximately 3000 psi in the welds.

7.6 REPLACEMENT OF SAFE END AND SLEEVE

Supplement No. 1 to Procedure No. 3, in Appendix D is the procedure governing the welding and inspecting of all replacement safe end and thermal sleeve attaching welds. Appendix D Specialty Shop Fabrication Procedure No. 1 governed the welding of the Inconel butter on the end of the inner safe end part. The Inconel weld attaching the inner safe end to the nozzle was controlled by Procedure No. 4, Appendix D.

Sleeve end replacement welding was governed by Procedure No. 5, Appendix D, as was the welding joining the inner and outer safe end. Inspection of the safe end welds includes radiograph in accordance with Procedure No. 7, Appendix D, ultrasonic examinations in accordance with General Electric Company Specification 21A8592 and ASME B&PB Code Section III, and liquid penetrant examination in accordance with PT Code Acceptance NMP-6, Appendix D. The welds attaching the sleeve end were examined by liquid penetrant techniques in accordance with PT Code Acceptance NMP-6, Appendix D.

Nozzle N6A safe end removal and replacement will be governed by Procedure No. 9, Appendix D.

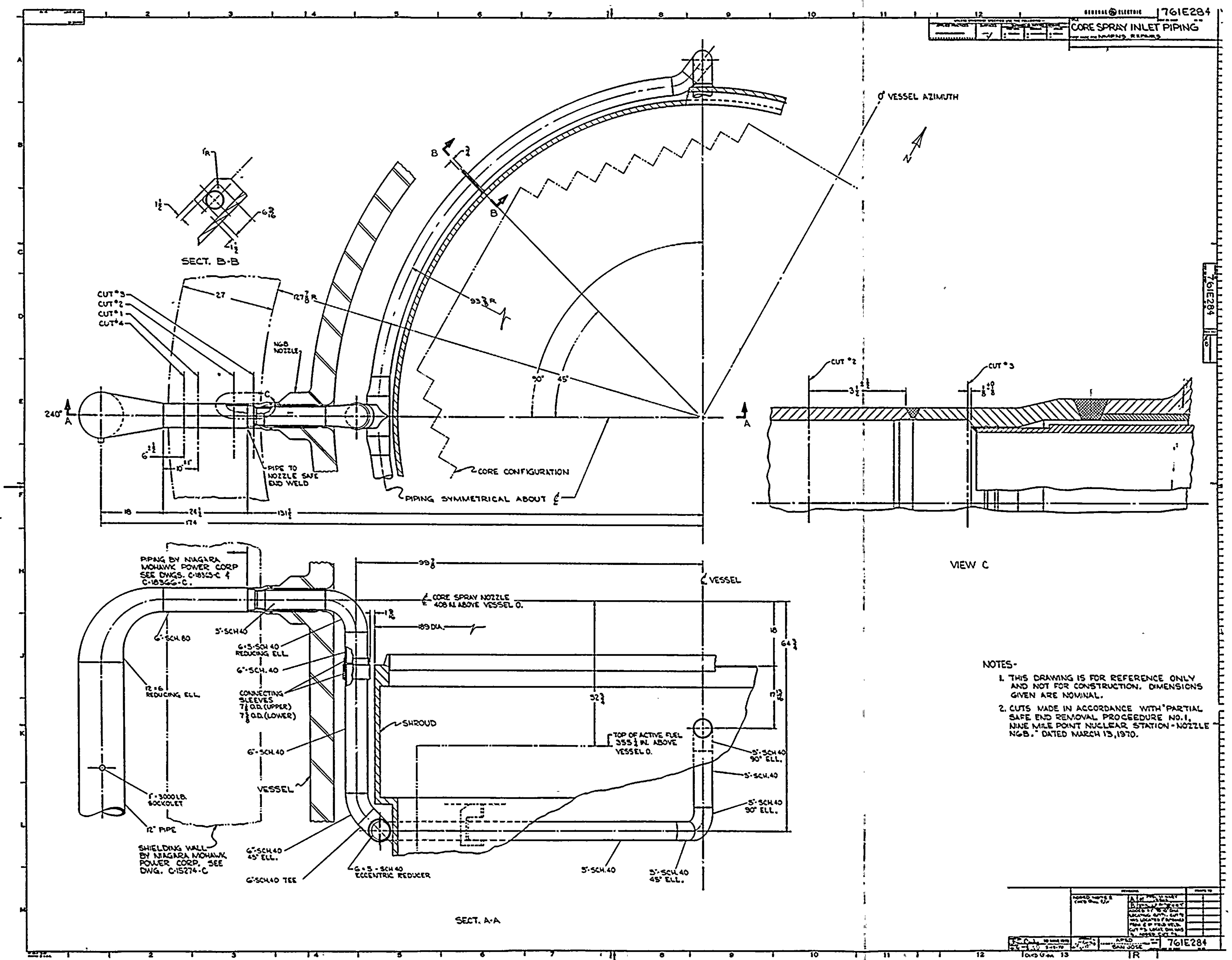


FIGURE 7-1. CORE SPRAY INLET PIPING

8. SENSITIVITY LIMITS OF PT, UT, AND RT

The detectability of a specific defect is determined by one or more of the following parameters:

a. depth
b. length
c. width
d. orientation
e. crack face roughness.

The relative importance of each parameter is determined by the examination technique being used. For example:

1. The detectability by penetrant examination is dependent on the width of the crack at the surface and the crack depth. Detection by penetrant requires that the crack be open to the surface, wide enough to permit penetrant to flow into the crack, and deep enough to provide a reservoir of penetrant which will not be removed by the removal of surface penetrant.

2. The detectability by an angle beam ultrasonic examination is dependent upon the length, depth, orientation and the crack face roughness. The reflection from the crack face must return to the transducer with sufficient amplitude to distinguish it from the material and electronic noise. The use of simulated defects as a calibration reference does not assure that a defect of similar length and depth dimensions will be detected. A smooth face, straight walled crack oriented at 90^{o} to the surface will produce a similar amplitude, but, this crack rarely if ever exists.

3. The detectability by the radiographic method is dependent on the amount of metal missing in the dimension parallel to the X-ray beam. A multiple branching tight crack can penetrate 100% of the material thickness and remain undetectable by the radiographic technique.

The actual sensitivity of an examination technique for the detection of a specific type of defect can be determined only by metallographic examination of what was actually detected or missed in material containing defects typical of those being sought.

The metallographic, PT, UT, and RT results obtained on Samples 1 and 3 of safe end N6B and Sample 2 from safe end N5A were analyzed to determine what sensitivity limits could be established on each examination technique. Additional metallography (Figure 8-1) was performed at 9:15, 9:45, 10:20, and 1:45 on Sample 1 and 1:30 on Sample 3 to obtain additional data for the ultrasonic sensitivity evaluation.

Table 8-1 is a compilation of the data obtained for the evaluation. The conclusions from this evaluation are as follows:

1. Cracking as shallow as 0.008 inch can be detected by liquid penetrant examination, however individual cracks as deep as 0.040 inch may not be detected due to small openings to the surface. Due to the quantity of cracks observed in areas of attack, the failure to detect some of the cracks with small openings is not considered important.

2. The lower sensitivity limit of the ultrasonic examination technique for the detection of intergranular cracking is 10% of the wall and 1/4 inch long. Shorter, deeper cracks or longer, shallower cracks may occasionally be detected.

   The ultrasonic technique should be used for examining surfaces which are not accessible for liquid penetrant examination and where assurances are required that if intergranular attack is present, the attack has not progressed beyond the lower sensitivity limit.

3. Radiographic examination should not be relied upon for the detection of intergranular cracking. The technique can be useful as a supplemental tool for determining the extent and location of cracks when major cracking is detected by the ultrasonic method.

Table 8-1

ULTRASONIC INSPECTION LIMITS

	Technique	Crack Dimensions (Length)	(Depth)	Location			Reference Data
PT	a. Shallowest Detected	–	008 - 015" (and deeper)	6:00 - 7:00	OD Sample No. 1	Fig. 3-5	
	b. Missed	–	010, 030"	11:20	ID Sample No. 1	Fig. 3-6	
		–	:040"	2:15	ID Sample No. 1	Fig. 3-6	
		–	.040"	–	OD Sample No.2		
UT	(Detected)	5/8"	4.7% of wall	Location F	ID Sample No. 3	Fig. 8-1	(Missed in NMP examination)
		1/4"	9% of wall	Location C	ID Sample No. 1	Fig. 8-1	
		1/8"	15.5% of wall	11:20	ID Sample No. 1	Fig. 3-6	(near cut)
	(Missed)	Not available	3.1% of wall	11:30	ID Sample No. 3	Fig. 3-6	
		Not available	5.4% of wall	11:30	ID Sample No. 3	Fig. 3-6	
		Not available	6.2% of wall	11:30	ID Sample No. 3	Fig. 3-6	
		1/16"	10% of wall	Location E	ID Sample No. 3	Fig. 8-1	
		5/8"	4.7% of wall	Location F	ID Sample No. 3	Fig. 8-1	(Detected in San Jose examination only)
RT	(Shallowest detected)		15.5% of wall	11:20	ID Sample No. 1	Fig. 3-6	
	(Missed)		40% of wall	11:30	ID Sample No. 1	Fig. 3-6	(Detected by PT on ID)
			56% of wall	12:00	ID Sample No. 1	Fig. 3-6	(Axial crack not open to surface)

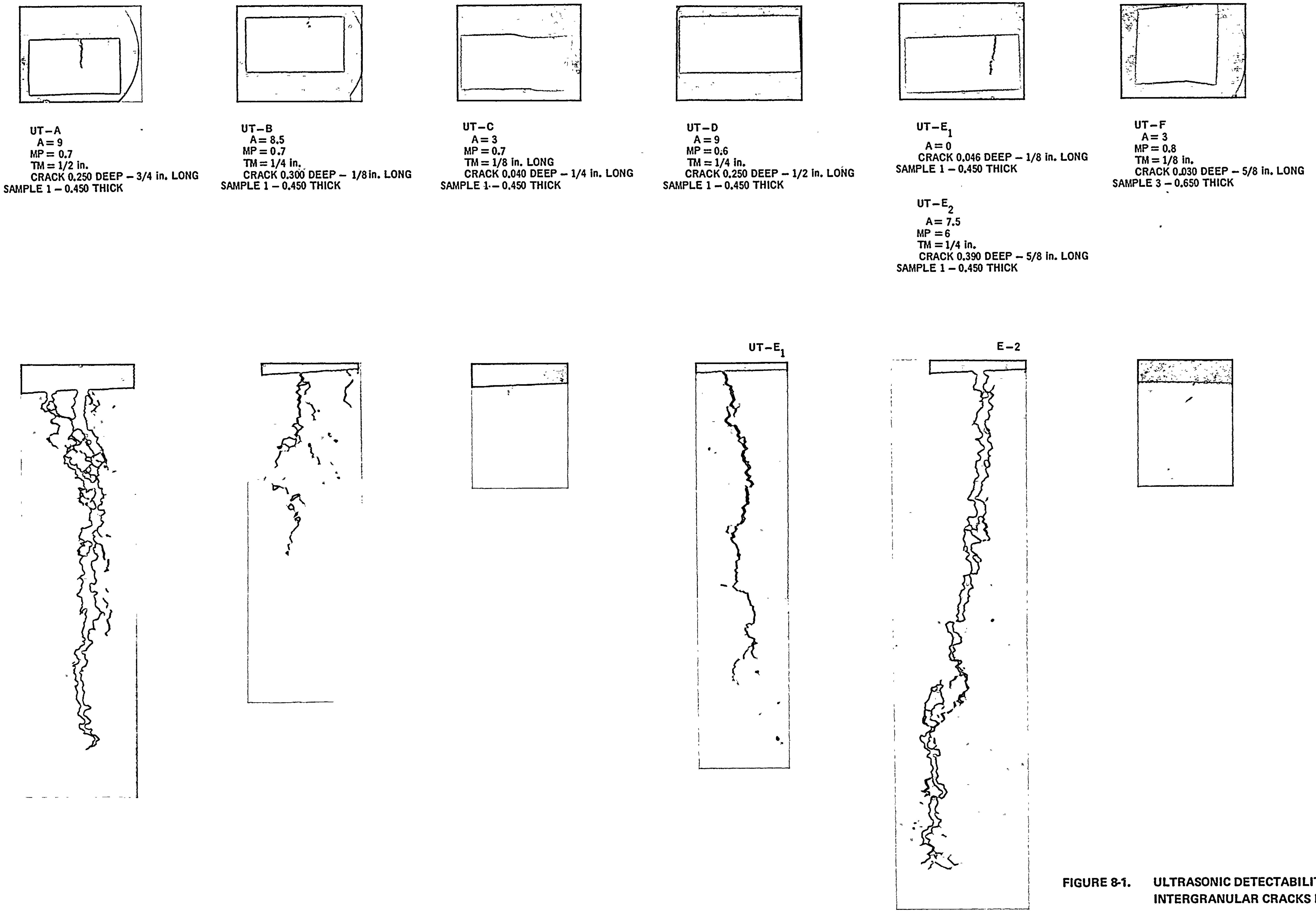


FIGURE 8-1. ULTRASONIC DETECTABILITY OF INTERGRANULAR CRACKS IN SAFE END N6B

APPENDIX A
NINE MILE POINT REACTOR VESSEL

Drawing 237E433, sheets 1 through 4, comprise Appendix A.

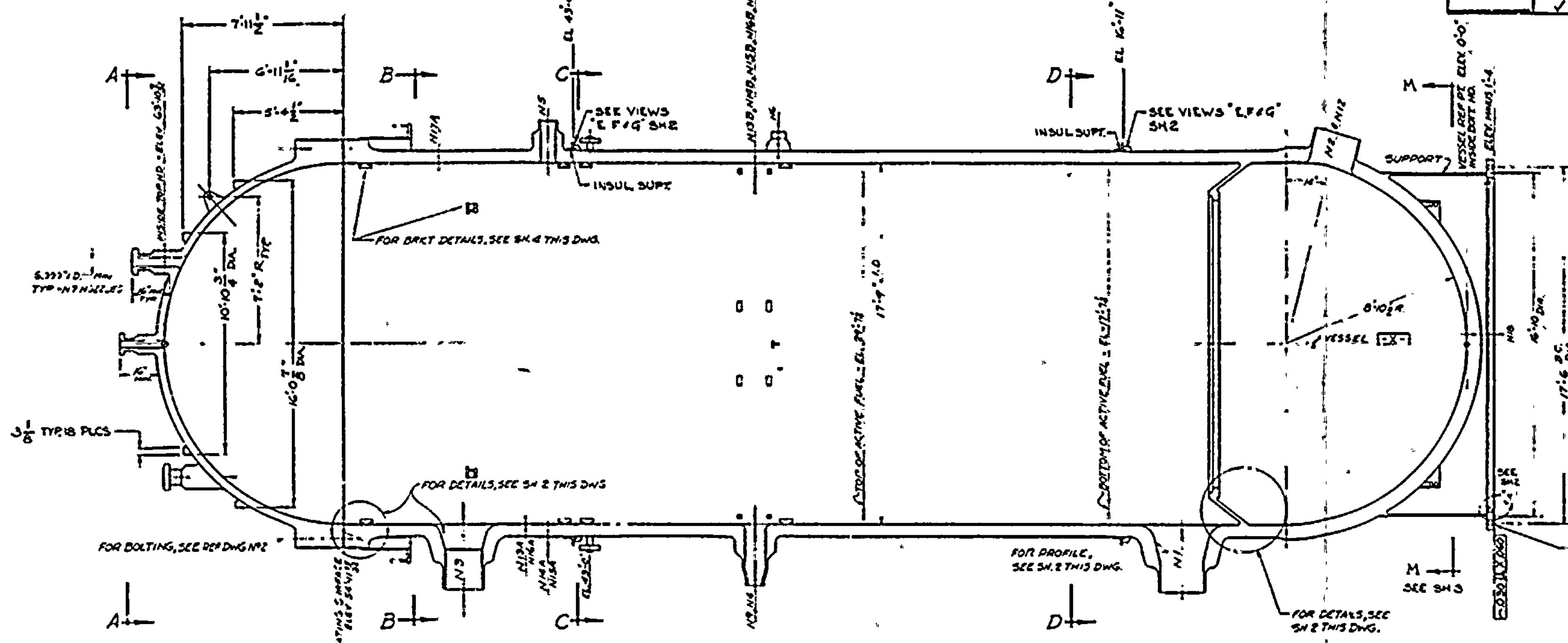
GENERAL ELECTRIC 237E433

SPEC. CONTROL
REACTOR VESSEL
NINE MILE POINT NUCLEAR STATION

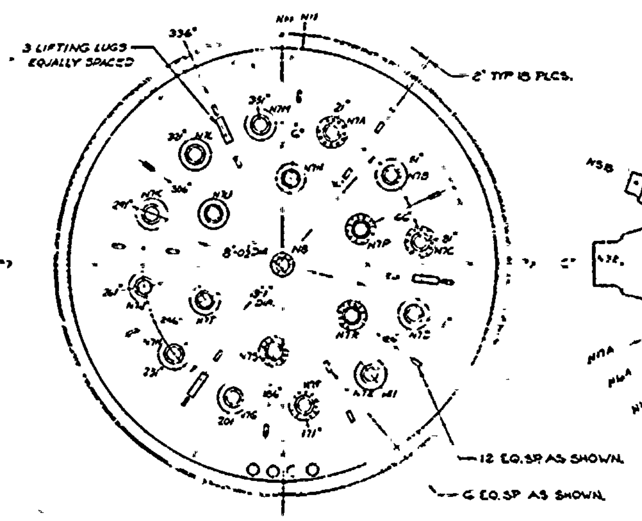
EQ. PC. Nº NR02

REFERENCE DRAWINGS		
Nº	DWG. Nº	TITLE
1	237E434	REACTOR VESSEL LOADINGS
2	237E435	REACTOR VESSEL BOLTING
3	237E436	REAC. VESS THERMOCOUPLE LOCATIONS
4	107C4901	REACTOR VESSEL NOZZLE ENDS
5		

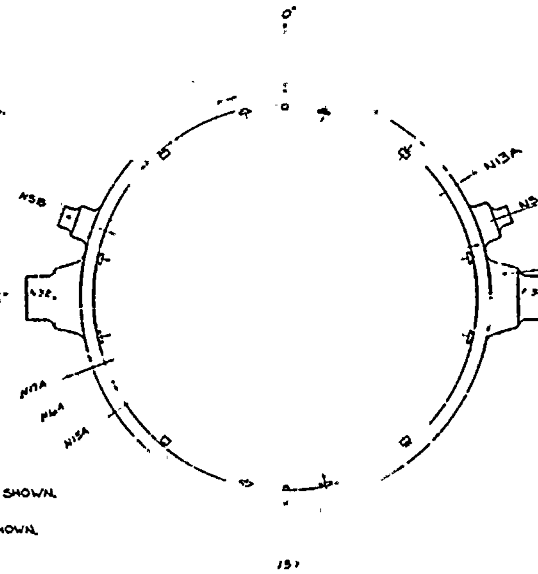
NOTES -
1. DESIGN PRESSURE - 1250 PSIG @ 575°F. (@ VESSEL ELEV. 0-0")
2. DESIGN TEMPERATURE - 575°F @ 1250 PSIG.
3. NORMAL OPERATING PRESSURE - 1000 PSIG @ SATURATION TEMP. (@ VESSEL ELEV. 61-2)
4. NORMAL OPERATING TEMPERATURE - SATURATION TEMPERATURE @ 1000 PSIG
5. PURCHASED FOR - NIAGARA MOHAWK POWER CORPORATION
6. PLANT SITE - STATE OF NEW YORK, COUNTY OF OSWEGO
7. PLANT NAME - NINE MILE POINT NUCLEAR POWER PLANT.

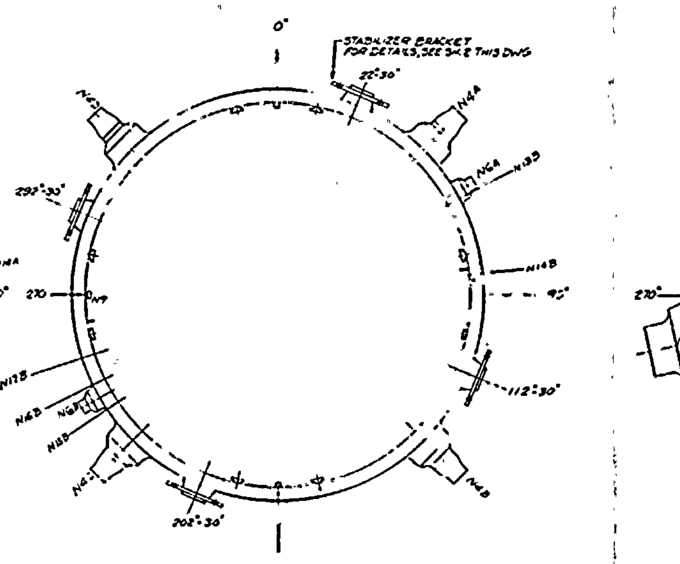


LONGITUDINAL SECT.

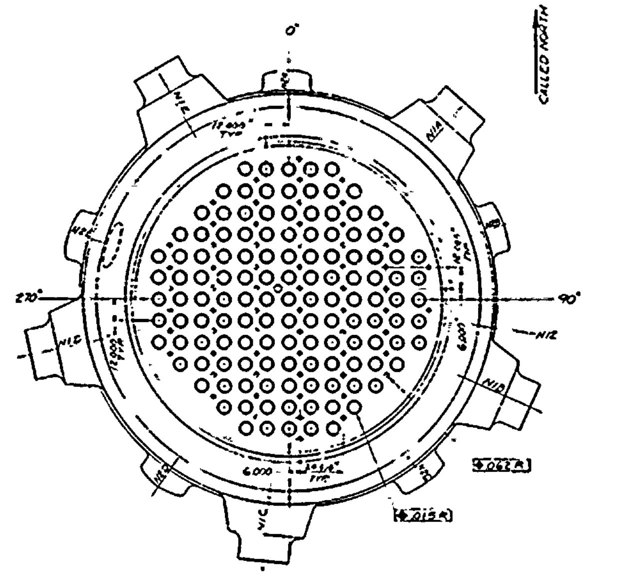


VIEW A-A


SECT. B-B



SECT. C-C

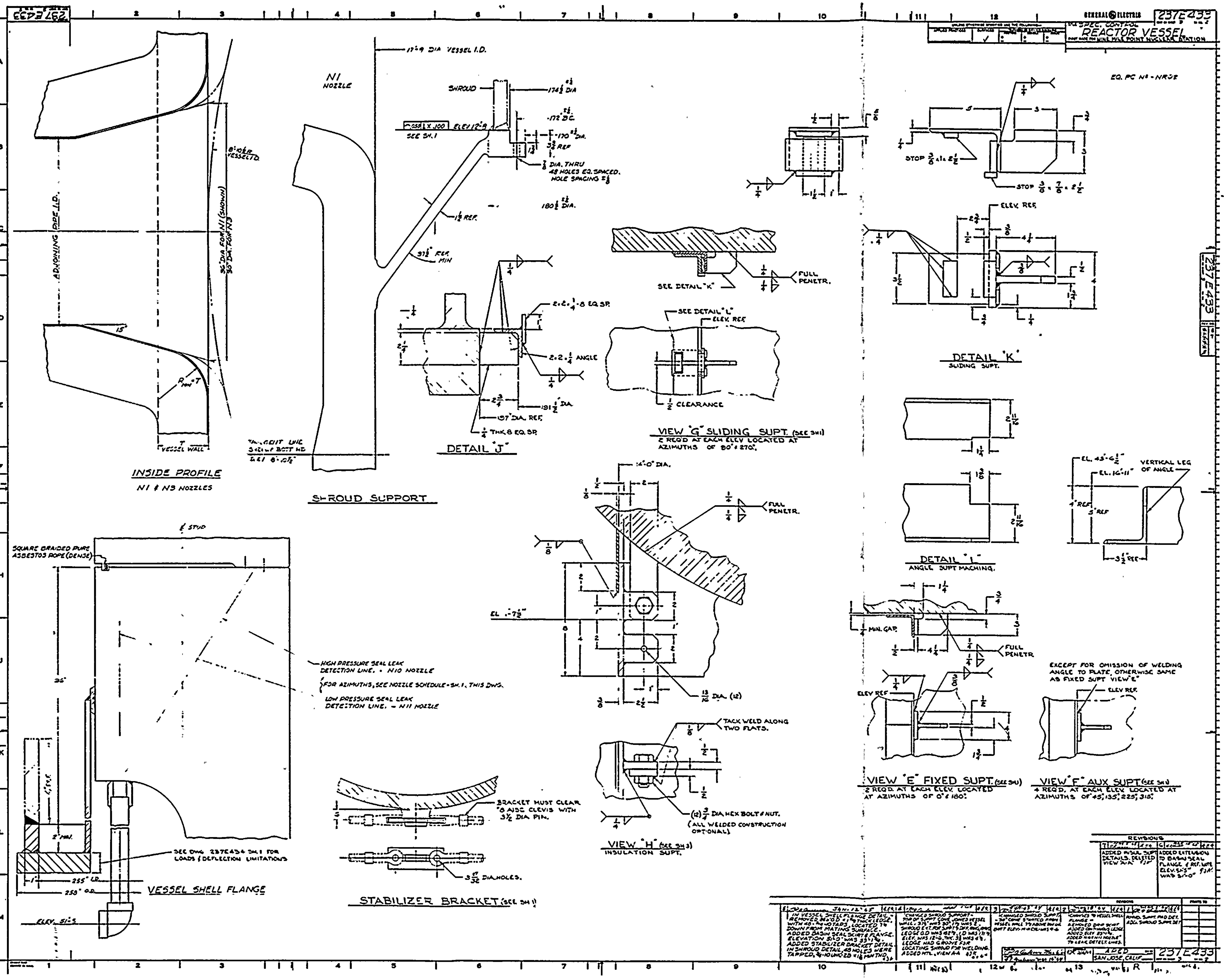

SECT. D-D

SCALE - ⅜" = 1'-0"

NOZZLE NUMBER	QUANTITY	SIZE	FUNCTION	AZIMUTH	ELEVATION	MATING PIPE O.D.	MATING PIPE SCH. & WALL THK.	MATING PIPE MTL.	REMARKS
N1A thru N1E	5	36" x 28"	RECIRCULATION OUTLET	42°, 114°, 186°, 258°, 330°	14'-0"	28"	1.125"	SA240-TP304	
N2A thru N2E	5	28"	RECIRCULATION INLET	0°, 72°, 144°, 216°, 288°	SEE LONGTDNL. SECT.	28"	1.125"	SA240-TP304	
N3A, N3B	2	24" SPCL	STEAM OUTLET - TURBINE	90°, 270°	49'-3"	24"	1.250"	SA212-GR B	
N4A thru N4D	4	10" SPCL	FEEDWATER	45°, 135°, 225°, 315°	35'-2"	10.750"	SCH. 100	SA106 GR B	SEE SH. 3
N5A, N5B	2	10"	STEAM OUTLET - EMERG. CONDENS.	70°, 290°	45'-1"	10.750"	SCH. 100	SA312-TP304	
N6A, N6B	2	6"	CORE SPRAY	60°, 240°	34'-0"	6.625"	SCH 80	SA312-TP304	5.761 I.D. SEE SH. 3
N7A thru N7U	16 PLUS 2	6"	SAFETY VALVE & INSTR.	SEE VIEW A-A	SEE LONGTDNL. SECT.	—	—	—	6" - 1500 LB FLANGE, SMALL GROOVE F. NS
N8	1	4"	VENT	SEE VIEW A-A	SEE LONGTDNL. SECT.	—	—	—	4" - 1500 LB FLANGE, SMALL GROOVE F. NS
N9	1	3" SPCL	CONT. ROD DR. - HYDR. SYS. RETURN	273°	35'-2"	3.500"	SCH. 80	SA312-TP304	3.650" I.D. SEE SH. 3
	129	6" SPCL	CONTROL ROD DRIVE	SEE SECT. D-D					SEE SH 4
	64	2" SPCL	FLUX MONITOR	SEE SECT. D-D					SEE SH 4
N10	1	1"	HIGH PRESS. SEAL LEAK DETECT.	0°	SEE SH 2	—	—	—	1" - 3000 LB. SOCKET - WELDING FITTING
N11	1	1"	LOW PRESS. SEAL LEAK DETECT.	5°-37½'	SEE SH. 2	—	—	—	1" - 3000 LB SOCKET - WELDING FITTING
N12	1	2"	CORE DIFFERENTIAL PRESS.	98°	SEE LONGTDNL. SECT.	2.375"	SCH 80	SA312-TP304	INTERNAL END PREPPED FOR SOCK WELD TO 1" PIPE - SEE SH 3
N13A	1	2"	PROTECTION SYSTEM REF. COLUMN - TOP	57°	46'-1"	2.375"	SCH. 80	SA312-TP304	
N13B	1	1"	PROTECTION SYSTEM REF. COLUMN - BOTT.	62°	35'-2"	1.315"	SCH. 80	SA312-TP304	
N14A	1	1"	LEVEL CONTROL REF POT.	84°	45'-1"	1.315"	SCH 80	SA312-TP304	
N14B	1	1"	LEVEL CONTROL STATIC LEG	82°	35'-2"	1.315"	SCH 80	SA312-TP304	
N15A	1	1"	LEVEL CONTROL REF POT	236°	45'-1"	1.315"	SCH 80	SA312-TP304	
N15B	1	1"	LEVEL CONTROL STATIC LEG	236°	35'-2"	1.315"	SCH 80	SA312-TP304	
N16A	1	2"	PROTECTION SYSTEM REF. COLUMN - TOP	244°	46'-1"	2.375"	SCH 80	SA312-TP304	
N16B	1	1"	PROTECTION SYSTEM REF. COLUMN - BOTT.	244°	35'-2"	1.315"	SCH 80	SA312-TP304	
N17A	1	1"	WIDE RANGE LEVEL - TOP	250°	50'-8"	1.315"	SCH 80	SA312-TP304	
N17B	1	1"	WIDE RANGE LEVEL - BOTT.	252°	85'-2"	1.315"	SCH. 80	SA312-TP304	
N18	1	2"	DRAIN	315°	SEE LONG. SECT.	2.375"	SCH 160	SA106 GR B	

REVISIONS

APED SAN JOSE, CALIF. 237E433


237E433
REACTOR VESSEL
NINE MILE POINT NUCLEAR STATION
GENERAL ELECTRIC
INSIDE PROFILE
N1 & N3 NOZZLES
ADJOINING PIPE I.D.
T
VESSEL WALL
N1
NOZZLE
SHROUD SUPPORT
174 1/2 DIA VESSEL I.D.
SHROUD
SEE SH.1
DETAIL "J"
VIEW "G" SLIDING SUPT. (SEE SH1)
2 REQD AT EACH ELEV LOCATED AT AZIMUTHS OF 90° & 270°.
FULL PENETR.
SEE DETAIL "K"
SEE DETAIL "L"
ELEV. REF
1/2 CLEARANCE
DETAIL "K"
SLIDING SUPT.
DETAIL "L"
ANGLE SUPT MACHINING
VERTICAL LEG OF ANGLE
SQUARE BRAIDED PURE ASBESTOS ROPE (DENSE)
HIGH PRESSURE SEAL LEAK DETECTION LINE. - N10 NOZZLE
FOR AZIMUTHS, SEE NOZZLE SCHEDULE - SH.1, THIS DWG.
LOW PRESSURE SEAL LEAK DETECTION LINE. - N11 NOZZLE
SEE DWG 237E434 SH.1 FOR LOADS & DEFLECTION LIMITATIONS
VESSEL SHELL FLANGE
BRACKET MUST CLEAR 8 AISC CLEVIS WITH 3 1/2 DIA PIN.
STABILIZER BRACKET (SEE SH 1)
TACK WELD ALONG TWO FLATS.
(12) 3/4 DIA HEX BOLT & NUT.
(ALL WELDED CONSTRUCTION OPTIONAL)
VIEW "H" (SEE SH 3)
INSULATION SUPT.
VIEW "E" FIXED SUPT. (SEE SH1)
2 REQD. AT EACH ELEV. LOCATED AT AZIMUTHS OF 0° & 180°.
EXCEPT FOR OMISSION OF WELDING ANGLE TO PLATE, OTHERWISE SAME AS FIXED SUPT VIEW "E"
VIEW "F" AUX SUPT (SEE SH1)
4 REQD. AT EACH ELEV. LOCATED AT AZIMUTHS OF 45°, 135°, 225°, 315°.
REVISIONS
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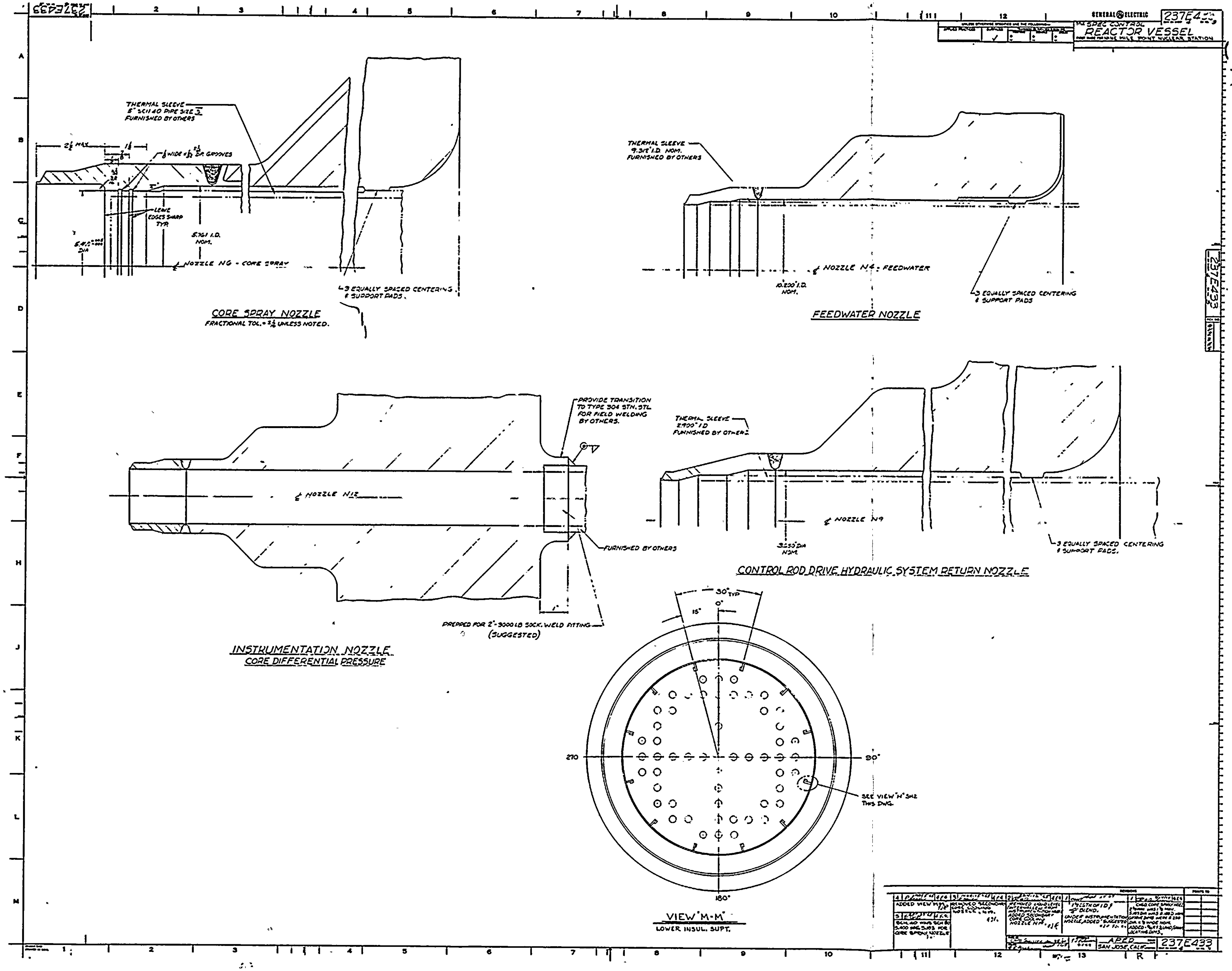

GENERAL ELECTRIC
237E433
SPEC CONTROL
REACTOR VESSEL
NINE MILE POINT NUCLEAR STATION
THERMAL SLEEVE 5" SCH 40 PIPE SIZE FURNISHED BY OTHERS
2 1/2 MAX
1/8 WIDE x 3/32 DP. GROOVES
LEAVE EDGES SHARP TYP.
5.761 I.D. NOM.
℄ NOZZLE N6 - CORE SPRAY
3 EQUALLY SPACED CENTERING & SUPPORT PADS.
CORE SPRAY NOZZLE
FRACTIONAL TOL. = ±1/16 UNLESS NOTED.
THERMAL SLEEVE 9.312 I.D. NOM. FURNISHED BY OTHERS
℄ NOZZLE N4 - FEEDWATER
10.250 I.D. NOM.
3 EQUALLY SPACED CENTERING & SUPPORT PADS
FEEDWATER NOZZLE
PROVIDE TRANSITION TO TYPE 304 STN. STL. FOR FIELD WELDING BY OTHERS.
℄ NOZZLE N12
FURNISHED BY OTHERS
PREPPED FOR 2"-3000 LB SOCK. WELD FITTING
(SUGGESTED)
INSTRUMENTATION NOZZLE
CORE DIFFERENTIAL PRESSURE
THERMAL SLEEVE 2.900" I.D FURNISHED BY OTHERS
℄ NOZZLE N9
3.250 DIA NOM.
3 EQUALLY SPACED CENTERING & SUPPORT PADS.
CONTROL ROD DRIVE HYDRAULIC SYSTEM RETURN NOZZLE
30° TYP
15°
0°
270
90°
180°
SEE VIEW "N" SH2 THIS DWG.
VIEW "M-M"
LOWER INSUL. SUPT.
REVISIONS
ADDED VIEW M-M
SCH. 40 WAS SCH 80. 5.400 WAS 5.183 FOR CORE SPRAY NOZZLE
REMOVED SECONDARY CORE COOLING NOZZLE, N11.
REMOVED LIQUID LEVEL INSTRUMENTATION NOZZLE. ADDED SECONDARY CORE COOLING NOZZLE N11.
UNDER INSTRUMENTATION NOZZLE, ADDED "SUGGESTED"
CHGD CORE SPRAY NOZZLE
ADDED LOCATING DIMS.
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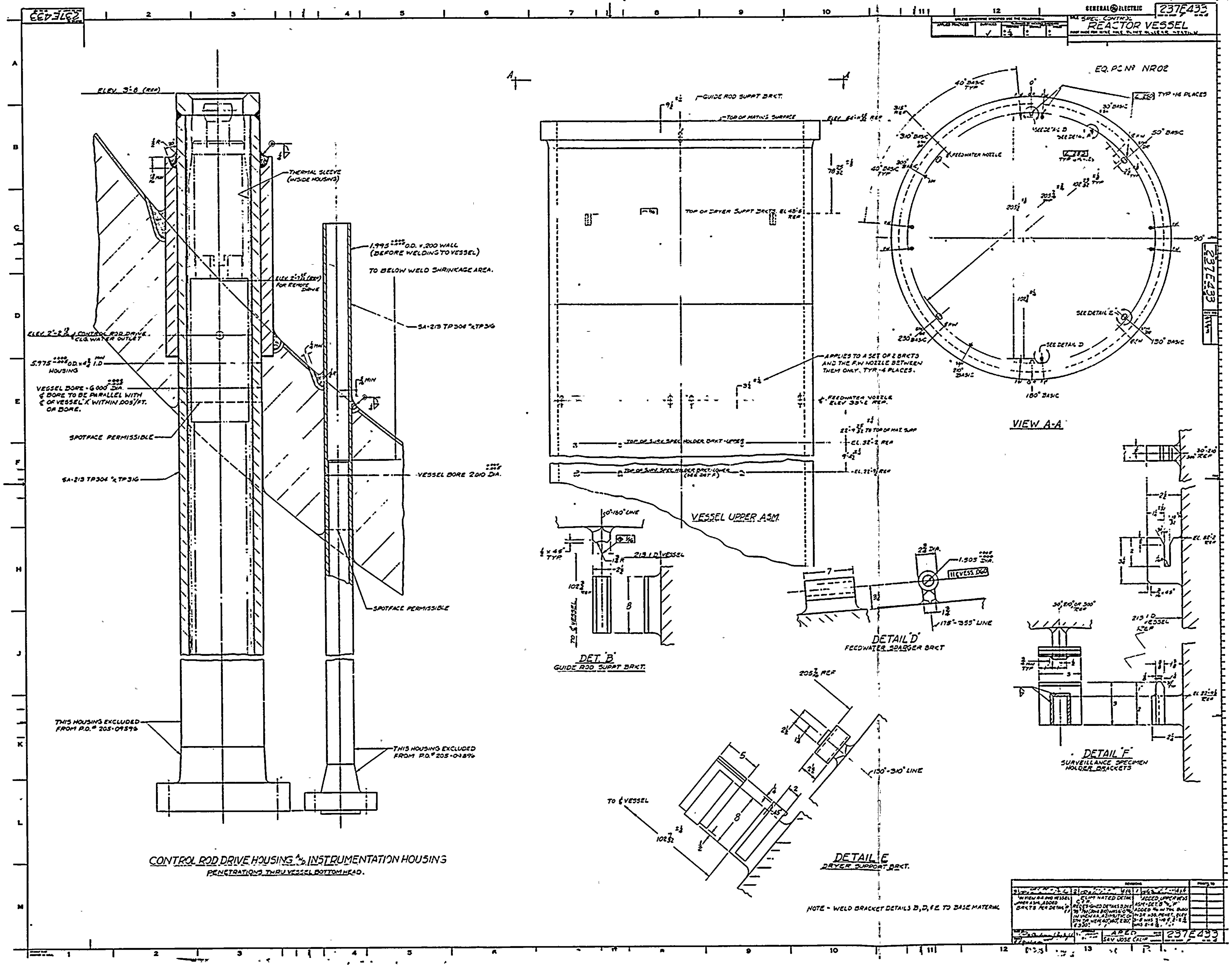
237E433



GENERAL ELECTRIC
237E433
SPEC. CONTROL
REACTOR VESSEL
EQ. PC Nº NR02
ELEV. 3'-8 (REF)
THERMAL SLEEVE (INSIDE HOUSING)
1.995 O.D. x .200 WALL (BEFORE WELDING TO VESSEL)
TO BELOW WELD SHRINKAGE AREA.
FOR REMOTE DRIVE
SA-213 TP304 or TP316
CONTROL ROD DRIVE CLG WATER OUTLET
HOUSING
VESSEL BORE - 6.000 DIA.
SPOTFACE PERMISSIBLE
VESSEL BORE 2.010 DIA.
THIS HOUSING EXCLUDED FROM P.O.# 205-09596
THIS HOUSING EXCLUDED FROM P.O.# 205-09896
CONTROL ROD DRIVE HOUSING & INSTRUMENTATION HOUSING
PENETRATIONS THRU VESSEL BOTTOM HEAD.
GUIDE ROD SUPPT BRKT.
TOP OF MATING SURFACE
TOP OF DRYER SUPPT BRKTS.
APPLIES TO A SET OF 2 BRCTS AND THE F.W. NOZZLE BETWEEN THEM ONLY. TYP.-4 PLACES.
FEEDWATER NOZZLE
TOP OF SURV. SPEC. HOLDER BRKT-UPPER
TOP OF SURV. SPEC. HOLDER BRKT-LOWER (SEE DET F)
VESSEL UPPER ASM.
FEEDWATER NOZZLE
SEE DETAIL B
SEE DETAIL E
SEE DETAIL D
VIEW A-A
DET. B
GUIDE ROD SUPPT BRKT.
TO ℄ VESSEL
DETAIL D
FEEDWATER SPARGER BRKT
178°-358° LINE
130°-310° LINE
TO ℄ VESSEL
DETAIL E
DRYER SUPPORT BRKT.
DETAIL F
SURVEILLANCE SPECIMEN HOLDER BRACKETS
NOTE - WELD BRACKET DETAILS B, D, & E TO BASE MATERIAL.
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237E433

APPENDIX B
APPENDIX SHEET SUMMARY

The following items comprise Appendix B.

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Table B-1	B-3
Table B-2	B-4
Drawing 921D743	B-5/B-6
Drawing 209A7144, sheets 1 through 13	B-7
Drawing 209A7148, sheets 1 through 18	B-21
Drawing 209A7058, sheets 1 through 3	B-39
Drawing 209A7059, sheets 1 and 2	B-43
Drawing 209A7160, sheets 1 and 2	B-45
Drawing 209A7161, sheets 1 through 3	B-47
Drawing 209A7162, sheets 1 and 2	B-51
Drawing 209A7153, sheets 1 through 10	B-53
Drawing 21A8570	B-63
Drawing 21A8592	B-71
PS-1 Original Procedure	B-79

TABLE B-1

SUMMARY OF INSPECTIONS
FURNACE SENSITIZED STAINLESS STEEL COMPONENTS
(Exclusive of Safe Ends)

Item	Description	Quantity	PT	UT	RT	
H	Stub Tubes	129	NA	NA	NA	
J	*Dryer Support Bracket 50°	4	209A7161SH1 209A7058SH1	ND	ND	Sample #5
	130°		OK	ND	ND	
	230°		209A7161SH2 209A7058SH2	ND	ND	
	310°		209A7058SH3 209A7161SH3	ND	ND	
K	Guide Rod Support Bracket 0°	2	209A7160SH1 209A7059SH1	ND	ND	Sample #6
	180°		209A7059SH2 209A7160SH2	ND	ND	
L	Core Support Ring	1	NA	NA	NA	

*Lug portion only - furnace sensitized
NA = Not Accessible
ND = Not Done to Date

TABLE B-2

SUMMARY OF INSPECTIONS
FURNACE SENSITIZED STAINLESS STEEL SAFE ENDS

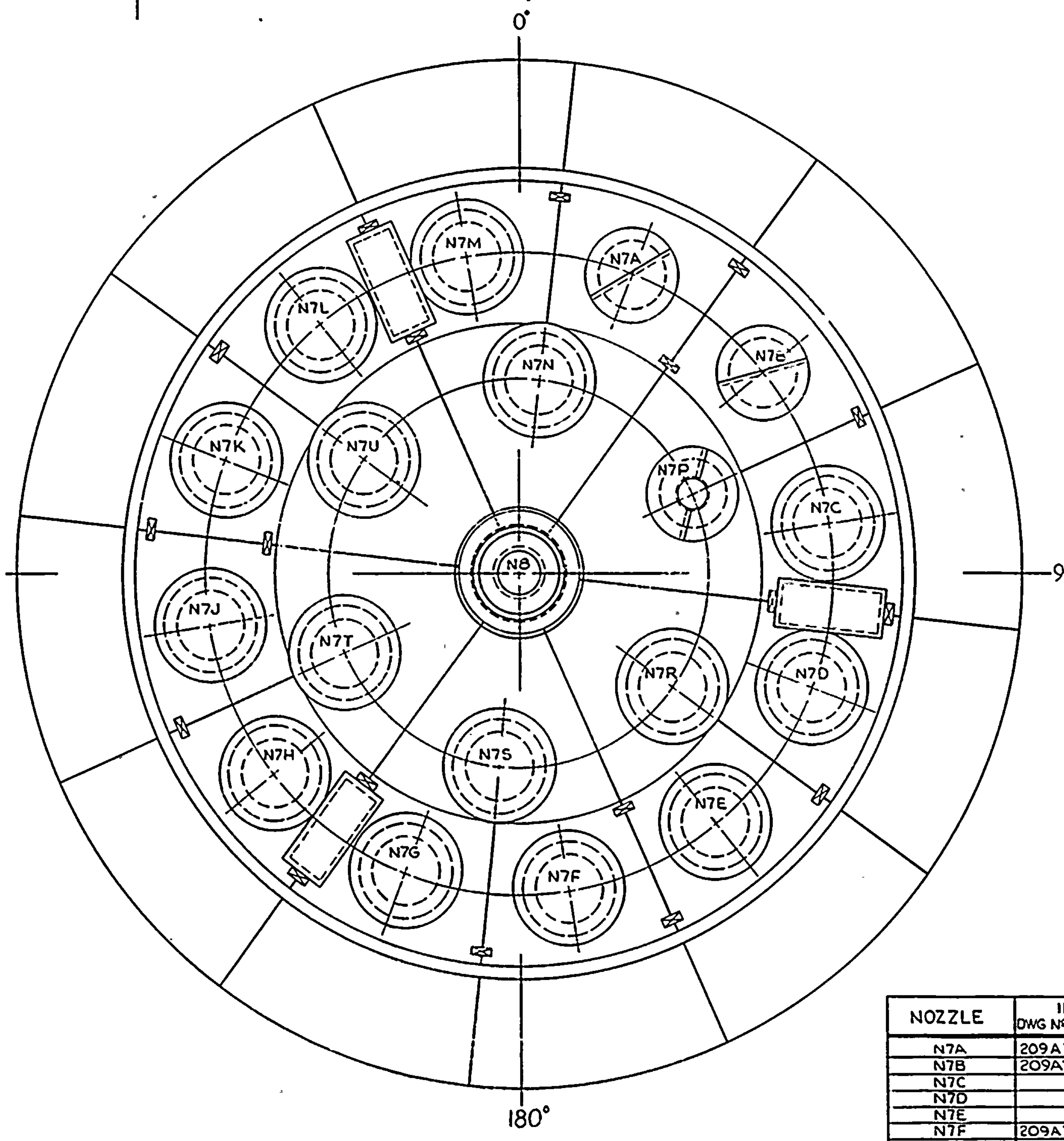
					PT Inspection				UT Insp. 209A7153		RT Inspection	
Item	Description	Qty.	I.D. Size (in.)	G.E. No.	O.D. Dwg.	Sh.	I.D. Dwg.	Sh.	Safe End	Weld Root		
A	Recir. Outlet S.E.	5	26-1/8	N1A	209A7144	7	N.A.		O.K.	1	O.K.	
				N1B	209A7144	8	N.A.		O.K.	O.K.	O.K.	
				N1C	209A7144	9	N.A.		O.K.	2	O.K.	
				N1D	209A7144	10	N.A.		O.K.	3	O.K.	
				N1E	O.K.		N.A.		O.K.	4	O.K.	
B	Recirc. Inlet S.E.	5	25-11/16	N2A	209A7144	3	N.A.		O.K.	5	O.K.	
				N2B	O.K.		N.A.		O.K.	6	O.K.	
				N2C	209A7144	2	N.A.		O.K.	7	O.K.	
				N2D	O.K.		N.A.		O.K.	8	O.K.	
				N2E	O.K.		N.A.		O.K.	9	O.K.	
C	Isolation Cond. S.E.	2	9-3/8	N5A	209A7144	5	O.K.		O.K.	O.K.	O.K.	Sample No. 2, 2A (AEC)
				N5B	209A7144	4	O.K.		O.K.	O.K.	O.K.	
D	Core Spray S.E.	2	5-3/16	N6A	O.K.		N.A.		O.K.	O.K.	O.K.	Sample No. 7, 7A
				N6B	(117C4601)		(117C4602)		10	10	X	Leaker-Sample No. 1,1A (AEC) 3, 4
E	Safety Valve & Inst. Long Neck Flange	18	6	N7A	O.K.		209A7148	1	O.K.	O.K.	O.K.	
				N7B	209A7144	1	209A7148	2	O.K.	O.K.	O.K.	
				N7C	O.K.		O.K.		O.K.	O.K.	O.K.	
				N7D	O.K.		O.K.		O.K.	O.K.	O.K.	
				N7E	209A7144	12	O.K.		O.K.	O.K.	O.K.	
				N7F	O.K.		209A7148	3	O.K.	O.K.	O.K.	
				N7G	O.K.		209A7148	11	O.K.	O.K.	O.K.	
				N7H	O.K.		209A7148	4	O.K.	O.K.	O.K.	
				N7J	O.K.		209A7148	5	O.K.	O.K.	O.K.	
				N7K	209A7144	13	O.K.		O.K.	O.K.	O.K.	
				N7L	O.K.		209A7148	6	O.K.	O.K.	O.K.	
				N7M	209A7144	11	O.K.		O.K.	O.K.	O.K.	
				N7N	209A7148	12	O.K.		O.K.	O.K.	N.D.	
				N7P	209A7148	13	209A7148	7	O.K.	O.K.	N.D.	
				N7R	209A7148	14	209A7148	8	O.K.	O.K.	N.D.	
				N7S	209A7148	15	209A7148	9	O.K.	O.K.	N.D.	
				N7T	209A7148	16	O.K.		O.K.	O.K.	N.D.	
				N7U	209A7148	17	209A7148	10	O.K.	O.K.	N.D.	
F	Head Vent Long Neck Flange	1	3-15/16	N8	209A7148	18	O.K.		O.K.	O.K.	N.D.	
G	CRD-Hyd. Ret. Line S.E.	1	3-5/8	N9	O.K.		N.A.		O.K.	O.K.	O.K.	

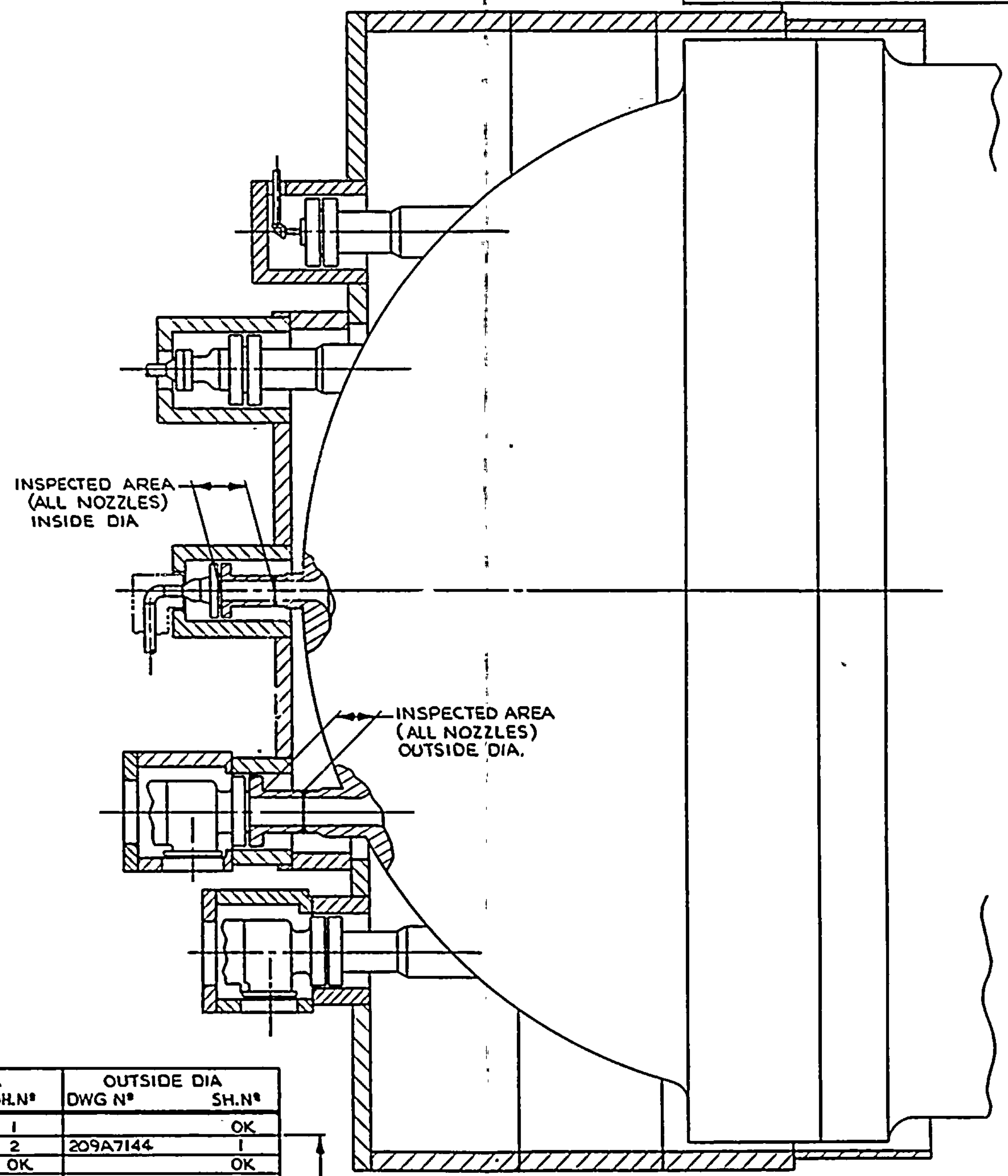
ND - Not Done to Date
NA - Not Accessible
X - Composite Radiograph

GENERAL ELECTRIC

DYE PENETRANT INSPECTIONS (VESSEL HEAD SAFE ENDS) (I.D.&O.D.)

FIRST MADE FOR NMPNS — 921D743





NOZZLE	INSIDE DIA DWG Nº	INSIDE DIA SH.Nº	OUTSIDE DIA DWG Nº	OUTSIDE DIA SH.Nº
N7A	209A7148	1		OK
N7B	209A7148	2	209A7144	1
N7C		OK		OK
N7D		OK		OK
N7E		OK	209A7144	12
N7F	209A7148	3		OK
N7G	209A7148	11		OK
N7H	209A7148	4		OK
N7J	209A7148	5		OK
N7K		OK	209A7144	13
N7L	209A7148	6		OK
N7M		OK	209A7144	11
N7N		OK	209A7148	12
N7P	209A7148	7	209A7148	13
N7R	209A7148	8	209A7148	14
N7S	209A7148	9	209A7148	15
N7T		OK	209A7148	16
N7U	209A7148	10	209A7148	17
N8		OK	209A7148	18

SHOWN IN PRELIMINARY REPORT. NEDM-10159 (N7B through N7M)

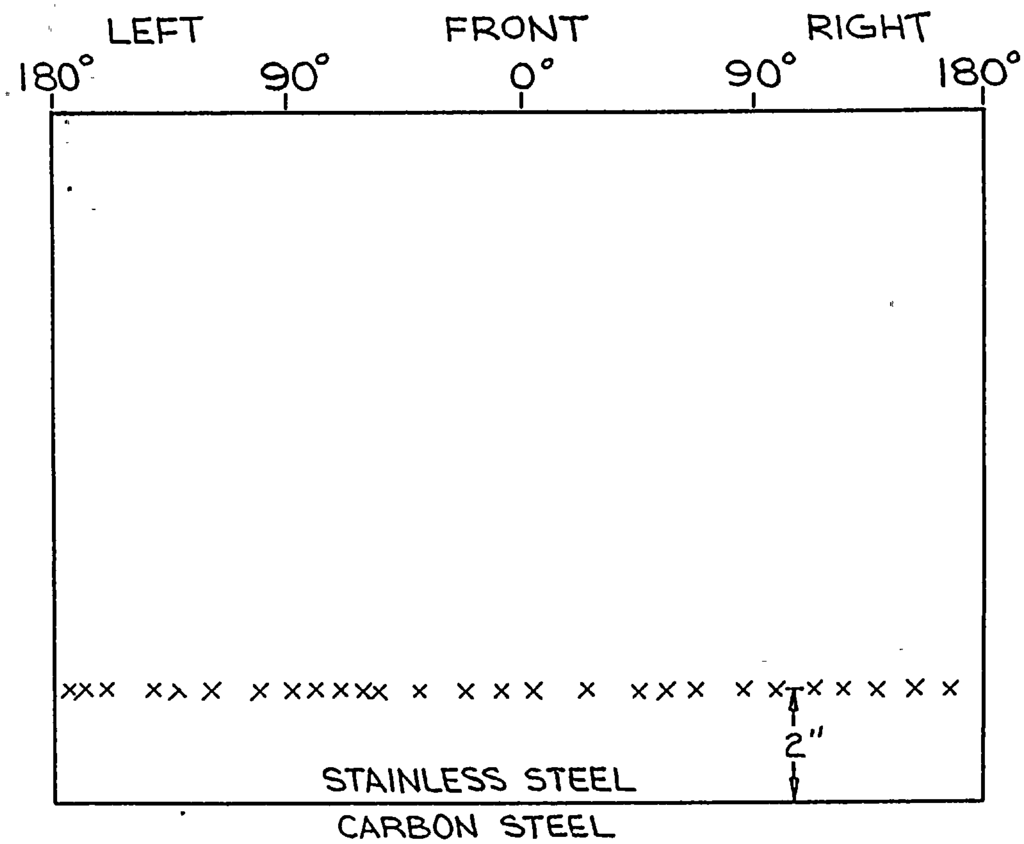
REVISIONS: A — PRELIMINARY ISSUE

APR. 4, 1970 — 4-7-70 — 4/7/70

APED SAN JOSE — 921D743

SKETCH

DYE PENETRANT INSPECTION-NINE MILE POINT



IDENTIFICATION: N7B—VESSEL HEAD SAFE END O.D.
INSPECTION DATE: 3-12-70
BY: Original signed by M. [illegible] /mk

REMARKS: 2-1 SHOWS A SAMPLE 30° RIGHT OF 0°.
2-4 SHOWS THE 30° TO RIGHT AREA
AFTER FIRST GRIND.
INDICATIONS REDEVELOPED.

PT PROCEDURE USED: 21A8570

REVISIONS
A PRELIMINARY ISSUE

GENERAL ELECTRIC

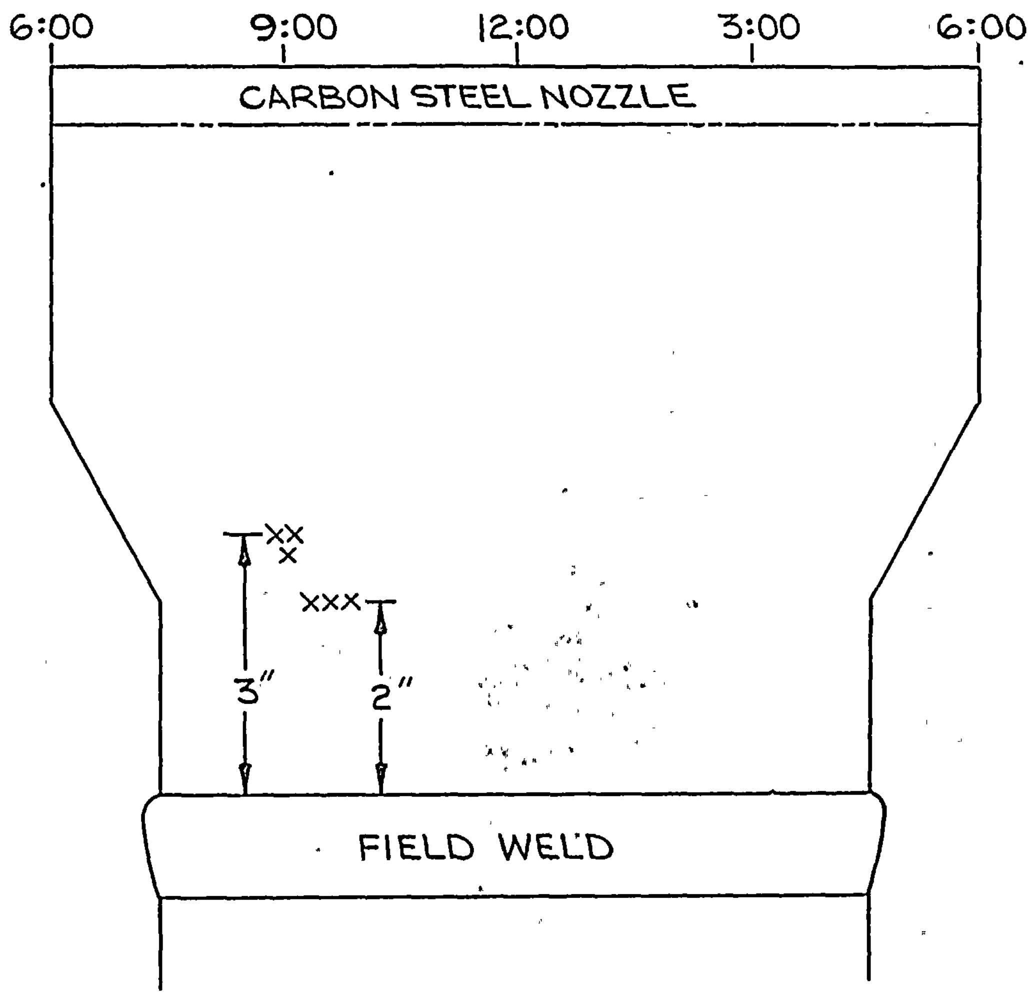
MADE BY	APPROVALS	DIV OR DEPT	
D. Kinoshita MARCH 23,'70	M. Eudlick	APED	209A7144
ISSUED [illegible] 3-23-70	3/23/70	LOCATION SAN JOSE	CONT ON SHT 2 SHT NO. 1

CHKD [illegible]

R

SKETCH

DYE PENETRANT INSPECTION-NINE MILE POINT



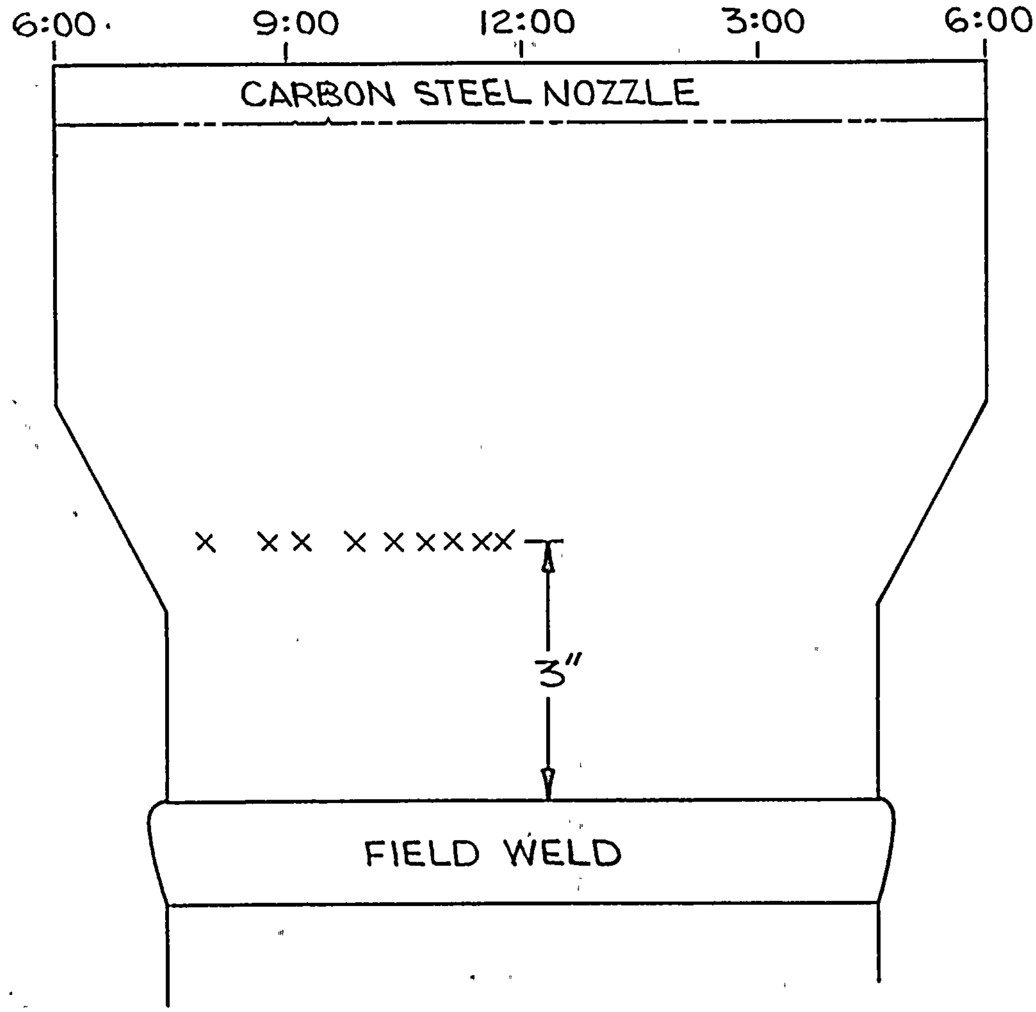
IDENTIFICATION: N2C-RECIRC. INLET SAFE END O.D.
INSPECTION DATE: 3-13-70
BY : *Original signed by M Johnson /mk*

REMARKS: PHOTO 2-7 SHOWS 10:00 INDICATION
ALL INDICATIONS REDEVELOPED

PT PROCEDURE USED: 21A8570

209A7144
CONT ON SHT 3 SHT NO. 2
SKETCH

DYE PENETRANT INSPECTION-NINE MILE POINT



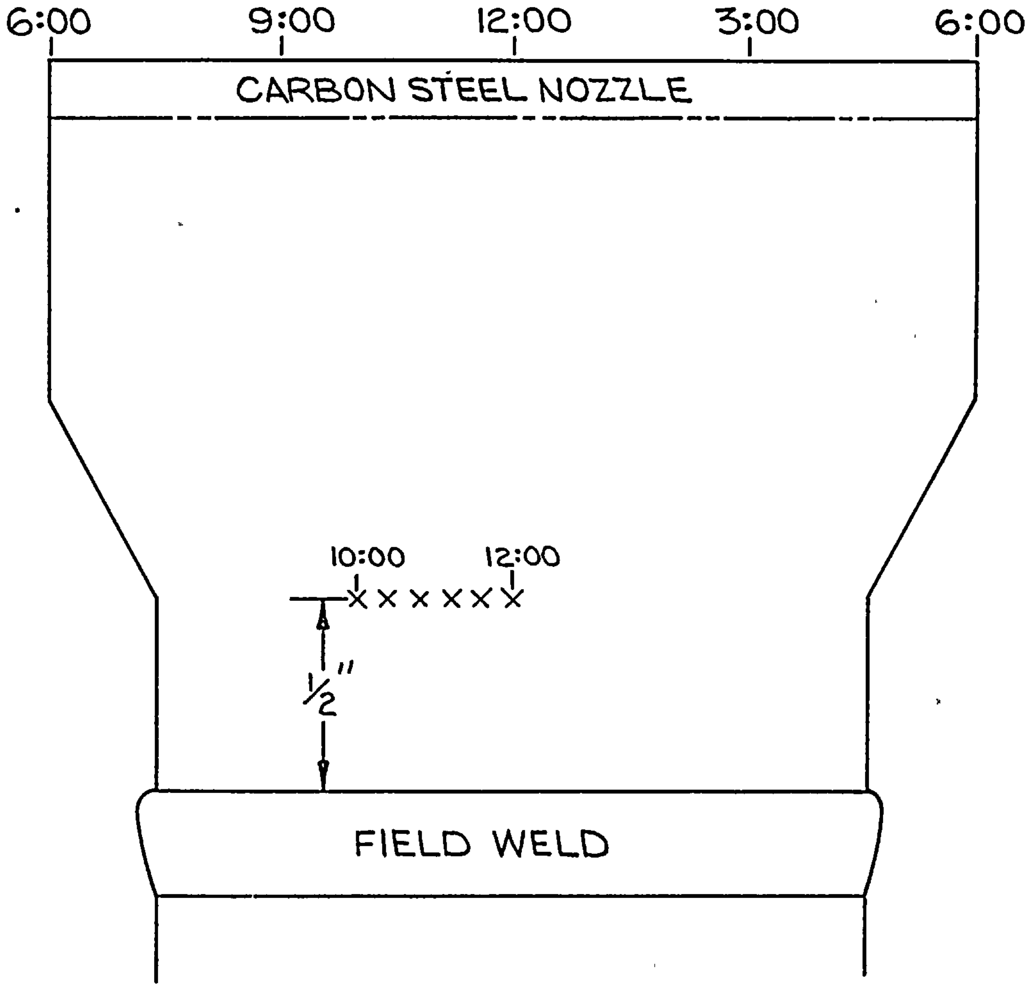
IDENTIFICATION: N2A-RECIRC. INLET SAFE END O.D.
INSPECTION DATE: 3-12-70
BY: Original Signed by M. Johnson/MWK

REMARKS: PHOTO 2-6 SHOWS THE 10:00 AREA.
ALL INDICATIONS REDEVELOPED.
THE 10:00 INDICATION DISAPPEARED AFTER
15 MIL GRIND.

PT PROCEDURE USED: 21A8570

209A7144	
CONT ON SHT. 4	SHT. NO. 3
SKETCH	

DYE PENETRANT INSPECTION-NINE MILE POINT

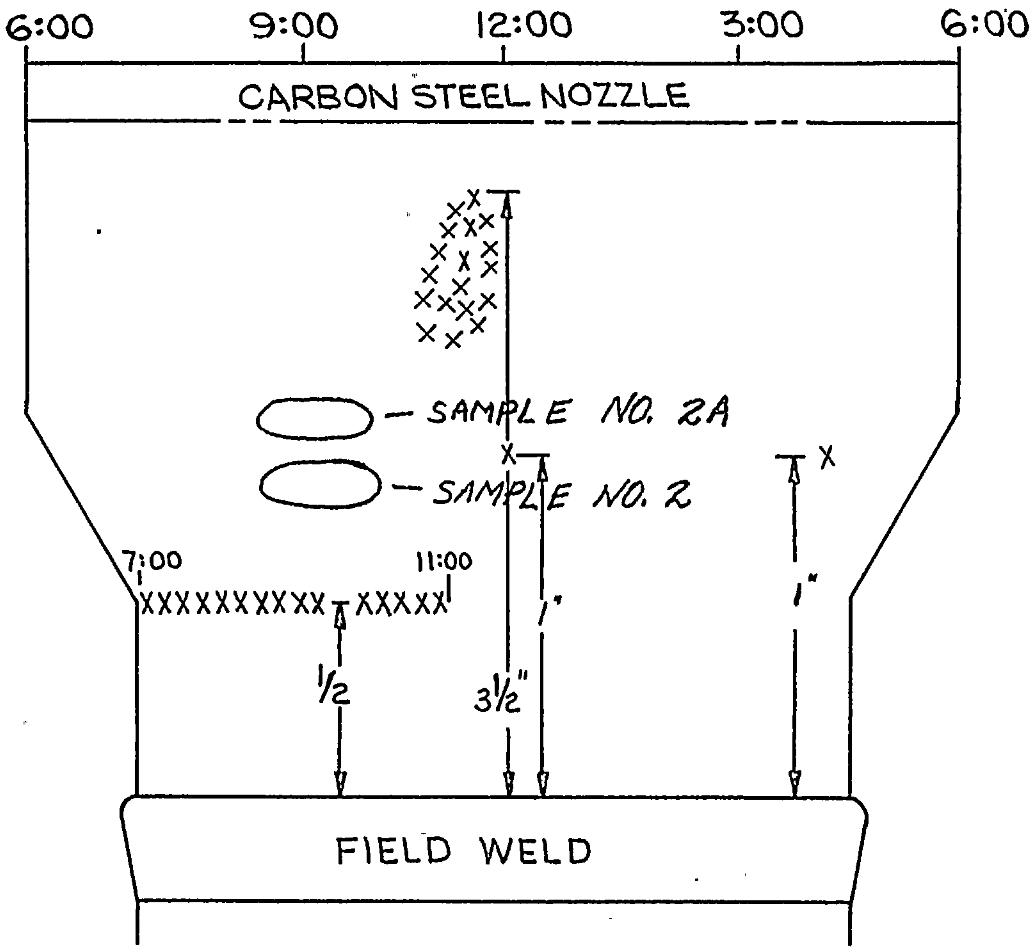


IDENTIFICATION: N5B–ISOLATION CONDENSER SAFE END O.D.
INSPECTION DATE: 3-11-70
BY: Original Signed by M. Johnson /MJ
REMARKS: PHOTO 1-8 12:00 AREA OF INDICATION
1-9 12:00 AREA OF REDEVELOPMENT
1-10 12:00 AREA AFTER FIRST GRIND
1-11 12:00 AREA AFTER REDEVELOPMENT
1-12 10:00 AREA AFTER SECOND GRIND
1-13 10:00 AREA AFTER REDEVELOPMENT

PT PROCEDURE USED: 21A8570

209A7144
CONT. ON SHT. 5 SHT. NO. 4
SKETCH

DYE PENETRANT INSPECTION-NINE MILE POINT



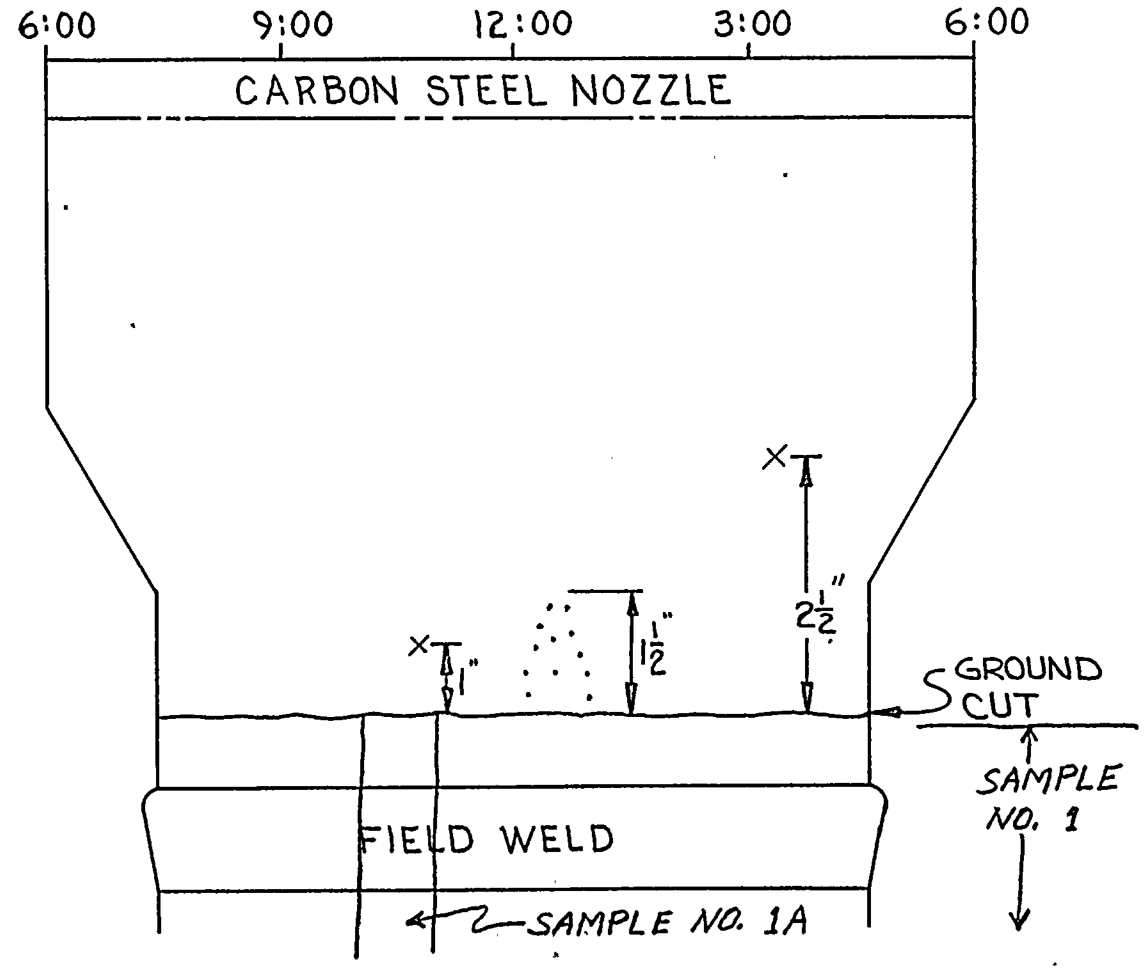
IDENTIFICATION: N5A-ISOLATION COND. SAFE END O.D.
INSPECTION DATE: 3-11-70
BY: Original signed by M. Johnson /mx.

REMARKS: PHOTO 1-5 SHOWS LARGE AREA AS FOUND.
1-7 SHOWS LARGE AREA AFTER 1ST GRIND
2-8 SHOWS LARGE AREA AFTER 30 MILL GRIND
2-9 SHOWS LARGE AREA WITHOUT DYE CHECK MAT'L

PT PROCEDURE USED: 21A8570

209A7144
CONT ON SHT. 6 SH NO. 5
SKETCH

DYE PENETRANT INSPECTION-NINE MILE POINT



IDENTIFICATION-N6B- CORE SPRAY SAFE END O.D.
INSPECTION DATE: 3-16-70
BY : Original Signed by M. Johnson/MK

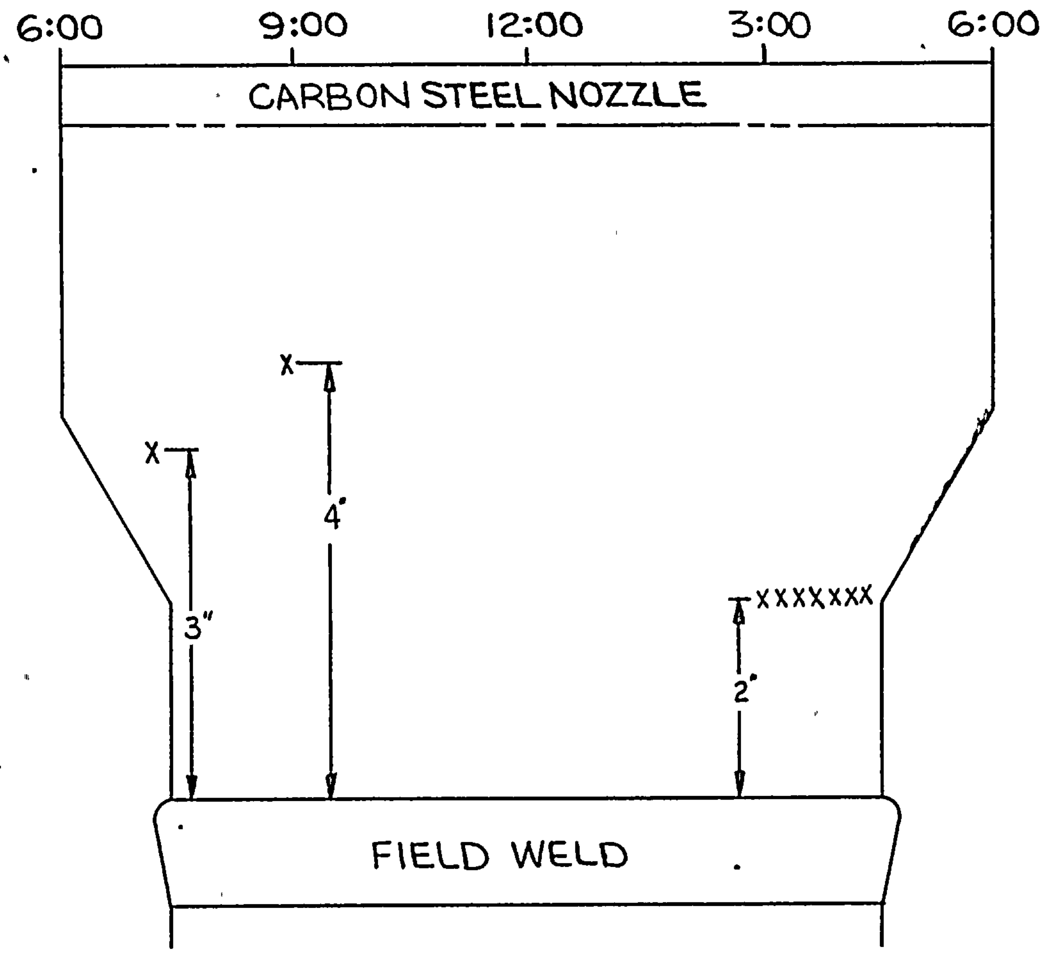
REMARKS: PHOTO 2-10. SHOWS 11:00 CRAZE

LOOKING AT CUT FACE

PT PROCEDURE USED: 21A8570

209A7144	
CONT ON SHT. 7	SH. NO. 6
SKETCH	

DYE PENETRANT INSPECTION-NINE MILE POINT



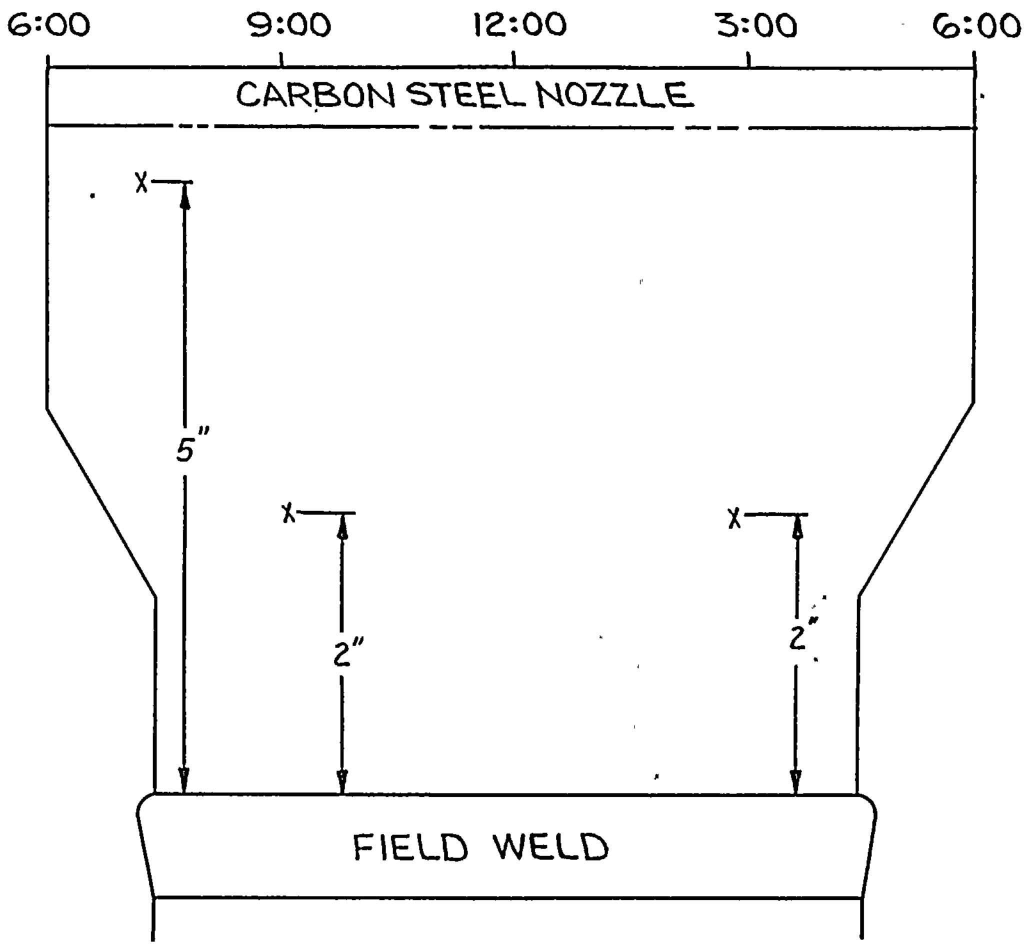
IDENTIFICATION: N I-A-RECIRC. OUTLET SAFE END O.D.
INSPECTION DATE: 3-13-70
BY : Original Signed by M. Johnson / MHC

REMARKS: ALL INDICATIONS REDEVELOPED

PT PROCEDURE USED: 21A8570

209A7144	
CONT ON SHEET 8	SH. NO. 7
SKETCH	

DYE PENETRANT INSPECTION-NINE MILE POINT



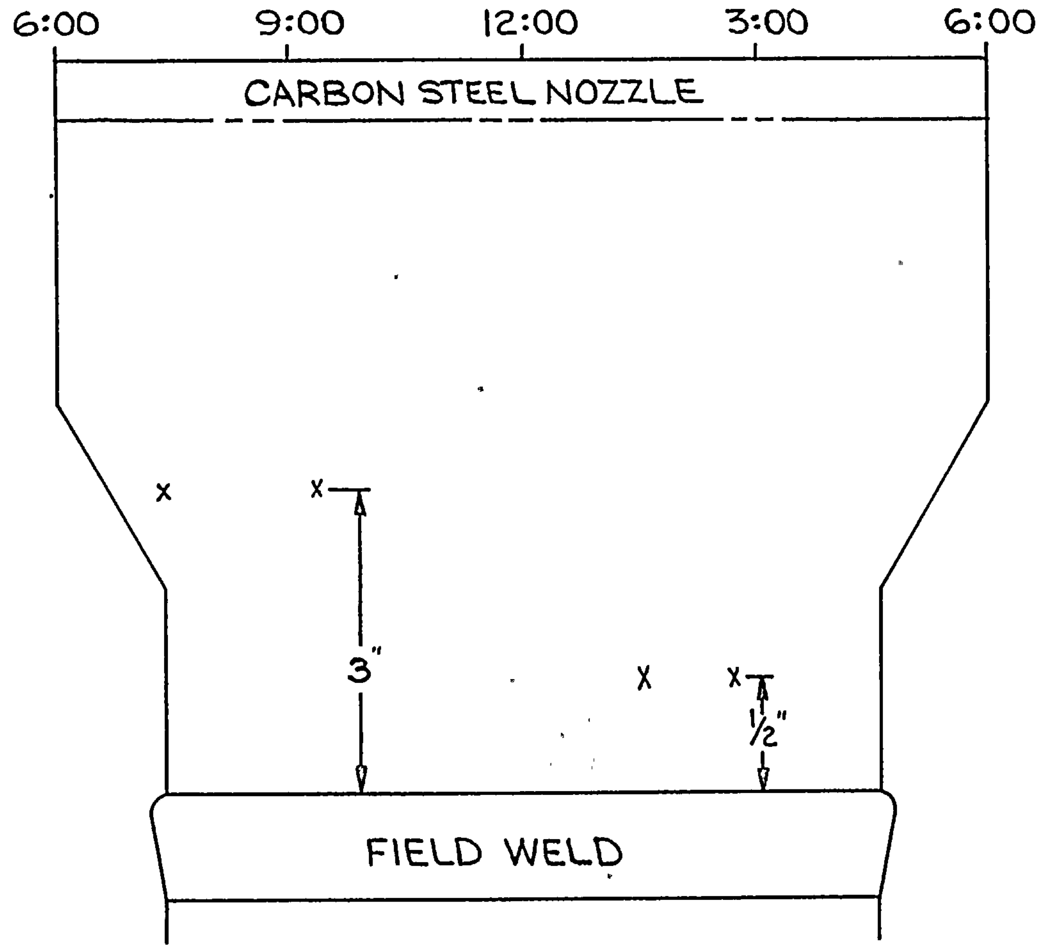
IDENTIFICATION: N1B-RECIRC. OUTLET SAFE END O.D.
INSPECTION DATE: 3-13-70
BY : Original Signed by M. Johnson / MWC

REMARKS: ALL INDICATIONS REDEVELOPED

PT PROCEDURE USED: 21A8570.

209A7144	
CONT ON SHT 9	SHT. NO. 8
SKETCH	

DYE PENETRANT INSPECTION-NINE MILE POINT



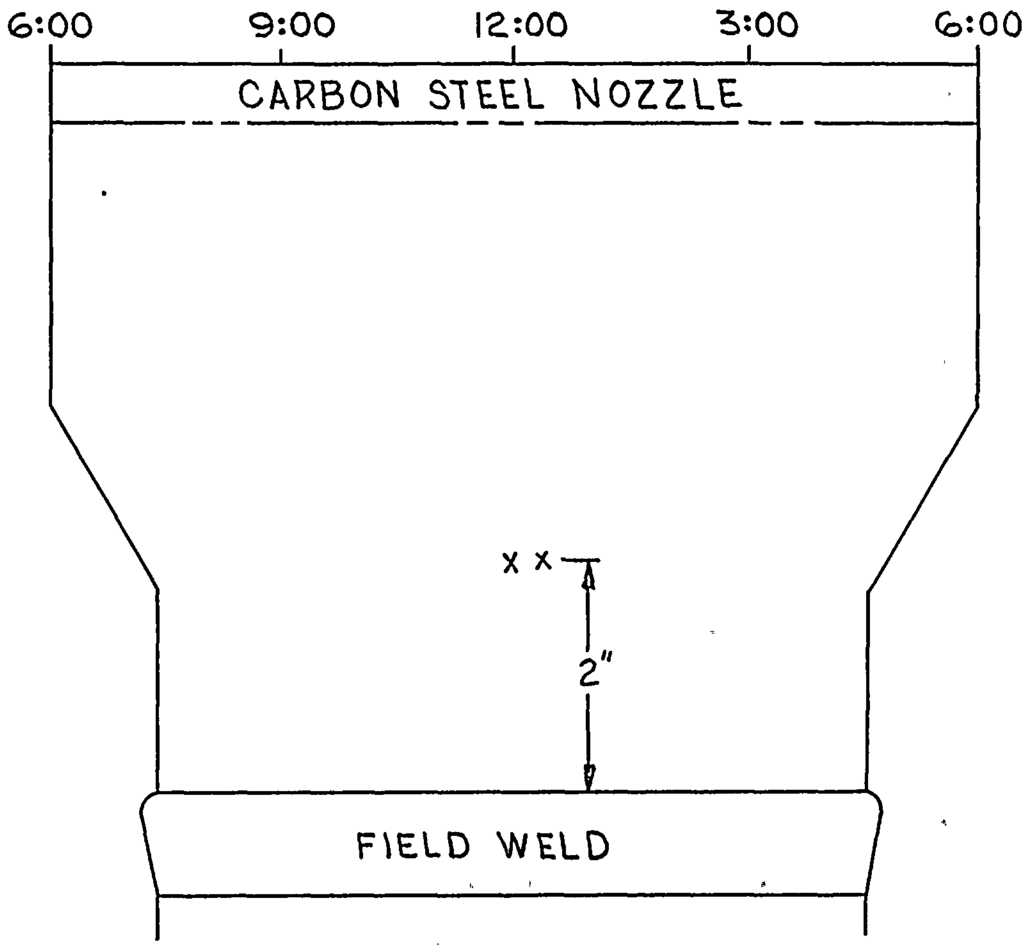
IDENTIFICATION: N1C-RECIRC. INLET SAFE END O.D.
INSPECTION DATE: 3-13-70
BY : Original Signed by M. Johnson /MK

REMARKS: ALL INDICATIONS REDEVELOPED

PT PROCEDURE USED: 21A8570

209A7144
CONT ON SHT. 10 SHT. NO. 9
SKETCH

DYE PENETRANT INSPECTION-NINE MILE POINT

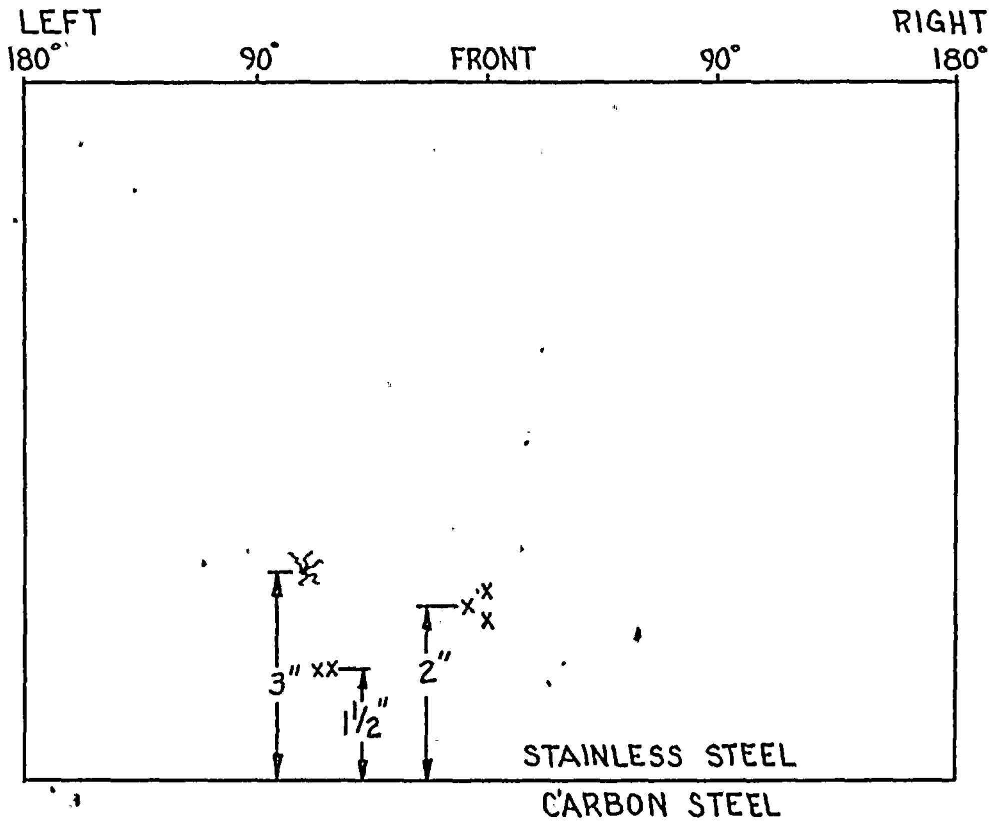


IDENTIFICATION: N I D-RECIRC. INLET SAFE END O.D.
INSPECTION DATE: 3-13-70
BY : Original signed by M. Johnson/MHC

REMARKS: ALL INDICATIONS REDEVELOPED

209A7144	
CONT. ON SHT. 11	SHT. NO. 10
SKETCH	

DYE PENETRANT INSPECTION-NINE MILE POINT

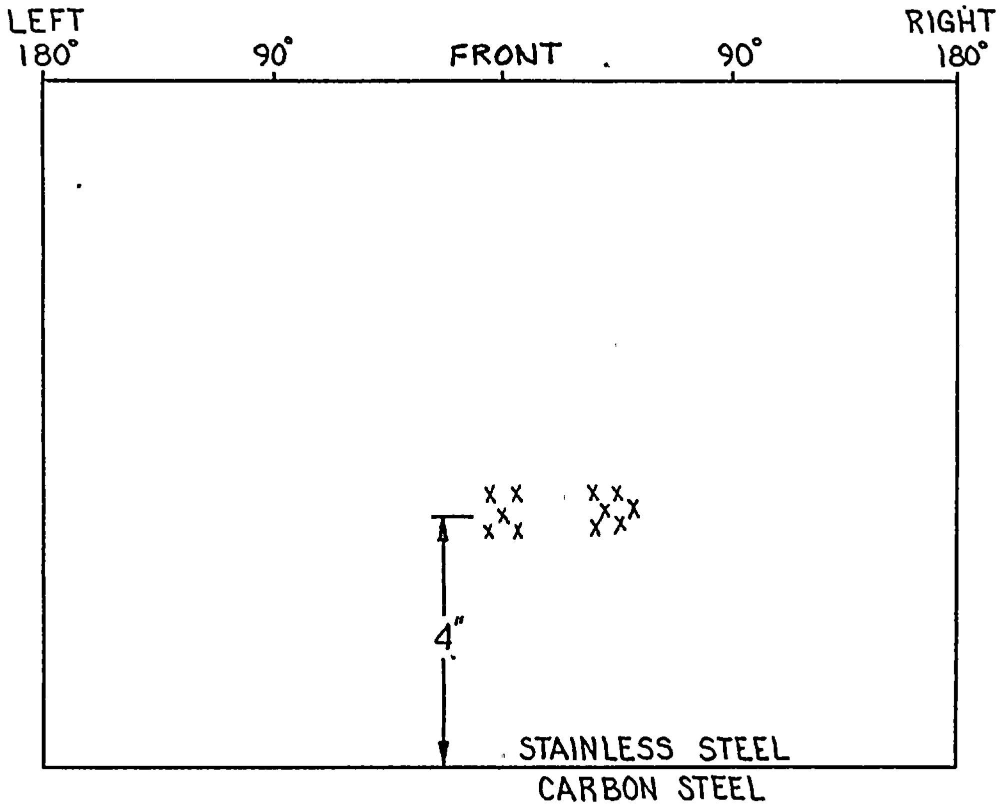


IDENTIFICATION: N7M-VESSEL HEAD SAFE END O.D.
INSPECTION DATE: 3-12-70
BY : *Original signed by M. Johnson /sec*

REMARKS: PHOTO 2-5 SHOWS LINEAR CRAZE INDICATION
ALL INDICATIONS REDEVELOPED

209A7144
CONT. ON SHT. 12 SHT. NO. 11
SKETCH

DYE PENETRANT INSPECTION-NINE MILE POINT



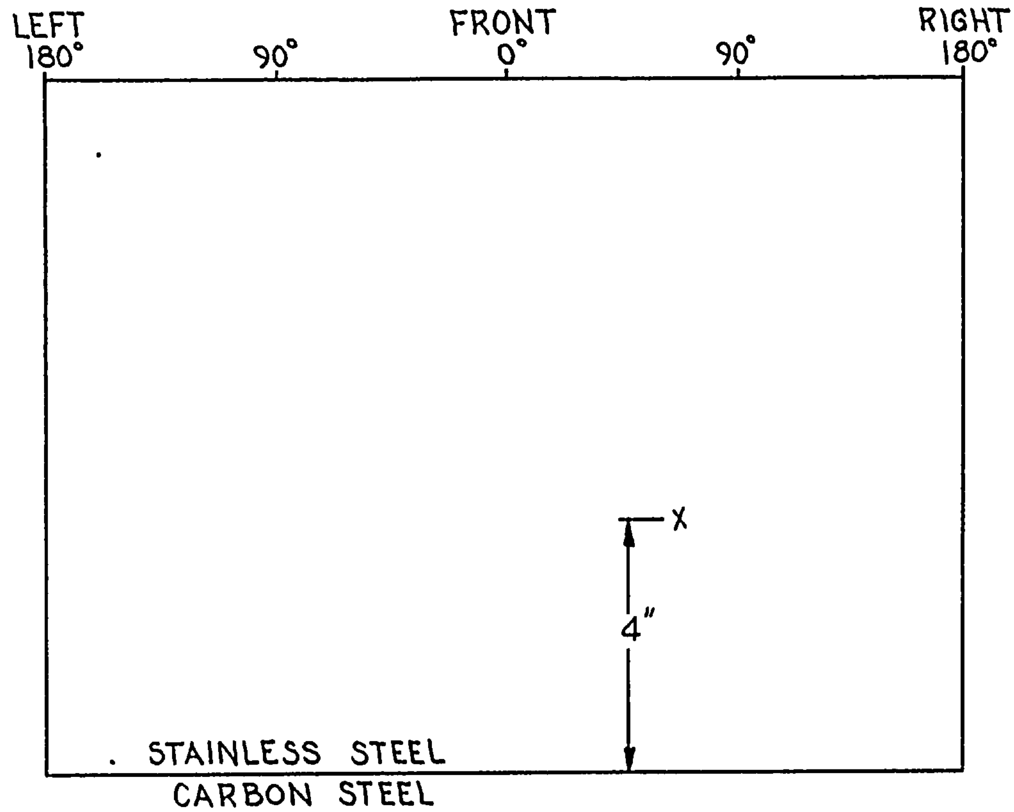
IDENTIFICATION: N7E—VESSEL HEAD SAFE END O.D.
INSPECTION DATE: 3-12-70
BY: *Original Signed by M. Johnson/MK*

REMARKS: PHOTO 2-2 SHOWS 0° INDICATION
INDICATIONS GONE UPON REDEVELOPMENT

PT PROCEDURE USED: 21A8570

209A7144
CONT. ON SHT 13 SHT. NO. 12
SKETCH

DYE PENETRANT INSPECTION-NINE MILE POINT



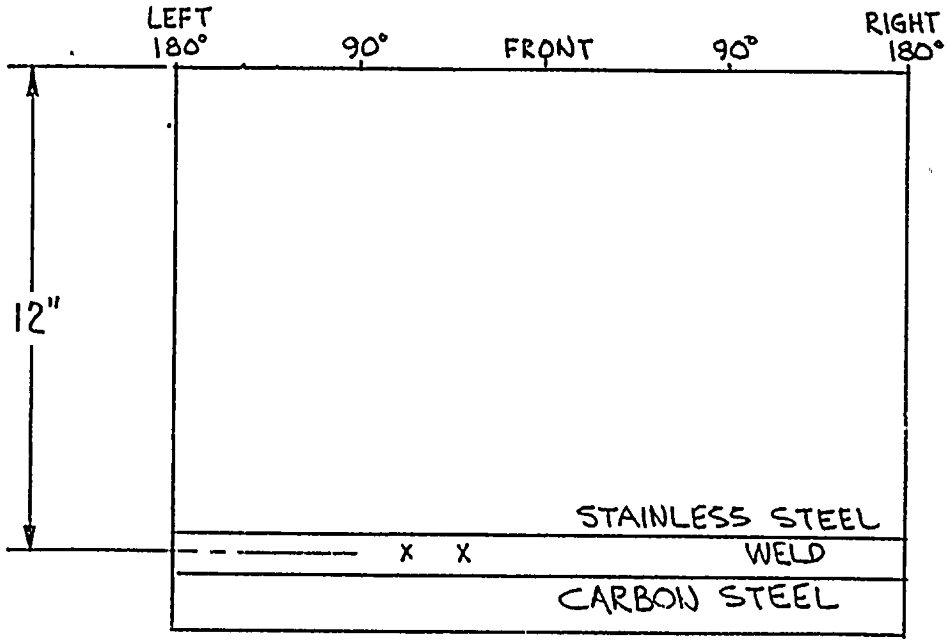
IDENTIFICATION: N7K-VESSEL HEAD SAFE END O.D.
INSPECTION DATE: 3-12-70
BY : *Original Signed by M. Johnson /[illegible]*

REMARKS: PHOTO 2-3 SHOWS INDICATION
INDICATION REDEVELOPED

PT PROCEDURE USED: 21A8570

209A7144	
CONT. ON SHT. FINAL	SHT. NO. 13
SKETCH	

DYE PENETRANT INSPECTION-NINE MILE POINT



INDENTIFICATION: N7A-VESSEL HEAD SAFE END I.D.
INSPECTION DATE: 3-28-70
BY: R.E. Lindemann

REMARKS: PHOTO 3-10 SHOWS FRONT LEFT INDICATION

PT PROCEDURE USED: 21A8570

FCF-921D743

REVISIONS

A PRELIMINARY ISSUE

GENERAL ELECTRIC

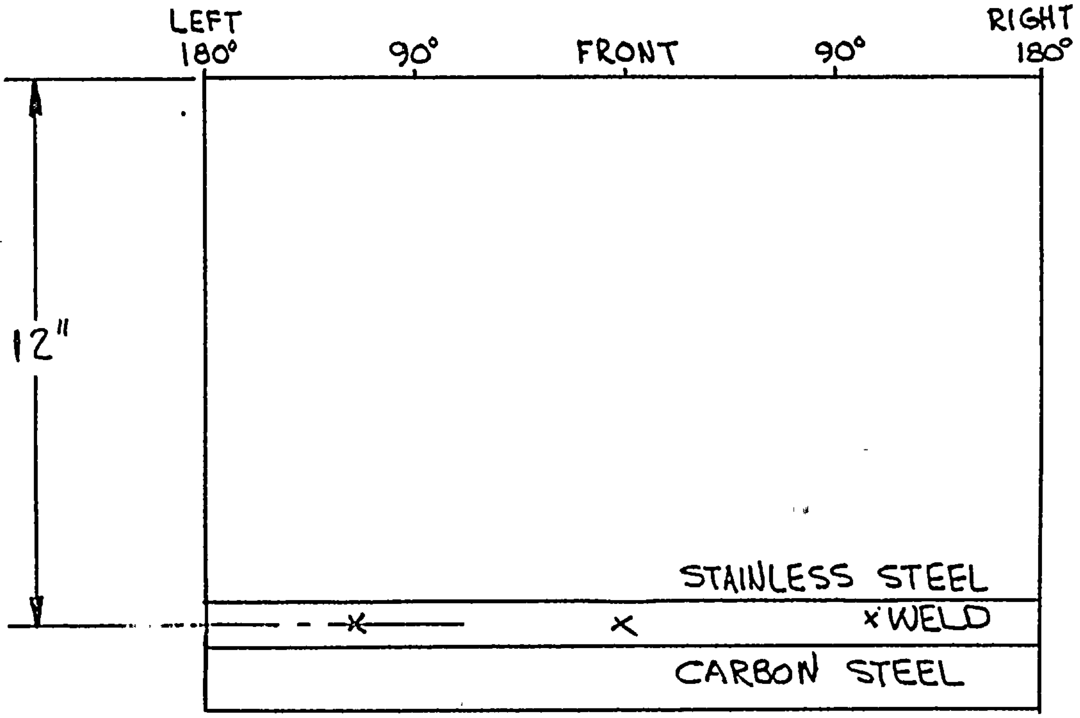
MADE BY [signature] April 6, 1970 | APPROVALS [signature] 4/7/70 | APED DIV OR DEPT | 209A7148
ISSUED E.H. Thiel 4-7-70 | | SAN JOSE LOCATION | CONT ON SH. 2 SH. 1

CHKD [signature]

R

SKETCH

DYE PENETRANT INSPECTION-NINE MILE POINT



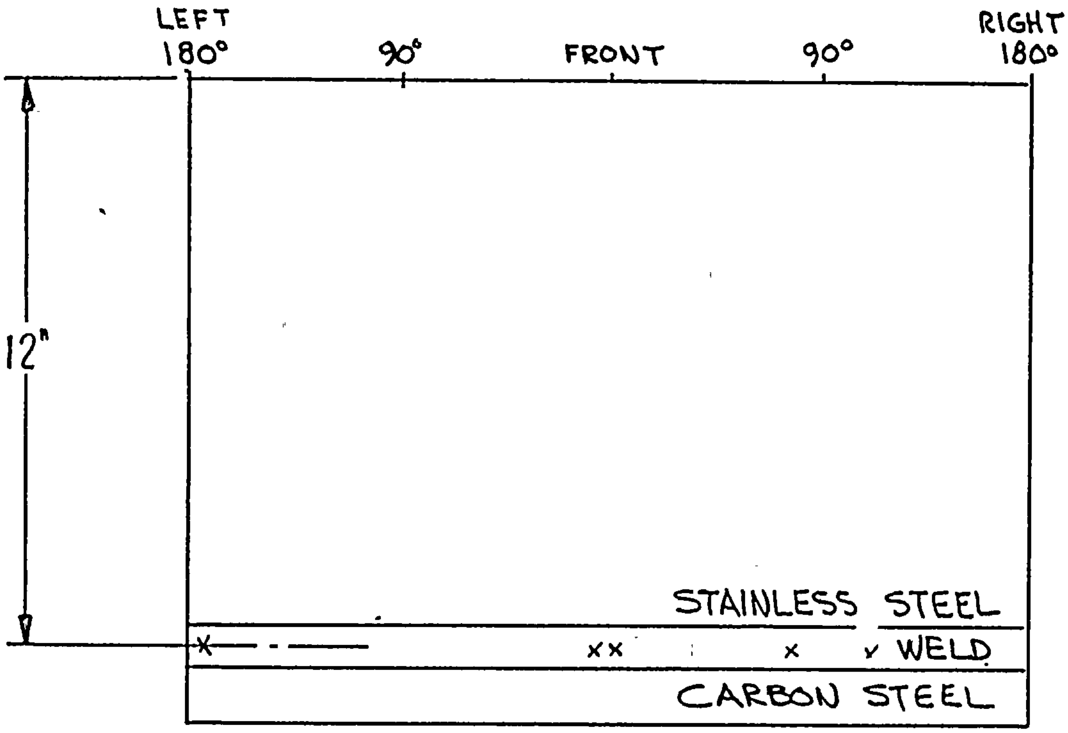
IDENTIFICATION: N7B-VESSEL HEAD SAFE END I.D.
INSPECTION DATE : 3-28-70
BY: R.E. Linderman

REMARKS: PHOTO 3-11 SHOWS FRONT INDICATION.

PT PROCEDURE USED: 21A8570

209A7148
CONT ON SH 3 SH No 2
SKETCH

DYE PENETRANT INSPECTION-NINE MILE POINT



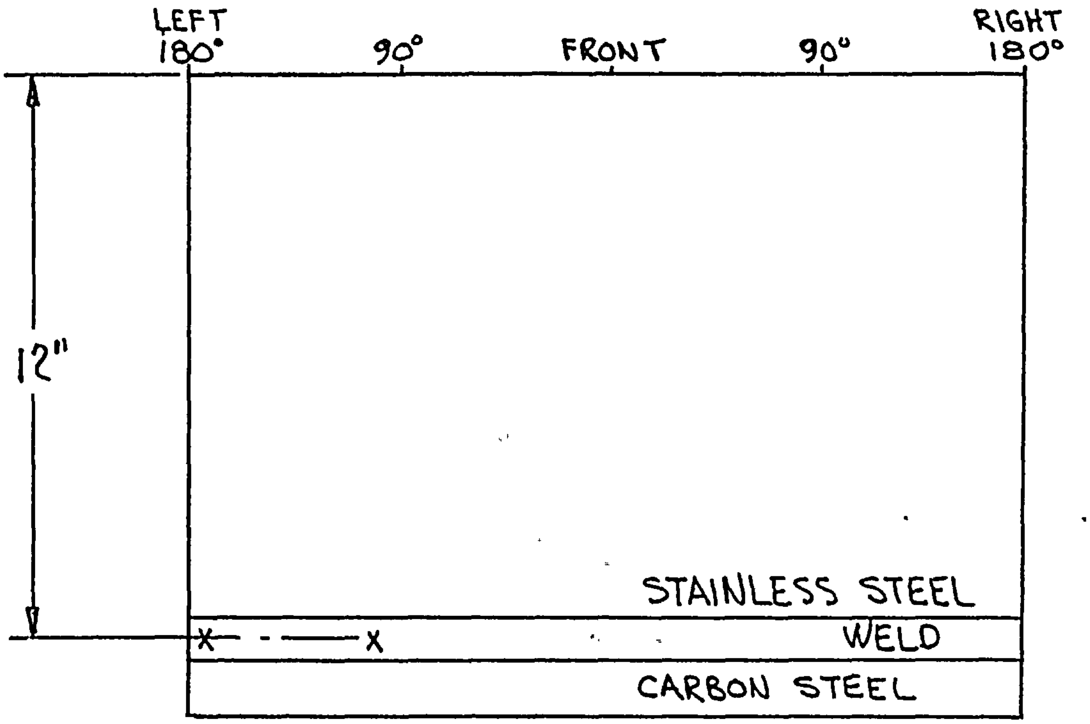
IDENTIFICATION: N7F-VESSEL HEAD SAFE END I.D.
INSPECTION DATE: 3-28-70
BY: R.E. Lindeman

REMARKS: PHOTO 3-12 SHOWS FRONT INDICATION.

PT PROCEDURE USED: 21A8570

209A7148
CONT ON SH 4 SH NO 3
SKETCH

DYE PENETRANT INSPECTION-NINE MILE POINT



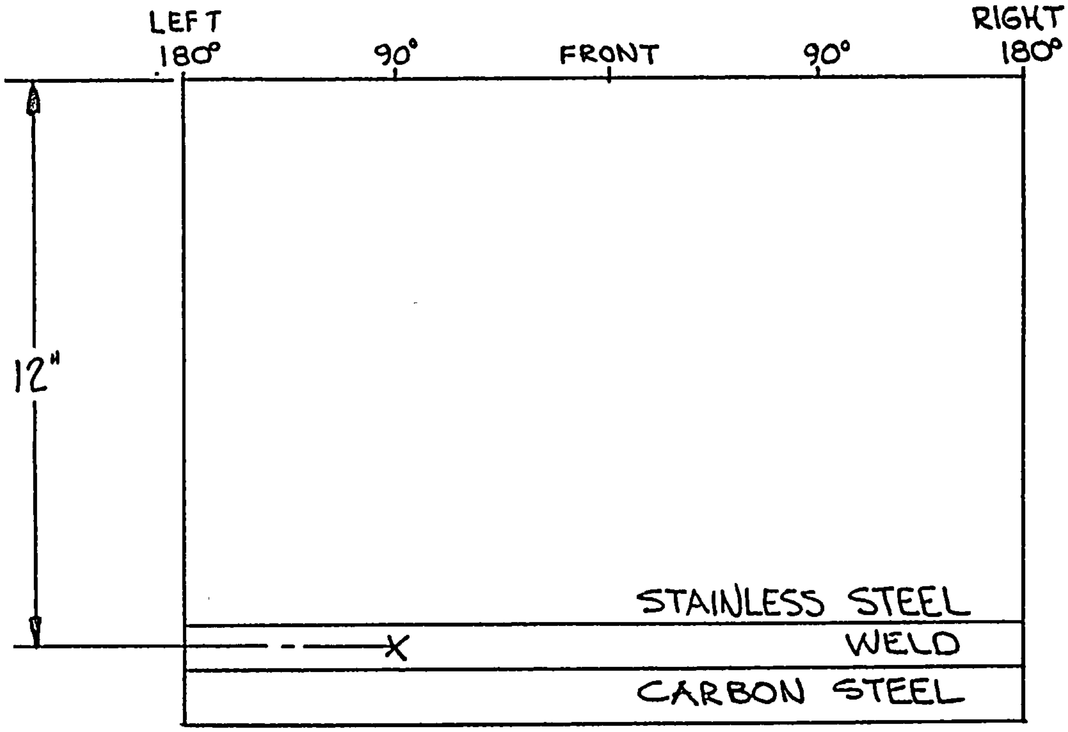
IDENTIFICATION: N7H - VESSEL HEAD SAFE END I.D.
INSPECTION DATE: 3-28-70
BY R. E. Lindeman

REMARKS: PHOTO 4-2 SHOWS 90° LEFT INDICATION

PT PROCEDURE USED: 21A8570

209A7148
CONT ON SH 5 SH No 4
SKETCH

DYE PENETRANT INSPECTION-NINE MILE POINT



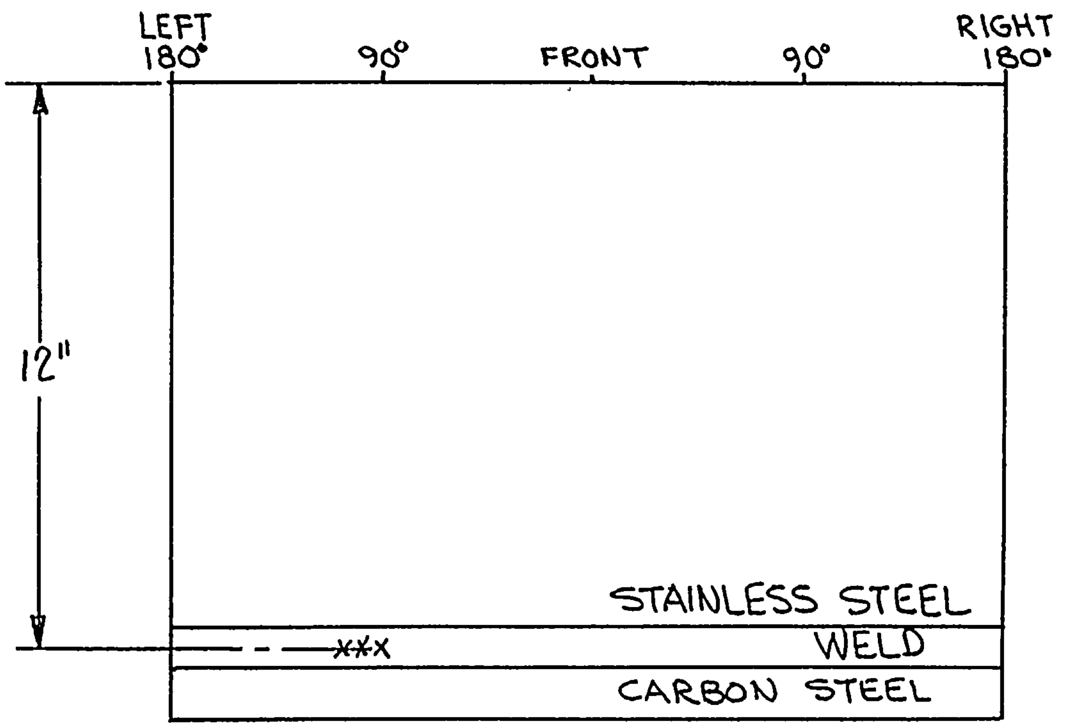
IDENTIFICATION-N7J-VESSEL HEAD SAFE END I.D.
INSPECTION: 3-28-70
BY: R. E. Sindum

REMARKS: PHOTO 4-3 SHOWS 90° LEFT INDICATION

PT PROCEDURE USED: 21A8570

209A7148
CONT ON SH 6 SH' NO 5
SKETCH

DYE PENETRANT INSPECTION-NINE MILE POINT



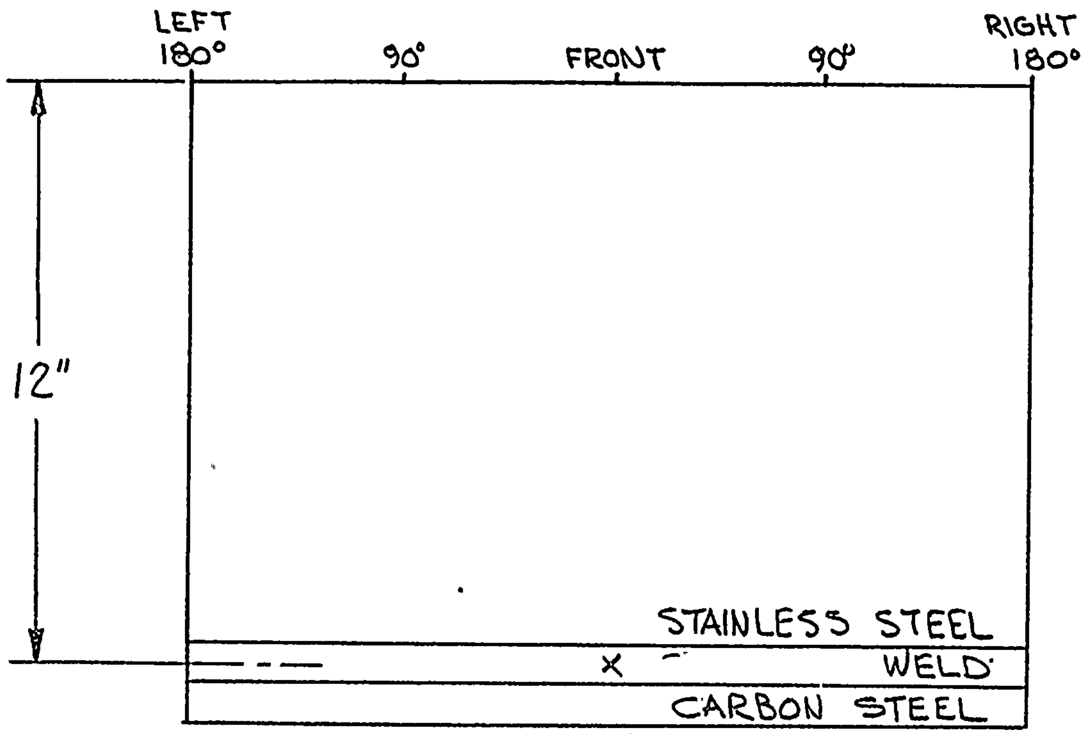
IDENTIFICATION: N7L-VESSEL HEAD SAFE END I.D.
INSPECTION DATE: 3-20-70
BY: R.E. Lindeman

REMARKS: PHOTO 4-4 SHOWS 90° LEFT INDICATION

PT PROCEDURE USED: 21A8570

209A7148
CONT ON SH 7 SH NO. 6
SKETCH

DYE PENETRANT INSPECTION–NINE MILE POINT



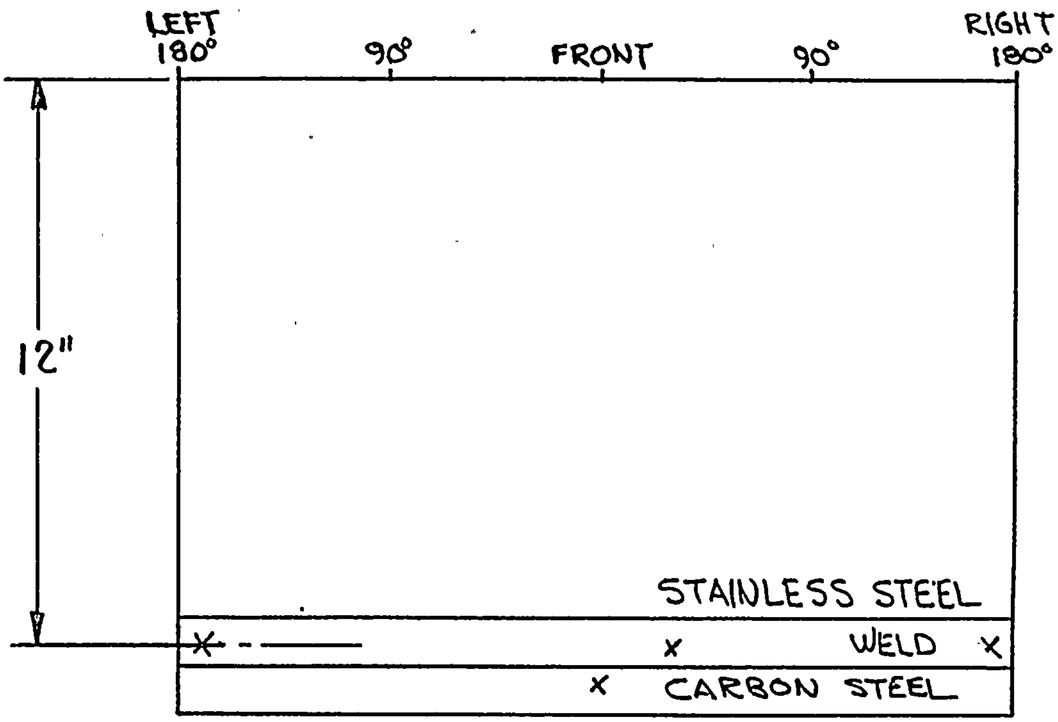
IDENTIFICATION: N7P – VESSEL HEAD SAFE END I.D.
INSPECTION DATE: 3-29-70
BY: R. E. Lindeman

REMARKS: PHOTO 4-5 SHOWS FRONT INDICATION AFTER .020 GRIND INDICATION GETTING SMALLER

PT PROCEDURE USED: 21A8570

209A7148	
CONT ON SH 8	SH NO 7
SKETCH	

DYE PENETRANT INSPECTION-NINE MILE POINT



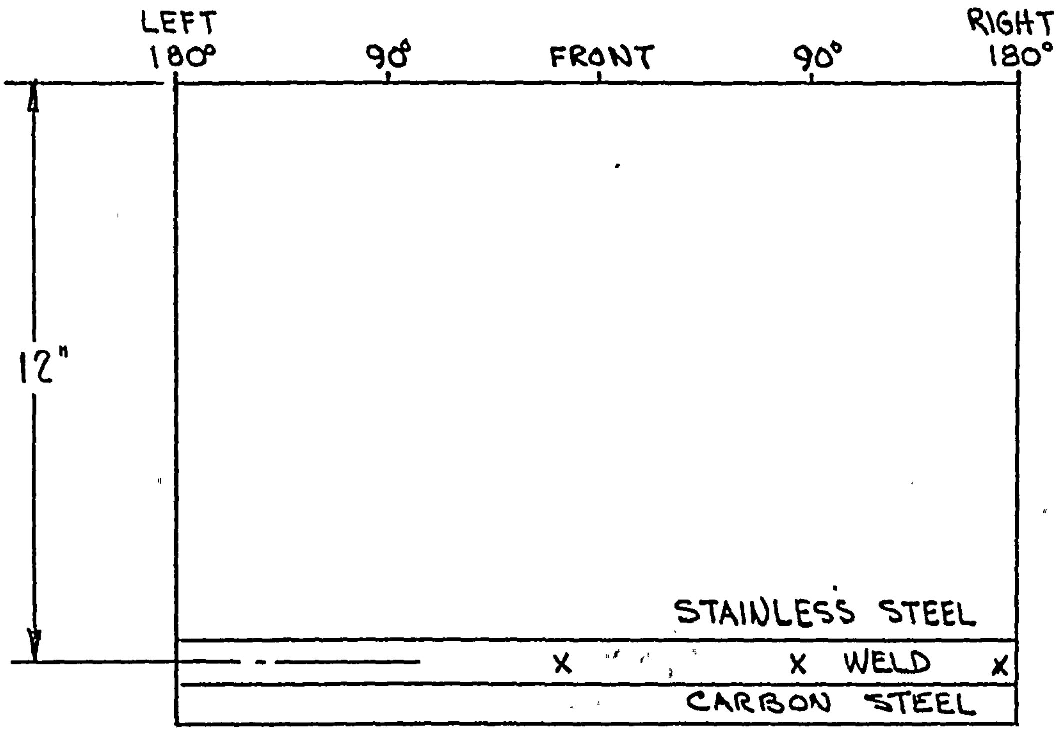
IDENTIFICATION: N7R-VESSEL HEAD SAFE END I.D.
INSPECTION DATE: 3-19-70
BY R.E. Lindeman

REMARK: PHOTO 4-6 SHOWS FRONT RIGHT INDICATION

PT PROCEDURE USED: 21A8570

209A7148
CONT ON SH 9 SH NO 8
SKETCH

DYE PENETRANT INSPECTION-NINE MILE POINT



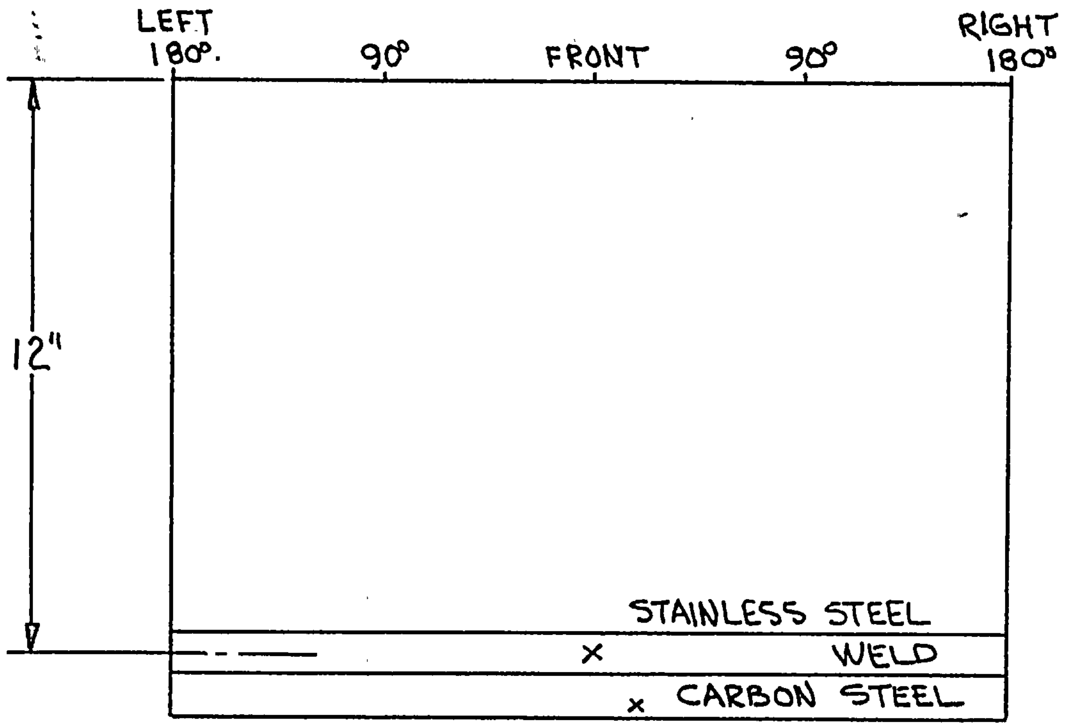
IDENTIFICATION: N7S-VESSEL HEAD SAFE END I.D.
INSPECTION DATE: 3-29-70
BY: R. E. Lindeman

REMARKS: PHOTO 4-7 SHOWS FRONT RIGHT INDICATION

PT PROCEDURE USED: 21A8570

209A7148 CONT ON SH 10 SH NO. 9
SKETCH

DYE PENETRANT INSPECTION–NINE MILE POINT



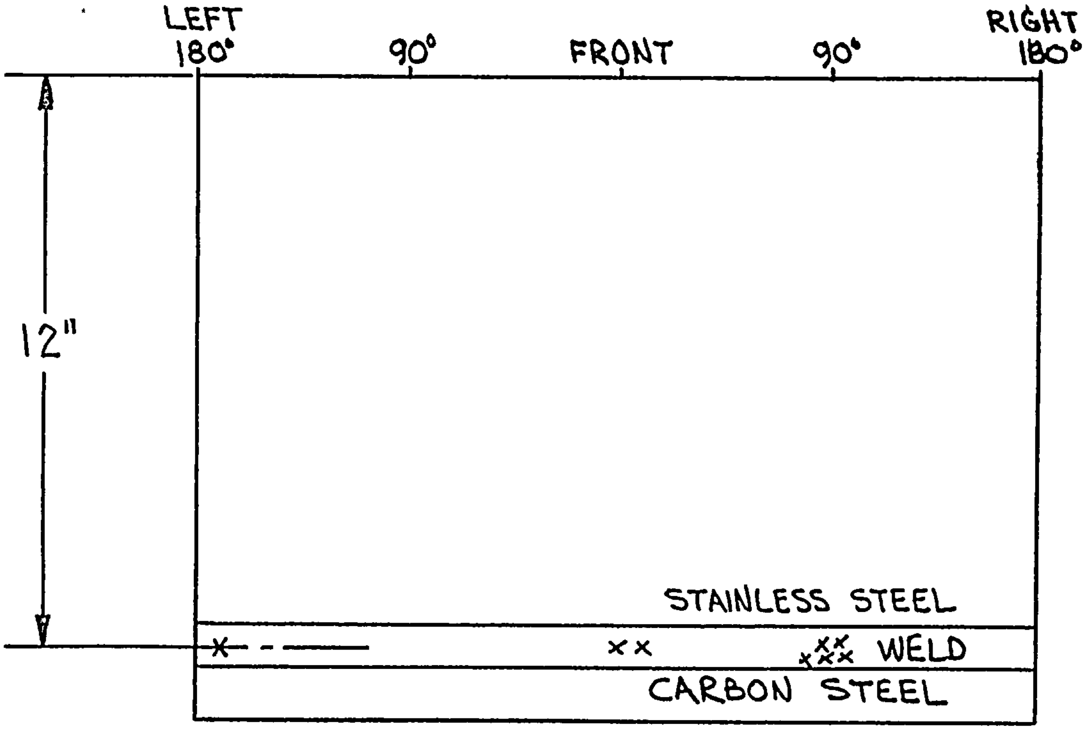
IDENTIFICATION: N7U-VESSEL HEAD SAFE END I.D.
INSPECTION DATE: 3-29-70
BY: R.E. Lindeman

REMARKS: PHOTO 4-8 SHOWS FRONT RIGHT INDICATION.

PT PROCEDURE USED: 21A8570

209A7148
CONT ON SH 11 SH No 10
SKETCH

DYE PENETRANT INSPECTION-NINE MILE POINT



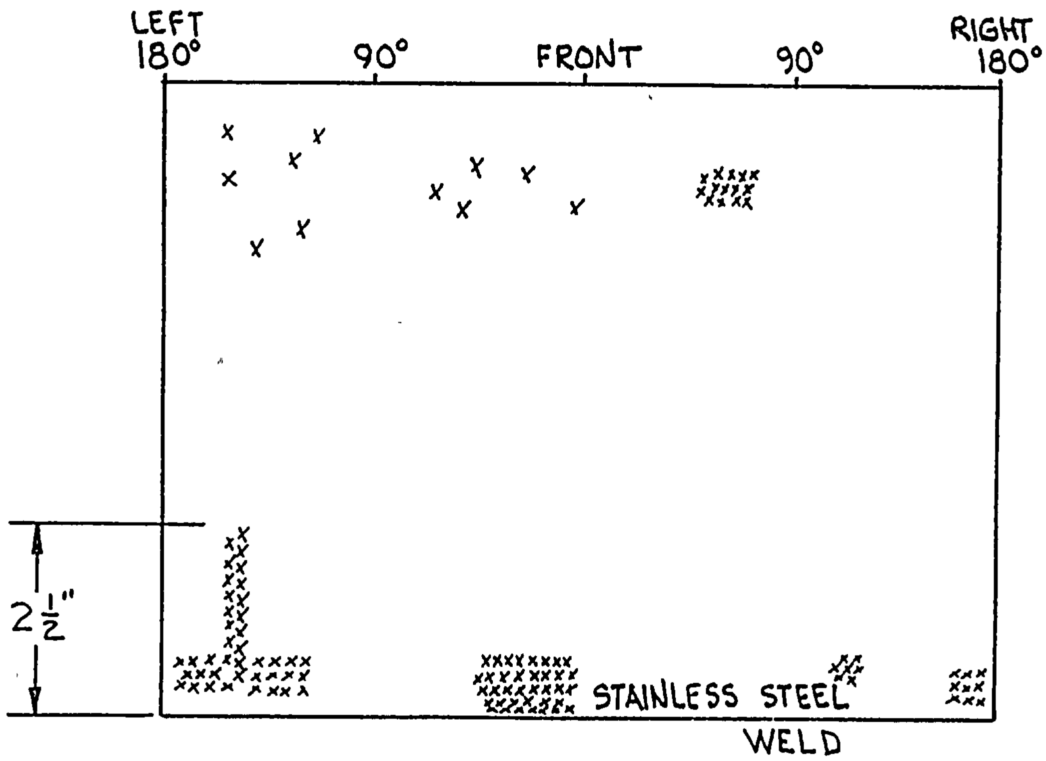
IDENTIFICATION: N7G-VESSEL HEAD SAFE END I.D.
INSPECTION DATE: 3-28-70
BY: R.E. Lindman

REMARKS: PHOTO 4-1 SHOWS 90° RIGHT INDICATION

PT PROCEDURE USED: 21A8570

209A7148
CONT ON SH 12 SH No. 11
SKETCH

DYE PENETRANT INSPECTION-NINE MILE POINT

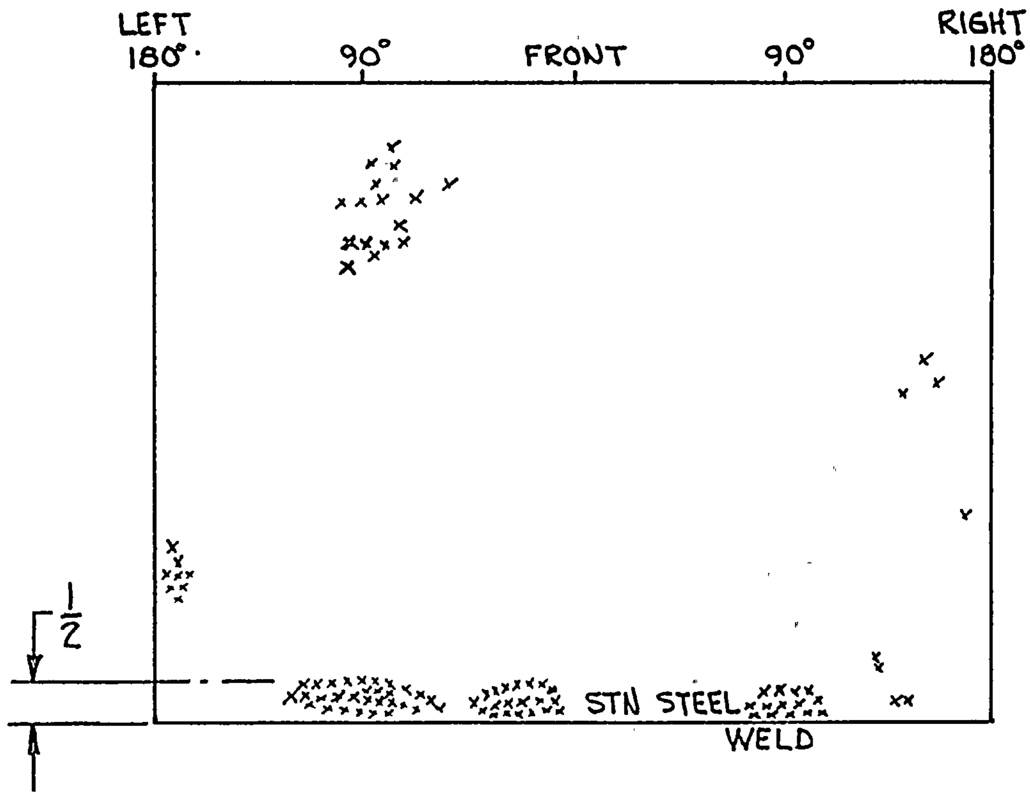


IDENTIFICATION: N7N -VESSEL HEAD SAFE END O.D.
INSPECTION DATE: 3-30-70
BY: R.E. Linderman

REMARKS: PHOTO 3-1 SHOWS 60° RIGHT INDICATION
PHOTO 3-2 SHOWS 150° LEFT INDICATION
PHOTO 6-1 SHOWS LEFT 90° AFTER GRIND
PT PROCEDURE USED: 21A8570

209A7148
CONT ON SH 13 SH.NO. 12
SKETCH

DYE PENETRANT INSPECTION - NINE MIILE POINT



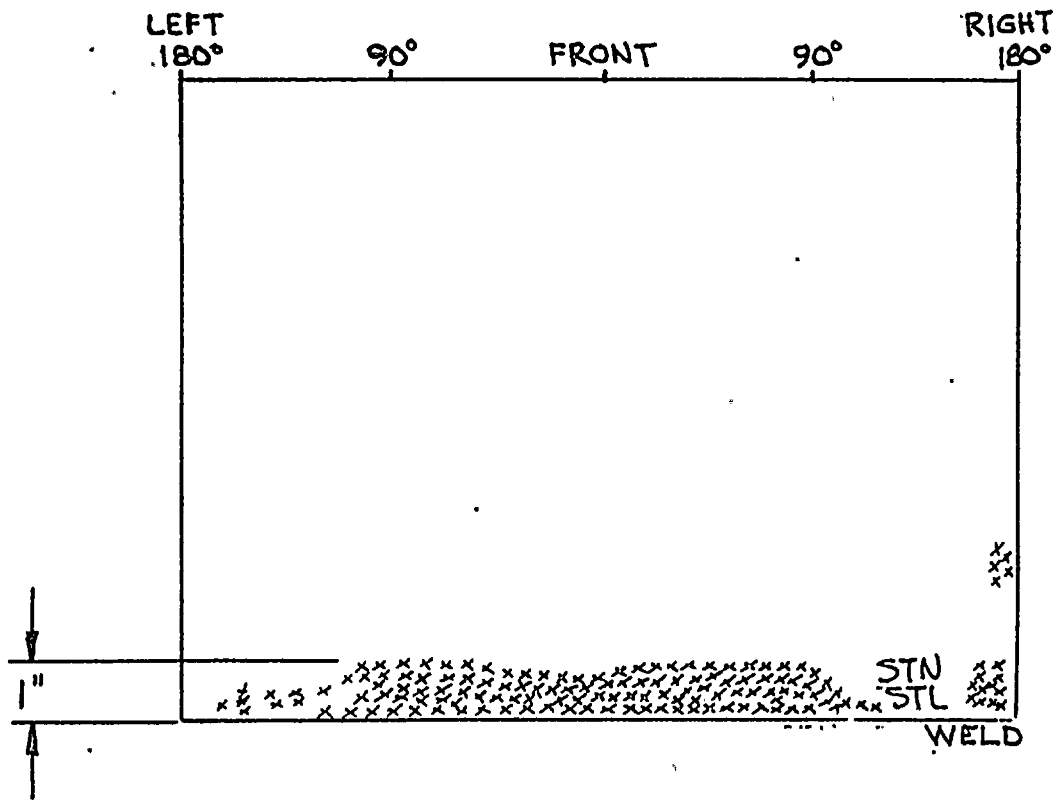
IDENTIFICATION: N7P - VESSEL HEAD SAFE END O.D.
INSPECTION DATE: 3-30-70
BY: R. E. Lindeman

REMARKS: PHOTO 3-3 SHOWS 90° LIFT INDICATIONS
PHOTO 3-4 SHOWS 90° LIFT INDICATIONS

PT PROCEDURE USED: 21A8570

209A7148	
CONT ON SH 14	SH. NO. 13
SKETCH	

DYE PENETRANT INSPECTION–NINE MILE POINT



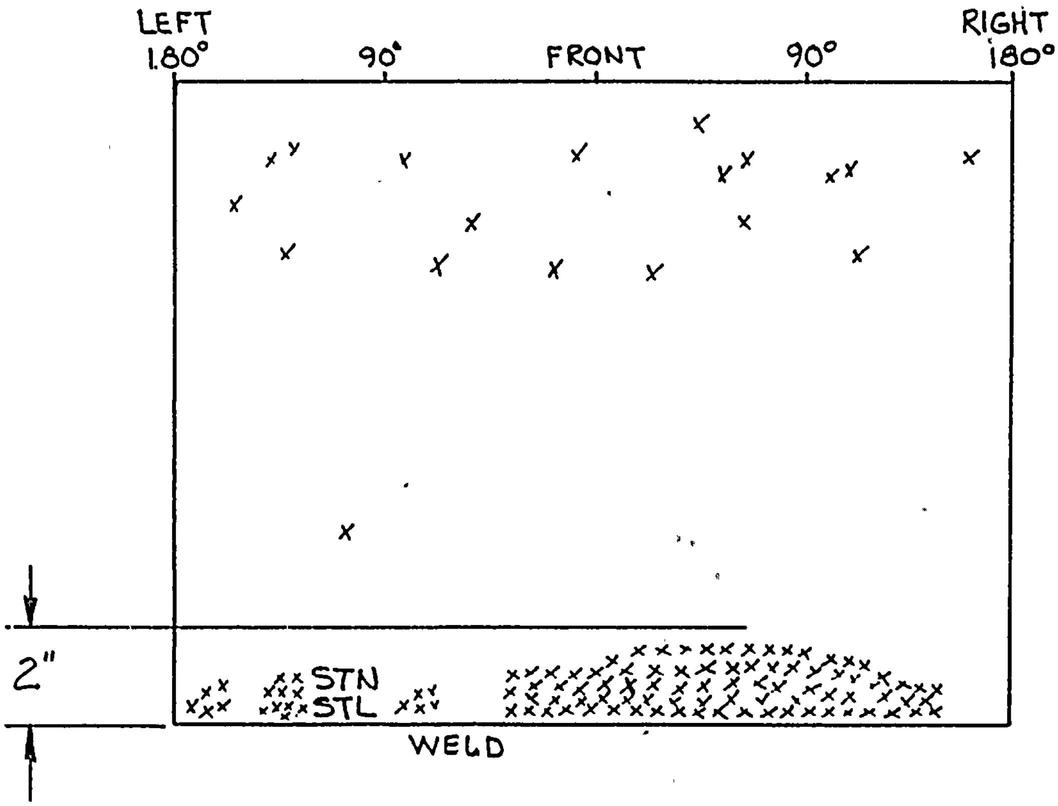
IDENTIFICATION: N7R–VESSEL HEAD SAFE END O.D.
INSPECTION DATE: 3-30-70
BY: R. E. Lindeman

REMARKS: PHOTO 3-5 SHOWS FRONT LEFT INDICATION
PHOTO 6-2 SHOWS RIGHT FRONT AFTER GRIND.

PT PROCEDURE USED: 21A8570

209A7148
CONT ON SH 15 SH NO 14
SKETCH

DYE PENETRANT INSPECTION-NINE MILE POINT



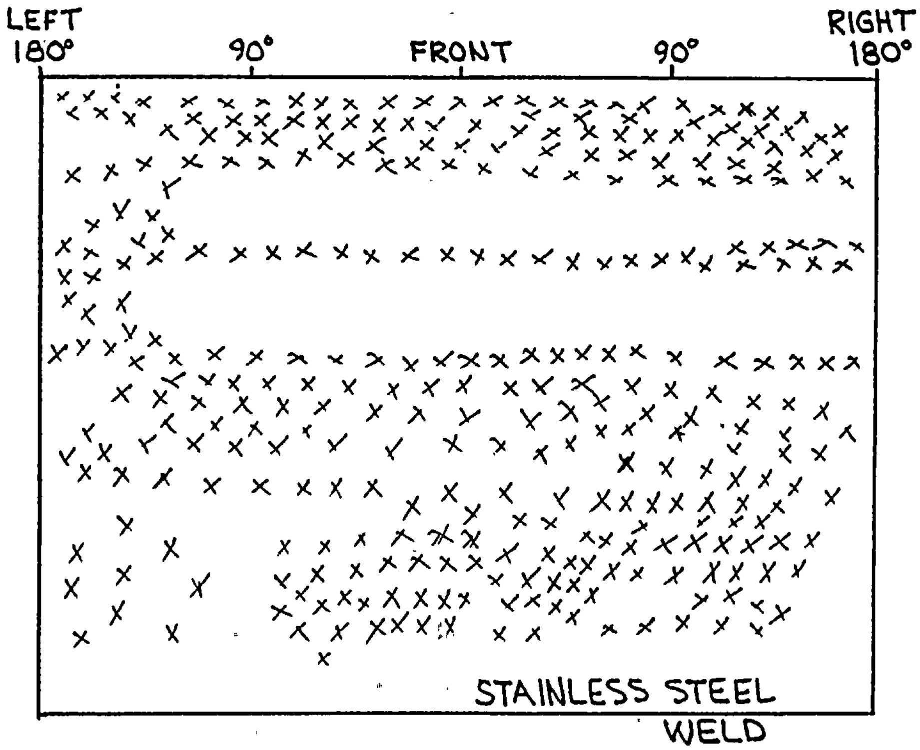
IDENTIFICATION: N7S-VESSEL HEAD SAFE END O.D.
INSPECTION DATE: 3-30-70
BY: R.E. Lindeman

REMARKS: PHOTO 3-6 SHOWS FRONT RIGHT INDICATIONS.
PHOTO 6-3 SHOWS RIGHT FRONT AFTER GRIND

PT PROCEDURE USED: 21A8570

209A7148
CONT ON SH 16 SH NO 15
SKETCH

DYE PENETRANT INSPECTION-NINE MILE POINT



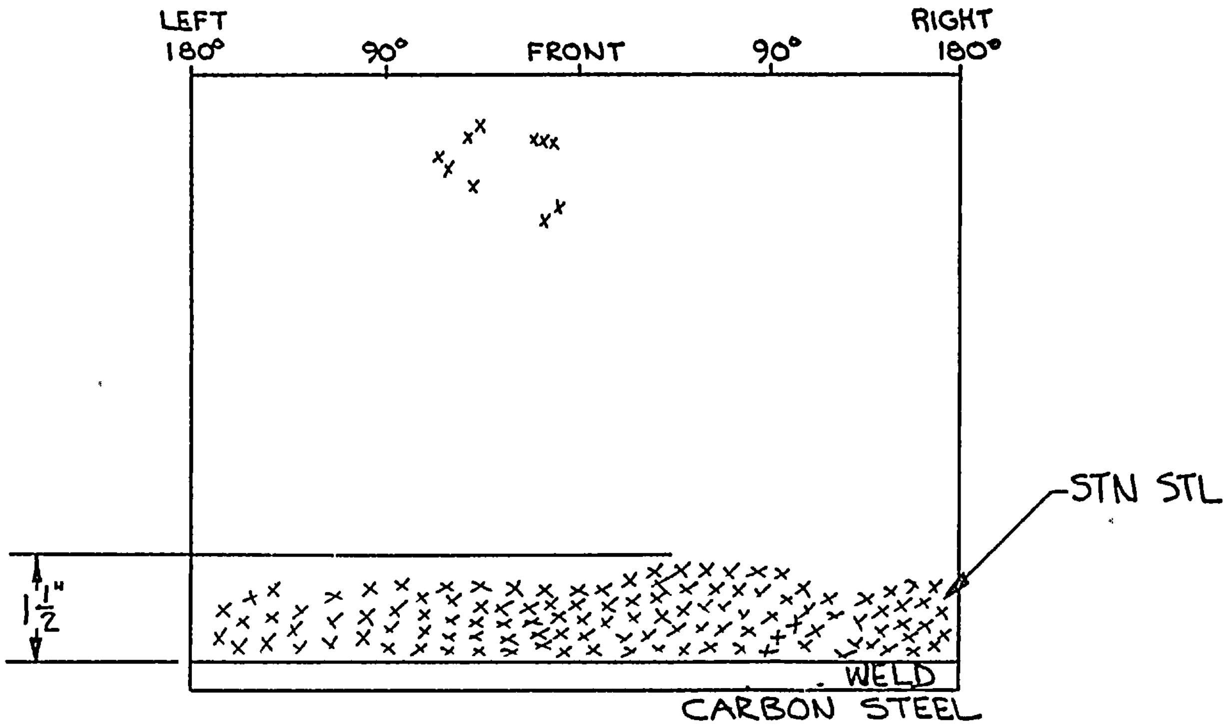
IDENTIFICATION: N7T-VESSEL HEAD SAFE END O.D.
INSPECTION DATE: 3-30-70
BY R.E. Lindeman

REMARKS: PHOTO 3-7 SHOWS 90° RIGHT INDICATION
PHOTO 6-4 SHOWS LEFT FRONT AFTER LIGHT GRIND.

PT PROCEDURE USED: 21A8570

209A7148
CONT ON SH 17 SH NO 16
SKETCH

DYE PENETRANT INSPECTION-NINE MILE POINT



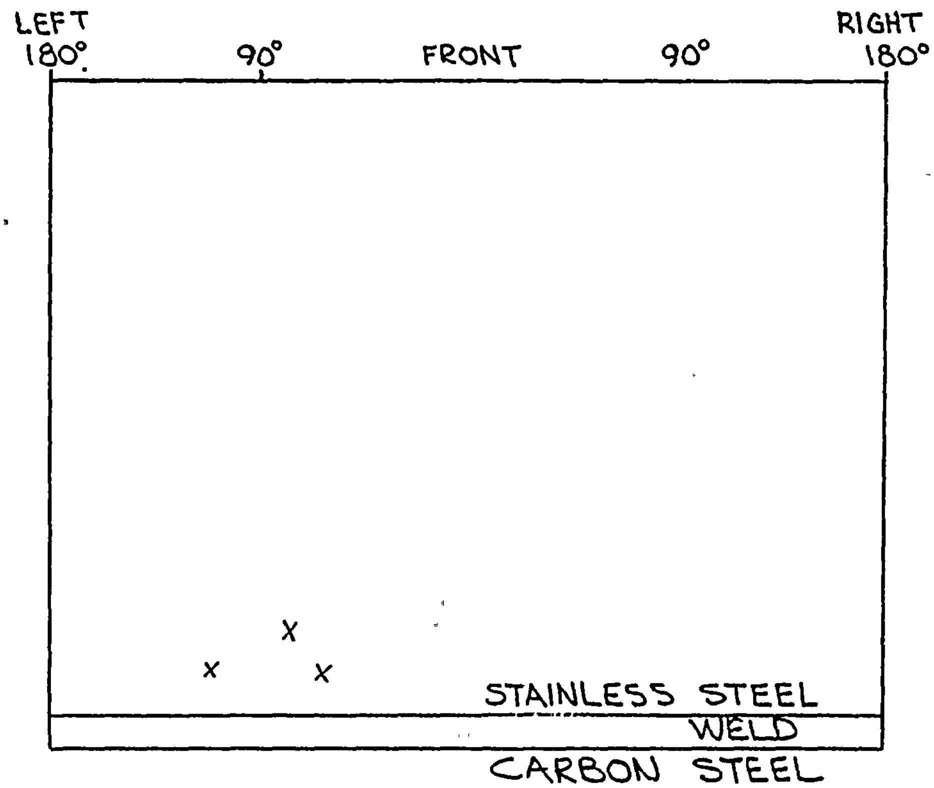
IDENTIFICATION: NTU- VESSEL HEAD SAFE END O.D
INSPECTION DATE: 3-30-70
BY: R.E. Lindeman

REMARKS: PHOTO 3-8 SHOWS FRONT LEFT INDICATION.
PHOTO 6-5 SHOWS RIGHT 120° AFTER GRIND
LESS INDICATION AFTER GRIND.

PT PROCEDURE USED: 21A8570

209A7148
CONT ON SH 18 SH. NO. 17
SKETCH

DYE PENETRANT INSPECTION-NINE MILE POINT



IDENTIFICATION: N8-VESSEL HEAD SAFE END O.D.
INSPECTION DATE: 3-30-70
BY: R.E. Lindeman

REMARKS: PHOTO 3-9 SHOWS 90° LEFT INDICATION

PT PROCEDURE USED: 21A8570

209A7148
CONT ON SH. F SH No 18
SKETCH

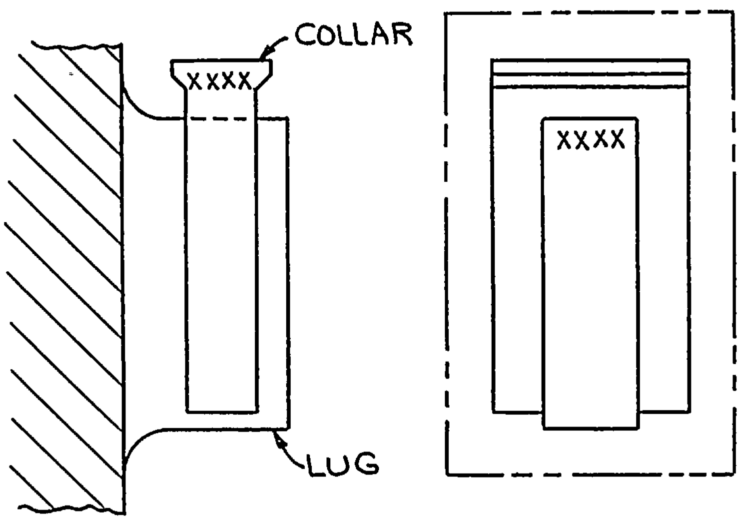
GENERAL ELECTRIC

209A7058
CONT ON SHEET 2 SH NO. 1

REV NO. A	TITLE
209A7058 CONT ON SHEET 2 SH NO. 1	DRYER SUPPORT BRACKET FIRST MADE FOR NMPNS

REVISIONS

A PRELIMINARY ISSUE



IDENTIFICATION: BRACKET @ 50° AZIMUTH

INSPECTION DATE: 3-31-70
BY: R.E. Lindeman

REMARKS: PICTURE 4-9 SHOWS FRONT FACE INDICATION

P.T. PROCEDURE USED: 21A8570

PRINTS TO

MADE BY R.B. Moore April 7, 1970 ISSUED H.H. Theil 4-7-70	APPROVALS M Kudlacek 4/7/70.	APED DIV. OR DEPT. SAN JOSE LOCATION	209A7058 CONT ON SHEET 2 SH NO. 1

FF-803-WF (8-66) PRINTED IN U.S.A. CHKD Gor.

R SKETCH

CODE IDENT NO.

GENERAL ELECTRIC

209A7058
CONT ON SHEET 3 SH NO. 2

REV NO. A

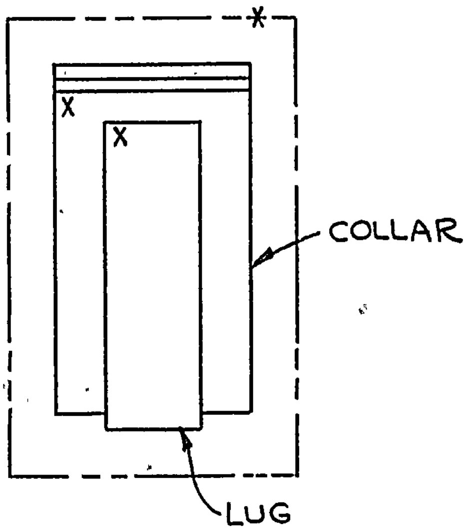
209A7058
CONT ON SHEET 3 SH NO. 2

TITLE
DRYER SUPPORT BRACKET

FIRST MADE FOR NMPNS

REVISIONS

FOR REVISIONS, SEE SH 1



IDENTIFICATION: BRACKET @ 230° AZIMUTH

INSPECTION DATE: 3-31-70

BY: R.E. Lindeman

REMARKS: PICTURE 4-11 SHOWS WELD INDICATION

P.T. PROCEDURE USED: 21A8570

PRINTS TO

MADE BY R.D. Horne April 7, 1970	APPROVALS	APED DIV OR DEPT.	209A7058
ISSUED H.H. Thiel 4-7-70	4/7/70	SAN JOSE LOCATION	CONT ON SHEET 3 SH NO. 2

FF-803-WF (9-66) PRINTED IN U.S.A. CHKD Ron

CODE IDENT NO.

R | SKETCH

GENERAL ELECTRIC

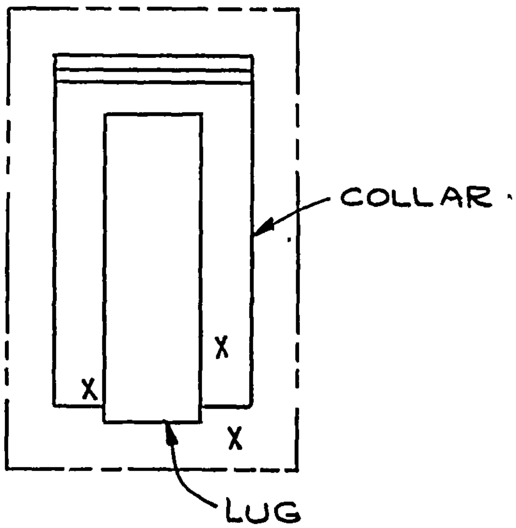
209A7058
CONT ON SHEET F SH NO. 3

REV NO. A

209A7058
CONT ON SHEET F SH NO. 3

TITLE DRYER SUPPORT BRACKET
FIRST MADE FOR NMPNS

REVISIONS
FOR REVISIONS SEE SH 1



IDENTIFICATION: BRACKET @ 310° AZIMUTH

INSPECTION DATE: 3-31-70
BY: R.E. Lindeman

REMARKS: PICTURE 4-10 SHOWS LOWER INDICATION

P.T. PROCEDURE USED: 21A8570

PRINTS TO

MADE BY R.D. Moore April 7, 1970
ISSUED M.A. Thiel 4-7-70
APPROVALS M Kalbi 4/7/70
APED DIV OR DEPT.
SAN JOSE LOCATION
209A7058
CONT ON SHEET F SH NO. 3
CODE IDENT NO.
FF-803-WF (9-68) PRINTED IN U.S.A. CHKD Rox
R SKETCH

GENERAL ELECTRIC

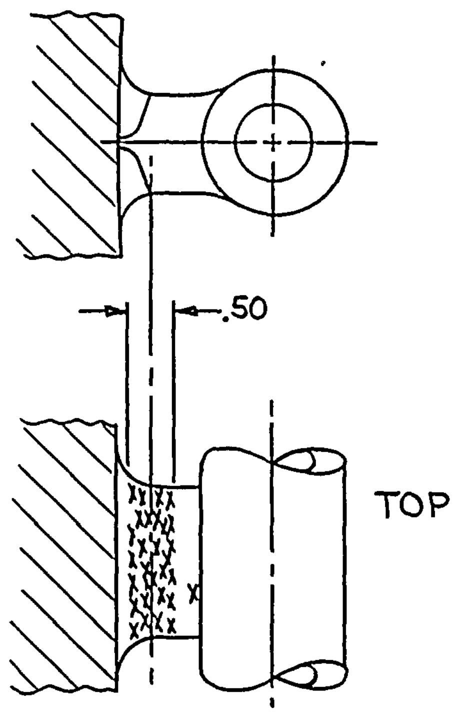
209A7059
CONT ON SHEET 2 SH NO. 1

REV NO. A

209A7059
CONT ON SHEET 2 SH NO. 1

TITLE
GUIDE ROD SUPPORT BRACKET
FIRST MADE FOR NMPNS

REVISIONS
A PRELIMINARY ISSUE



IDENTIFICATION: BRACKET @ 0° AZIMUTH

INSPECTION DATE: 3-31-70

BY: R.E. Lindeman

REMARKS: PICTURE 5-9 SHOWS INDICATIONS ON LEFT SIDE

P.T. PROCEDURE USED: 21A8570

PRINTS TO

MADE BY R.W. Moore April 7, 1970	APPROVALS	APED DIV OR DEPT.	209A7059
ISSUED H.H. Thiel 4-7-70	M. Kudlak 4/7/70	SAN JOSE LOCATION	CONT ON SHEET 2 SH NO. 1

FF-603-WF (9-66) PRINTED IN U.S.A. CHKD

CODE IDENT NO.

I R | SKETCH

GENERAL ELECTRIC

209A7059
CONT ON SHEET F SH NO. 2

REV NO. A

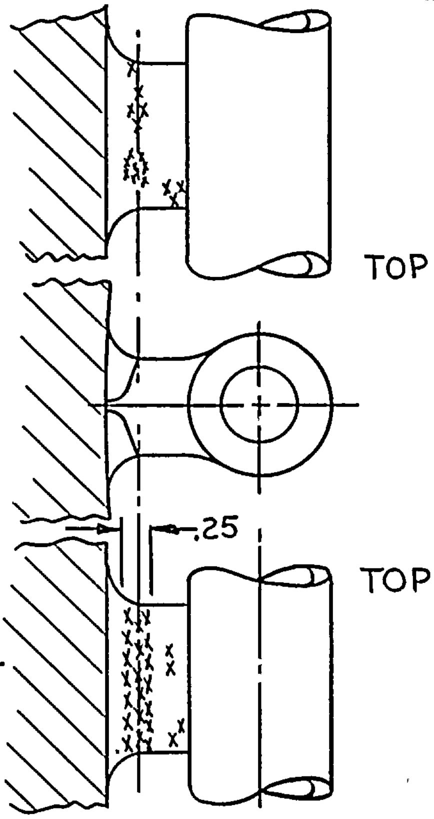
209A7059
CONT ON SHEET F SH NO. 2

TITLE
GUIDE ROD SUPPORT BRACKET
FIRST MADE FOR NMPNS

REVISIONS

FOR REVISIONS, SEE SHEET 1

PICTURE 5-8



PICTURE 4-12

IDENTIFICATION: BRACKET @ 180° AZIMUTH

INSPECTION DATE: 3-31-70

BY: R.E. Lindeman

REMARKS:

P.T. PROCEDURE USED: 21A8570.

PRINTS TO

MADE BY R.J. Moore April 7, 1970	APPROVALS M. Kidlock	APED — DIV OR DEPT.	209A7059
ISSUED H.H. Thiel 4-7-70	4/7/70	SAN JOSE — LOCATION	CONT ON SHEET F SH NO. 2

PF-803-WP (9-68) PRINTED IN U.S.A. CHKD [illegible]

CODE IDENT NO.

1 R 1 SKETCH

GENERAL ELECTRIC

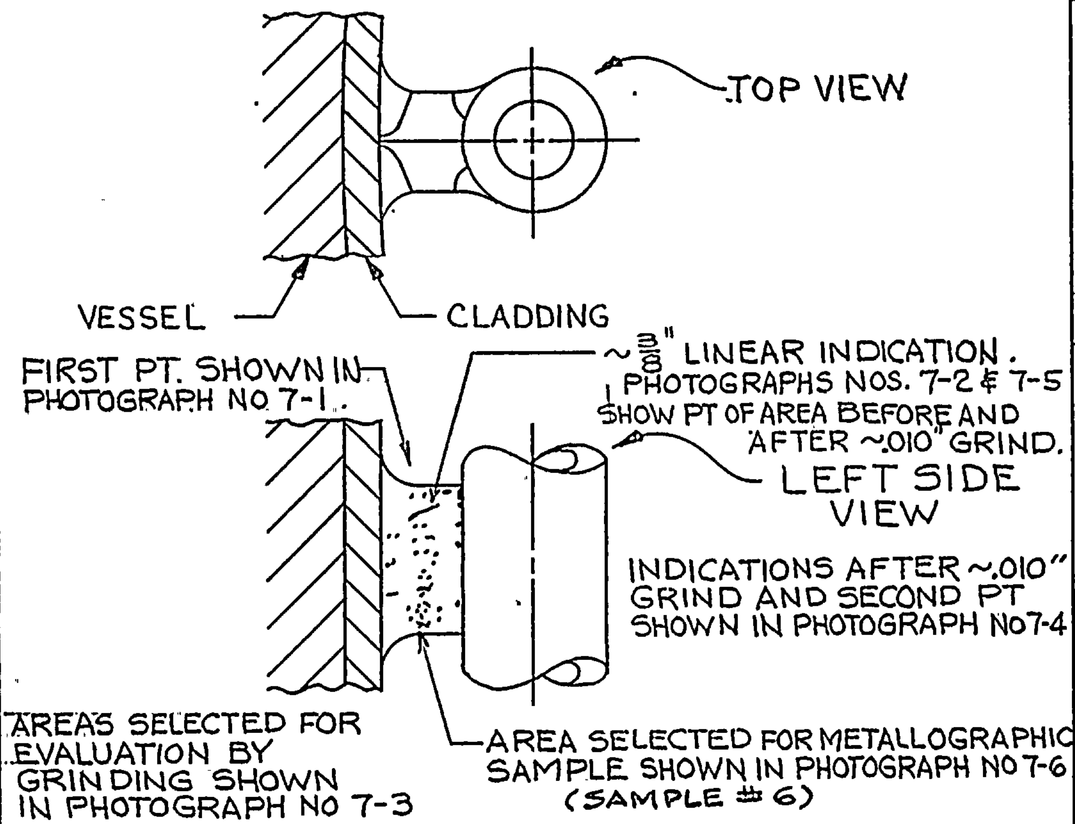
209A7160
CONT ON SHEET 2 SH NO. 1

REV NO. A

209A7160
CONT ON SHEET 2 SH NO. 1

TITLE
GUIDE ROD SUPPORT BRACKET
FIRST MADE FOR NMPNS

REVISIONS
A PRELIMINARY ISSUE



EXAMINED LEFT SIDE ONLY,
INCLUDING SHOP WELD & FIELD WELD.

LOCATION: VESSEL I.D. BRACKET @ 0° AZIMUTH
INSPECTED BY J B Higgins ON 4/12/70
TO P.T. PROCEDURE NO. 21A8570

PRINTS TO

MADE BY	APPROVALS	DIV OR DEPT. / LOCATION	
J. Jensen APRIL 16, 1970	JBH 4/16/70	APED	209A7160
ISSUED		SAN JOSE	CONT ON SHEET 2 SH NO. 1

CODE IDENT NO

FF-403-WA (9-67)
PRINTED IN U.S.A.

GENERAL ELECTRIC 209A7160

CONT ON SHEET F SH NO. 2

REV NO. A

209A7160

CONT ON SHEET F SH NO. 2

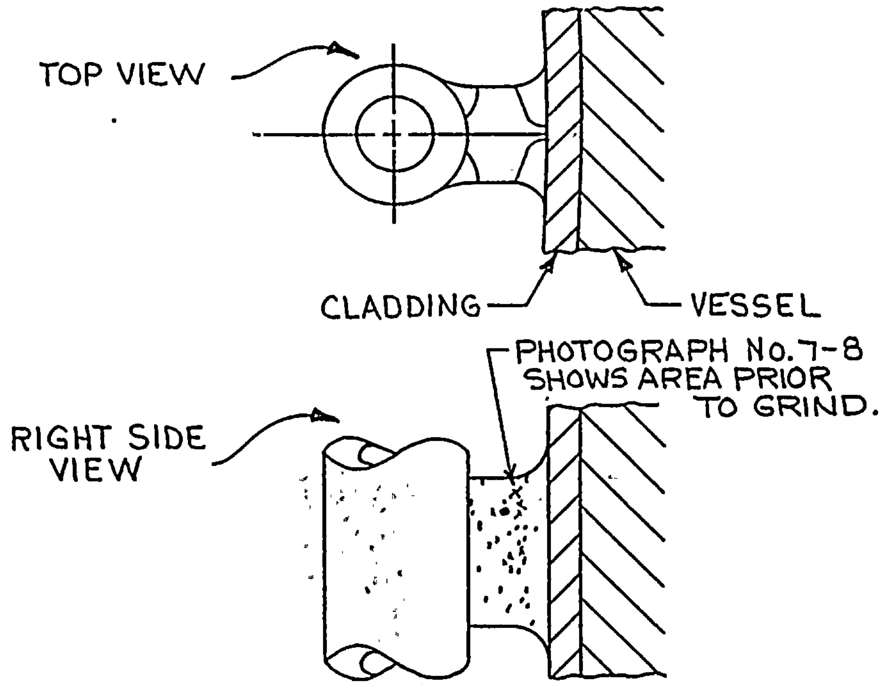
TITLE

GUIDE ROD SUPPORT BRACKET

FIRST MADE FOR NMPNS

REVISIONS

A PRELIMINARY ISSUE



EXPLORED TWO TYPICAL AREAS BY
~.010" GRIND - PT INDICATIONS
STILL PRESENT AFTER GRIND
AND SECOND PT.

EXAMINED RIGHT SIDE ONLY,
INCLUDING SHOP WELD AND FIELD
WELD AS SHOWN IN PHOTOGRAPH No 7-7

LOCATION: VESSEL I.D. BRACKET @ 180° AZIMUTH
INSPECTED BY: J B Higgins ON 4/12/70
TO P.T PROCEDURE NO. 21A8570

PRINTS TO

MADE BY J. Jansen APRIL, 1970	APPROVALS JBH 4/18/70	APED / SAN JOSE	DIV OR DEPT. / LOCATION	209A7160 CONT ON SHEET F SH NO. 2
ISSUED				CODE IDENT NO.

FF-403-WA (9-67)
PRINTED IN U.S.A.

R

GENERAL ELECTRIC

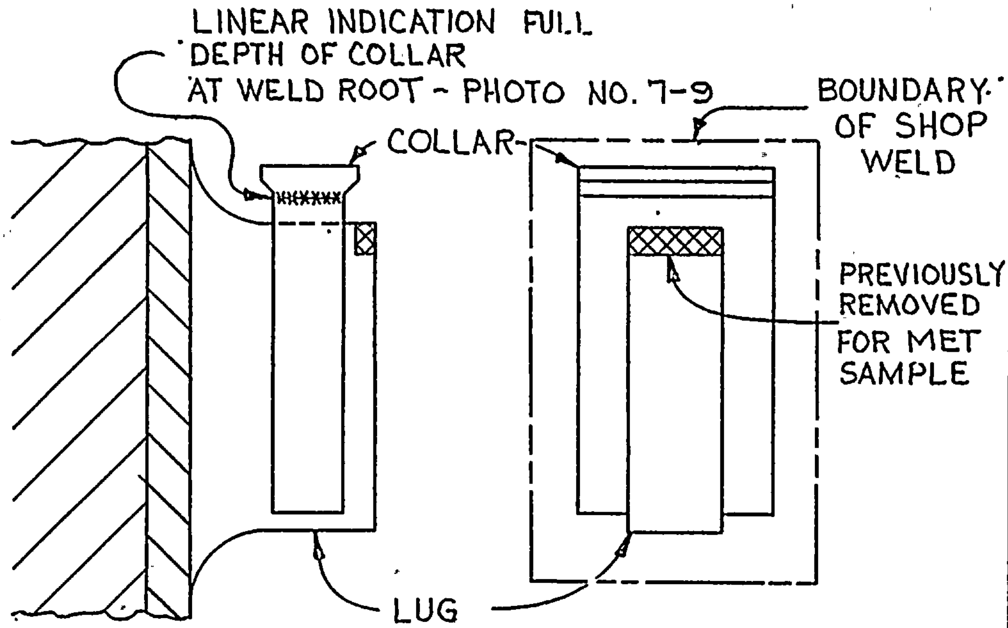
209A7161
CONT ON SHEET 2 SH NO. 1

REV NO. A

209A7161
CONT ON SHEET 2 SH NO. 1

TITLE
STEAM DRYER SUPPORT BRACKET
FIRST MADE FOR NMPNS

REVISIONS
A PRELIMINARY ISSUE



LOCATION: VESSEL I.D. BRACKET @ 50° AZIMUTH
INSPECTED BY J.B. Higgins ON 4/12/70
TO REQUIREMENTS OF P.T. PROCEDURE NO. 21A8570
EXAMINED ONLY AREAS INDICATED

PRINTS TO

MADE BY J. Jensen APRIL 17, 1970	APPROVALS 4/18/70	APED (DIV OR DEPT.)	209A7161
ISSUED		SAN JOSE (LOCATION)	CONT ON SHEET 2 SH NO. 1

FF-403-WA (9-67)
PRINTED IN U.S.A.

IR

CODE IDENT NO.

GENERAL ELECTRIC

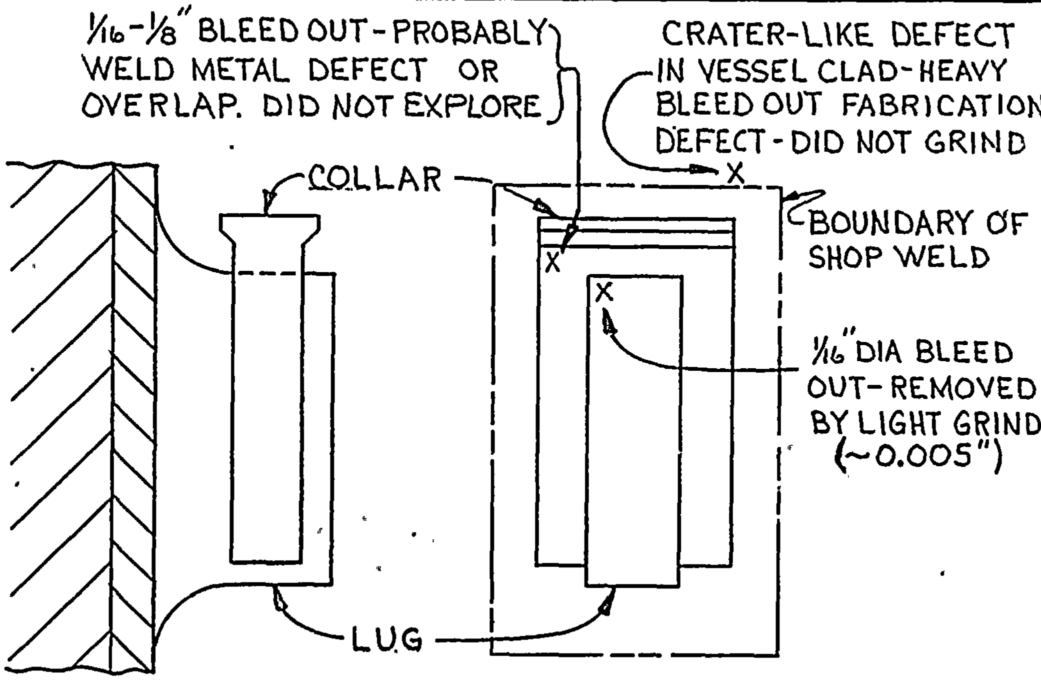
209A7161
CONT ON SHEET 3 SH NO. 2

REV NO. A

209A7161
CONT ON SHEET 3 SH NO. 2

TITLE
STEAM DRYER SUPPORT BRACKET
FIRST MADE FOR NMPNS

REVISIONS
A PRELIMINARY ISSUE



LOCATION: VESSEL I.D. BRACKET @ 230° AZIMUTH
INSPECTED BY J B Higgins ON 4/12/70
TO REQUIREMENTS OF P.T. PROCEDURE NO. 21A8570
EXAMINED ONLY AREAS INDICATED

PRINTS TO

MADE BY J Jensen APRIL 17, 1970 ISSUED	APPROVALS JBH 4/15/70	APED DIV OR DEPT. SAN JOSE LOCATION	209A7161 CONT ON SHEET 3 SH NO. 2

FF-403-WA (9-67) PRINTED IN U.S.A.

IR

CODE IDENT NO.

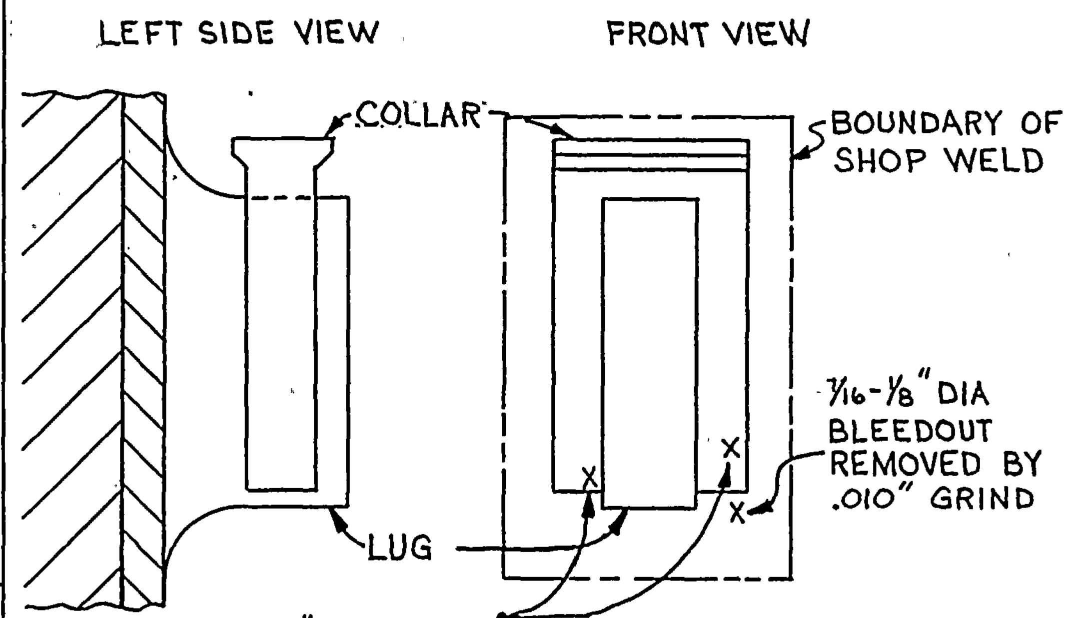
GENERAL ELECTRIC

209A7161
CONT ON SHEET F SH NO. 3

REV NO. A	TITLE STEAM DRYER SUPPORT BRACKET
209A7161	
CONT ON SHEET F SH NO. 3	FIRST MADE FOR NMPNS

REVISIONS

A PRELIMINARY ISSUE



1/8" LINEAR BLEEDOUT-PROBABLE WELD METAL DEFECTS; STILL VISIBLE TO UNAIDED EYE AFTER .010" GRIND BUT NO BLEEDOUT AFTER P.T. TEST; THEREFORE INDICATIONS INTERPRETED AS FAIRLY BROAD SHALLOW WELD DEFECT.

LOCATION: VESSEL I. D. BRACKET @ 310° AZIMUTH
INSPECTED BY J B Higgins ON 4/12/70
TO REQUIREMENTS OF P.T. PROCEDURE NO. 21A8570
EXAMINED ONLY AREAS INDICATED

PRINTS TO

MADE BY J. Jensen APRIL 17, 1970 ISSUED	APPROVALS JBH 4/16/70	APED DIV OR DEPT. SAN JOSE LOCATION	209A7161 CONT ON SHEET F SH NO. 3

PF-403-WA (9-67) PRINTED IN U.S.A.

IR

CODE IDENT NO.

GENERAL ELECTRIC

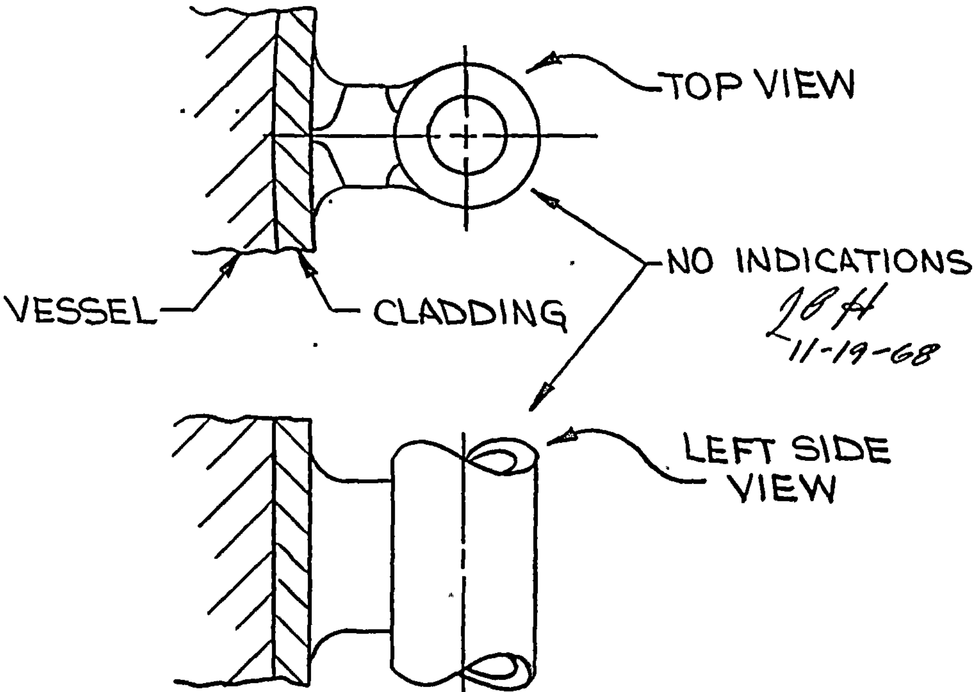
209A7162
CONT ON SHEET 2 SH NO. 1

REV NO. A	TITLE
209A7162	GUIDE ROD SUPPORT BRACKET
CONT ON SHEET 2 SH NO. 1	FIRST MADE FOR NMPNS

REVISIONS

PRELIMINARY ISSUE

A



DUE TO INADEQUATE REMOVAL OF HYDROTEST H_2O TSP INHIBITOR INITIAL PT EXAMINATION SHOWED NUMEROUS INDICATIONS OVER MUCH OF SURFACE – SUSPECT POOR CLEANING DUE TO TSP ADHERING TO TO SURFACE WHICH WAS NOT READILY REMOVED BY PENETRANT CLEANER – SECOND PT AFTER CAREFUL CLEANING TO REMOVE TSP SHOWED NO INDICATIONS – EXAMINATION INCLUDED ALL BRACKET SURFACES FROM TOE OF SHOP WELD TO TOE OF FIELD WELD – AS A RESULT OF THIS EXAMINATION THE CLEANING PROCEDURE FOR ALL I.D. SURFACES WAS MODIFIED TO INCLUDE SPONGING WITH H_2O SOAKED RAG PRIOR TO CLEANING WITH PENETRANT CLEANER SO AS TO REMOVE TSP.

LOCATION: VESSEL I.D. BRACKET @ 0° AZIMUTH

INSPECTED BY JBHiggins ON 11-19-68 TO P.T. PROCEDURE № PS-1

PRINTS TO

MADE BY J. Trovato APRIL 18, 1970 ISSUED	APPROVALS JBH 4/18/70	APED SAN JOSE	DIV OR DEPT. LOCATION	209A7162 CONT ON SHEET 2 SH NO. 1

FF-803-WF (8-68)
PRINTED IN U.S.A.

CODE IDENT NO.

R

GENERAL ELECTRIC

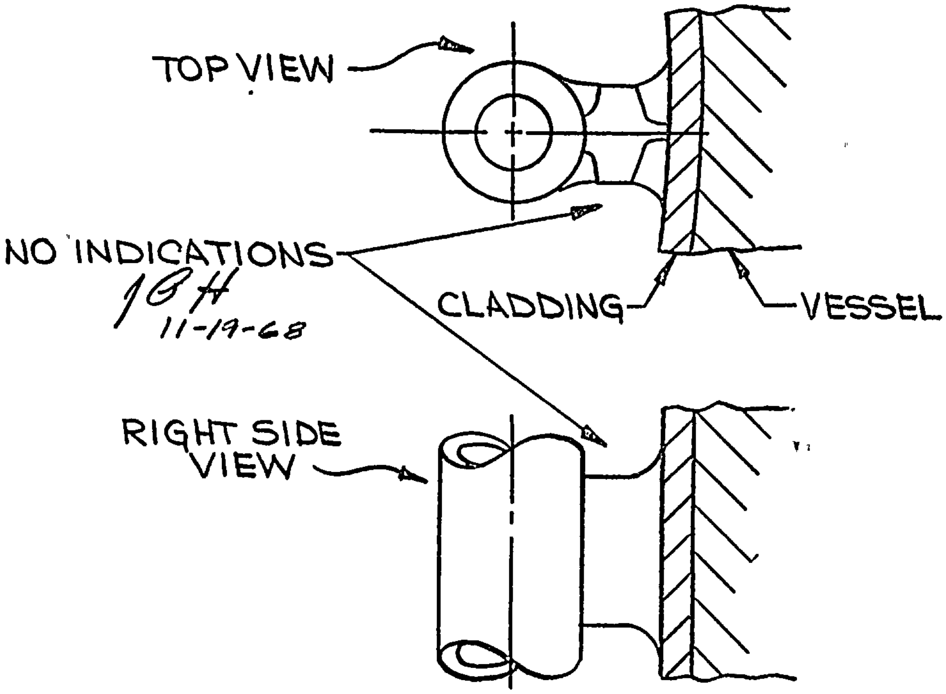
209A7162
CONT ON SHEET F SH NO. 2

REV NO. A

209A7162
CONT ON SHEET F SH NO. 2

TITLE
GUIDE ROD SUPPORT BRACKET
FIRST MADE FOR NMPNS

REVISIONS
A PRELIMINARY ISSUE



PT EXAMINATION AFTER CAREFUL CLEANING AS PER EXPERIENCE ON 0° AZIMUTH GUIDE ROD BRACKET TO REMOVE TSP DISCLOSED NO INDICATIONS — EXAMINATION INCLUDED ALL BRACKET SURFACES FROM TOE OF SHOP WELD TO TOE OF FIELD WELD.

LOCATION: VESSEL I.D. BRACKET @ 180° AZIMUTH

INSPECTED BY: J. P. HIGGINS/MAE ON 11-19-68

TO PT PROCEDURE Nº PS-1

PRINTS TO

MADE BY	APPROVALS		DIV OR DEPT.	
[signature] APRIL 8, 1970	JGH 4/18/70	APED		209A7162
ISSUED		SAN JOSE	LOCATION	CONT ON SHEET F SH NO. 2

FF-803-WF (9-68)
PRINTED IN U.S.A.

CODE IDENT NO.

R

GENERAL ELECTRIC

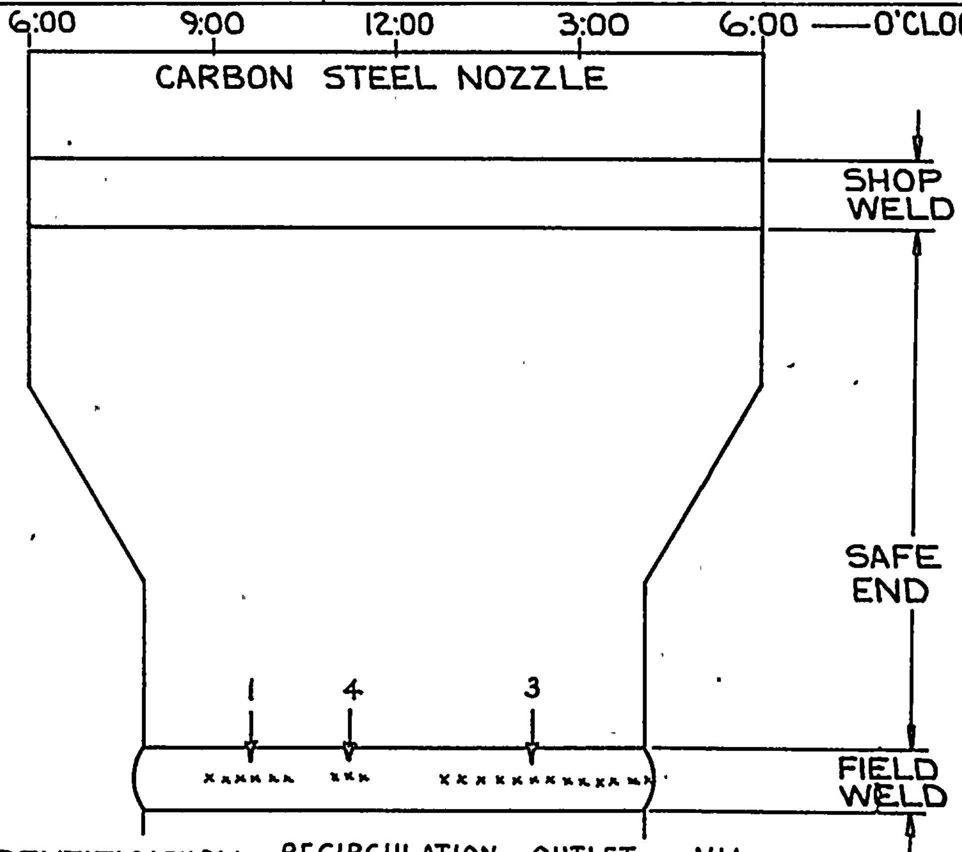
209A7153
CONT ON SHEET 2 SH NO. 1

REV NO. A

209A7153
CONT ON SHEET 2 SH NO. 1

TITLE
ULTRASONIC INSPECTION
FIRST MADE FOR NINE MILE POINT NUCLEAR STATION

REVISIONS
A PRELIMINARY ISSUE



IDENTIFICATION RECIRCULATION OUTLET N1A

INSPECTED BY TG LAMBERT DATE MARCH 13, 1970

INDICATION	LOCATION	POSITION	AMPLITUDE (% OF 3% I.D. NOTCH)
1	FIELD WELD	8-10	75
3	FIELD WELD	2-6	25
4	FIELD WELD	11	25

REMARKS: ↑ DIRECTION OF SOUND PROPAGATION

UT PROCEDURE: 21A8592 REV.0 ANGLE BEAM ONLY.

PRINTS TO

MADE BY J. Jensen MAR. 27, 1970
ISSUED
APPROVALS

APED DIV OR DEPT.
SAN JOSE LOCATION

209A7153
CONT ON SHEET 2 SH NO. 1
CODE IDENT NO.

FF-803-WP (9-66) PRINTED IN U.S.A. CHK'D:

IR

GENERAL ELECTRIC

209A7153
CONT ON SHEET 3 SH NO. 2

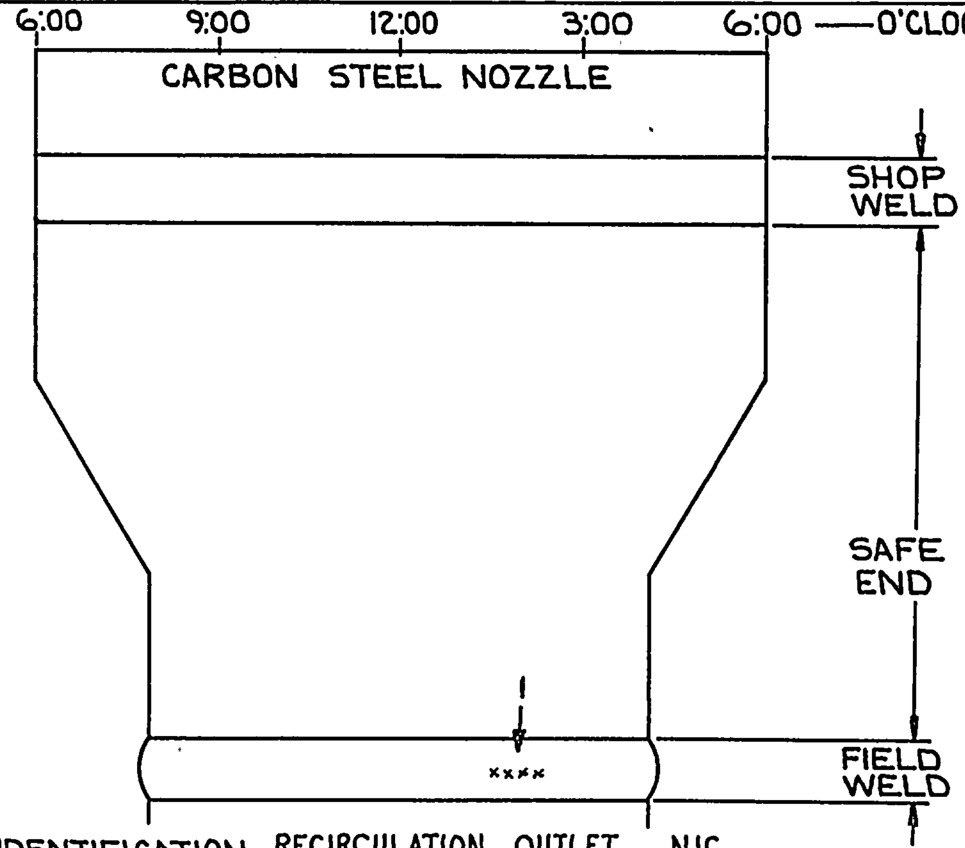
REV NO. A

209A7153
CONT ON SHEET 3 SH NO. 2

TITLE
ULTRASONIC INSPECTION

FIRST MADE FOR NINE MILE POINT NUCLEAR STATION

REVISIONS
A PRELIMINARY ISSUE



IDENTIFICATION RECIRCULATION OUTLET N1C

INSPECTED BY TG LAMBERT DATE MARCH 14, 1970

INDICATION	LOCATION	POSITION	AMPLITUDE (% OF 3% I.D. NOTCH)
1	FIELD WELD	2:30	75

REMARKS: ↑ DIRECTION OF SOUND PROPAGATION

UT PROCEDURE: 21A8592 REV. 0 ANGLE BEAM ONLY.

PRINTS TO

MADE BY J. Jensen MAR 27, 1970
ISSUED
APPROVALS

APED DIV OR DEPT.
SAN JOSE LOCATION

209A7153
CONT ON SHEET 3 SH NO. 2
CODE IDENT NO.

FF-803-WF (9-66) PRINTED IN U.S.A. CHK'D:

R

GENERAL ELECTRIC

209A7153 CONT ON SHEET 4 SH NO. 3

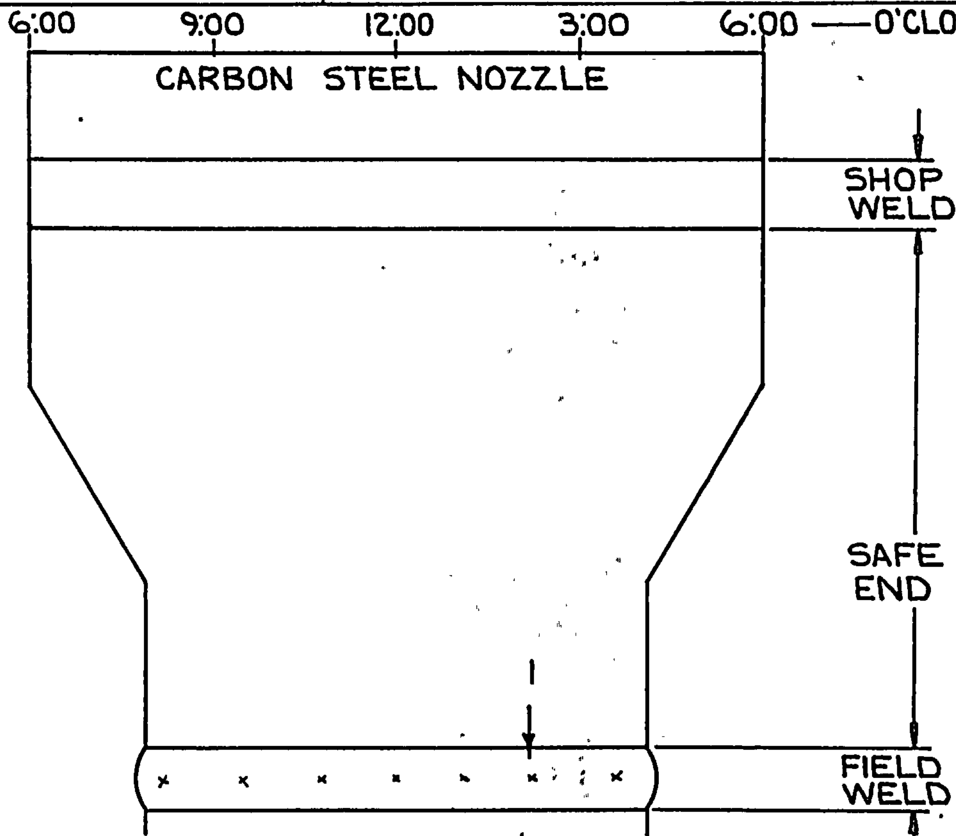
REV NO. A

209A7153 CONT ON SHEET 4 SH NO. 3

TITLE
ULTRASONIC INSPECTION

FIRST MADE FOR NINE MILE POINT NUCLEAR STATION

REVISIONS: A PRELIMINARY ISSUE



IDENTIFICATION RECIRCULATION OUTLET N1D

INSPECTED BY T.G. LAMBERT DATE MARCH 14, 1970

INDICATION	LOCATION	POSITION	AMPLITUDE(% OF 3% I.D. NOTCH)
1	FIELD WELD	SCATTERED	10

REMARKS: ↑ DIRECTION OF SOUND PROPAGATION

UT PROCEDURE: 21A8592 REV. 0 ANGLE BEAM ONLY.

PRINTS TO

MADE BY J. Jensen MAR 27, 1970 | ISSUED | APPROVALS | APED DIV OR DEPT. | SAN JOSE LOCATION | 209A7153 CONT ON SHEET 4 SH NO. 3 | CODE IDENT NO.

PF-603-WF (9-68) PRINTED IN U.S.A. CHK'D:

IR

GENERAL ELECTRIC

209A7153
CONT ON SHEET 5 SH NO. 4

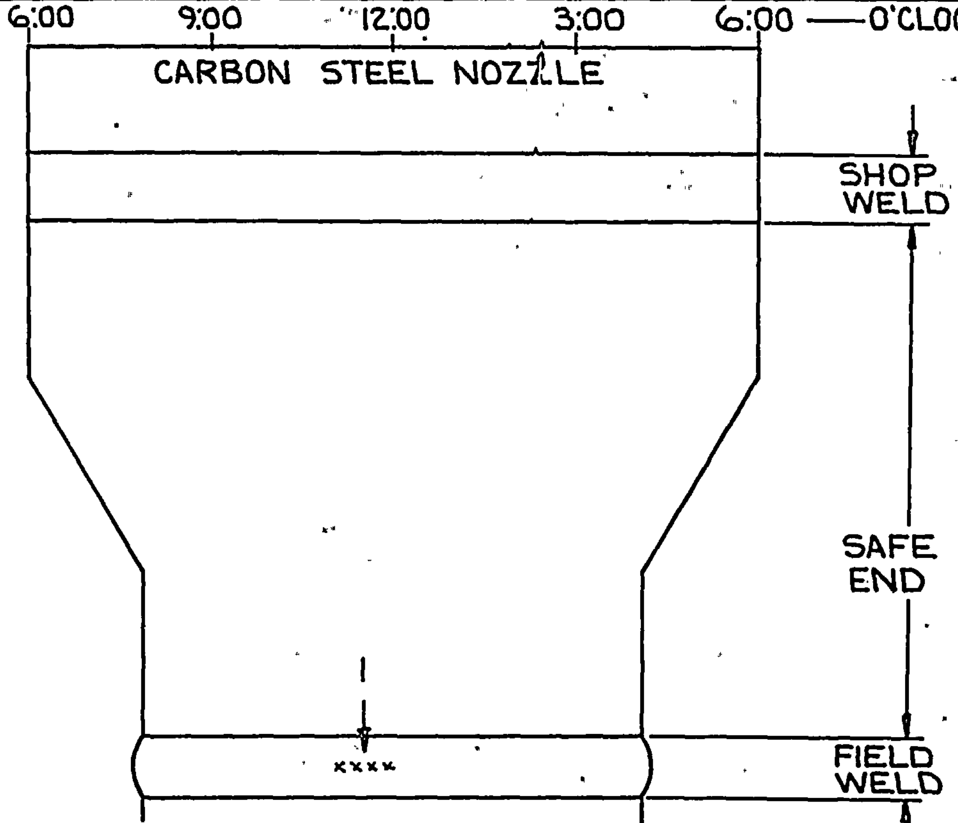
REV NO. A

209A7153
CONT ON SHEET 5 SH NO. 4

TITLE
ULTRASONIC INSPECTION

FIRST MADE FOR NINE MILE POINT NUCLEAR STATION

REVISIONS
A PRELIMINARY ISSUE



IDENTIFICATION RECIRCULATION OUTLET N1E

INSPECTED BY T.G. LAMBERT DATE MARCH 13, 1970

INDICATION	LOCATION	POSITION	AMPLITUDE (% OF 3% I.D. NOTCH)
1	FIELD WELD	11-12	60

REMARKS: ↑ DIRECTION OF SOUND PROPAGATION

UT PROCEDURE: 21A8592 REV. 0 ANGLE BEAM ONLY.

PRINTS TO

MADE BY J. Jensen MAR 27, 1970
ISSUED

APPROVALS

APED
SAN JOSE

DIV OR DEPT.
LOCATION

209A7153
CONT ON SHEET 5 SH NO. 4
CODE IDENT NO.

FF-803-WF (8-68) PRINTED IN U.S.A. CHK'D:

IR

GENERAL ELECTRIC

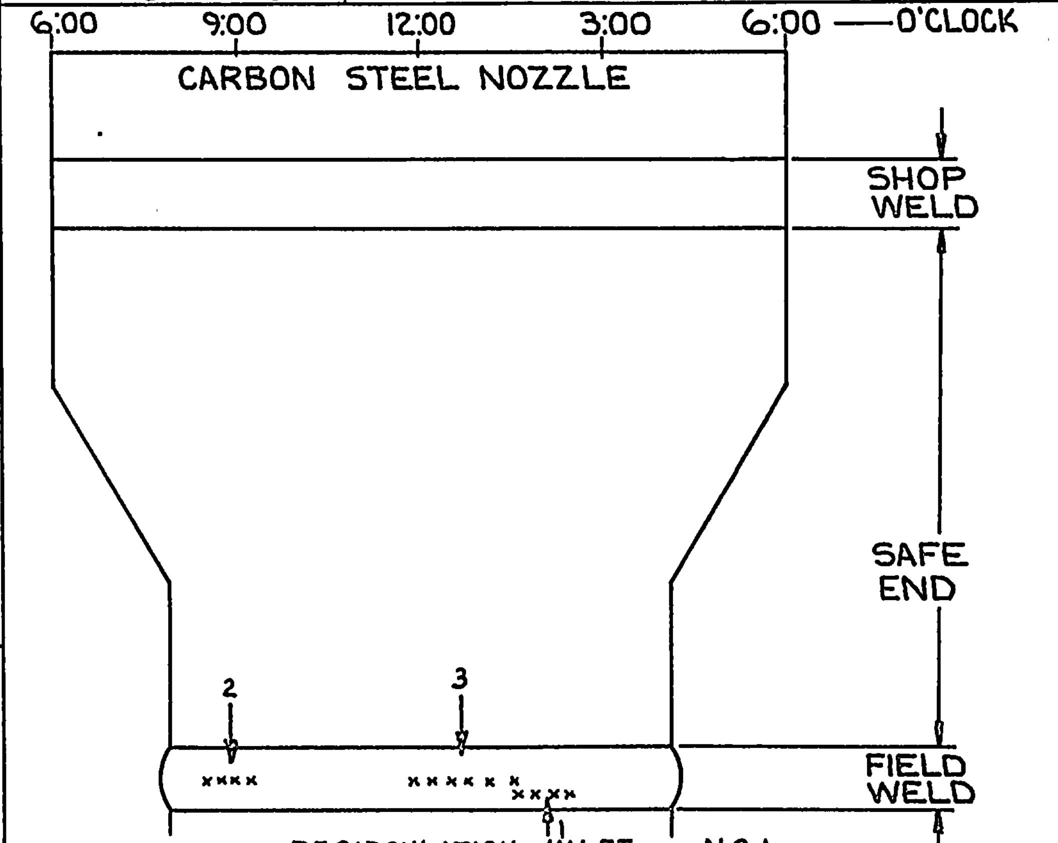
209A7153
CONT ON SHEET 6 SH NO. 5

REV NO. A

209A7153
CONT ON SHEET 6 SH NO. 5

TITLE
ULTRASONIC INSPECTION
FIRST MADE FOR NINE MILE POINT NUCLEAR STATION

REVISIONS
A PRELIMINARY ISSUE



IDENTIFICATION RECIRCULATION INLET N2A
INSPECTED BY TG LAMBERT DATE MARCH 12, 1970

INDICATION	LOCATION	POSITION	AMPLITUDE (% OF 3% I.D. NOTCH)
2	FIELD WELD	7	50
3	FIELD WELD	12-3	100
1	FIELD WELD	3	50

REMARKS: ↑ DIRECTION OF SOUND PROPAGATION

UT PROCEDURE: 21A8592 REV. 0 ANGLE BEAM ONLY.

PRINTS TO

MADE BY J. Jensen MAR 27, 1970
ISSUED
APPROVALS
APED DIV OR DEPT.
SAN JOSE LOCATION
209A7153
CONT ON SHEET 6 SH NO. 5
CODE IDENT NO.

FF-803-WF (9-66) PRINTED IN U.S.A. CHK'D:

IR

GENERAL ELECTRIC

209A7153
CONT ON SHEET 7 SH NO. 6

REV NO. A

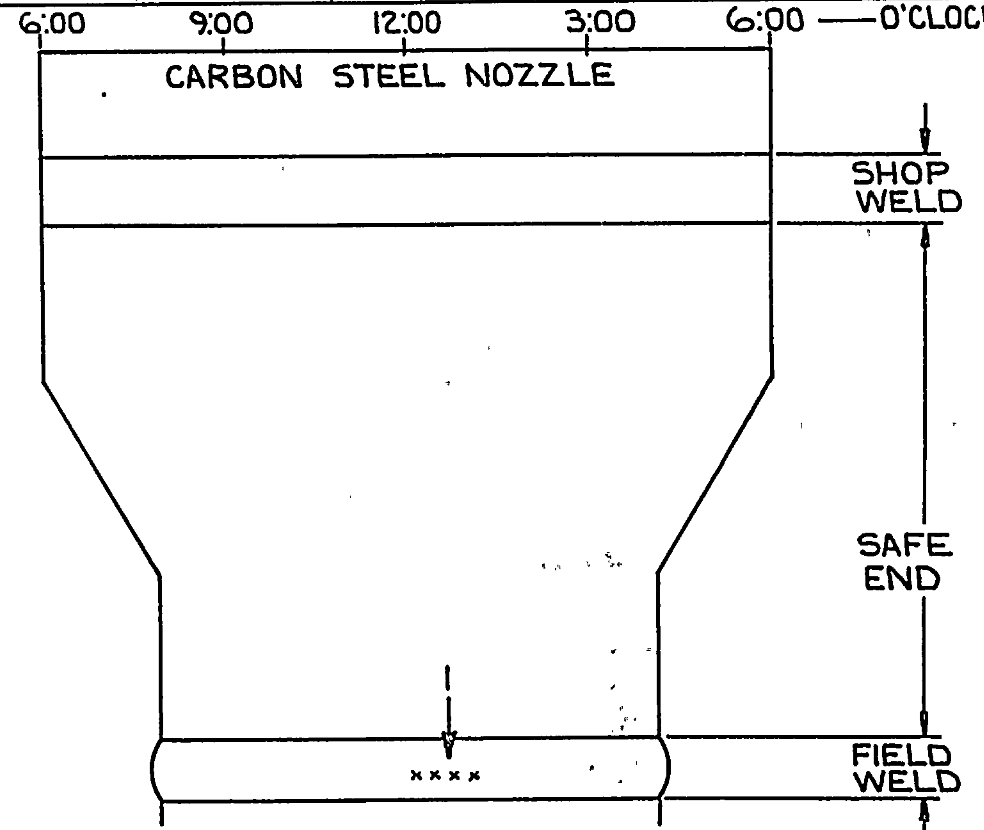
209A7153
CONT ON SHEET 7 SH NO. 6

TITLE
ULTRASONIC INSPECTION

FIRST MADE FOR NINE MILE POINT NUCLEAR STATION

REVISIONS

A PRELIMINARY ISSUE



IDENTIFICATION RECIRCULATION INLET N2B
INSPECTED BY TG LAMBERT DATE MARCH 13, 1970

INDICATION	LOCATION	POSITION	AMPLITUDE (% OF 3% I.D. NOTCH)
1	FIELD WELD	12-1	50

REMARKS: ↑ DIRECTION OF SOUND PROPAGATION

UT PROCEDURE: 21A8592 REV. 0 ANGLE BEAM ONLY.

PRINTS TO

MADE BY J. Jensen MAR 27, 1970
ISSUED
APPROVALS
APED DIV OR DEPT.
SAN JOSE LOCATION
209A7153
CONT ON SHEET 7 SH NO. 6
CODE IDENT NO.

FF-803-WF (8-68) PRINTED IN U.S.A. CHK'D:

IR

GENERAL ELECTRIC

209A7153
CONT ON SHEET 8 SH NO. 7

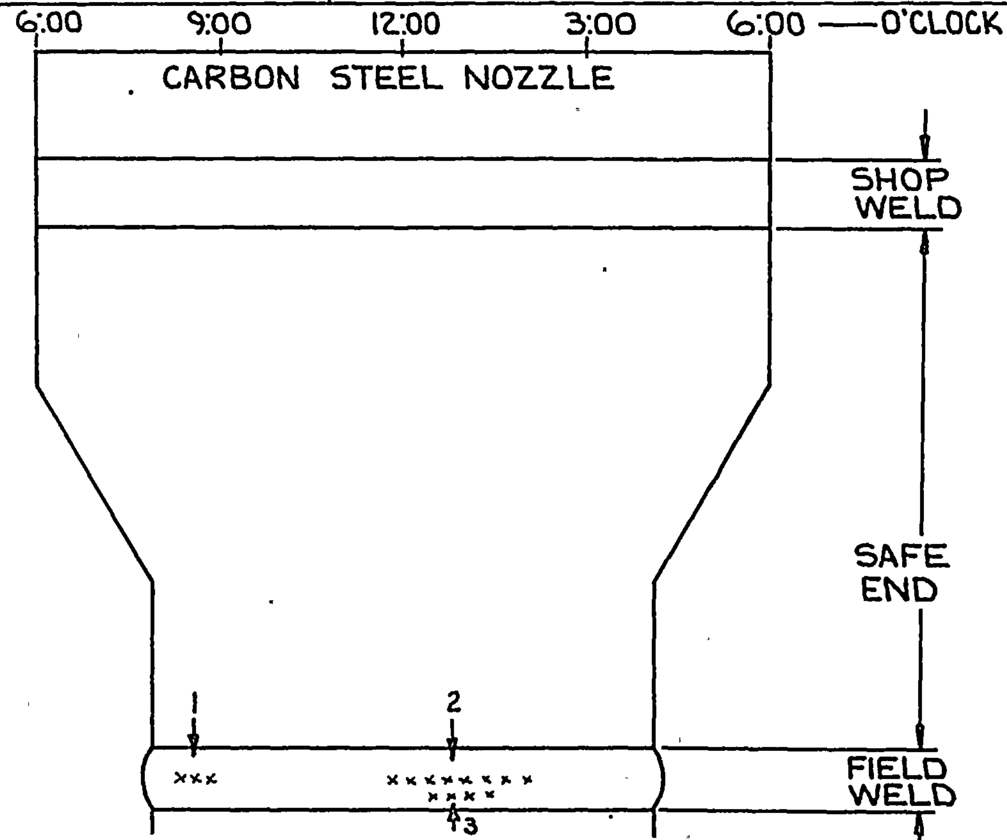
REV NO. A

209A7153
CONT ON SHEET 8 SH NO. 7

TITLE
ULTRASONIC INSPECTION

FIRST MADE FOR NINE MILE POINT NUCLEAR STATION

REVISIONS
A PRELIMINARY ISSUE



IDENTIFICATION RECIRCULATION INLET NC 2
INSPECTED BY TG LAMBERT DATE MARCH 13, 1970

INDICATION	LOCATION	POSITION	AMPLITUDE (% OF 3% I.D. NOTCH)
1	FIELD WELD	7	50
2	FIELD WELD	12-3	75
3	FIELD WELD	1-2	50

REMARKS: ↑ DIRECTION OF SOUND PROPAGATION

UT PROCEDURE: 21A8592 REV. 0 ANGLE BEAM ONLY.

PRINTS TO

MADE BY J. Jansen MAR 27, 1970 ISSUED	APPROVALS	APED (DIV OR DEPT.) SAN JOSE (LOCATION)	209A7153 CONT ON SHEET 8 SH NO. 7

FF-803.WF (9-69) PRINTED IN U.S.A. CHK'D:

CODE IDENT NO.

IR

GENERAL ELECTRIC

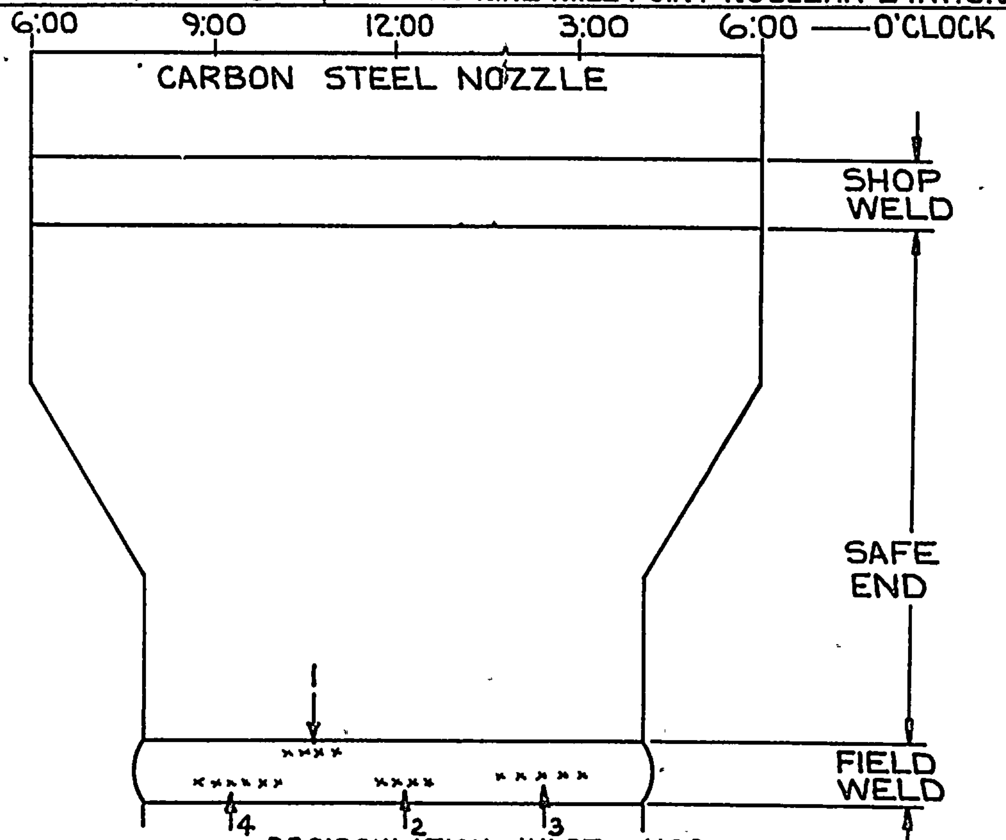
209A7153
CONT ON SHEET 9 SH NO. 8

REV NO. A

209A7153
CONT ON SHEET 9 SH NO. 8

TITLE
ULTRASONIC INSPECTION
FIRST MADE FOR NINE MILE POINT NUCLEAR STATION

REVISIONS
A PRELIMINARY ISSUE



IDENTIFICATION RECIRCULATION INLET N2D
INSPECTED BY TG LAMBERT DATE MARCH 13 1970

INDICATION	LOCATION	POSITION	AMPLITUDE (% OF 3% I.D. NOTCH)
1	FIELD WELD	11	50
2	FIELD WELD	12-1	75
3	FIELD WELD	3^{30}- 4^{30}	75
4	FIELD WELD	8-10	120

REMARKS: ↑ DIRECTION OF SOUND PROPAGATION

UT PROCEDURE: 21A8592 REV. 0 ANGLE BEAM ONLY.

PRINTS TO

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J. Jensen MAR 27, 1970		APED / SAN JOSE	DIV OR DEPT. / LOCATION	209A7153 CONT ON SHEET 9 SH NO. 8

FF-803-WF (9-68) PRINTED IN U.S.A. CHK'D:

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GENERAL ELECTRIC

209A7153
CONT ON SHEET 10 SH NO. 9

REV NO. A

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ULTRASONIC INSPECTION
FIRST MADE FOR NINE MILE POINT NUCLEAR STATION

REVISIONS
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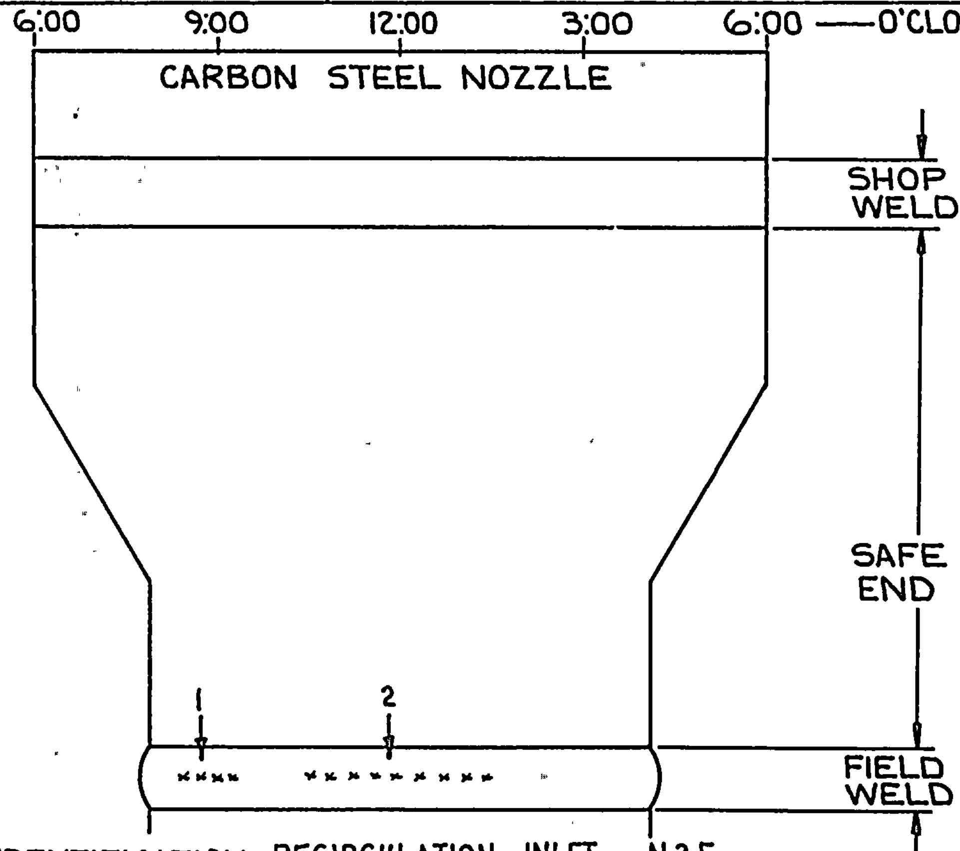

IDENTIFICATION RECIRCULATION INLET N2E
INSPECTED BY TG LAMBERT DATE MARCH 13, 1970

INDICATION	LOCATION	POSITION	AMPLITUDE (% OF 3% I.D. NOTCH)
1	FIELD WELD	8	50
2	FIELD WELD	10-2^{30}	25

REMARKS: ↑ DIRECTION OF SOUND PROPAGATION

UT PROCEDURE: 21A8592 REV. 0 ANGLE BEAM ONLY.

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MADE BY J. Jensen MAR 27, 1970
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209A7153
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GENERAL ELECTRIC

209A7153
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TITLE
ULTRASONIC INSPECTION
FIRST MADE FOR NINE MILE POINT NUCLEAR STATION

REVISIONS
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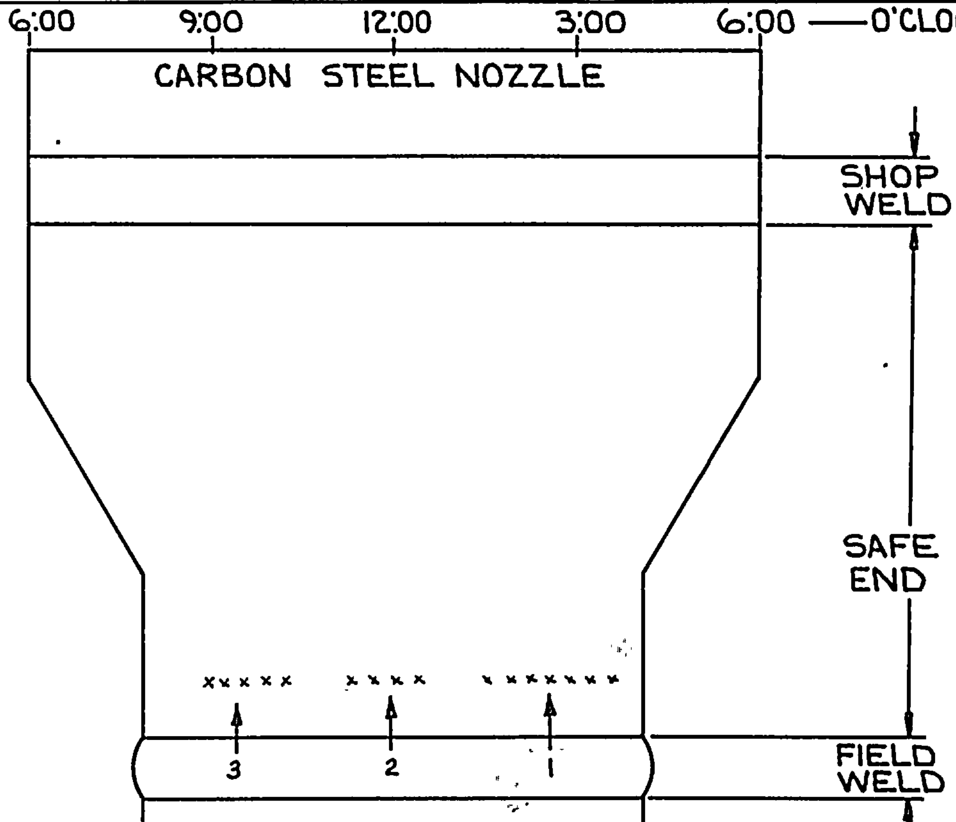

IDENTIFICATION CORE SPRAY N6B
INSPECTED BY TG LAMBERT DATE MARCH 7, 1970

INDICATION	LOCATION	POSITION	AMPLITUDE (% OF 3% I.D. NOTCH)
1	SAFE END	2-5	200
2	SAFE END	12	60
3	SAFE END	9-10	200

REMARKS: ↑ DIRECTION OF SOUND PROPAGATION

UT PROCEDURE: 21A8592 REV. 0 ANGLE BEAM ONLY.

PRINTS TO

MADE BY J. Jensen MAR 27, 1970
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CODE IDENT NO.

FF-803-WF (8-66) PRINTED IN U.S.A. CHK'D:

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GENERAL ELECTRIC
NUCLEAR ENERGY DIVISION
ATOMIC POWER EQUIPMENT DEPARTMENT
San Jose, California

DOCUMENT NO. 21A8570 REV. 0

APPLICATION

☒ SPECIFICATION ☐ DRAWING

TYPE TEST PROCEDURE

DOCUMENT TITLE SPECIAL LIQUID PENETRANT EXAMINATION FOR INTERGRANULAR CORROSION

REVISIONS			
0	New Document		

MADE BY	APPROVALS		
PH GREGORY P.H. Gregory	M JOHNSON M. L. Johnson 7-1-69	JUL 1 1969	CONT ON SHEET 2 SH NO. 1
ISSUED 7-1-69			

REVISION STATUS SHEET

GENERAL ELECTRIC
ATOMIC POWER EQUIPMENT DEPARTMENT

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TEST PROCEDURE

TITLE
SPECIAL LIQUID PENETRANT EXAMINATION FOR INTERGRANULAR CORROSION

1. SCOPE

1.1. This test procedure establishes the technical requirements for liquid penetrant examination of austenitic stainless steel surfaces that have been or that are suspected of having been subjected to conditions that may lead to intergranular corrosion.

1.2. This procedure is to be used as a discriminating means to obtain documentary evidence which identifies and differentiates between:

a. Indications which are characteristic patterns of intergranular corrosive attack on stainless steel surfaces and

b. Other indications which are characteristic of mechanical of fabrication defects.

1.3. As used in this procedure, the term "Seller," refers to the organization performing the examination and the term "Buyer" refers to General Electric - Atomic Power Equipment Department San Jose, (specifically Design Engineering and where applicable Purchasing).

2. APPLICABLE DOCUMENTS, CODES, AND STANDARDS

2.1. The latest issue of the following documents form a part of this procedure to the extent specified herein. If there is any conflict between this document and the referenced specifications, drawings, and other documents, this document shall govern.

2.2. <u>Codes and Standards</u>

American Society of Mechanical Engineers Code for Nuclear Vessels, Section III

3. PROCEDURE

3.1. <u>Materials</u>

3.1.1. The materials to be used for the liquid penetrant inspection shall be of the visible solvent removable dye penetrant type and shall be approved by GE-NED.

GE-NED materials include the following:

a. <u>Penetrant</u>

Spot check SKL-S (Magnaflux) or
Dy-chek Penetrant (Turco)

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TEST PROCEDURE

3.1.1. (continued)

b. Developer

Spot check SKD-S (Magnaflux) or
Dy-chek Developer Nonaqueous (Turco)

c. Solvent Cleaner

Spot check SKC-S (Magnaflux) or
Dy-chek Remover No. 3 (Turco)
Acetone, Tech. or CP Grade

3.2. Cleaning

3.2.1. All material to be examined by the liquid penetrant inspection shall be cleaned by dipping in a solvent, by swabbing with a clean lint-free cloth saturated with a volatile solvent, or by vapor degreasing. If a solvent is used as a cleaner, all parts shall stand for 5 minutes after they appear to be dry. The solvent acts as a penetrant and must be allowed to dry from all possible discontinuities.

3.2.2. Surface finish and cleanliness shall be such as to not interfere with an interpretation of the results.

3.3. Test Method

3.3.1. Penetrant Application. After cleaning the surface in accordance with Paragraph 3.2, apply the penetrant to the surface by either spraying or brushing. A wet film of penetrant must cover the surface of the part being tested at all times so that the penetrant is continually fed into any surface discontinuities. The penetrant shall not be allowed to become dry or tacky. After application of penetrant allow 15 minutes penetration time.

3.3.2. Temperature. The part being tested and the liquid penetrant shall be maintained at a temperature between 60 and 90 degrees Fahrenheit.

3.3.3. Penetrant Removal. The excess penetrant shall be removed from all test surfaces by wiping with clean lint-free cloths moistened with the cleaner recommended by the site procedures. Avoid an excessive application of the cleaner to prevent the possibility of removing the penetrant from discontinuities, which would cause a decrease in the sensitivity of the test. It is best to dampen a cloth with the cleaner and wipe the part rather than to flush the part with a liquid cleaner.

NOTE

Flammable solvents shall not be used near open flames or on parts at an elevated temperature.

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3.3.4. Surface Drying. The surface shall be dried either by use of clean lint-free rags, paper towels, or normal evaporation.

3.3.5. Developer Application. The wet developer shall be applied in a thin uniform film by spraying or brushing. Pools of wet developer shall be avoided to prevent masking of indications. After the developer has been applied allow 15 minutes for the development of any indication.

3.3.6. Illumination. The test area shall be illuminated for proper evaluation of any indication.

3.4. Acceptance Criteria

3.4.1. The characteristic patterns of liquid penetrant indications which are indicative of intergranular corrosive attack on austenitic stainless steel will appear as:

a. A blush, script, or maze network of cracklike indications

b. A spot or linear indication that represents a single entry point or line which opens to a blush, script, or maze network upon removal of the surface layer of a few grains in depth.

3.4.2. Liquid penetrant indications having characteristic other than those described in Paragraph 3.4.1 shall be recorded and reported to the Buyer, and further work on such indications shall be suspended pending a joint resolution by the Seller and the Buyer. Such indications must have well established evidence that their presence results from mechanical or fabrication defects rather than corrosion attack.

3.4.3. No repair welding or other types of repair are authorized by this procedure. The need for repair and the exact nature of the repair shall be determined from records of results of application of this procedure.

3.4.4. Any surface discontinuities remaining after this investigation shall meet the acceptance standards for liquid penetrant examination as specified in Paragraph 5.8.

3.5. Sequence of Examination

3.5.1. Records - Complete detailed records of revealed indications at each examination, as detailed below, are required and are necessary to determine the change in characteristics or change in size of the indications as they are explored in depth. Color photographs shall be made and recorded of typical areas of corrosion attack and of mechanical or fabrication defects.

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TABLE I (b) (continued)

Indication	Action
	(2) Evaluate the results of the redevelopment of the indications, as follows: (a) If no indications are revealed, the condition is acceptable. (b) If indications are revealed as described in Paragraph 3.4, they shall be reported in accordance with the procedure of Paragraph. 3.5.5. Other types of indications shall receive a light grind of 0.010 to 0.020 inch depth in the area of the indication, provided removal of the metal does not reduce the thickness of the part below drawing minimum dimension. After grinding perform a second liquid penetrant examination as specified in Para. 3.3. Whenever grinding cannot be performed because the wall thickness is at minimum allowed drawing dimension, report this condition to the Buyer for evaluation and further instruction.

3.5.4.1. Repeat the sequence of examination shown in Table I parts a and b (1). At this time, if there are any indications, they will require action as specified in Paragraphs 3.5.5, 3.5.6, 3.5.7, and 3.5.8.

3.5.5. If at any time during the investigation it is observed that indications have characteristics indicative of intergranular corrosion, as described in Paragraph 3.4, they shall be recorded and reported to the Buyer and preparations made for their complete removal under an approved repair procedure.

3.5.6. Linear indications shall be investigated by selecting typical indications, as described in Paragraph 3.5.2, and subjecting them to a second light grinding 0.010 to 0.020 inch deep (but not below approved drawing minimum dimensions) and liquid penetrant inspection. If indications have characteristics of intergranular corrosion, as described in Paragraph 3.4, follow the procedure of Paragraph 3.5.5. If indications stay linear, the nature of the indication shall be resolved by

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3.5.2. It is important in following this sequence that on the first liquid penetrant examination any indication revealed shall be studied in detail to determine if the indication is one-of-a-kind or if there are other indications of a similar nature. Metallurgical sampling may be required to determine the exact nature of some type of linear and spot indications, if so, it is desirable to sample an indication that has been untouched (see Paragraph 3.5.3). It is equally important to establish the nature of indications from mechanical or fabrication defects to support and substantiate any arguments to the effect that corrosive attack has <u>not</u> occurred. It is also important to follow the steps in the sequence of examination including grinding so that evidence of corrosion attack is not destroyed or misconstrued.

3.5.3. Where the need for sampling arises, the Buyer is to be notified of the details and actual sampling shall proceed under direction of the Buyer.

3.5.4. <u>Liquid Penetrant Examination</u>. Conduct a liquid penetrant examination in accordance with Paragraph 3.3 and evaluate results in accordance with Table I.

CAUTION

In the following detailed sequence of evaluating penetrant examination results, it will be necessary in the case of multiple like indications to work on one to determine if metallurgical sampling is required and, if sampling is required, to take a sample of an undisturbed indication.

TABLE I
LIQUID PENETRANT EXAMINATION SEQUENCE

Indication	Action
a. No indications (no pink or red discoloration allowed)	Condition acceptable
b. Indications revealed (any pink or red discoloration)	(1) Indications which appear as described in Paragraph 3.4 shall be reported in accordance with the procedure of Paragraph 3.5.5. Clean the surface and discoloration by dry wiping or dry brushing, as with a toothbrush. Add more developer to the area as in Paragraph 3.3.5 to redevelop the indication without adding liquid penetrant.

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3.5.6. (continued)

metallography examination of a sample removed from like undisturbed indication of if only one like it remove sample of the single indication only after all other indication types have been explored.

3.5.7. Spot indications shall be investigated by selecting typical areas of indications and subjecting them to a second light grinding 0.010 to 0.020 inch deep (but not below approved drawing minimum dimensions) and liquid penetrant examinations. If indications have characteristic of intergranular corrosion, as described in Paragraph 3.4, follow the procedure of Paragraph 3.5.5.

3.5.8. All remaining indications shall be considered to be relevant indications and their acceptance shall be judged in accordance with the liquid penetrant acceptance criteria of N-627.3 of the 1968 American Society Mechanical Engineers Code for Nuclear Vessels, Section III.

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JUL 1 1969

GENERAL ELECTRIC
NUCLEAR ENERGY DIVISION
ATOMIC POWER EQUIPMENT DEPARTMENT
San Jose, California

DOCUMENT NO. 21A8592 REV. 0

APPLICATION

[X] SPECIFICATION [ ] DRAWING

TYPE PURCHASE

DOCUMENT TITLE ULTRASONIC EXAMINATION OF PIPE AND SAFE END WELDS

REVISIONS			

MADE BY PH GREGORY	APPROVALS M JOHNSON M Johnson 1-9-70 RCN	CONT ON SHEET 2	SH NO. 1
ISSUED P.H. Gregory 1/9/70			

REVISION STATUS SHEET

NED 265 (3-69)

GENERAL ELECTRIC

ATOMIC POWER EQUIPMENT DEPARTMENT

PURCHASE SPECIFICATION

1p t-ad	SPEC. NO. 21A8592 REV. NO. 0
	SH NO. 2. CONT. ON SHEET 3

TITLE

ULTRASONIC EXAMINATION OF PIPE AND SAFE END WELDS

1. SCOPE

1.1. The ultrasonic method of examination described herein is applicable to safe end-to-pipe welds, pipe-to pipe welds, and longitudinal seam welds in pipe.

2. APPLICABLE DOCUMENTS. CODES. AND STANDARDS

2.1. The following references form a part of this examination procedure to the extent specified herein. If there is any conflict between this document and the referenced specifications, codes, standards, and other documents; this document shall govern.

2.2. Codes and Standards

American Society of Mechanical Engineers, "ASME Boiler and Pressure Vessel Code" Section III, Appendix IX,

American Society of Nondestructive Testing "Recommended Practice for Nondestructive Testing, Personnel Qualifications and Certification" ASNT-TC-1A and Supplements,

American Society for Testing and Materials, "Ultrasonic Contact Inspection of Weldments" E164 latest revision

International Institute of Welding, AISI 4340 IIW-2 Calibration Block

Draft ASME Code for In-Service Inspection of Nuclear Reactor Coolant Systems (Dated Oct. 1969)

3. APPLICATION

3.1. The principal objective of the methods given herein is the location and recording of indications within the weld, the heat affected zone and the base material.

3.2. The examination shall be performed from the piping outside diameter following at least one hydrostatic test of the pipe and prior to placing the nuclear facility into commercial operation.

3.2.1. For the detection of defects parallel to the weld, the welds shall be examined by an angle beam from both sides of the weld.

3.2.1.1. Where geometric restrictions preclude examination from both sides of the weld, the weld shall be examined by a combination of an angle beam from the unrestricted side and a straight beam from the surface of the weld.

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3.2.2. For the detection of defects transverse to the weld, the weld shall be examined by an angle beam from the weld surface with the beam directed along the weld.

3.2.2.1. Where the weld surface roughness precludes examination from the weld surface, angle beam examination using two search units one on each side of the weld, oriented at 45 degrees or less to the weld axis shall be used.

3.3. This examination method shall be used to perform the preoperational and subsequent examinations specified in Sections ISI 230, ISI 250, and ISI 260 of the Draft ASME Code for In-Service Inspection of Nuclear Reactor Coolant Systems (Dated October, 1969).

4. REQUIREMENTS

4.1. <u>Equipment</u>

4.1.1. Ultrasonic equipment meeting the requirements of ASTM E-164, latest revision, shall be used.

4.1.1.1. The ultrasonic instrument shall be capable of generating, receiving, amplifying, and displaying high frequency electrical pulses at energy levels compatible with the required ultrasonic frequency and examination sensitivity.

4.1.1.2. Straight beam and angle beam transducers shall be used.

4.1.1.2.1. The frequency shall be 2.25 mHz unless variables, such as production material grain structure, necessitate the use of other frequencies to ensure adequate penetration.

4.1.1.2.2. The straight beam transducer shall be between 1/2 and 1-1/8 inch in diameter.

4.1.1.2.3. The angle beam transducer shall be between a 1/2 inch diameter or square and a 1/2 by 1 inch configuration.

4.1.1.2.4. The beam angle in the material shall be 45 ± 3 degrees measured within ± 1 degree with respect to perpendicular of the contact surface.

4.1.2. An ASME Boiler and Pressure Vessel Code, Section III, Appendix IX Basic Calibration Block shall be used as the primary reference standard.

4.1.3. An AISI 4340 IIW-2 Calibration block may be used as a transfer standard.

4.1.4. Glycerin shall be used as the couplant, except in cases of rough surfaces where heavy oil or light grease may be used.

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4.2. Surface Preparation

4.2.1. Base Material

4.2.1.1. The scanning surface shall be free of weld spatter, loose mill scale, dirt, and other materials that would interfer with free movement of the transducer or impair transmission of ultrasonic vibrations into the materials.

4.2.2. Weld Surface

4.2.2.1. The weld surface shall be sufficiently smooth to prevent interference with the interpretation of examination results. The weld surface shall merge smoothly with the base material surface.

4.2.3. Surface preparation shall include the weld surface and the base material surface on each side of the weld for a distance equal to two times the base material thickness. When this distance cannot be achieved on one side due to the location of flanges or nozzles, the extent of base metal surface preparation on the restricted side shall be that surface which is parallel to the pipe wall.

4.3. Calibration of Equipment

4.3.1. Distance Amplitude Correction (DAC) Curve

4.3.1.1. To compensate for the actual distance traversed by the ultrasonic beam as it passes through the material, a DAC curve shall be determined from a set of side drilled holes in a calibration block. The calibration block shall be fabricated in accordance with Paragraph IX-343 of the ASME Boiler and Pressure Vessel Code, Section III, Appendix IX. The largest amplitude response from the holes shall be set at 80 percent of full screen height. A DAC curve shall be marked on the graticule by drawing a line between the peaks of the amplitudes obtained at the various metal paths used. This is the primary reference level DAC curve.

4.3.1.2. The amplitude of 3 percent outside diameter and inside diameter notches shall be determined and recorded at the primary reference level for the pipe wall thickness and material being examined.

4.3.2. Transfer standard distance amplitude correction curve: Following the correlation of the responses from the 1/8 inch inch diameter side drilled hole in both the 1-1/4 and 2-3/4 inch position with the primary reference level DAC curve, the AISI IWW-2 Calibration Block may be used as a transfer standard.

4.3.3. Sweep or Marker Calibration

4.3.3.1. The sweep or markers shall be calibrated to indicate the metal path to an indication producing area within the weld or base material. This calibration shall be performed using the AISI IIW-2 Calibration Block.

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4.3.4. The beam angle of angle beam transducers shall be measured using the AISI IIW-2 Calibration Block.

4.3.5. Recalibration is required whenever any part or components of the original setup used for calibration is changed.

4.4. Examination

4.4.1. Angle Beam Method

4.4.1.1. Prior to the angle beam examination, the area of the base materials through which the sound will travel in the angle beam examination shall be completely scanned with a straight search unit to detect reflectors which might affect the interpretation of the angle beam results. Consideration must be given to these reflectors during interpretation of the angle beam indications.

4.4.1.2. Scanning sensitivity

4.4.1.2.1. The scanning sensitivity shall be equal to or greater than two times the primary reference level.

4.4.1.3. Coverage

4.4.1.3.1. The welds shall be examined from the outside diameter surface of the pipe. The welds shall be examined from both sides of the weld with the beam directed toward the weld and from the surface of the weld with the beam directed along the weld.

4.4.1.3.2. Where geometrical restrictions prevent examination from both sides of the welds, i.e., there is a restriction to prevent placement of the transducer two wall thicknesses from the fusion line, an additional pass down the center of the weld using a straight beam shall be substituted for the angle beam from the restricted side of the weld.

4.4.1.4. Scanning Motion

4.4.1.4.1. The weld shall be examined from each side for the detection of discontinuities parallel to the weld by moving the search unit in an angulatory motion of 10 to 20 degrees, and an oscillating motion as the transducer is progressively moved along and across the contact area so as to scan the entire weld with 10 percent overlap of the transducer movement. In addition, the transducer shall be passed down the centerline of the weld in both directions in a similar scanning motion for the detection of discontinuities transverse to the weld.

4.4.2. Straight Beam Method

4.4.2.1. Scanning sensitivity

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4.4.2.1.1. The scanning sensitivity shall be equal to or greater than the primary reference level.

4.4.2.2. Coverage

4.4.2.2.1. The base material through which the sound will travel in the angle beam examination shall be completely examined.

4.4.2.3. Scanning Motion

4.4.2.3.1. The area shall be examined by moving the search unit progressively along and across a sufficient contact area so as to scan the entire area with a 10 percent overlap of the transducer movement.

4.4.2.4. Verification of Penetration

4.4.2.4.1. Penetration shall be verified by obtaining a reflection from the pipe inside diameter.

4.5. Evaluation of Indications

4.5.1. All angle beam indications which produce a response greater than 5 percent of the primary reference level DAC curve shall be investigated to the extent that the operator can determine the shape, orientation, identity, and location of the indication producing area.

4.5.2. All indications which produce a maximum response greater than 10 percent of the primary reference level DAC curve shall be fully evaluated as to length and amplitude of indication. The following data shall be obtained and recorded using 10 percent of the DAC or 10 percent of the maximum amplitude, whichever is smaller at the terminal points.

a. Initial detection point - metal path
b. The metal path at the maximum amplitude
c. Maximum amplitude
d. Terminal detection point-metal path
e. Lateral transducer movement between initial and terminal detection points.

4.5.2.1. Evaluation of indications shall be performed at the primary reference level and at the examination frequency. Other frequencies or variable angle transducers may be used as an aid in interpreting the examination results.

4.5.2.2. Amplitude of indications shall be recorded as percent of full screen height and percent of DAC curve, at the primary reference level.

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4.5.2.3. Ultrasonic noise levels in excess of 20 percent of the primary DAC curve shall be evaluated as indications.

4.5.3. Any unusual conditions detected by angle beam or straight beam such as large numbers of clustered small indications, loss of back reflection excessive metal noise, and areas requiring evaluation which did not require recording in the above paragraphs shall be recorded as to location and type of indications observed.

4.6. Personnel Qualifications

4.6.1. Personnel performing these nondestructive examination operations shall be qualified at least to Level 1 in accordance with ASNT-TC-1A, Supplements and Appendices, in accordance with Section III of the Boiler and Pressure Vessel Code. Alternately, personnel shall be acceptable to General Electric Company - Atomic Power Equipment Department.

4.7. Report

4.7.1. Reporting Criteria

4.7.1.1. All recordable indications shall be reported in sufficient detail to meet the requirements of Paragraphs 4.3.1.2 and 4.5.

4.7.1.2. The information regarding the location of recorded indications shall be in sufficient detail to duplicate the examination.

4.7.1.3. The information regarding the transducer position, beam angle, and direction of scan shall be in sufficient detail to duplicate all recorded indications.

4.7.2. Information regarding the examination procedure shall include the following:

4.7.2.1. All procedures and equipment shall be identified sufficiently to permit duplication of the examination at a later date. This shall include initial calibration data for the equipment and any significant changes.

4.7.2.2. A marked-up drawing or sketch indicating the welds examined, the item or piece number, and identification of the operator who carried out each inspection or part thereof.

4.7.2.3. A record shall be made of the method used for measuring the depth of the indication; such as screen calibration or projected distance method.

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4.7.2.4. Ultrasonic examinations performed in accordance with this procedure shall have at least the following information recorded:

a. Weld types and configurations examined, including thickness

b. Automatic defect alarm and recording equipment, or both, if used

c. Special search units, wedges, shoes, or saddles; if used

d. State of manufacture when examinations are conducted

e. Rotating or revolving scanning mechanisms, if used

f. Surface or surfaces from which the examination is performed

g. Transducer size, shape, and beam angle

4.7.3. The primary reference level DAC curve and sweep calibration shall be reported as a function of depth, either in graphical or tabular form.

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Procedure Specification No. PS-1
Revision 0
Date: October 14, 1968

SPECIAL LIQUID PENETRANT EXAMINATION FOR INTERGRANULAR CORROSION

1.0 SCOPE

1.1 The extent and area(s) to be examined to this procedure shall be defined elsewhere.

1.2 This procedure establishes the general technical requirements for liquid penetrant examination of austenitic stainless steel surfaces that have been or may be suspected of having been subjected to conditions that may lead to intergranular corrosion. It is intended that this procedure be used as a discriminating means whereby documentary evidence is obtained which identifies and differentiates between a) indications which are characteristic patterns of intergranular corrosive attack on stainless steel surfaces and b) other indications which are characteristic of mechanical or fabrication defects. It is further intended that any surface discontinuities which remain after investigation fully meet the applicable acceptance standards for liquid penetrant examination.

1.3 The characteristic patterns of liquid penetrant indications which are indicative of intergranular corrosive attack on austenitic stainless steels are described briefly as follows:

1.3.1 Indication appears as a blush, script or maze network of cracklike indications.

1.3.2 Indication which appear either as a spot or as a linear indication that represents a single entry point or line which opens to a blush, script or maze network upon removal of the surface layer of a few grains in depth.

1.4 Liquid penetrant indications having characteristics other than those described in 1.3 shall be recorded and reported to APED San Jose and further work on such indications suspended pending joint resolution by Site and San Jose personnel. Such indications must have well established evidence that their presence results from mechanical or fabrication defects rather than corrosion attack.

1.5 No repair welding or other types of repair are permitted by this procedure. The need for repair and the exact nature of repair shall be determined from records of results of application of this procedure.

2.0 SURFACE FINISH

Surface finish and cleanliness shall be such as to not interfere with interpretation of results.

3.0 PROCEDURE

Liquid penetrant examinations shall be in accordance with General Electric Company APED Liquid Penetrant Procedure, dated September 5, 1968.

4.0 DETAILED SEQUENCE OF EXAMINATION

4.1 Records—Complete detailed records of revealed indications at each examination, as detailed below, are required and necessary so as to determine the change in characteristics or change in size of the indications as they are explored in depth. Photographic records, preferably in color, shall be made of typical areas of corrosion attack and of mechanical or fabrication defects.

4.2 It is important in following the sequence of examination below, that on the first liquid penetrant examination any pattern of indications that are revealed should be studied in detail to determine if indication is one-of-a-kind or if there are more similar indications. Certain linear and spot indications may require metallurgical sampling to determine their exact nature and as such, it is desirable to sample an indication that has been untouched. It is equally important to establish the nature of indications from mechanical or fabrication defects to support and substantiate any arguments to the effect that corrosive attach has *not* occurred. It is also important to follow the steps in the sequence of examination including grinding so that evidence of corrosion attack is not destroyed or misconstrued.

4.3 Where the need for sampling arises, APED San Jose is to be notified of the details and actual sampling shall proceed under direction of APED San Jose.

4.4 First Liquid Penetrant Examination

CAUTION

In the following detail sequence it will be necessary in the case of multiple like indications to work on one to determine if metallurgical sampling is required or not and, if sampling is required, take the sample of the undistrubed indication.

4.4.1 No indications (no pink or red discoloration allowed)—condition acceptable.

4.4.2 Indications revealed (any pink or red indication)—Action.

4.4.2.1 Indications which appear as described in paragraph 1.3 shall be reported in accordance with paragraph 4.6. Clean by dry wiping or dry brushing, such as with a toothbrush. Redevelop without further liquid penetrant addition.

4.4.2.2 Second Development of indications as called for in 4.4.2.1.

4.4.2.2.1 No indications—condition acceptable.

4.4.2.2.2 Indication revealed—Action—Indications which appear as described in paragraph 1.3 shall be reported in accordance with paragraph 4.6. Other indications shall receive a light grind (0.010 inch to 0.020 inch metal removal) in area of indication and perform a liquid penetrant examination a second time.

4.5 Second Liquid Penetrant Examination

Repeat sequence of examination under 4.4.1 through 4.4.2.1 remaining unacceptable indications will require action specified in 4.6, 4.7, and 4.8.

4.6 If at anytime during the investigation it is observed that indications have characteristics indicative of intergranular corrosion, as described in paragraph 1.3, they shall be recorded and reported to APED San Jose and preparations made for their complete removal under an approved repair procedure.

4.7 Linear indications shall be investigated by selecting typical indications as described in paragraph 4.2 and subjecting them to a second light grinding (0.010 inch to 0.020 inch metal removal) and liquid penetrant inspected. If indications have characteristics of intergranular corrosion, as described in paragraph 1.3, follow 4.6 above. If indications stay linear, the nature of the indication shall be resolved by metallographic examination of a sample removed from like undisturbed indication or if only one like it remove sample of the single indication only after all other indications types have been explored.

4.8 Spot indications shall be investigated by selecting typical areas of indications and subjecting them to a second light grinding (0.010 inch to 0.020 inch metal removal) and liquid penetrant examinations. If indications have characteristic of intergranular corrosion, as described in paragraph 1.3, follow 4.6 above. If indication stays a spot it should be judged in accordance with 5.0.

5.0 ACCEPTANCE STANDARDS

NOTE

The acceptance standards given in 5.1 through 5.4 form the basis for acceptance in 4.8 *Detailed Sequence of Examination.*

5.1 Relevant indications of any cracks or linear indications are unacceptable.

5.2 Rounded indications with dimensions greater than 1/16 inch are unacceptable.

5.3 Four or more rounded indications in a line separated by 3/16 inch or less are unacceptable.

5.4 Ten or more rounded indications with dimensions over 1/64 inch in any 6 square inches of surface with the area taken in most unfavorable location relative to the indications under evaluation are unacceptable.

APPENDIX C
METALLOGRAPHY OF SAMPLES

The following items comprise Appendix C.

Figure C-1	Metallography of Sample No. 1
Figure C-2	Root of Safe End-to-Pipe Field Weld
Figure C-3	Morphology of Arial Cracks in Failed Safe End, Sample 1
Figure C-4	Metallography of Sample No. 2
Figure C-5	Metallography of Sample No. 3
Figure C-6	Metallography of Sample No. 4
Figure C-7	Metallography of Sample No. 5
Figure C-8	Metallography of Sample No. 6
Figure C-9	Penetrant Test of Sample No. 1 (o.d.)
Figure C-10	Penetrant Test of Sample No. 1 (i.d.)
Figure C-11	Penetrant Test of Sample No. 3 (i.d. and o.d.)
Figure C-12	Cutting Plan, Sample No. 1
Figure C-13	Cutting Plan, Sample No. 3

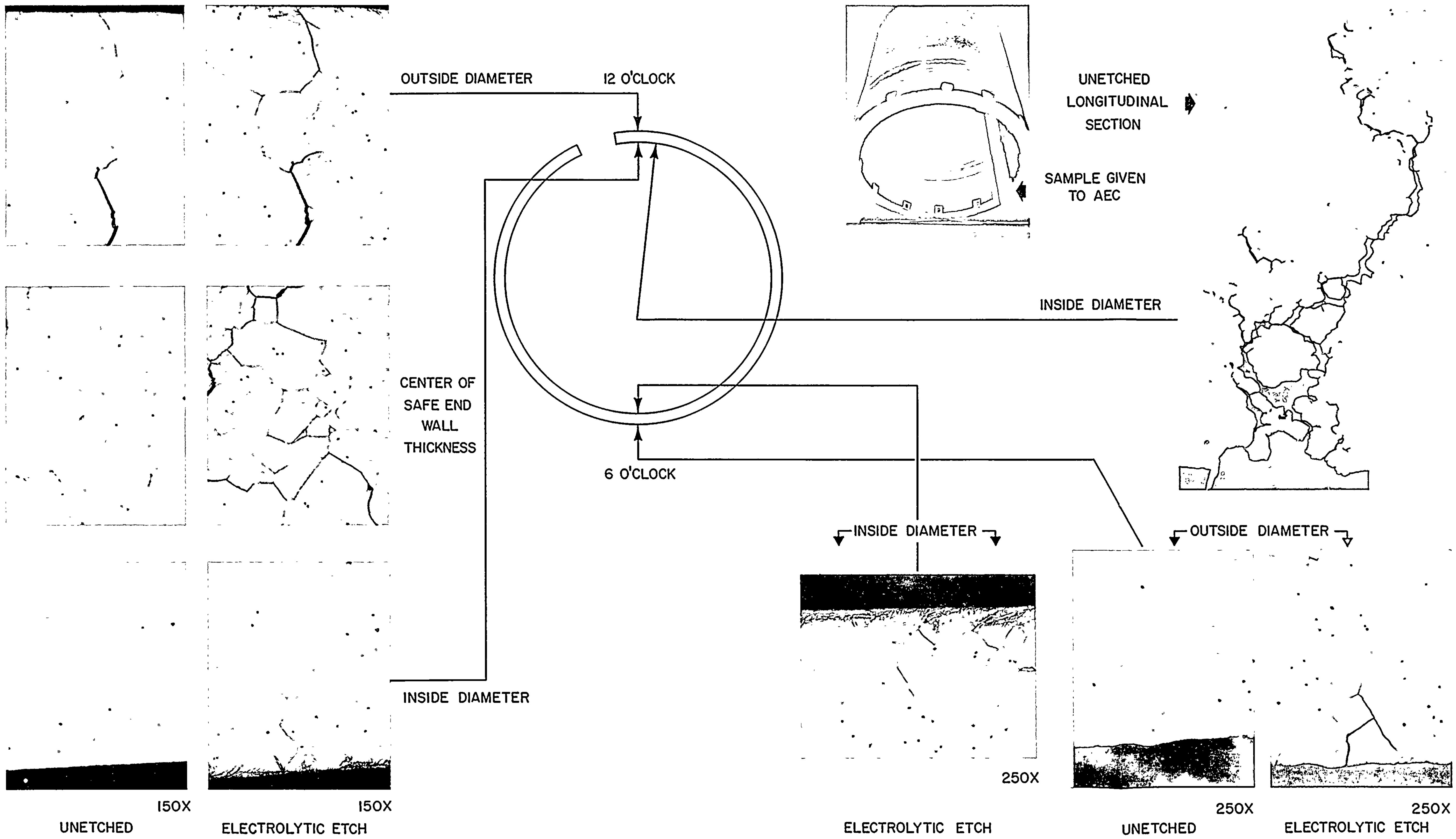
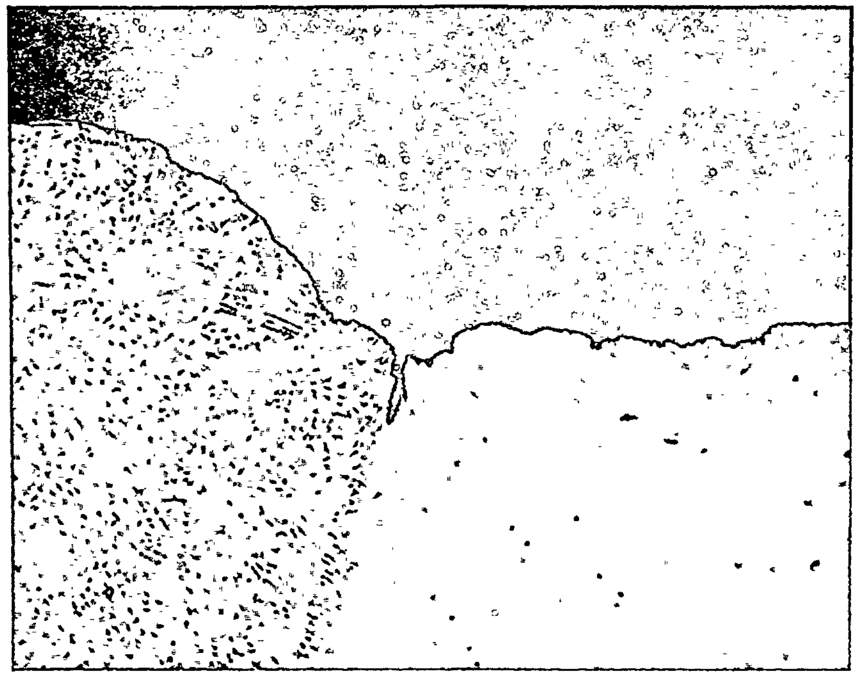
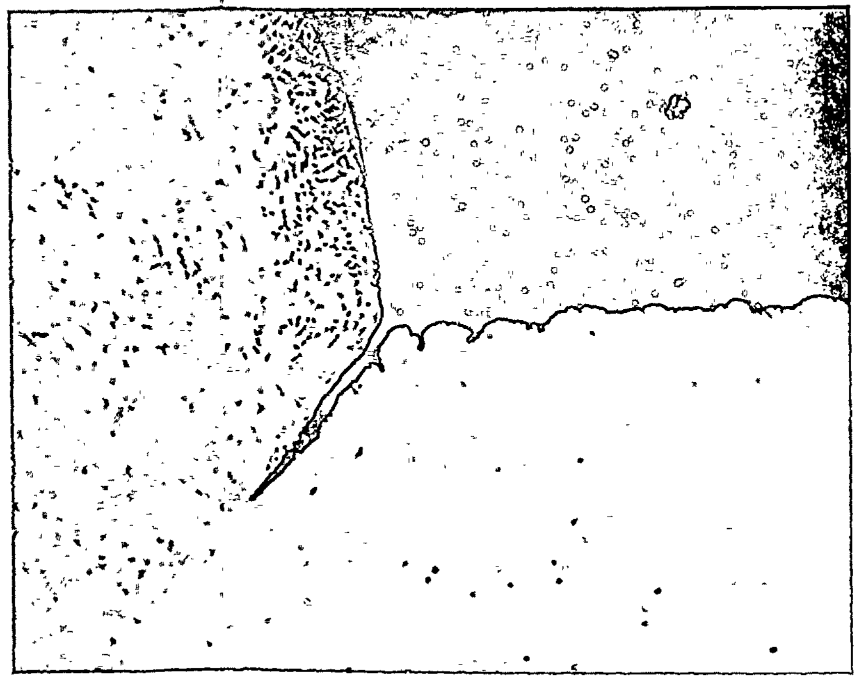


FIGURE C-1 METALLOGRAPHY OF SAMPLE NO. 1, CORE SPRAY NOZZLE SAFE END N6B (PIPE END)

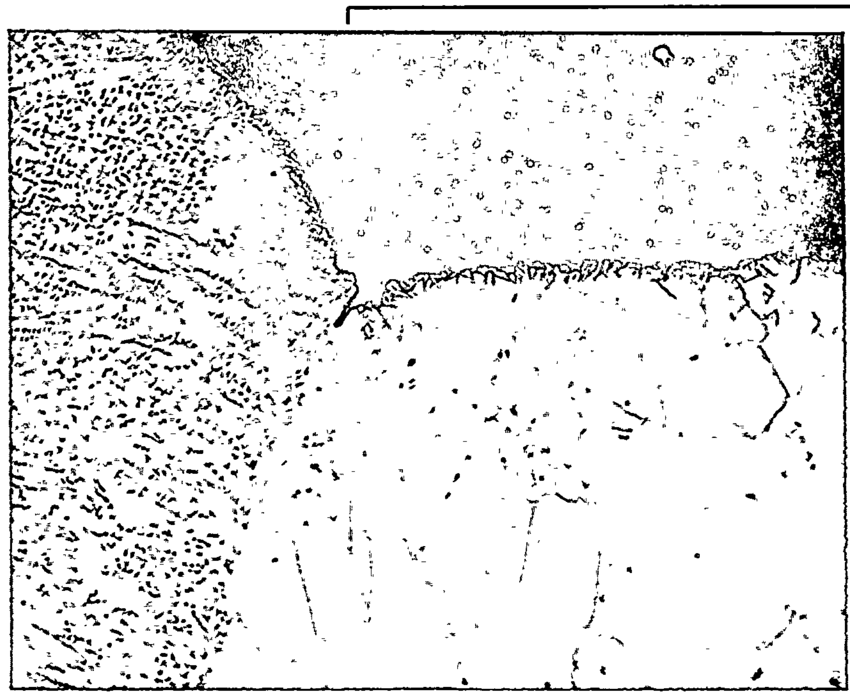


1:30 CLOCK POSITION 100X



10:30 CLOCK POSITION 100X

APPROX 1/4 INCH



2:00 CLOCK POSITION 100X

100X

FIGURE C-2. ROOF OF SAFE END-TO-PIPE FIELD WELD
CORE SPRAY SAFE END N6B—SAMPLE NO. 1

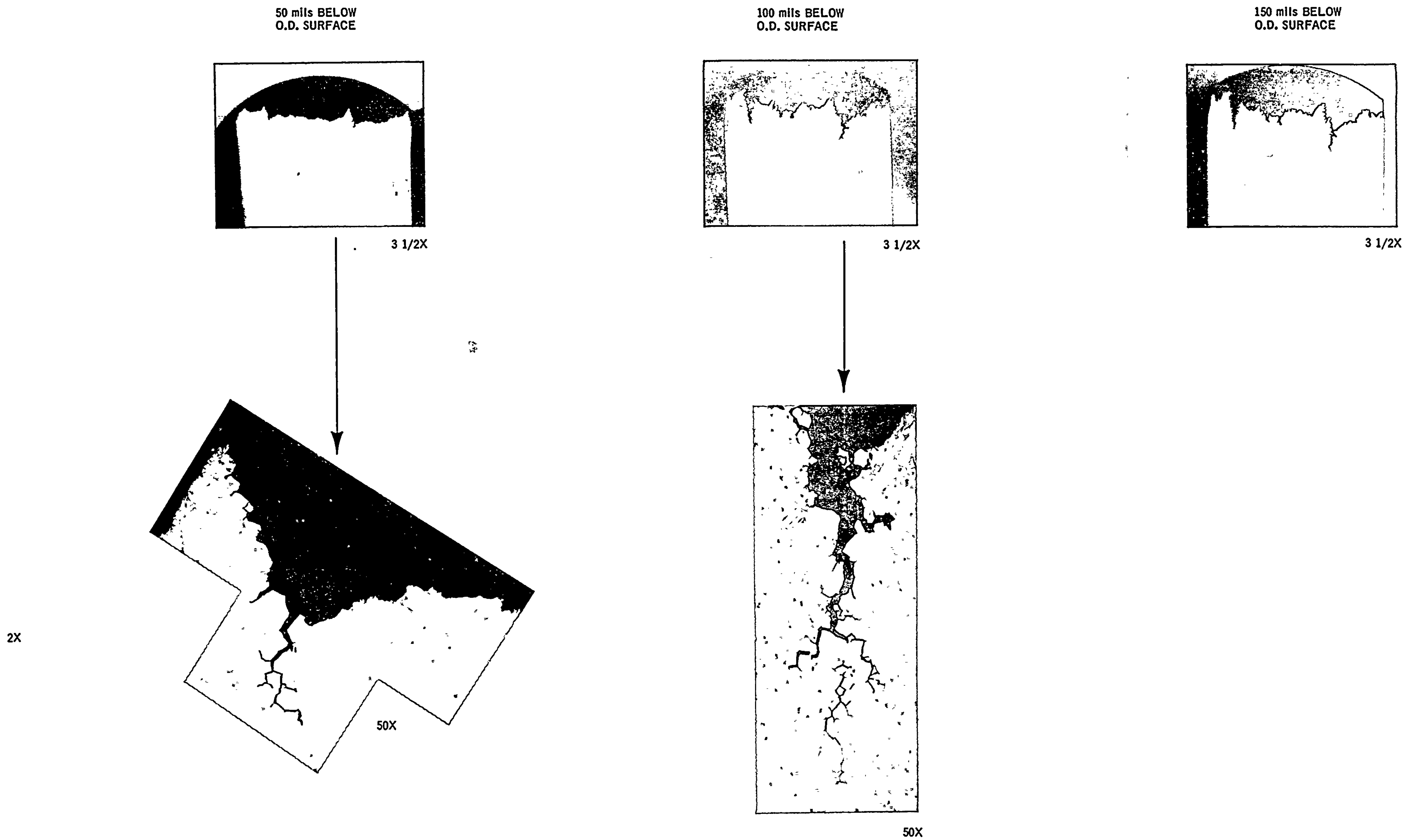


FIGURE C-3. MORPHOLOGY OF AXIAL CRACKS IN FAILED SAFE END – SAMPLE NO. 1

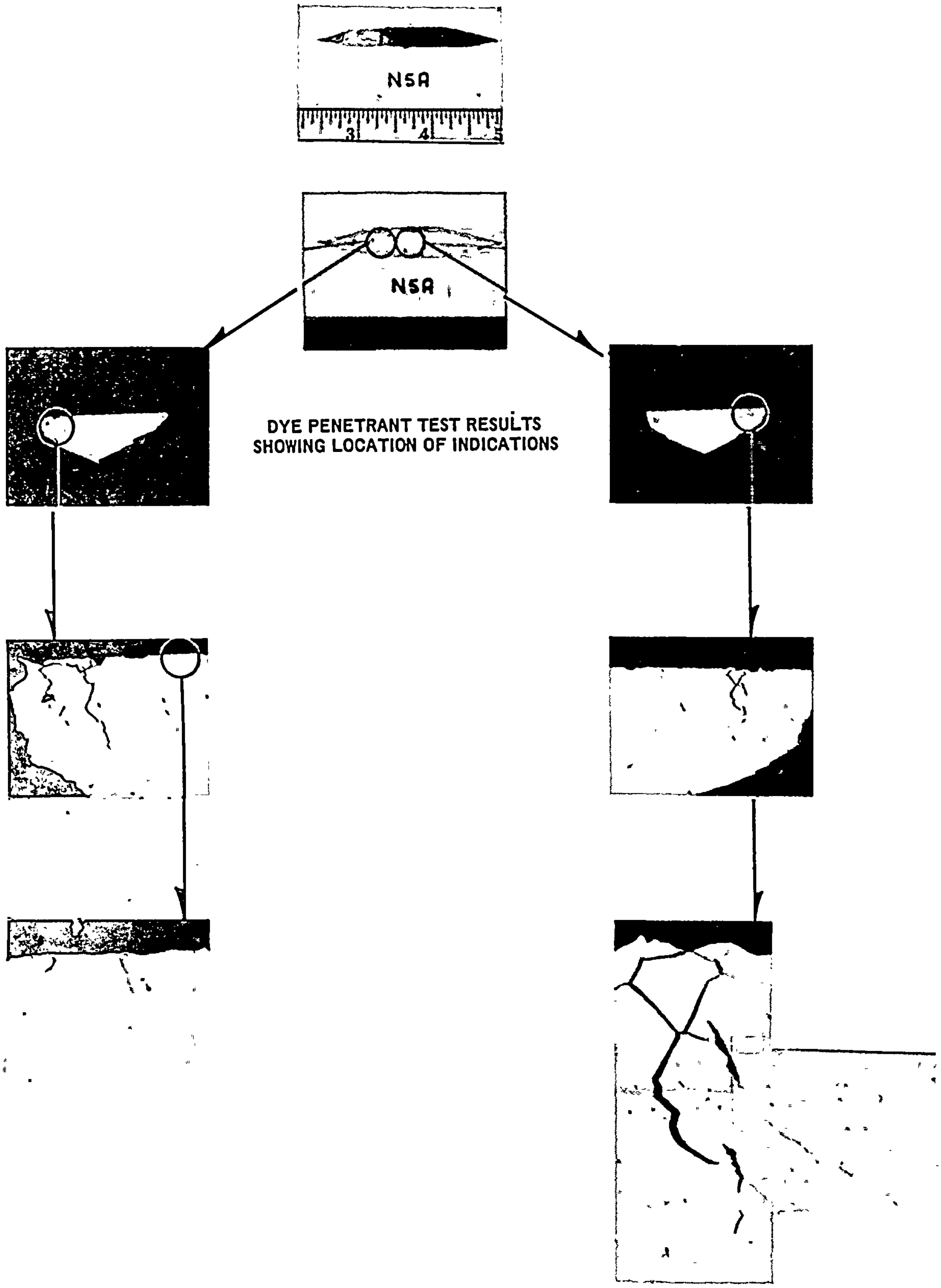


FIGURE C-4. METALLOGRAPHY OF SAMPLE NO. 2
ISOLATION CONDENSER SAFE END O.D. (N5A)
WEDGE SAMPLE

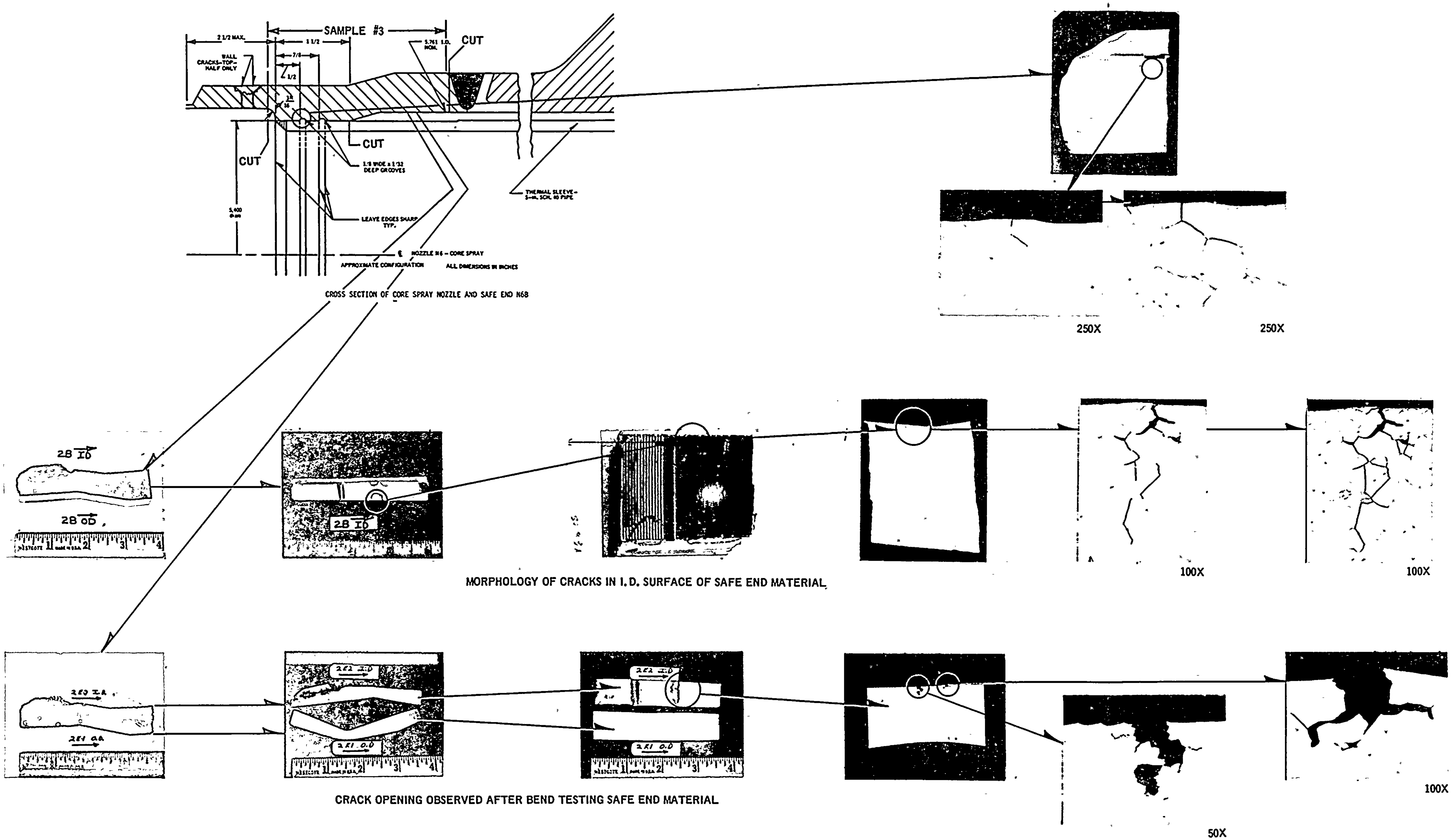
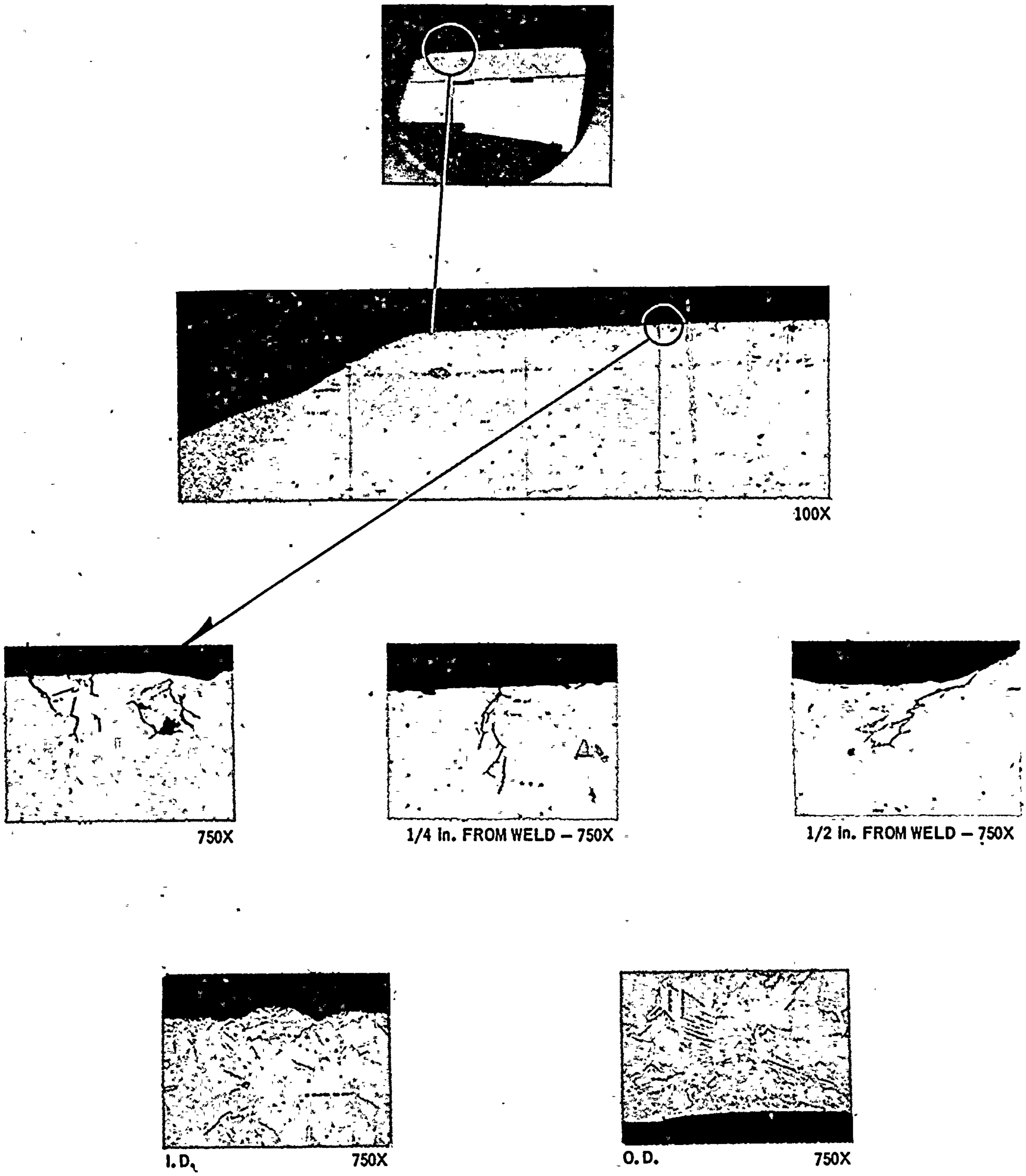


FIGURE C-5. METALLOGRAPHY OF SAMPLE NO. 3
CORE SPRAY NOZZLE SAFE END (N6B)
LEAKER-NOZZLE END



SURFACE COLD WORK IN THERMAL SLEEVE

FIGURE C-6. METALLOGRAPHY OF SAMPLE NO. 4
THERMAL SLEEVE
CORE SPRAY LOCATION N6B

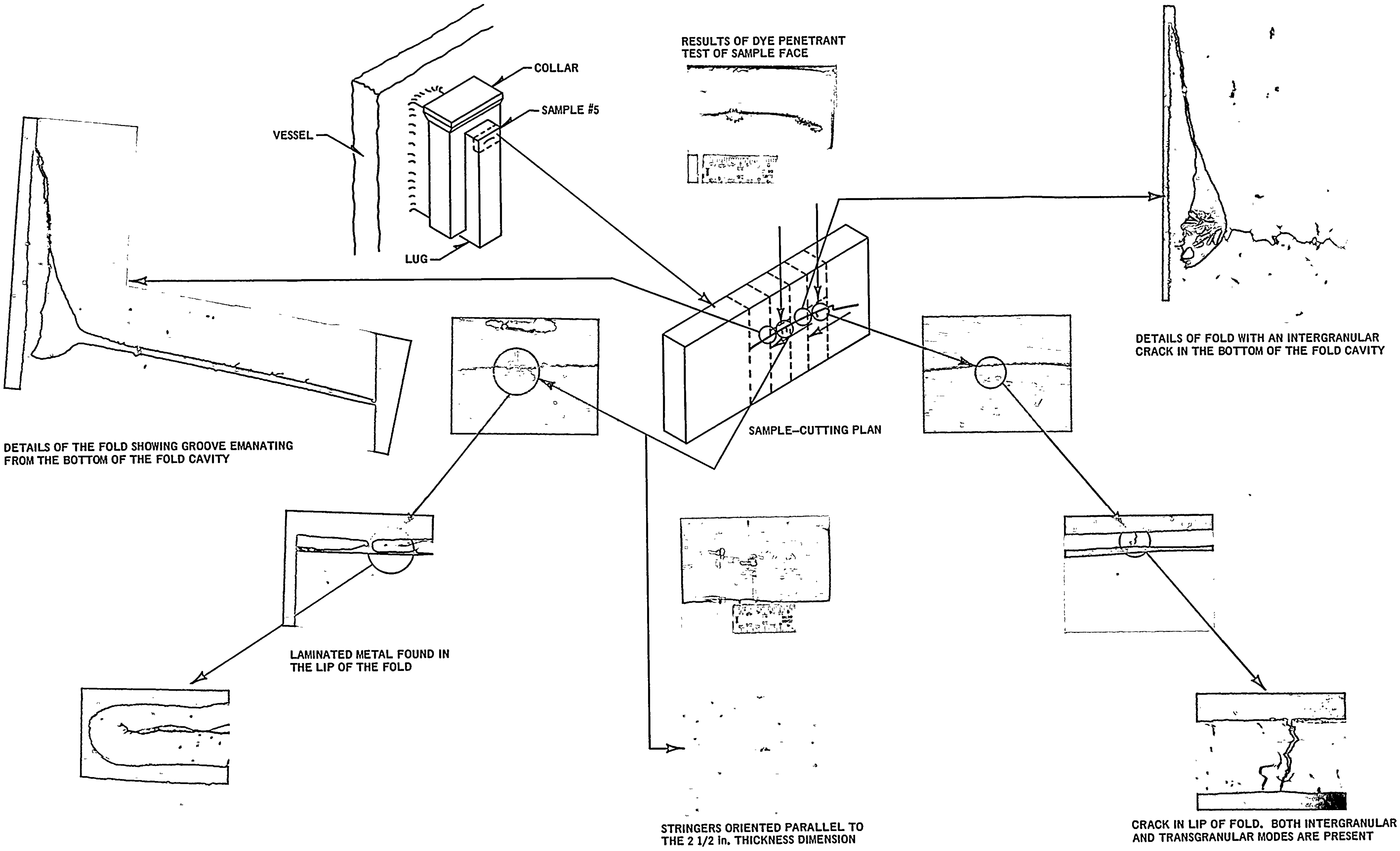


FIGURE C-7. METALLOGRAPHY OF SAMPLE NO. 5
STEAM DRYER SUPPORT BRACKET—
50° LOCATION
BAR SAMPLE

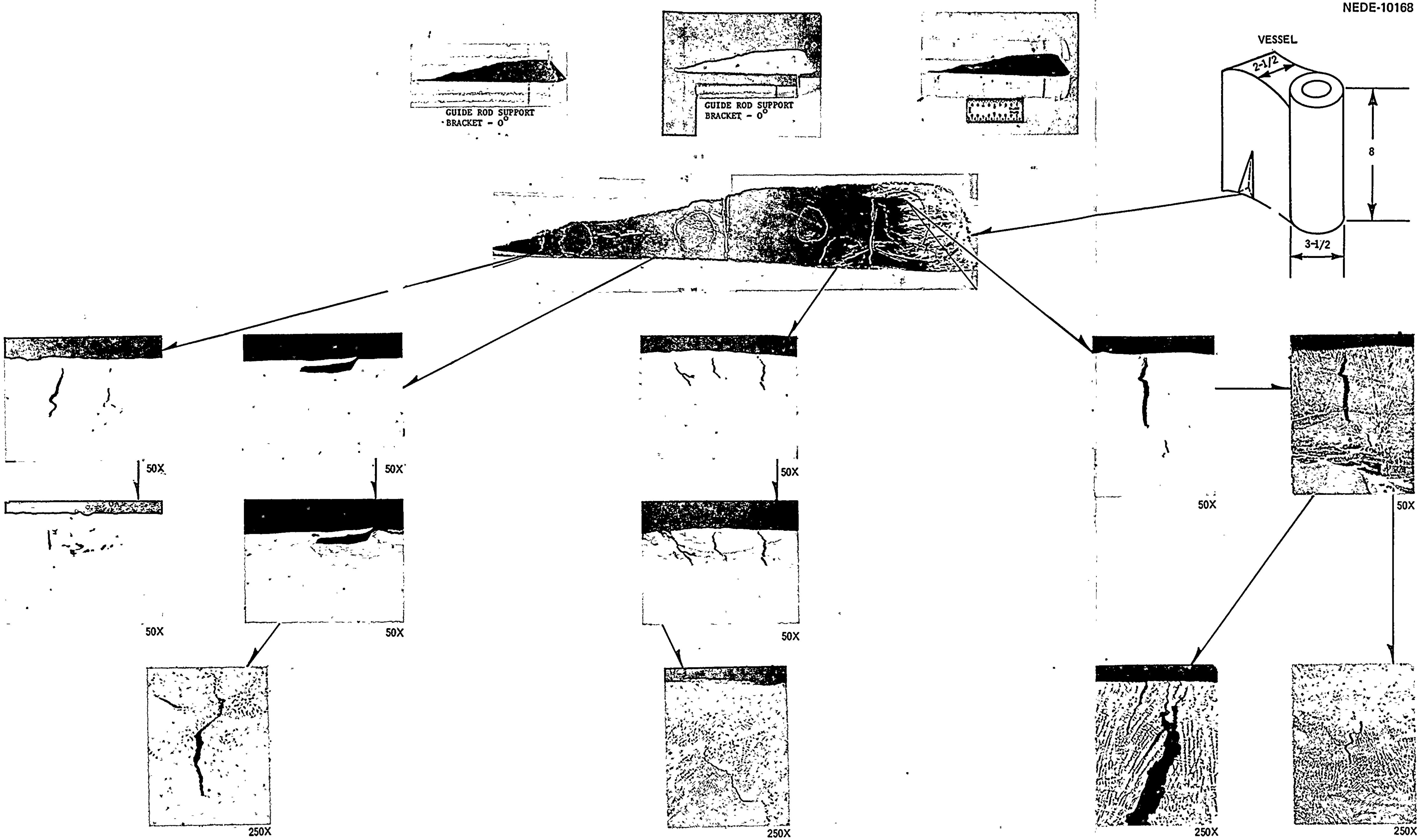


FIGURE C-8. METALLOGRAPHY OF SAMPLE NO. 6
GUIDE ROD SUPPORT BRACKET–0°
WEDGE SAMPLE

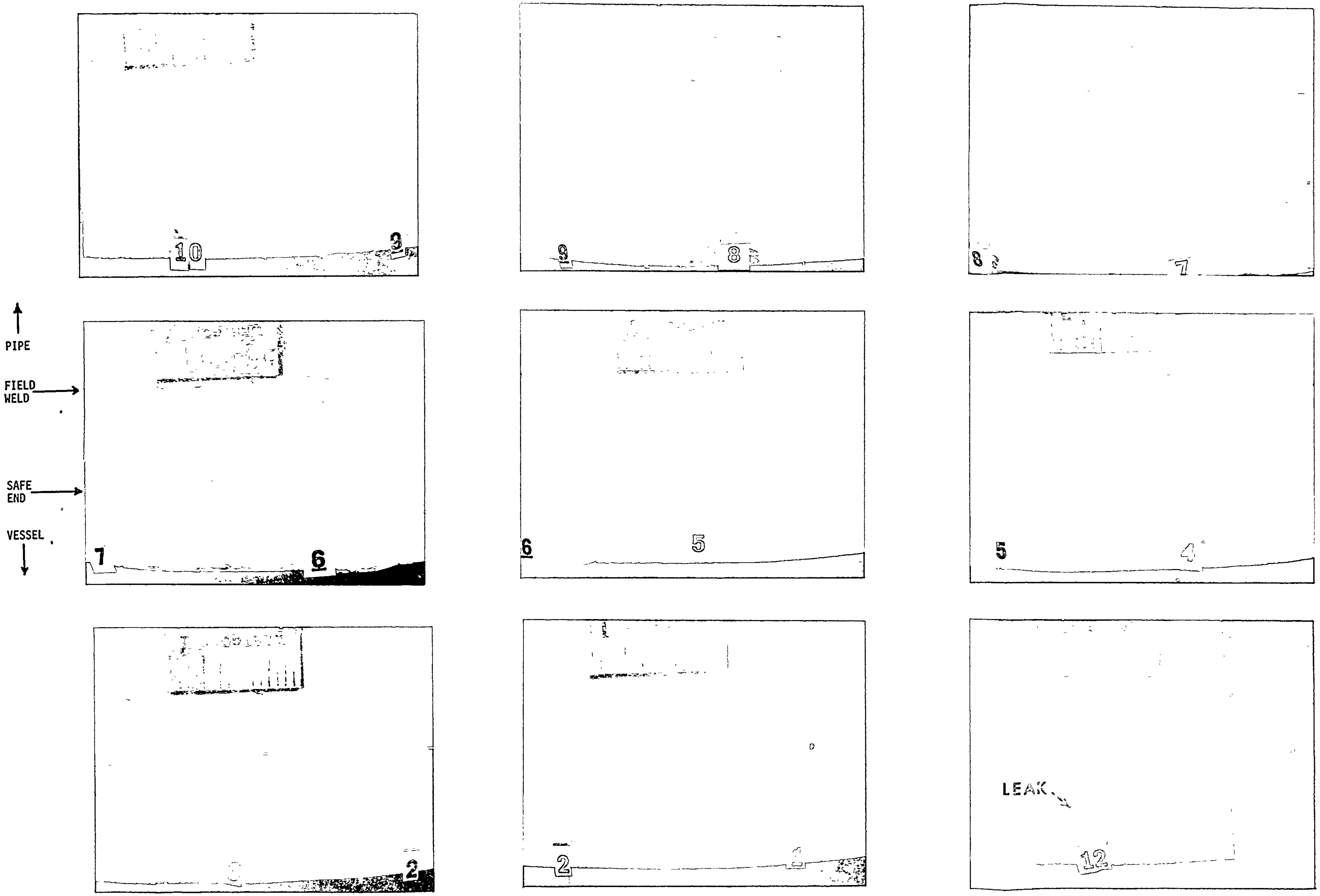


FIGURE C-9. LIQUID PENETRANT RECORD, AS RECEIVED, SAMPLE NO. 1, O (O.D.), CORE SPRAY NOZZLE SAFE END N6B. Photos 50-54B, C, D, E, F, G, H, J, K.

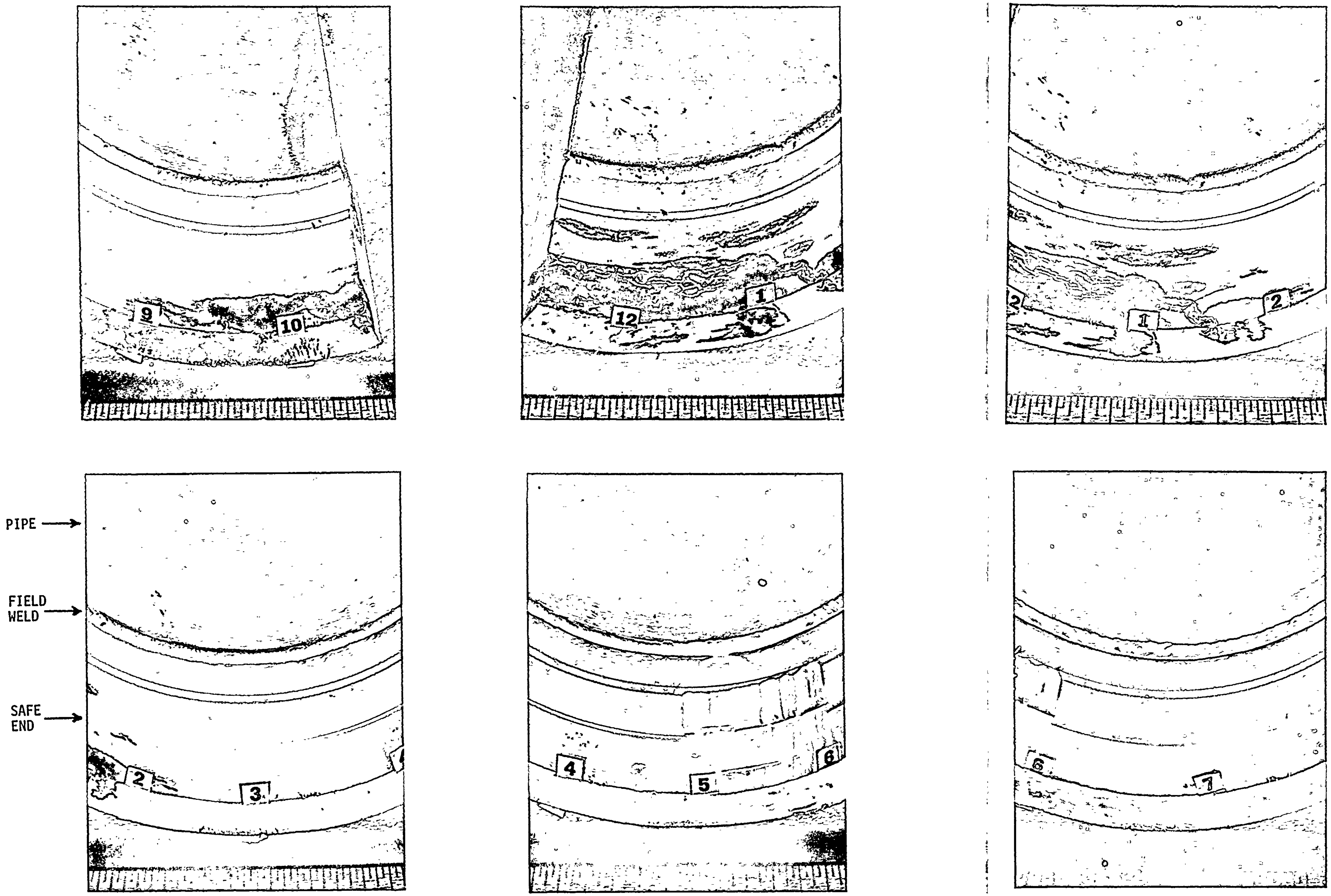
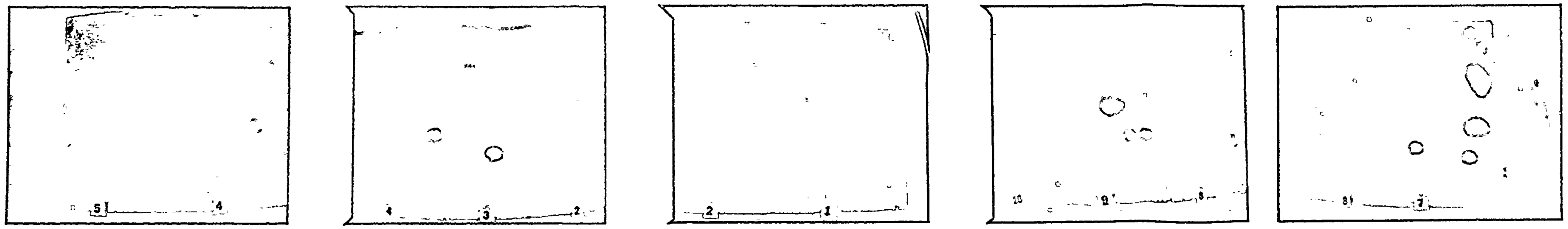
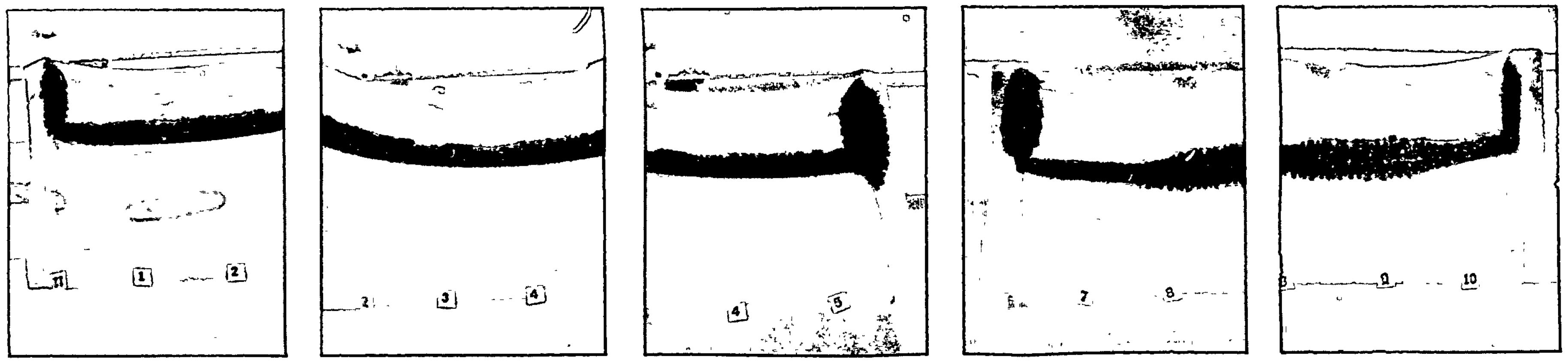


FIGURE C-10. LIQUID PENETRANT RECORD, AS RECEIVED, XAMPLE NO. 1, (I.D.), CORE SPRAY NOZZLE SAFE END N6B. Photos 50-53G, A, B, C, D, E.



OUTER SURFACE



INNER SURFACE

FIGURE C-11. DYE PENETRANT TEST OF SAMPLE NO. 3, I.D. AND O.D.

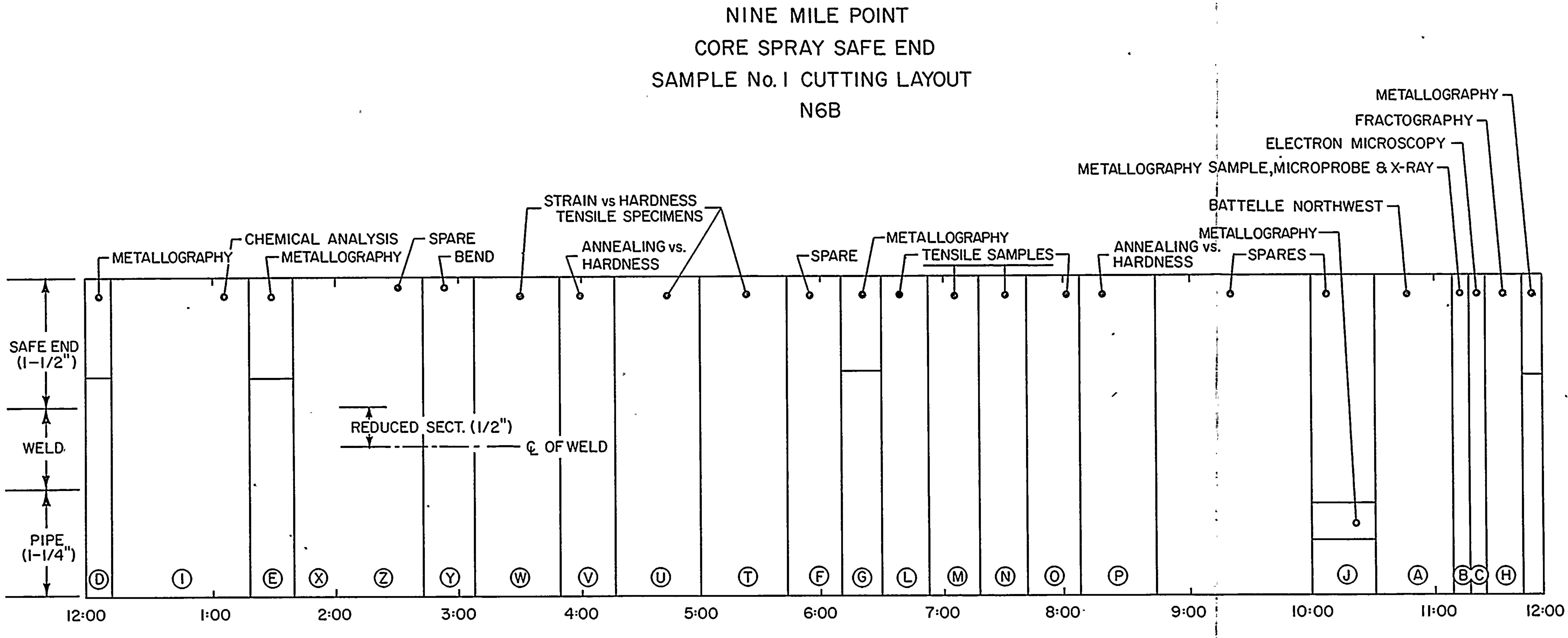
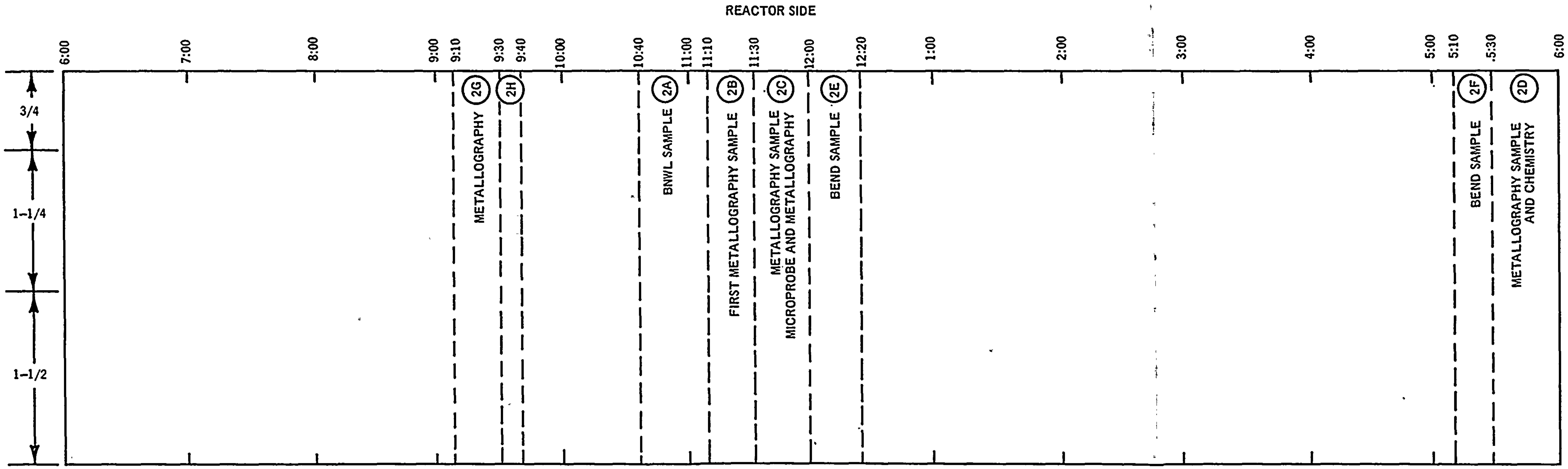


FIGURE C-12. SAMPLE NO. 1 CUTTING LAYOUT (LOOKING AT O.D.)



MAP OF OUTSIDE SURFACE OF SECOND PIECE OF NINE MILE POINT CORE SPRAY SAFE END

3-27-70

FIGURE C-13. CUTTING SAMPLE LAYOUT NO. 13

APPENDIX D
SAFE END REPAIR

The following items comprise Appendix D.

Specialty Shop Fabrication Procedure, Revision 0, March 31, 1970

Partial Safe End Removal, Nozzle N6B, Procedure 1, Revision 0, March 13, 1970

Specimen Removal from Isolation Condenser, Procedure 2, Revision 0, March 19, 1970

Removal and Replacement of Core Spray Nozzle Safe End, Procedure 3, Revision 1, April 15, 1970

Supplement to Procedure 3, Revision 1

Welding Procedure NMP-4, Revision 0

Welding Procedure NMP-5, Revision 0

Penetrant Test Code Acceptance NMP-6, Revision 0

Radiography Procedure NMP-7, Revision 0

Removal and Replacement of Core Spray Nozzle Safe End N6A, Procedure 9

Specialty Shop Fabrication
Procedure No. 1
Revision 0
Date: March 31, 1970

SPECIALTY SHOP FABRICATION PROCEDURE INCONEL WELD OVERLAY ON AUSTENITIC STAINLESS STEEL SAFE ENDS FOR PRESSURE VESSELS

1.0 Scope

1.1 This shop fabrication procedure covers Inconel weld overlay on austenitic stainless steel replacement safe ends for pressure vessel nozzles.

1.2 This procedure is to be used with approved detail drawings and Engineering Instructions applicable to a specific project pressure vessel.

2.0 Applicable Documents, Codes and Standards

2.1 ASME B&PV Code Section III 1968 Edition with Addenda through June 30, 1969.

2.2 GE APED P50YP105 *Arc Welding of Nickel and Nickel Base Alloys.*

2.3 GE APED P8BYP46 *Welding Procedure Specification.*

2.4 GE APED 21A8592 *Ultrasonic Examination of Pipe and Safe End Welds.*

2.5 GE APED 21A8570 *Special Liquid Penetrant Examination for Intergranular Corrosion.*

3.0 Filler Materials

Electrodes for SMAW shall be 5/32-inch or 1/8-inch Inconel 182 except in some cases where weld repair is performed using Inconel 82 as described under repairs and may also be used for buildup of additional layers over deposited Inconel 182 only.

4.0 Cleaning

Prior to welding, swab the parts to be welded with a clean cotton cloth saturated with acetone. All surfaces of the part shall be cleaned. Be careful to remove all traces of dirt, grease, oil, and liquid penetrant materials.

5.0 Runoff Rings or Pads

Where applicable, use runoff rings or pads.

6.0 Weld Overlay

6.1 Welding shall be conducted in accordance with 2.2 and 2.3.

6.2 Apply a minimum of three or more layers of overlay using SMAW. Additional layers may be applied using GTAW. Process variables for SMAW overlay welding are as follows:

6.2.1 Weld current 75-95 amperes. Travel speed as required to maintain a weld width of 1/4 inch to 3/8 inch. Do not weave and angle rod into the puddle 15 to 20 degrees from perpendicular. Fixture the part so that the overlay weld can be applied in the flat position. Start and stop off the weld wherever possible. After applying each bead grind the entire surface of the weld removing all ripples and grinding out the start and stop of the weld. Check the interpass temperature with a contact pyrometer. The interpass temperature must be kept below 250°F.

7.0 Weld Inspection

7.1 Liquid penetrant inspection of weld and adjacent austenitic stainless steel shall be conducted using techniques and material prescribed in 2.5. Acceptance standards shall be per 9.1.

7.2 Ultrasonic examinations of the weld and adjacent austenitic stainless steel shall be conducted using 2.4 as a guide except that application does not preclude inspection following hydrostatic testing nor access to inside of pipe or safe end. Acceptance standards shall be per 9.2.

7.3 Radiographic examination of the weld shall comply with N-624 of 2.1 with acceptance standards as prescribed therein.

8.0 Repairs

8.1 Repairs to the first layer must be accomplished with Inconel 182 to prevent hot short cracking. For subsequent passes where the repair is entirely within the 182 overlay, the repair may be accomplished with GTAW using Inconel 82 filler material. All penetrant indications must be removed. Blend all repair areas to reduce the possibility of oxide and/or slag entrapment. All repaired areas shall be re-examined per 7. above.

8.2 Liquid penetrant indications may be ground to a total depth of 2 percent of the uniform wall thickness on cylindrical surfaces and need not be weld repaired provided the indications have been totally removed and the area blended into adjacent surfaces.

9.0 Acceptance Standards

9.1 Liquid Penetrant Examination Acceptance Standards

9.1.1 Relevant indications of any cracks or linear indications are unacceptable.

9.1.2 Rounded indications with dimensions greater than 1/16 inch are unacceptable.

9.1.3 Four or more rounded indications in a line separated by 3/16 inch or less are unacceptable.

9.1.4 Ten or more rounded indications with dimensions over 1/64 inch in any 6 square inches of surface with the area taken in the most unfavorable location relative to the indications under elevation are unacceptable.

9.2 Ultrasonic Examination Acceptance Standards

9.2.1 A calibration block shall be prepared of like materials weld overlayed to the same thickness as on the piece under examination and having the same angle between the overlay surface and examining surface as is on the piece under examination with sufficient surface to permit calibration. The reference standard shall be a 1/16-inch diameter flat bottom hole with the bottom of the hole located in the plane of the bond line between the Inconel weld and austenitic stainless steel. The hole shall be drilled from both sides; e.g., through overlay to bond line and through stainless steel to bond line. Any indications greater than the reference standard indications, using both straight and angle beam examinations shall be reported and locations recorded.

9.2.2 Remainder of the weld shall be examined per 2.4. Any indications shall be evaluated as prescribed in 2.4.

9.2.3 The need to repair shall be resolved upon evaluation of indications and review of results by knowledgeable engineering and manufacturing personnel.

STANDARDS GENERAL ELECTRIC
ATOMIC POWER EQUIPMENT DEPARTMENT
PROCESSES SPECIFICATION - GENERAL

SPEC NO.	P50YP105	REV. NO.	0
SH NO	1	CONT ON SHEET	2

ARC WELDING OF NICKEL AND NICKEL BASE ALLOYS

REFERENCE DOCUMENTS

GE-APED E5DYP4 - "Liquid Penetrant Inspection"

ASME Boiler and Pressure Vessel Code Section IX

1.0 SCOPE

1.1 This specification defines the requirements for the arc welding of nickel and nickel base alloys, Inconel 600, Inconel X750, Inconel 718, and Incoloy 800 to each other or to austenitic stainless steels, 302, 304, 304L, 308, 316 and 316L.

2.0 PROCESS REQUIREMENTS

2.1 Filler Material

Covered welding electrodes or bare filler metal for the combination of materials to be joined shall be as follows:

Base Materials	Filler Material
Inconel 600, Incoloy 800 to Inconel 600, Incoloy 800, AISI Type 302, 304, 304L, 316, 316L	Inconel Welding Electrode 182 or Inconel Filler Metal 82
Inconel X-750 to Inconel X-750	Inconel Filler Metal 69
Inconel X-750 to AISI Type 302, 304, 304L, 316, 316L	Inconel Filler Metal 82
Inconel 718 to Inconel 718	Inconel 718 Filler Metal

2.2 Base Material

2.2.1 Inconel X-750 shall be in the solution heat treated or equalized condition prior to welding. Incoloy 800 shall be in the annealed or as extruded condition prior to welding.

2.2.2 Where flame-powder cutting or carbon arc gouging is used to prepare weld joints, a minimum of 1/32" of material shall subsequently be removed from weld joint surfaces by machining or grinding.

2.2.3 The weld joint, the base material for a distance of 6" from the weld, surfaces which exceed 500°F during welding, and filler material shall be free of moisture, oil, grease, oxides and all foreign materials.

2.3 Welding

2.3.1 Welding shall be performed by the gas tungsten arc, gas metal arc, or shielded metal arc processes.

2.3.2 Weldor and welding procedures shall be qualified in accordance with Section IX of the ASME Boiler and Pressure Vessel Code, or Engineered approved alternate.

2.3.3 All flux, slag, and oxide shall be removed between weld passes. Any cracks, porosity, or blow holes that appear on the surface of any weld shall be removed by grinding or machining before depositing the next bead. Tack welds which are incorporated in the weld shall be completely fused.

2.3.4 Double welded, full penetration joints shall be back grooved to sound metal, and the resulting cavity shall be examined in accordance with GE-APED Test Method, E5DYP4, "Liquid Penetrant Inspection".

2.3.5 Repair of completed welds by rewelding requires proper authorization. Repair shall be made and reinspected in conformance to this specification. Complete removal of defects shall be determined by liquid penetrant inspection prior to rewelding. Repeated repairs in excess of two in any one area shall be subject to approval by engineering for the effect of grain coarsening on the serviceability of the material.

2.4 Post Weld Heat Treatment

2.4.1 Inconel 718 to Inconel 718 welds shall be post weld heat treated at 1325°F $\pm$25° for 16 hrs and furnace cooled.

3.0 REQUIRED ATTRIBUTES

3.1 There shall be complete fusion between the weld metal and base metal and between successive passes throughout the joint.

3.2 Full penetration joints shall have sound weld metal throughout the base metal thickness and shall not fall below the full section at any point.

3.3 Partial penetration welds with groove angles greater than 70° shall have penetration through the depth of the groove. Groove angles less than 70° shall have penetration to within 1/16 inch of the groove depth.

3.4 Fillet welds penetration shall be to the root.

3.5 Surfaces heated during welding shall not be blackened or have loosely adhering oxides.

3.6 The weld, including the backside shall blend smoothly into the base metal with no visible undercutting or overlapping and shall be reasonably smooth and regular without pronounced protrusions and depressions.

3.7 The weld and base metal shall be free of solidified slag and weld splatter.

3.8 The weld shall be free of cracks, porosity or blow holes as determined by visual examination.

3.9 Weld dimensions shall be in accordance with the drawing requirements. The leg size of fillet welds shall be equal to or larger than the size specified on the drawing but shall not exceed minimum dimensions to such an extent as to cause interference with mating parts or excessive warpage or distortion.

GENERAL ELECTRIC

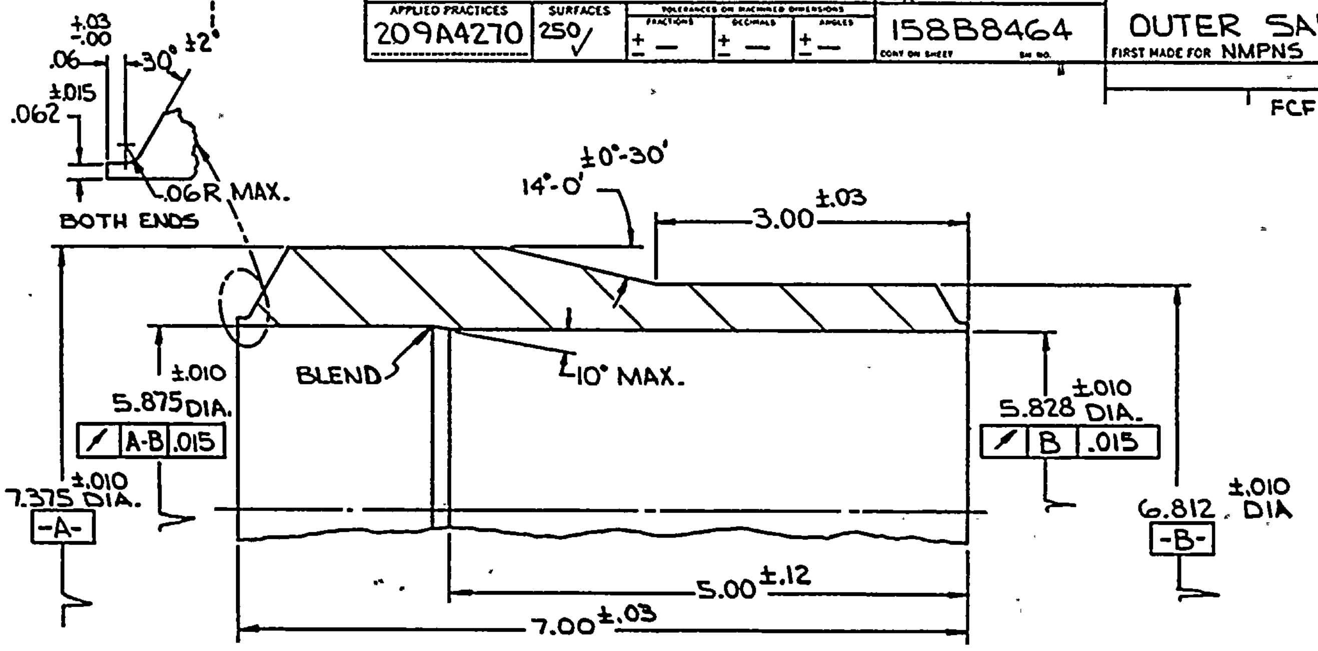
UNLESS OTHERWISE SPECIFIED USE THE FOLLOWING:

APPLIED PRACTICES	SURFACES	FRACTIONS	DECIMALS	ANGLES	REV	DWG NO.
209A4270	250 √	± —	± —	± —	A	158B8464

TITLE: OUTER SAFE END

FIRST MADE FOR NMPNS REPAIRS

FCF- 922D131



(1) MAKE FROM FORGING AS SUPPLIED PER P.O. NO. 205-AC 880

MAT'L- ASTM ASME SA-182 F-304L

REVISIONS

A PRE-PRODUCTION ISSUE

PRINTS TO

R. Coste MAR 24, 1970	3-27-70	3-26-70	APED SAN JOSE	158B8464

CHK'D- R

R

D-9

NEDE-10168

GENERAL ELECTRIC

UNLESS OTHERWISE SPECIFIED USE THE FOLLOWING—				
APPLIED PRACTICES	SURFACES	TOLERANCES ON MACHINED DIMENSIONS: FRACTIONS	DECIMALS	ANGLES
209A4270	125/	+ —	+ —	+ —

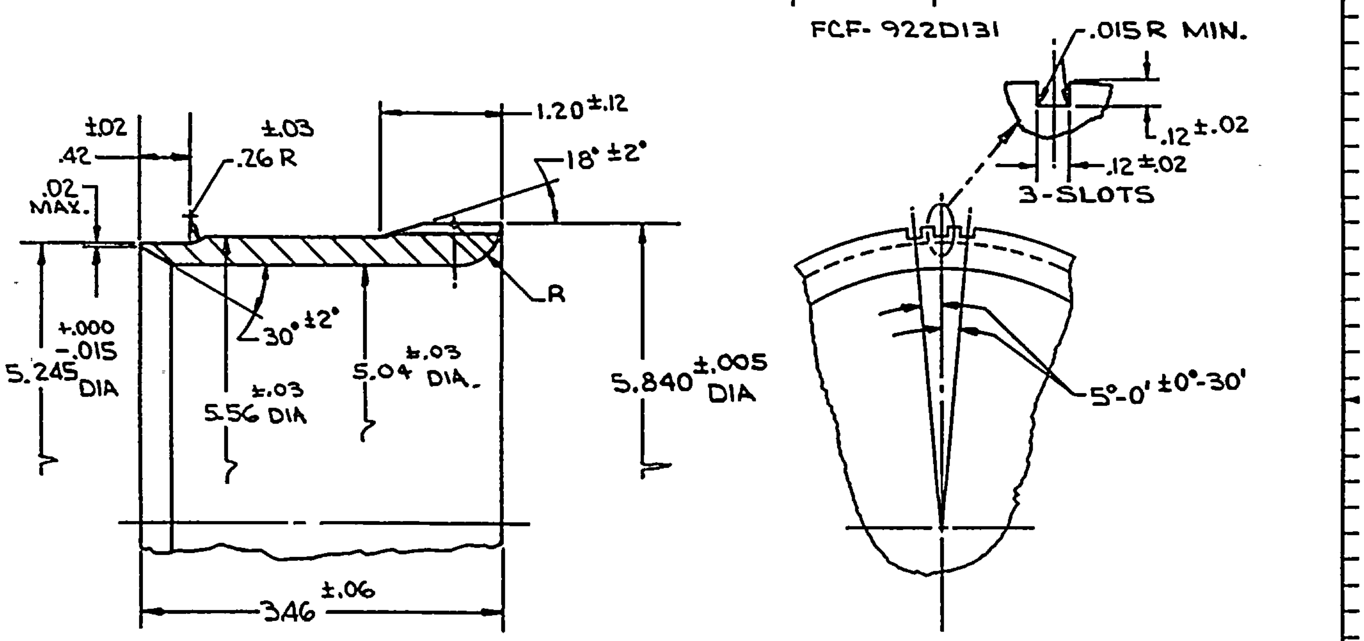
REV KBC

158B8465

TITLE: SLEEVE END REPLACEMENT

FIRST MADE FOR NMPNS REPAIRS

FCF- 922D131



(1) MAKE FROM FORGING AS SUPPLIED PER P.O. NO. 205-AC880

MAT'L- ASTM ASME SA-182 F-304L

REVISIONS	PRINTS TO
A PRE-PRODUCTION ISSUE	
B R Coste 4-8-70 M H.H.T. ADDED 3-SLOTS CHKD Ron	
C R Coste 4-8-70 M H.H.T. 5.245 DIA WAS 5.370, 3.46 WAS 3.50, .42 WAS .50 CHKD Ron	

R Coste MAR 23, 1970

H.H. Thiel 3-27-70

APPROVALS 3-26-70

APED

SAN JOSE

158B8465

CHK'D- Ron

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D-10

NEDE-10168

GENERAL ELECTRIC

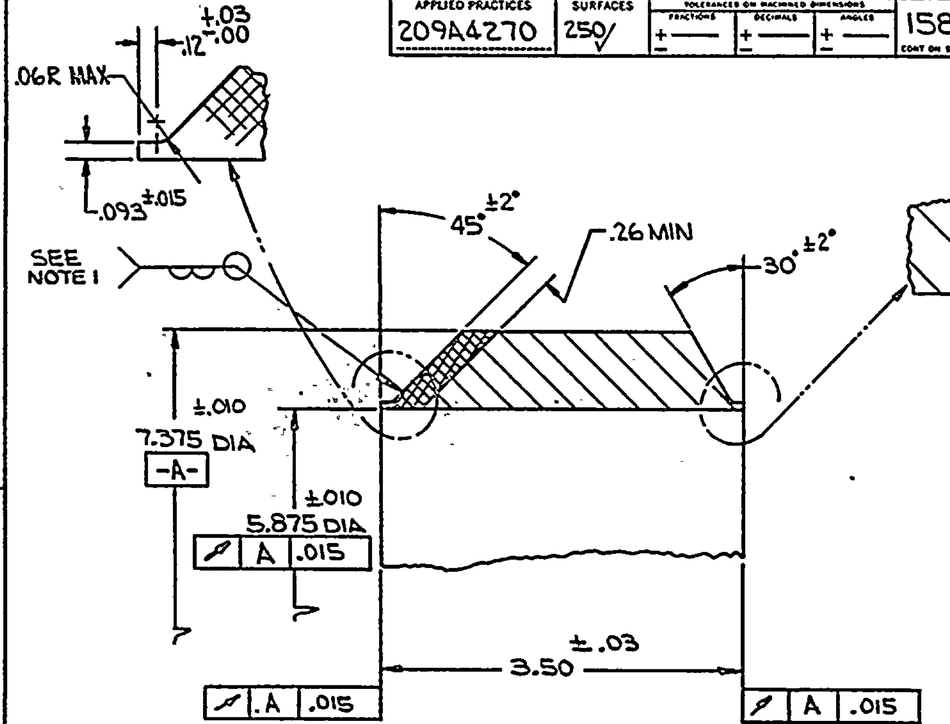
UNLESS OTHERWISE SPECIFIED USE THE FOLLOWING:			
APPLIED PRACTICES	SURFACES	TOLERANCES ON MACHINED DIMENSIONS	
209A4270	250/		

REV A 158B8463

TITLE: INNER SAFE END

FIRST MADE FOR NMPNS REPAIRS

FCF-922D131



NOTES:

1. WELDING SHALL BE IN ACCORDANCE WITH G.E. APED P50YP105 "ARC WELDING OF NICKEL & NICKEL BASE ALLOYS". THE WELDING PROCEDURE SPECIFICATION GOVERNING WELDING IS G.E. APED IS P8BYP46.
2. SOLUTION HEAT TREAT AFTER WELDING & PRIOR TO FINAL MACHINING. HEAT TO 1950°F ±50°F. HOLD AT THIS TEMP. FOR 1½ HOURS. QUENCH FROM THIS TEMP. IN COLD POTABLE WATER (30 GAL. MIN. CAPACITY OF QUENCH TANK EST.).

(1) MAKE FROM FORGING AS SUPPLIED PER P.O. NO. 205-AC880
MAT'L - ASTM ASME SA-182 F-304L

REVISIONS	PRINTS TO
A PRE-PRODUCTION ISSUE	

MAR 24, 1970 — 3-27-70 — 3-26-70

APED SAN JOSE — 158B8463

CHKD-

R

D-11

NEDE-10168

P 8BYP46, Rev. 0

STANDARDS

PROCESSES

DETAIL WELDING PROCEDURE

BUILD-UP

GROUPING - 8-43.4-SMAW-2

ISSUED 12-6-68

ENGINEERING

BASE METAL: 304 Stainless Steel

WELDED TO - Inconel 182 Overlay

ASME SECT. IX: P# 8 TO P# 43.4

G.E. SPEC. ______ TO ______

WELDING MATL: ASME SB295 E-Ni-Cr-Fe-3

ASME SECT. IX: F# 43.4

SHLD. GAS ______

CONSUM. ISR. RING: ______

FLUX: ______

WELDING PROCESS: Manual Shielded Metal Arc Welding

PRE-HEAT & INTERPASS TEMP (°F): 40°F minimum preheat, 250° maximum interpass

POST-WELD HEAT TREAT: ______

THICKNESS: 3/8 inch MIN. Unlimited MAX.

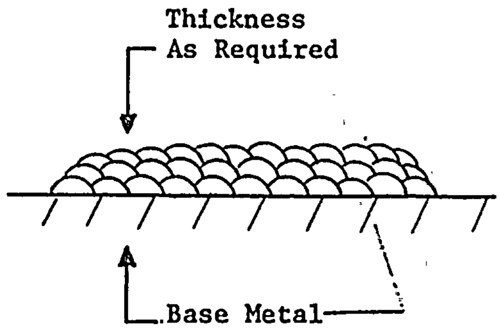
APPLICABLE GEN. WELD PROC. P50YP105

BACKING STRIP ☐ YES ☒ NO

ADDITIONAL REQUIREMENTS Welding Positions - Flat.

(See back of page for other requirements

WELD JOINT



GAP: ______

MISMATCH: ______

MANUFACTURING

WELDING PROCESS						
PASS NO.						
TRAVEL SPEED (IN./MIN)						
CURRENT (AMPS OR WES)						
ELECTRODE POLARITY						
ARC LG (VOLTS OR IN.)						
TORCH GAS (C.F.H.)						
BACKING GAS						
CUP SIZE						
TRAILING SHIELD						
ELECTRODE/WIRE DIA.						
ELECTRODE EXT.						

ADDITIONAL INSTRUCTION ______

REPAIR WELDING ______

(SEE REVERSE SIDE

PROCEDURE QUALIFICATION NO. P8BYP46

DISTRIBUTION S2A

DEC 30 1968

P8BYP46, Rev. 0 Side 2

Additional Requirements (continued)

1. All starts and stops, including starts and stops for tack welds, shall be removed and blended with a power grinder or rotary file prior to re-welding.

2. Each weld bead shall be thoroughly cleaned of slag and blended into adjacent metal with a power grinder or rotary file prior to depositing subsequent beads.

   a. Major slag on weld crown may be removed by chipping-hammer, chisel or impact type guns.

   b. Slag at edges of weld beads and slag on rough areas of the weld shall be removed only by grinder or rotary file.

NINE MILE POINT NUCLEAR STATION
NOZZLE N6B
PARTIAL SAFE END REMOVAL PROCEDURE NO. 1, REV. 0

1.0 PREPARATION

1.1 All work and workmen shall conform to NMP radiation control specifications.

1.2 Provide chip retention plastic sheet under working area.

1.3 Provide temporary axial and radial support to limit relative movement during first cut.

1.4 Scribe pipe at quadrants 6" length centered on first cut. Make 6" trammel marks on scribe lines. Record trammel spacing.

1.5 Scribe 12:00 position on safe end to permanently identify orientation of ring to be removed.

1.6 Lower water level of reactor vessel in accordance with NMP Special Operating Procedures.

2.0 REMOVAL OF SPECIMEN IN FOLLOWING SEQUENCE

2.1 Make cut no. 1 per sketch no. 1.

2.2 Release restraint on ELL and measure relative movement. Record.

2.3 RT one shot at field weld.

2.4 Make cut no. 2 per sketch no. 1.

2.5 Measure location of shoulder on i.d. of safe end, and locate cut no. 3 per sketch no. 1.

2.6 Make cut no. 3 per sketch no. 1
NOTE: Do *NOT* make cut no. 4 at this time. See 8.0 below.

3.0 Survey and remove safe end ring to machine shop. At machine shop cut longitudinal slice from ring at approximately 10:00 position. Slice to be approximately 3/8" - 1/2" wide. Prepare both pieces for shipment. Slice goes to AEC. Balance goes to GE.

4.0 Plug i.d. of thermal sleeve with expanding plug. Also provide additional axial support (at least 3 points) to prevent cocking of plug and for additional blow-out support. Also provide tie wire to prevent inward movement of plug.

5.0 Raise water level in accordance with NMP Special Operating Procedure.

6.0 Provide temporary debris barrier near weld inside 6" end of ELL, with cardboard and tape (to prevent chips and debris from entering ELL).

7.0 Prepare the freshly cut end of safe end for PT, UT, and RT, and make these examinations.

8.0 Make cut no. 4 per sketch no. 1. Remove interior barrier. Replace with exterior cap.

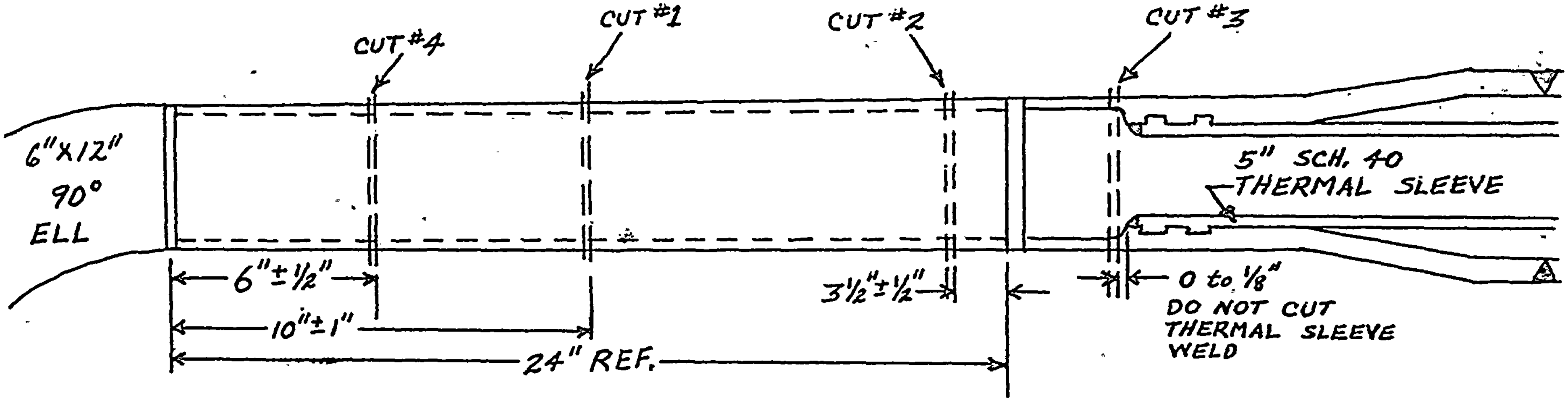
9.0 Make weld preps and reinstall spool piece per later procedures and drawings.

APPROVED:

— —

— —

Rev. 0
3-13-70



SKETCH #1 OF NMP NOZZLE N6B

PARTIAL SAFE END REMOVAL PROCEDURE NO. 1, REV. 1

Procedure No. 2
Revision 0
Date: March 19, 1970

NINE MILE POINT NUCLEAR STATION
SPECIMEN REMOVAL FROM ISOLATION CONDENSER NOZZLE N5A

1. Clean blemish area (10 to 12 o'clock) and adjacent Inconel weld with Kotex moistened with acetone.

2. Etch three (3) spots adjacent to the blemish to identify the toe of the Inconel/stainless steel weld. Use the following procedure for etching:
   a. Prepare a saturated solution of oxalic acid in demineralized water, 90°F to 130°F.
   b. Clamp the positive terminal of a 6 volt battery to the nozzle.
   c. Attach the negative terminal of the battery to a one-half (1/2) inch diameter copper disk. Use a long enough lead for easy manipulation.
   d. Saturate a cloth pad, 1/2 inch to 1 inch diameter, with oxalic acid and place it on the weld joint with the copper disk on the back of the pad.
   e. Press down lightly on the copper disk and saturated pad while scrubbing in a small area. Keep the area small and wet with acid. Scrub for two (2) to five (5) minutes as needed.
   f. Wash the entire area with demineralized water and dry with Kotex after etching is complete. Repeat the washing and drying three times.

CAUTION

For good results use a strong battery and keep the pad saturated. Do not allow any drip or contact of the etchant to any other materials. In case of spills wash three times as described in f.

3. Lightly scribe a line through the etched areas to identify the approximate Inconel/stainless junction (interface).

4. Lightly scribe a parallel line on the stainless steel safe end one-quarter (1/4) inch from the Inconel/stainless steel weld. The one-quarter (1/4) inch wide zone is a safety barrier. No cuts shall be made within one-quarter (1/4) inch of the Inconel weld.

5. Prepare a 45 degree cutting guide for a normal hand hacksaw. The cuts should be centered on the blemish or at least one-quarter (1/4) inch from the Inconel weld. The cuts shall be started three-quarters (3/4) inch apart and angled toward each other. The cuts are intended to go three-eighths (3/8) inch deep plus the blade kerf. The total depth of material removed shall not exceed one-half (1/2) inch. Alternate cutting from one side to the other to assure no over-cutting.

6. Clean the entire area with Kotex and acetone.

Procedure No. 3
Revision 1
Date: April 15, 1970

NINE MILE POINT NUCLEAR STATION
REMOVAL AND REPLACEMENT OF CORE SPRAY NOZZLE SAFE END

1.0 Scope

1.1 This procedure specifies the technical requirements for the removal and replacement of core spray nozzle safe ends and the removal and replacement of portions of the core spray nozzle thermal sleeve to facilitate access for safe end replacement. It is necessary to remove and replace certain portions of the core spray piping to gain access for removal and replacement of the safe end.

1.2 The following General Electric Company drawings are a part of, and are to be used with this procedure:

922D131	Core Spray Nozzle N6B Safe End Replacement
158B8462P1	Centering Sleeve
158B8463P1	Inner Safe End
158B8464P1	Outer Safe End
158B8465P1	Sleeve End Replacement
209A7152	Consumable Insert

1.3 References are made to the following additional documents:

A. Procedure No. 1 — Nine Mile Point Nuclear Power Station, Partial Safe End Removal — Nozzle N6B.

B. Procedure No. 2 — Nine Mile Point Nuclear Power Station, Specimen Removal from Emergency Condenser Nozzle N5A.

C. 21A8570 — Special Liquid Penetrant for Intergranular Corrosion.

D. Rework Procedure No. NMP-4 — General Welding Procedure for Inconel 600, Inconel 182, Inconel 82.

E. Detail Welding Procedure NMP-4A.

F. Rework Procedure No. NMP-5 — General Welding Procedure for Welding Stainless Steel.

G. Detail Welding Procedure NMP-5A.

H. Detail Welding Procedure NMP-5B.

I. Rework Procedure No. NMP-6 — Standard Liquid Penetrant Examination for ASME Code Acceptance.

J. Rework Procedure No. NMP-7 — General Radiography for welds.

K. 21A8592 — Ultrasonic Examination of Pipe and Safe End Welds.

2.0 Safe End Removal and Replacement

2.1 Before cutting pipe or safe end or machining weld preps on remaining fixed ends of piping and nozzles in situ, adequate provisions must be made to provide for cleaning the vessel and piping to remove all chips, debris, fluids used in machining, if any, inspection fluids, etc.

2.2 Before any welding is done and before surfaces are covered so as to prevent cleaning, the surfaces in the vicinity of the welding and surfaces to be covered shall be thoroughly cleaned with either isopropyl alcohol or acetone and completely dried.

2.3 No welding, cutting or metal removal is to be performed closer than 1/8 inch away from the low alloy steel portion of the vessel nozzles.

2.4 Sequence of Work

Note: ◯ indicates sequence on Drawing 922D131.

A. Cuts number 2 and number 3, completed in accordance with reference 1.3A, and plugs are installed in thermal sleeve to prevent entry of dirt into reactor.

B. Locate cut number 5 as shown. Cut number 5 may be located closer to vessel to clear rolled-in portion of sleeve. Use abrasive cut off unit with internal attachments and make cut without coolant or lubrication at cut. Vacuum away all chips and debris before, during and after cutting.

CAUTION

Ventilating air pressure shall be equalized between reactor vessel interior and drywell region in way of this nozzle during this and all remaining sequences of work.

Next, locate the junction between the Ni-Cr-Fe shop weld and the sensitized stainless steel safe end at three equally spaced positions, using the procedure described in paragraph 2 in Reference 1.3B. Scribe a line through each etched area where Ni-Cr-Fe to stainless steel junction occurs, and completely around the nozzle, thus locating cut number 6. Scribe a line along the top of 12 o'clock position of the sensitized stainless steel safe end. Make cut number 6 using abrasive cut-off unit without coolant or lubrication. Cut number 6 should be made as concentric with nozzle o.d. as practical, and should not cut into the Ni-Cr-Fe shop weld. Abrasive cut off should proceed until all but 1/16 inch of sensitized stainless steel safe end wall remains. Vacuum away all chips and debris. Cut number 6 should then be completed using a cold chisel. Save safe end just removed for separate handling instructions.

C. Vacuum and clean o.d. of sleeve. Inventory fiber glass rope. Use one continuous length of rope. Carefully insert rope into gap between sleeve and nozzle. Insert only far enough to just clear centering sleeve. Note position of end of rope for later removal. Measure o.d. of sleeve for use in finish machining of centering sleeve. Make cut number 7 as close as practical to cut number 6, using abrasive cut-off unit without coolant or fluids of any kind. Vacuum away all chips and debris during the following cut. Save portion of sleeve just removed for separate handling instructions. Locate junction of Ni-Cr-Fe shop weld and low-alloy steel nozzle. It may be necessary to wire brush this area to remove paint so that the junction can be clearly seen for entire circumference. Locate cut number 8 from this junction. Make cut number 8 using abrasive cut-off unit with internal attachments, using no coolants or liquids. Vacuum away all chips and debris during and following this operation. Take care not to cut into nozzle cladding or shop weld at any location. Save portion of sleeve just removed for separate handling instructions. Measure i.d. of nozzle to determine smallest i.d. Use this dimension together with dimension between cut number 6 and cut number 8 and complete machining of centering sleeve.

Locate junctions of Ni-Cr-Fe shop weld and stainless steel cladding and remaining safe end on nozzle i.d., using procedure described in paragraph 2 in Reference 1.3B. Be very careful to avoid any excess of oxalic acid at any time to prevent entry into gap between sleeve and nozzle. Report results. Measure and record location of these junctions relative to the Ni-Cr-Fe shop weld to low-alloy steel junction. Clean and dry etched area thoroughly. Examine existing Ni-Cr-Fe shop weld using radiographic, ultrasonic and liquid penetrant examinations, and report these results. Install centering sleeve and tack weld as shown on drawing, then tack weld sleeve to centering sleeve (not shown on drawing).

D. Machine counterbore in sleeve. Use no coolants or cutting fluids of any kind. Liquid penetrant examine machined surfaces. Surfaces so examined shall be free of any crack-like indications and indications of porosity. Carefully remove tack welds holding centering sleeve in place and remove centering sleeve.

E. Before proceeding with machining, results of examinations of the Ni-Cr-Fe shop weld under C above must be satisfactory to all parties concerned. If repair of the shop weld is indicated, this work shall be done at this time using approved procedures. If no repair is indicated, proceed with machining to produce the weld prep shown on the drawing. Use no coolants or cutting fluids of any kind.

NOTE

This is the first portion of Procedure No. 3. The remaining portions are to be issued as supplements to this procedure.

GENERAL ELECTRIC

UNLESS OTHERWISE SPECIFIED USE THE FOLLOWING:—

APPLIED PRACTICES	SURFACES	TOLERANCES ON MACHINED DIMENSIONS: FRACTIONS	DECIMALS	ANGLES
209A4270	125√	± —	± —	± —

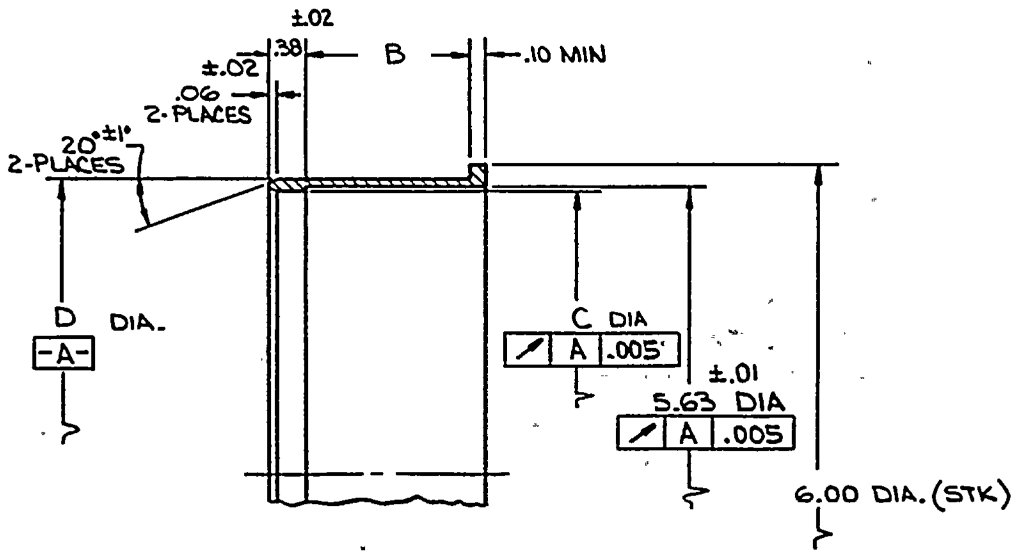
REV A

158B8462

TITLE: CENTERING SLEEVE

FIRST MADE FOR NMPNS REPAIRS

FCF- 922D131



PT. NO.	B ±.03	C DIA ±.01	D DIA ±.01
.1	LENGTH BETWEEN CUT ⌀6 & ⌀8 + .12	O.D. OF SLEEVE +.010	I.D. OF NOZZLE -.010

6.00 O.D X .25 WALL TUBING
MAT'L- ASTM A-269 GR TP-304
OR ENGR. APPROVED EQUIV.

REVISIONS	PRINTS TO
A PRE-PRODUCTION ISSUE	

R. Conte MAR 23 1970

3-31-70

APPROVALS 3-26-70

APED

SAN JOSE

158B8462

CHKD:

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D-24

NEDE-10168

GENERAL ELECTRIC

209A7152
CONT ON SHEET SH NO.

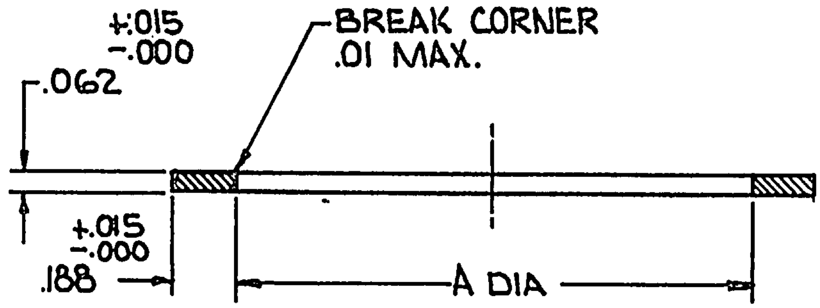
REV NO. A

209A7152
CONT ON SHEET SH NO.

TITLE
CONSUMABLE INSERT
FIRST MADE FOR NMPNS REPAIRS

PURCHASED PART

FCF-P1, P2 & P3 922D131



PT. NO.	A ±.015 DIA.	MATERIAL
1	5.780	ASTM B-304 TYPE ERNI-CR-3
2	5.780	ASTM A-371 TYPE 308L
3	5.734	ASTM A-371 TYPE 308L

NOTE
MATERIAL CERTIFICATION REQUIRED.

UNLESS OTHERWISE SPECIFIED USE	APPLIED PRACTICES	SURFACES	TOLERANCES ON MACHINED DIMENSIONS FRACTIONS	DECIMALS	ANGLES
		250/	±	±	±

REVISIONS

A PRE-PRODUCTION ISSUE

PRINTS TO

MADE BY R. Coate MAR 25, 1970
ISSUED H.H. Thiel 3-27-70
APPROVALS J.K. Robinson 3-27-70
APED DIV OR DEPT
SAN JOSE LOCATION
209A7152
CONT ON SHEET SH NO.

FF-803-F (11-69) CHK'D: Cox.
PRINTED IN U.S.A.

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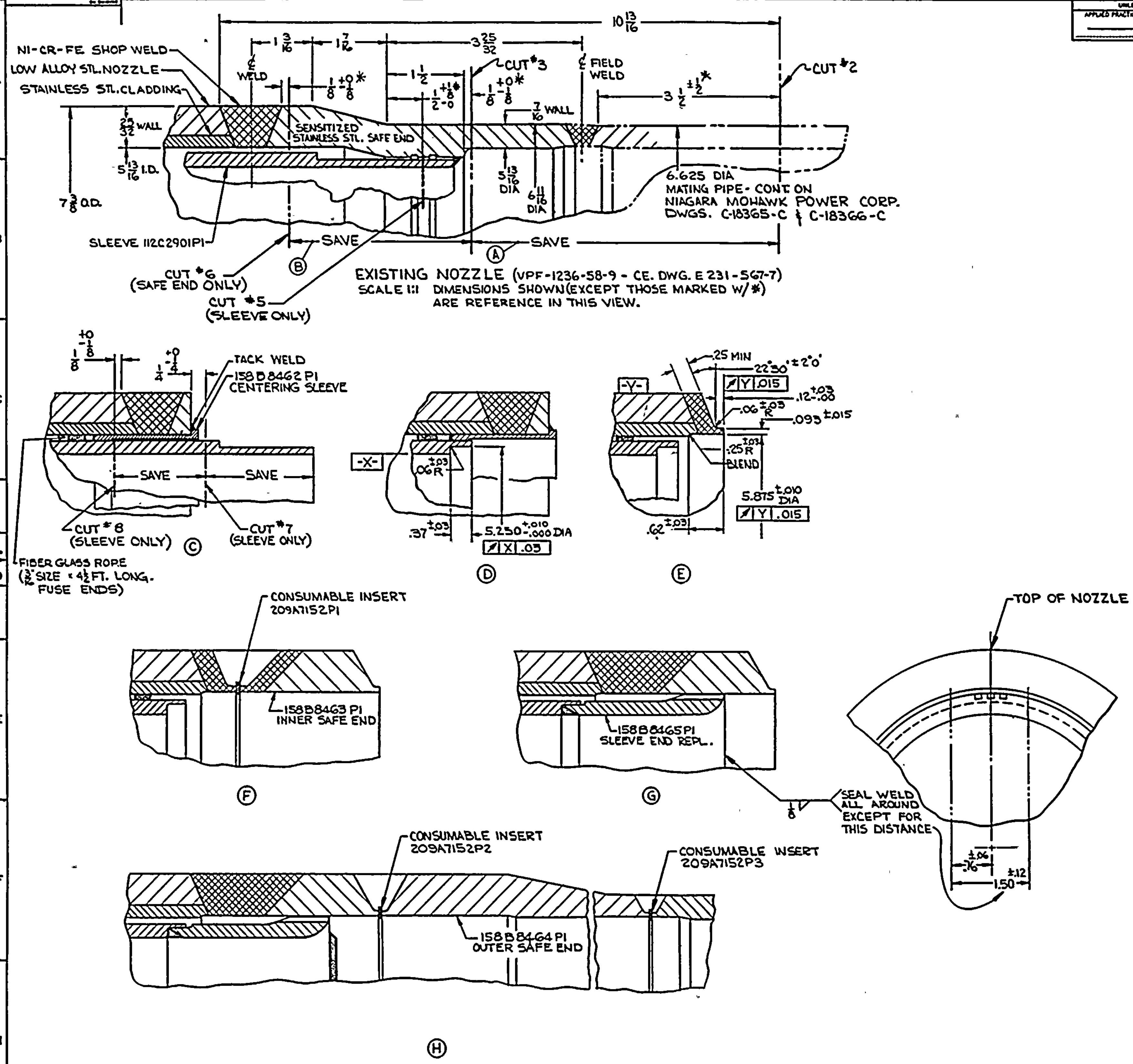


NOTES:

1. THIS DRAWING IS A PART OF AND SHALL BE USED WITH NINE MILE POINT NUCLEAR STATION - REMOVAL & REPLACEMENT OF CORE SPRAY NOZZLE SAFE END - PROCEDURE NO. 3.
2. ALL WELDING PROCEDURES AND WELDER SHALL BE QUALIFIED AS REQUIRED BY THE ASME BOILER & PRESSURE VESSEL CODE SECTION IX WELDING QUALIFICATIONS.
3. ALL MATERIALS USED FOR THIS REPAIR SHALL BE ASME BOILER AND PRESSURE VESSEL CODE MATERIALS GIVEN IN SECTION II. CERTIFIED MILL TEST REPORTS OF ALL MATERIALS ARE REQUIRED.
4. ALL PRESSURE CONTAINING WELDS MADE AS RESULT OF THIS REPAIR AND ALL PRESSURE CONTAINING PARTS THAT REQUIRE DEFECT REMOVAL AND REPAIR TO A DEPTH EQUAL TO OR IN EXCESS OF 3/8" OR 25% OF THE WALL THICKNESS AT THE REPAIR LOCATION WHICHEVER IS THE LEAST SHALL BE RADIOGRAPHED USING TECHNIQUES AND STANDARDS GIVEN IN ASME BOILER AND PRESSURE VESSEL CODE SECTION III.
5. ACCESSIBLE SURFACE OF ALL WELDS, REPLACEMENT MATERIALS AND REPAIRS SHALL BE INSPECTED USING TECHNIQUES AND STANDARDS CONTAINED IN REFERENCE PROCEDURES IN NOTE 1.

GENERAL ELECTRIC

TITLE: CORE SPRAY NOZZLE N6-B SAFE END REPLACEMENT

FIRST MADE FOR NMPNS REPAIRS

UNLESS OTHERWISE SPECIFIED USE THE FOLLOWING: SURFACES 125/; ± 1/16

922D131

REVISIONS

C	ADDED SLOTS & FILLET WELD TO SLEEVE END REPL. CHG'D 5.375 DIA. TO 5.250 +.010 -.000 DIA. IN (D)
A	PRE PRODUCTION ISSUE
B	CHG'D LOC. OF CUT 2 & 3. ADDED CUT 5 & 6. ADDED (C) THRU (H). DELETED SEQUENCE OF WORK & ADDED NOTES 1 & 2

MAR 10, 1970 — 3-13-70 — 3-13-70

APED — SAN JOSE — 922D131

Procedure No. 3
Revision 1
Supplement No. 1
Revision 1
Date: April 15, 1970

NINE MILE POINT NUCLEAR STATION
REMOVAL AND REPLACEMENT OF CORE SPRAY NOZZLE SAFE END

SUPPLEMENT NO. 1

2.4 Sequence of Work (Continued)

F. Fit consumable insert and inner safe end. Arrange back purge so that no weld flux fumes that may be generated enter the inside of the nozzle or replacement safe end. Weld per qualified detailed welding procedure NMP-4A. Continue welding to complete joint in accordance with the welding procedure for that joint. Do not remove back purge barriers until welding is complete; this is to protect inside surfaces from any welding flux fumes.

Weld shall be smoothed for RT, PT and UT examinations.

Radiograph entire weld in accordance with radiography procedure NMP-7.

Liquid penetrant examine weld surfaces and adjacent material for one inch on either side of weld, both inside and outside of nozzle. Liquid penetrant techniques shall be per General Electric Company Procedure NMP-6.

Ultrasonic examination shall be in accordance with N-625 of Section III. Use General Electric Specification 21A8592 for procedure guide.

Exploration of indications as a result of above examinations shall not be attempted until General Electric Company's APED Design Engineering has been appraised of all indications and directions for repair formulated.

After all repair, if required, and upon completion of welding, the weld shall be re-examined by PT, RT and UT as above and, in addition, UT examined and reported per G.E. Specification 21A8592.

Remove shield plug and fiber glass rope that was installed under C and clean sleeve i.d. and end and nozzle i.d. and o.d. thoroughly with isopropyl alcohol or acetone and let dry.

G. Clean sleeve and replacement with isopropyl alcohol or acetone and let dry. Use GTAW process for all sleeve end replacement welding. Fit sleeve end into sleeve socket machined in step D . Use qualified detailed welding procedure NMP-5B and weld sleeve end to sleeve first; then complete seal weld as shown. Let cool, then tape over three slot openings and unwelded area using "3M" #480 or #850 pressure-sensitive tape to preclude entry of liquid penetrant materials behind sleeve. Liquid penetrant examine both welds per NMP-6. When liquid penetrant examining the seal weld, terminate the examination 1 inch from end of weld or 1/2 inch from the tape, whichever is greater, to make certain that no penetrant or developer gets near tape edge and into crack beyond the seal weld. Visual and liquid penetrant examine both welds as in F . If unacceptable indications are present, report this fact to the General Electric Company's APED Design Engineering to obtain instructions for repair.

Clean area of liquid penetrant materials. Remove pressure-sensitive tape and clean by scrubbing area which was under the tape and adjacent areas with a clean rag dampened with acetone.

H. Fit outer safe end and consumable insert and arrange back purge barriers. Weld per qualified detailed welding procedure NMP-5A. Complete weld using the procedure for that joint. Again, do not let weld fumes from coated electrodes contact inside surface of nozzle or pipe. Smooth weld for RT, PT and UT examinations as in F . Report findings to General Electric Company's APED Design Engineering for directions for repair, if required. After all repair and upon completion of welding, the weld shall be re-examined as in F . It is suggested that similar procedures be used for remaining pipe welds. Retain all records of final examinations of welds and materials. Radiographs of new welds will replace radiographs of welds removed as a result of this alteration and repair.

GENERAL WELDING PROCEDURE
FOR
INCONEL 600, INCONEL 182, INCONEL 82
OR ANY COMBINATION OF THE THREE ALLOYS

1.0 SCOPE

This procedure specification covers welding requirements for Inconel alloy numbers 600, 182, 82 or any combination thereof by gas tungsten arc welding and/or shielded metal welding.

2.0 BASE METAL

2.1 Arc welding of Inconel 600 shall be in ASME Hardenability Classification "P", Group 43 of Table QN11.1 of the ASME Boiler and Pressure Vessel Code.

2.2 Backing rings if used shall be of the same classification and group as specified in 2.1 above.

3.0 FILLER METAL

3.1 Filler metal for the welding processes in 1.0 shall conform to the following:

3.1.1 Shielded metal arc welding (SMAW) filler metal shall conform to ASME Specification SB295, Classification E NiCrFe-3.

3.1.2 Gas tungsten arc welding (GTAW) filler metal shall conform to ASME Specification SB304, Classification ERNiCr-3.

3.1.3 Gas metal arc welding (GMAW) filler metal shall conform to ASME Specification SB304, Classification ERNiCr-3.

3.1.4 Consumable inserts for Inconel 600 welds shall conform to ASME Specification SB304, Classification ERNiCr-3.

3.2 A certified chemical analysis shall be obtained on all weld metal to be used including consumable inserts. For coated electrode, the chemical analysis shall be performed on undiluted weld deposits—this test is required on each lot of coated electrode. For bare electrode and inserts, the chemical analysis shall be performed on undiluted weld deposits or may be performed on the bare wire. This test is required on each heat of bare electrode. The chemical analysis shall include those elements required by the weld material specification.

3.3 Mechanical properties shall meet the ASME Specification requirements of paragraph 3.1 and the actual test results shall be reported.

3.4 Coated electrodes and bare filler wire shall be stored and cared for as recommended by the manufacturer to assure dry and clean material.

3.5 Issue to welders of electrode for shielded metal arc welding shall be limited to a quantity that may be consumed in five hours. Electrode in the possession of a welder for more than five hours shall be returned to a baking oven for re-baking per the manufacturer's instructions. Electrode returned in less than five hours may be returned to a holding oven at a temperature of 250°F to 350°F.

3.6 All persons responsible for welding material shall be cautious of material contamination by liquids, vapors, or solids. Materials being issued or returned shall be visually inspected for moisture, oil, grease, paints, hand prints or any other matter that discolors or marks the surface of the filler material. Bare wire may be cleaned with isopropyl alcohol, acetone and/or stainless steel wool. Soiled SMAW electrodes shall be discarded.

4.0 WELDING GASES

4.1 Shielding gases shall be welding grade argon, helium, or combination thereof.

4.2 Backing or purging gases shall be welding grade argon, helium, or combination thereof.

4.3 Any gases used as a mixture shall be commercially mixed and bottled.

5.0 PREPARATION OF BASE METAL

5.1 The edges or surfaces of parts to be welded shall be prepared by machining, shearing, grinding, or chipping. If cutting oils are used they shall be sulphur free.

5.2 Irregularities in the weld preparation surface shall be blended into adjacent surfaces by grinding.

5.3 The machining, grinding, or other metal removal method of weld end preparation for matching ends, or for correcting out-of-roundness in pipe shall not result in a wall thickness less than the minimum design wall thickness.

5.4 The angle of bevel, spacing, and other details shall be in accordance with weld end preparation drawings included in the job specifications. If not included in the job specifications, the angle of bevel, spacing, and other details shall be essentially in accordance with the applicable detail welding specification.

5.5 The edges or surfaces of parts to be welded shall be free of oil, grease, paint, oxides, and all other foreign materials. All welding and adjacent surfaces, front and back, for a minimum distance of two inches from the weld shall be wiped clean using alcohol or acetone immediately prior to beginning welding.

5.6 Austenitic stainless steel brushes shall be used for power or hand brushing. These brushes shall be free of grease and oil and shall not have been previously used on carbon steel.

5.7 Grinding shall be done with rubber or resin bonded alumina or silicon carbide grinding wheels. No grinding shall be done with wheels previously contaminated by grinding carbon steel.

5.8 Consumable insert rings shall be degreased with alcohol or acteone and cleaned with stainless steel wool or emery cloth within four hours of their use.

5.9 No welding shall be done when surfaces to be welded are wet or covered with ice. No welding shall be done in rain, snow, or wind unless the work and welder are properly protected.

6.0 WELDING

6.1 The specific welding process or processes, positions, electrode sizes, and mean voltages and currents for each electrode, shall be substantially as shown on the applicable detailed welding specification.

6.2 Where required by job specifications to submit detailed step-by-step welding instructions, the instructions shall be a part of the applicable detailed welding specification.

6.3 All slag or flux remaining on weld beads and craters at stops shall be completely removed prior to applying subsequent weld beads.

6.4 Each layer of weld metal shall be lightly ground. Particular care shall be taken to assure grinding of low areas in the welded surface.

6.5 Any visible defects such as crater cracks, blow holes, surface porosity, and inclusions that appear shall be removed by grinding before depositing subsequent weld passes. Each bead shall blend smoothly into the adjacent metal to obviate sharp inter-bead depressions.

6.6 Tack welds shall be made in conformance with root pass requirements in the applicable welding specification. If not removed, tack welds shall be completely fused and visually inspected for evidence of cracking.

6.7 Welding operations shall be conducted under sheltered conditions. Welding shall be planned and conducted so as to minimize warping or undue distortion of the assembled unit. Machined surfaces and threads shall be protected against weld spatter.

6.8 Weld layers shall be built up uniformly along the joint and across the width of the joint. Block welding shall not be permitted. Weld starts and stops shall be staggered.

6.9 Inert gas purging before welding shall be sufficient to pass at least six (6) volumes of gas through the volume being purged or welding may be started when a gas sample (at the joint or nearby purge vent) shows less than 1% oxygen.

6.10 For SMAW, bead width shall be limited to three times the diameter of the electrode.

6.11 All double-welded, full penetration joints shall be back-grooved to sound metal and liquid penetrant inspected per ASME Boiler and Pressure Vessel Code, Section III, including latest addenda.

6.12 Sufficient finishing shall be performed to provide a surface suitable for the specified nondestructive inspection. Power wire brushing shall not be used on surfaces to be liquid penetrant tested prior to testing. All unacceptable defects visually observed or revealed by nondestructive tests shall be repaired as defined in 9.0 below.

6.13 Peening of welds is prohibited.

6.14 Backing rings shall either be removed or the seam in the backing ring shall be welded.

7.0 PREHEAT, INTERPASS TEMPERATURE AND HEAT TREATMENT

7.1 Inconel 600 shall not be preheated for welding unless the metal temperature is below 32°F; then the first 6 inches of the joint area should be preheated to 70–100°F.

7.2 Inconel 600 interpass temperature shall not exceed 350°F for all welding. The interpass temperature shall be checked on the base metal within 1 inch of the weld edge. Temperature shall be checked using either a contact pyrometer or contact thermometer. No temperature indicating crayons, paint, or pellets shall be used on Inconel welds.

7.3 Post-weld heat treatment of Inconel 600 is not required, and any such treatment is prohibited.

8.0 INSPECTION

8.1 Each bead shall be visually inspected by the welder after cleaning. Any defects shall be repaired before a covering layer is applied.

8.2 The final weld pass and adjacent metal for all welds, but excluding tack welds, shall be inspected by liquid penetrant inspection and acceptance standards in accordance with ASME Boiler and Pressure Vessel Code, Section III, including latest addenda. This shall also apply to back-chipped, ground or gouged surfaces.

8.3 When radiography is required, radiographic techniques and standards of acceptance shall comply with ASME Boiler and Pressure Vessel Code, Section III, including latest addenda.

9.0 REPAIR OF DEFECTS

9.1 Cracks that may occur during welding shall be removed by grinding. The excavated area shall be liquid penetrant examined to assure complete defect removal. Welding may continue upon completion of TP testing.

9.2 After welding has been completed all of the applicable required nondestructive tests shall be made as quickly as practical to determine acceptability of the weld.

9.3 All defects in excess of the applicable standard shall be removed by grinding and/or chipping. Completeness of defect removal shall be verified by PT examination. Repair welding shall be in accordance with the original procedure except that GTAW may be used to fill the entire excavation (provided the weld and welder are qualified).

10.0 QUALIFICATION

10.1 Weld Procedure Qualification shall be in accordance with ASME Section IX, Boiler and Pressure Vessel Code. Essential and non-essential variables shall be delineated on the Detail Welding specification.

10.2 Welder Performance Qualification shall be in accordance with ASME Section IX, Boiler and Pressure Vessel Code.

NMP-4A

DETAIL WELDING PROCEDURE

INCONEL GROOVE WELD W/INSERT

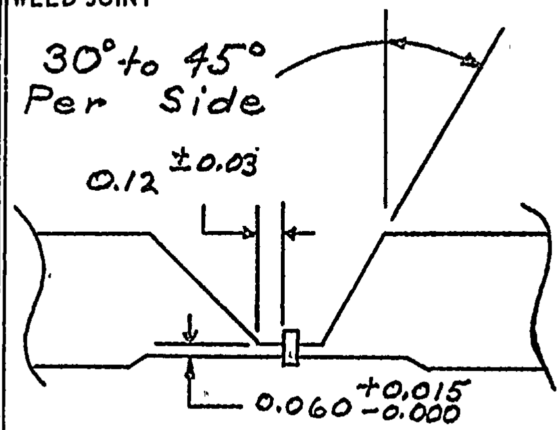
BASE METAL: Inconel 600, 182 or 82
WELDED TO - Inconel 600, 182 or 82
ASME SECT. IX: P# 43 TO P# 43
G.E. SPEC. TO
WELDING MATL: Inconel 82 and 182

ASME SECT. IX: F# 43
SHLD. GAS Argon
CONSUM. ISR. RING: Grinnell Type
FLUX: None
WELDING PROCESS: Combination GTAW and SMAW

PRE-HEAT & INTERPASS TEMP (°F): No Preheat
350° Maximum Interpass Temperature
POST-WELD HEAT TREAT: None

THICKNESS: 3/16" MIN. 1-1/2" MAX.
APPLICABLE GEN. WELD PROC. NMP-4
BACKING STRIP ☐ YES ☒ NO
ADDITIONAL REQUIREMENTS Argon Gas Backing for root and 2 layers.

WELD JOINT



GAP: 1/32 Max.
MISMATCH: 1/16 Max.

WELDING PROCESS	GTAW	SMAW	SMAW			
PASS NO.	Root -1st & 2nd Layer	3rd Layer	To completion			
TRAVEL SPEED (IN./MIN)						
CURRENT (AMPS OR WES)	65-100	40-65	65-95			
ELECTRODE POLARITY	St	Rev	Rev.			
ARC LG (VOLTS OR IN.)	12-20	14-25	16-28			
TORCH GAS (C.F.H.)	4-10					
BACKING GAS	Argon		None			
CUP SIZE	5-8					
TRAILING SHIELD	None					
ELECTRODE/WIRE DIA.	1/16-3/32	3/32	1/8			
ELECTRODE EXT.	3/8					
FILLER WIRE DIA.	1/16 or 3/32					

ADDITIONAL INSTRUCTION Liquid Penetrant, Radiograph and UT per ASME Code. Section III, Paragraphs N-627, N-624 and N-625 respectively. Positions - all.

REPAIR WELDING Per NMP-4 and this detailed procedure.

PROCEDURE QUALIFICATION NO.

Rework Procedure Number NMP-5
Revision 0

GENERAL WELDING PROCEDURE FOR AUSTENITIC STAINLESS STEEL TO AUSTENITIC STAINLESS STEEL

1.0 SCOPE

1.1 This procedure defines the general processing requirements for arc welding of austenitic stainless steel to austenitic stainless steel by the following processes:

Process	AWS Designation
Shielded Metal Arc Welding	SMAW
Gas Metal Arc Welding	GMAW
Gas Tungsten Arc Welding	GTAW

2.0 BASE METAL

2.1 Arc welding of austenitic stainless steels shall be in ASME Hardenability Classification "P", Group 8.

2.2 Backing rings, if used, shall be of the same classification and group as specified in 2.1 above.

3.0 FILLER METAL

3.1 Filler metal for the welding processes in 1.1 shall conform to the following:

3.1.1 Shielded metal arc welding filler metal shall conform to ASME Filler Metal Group F-5, ASME Specification SA298, EXXX per table in 3.1.4.

3.1.2 Gas metal arc welding filler metal shall conform to ASME Filler Metal Group F-7, ASME Specification SA371, ERXXX per table in 3.1.4.

3.1.3 Gas tungsten arc welding filler metal shall conform to ASME Filler Metal Group F-7, ASME Specification SA371, ERXXX per table in 3.1.4.

3.1.4

TABLE — Filler Metal Classification

Base Metal	304	304L	308	316	316L
304	308	308	308	308	308
304L		308L	308	308	308L
308			308	308	308
316			308 or 316	308 or 316	316

For SMAW use EXXX-15 or EXXX-16 per table.
For GMAW and GTAW use ERXXX per table.
NOTE: Low carbon may be substituted for all regular types above.

3.1.5 Consumable inserts for austenitic stainless steel welds shall conform to ASME Filler Metal Group F-7, SA371, classification per table 3.1.4.

3.2 A certified chemical analysis shall be obtained on each heat of weld metal to be used. For coated electrode, the chemical analysis shall be performed on undiluted weld deposits. For bare electrode and consumable inserts, the chemical analysis shall be performed on undiluted weld deposits or may be performed on the bare wire. The chemical analysis shall include those elements required by the weld material specification and, in addition, a minimum of 5% ferrite.

3.3 Mechanical properties shall meet the ASME specification requirements of paragraph 3.1 and the actual test results shall be reported.

3.4 Coated electrodes and bare filler wire shall be stored and cared for as recommended by the manufacturer to assure dry and clean material.

3.5 Only enough electrode for SMAW and GTAW shall be drawn from stock for 5 hours usage. Care shall be taken by the welder to prevent filler metal in his possession from becoming contaminated; it shall be returned to stock and treated as in 3.6.

3.6 Return of unused filler metal for storage or later use shall be examined for contaminants such as oil, grease, moisture, etc. Dirty SMAW electrodes shall be disposed of, and dirty bare filler wire shall be cleaned prior to storage, with isopropyl alcohol or acetone and/or stainless steel wool.

4.0 WELDING GASES

4.1 Shielding gases shall be welding grade argon, helium or combination thereof.

4.2 Backing or surging gases shall be welding grade argon, helium, or combination thereof.

4.3 Any gases used as a mixture shall be commercially mixed and bottled.

5.0 PREPARATION OF BASE METALS

5.1 The edges or surfaces of parts to be welded shall be prepared by machining, shearing, grinding, or chipping. If cutting oils are used they shall be sulphur free.

5.2 Irregularities in the weld preparation surface shall be blended into adjacent surfaces by grinding.

5.3 The machining, grinding or other metal removal method of weld end preparation for matching ends, or for correcting out-of-roundness in the pipe shall not result in a wall thickness less than the minimum design wall thickness.

5.4 The angle of bevel, spacing, and other details shall be in accordance with weld end preparation drawings included in the job specifications. If not included in the job specifications, the angle of bevel, spacing, and other details shall be essentially in accordance with the applicable welding specification.

5.5 The edges or surfaces of parts to be welded shall be free of oil, grease, paint, scale and all other foreign materials. All welding and adjacent surfaces, front and back, for a minimum distance of two inches from the weld shall be wiped clean using alcohol or acetone.

5.6 Austenitic stainless steel brushes shall be used for power or hand brushing. These brushes shall be free of grease and oil, and shall not have been previously used on carbon steel.

5.7 Grinding shall be done with rubber or resin bonded alumina or silicon carbine grinding wheels. No grinding shall be done with wheels previously contaminated by grinding carbon steel.

5.8 Consumable insert rings shall be degreased with alcohol or acetone and lightly cleaned with stainless steel wool or emery cloth within four hours of their usage.

5.9 No welding shall be done when surfaces to be welded are wet or covered with ice. No welding shall be done in rain, snow or wind unless the work and welder are properly protected.

6.0 WELDING

6.1 The specific welding process or processes, electrical characteristics, welding positions, electrode sizes, and mean voltages and currents for each electrode, shall be substantially as shown on the applicable welding specification.

6.2 Where required by job specifications to submit detailed step by step welding instructions, the instructions shall be a part of the applicable welding specification.

6.3 All slag or flux remaining on weld beads and craters at stops shall be completely removed prior to applying subsequent weld beads.

6.4 Each layer of weld metal shall be lightly ground. Particular care shall be taken to assure grinding of low areas in the welded surface.

6.5 Any visible defects such as crater cracks, blow holes, surface porosity, and inclusions that appear shall be removed by grinding before depositing subsequent weld passes. Each bead shall blend smoothly into the adjacent metal to obviate sharp interbead depressions.

6.6 Tack welds shall be made in conformance with root pass requirements in the applicable welding specification. If not removed, tack welds shall be completely fused and visually inspected for evidence of cracking.

6.7 Welding operations shall be conducted under sheltered conditions. Welding shall be planned and conducted so as to minimize warping or undue distortion of the assembled unit. Machined surfaces and threads shall be protected against weld spatter and restrained against warping.

6.8 Weld layers shall be built up uniformly along the joint and across the width of the joint. Block welding shall not be permitted. Weld starts and stops shall be staggered.

6.9 Inert gas purging before welding shall be sufficient to pass at least 6 volumes of gas through the volume being purged or welding may be started when a gas sample (at the joint or nearby purge vent) shows less than 1% oxygen.

6.10 For SMAW, bead width shall be limited to three times the diameter of the electrode.

6.11 All double-welded, full penetration joints shall be backgrooved to sound metal and liquid penetrant inspected per ASME Boiler and Pressure Vessel Code, Section III, including latest addenda.

6.12 Sufficient finishing shall be performed to provide a surface suitable for the specified nondestructive inspection. Power wire brushing shall not be used on surfaces to be liquid penetrant tested prior to testing. All unacceptable defects visually observed or revealed by nondestructive tests shall be repaired as defined in 9.0 below.

7.0 PREHEAT, INTERPASS TEMPERATURE AND HEAT TREATMENT

7.1 Stainless steel shall not be preheated for welding unless the metal temperature is below 32°F; then the first 6 inches of the joint area should be preheated to 70–100°F.

7.2 Stainless steel interpass temperature shall not exceed 350°F for all welding. The interpass temperature shall be checked on the base metal within 1 inch of the weld edge. Temperature shall be checked using either a contact pyrometer or contact thermometer. No temperature indicating crayons, paint, or pellets shall be used on stainless steel.

7.3 Post-weld heat treatment of stainless steel is not required, and any such treatment is prohibited.

8.0 INSPECTION

8.1 Each bead shall be visually inspected by the welder after cleaning. Any defects shall be repaired before a covering layer is applied.

8.2 The final weld pass and adjacent metal for all welds, but excluding tack welds, shall be inspected by liquid penetrant inspection and acceptance standards in accordance with ASME Boiler and Pressure Vessel Code, Section III, including latest addenda. This shall also apply to backchipped, ground or gouged surfaces.

8.3 When radiography is required, radiographic techniques and standards of acceptance shall comply with ASME Boiler and Pressure Vessel Code, Section III, including latest addenda.

9.0 REPAIR OF DEFECTS

9.1 Cracks that may occur during welding shall be removed by grinding. The excavated area shall be liquid penetrant examined to assure complete defect removal. Welding may continue upon completion of PT testing.

9.2 After welding has been completed, all of the applicable required nondestructive tests shall be made as quickly as practical to determine acceptability of the weld.

9.3 All defects in excess of the applicable standard shall be removed by grinding and/or chipping. Completeness of defect removal shall be verified by PT examination. Repair welding shall be in accordance with the original procedure except that GTAW may be used to fill the entire excavation (provided the weld and welder are qualified).

10.0 QUALIFICATION

10.1 Weld Procedure Qualification shall be in accordance with ASME Section IX, Boiler and Pressure Vessel Code. Essential and non-essential variables shall be delineated on the Detail Welding Specification.

10.2 Welder Performance Qualification shall be in accordance with ASME Section IX, Boiler and Pressure Vessel Code.

NMP-5A

PROCESSES

DETAIL WELDING PROCEDURE

Stainless Steel Groove Weld W/Insert

BASE METAL: Austenitic Stainless Steel

WELDED TO - Austenitic Stainless Steel

ASME SECT. IX: P# 8 TO P# 8

G.E. SPEC. ______ TO ______

WELDING MATL: SA371 and SA298

ASME SECT. IX: F# 5 and 7

SHLD. GAS Argon

CONSUM. ISR. RING: Grinnell Type

FLUX: None

WELDING PROCESS: Combination GTAW and SMAW

PRE-HEAT & INTERPASS TEMP (°F): No Preheat
350 F Maximum Interpass Temperature

POST-WELD HEAT TREAT: None

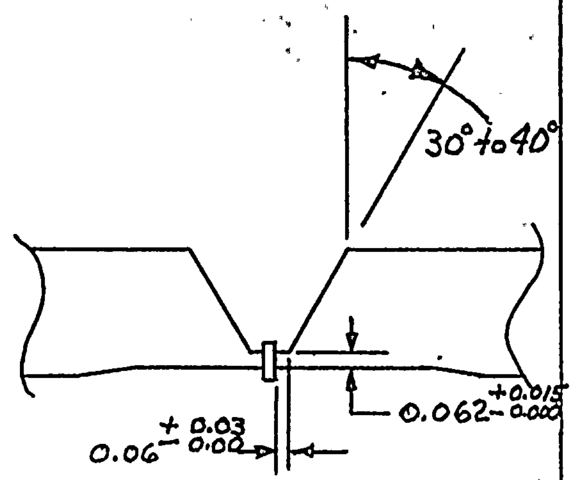
THICKNESS: 3/16" MIN. 7/8" MAX.

APPLICABLE GEN. WELD PROC. NMP-5

BACKING STRIP ☐ YES ☒ NO

ADDITIONAL REQUIREMENTS Argon Gas Back Purge for root and 2 layers

WELD JOINT



GAP: 1/32" Max.

MISMATCH: 1/16" Max.

WELDING PROCESS	GTAW	SMAW				
PASS NO.	Root 1st & 2nd Layer	To Completion				
TRAVEL SPEED (IN./MIN)						
CURRENT (AMPS OR WES)	65-100	65-110				
ELECTRODE POLARITY	St	Rev				
ARC LG (VOLTS OR IN.)	12-20	16-28				
TORCH GAS (C.F.H.)	4-10					
BACKING GAS	Argon	None				
CUP SIZE	5-8					
TRAILING SHIELD						
ELECTRODE/WIRE DIA.	1/16 or 3/32	1/8				
ELECTRODE EXT.	1/8 - 3/8					
Filler Wire Dia.	1/16 to 3/32					

ADDITIONAL INSTRUCTION Liquid Penetrant (PT), Radiograph (RT) and Ultrasonic (UT) per ASME Code, Section III, paragraphs N-627, N-624 and N-625, respectively. Positions - all.

REPAIR WELDING Per NMP-5 and this detailed Procedure.

PROCEDURE QUALIFICATION NO. ______

NMP-5B

PROCESSES
DETAIL WELDING PROCEDURE

Stainless Steel Groove Weld W/Backing Ring

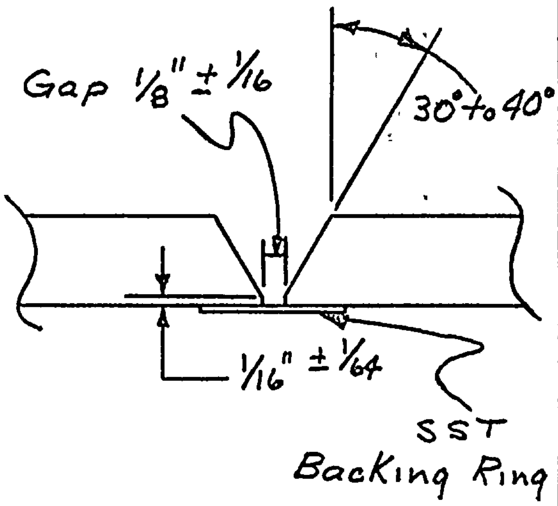
BASE METAL: Austenitic Stainless Steel
WELDED TO - Austenitic Stainless Steel
ASME SECT. IX: P# 8 TO P# 8
G.E. SPEC. ______ TO ______
WELDING MATL - SA-371

ASME SECT. IX: F# 7
SHLD. GAS Argon
CONSUM. ISR. RING: None
FLUX: None
WELDING PROCESS: Gas Tungsten Arc Welding

PRE-HEAT & INTERPASS TEMP (°F): Maximum Interpass Temperature 350°
POST-WELD HEAT TREAT: None

THICKNESS: 3/16 MIN. 0.860 MAX.
APPLICABLE GEN. WELD PROC. GE NMP- 5
BACKING STRIP ☒ YES ☐ NO
ADDITIONAL REQUIREMENTS ______

WELD JOINT



GAP: 1/8" ± 1/16
MISMATCH: 1/16" Max.

WELDING PROCESS	GTAW					
PASS NO.	All					
TRAVEL SPEED (IN./MIN)						
CURRENT (AMPS OR WES)	65-100					
ELECTRODE POLARITY	St					
ARC LG (VOLTS OR IN.)	12-20					
TORCH GAS (C.F.H.)	4-10					
BACKING GAS	None					
CUP SIZE	5-8					
TRAILING SHIELD	None					
ELECTRODE/WIRE DIA.						
ELECTRODE EXT.						
FILLER WIRE DIA.	1/16 or 3/32					

ADDITIONAL INSTRUCTION Backing Ring W/O Back Purge Liquid Penetrant - examine finished weld per NMP-6. Positions - all.

REPAIR WELDING Utilize this procedure following excavation.

PROCEDURE QUALIFICATION NO. ______

STANDARD LIQUID PENETRANT EXAMINATION FOR ASME CODE ACCEPTANCE

1.0 SCOPE

This test procedure establishes the materials and methods to be used to perform a valid examination for ASME code and General Electric Company criteria. The acceptance requirements for test results shall be in accordance with ASME Section III.

2.0 MATERIALS

The following listed Brand Names and types may be used for liquid penetrant examination. Any material not listed shall not be used without specific written consent from GE-APED.

2.1 Penetrant
Spot Check SLK-S (Magnaflux Corp.)
Dy Chek Penetrant (Turco Co.)

2.2 Developer
Spot Check SKD-S
Dy Chek Developer Nonaqueous

2.3 Solvent Cleaner
Spot Check SKC-S
Dy Chek Remover No. 3
Acetone, technical grade or Chemically Pure Grade

2.4 All penetrant materials shall be certified to have less than 5000 ppm total chlorides and 10,000 ppm total halogen and sulphur.

3.0 TEST METHOD

3.1 CLEANING

All material to be examined by the liquid penetrant inspection shall be cleaned by heavy swabbing with clean lint-free cloths saturated with a volatile solvent, or by vapor degreasing. If a solvent is used as a cleaner, all parts shall stand for 5 minutes after the surface appears to dry. The solvent acts as a penetrant and must be allowed to evaporate from all discontinuities.

3.2 SURFACE FINISH

The surface shall be inspected to determine that the surface is adequately smooth for penetrant removal and developing. Usually surfaces may be locally ground to remove areas of excessive roughness.

3.3 TEMPERATURE

The temperature of the surface to be examined shall be maintained between 60 and 125°F.

3.4 PENETRANT APPLICATION

Penetrant application may be by spray or brushed over the entire area to be examined. The area being examined must be kept wet for 15 minutes. If an area becomes dry or tacky, the surface shall be recleaned per paragraph 3.1 and begin another test. Dry or tacky penetrant may clog the entrance to a defect and cause the test to be inconclusive.

3.5 PENETRANT REMOVAL

After 15 minutes the penetrant remaining on the surface must be removed. First, thoroughly wipe the surface with dry lint-free rags. Continue wiping with dry rags until the surface is dry. Secondly, dampen a lint-free rag with cleaner. DO NOT saturate the rag. Continue wiping the surface with a dampened rag until no red staining appears on the rag and the surface is dry.

3.6 DEVELOPER APPLICATION

Developer shall be applied in a thin uniform film by spraying. Any pools of wet developer shall be cause for retest. Immediately prior to application the developer shall be agitated to prevent settling of solid particles.

3.7 TEST EVALUATION

The prepared area may be evaluated for acceptance after 7 minutes and less than 30 minutes. Lighting shall be adequate to interpret results.

3.8 ACCEPTANCE CRITERIA

The criteria for acceptance shall be as described in ASME Section III, paragraph N627 and the following:

a. Relevant indications of any cracks or linear indications are unacceptable.

b. Rounded indications with dimensions greater than 1/16 inch are unacceptable.

c. Four or more rounded indications in a line separated by 3/16 inch or less are unacceptable.

d. Ten or more rounded indications with dimensions over 1/64 inch in any 6 square inches of surface with the area taken in the most unfavorable location relative to the indications under evaluation are unacceptable.

4.0 All penetrant materials shall be completely removed after examination with the cleaner specified in paragraph 2.3.

Rework Procedure Number NMP-7
Revision 0

GENERAL RADIOGRAPHY PROCEDURE FOR WELDS

1.0 SCOPE

1.1 This procedure specification delineates materials, methods, and evaluation criteria for weld examination by radiography.

2.0 RADIATION SOURCES

2.1 X-Ray

Energy (Kv)	Material Min.	Thickness (Incl.) Max.
50	0	0.25
100	0.25	0.55
200	0.40	1.00
300	0.55	1.30
400	0.80	1.70
600	1.20	2.30
1000	1.80	3.00

Either voltage or thickness may be varied outside the above limits provided a demonstration radiograph is made which clearly shows a hole one-half the diameter required by the ASME Code. The demonstration radiograph shall be fully representative of the actual part and conditions.

2.2 Gamma ray radiography shall be acceptable with Iridium 192 for steel thicknesses of 1/4 inch to 2-1/2 inches. Other isotopes will not be considered.

3.0 FOCAL SPOT SIZE VS SOURCE TO FILM DISTANCE

3.1 The following relationship of focal spot size and source to film distance shall be followed:

MATERIAL THICKNESS (Inches of Steel)

Focal Spot Size, (millimeters)	0.5	1	1.5	2	2.5	3	4	5	6	8	10	12	14	16
1	8.5	9	10.5	14	17.5	21	28	35	42	56	70	84	98	112
1.5	12.5	13	13.5	14	17.5	21	28	35	42	56	70	84	98	112
2.0	16.5	17	17.5	18	18.5	21	28	35	42	56	70	84	98	112
2.5	20.5	21	21.5	22	22.5	23	28	35	42	56	70	84	98	112
3.0	24.5	25	25.5	26	26.5	27	28	35	42	56	70	84	98	112
4.0	32.5	33	33.5	34	34.5	35	36	37	42	56	70	84	98	112
5.0	40.5	41	41.5	42	42.5	43	44	45	46	56	70	84	98	112
6.0	48.5	49	49.5	50	50.5	51	52	53	54	56	70	84	98	112
8.0	64.5	65	65.5	66	66.5	67	68	69	70	72	74	84	98	112
10.0	80.5	81	81.5	82	82.5	83	84	85	86	88	90	92	98	112

Minimum Source-to-Film Distance
(Inches)

NOTE

(1) Focal spot size is considered to be the longest projected dimension perpendicular to the beam.

(2) Straight line interpolation or extrapolation may be used for material thicknesses and focal spot sizes less than 16 inches or 1.0 millimeters, respectively.

(3) Source to film distances greater than those shown are acceptable. Source to film distances less than those shown shall be proven by making a demonstration radiograph as described in paragraph 2.1.

4.0 FILM PER CASSETTE

Each cassette shall be loaded with two films of equal speed. Each individual film shall meet the density requirements of paragraph 5.0.

5.0 FILM DENSITY

Film density shall be within the following limitations:

	Minimum H & D	Nominal H & D
X-Ray	2.0	2.6
Gamma Ray	2.0	2.9

6.0 FILM TYPE

Acceptable film brands shall be well-known, such as, Kodak, Ansco, Dupont, Gaevert, for which characteristic curves, film speeds, grain size and contrast are readily available. Any film used shall be equivalent to Kodak Type AA, M or L.

7.0 TYPE AND THICKNESS OF FILTERS AND SCREENS

7.1 Lead filters and screens shall be used within the following limitations:

	FRONT		BACK	
X-Ray	Min.	Max.	Min.	Max.
Up to 500 Kv	0.005	0.010	0.005	0.020
500 Kv to 2 Mev	0.010	0.020	0.020	0.040
2 Mev to 30 Mev	0.010	0.020	0.020	0.060
Iridium 192				
Up to 10 curie	0.005	0.010	0.010	0.020
Over 10 curie	0.010	0.020	0.040	0.060

Lead filters or screens different from those listed above may be proven by a demonstration radiograph described in paragraph 2.1

7.2 Flourescent intensifying screen shall not be used.

8.0 BACK SCATTER

The absence of back scatter shall be confirmed by placing a lead letter B on the back side of the cassette. The appearance of the letter image on the film shall be cause for rejection.

9.0 BLOCKING

If end or edge effects cause masking of an area to be inspected, blocking shall be used. Technique shots shall be made to verify acceptable results.

10.0 FILM OVERLAP

Where radiographic coverage requires multiple films, the overlap shall be planned. The nominal film overlap shall be 1 inch and the minimum film overlap shall be 1/2 inch. Film station markers shall appear on each end of each film.

11.0 SHIMS

Shims shall be used under the penetrameters to produce a total thickness under the penetrameter equal to the nominal thickness being examined plus the total thickness of the crown, or reinforcement, on each side of the weld. Shim material shall be radiographically similar to the base material.

12.0 FILM VIEWING

Film viewing shall be done in a darkened room. For film densities less than 2.5, either a high intensity or a flourescent viewer may be used, whichever is more suitable. For film densities greater than 2.5, a high intensity viewer shall be used.

13.0 FILM IDENTIFICATION AND CORRELATION TO THE PART

13.1 Each individual film shall be identified and include the following information: weld joint and number, film numbers (on each side of each film in a sequence), identification as to repair or reshot status, radiographic contractor's i.d. and job or project i.d.

13.2 The area radiographed shall be marked to permit accurate relocation of the film for evaluation or repair. The area shall be (1) low stress steel stamped, (2) stamped steel tag attached, or (3) Vibrotool.

14.0 PENETRAMETER TYPE AND LOCATION

14.1 Penetrameters shall be of the material specified and of appropriate thickness as stated by ASTM of Radiographic Testing, E-142-68.

14.2 The penetrameter(s) shall be placed on the source side of the material. Film side location of the penetrameter is permitted, provided, the configuration requires film side placement and a demonstration film is made showing the source side penetrameter image quality equal to a one-half thickness film side penetrameter. Film side penetrameters shall be accompanied by a lead letter F.

14.3 In the case of small pipe welds, the penetrameter may be placed to one side of the pipe on a shim meeting the requirements of 10.0. In this case, the shim shall be sufficiently large to prevent edge effects from obscuring the image of the penetrameter.

14.4 Multiple film exposures shall have at lease one pentrameter for each film.

15.0 FILM PROCESSING

Film processing shall be planned and a controlled program shall be followed. "Sight" developing is unacceptable.

15.1 Temperature of all solutions shall be monitored and controlled. Developer shall be maintained as close as practical to 68°F. No developing shall be done if the developer is less than 61°F or greater than 75°F.

A chart or curve of time compensation versus temperature shall always be available for ready reference and compensation shall be made for solution temperature changes greater than 2°F.

15.2 Developing shall be terminated by one of the following:

a. Immersion of the film in stop bath.

b. Films are rinsed by immersion in agitated running water for at least 2 minutes before fixing.

c. Films are immersed in an agitated fixing solution. If this method is used, a special program of replenishing fixing solution is needed.

Fixing shall be per the manufacturer's instructions. In no case shall fixing be less than twice the clearing time nor more than three times the clearing time.

15.3 Final washing after fixing will be acceptable if films and hangers are totally immersed in running water for at least 30 minutes, and if the water is well circulated to all films at a temperature greater than 60°F with complete change of water volume at least four times per hour.

15.4 Automatic film processing must be evaluated and accepted on a case basis by GE-APED Field Applications Engineering.

16.0 FILM EVALUATION

16.1 A Shooter's Sketch shall be prepared prior to radiography and shall contain the information shown on the attached sheet. The Geometry and Distance Sketch shall depict the source, angles, distance and radial location.

16.2 A Reader's Sheet shall be used when grading film. The attached reader's sheet is acceptable for content. The film reader must be a Level II per SNT-TC-1A, with supplements thereto. Each film shall be graded and all indication noted by the film reader.

16.3 Film exposure and film processing errors are not listed on the Reader's Sheet because these types of errors are intended to automatically be rejected.

17.0 ACCEPTABLE STANDARDS

Weld joint acceptance criteria shall be in accordance with the appropriate code which may be:

ASME Section III, Paragraph N-624
ASME Section VIII, Paragraph UW-51
Nuclear Power Piping USAS B31.7, Paragraph 1-736.4.2

SHOOTER'S SKETCH

SYSTEM__________ BUILDING__________ CODE__________

JOINT NUMBER________ RT PROCEDURE NO.________ NUMBER OF EXPOSURES________

BRAND NAME AND FILM TYPE____________________

PENNY NO.________ SHIM________ SINGLE WALL________ DOUBLE WALL________

MATERIAL__________ DIAMETER__________ WELD THICKNESS__________

JOINT TYPE: INSERT BACKING RING OPEN BUTT OTHER

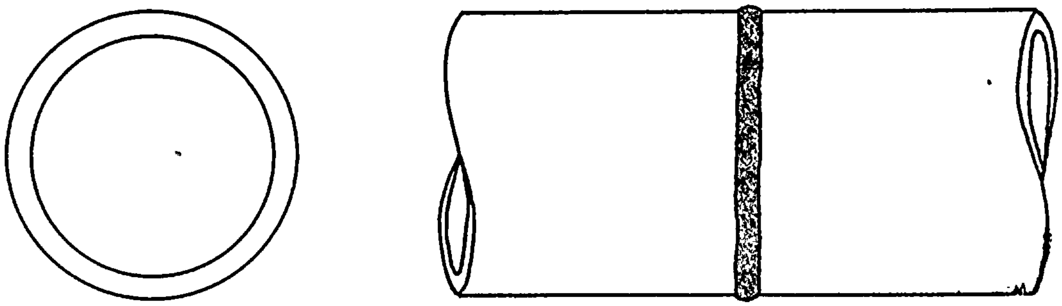
X RAY

MACHINE________ FOCAL SPOT________ KVP________ MA________

ISOTOPE

TYPE__________ STRENGTH (CURIES)__________ SIZE__________

GEOMETRY AND DISTANCE SKETCH:



SHOW FILM, SOURCE, BACKING, SHIMS, PENETRAMETER
SCREENS, ANGLES, SOURCE TO FILM DISTANCE, MARKERS

REQUESTED BY________________ RADIOGRAPHER________________

DATE____________ DATE____________

READER'S SHEET

SYSTEM ________________ BUILDING ________________ JOINT NUMBER ________________

READER ________________ DATE ________________ CODE ________________

film station numbers	unacceptable penetrameter	cracks	slag inclusion	general porosity	in-line porosity	cluster pososity	incomplete penetration	lack of fusion	melt through	burn through	crater pit	oxidation	tungsten inclusion	backing ring root undercut	backing ring root rollout	root concavity (suckback)	excess. reinforce. (crown)	root undercut	incomplete insert fusion	root centerline crease	COMMENTS	REJECT	REPAIR	RETAKE	ACCEPT

NINE MILE POINT NUCLEAR STATION

REMOVAL AND REPLACEMENT OF CORE SPRAY NOZZLE SAFE END

1.0 Scope

1.1 This procedure specifies the technical requirements for the removal and replacement of core spray nozzle safe ends and the removal and replacement of portions of the core spray nozzle thermal sleeve to facilitate access for safe end replacement. It is necessary to remove and replace certain portions of the core spray piping to gain access for removal and replacement of the safe end.

1.2 The following General Electric Company drawings are a part of, and are to be used with this procedure:

921D857	Core Spray Nozzle N6A Safe End Replacement
158B8462P1	Centering Sleeve
158B8463P1	Inner Safe End
158B8464P1	Outer Safe End
158B8565P1	Sleeve End Replacement
209A7152	Consumable Insert

1.3 References are made to the following additional documents:

A. 21A8570 - Special Liquid Penetrant for Intergranular Corrosion

B. Rework Procedure No. NMP-4 - General Welding Procedure for Inconel 600, Inconel 182, Inconel 82

C. Detail Welding Procedure NMP-4A

D. Rework Procedure No. NMP-5 - General Welding Procedure for Welding Stainless Steel

E. Detail Welding Procedure NMP-5A

F. Detail Welding Procedure NMP-5B

G. Rework Procedure No. NMP-6 - Standard Liquid Penetrant Examination for ASME Code Acceptance

H. Rework Procedure No. NMP-7 - General Radiography for Welds

I. 21A8592 - Ultrasonic Examination of Pipe and Safe End Welds

2.0 Safe End Removal and Replacement

2.1 Before cutting pipe or safe end or machining weld preps on remaining fixed ends of piping and nozzles in situ, adequate provisions must be made to provide for cleaning the vessel and piping to remove all chips, debris, inspection fluids, etc.

Note: All machining and cutting operations shall be done dry (no lubricants or coolants).

2.2 Before any welding is done and before surfaces are covered so as to prevent cleaning, the surfaces in the vicinity of the welding and surfaces to be covered shall be thoroughly cleaned with either isopropyl alcohol or acetone and completely dried.

2.3 No welding, cutting or metal removal is to be performed closer than 1/8 inch away from the low alloy steel portion of the vessel nozzles.

2.4 All work and workmen shall conform to NMP radiation control specifications.

2.5 Provide chip retention plastic sheet under working area.

2.6 Provide temporary axial and radial support to limit relative movement during first cut.

2.7 Scribe pipe at quadrants 6" length centered on first cut. Make 6" trammel marks on scribe lines. Record trammel spacing.

2.8 Scribe 12:00 position on safe end to premanently identify orientation of ring to be removed.

2.9 Sequence of Work

Note: ◯ indicates sequence on Drawing 921D857.

(A) Before any cuts are made in pipe or safe end, the reactor water level shall be six inches above the highest portion of the core spray piping. A hole will be drilled in the bottom of the six-inch schedule 80 pipe adjacent to the safe end. This pipe has a wall thickness of .432 inches. The hole will be 7/32 inch diameter and will be drilled to a maximum depth of .370 inch. A 1/16-inch diameter drill will be used to finish the penetration of the pipe wall. A syringe septum will be immediately placed in the 7/32-inch hole. An 8-inch syringe needle will be inserted through the septum concurrently withdrawing the plunger. The heighth at which gas is first observed will be recorded. Samples of both the gaseous and the aqueous phases will be collected by the syringes. Oxygen analysis will be performed on the samples at the Site; the gas samples will be analyzed by gas chromatography at Vallecitos. A liquid sample will be returned to Vallecitos for fluoride and chloride analysis.

Lower water level of reactor vessel in accordance with NMP Special Operating Procedures.

Make cut No. 1 per sketch No. 1.

Release restraint on ELL and measure relative movement. Record.

Install dynamometer on lift and lift pipe level with nozzle and read and record load.

Elevate pipe until it is 1.5" above nozzle and read and record load. Return pipe to blocked position.

Locate and make cut No. 2. Remove pipe, clean, nozzle and remaining pipe of all chips and debris both inside and out and install plugs in nozzle and pipe to prevent entry chips and debris during remaining sequence of work.

Locate cut No. 3 and make cut.

B. Locate cut No. 4 as shown. Cut No. 4 may be located closer to vessel to clear rolled-in portion of sleeve. Use abrasive cut off unit with internal attachments and make cut without coolant or lubrication at cut. Vacuum away all chips and debris before, during and after cutting.

CAUTION: Ventilating air pressure shall be equalized between reactor vessel interior and drywell region in way of this nozzle during this and all remaining sequences of work.

Next, locate the junction between the Ni-Cr-Fe shop weld and the sensitized stainless steel safe end at three equally spaced positions, using the following:

a. Prepare a saturated solution of oxalic acid in demineralized water, 90°F to 130°F.

b. Clamp the positive terminal of a 6 volt battery to the nozzle.

c. Attach the negative terminal of the battery to a one half (1/2) inch diameter copper disk. Use a long enough lead for easy manipulation.

d. Saturate a cloth pad, 1/2" to 1" diameter, with oxalic acid and place it on the weld joint with the copper disk on the back of the pad.

e. Press down lightly on the copper disk and saturated pad while scrubbing in a small area. Keep the area small and wet with acid. Scrub for two (2) to five (5) minutes as needed.

f. Wash the entire area with demineralized water and dry with Kotex after etching is complete. Repeat the washing and drying three times.

<u>CAUTION:</u> For good results use a strong battery and keep the pad saturated.

Do not allow any drip or contact of the etchant to any other materials.

In case of spills wash three times as described in f.

Scribe a line through each etched area where Ni-Cr-Fe to stainless steel junction occurs, and completely around the nozzle, thus locating cut No. 5. Scribe a line along the top of 12 o'clock position of the sensitized stainless steel safe end. Make cut No. 5 using abrasive cut-off unit without coolant or lubrication. Cut No. 5 should be made as concentric with nozzle O.D. as practical, and should not cut into the Ni-Cr-Fe shop weld. Abrasive cut off should proceed until all but 1/16 inch of sensitized stainless steel safe end wall remains. Vacuum away all chips and debris. Cut No. 5 should then be completed using a cold chisel. Save safe end just removed for separate handling instructions.

C. Vacuum and clean O.D. of sleeve. Inventory fiber-glass rope. Use one continuous length of rope. Carefully insert rope into gap between sleeve and nozzle. Insert only far enough to just clear centering sleeve. Note position of end of rope for later removal. Measure O.D. of sleeve for use in finish machining of centering sleeve. Make cut No. 6 as close as practical to cut No. 5, using abrasive cut-off unit without coolant or fluids of any kind. Vacuum away all chips and debris during the following cut. Save portion of sleeve just removed for separate handling instructions. Locate junction of Ni-Cr-Fe shop weld and low-alloy steel nozzle. It may be necessary to wire brush this area to remove paint so that the junction can be clearly seen for entire circumference. Locate cut No. 7 from this junction. Make cut No. 7 using abrasive cut-off unit with internal attachments, using no coolants or liquids. Vacuum away all chips and debris during and following this operation. Take care not to cut into nozzle cladding or shop weld at any location. Save portion of sleeve just removed for separate handling instructions. Measure I.D. of nozzle to determine smallest I.D. Use this dimension together with dimension between cut No. 5 and cut No. 7 and complete machining of centering sleeve.

Locate junctions of Ni-Cr-Fe shop weld and stainless steel cladding and remaining safe end on nozzle I.D., using procedure previously described. Be very careful to avoid any excess of oxalic acid at any time to prevent entry into gap between sleeve and nozzle. Report results. Measure and record location of these junctions relative to the Ni-Cr-Fe shop weld to low-alloy steel junction. Clean and dry etched area thoroughly. Examine existing Ni-Cr-Fe shop weld using radiographic, ultrasonic and liquid penetrant examinations, and report these results. Install centering sleeve and tack weld as shown on drawing, then tack weld sleeve to centering sleeve (not shown on drawing).

D. Machine counterbore in sleeve. Use no coolants or cutting fluids of any kind. Liquid penetrant examine machined surfaces. Surfaces so examined shall be free of any crack-like indications and indications of porosity. Carefully remove tack welds holding centering sleeve in place and remove centering sleeve.

E. Before proceeding with machining, results of examinations of the Ni-Cr-Fe shop weld under C above must be satisfactory to all parties concerned. If repair of the shop weld is indicated, this work shall be done at this time using approved procedures.

If no repair is indicated, proceed with machining to produce the weld prep shown on the drawing. Use no coolants or cutting fluids of any kind.

F. Fit consumable insert and inner safe end. Arrange back purge so that no weld flux fumes that may be generated enter the inside of the nozzle or replacement safe end. Weld per qualified detailed welding procedure NMP-4A. Continue welding to complete joint in accordance with the welding procedure for that joint. Do not remove back purge barriers until welding is complete; this is to protect inside surfaces from any welding flux fumes.

Weld shall be smoothed for RT, PT and UT examinations.

Radiograph entire weld in accordance with radiography procedure NMP-7.

Liquid penetrant examine weld surfaces and adjacent material for one inch on either side of weld, both inside and outside of nozzle. Liquid penetrant techniques shall be per General Electric Company Procedure NMP-6.

Ultrasonic examination shall be in accordance with N-625 of Section III. Use General Electric Specification 21A8592 for procedure guide.

Exploration of indications as a result of above examinations shall not be attempted until General Electric Company's APED

Design Engineering has been appraised of all indications and directions for repair formulated.

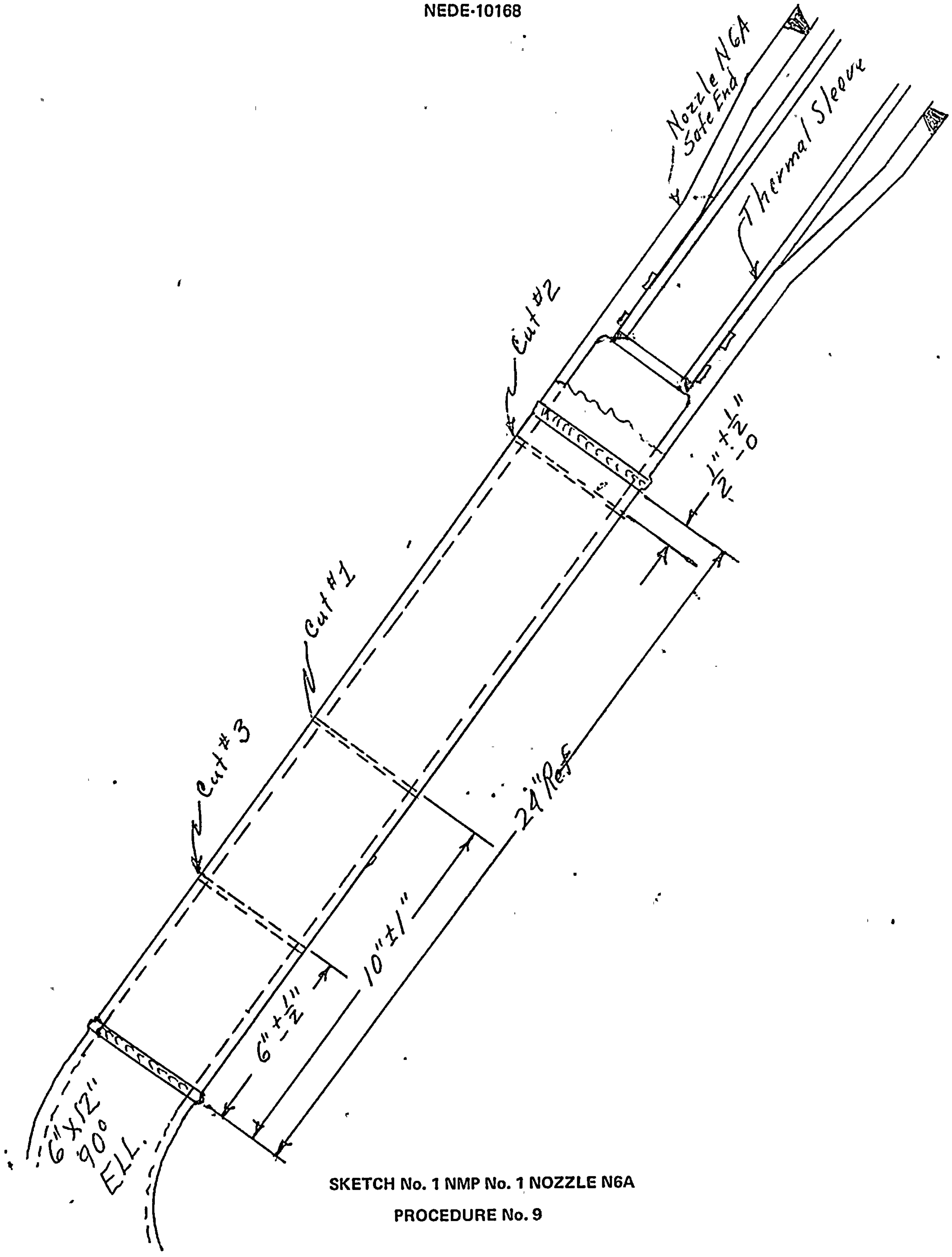
After all repair, if required, and upon completion of welding, the weld shall be re-examined by PT, RT and UT as above and, in addition, UT examined and reported per G.E. Specification 21A8592.

Remove shield plug and fiber glass rope that was installed under (C) and clean sleeve I.D. and end and nozzle I.D. and O.D. thoroughly with isopropyl alcohol or acetone and let dry.

(G.) Clean sleeve and replacement with isopropyl alcohol or acetone and let dry. Use GTAW process for all sleeve end replacement welding. Fit sleeve end into sleeve socket machined in step (D.) Use qualified detailed welding procedure NMP-5B and weld sleeve end to sleeve first; then complete seal weld as shown. Let cool, then tape over three slot openings and unwelded area using "3M" #480 or #850 pressure-sensitive tape to preclude entry of liquid penetrant materials behind sleeve. Liquid penetrant examine both welds per NMP-6. When liquid penetrant examining the seal weld, terminate the examination one inch from end of weld or 1/2 inch from the tape, whichever is greater, to make certain that no penetrant or developer gets near tape edge and into crack beyond the seal weld. Visual and liquid penetrant examine both welds as in (F). If unacceptable indications are present, report this fact to the General Electric Company's APED Design Engineering to obtain instructions for repair.

Clean area of liquid penetrant materials. Remove pressure-sensitive tape and clean by scrubbing area which was under the tape and adjacent areas with a clean rag dampened with acetone.

H. Fit outer safe end and consumable insert and arrange back purge barriers. Weld per qualified detailed welding procedure NMP-5A. Complete weld using the procedure for that joint. Again, do not let weld fumes from coated electrodes contact inside surface of nozzle or pipe. Smooth weld for RT, PT and UT examinations and examine as in F. Report findings to General Electric Company's APED Design Engineering for directions for repair, if required. After all repair and upon completion of welding, the weld shall be re-examined as in F. It is suggested that similar procedures be used for remaining pipe welds. Retain all records of final examinations of welds and materials. Radiographs of new welds will replace radiographs of welds removed as a result of this alteration and repair.



SKETCH No. 1 NMP No. 1 NOZZLE N6A

PROCEDURE No. 9

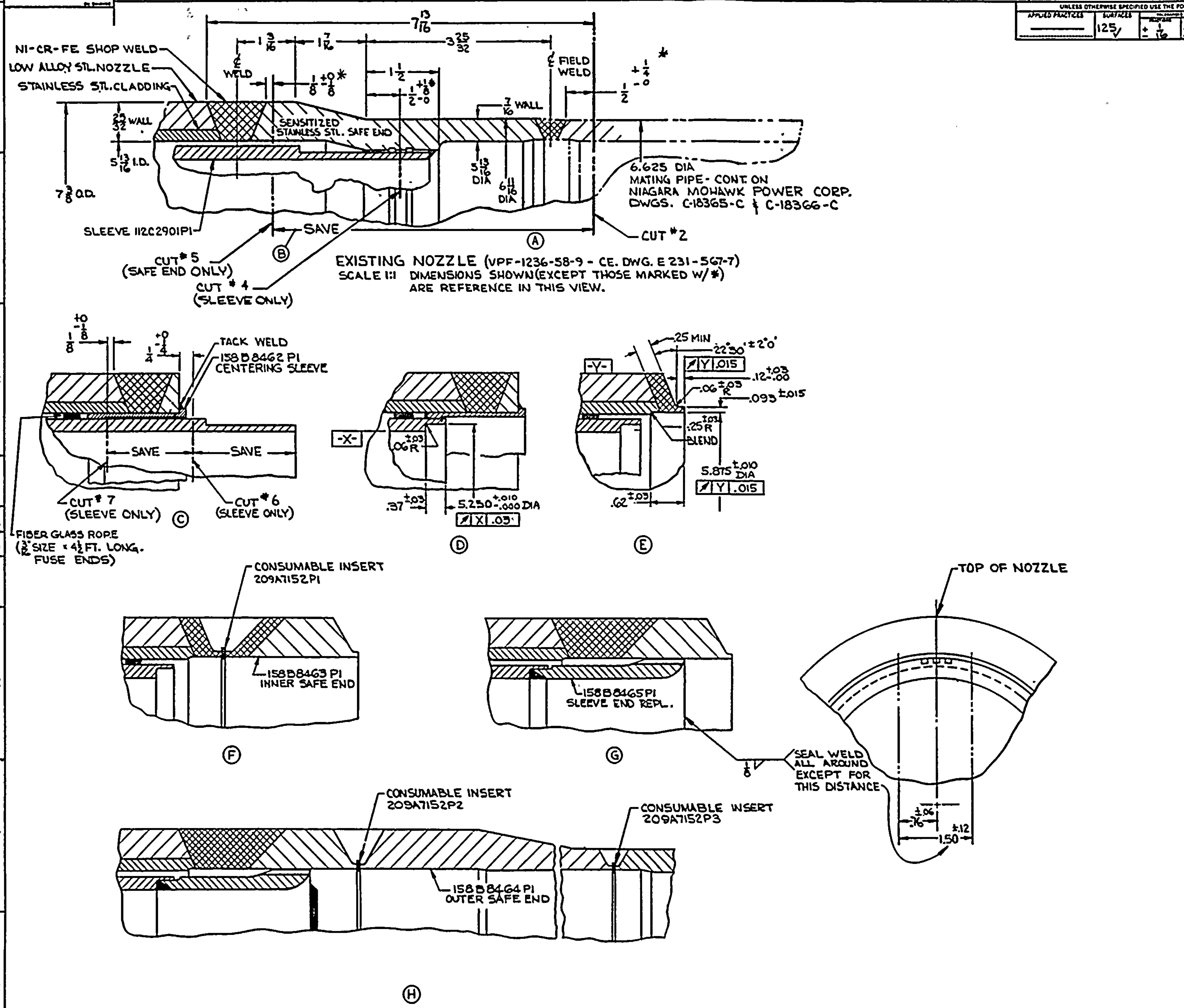
GENERAL ELECTRIC

TITLE: CORE SPRAY NOZZLE N6-A SAFE END REPLACEMENT

FIRST MADE FOR NMPNS REPAIRS

921D857

UNLESS OTHERWISE SPECIFIED USE THE FOLLOWING — SURFACES 125; $\pm\frac{1}{16}$



NOTES:

1. THIS DRAWING IS A PART OF AND SHALL BE USED WITH NINE MILE POINT NUCLEAR STATION - REMOVAL & REPLACEMENT OF CORE SPRAY NOZZLE SAFE END - PROCEDURE NO. 9.
2. ALL WELDING PROCEDURES AND WELDER SHALL BE QUALIFIED AS REQUIRED BY THE ASME BOILER & PRESSURE VESSEL CODE SECTION IX WELDING QUALIFICATIONS.
3. ALL MATERIALS USED FOR THIS REPAIR SHALL BE ASME BOILER AND PRESSURE VESSEL CODE MATERIALS GIVEN IN SECTION II. CERTIFIED MILL TEST REPORTS OF ALL MATERIALS ARE REQUIRED.
4. ALL PRESSURE CONTAINING WELDS MADE AS RESULT OF THIS REPAIR AND ALL PRESSURE CONTAINING PARTS THAT REQUIRE DEFECT REMOVAL AND REPAIR TO A DEPTH EQUAL TO OR IN EXCESS OF 3/8" OR 25% OF THE WALL THICKNESS AT THE REPAIR LOCATION WHICHEVER IS THE LEAST SHALL BE RADIOGRAPHED USING TECHNIQUES AND STANDARDS GIVEN IN ASME BOILER AND PRESSURE VESSEL CODE SECTION III.
5. ACCESSIBLE SURFACE OF ALL WELDS, REPLACEMENT MATERIALS AND REPAIRS SHALL BE INSPECTED USING TECHNIQUES AND STANDARDS CONTAINED IN REFERENCE PROCEDURES IN NOTE 1.

REVISIONS: A PRE-PRODUCTION ISSUE

APR. 17, 1970 — APPD — SAN JOSE — 921D857 — R

APPENDIX E

CALCULATION OF OXYGEN LEVEL

Calculation of Oxygen Levels if Core Spray System is Backfilled from Reactor

Assume 60 feet of 12-inch pipe to stop valve.

$$V = 60 \times \frac{115}{144} = 48 \text{ cu ft}$$

Assume 100 feet of 5-inch sparger + header.

$$V = 100 \times \frac{20}{144} = 14 \text{ cu ft}$$

Assume 10 feet of 6-inch thermal sleeve and downcomer.

$$V = 10 \times \frac{29}{144} = 2 \text{ cu ft}$$

Total volume = 48 + 14 + 2 = 64 cu ft of air.

Total value of O_2 = 64 X 0.2 = 12.8 cu ft

Total weight of O_2 STP = 12.8 X 0.089 = 1.14 lb.

Total weight of water in horizontal pipe at 544°F

$$\frac{1 \text{ cu ft}}{0.022 \text{ cu ft/lb}} = 45.5 \text{ lb}$$

$$\text{ppm } O_2 = \frac{1.14}{45.5} \times 10^6 = 25{,}000 \text{ ppm} = 2.5\%$$

Total weight of water in 12-inch section at 120°F

$$\frac{48}{0.016} = 3000 \text{ lb}$$

Total weight of water in 100 ft at 544°F

$$\frac{14}{0.022} = 635 \text{ lb}$$

Total weight of water

$$3000 + 635 + 45.5 \times 2 = 3725 \text{ lb}$$

$$\text{ppm } O_2 \doteq \frac{1.14}{3725} \times 10^6 = 300 \text{ ppm}$$

Calculation of Oxygen Levels if Core Spray System Water Level Drops When Reactor Water Level Drops During Shutdown

Assume 79-inch horizontal run + 36-inch vertical.

$$\text{Volume} = (79 + 36) \times 29 = 3340 \text{ cu in}$$
$$= 3340 \times 16.4 = 55{,}000 \text{ cm}^3$$

$$\text{Volume } O_2 = 55 \text{ liters} \times 0.2 = 11 \text{ liters } O_2$$

$$\frac{11}{22.4} \text{ gram mol wts} \times 32 \text{ g/mol} = 16 \text{ g } O_2$$

Weight of water in horizontal run at 550°F.

$$79 \times 2.54 \times 29 \times 6.5 \times \frac{0.016}{0.022} \times 1 \text{ g/cc} = 2.75 \times 10^4 \text{g } H_2O$$

$$\text{ppm } O_2 = \frac{16 \times 10^6}{2.75 \times 10^4} = 580 \text{ ppm}$$

REACTOR PRIMARY SYSTEM INVESTIGATION

AT NINE MILE POINT NUCLEAR STATION

REPORT NO. 2

May 11, 1970

NIAGARA MOHAWK

TABLE OF CONTENTS

1. Metallurgical Examination of N6A Core Spray Safe End

2. Results of Sample Analyses for Halides

3. Supplemental Information Regarding Stress Analyses

1. METALLURGICAL EXAMINATION OF N6A CORE SPRAY SAFE END

1.1 SUMMARY

Small penetrations were found on both the inside and outside surfaces of the N6A safe end. The maximum depth of these were .010", with an average depth in the range ~ .004" - .008". The length was about .010" - .020". They were intergranular and the surfaces appeared oxidized when viewed with a stereomicroscope after bend testing. Four very small transgranular defects were found, three on the inside and one on the outside surface of the safe end. Their depth was .002" - .004".

Three longitudinal intergranular cracks were found on the inside surface of the pipe about one-quarter inch from the root of the weld. The deepest of the cracks was about .090". The stainless steel pipe material was sensitized at the location of the cracks.

No unusual features were found in the field weld between the core spray safe end and the 6-inch pipe.

1.2 SAMPLE EVALUATION

The N6A core spray safe end was received for examination on April 27, 1970. The sample was visually inspected for cracks or other unusual features. None were observed. A longitudinal strip of the sample had been removed at the Nine Mile Point site for examination by the AEC. This sample had been removed at the 10:45 - 11:15 o'clock position as seen facing the reactor pressure vessel. An additional longitudinal cut had been made at the site at the 5 o'clock position to facilitate handling.

The outside surface of the safe end was covered with a light golden brown oxidation film with some patches of a darker brownish-grey oxide where the surface had not been ground. Most of the outside surface showed evidence of light grinding. The inside surface of the safe end was covered with a dark brownish-grey oxide film typical of that developed on stainless steel in high temperature water. No unusual features were observed.

A transverse saw cut was made to facilitate further handling. The inside surfaces of the four resulting "clam shell" shaped pieces of the safe end were examined with the stereomicroscope. No defects of the type detected by stereo-

1.2 SAMPLE EVALUATION - (Continued)

microscope examination of the N6B failed core spray safe end were found.

Both the inside and outside surfaces were inspected by dye penetrant test methods and the indications found were charted as shown in sketches numbered 117C4622 and 117C4623 (Figures 1-1 and 1-2). All of the indications found were of the "dot" variety with no linear indications except on the inside surfaces of the pipe as shown in sketch numbered 117C4623 (Figure 1-2).

Longitudinal samples were cut from the safe end for metallographic evaluation and for bend testing followed by metallography as shown in Figures 1-3 and 1-4. It was found that bend testing opened the indications as shown by the typical example in Figures 1-5 and 1-6. The indications were about .010" - .020" in length before bending as determined by stereomicroscope observation, roughly lenticular inshape, and difficult to locate with the stereomicroscope. This is in contrast to experience with the N6B core spray safe end where indications that were generally linear were sometimes detected by stereomicroscope but not by dye penetrant testing. The

1.2 SAMPLE EVALUATION - (Continued)

penetrations in the safe end material were about .004" - .008" deep in both the outside and inside surfaces with the deepest found being about .010" deep. They were intergranular. Four small transgranular indications with depths of .002" - .004" were also found; three in the inside surface and one in the outside surface of the safe end. Examples of these are shown in Figure 1-7.

Bend testing was utilized as a method for opening the tiny indications to facilitate their evaluation. Inspection with stereomicroscope after bend testing indicated that the crack surfaces were oxidized. Indications in the outside surface of the safe end had a light golden brown appearance similar to that on the general outside surface of the safe end, while those in the inside surface had a dark brownish-grey appearance similar to that on the general inside surface which was exposed to water during service.

Three longitudinal cracks or penetrations were found on the inside surface of the pipe near the 5:00 o'clock location. The location of the dye penetrant indications associated with these cracks is illustrated in sketch 117C4623.

1.2 SAMPLE EVALUATIONS - (Continued)

A photomicrograph of one of the cracks is shown in Figure 1-8. The cracks were intergranular, very tight, and reached depths of about .045", .062" and .090". The pipe material in the vicinity of the cracks was sensitized and the sensitization extended through the available pipe material sample to at least one inch from the root of the weld. Grain boundary decoration by carbides in the pipe material is illustrated in Figure 1-9.

Very shallow penetrations were found in the inside surface of the thermal sleeve of mixed mode and averaged about .002" - .003" deep. These cracks are believed to be associated with the mill pickling process. Typical examples are shown in Figure 1-10. No crack or other defect was found in the outside surface of the thermal sleeve material. Some scattered nitrides were observed in the thermal sleeve base material.

The field weld between the safe end and the connecting pipe is shown in Figure 1-9. A lighting "halo" effect around the weld was unintentionally obtained in photographing the sample. Magnigauge measurements on the weld indicated

1.2 SAMPLE EVALUATIONS - (Continued)

the presence of 4 - 5 percent ferrite. A slight lack of fusion approximately .008" - .010" deep was observed between the weld insert and the safe end material at the root of the weld. Sensitization of both the pipe and safe end materials was found near the weld as illustrated by the photomicrographs in Figure 1-9. In addition, a surface effect occurred on both the inside and outside surfaces adjacent to the weld, in the form of a very fine grain structure suggesting the start of recrystallization. Evidence of some slight surface cold work, believed to be the result of the safe end machining process, was observed in other parts of the safe end and might have assisted in the recrystallization process.

The tensile properties of the safe end material were measured with the results shown in Table 1-1. Rockwell "B" hardness measurements were also made on the pipe material, safe end material, and thermal sleeve material as shown in Table 1-2. These test results are typical of normal, as-received type 304 stainless steel.

TABLE 1-1

TENSILE PROPERTIES OF STAINLESS STEEL FROM THE N6A CORE SPRAY SAFE END AT 550°F

Sample No.	Ultimate Strength (Ksi)	0.2% Offset Yield Strength (Ksi)	Elongation (% in. 75")	Reduction of Area (%)
7G	60.1	28.7	20.0*	32.8
7H	61.4	26.3	33.3*	53.2

*Fracture occurred at extensometer gauge marks making elongation values low.

TABLE 1-2

ROCKWELL "B" HARDNESS DATA FROM N6A CORE SPRAY SAFE END MATERIALS

Measurement Location	R_B Hardness Number
Safe End	
(a) ID Surface	73.4 (average of 6 readings)
(b) OD Surface	75.6 (average of 8 readings)
Thermal Sleeve	
(a) ID Surface	90.9 (average of 5 readings)
(b) OD Surface	78.2 (average of 10 readings)
Pipe	
(Transverse Surface)	76.0 (average of 4 readings)

1.3 CONCLUSIONS

1. Numerous small indications observed on the ID and OD of the safe end are intergranular and have no observable relation to the applied stress. Those on both the ID and OD are similar with respect to length and depth.

2. The thermal sleeve is satisfactory for continued use.

3. The few isolated transgranular penetrations observed on the ID and OD surfaces of the safe end are considered incidental to this investigation.

4. The penetrations may have been induced by residual welding stresses in the longitudinal direction, or they could be the result of intergranular corrosion. If welding was responsible, the penetrations should not propagate under low applied operating stresses. If corrosion is responsible, the cracks might conceivably have propagated through the pipe wall. However, the propagation would have resulted in a small leak which would have been detected before it became a safety hazard.

1.3 CONCLUSIONS - (Continued)

Further investigations are being carried out in an attempt to obtain confirmation of the cause of the axial penetrations.

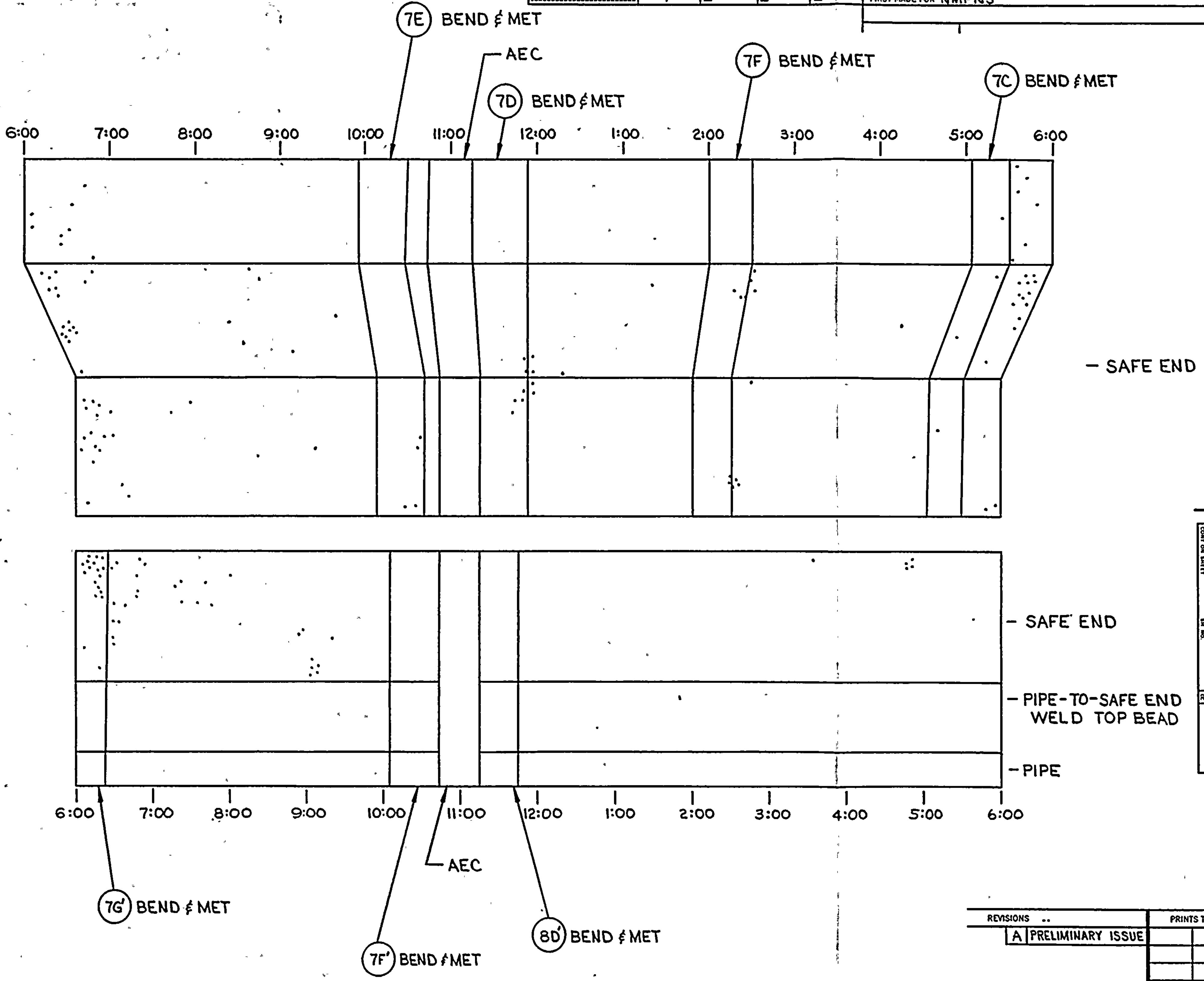
GENERAL ELECTRIC 117C4622

UNLESS OTHERWISE SPECIFIED USE THE FOLLOWING:—

APPLIED PRACTICES	SURFACES	FRACTIONS	DECIMALS	ANGLES
	√	±	±	±

TITLE N6A CORE SPRAY SAFE END O.D. COMPOSITE LIQUID PENETRANT PLUS BEND AND 6X STERIO MICROSCOPE

FIRST MADE FOR NMPNS



REVISIONS

A PRELIMINARY ISSUE

PRINTS TO

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APPROVALS

APED

SAN JOSE

117C4622

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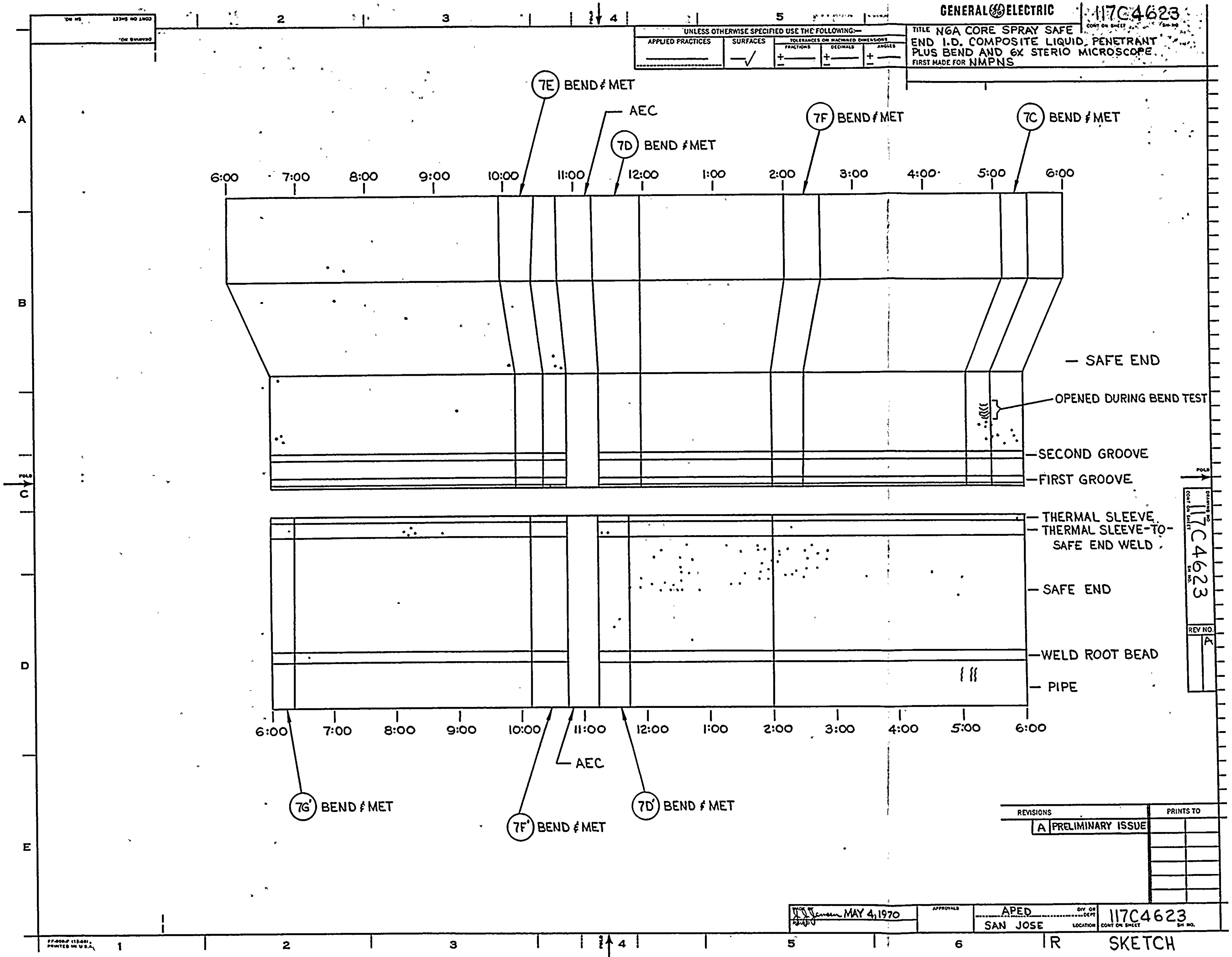
SKETCH

Fig 1


GENERAL ELECTRIC
117C4623
UNLESS OTHERWISE SPECIFIED USE THE FOLLOWING:
APPLIED PRACTICES
SURFACES
TOLERANCES ON MACHINED DIMENSIONS
FRACTIONS
DECIMALS
ANGLES
TITLE N6A CORE SPRAY SAFE END I.D. COMPOSITE LIQUID PENETRANT PLUS BEND AND 6X STERIO MICROSCOPE
FIRST MADE FOR NMPNS
7E BEND & MET
AEC
7D BEND & MET
7F BEND & MET
7C BEND & MET
6:00
7:00
8:00
9:00
10:00
11:00
12:00
1:00
2:00
3:00
4:00
5:00
6:00
SAFE END
OPENED DURING BEND TEST
SECOND GROOVE
FIRST GROOVE
THERMAL SLEEVE
THERMAL SLEEVE-TO-SAFE END WELD
SAFE END
WELD ROOT BEAD
PIPE
6:00
7:00
8:00
9:00
10:00
11:00
12:00
1:00
2:00
3:00
4:00
5:00
6:00
AEC
7G' BEND & MET
7F' BEND & MET
7D' BEND & MET
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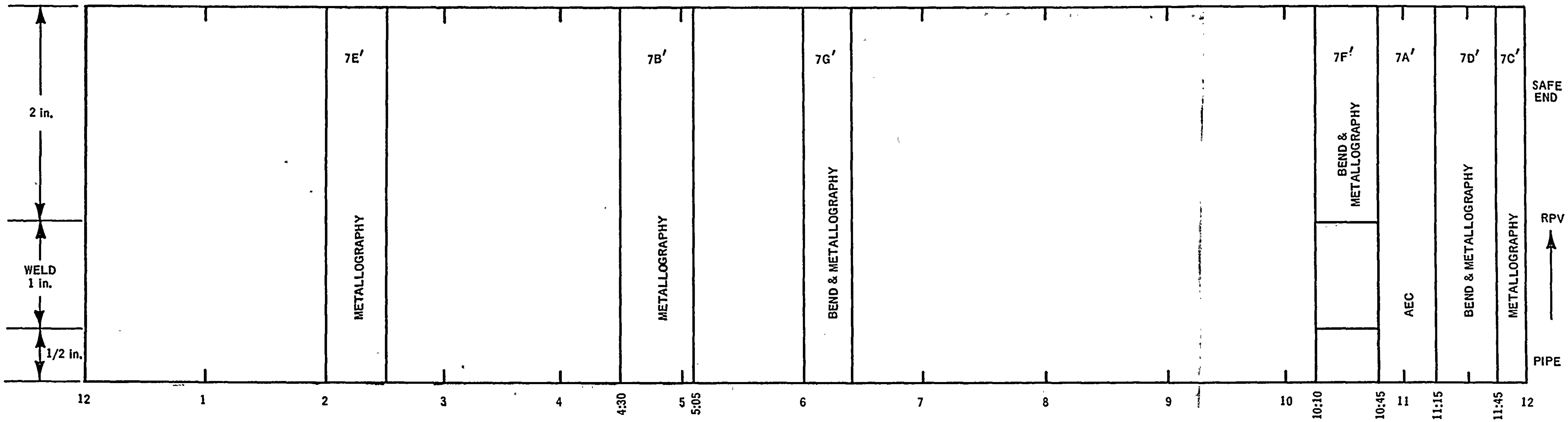
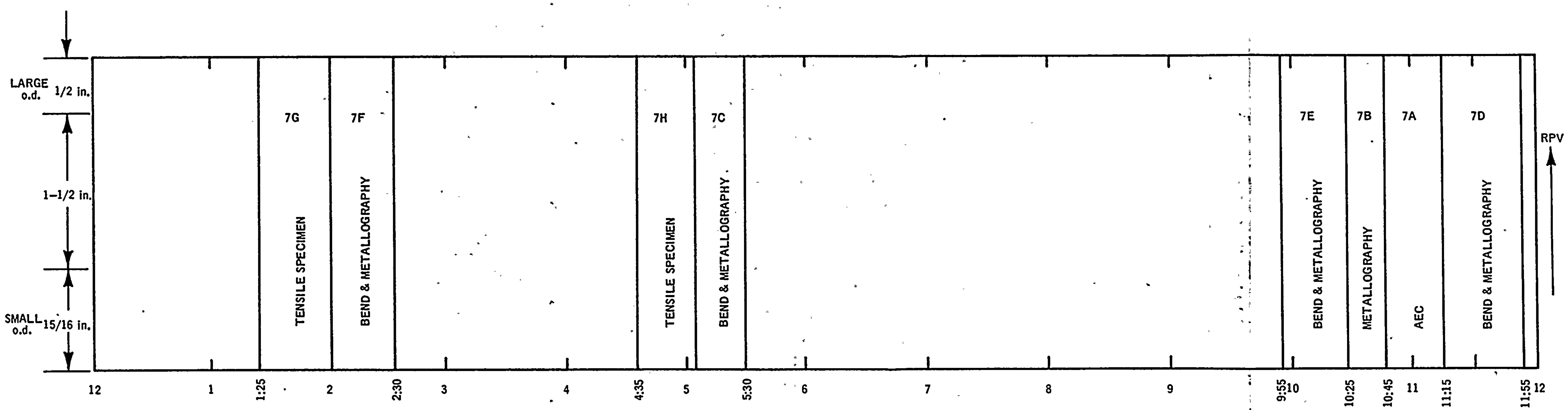
SKETCH

Fig 2



SAMPLE #7′ CUTTING LAYOUT (LOOKING AT O.D.) PIPE END – CORE SPRAY N6A

Fig 3

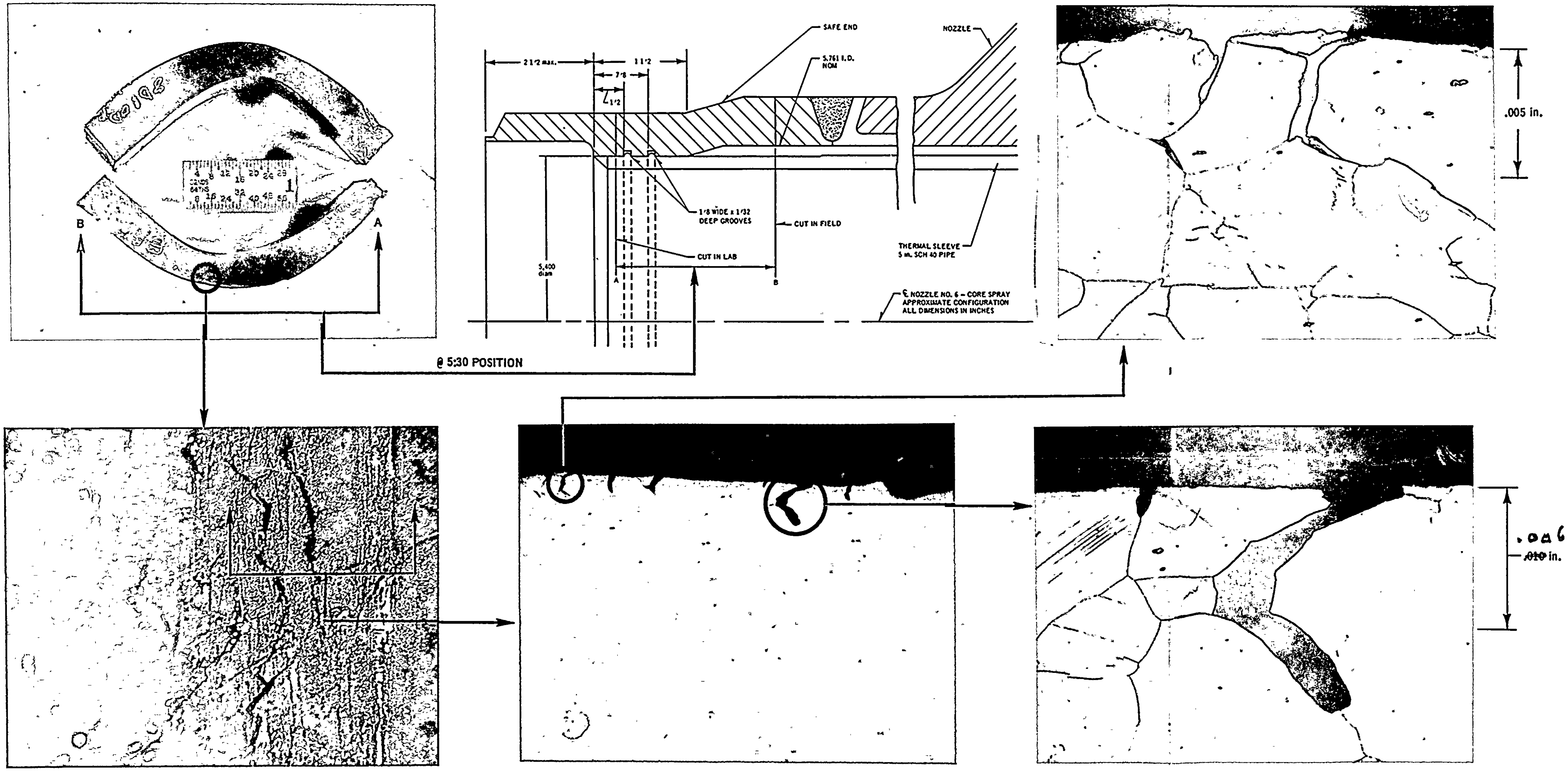


SAMPLE #7 CUTTING LAYOUT (LOOKING AT O.D.) NOZZLE END – CORE SPRAY N6A

Fig 26

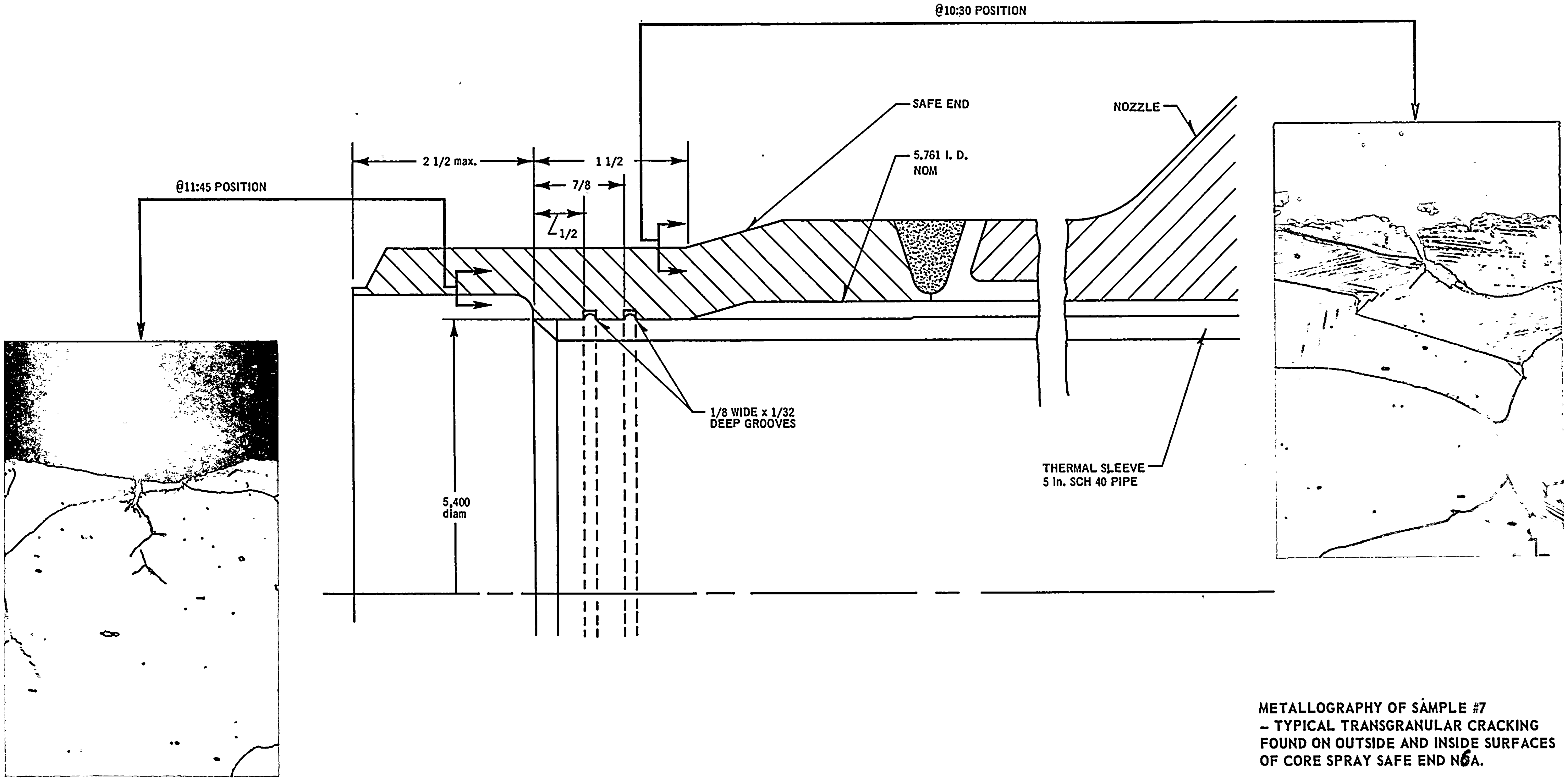
FIGURE 5

DELETED



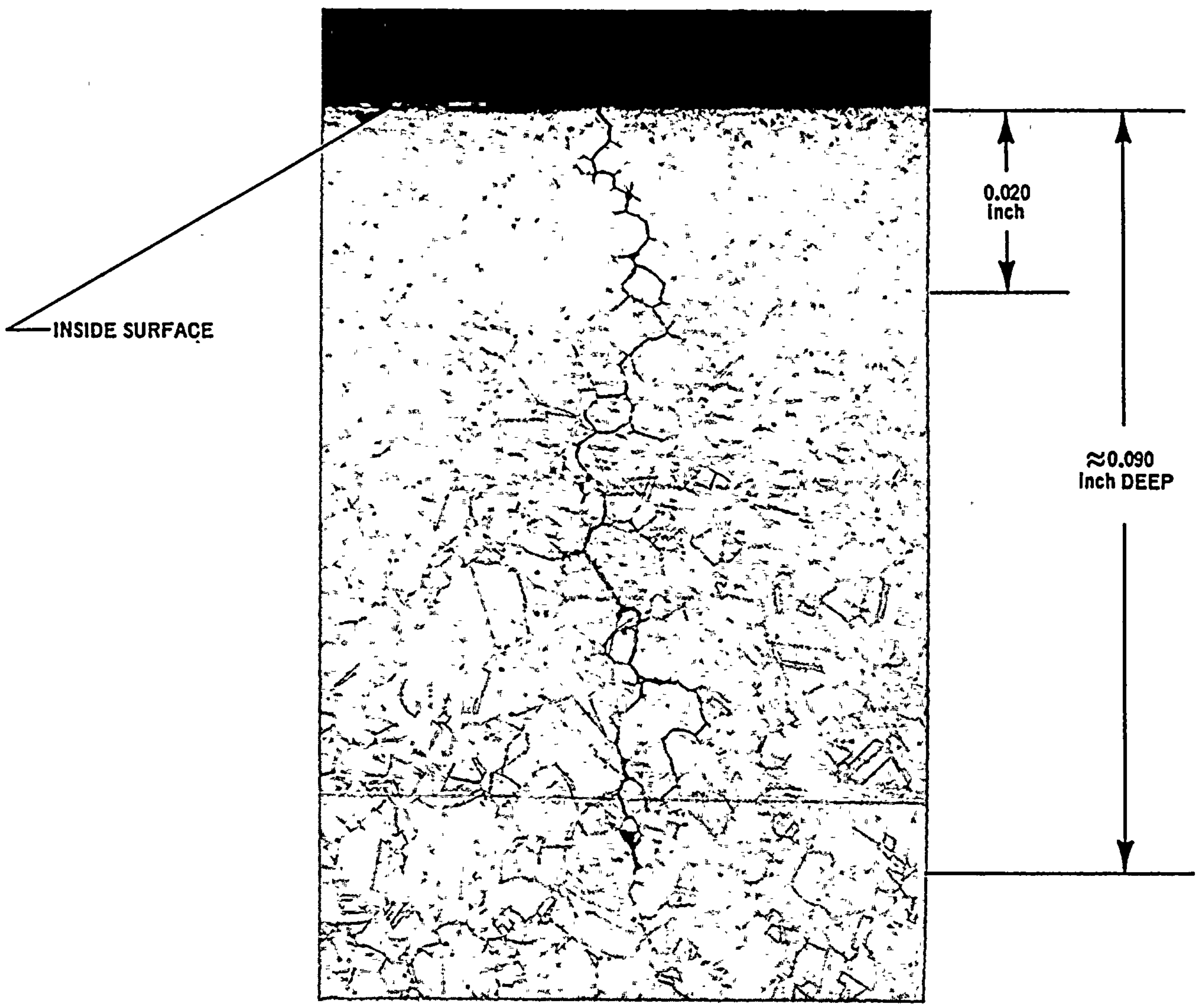
METALLOGRAPHY OF SAMPLE #7
INSIDE SURFACE OF CORE SPRAY SAFE END
N6A – BEND SAMPLE OF THICK END.

Fig 6



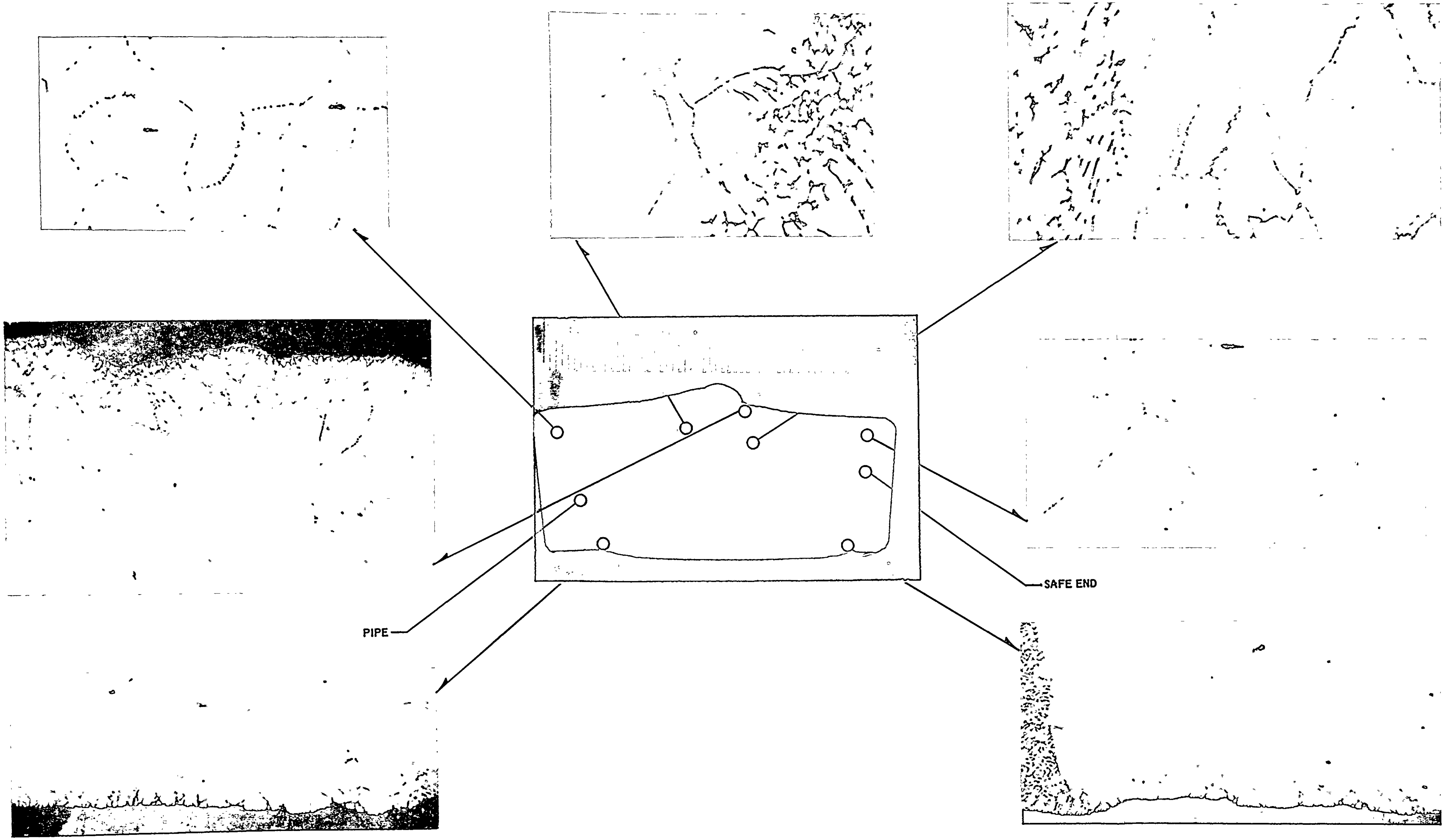
METALLOGRAPHY OF SAMPLE #7
– TYPICAL TRANSGRANULAR CRACKING
FOUND ON OUTSIDE AND INSIDE SURFACES
OF CORE SPRAY SAFE END N6A.

Fig 7



INTERGRANULAR CRACK IN PIPE MATERIAL LOCATED 1/4 inch FROM FIELD WELD ATTACHING PIPE TO CORE SPRAY SAFE END N6A – 5 O'CLOCK POSITION

Fig 8



METALLOGRAPHY OF FIELD WELD BETWEEN SAFE END AND PIPE ON CORE SPRAY N6A – 2:15 O'CLOCK POSITION

Fig 9

10:30 CLOCK POSITION

5:10 CLOCK POSITION

TYPICAL EXAMPLES OF MIXED MODE CRACKING ON INSIDE DIAMETER OF THERMAL SLEEVE ATTACHED TO CORE SPRAY SAFE END N6A

Fig 10

2. RESULTS OF SAMPLE ANALYSES FOR HALIDES

Concentrations of fluoride and chloride in all of the samples of water from the primary system and both core spray lines were either undetectable or very nearly so. The detection limits were 0.05 and 0.02 ppm for fluoride and chloride, respectively. Operating chloride concentrations of 0.068 ppm have been reported by the site. These low values are probably the best measure of the actual potential these constituents present in regard to their influence on corrosion.

Table 2-1 presents the results of analyses for total fluorides and chlorides performed on samples taken. Concentrations of fluoride and chloride contamination found on the solid material samples removed from the reactor vessel were of higher magnitudes than those found in the bulk reactor water. However, the values are very low - less than one microgram per square centimeter of surface area. The one measured surface contamination above this level was about 5 micrograms per square centimeter in the crevice between the core spray safe end and thermal sleeve.

An estimate of the magnitude of the Nine Mile Point reactor vessel surfacecontamination can be made by comparing the measured values with an acceptable industry standard, such as that specified for "as-received" stainless steel by Carpenter Technology Corp.(1) Carpenter states, "We can now guarantee that the chloride ion level on the surface of every finished stainless feedwater heater and condenser tube that leaves our Tube Division will not exceed 20 milligrams of chlorides per square foot of tube surface." The limit of 20 mg. per sq. ft. converts to 21 micrograms per square centimeter. All measured reactor contamination was much lower that the above allowable "as-received" standard.

Samples were also collected by brushing dust from external reactor pipe surfaces. Other dirt samples, cutting wheels, abrasive grinding material, and weld rod coatings were analyzed. All these samples showed high external chloride and fluoride contamination. This is not unusal.

Spectrographic analyses of the external dust samples showed high zinc content. Since the reactor vessel was coated with Carbozinc paint, the presence of zinc is readily explained. The results are shown in Table 2-2.

Reference (1) "Chloride Contamination of Tubing" by S.E. Doughty, Carpenter Technology Corp. - Power Engineering, Sept. 1969.

TABLE 2-1

RESULTS OF ANALYSES FOR FLUORIDES AND CHLORIDES

Sample Description	Azimuthal Location	Results μg F	Results μg Cl	Remarks	Sample Size cm^2
N6B Pipe + Safe End Pump Side	0000-12:00	288	12	Ultrasonic Crud (a)(e)	2050
N6B Pipe + Safe End Pump Side	0000-12:00	332	400	Ultrasonic Filtrate (b)(e)(f)	2050
N6B Safe End ID Pump Side	5-6	15		Machining (a)	12
B6B Safe End ID Reactor Side	6-10:30	26.4	17.9	Wipe (a)	95
N6B Thermal Sleeve ID	12-6	28.0	23.2	Wipe (a)	50
N6B Safe End OD	12-6	21.0	15.4	Wipe (a)	240
N6B Safe End ID Crevice	5:30-6	4.6	21.1	Wipe (a)	4.6
N6B Thermal Sleeve OD Crevice	5:30-6	5.0	--	Acid (b)	4.6
Blank	--	<0.04	--	Acid (b)	--
N6B Safe End ID Reactor Side	6-9	20.5	28.0	Machining (a)	29
N6B Thermal Sleeve ID	6-9	17.1		Machining (a)	21
N6B Thermal Sleeve ID	6-9	18.9	1.25	Machining (a)	21
N6B Safe End OD Pump Side	6-9	14.7	12.5	Machining (a)	26
N6A Scrapings from core spray pipe	9-3	7.4	27.8	Knife (a)	~100
Stock 304 Pipe	--	16.1	16	Machining (a)	33
Metal Turnings from previously machined area	--	6.3 ppm	5.3 ppm	Machining (a)	
Sediment from reactor support shroud	--	6.8	22.6	Vacuum (a)	?
Moisture separator coupon basket	--	3.7	<2.8	Knife (a)	~25
Moisture separator coupon basket	--	5.1	11.2	Wipe (a)	-
Steam dryer coupon basket	--	7.2	28.1	Wipe (a)	-
Crud sample from basket & rack adjacent to core	--	2.9	23.3	Wipe (a)	-
Same location, 2nd sample	--	9.2	6.0	Wipe (a)	-
Same location, 3rd sample	--	10.9	87.5	Wipe (a)	-
Same location, 4th sample	--	6.9	8.0	Wipe (a)	-
Washings from mirror insulation	--	~1000	~6000	Rinse (b)	5600
White deposit left where N6B leak had been	--	36	39	Knife (a)	(g)
Drippings from Safe End N6B	--	0.12-0.2ppm		(b)	
Reactor Water	--	<0.05 ppm	<0.02ppm	(b)	
Water from core spray line N6B	--	<0.05 ppm			
Water from core spray line N6A	--	~0.05 ppm	0.02ppm	(b)	
Water from region of reactor support shroud	--	<0.05 ppm	0.02ppm	(b)	

TABLE 2-1 (Continued)

Sample Description	Azimuthal Location	Results ppm F	Results ppm Cl	Remarks	Sample Size cm^2	Sample Weight grams
Dust on top of N3A water leachable material		221	445		0.100	
Dust on top of N3A total		2008	808		0.100	
Dust on top of Recirc outlet nozzle water leachable material		394	216		0.266	
Dust on top of recirc outlet total		8900	818		0.300	
Dust on top of fire extinguisher outside building water leachable material		386	947		0.072	
Dust on top of fire extinguisher total		1372	1962		0.072	
Dirt from door filter in plant (chem. lab emergency exit)		2102	5705			
Small cutting wheel 76190-9		13.7	26,658			0.507
Large cutting wheel 76190-9		12.7	25,748			0.503
Small stone on shaft		45.9	<5			0.503
Welderaser grinding wheel A-46-S5B		22,842	140			0.531
Calumet abrasives						
Bay States grinding wheel A24J ≈1/4" thick		27.8	18,463			0.513
Dust from Holiday Inn window sill Chattanooga		972	844			0.192
Dirt found in abandoned freezer Chattanooga		174	186			0.496
New welding rod coating water leachable material		224	-	(b)		
New welding rod coating total		18,800	162	(a)		
Fused welding rod coating water leachable material		330	95	(b)		
Fused welding rod coating total		18,153	108	(a)		
Developer SKD-5		7 ug	high	(c)		5
Developer SKD-5 Dry		5 ug		(d)		2
Penetrant SKL-S		<0.5 ug		(c)		5
Cleaner SKC-S		<0.5 ug		(c)		5

(a) Fluoride electrode after pyrohydrolysis. Applicable to all forms of fluoride directly.
(b) Fluoride electrode specific for fluoride ions.
(c) ~5 grams of the as-sprayed material were collected and dried at 85°C for 1.5 hours. The resulting residue was leached into water and analyzed by method (b).
(d) ~2 grams of the as-sprayed material were collected, dried for 1.5 hours at 85°C and analyzed by method (a).
(e) Chloride by neutron activation. Chloride in all other samples measured turbidimetrically.
(f) Sodium by neutron activation was 500 ug.
(g) Contained the Co-60 which would be contained in 3.1 liters of reactor water.

NOTE: Boron analysis on wipe samples from areas 1, 2, and 3 indicate that fluoride from the grinding stone is not significant.
NOTE: Chloride in all samples where an (e) does not appear was measured turbidimetrically. Pyrohydrolysis was performed where an (a) appears.

TABLE 2-2

SPECTROGRAPHIC ANALYSES

	White deposit left by leak of N6B %	Dust on top of N3A %	Dust on top of recirc outlet nozzle %	Dust from top of fire extinguisher outside building %
Al	6	2	2	2
B	0.07	<0.1	<0.2	<0.1
Ca	7	10	10	10
Cr	--	0.5	2	0.5
Cu	0.1	--	--	--
Fe	22	30	30	30
Mg	2	0.5	0.5	0.5
Mn	1	5	5	2
Mo	--	2	2	0.2
Ni	0.4	2	5	0.5
Pb	1.5	0.5	0.1	0.2
Si	15	15	20	20
Sn	--	0.02	0.2	0.02
Ti	1	0.5	0.5	0.5
Zn	45	50	25	20*

* Other fractions of this sample gave zinc value as low as 2 indicating the nonuniformity of the sample.

3. SUPPLEMENTAL INFORMATION REGARDING STRESS ANALYSES

Supplementing the Teledyne Materials Research Corporation report contained in Section 6, Reactor Primary System Investigation report dated May 1, 1970, the following analytical assumptions and input were used to calculate flexibility and weight stresses in the applicable piping systems. Flexibility of the reactor vessel at the point of piping attachment was taken as zero.

System	Temperature	Thermal Effect At Anchor Displacement (in) X	Y	Z	Total Wt. (lbs)
Core Spray					
East (N6A)	120F-545F	-.278	1.572	-.486	22,694
West (N6B)	120F-545F	.278	1.572	.486	26,972
Reactor Cleanup					
Discharge	120F-545F	-.2108	-.5339	-.6489	3,722
Suction	550F	-.4566	.3051	-.5071	3,531
Emergency Cooling Condensate					
East	130F-550F	-.5071	.5458	-.4566	9,303
West	550F	-.5910	.4023	.3412	9,418
Main Steam	545F	0	2.585	.559	31,742
Emergency Cooling Steam					
East	550F	-.1578	2.077	.4354	9,614
West	550F	-.1578	2.077	-.4354	9,393
Shutdown Cooling					
Suction	.350F-545F	.1419	.5386	.6675	9,851
Discharge	545F	.2858	.1889	.8796	6,790
Feedwater	120-545F	-.3529	1.3831	.3529	30,352
Control Rod Drive Return to Reactor	120F	0	1.6623	.5705	1,039
Reactor Recirculation	545F	.1493	.776	.7023	68,806

Where two temperatures are listed, the piping was analyzed for both conditions. The anchor displacements listed were used for both temperature conditions since the reactor is at 545F.

PROGRAM FOR RESTORATION TO SERVICE

BASED ON REPORTS OF PRIMARY SYSTEM INVESTIGATION

NINE MILE POINT NUCLEAR STATION

NIAGARA MOHAWK

PROGRAM FOR RESTORATION TO SERVICE

BASED ON REPORTS OF PRIMARY SYSTEM INVESTIGATION

NINE MILE POINT NUCLEAR STATION

May 11, 1970

NIAGARA MOHAWK

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1.. WORK TO BE PERFORMED PRIOR TO RESTORATION TO SERVICE

All furnace sensitized stainless steel accessible without physically descending into the vessel and necessitating removal of fuel was examined and found to be free from service oriented attack or cracking with the exception of the west core spray safe end (N6B). Nozzle N6B was determined to have had extremely high longitudinal stress at the point of failure. Stress in other nozzles attached to the vessel or piping are shown in the report of Teledyne Materials Research as Section 6 of the May 1, 1970 report of Reactor Primary System Investigation.

As a result of investigations described in the above report and Report No. 2 dated May 11, 1970, the following actions will be taken to restore the Nine Mile Point Reactor to service:

1. Replace both core spray safe ends with non-furnace sensitized stainless steel of 304-L grade. (Safe end N6B had been subjected to about 4-1/2 times yield and had failed. While N6A, although subjected to 1-1/2 times yield, had not failed, it is being replaced because of possible question of condition due to high stress and corrosive atmosphere.)

   The outboard portions of both thermal sleeves are being replaced with a slightly different design which

allows the inverted "U" to vent gases through three slots into the reactor proper.

2. Replace safe end of nozzle N5A emergency condenser steam supply. This safe end has several boat samples cut from its surface and, in preference to pad welding, the nozzle will be changed out to 304-L non-sensitized stainless steel. Additional metallurgical information will also be obtained on its condition.

3. Rehang all piping systems indicated by the Teledyne Report (Section 6, Reactor Primary System Investigation report dated May 1, 1970.) The objective will be to keep stress as low as practical but in no case will any stresses exceed code requirements. Restraints not required or that interfere will be removed. No furnace sensitized safe ends, other than core spray, fall into this category.

4. Investigate highly stressed welds in all systems that have shown high stress by PT and UT examination as follows:

Reactor Clean-Up Suction

Two-inch reactor drain connection to six-inch reactor clean-up, including two-inch pipe between first valve and connection.

Six-inch reactor clean-up connection to reactor recirculating piping.

Reactor Clean-Up Discharge

Reactor clean-up connection to reactor recirculating piping.

Elbow in reactor clean-up system outside the containment vessel just below system anchor.

Shutdown Cooling System Suction

Connection of shutdown cooling suction piping to reactor recirculating system.

West Core Spray N6B

All welds in entire system inside dry-well.

5. Remove all indications of intergranular attack on exterior of all furnace sensitized safe ends or repair. Flapper grinding of surface shall be done before PT. Surface shall be spot ground to an all-white condition. After required grinding, the safe

ends will be thoroughly cleaned using a 0.5% TSP solution. Mirror insulation will be similarly cleaned and reinstalled to protect surfaces.

6. Grind out and eliminate the interdendritic cracking on the surface of guide rod support weld. Blend edges where boat sample was removed to contour.

7. Blend by grinding the remnant surfaces on the dryer support lug where the slab sample was removed.

8. Replace or adjust timer of present leak detection system in order that alarm will sound when rate of fill of sump increases to one-half gallon per minute over normal. (Present alarm is set at 5 gpm.)

9. Impress hydrostatic test of approximately 1300 psi on fully assembled vessel before heating.

2. INVESTIGATIONS DURING STARTUP

Maintaining lowest possible stresses at the nozzles and all parts of the piping is the surest way to prevent cracking, leakage and failure. Piping systems properly supported for dead weight with flexibility allowance for the transition from cold to hot conditions should produce no excessive stresses in critical sections. For this reason, the following program will be instituted during the initial heating of the reactor:

1. Station personnel and Teledyne Materials Research will conduct a system by system, pipe-by-pipe walk through in the dry well to ensure that all hanger changes as well as other recommendations have been properly completed.
2. The Station staff with TMR in consultation will design tests to demonstrate that all systems connected to the reactor vessel move in accordance with the design intent and that resultant stresses are no greater than the Teledyne analysis.
3. During the first heating of the vessel from cold to operating pressure and temperature, the above tests will be implemented. Heating will be done in steps in order that no restraint will go undetected. Station personnel and TMR will co-operate both in the inspection and analysis phases.

3. CONTINUING SURVEILLANCE

Once the reactor has been restored to service and stress levels in piping systems proven in accordance with design, measures will be taken to maintain piping integrity. Any troubles which might occur would probably happen during thermal cycling. The philosophy of the surveillance program is for repeated assurance of flexibility and visual examination of the result as outlined below.

1. After twelve months' operation, within practical limits, all of the furnace sensitized safe ends that have not been examined during the year will be examined by both PT and UT.
2. Should the Station be off-line for a two week or greater period during the first year for other reasons, as many safe ends as possible will be examined by PT and UT.
3. Each time the reactor is shut down and goes through a full thermal cycle and until repeatability is assured trammel points in each piping system will be examined to assure movement in accordance with the original test. These points will be selected as being the most indicative of piping system movement from the extensive testing during original heat-up.

4. Operating experience has shown typical routine flows to the drywell floor drain sump of approximately 0.3 gpm. It is anticipated that sustained increases above this value of roughly 50 percent will be discernible to the operators within a 24-hour time period. Thus, the sump system as it now exists appears to have the capability to detect a system leak of approximately 0.2 gpm within 24 hours. Studies will be continued to determine if better and redundant methods can be devised whereby the operators can be apprised earlier than the present system. Methods presently installed will be experimented with (i.e. humidity indication, condensate discharge from coolers, etc.)
5. The program will be reevaluated after one year's operation.

4. SAFETY ANALYSIS

4.1 SUMMARY

A safety evaluation defining the consequences of potential failures of any of the furnace-sensitized stainless steel components has been performed. The components analyzed are:

Control Rod Drive Stub Tubes

Shroud Support Ring

Reactor Vessel Nozzle Safe Ends

Dryer and Guide Rod Support Brackets

The mechanical characteristics of each of these components have been evaluated in detail and safety analyses have been performed to evaluate safety implications should any of the above components fail. The overall conclusions reached are:

1. Failure at the weld which attaches the control rod drive housing to the stub tube would result in coolant loss from the reactor vessel at a rate of about 5 gpm. Leaks of this magnitude are easily detectable and can be accommodated by the control rod drive pump.

2. Failure of the stub tube components would not cause failure of the control rod drive housing. If a housing failure were postulated, the restraining action provided by control rod drive housing support would prevent the ejection of a control rod drive housing.

3. No mechanism has been found by which flaws in the stub tubes could propagate in a manner as to cause a failure of the reactor vessel.

4. Failure of the shroud support ring such that vertically upward loads and lateral loads imposed by the shroud could not be supported would not prevent insertion of the control rods or shutdown of the reactor in a safe orderly manner, but could result in decreased coolant flow through the core. However, the core bypass flow would not be large and adequate core cooling would be maintained.

   Failure of the shroud support ring such that vertically downward loads applied by the shroud could not be supported would, if it occurred with and/or under the conditions of any large loss of coolant accident, result in loss of core cooling and become a significant safety concern. Probability

of such a failure, however, is considered to be extremely remote,[1] if not almost inconceivable, under the stress and/or corrosive exposure condition on this ring. In addition, indications of vessel internal furnace-sensitized stainless steel attack would be identified in other furnace-sensitized stainless steel components long before the shroud ring structure could deteriorate to the above-postulated conditions.

5. Failure of any reactor vessel nozzle safe end up to and including instantaneous circumferential double ended failure of a recirculation nozzle safe end will not result in loss of core cooling. The engineered safeguards systems described in the FSAR and Supplements thereto, provide the required core cooling across the entire break size spectrum. Further, long before any crack can reach a size critical to rapid failure, leakage from the crack will have been detected. Critical leakage would be on the order of 70 gpm as compared to the improved detection capability discussed in Section 3 of this report.

6. Failure in any of the dryer or guide rod support brackets will not result in any loss of core cooling. Failure of the dryer support brackets under a steam line break could result in dryer components entering the steam line with the attendant safety concern of possible isolation valve closure blockage. It is important to note, however, that there are two isolation valves in each main steam line and the potential for both to be blocked is remote. Further, the core remains covered for all steam line breaks. Thus no fuel perforations would occur and the accident exposure guides of 10CFR100 would not be exceeded. Such a failure condition is considered to be extremely remote under the low steady state stress conditions in these brackets. Further, indications of furnace sensitized stainless steel attack would be detected, as discussed in 4. above, long before failure of the dryer support brackets.

The following provides a detailed analysis of the consequences of failures of furnace sensitized stainless steel (F.S.S.S.) components listed above.

4.2 CONTROL ROD DRIVE STUB TUBES

Analyses have been made to determine and evaluate the consequences of a failure in various locations of the control rod drive stub tubes. It can be postulated that a failure might occur in any one of four regions of the as-built assembly (see Figure 4-1). The information contained herein is the result of detailed safety analyses for each of the four postulated failures. Failure for this analysis is defined as a complete circumferential severance of the stub tube from the vessel or the control rod drive housing resulting from the initiation and propagation of a crack through the stub tube and/or the field weld connecting the stub tube to the housing.

---

[1]Final Safety Analysis Report, Sixth Supplement

As shown below, a postulated failure of one stub tube could result in a coolant loss at a rate of about 5 gpm. Loss of coolant much less than this small rate can be detected, and make-up can be provided by various process systems. It is concluded that postulated failure of a control rod drive stub tube would result in a small coolant loss rate which could be accommodated by coolant makeup provisions. Evaluation of the postulated failures in the four regions includes the following (See Figure 4-1):

1. Failure of the weld attaching the stub tube to the control rod drive housing.

2. Failure in the base material of the stub tube between the field and the shop welds:

3. Failure of the stub tube in the vicinity of the weld attaching the stub tube to the vessel.

4. Failure of the stub tube below the stub tube-to-vessel weld.

5. Effect of earthquake and loss-of-coolant accidents.

6. Propagation of stub tube failure into vessel.

4.2.1 FAILURE AT THE FIELD WELD CONNECTING THE STUB TUBE TO THE CONTROL ROD DRIVE HOUSING

A postulated failure in this region could result in a small coolant leak, but would not result in control rod housing ejection or hindrance of control rod operation for scramming. Failure of the weld at Location 1 would not be expected to result in a control rod housing ejection since the crack would tend to propagate through the minimum cross-section or throat of the weld leaving a radial projection on the housing preventing an ejection. Alignment or ability of drive to function would be limited to a misalignment of less than 0.1 degrees; consequently, the control rod drive would not be hindered from scramming. See Section 4.3.3 for a discussion for the control rod drive scram capability under misalignment.

If a crack did form in this region, a leak may or may not develop, depending on the mode of failure. A complete circumferential crack through the weld will not necessarily result in separation of the drive housing from the stub tube. For example, if the failure occurred somewhat in the middle of the weld between the root and final cover passes, the portion of the weld below the failure line would still be integral with the stub tube. If a failure were postulated which produces a leak, the most likely failure mode consistent with the orientation of observed defects found previously on Oyster Creek would be a crack extending from the root of the weld horizontally outward to the outer diameter of the stub tube. The leakage area is computed assuming

a complete circumferential severance of the housing from the stub tube. There is no mechanical driving mechanism to propagate or open the crack since the weight of the four fuel bundles supported by the stub tube and the pressure load at the bottom of the drive housing, also supported by the stub tube, induces a compressive axial stress. However, the crack width is assumed to be a minimum of one mil in width through the thickness of the stub tube. From the above cross-sectional area, the total leak would be about 5 gpm. Such a leak is detectable by the sump pump activity and is easily made up by the control rod drive flow if normal feedwater is not available.

The above postulated failure would not allow a control rod drive housing ejection.

Because of the direction of applied stress and the orientation of observed defects from Oyster Creek investigations, failures in other manners to allow housing ejection are considered extremely remote.

From a statistical viewpoint, a remote possibility exists that failure could occur in such a manner as to leave a smooth cylindrical surface on the housing such that it can pass through the inner diameter of the stub tube and the minimum bore of the vessel. However, even if such a remotely possible mode of failure occurred, the housing would be prevented from being ejected by the control rod drive housing support system (discussed in the Final Safety Analysis Report, Section VII-E). The maximum leak that could be postulated for such a remote event is approximately 685 gpm. Such a leak is easily detectable and is well within the capability of the motor driven feedwater pumps.

4.2.2 FAILURE OF THE STUB TUBE BASE MATERIAL

A postulated failure in this region could result in a small coolant leak as discussed under Failure 1, but would not result in control rod drive housing ejection or hindrance of the control rod drive operation for scramming.

The housing is about 1-1/2 inches larger in diameter than the minimum vessel bore; consequently, the drive housing could not be ejected from the vessel.

Under the above postulated failure, the alignment of the drive and the subsequent scram requirements would not be adversely affected (See Section 4.3.3). If it were assumed that the housing were free to move radially within the 0.015 inch maximum radial clearance, (between the drive housing's outer diameter and the bore through the stub tube and vessel bottom head), the angular disalignment would be limited to less than 0.1 degree which is negligible in affecting the drive scram performance.

The coolant leak rate from a postulated failure in the drive housing would be the same as discussed in Section 4.2.1.

4.2.3. FAILURE OF WELD ATTACHING THE STUB TUBE TO THE VESSEL

A postulated failure in this region could result in a small coolant leak, but would not result in control rod ejection or hindrance of operation for scramming.

The stress analysis for the control rod drive stub tube assembly as shown in Figure 4-1 indicated that this region is the most highly stressed during normal operation and during a scram when 50° F coolant water enters the housing or at the end of startup.

The highest tensile stress is at the inside surface of the stub tube directly across from the final cover passes of the shop weld connecting the vessel to the stub tube. Note that this region is not exposed to reactor water. Crack propagation, if postulated to occur, would tend to propagate horizontally outward from the inner diameter toward the outer diameter of the stub tube.

This applied stress is caused by a self-limiting or secondary loading which is produced by a rotation and lateral displacement of the stub tube at the vessel wall-stub tube junction. The rotation is induced by the radial thermal gradient through the vessel bottom head thickness, and the lateral displacement is induced primarily by the meridianal tensile strain in the vessel head developed by the internal pressure.

As the crack propagates radially outward toward the outer diameter of the stub tube, the tensile stress at the crack is reduced. The outside surface of the stub tube at the weld junction is always in compression. Residual stresses due to the shop weld might be the mechanism for continuing the crack propagation but this joint has undergone a stress relief. However, it is possible that the field weld joining the stub tube to the drive housing can induce significant residual stress of the stub tube-vessel weld junction especially at the outer peripheral drives where the welds are close together. The primary vertical load on the housing induces a compressive axial stress (as noted in Section 4.2.1).

However, if it is still postulated that an eventual circumferential crack of the stub tube occurs, a housing ejection is not possible because of the larger diameter of the stub tube relative to the hole bored in the vessel for the drive housing.

Drive alignment or scram capability would not be adversely affected as a consequence of the above postulated failure. If it were free to move radially, the horizontal motion would be limited by 0.015 inch maximum radial clearance between the housing outer diameter and the bore through the stub tube and vessel wall. This restraint limits the angular misalignment to less than 0.1 degree which is negligible in affecting drive scram performance as discussed in Section 4.3.3.

The leak rate from these cracks would be the same as from the cracks discussed in 4.2.1 above.

A failure in this region has been analyzed for propagating into the reactor vessel base material. For a discussion of this potential, see Section 4.2.6.

4.2.4. FAILURE IN THE STUB TUBE BELOW THE VESSEL TO STUB TUBE WELD

A postulated failure in this region would not violate vessel integrity, would not result in control rod ejection, and would not hinder the drive from scramming.

This area is the most unlikely region to fail, since it is not exposed to reactor water environment, and there are no primary stresses imposed such as pressure or direct weight. The applied stress is directly related to the differential expansion between the stainless stub tube and carbon steel vessel, and the local rotation of the joint caused by radial thermal gradients in the vessel bottom head. The stress due to both the normal operating mode and reactor scram is compressive at the root of the vessel stub tube weld. Diametrically opposite this weld at the stub tube o.d. a tensile stress exists; therefore, the most likely mode of failure (assuming the residual stresses will not contribute to the crack initiation) would be for the crack to propagate from the inside to outside stub tube surface. Because the applied stress is caused by "secondary" loadings, a crack initiated in this region would probably not propagate very far before it would stop. Even if a failure by a complete circumferential severance to the vessel wall were postulated, no breach of vessel integrity would occur. The only potential deleterious result is that the resultant increase in flexibility of the stub tube vessel junction may produce a higher stress in that portion of the stub tube remaining connected to the vessel.

4.2.5 EFFECT OF EARTHQUAKES AND LOSS-OF-COOLANT ACCIDENTS

The potential of a stub tube failure is increased during a severe transient or accident condition which imposes a significant stress rise so as to initiate or propagate crack growth. This is especially true if the transient load is "primary" (stress not limited by deformation such

as induced by pressure and weight). Two such conditions are the earthquake and loss-of-coolant accident. Both are discussed below.

4.2.5.1 EARTHQUAKE (Vertical Acceleration Component)

The primary effect of the vertical acceleration component would be to increase the vertical compression load most of which would be attributed to the weight of four fuel assemblies. As discussed in Section 4.2.1, the compression load does not tend to initiate nor propagate cracks and therefore, would not be expected to create a more severe condition here for two reasons; first, if cracking exists at a stub tube to housing weld, leakage (See Section 4.4) would be detected before gross failure could occur and secondly, the stress condition and expected crack propagation or failure mechanism does not support the assumption of vertical weld cracking leaking to a housing ejection.

4.2.5.2 EARTHQUAKE (Horizontal Acceleration Component)

The highest stressed region in the control rod drive stub tube components due to a horizontal earthquake acceleration is at the field weld connecting the stub tube to the control rod drive housing. The maximum bending stress in this weld is less than 6,000 psi for a maximum earthquake.

If a failure were postulated due to a horizontal acceleration, the expected mode of failure would be such as to leave a radial protrusion on the housing such that the housing could not be ejected through the minimum bore of the vessel and stub tube. The stress distribution resulting from the horizontal load is such as to result in a linear stress distribution applied at the weld with diametrically opposite sides being in tension and compression. Failure, should it occur, would progress around the circumference of the weld which is exposed to the tensile stress. The housing would tend to rotate or pivot at the weld until it contacted the bore in the stub tube and vessel below the field weld, again resulting in a housing rotation of less than 0.1 degree which would have negligible effect upon scram capability.

The same deflection limitation applies to a failure in the stub tube. The bending stress applied to the stub tube due to a maximum earthquake is less than that applied above because of the stub tubes' larger moment of inertia. However, the rotation of the drive housing is somewhat greater because the axial distance over which the 0.015 inch maximum radial clearance exists is less. Nevertheless, the rotation of the housing is limited to less than 1/4 degree so that drive scram capability is not affected (See Section 4.3.3).

4.2.5.3 LOSS-OF-COOLANT ACCIDENTS

During Loss of Coolant Accidents, the maximum differential pressures applied to the control rod drive housing are an internal pressure of 132 psi due to a recirculation line break and an external pressure of 54 psi due to a steam line break upstream of the flow limiter.

The above differential pressures result in a hoop tension and compression respectively being applied to the housing above the field weld. These stresses are 750 psi tensile (due to the 132 psi differential resulting from the recirculation line break) and 300 psi compressive (due to the steam line break). These stresses are considered trivial and will not contribute to a failure.

For the recirculation line failure the forces caused by the differential pressure result in additional compressive forces of less than 3,000 pounds being applied to the housing above the field weld and in the stub tube. As discussed under the vertical earthquake above vertical compressive loads are not considered to contribute to housing field weld failures such as to cause housing ejection unless the loads were high enough to shear the weld. Shear stresses at the housing to field weld in this case would be less than 200 psi. These stresses are negligible; therefore, the recirculation line break would not prevent a safe shutdown of the reactor.

For the steam line break case, although there is an upward force on the control rod drive housing resulting from the differential pressure applied to the bottom of the guide tube, the net force on the housing to stub tube field weld remains compressive and, as discussed above, does not contribute to the probability of failure.

4.2.6 EVALUATION OF A STUB TUBE PROPAGATING INTO THE REACTOR VESSEL

For this analysis the Inconel weld connecting the stub tube to the vessel base material is considered as part of the base material.

Conservatively, it is postulated that a complete circumferential crack has progressed through the stub tube and terminates at the weld connecting the stub tube to the vessel. The only stress tending to propagate a crack of this nature is the radial stress through the wall thickness which is extremely small, and its value is compressive. In order to provide a more favorable orientation for crack propagation into the vessel wall, it must be assumed that the crack changes from the circumferential to axial orientation at the outer diameter of the stub tube. For crack growth to proceed it is necessary that crack tip stresses be present.

Stress at the crack tip will come from these three sources:

1. Any local discontinuity from the attachment of the stub tube,

2. The meridianal stress in the bottom vessel head due to the internal pressure,

3. The radial thermal gradients through the vessel wall.

The stress analysis indicates that the service stresses due to the local discontinuity are always compressive in the stub tube o.d. for the normal operating mode and transient conditions such as the control rod drive scram.

To analyze the extent of crack propagation to the vessel base material, a crack was assumed to exist through the wall of the stub tube. Starting with a 3/4 inch depth crack which is the wall thickness of the stub tube in this region and using crack propagation data developed by the Pipe Rupture Study (see Section 4.4), it is estimated that the crack would have propagated about 0.6 inch into the vessel at the end of vessel life. This result represents an extreme upper bound. Conservatism in the analysis comes from the following assumptions:

1. No portion of the vessel life time is consumed in propagating the crack through the stub tube (crack propagation rate is a strong function of the initial crack length).

2. Once the crack reaches the base metal, no time is consumed for crack incubation or initiation into the base material. It is roughly estimated that one quarter of the vessel life would be required to initiate a crack in the base material following a failure in the stub tube.

3. The crack, when it reached the base material, was in the most deleterious orientation; that is, the circumferential crack somehow oriented itself to an axial direction for the length of the stub tube vessel shop weld from the cover pass to the root.

4. All the vessel life transient cyclic conditions are assumed to be maximum. The transient utilized in the analysis is the one that results in the highest stress in the reactor vessel. Roughly two-thirds of the cycles applied to vessel would result in lower stress intensities.

To demonstrate the crack growth rate at end of vessel life, it is postulated the bottom head of the reactor vessel has a 0.6 inch length crack propagating radially from the vessel counterbase into the base metal. Similarly, the adjacent penetration is postulated to have another equally long crack so that the ligament between the holes is reduced by 1.2 inches. If a transient is assumed under this condition which exerts the largest primary tensile stress as defined in the FSAR, Transient Analysis, Appendix E, the result is a crack length increase of approximately one mil under the postulated conditions.

Thus, it can be concluded that no vessel failure potential exists as a result of possible crack propagation from the stub tubes.

4.3 SHROUD SUPPORT RING

Analyses have been made to determine and evaluate the consequences of failure of the shroud support ring as shown in Figure 4-2. Two failure mechanisms can occur; the first is a failure through the upper portion of the ring above the cone support to shroud support ring weld such that vertically upward loads and lateral loads imposed by the shroud could not be supported; the second is a failure through the outer portion of the ring between the o.d. of the shroud and the o.d. of the ring (approximately 1 inch width) such that vertically downward loads imposed by the shroud could not be supported.

Failure for this analysis is defined as a complete circumferential severence of the shroud support ring and/or ring weld material as described above. The shroud support ring is an internal component of the reactor vessel, and is fabricated of stainless steel which is in a sensitized condition. The information in this section summarized the structural capabilities of the ring, identifies the capabilities of control rods to insert if misaligned as a result of the ring failure, and discusses core cooling and thermal-hydraulic considerations.

4.3.1 STRUCTURAL CAPABILITY

4.3.1.1 VERTICALLY UPWARD AND LATERAL LOADS

Applied stresses to the shroud support ring during normal operating conditions are less than 13,000 psi in tension. Most of the bending and hoop stress results from the stainless steel ring and shroud expanding radially outward more than the Inconel cone support. The induced tensile stresses are a result of the net uplift force of approximately 250,000 pounds (due to the normal pressure drops across the core plate and shroud head) causing the rim to rotate outward toward the vessel wall and differential expansion stresses.

This stress would be the most significant in postulating a failure since it would exist for significant periods of time and would induce a circumferential orientated crack which, if propagated completely around the circumference, would result in complete separation of the shroud from the shroud support ring.

If it is hypothesized that cracks will initiate and propagate, then initiation will probably take place randomly around the circumference of the shroud support ring. Because of some eccentricity in the applied load and/or because of small variations in material properties, these small individual cracks would tend to propagate and concentrate in one region of the shroud support ring to form one major crack. A slight eccentricity in the uplift load would cause an increase in stress at the tips of the crack tending to propagate this one crack around the circumference.

As the crack propagates, the shroud would start to tilt until the top surface of the core plate comes in contact with the underside of the guide tube. The guide tube is restrained from lifting by means of a bayonnet coupling, which locks each guide tube to its associated control rod drive housing. Two features of the guide tube prevent it from being pulled through the hole in the core plate. First, there are two 1/4 inch by 1-1/4 inch cross-sectional lugs on each guide tube which must be sheared off. If it is postulated that these lugs shear off, then the core plate would contact a flange whose diametrical dimension is over 0.2 inch larger than the hole in the core plate, preventing the guide tube from being drawn through the core plate. Preventing the guide tube from being drawn through the core plate hole is the fuel support casting which slips inside the guide tube and fits with an average radial clearance of 0.006 inch. This casting provides a substantial backing support to the inside surface of the guide tube. The guide tube is capable of sustaining an axial pull in excess of 25,000 pounds; only ten of the total 129 guide tubes are needed to sustain the uplift load on the shroud.

Summarizing, the shroud would tilt until the distance between the core plate and the underside of the guide tube is taken up. This distance is 0.7 inch. The maximum tilt that can occur is approximately 1/4 degree, which would not prevent the control rod drive from scramming within designed safe limits (See

Section 4.3.3 for further discussion of the control rod drive capability.) Once contact is established with the guide tube, the applied stress to the propagating crack is drastically reduced, which either stops the crack or slows down the propagation rate.

If it is postulated that crack propagation continues, eventual severance of the shroud and shroud support would occur. The reduction in pressure drop due to increased core bypass flow through the crack would not reduce the uplift force enough to allow the severed shroud to settle back to the shroud support ring; the shroud would continue to float upward where it would be constrained by the guide tubes. The core bypass flow and core thermal hydraulic response has been analyzed and found to be of no safety concern. See Section 4.3.2 for this analysis and results.

Lateral motion of the shroud is restrained to about 1/4 inch to 1/2 inch radial movement at the shroud support ring by the flow baffle. The flow baffle is directly attached to the shroud by means of twenty-four equally spaced 1 inch thick radial clips welded around the inside wall. There is no weld or any mechanical attachment of the flow baffle to the shroud support ring. Structurally, the flow baffle represents a continuation of the shroud through the inside diameter of the shroud support ring.

In the normal operating mode, and assuming failure of the shroud support ring, as described above, the shroud would be lifted 0.7 inch and would be restrained laterally from moving at the shroud support ring within the radial clearance of 1/4 inch to 1/2 inch.

A conservative estimate of lateral thrust from the hydraulically induced forces has been made by assuming that the maximum thrust would be no greater than the resultant thrust applied by the water jet to the flow baffle from three adjacent recirculation inlet lines. Normally with all five pumps operating, the resultant force tending to move the shroud laterally is zero. However, with only three adjacent pumps in operation, a net thrust of approximately 4800 pounds is applied to the shroud. If it is assumed that this force is applied to six of twenty-four clips, the resultant stresses in the clip would be well below yield strength. Consequently, it may be concluded that the clips will not fail during this postulated shroud ring failure.

During a design earthquake an overturning moment of approximately 37 $X\ 10^6$ in-lb. would be applied to the shroud at the support cone. This would result in a force of about 250,000 pounds compressive and tensile, being applied to diametrically opposite ends of the support ring. The ring would be able to sustain the compressive load, but it is assumed that the tensile load would initiate a crack as described above, such that the shroud would tilt. As discussed above the guide tubes resist this tilt; about ten of the outer peripheral guide tubes would be able to sustain the load. Consequently, the result of the earthquake loading will be no different on the system than a failure during normal operation discussed above and the reactor can achieve a safe shutdown.

A maximum steam line break produces a million pound net uplift on the shroud which induces a 1,200 psi tensile load to the shroud ring. A postulated failure of the shroud support ring would result, also, in the uplift being applied to the guide tube after the 0.7 inch clearance is taken up. Approximately 40 guide tubes of the total of 129 could sustain this load; therefore, this event does not prevent a safe shutdown.

4.3.1.2 VERTICALLY DOWNWARD LOADS

The major safety concern involving the shroud support ring is postulated as follows:

a. The support ring cracks such as not to be able to support significant downward applied loads.

b. A recirculation line ruptures.

The result of the above postulated conditions would be to cause the shroud to move downward until either the bottom portion of the flow baffle contacts the lower vessel head or until the shroud head contacts the top of the core. In either case, the core spray would be disabled or the effectiveness severely altered such that needed core cooling would not be available. The core spray lines would not support the applied load resulting from the loss-of-coolant accident which is approximately 2×10^6 lb. for a maximum break (approximately 2500 psi compressive stress at the shroud to shroud support ring junction).

Shroud support ring failure under these conditions is considered highly unlikely. Certainly, any failure except a direct shear of the shroud through the shroud ring would, as previously discussed, assure a safe shutdown. The loading is such to introduce compression which would not inhibit the load carrying ability of the shroud ring. The loading under this condition would tendto close the cracks that were postulated to be initiated under the normal operating mode. Two types of stresses would be applied to the shroud ring; one is an axial compression stress and the second is a bending stress which is caused by an overturning moment applied to the ring. This latter load tends to counteract the outward roll on the ring due to the differential thermal expansion.

As discussed above, the induced stress is always such to make the postulated crack propagate horizontally inward or outward. During the normal operating mode, the shroud support ring is always in hoop compression due to the differential expansion between the stainless steel shroud ring and the Inconel cone.

Superimposed on this hoop compression is a hoop tensile stress on the upper part of the ring and a hoop compression on the lower portion of the ring caused by the tendency of the ring to roll outward toward the vessel wall. This rotation is caused primarily by the shroud applying an overturning moment to the ring and by differential expansions. The primary stress from the shroud

uplift is also the largest at the upper part of the ring at the shroud-shroud ring junction. Also, the residual stress caused by the field weld of the shroud to the ring would be the largest magnitude in this region.

Because of the above described stress distribution, it is felt that any crack would progress radially inward or outward; consequently, the failure would be such that the shroud never slips through the ring when or if the shroud uplift load were removed.

Another consideration with respect to the above postulated shroud ring failure is that any internal condition within the vessel and primary coolant which provides a mechanism for F.S.S.S. crack propagation would, it is felt, be detected in other F.S.S.S. components through a minor leakage or plant inservice inspection procedures long before the shroud support ring would have sufficient cracking to lead to the above postulated conditions. This is especially true of areas where high stress exists or material thickness is considerably less, such as in the control rod drive stub tubes discussed in Section 4.2 or in the vessel safe ends (see Section 4.4). In both cases the material wall thickness is much less than the thickness of the shroud support ring (3/4 inch for stub tube wall thickness as compared to 3-3/4 inches for the shroud support ring). It is important to note also that if it is assumed a vertical circumferential crack does exist in the ring, only 0.2 inch of sound material at the location of the crack is needed to support the maximum vertical shear load of approximately 2×10^6 pounds (recirculation line break); this then, requires a crack to initiate and grow not only circumferentially completely around the ring, but also vertically through the ring more than 3-1/2 inches as compared to stub tube or pipe walls. Therefore, it is expected that crack initiation and propagation would be detected by inspection procedures in the stub tubes and safe ends long before a condition attendant to failure could exist in the shroud support ring.

Another load condition that could be imposed on the ring under the postulated failure condition is an upload resulting from a steam line break. In this case, the shroud would again move upward and the results discussed under Section 4.3.11 are applicable. Once the blowdown transient is over, the shroud would tend to drop down and could damage the core spray. Loss of core cooling would be expected since the core spray lines could not support the weight of the shroud components. This condition would also hold true for any other loss-of-coolant accident which results in loss of the uplift load due to normal recirculation flow. Again, however, such a shroud support ring failure is considered to be extremely unlikely.

Thus, although the above postulated shroud support ring failure could potentially lead to degradation or loss of core cooling, such a failure condition is considered to be extremely remote and crack propagation conditions leading to such a failure would be detected in other F.S.S.S. components long before cracks in the shroud support ring could propagate to failure.

4.3.2 THERMAL-HYDRAULIC ASPECT OF SHROUD SUPPORT RING FAILURE

An analysis of the thermal-hydraulic response to a crack of varying length in the shroud support ring was performed. This analysis was conducted, taking into account the following aspects of the thermal-hydraulics:

1. Flow losses in the external piping
2. Variation of voids (steam generation) in the core with varying core flow rates
3. Variation of core pressure drop as a function of core exit quality.
4. Balancing of flow between the reactor core and shroud region as a function of total flow rate and crack size.

The flow rate through the crack into the annulus surrounding the shroud was calculated by first calculating the flow area of the crack as a function of crack length, or arc length. This flow area was then converted into a loss coefficient (assuming 1-1/2 velocity heads irreversible loss), which was used to calculate the leakage flow from the lower plenum into the region outside the shroud. Thus, for a given crack length and a total flow rate, the flow split between the core and the support ring crack, and the pressure drop from the lower to the upper plenum is determined.

Figure 4-3 presents the vessel internal loop loss versus recirculation flow rate results in parametric form, showing the effect of crack length, with the pump characteristic curve shown superimposed. Point A on the graph corresponds to normal operating conditions, with no crack in the shroud support ring. When the crack reaches half-way around the shroud support ring (180 degrees), the steady-state operating conditions are represented by point B, which results in a higher total recirculation flow rate (a bypass flow area is arbitrarily chosen to demonstrate an intermediate condition) and lower reactor vessel internal pressure drop. Similarly point C corresponds to a crack in the shroud support ring approaching 360 degrees but not opened the full 0.7 inch uplift of the shroud. Finally, point D corresponds to a full 360 degree crack with a shroud uplift of 0.7 inch which represents the worst condition as far as shroud leakage flow is concerned. Table 4-1 below (which is based on the proposed design rating power level) summarizes the results shown in Figure 4-3.

TABLE 4-1

Point	%* Change in MCHFR	Crack Length	Core Flow M lb/hr	Shroud Leakage Flow, M lb/hr	Total Pump Flow M lb/hr	Core Pressure Drop, psi
A	0	0	67.5	0	67.5	19.3
B	-5%	180°	64.8	4.0	69.0	18.1
C	-13%	360° (0.33 in.)	60.4	10.6	71.0	16.4
D	-30%	360° (0.7 in.)	53.8	19.5	73.3	13.9

*This result is based upon the assumption that the operator does not recognize the core ΔP and flow change and pulls rods to hold a constant power whereas actually MCHFR would be expected to increase with decreasing core flow. The expected MCHFR values would be +4%, +6%, and +14% for points B, C, and D respectively.

The interpretation of the results of these analyses are as follows:

1. In the case of a complete separation of the shroud support ring, where constant power was held in the reactor, the MCHFR decreases by 30% resulting in MCHFR > 1.3. Therefore, no violation of MCHFR would be experienced. Under expected conditions, MCHFR would increase by 14%.

2. Core pressure drop and recirculation pump flow, for complete separation of the shroud support ring, changes -28% and +8.6% respectively. Such changes would be of sufficient magnitude to alert the operator to a condition of possible core bypass flow. From the results shown in Table 4-1, the operator would have an indication before complete separation has occurred.

3. If oscillatory movement of the shroud were to occur as a result of complete separation of the shroud from the support ring, the flow through the core could change with the movement but these flow changes would be bounded by the values shown in Table 4-1. Such flow perturbations would result in neutron flux changes of about 13-1/2% in going from no separation to complete separation. Such a time variant change in flux would be clearly visible to the operator in the control room.

4.3.3 CONTROL ROD SCRAM CAPABILITY UNDER MISALIGNMENT

The control rod drive system provides forces during a scram which are many times the rod weight. The maximum force available to scram the drive is as much as 5600 pounds (cold) and 2800 pounds at operating pressure. Consequently, it is felt that friction forces could not develop to the point that the ability to scram is lost. Even with only reactor pressure available for scram, the force is greater than 1000 pounds. Furthermore, the flexibility of the drive line is such that considerable angular misalignment of the drive line can be tolerated without any appreciable reduction of scram capability. This has been demonstrated repeatedly in tests and by operating reactor experience, all evidence indicating that high drive line friction is manifested by difficulty or failure of the drive to withdraw, an event which is immediately obvious to the reactor operator.

The effect of lateral core displacement on drive performance was evaluated in a series of tests conducted in 1963 on a prototype unit, the results of which are shown in Figure 4-4. No scram impairment was observed with the maximum lateral misalignment of approximately 1/4 degree.

The effect of misalignment of the drive housing with respect to the core was evaluated in a series of tests conducted on a prototype unit in 1964. Results from this test are shown in Figure 4-5. In this test, the bottom of the housing was displaced from the center line by 1 inch, corresponding to an angular misalignment of approximately 1/2 degree. The change in scram time was approximately 0.1 second. The test was run with the bottom of the housing being oscillated with a displacement of 1 inch at its natural frequency, and is not a direct measure of the performance with a fixed core displacement. It is, however, indicative of the magnitude of misalignment required to have a measurable effect on scram performance.

4.4 REACTOR VESSEL NOZZLE SAFE ENDS

Analyses have been made to determine and evaluate the consequences of failure of any of the F.S.S.S. safe ends on the Nine Mile Point vessel. In the case of the safe ends, failure is defined as cracking initiating and propagating in the wall to a magnitude sufficient to cause a loss of coolant. The loss-of-coolant could be anything from a small leak up to and including an instantaneous double ended rupture.

Nozzle ruptures, up to and including the recirculation line nozzles, will not lead to unacceptable core temperatures, with the result that there is no break size within the reactor system which is not protected by the safety barriers and engineered safeguards systems.

The reactor vessel nozzles which have sensitized safe ends are listed in Table 4-2. None of the safe ends are a part of a safety system* and postulated

failure such as a small leak or an instantaneous double ended break would not jeopardize the ability of the reactor to achieve safe shutdown.

TABLE 4-2

SENSITIZED SAFE ENDS*

Quantity	Size (in.)	Nozzle Function
5	28	Recirc. Outlet
5	28	Recirc. Outlet
2	10 (Steam)	Emergency Condenser
18	6 (Steam)	Head Safety Valve and Inst. Long Neck Flange
1	4 (Steam)	Head Vent Long Neck Flange
1	3	Control Rod Drive Return Line Safe End

*Core Spray Safe Ends have been replaced with non-sensitized material and are not considered a part of this analysis.

The work conducted under the AEC sponsored Reactor Primary Coolant Rupture Study shows that large breaks or cracks will be preceded by gradual growth of smaller cracks. Although not complete, this study has produced a very useful compendium of experimental data encompassing crack initiation, crack propagation, and fracture behavior of piping materials and piping components. The fracture data in particular has led to some conclusions which are useful here. Basically, this program has shown that cracks can form and grow due to mechanical or thermal cycling or corrosion but that rapid failure will not occur until the crack reaches a critical magnitude.

Given a crack length, it is possible to calculate the leakage rate taking into account the crack extension under the multi-axial loading conditions. The leak rate from a crack of known dimensions was calculated and compared to the measured leak rate for pressurized water at room temperature. The leakage rates check within 15% but allowing for the other uncertainties in friction factor, the stress state and the temperature effects, it appears roughly that flow can still be calculated within a factor of at least two.

Thus, for a given crack length, it is possible to plot a curve of leakage rate as a function of "K", the stress intensity factor, the correlating parameter which is a function of crack length for various pipe sizes. Results of these calculations are shown in Figure 4-6.

Experimentally, it has been determined from the rupture study, indicated above, that for a variety of materials rapid failure does not occur until this stress intensity factor is greater than a given value. The average was about 148 Ksi-$\sqrt{\text{in.}}$ For conservatism, assuming that the critical "K" lies within 2 σ limits less than this, it is seen from Figure 4-6 that the leakage from such a crack would be at least 70 gpm depending on the pipe size. The leak detection capability in the primary containment is as discussed in Section 3 of this report. Therefore, the following conclusions can be drawn from Figure 4-6.

1. Long before the crack length has grown to even within 2 σ limits of observed critical crack length, the fact that a crack exists will have been detected.

2. The amount of leakage which occurs even for cracks near the critical size is within makeup capability so that the core is not uncovered. Thus for cracks below the thresh-hold of detection, the leakage is overwhelmed even by the control rod drive hydraulic feed pump.

Therefore, the probability of rapid breaks occurring without detection is extremely remote. Cracks below the threshold of detection are of no concern with respect of core cooling.

Even if a complete break were to occur, however, core cooling would be maintained. Table 4-3 summarizes the peak clad temperatures assuming a complete circumferential break of each of the sensitized pipe safe ends. The analysis details which apply to a specific pipe or break size can be found in the referenced documents in Table 4-3, but a summary is provided below.

Figure 4-7 shows peak clad temperature as a function of break size for liquid breaks.

A complete break of the recirculation line results in peak temperatures of below 2000° F through the action of either one of the two core spray system loops alone. This is the highest temperature for any break. The peak temperature decreases as the breaks become smaller.

All of the liquid lines listed in Tables 4-2 and 4-3 are covered by the analysis results shown in Figure 4-7. Figure 4-8 shows peak clad temperature as a function of break size for steam breaks. Steam breaks up to and including the main steam line (not a sensitized safe end) do not result in core uncovery, thus no clad temperature increase is experienced.

Thus, the entire break spectrum has been comprehensively examined in detail and the specific safe end sizes in Table 4-3 are merely discrete points in this spectrum. No conditions can be postulated by which a single safe end failure of any size can result in clad temperatures in excess of those determined and reported in the Final Safety Analysis Report and its Supplements.

TABLE 4-3

SUMMARY OF SAFETY EVALUATION OF SENSITIZED SAFE ENDS

Quantity	Nominal Size	Function	Type of Break	Approx. Break Size ft^2	Peak Clad* Temp.	Ref. Document
5	28 in.	Recirc. Inlet	Liquid	7.30	< 2000° F	FSAR App. E and
5	28 in.	Recirc. Outlet	Liquid	7.30	< 2000° F	Supp. No. 5
2	10 in.	Emerg. Cond. Outlet	Steam	0.48	No Uncovery	Supp. No. 5
18	6 in.	Head Safety Valve and Instrument Flanges	Steam	0.195	No Uncovery	Supp. No. 5
1	4 in.	Head Vent Flange	Steam	0.087	No Uncovery	Supp. No. 5
1	3 in.	Control Rod Dr. Hyd. System Return	Liquid	0.72	<2000° F	Supp. No. 5

* Refer to Figures 4-7 and 4-8.

4.5 DRYER AND GUIDE ROD SUPPORT BRACKETS

Analyses have been made to determine and evaluate the consequences of a failure in the dryer and guide rod support brackets.

Failure of the dryer and guide rod support brackets would not result in loss of core cooling. Failure of the dryer brackets could, however, result in debris entering the steam line under the conditions of a steam line break.

4.5.1 DRYER SUPPORT BRACKETS

There are four dryer support brackets located on the vessel wall at the elevation of the main steam line nozzles. These brackets are spaced equally around the vessel wall and restrain the dryer from movement due to any normal operation, transient, seismic or accident loads.

The bracket consists of a lug welded to the vessel wall approximately 8 inches high, 2-1/2 inches wide and 4-1/4 inches deep, with a welded collar for dryer retention.

4.5.1.1 NORMAL OPERATION

The normal operating pressure drop (uplift) across the dryer is insufficient to offset the dryer weight of approximately 46,000 pounds, thus during normal

operation should failure be experienced on all four brackets the dryer assembly would drop down until the lower dryer support ring contacts the upper bolting ring of the steam separator assembly.

Such a condition would not result in any impairment of core cooling capability. Steam flow and quality changes would occur due to displacement and damage of the drain return lines at the bottom of the dryer assembly. However, such changes would be expected to be small enough not to cause any major perturbation in the reactor system operation and no safety related response would occur. Bracket primary stresses under normal operation loads (assuming two of the four brackets carry the load) would be less than 6000 psi tension at the upper surface of the bracket.

Such stresses, although primary in nature, are not of the order of magnitude to initiate cracking (below yield) and would not, therefore, be expected to result in crack initiation, propagation and eventual failure of the dryer support bracket. However, even if such cracking were initiated, the crack would be required to propagate through the entire 8 inch height of at least three of the four support brackets before dryer support would be lost. As discussed in Section 4.3 any internal vessel condition promoting F.S.S.S. crack propagation would be detected in other F.S.S.S. components through minor leakage or plant inservice inspection procedures long before the dryer brackets would have sufficient cracking to lead to a failure.

4.5.1.2 EARTHQUAKE AND ACCIDENT CONDITIONS

Earthquake loads were considered in the design of the dryer support brackets. When earthquake loads are added to the normal operating loads, the worst case (assuming one bracket sees all maximum stresses-very conservative) results in a tension stress at the upper corner of the brackets of less than 16,000 psi. However, since earthquake loads are unlikely and of short duration, such a loading would not apply additional stresses to the brackets for a sufficient length of time to propagate cracks.

The only accident condition of concern to the dryer assembly and dryer support brackets is the steam line break. In this case, sufficient uplift ΔP (approximately 2 psi) exists across the dryer to overcome the dryer weight and apply an uplift load of approximately half the normal operation (downward) load. The resulting stresses would be less than 3000 psi and would be of short duration. Therefore, for the reasons discussed above for the normal loads, the steam line break load conditions would not result in failure of the dryer support brackets.

In the remote event the brackets had failed prior to or at the time of a steam line break accident, the dryer assembly would move upward until it contacted the vessel head. It is expected that the dryer assembly would suffer severe mechanical and structural damage upon impact with the vessel head; however, due to its low mass to volume ratio, the dryer assembly would crush and not damage the vessel. The dryer flow baffle would cover the steam nozzles, tending to significantly reduce steam flow. However, the possibility of dryer

parts exiting through the steam line cannot be ruled out. Such a condition, should it occur, could potentially be of safety significance since the main steam line isolation valves might not close with debris in the steam lines. It is important to note, however, that there are two isolation valves in each main steam line and the potential for both to be blocked is remote. Further, as shown in Figure 4-8, the core remains covered for all steam line breaks. Thus no fuel perforations would occur and the accident exposure guides of 10CRF100 would not be exceeded.

Such an event is considered to be extremely remote in view of the fact stress levels in the dryer support brackets are well below the threshold for F.S.S.S. crack initiation and propagation and in view of the fact that the material thickness required to fail is much greater than other F.S.S.S. components in the vessel where inservice inspection procedures or small leakage would be detected long before dryer bracket failure (see Section 4.3 for further discussion on this subject.)

4.5.2 GUIDE ROD SUPPORT BRACKETS

The guide rods and support brackets serve no function other than to assist in assembly and disassembly of the dryer and separator assemblies. There are no significant operational loads induced upon the guide rod support brackets and the weight of the guide rods is negligible from a failure stress standpoint.

Should the guide rod brackets fail, no safety significance can be found. The rods are guided and restrained laterally the entire length (approximately 22 feet) by the dryer and separator assemblies. The rods could not drop down more than approximately 1-1/2 inches due to a shoulder just above the upper shroud-to-shroud head attachment ring.

There are no significant forces on the guide rod tending to lift the rod vertically. Should the rod move vertically upward it would be laterally guided by the separator to dryer assemblies and could not exit a steam nozzle.

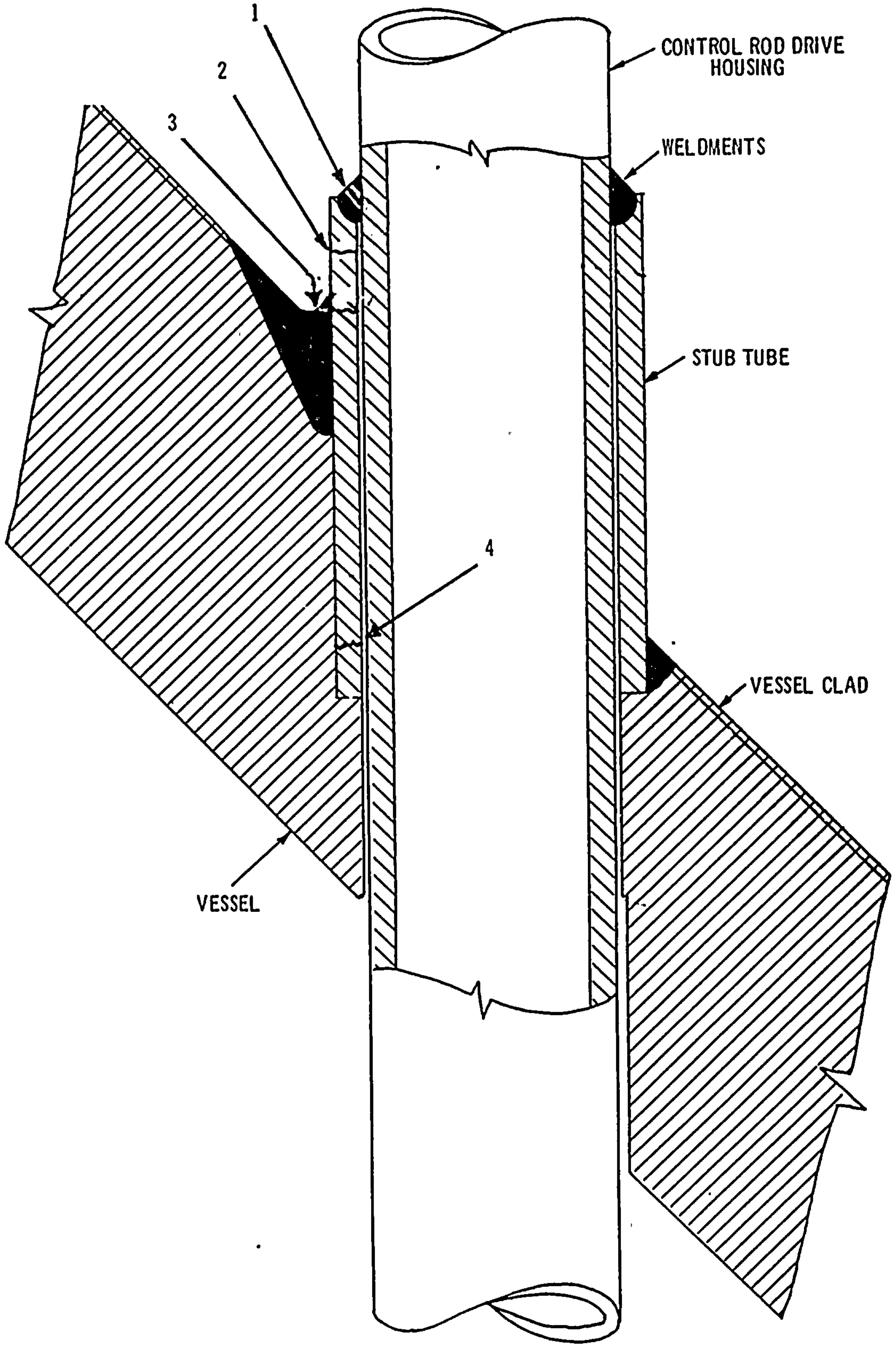


FIGURE ~~6-1~~. STUB TUBE CONFIGURATION

4-1

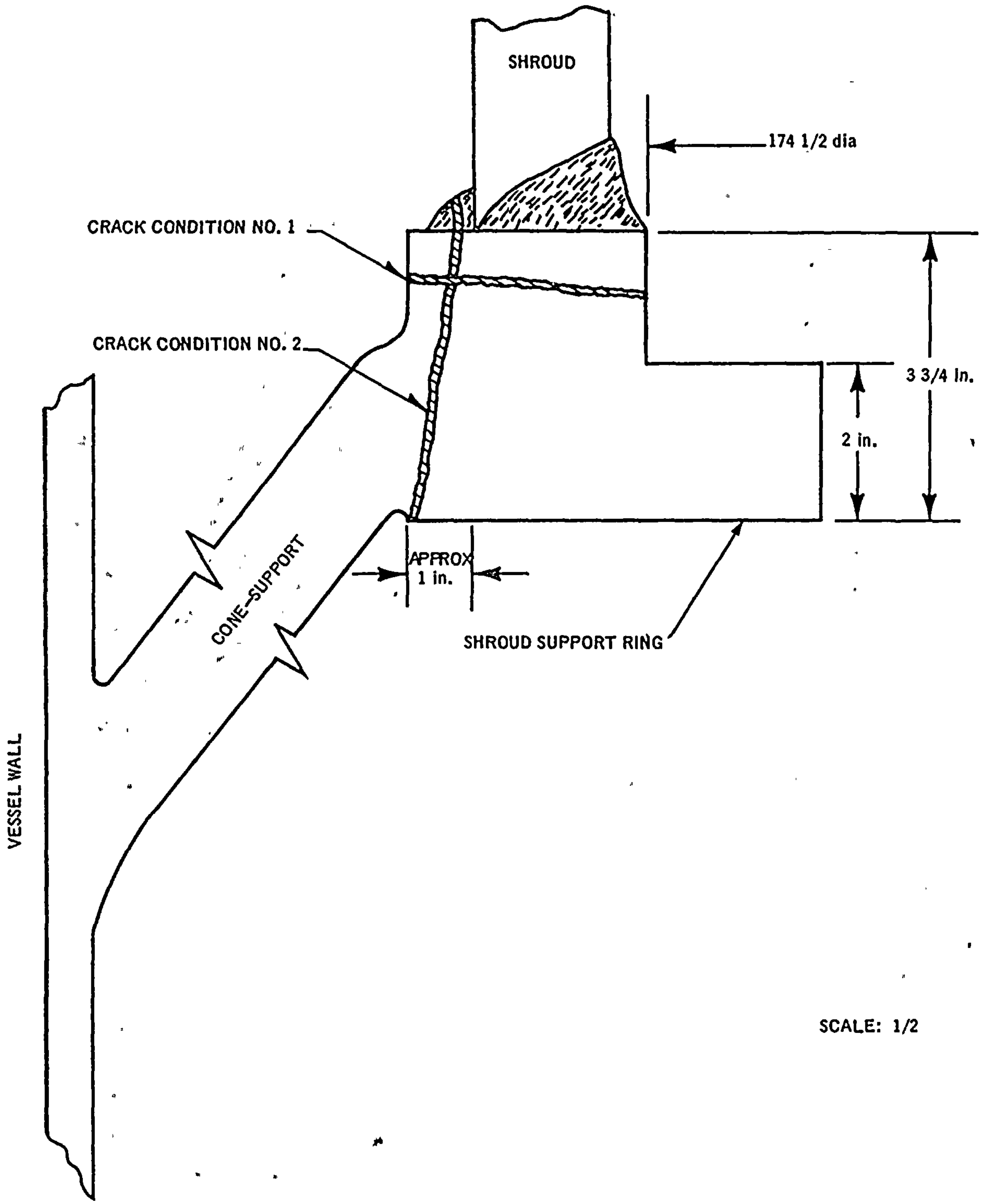


FIGURE [redacted] SHROUD SUPPORT·RING CONFIGURATION
4·2

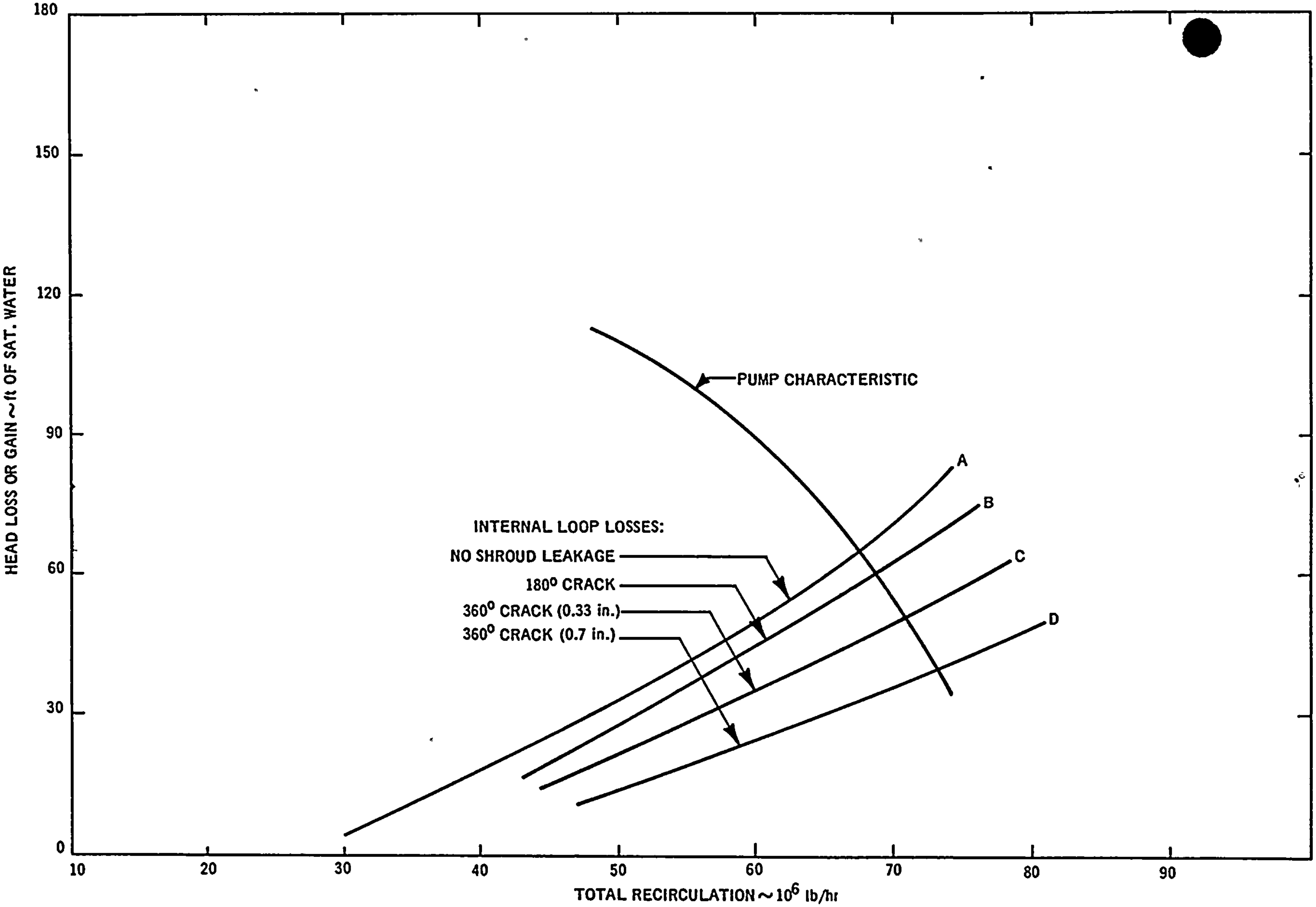


FIGURE ~~6-3~~. EFFECT OF SHROUD BYPASS LEAKAGE ON CORE FLOW
4-3

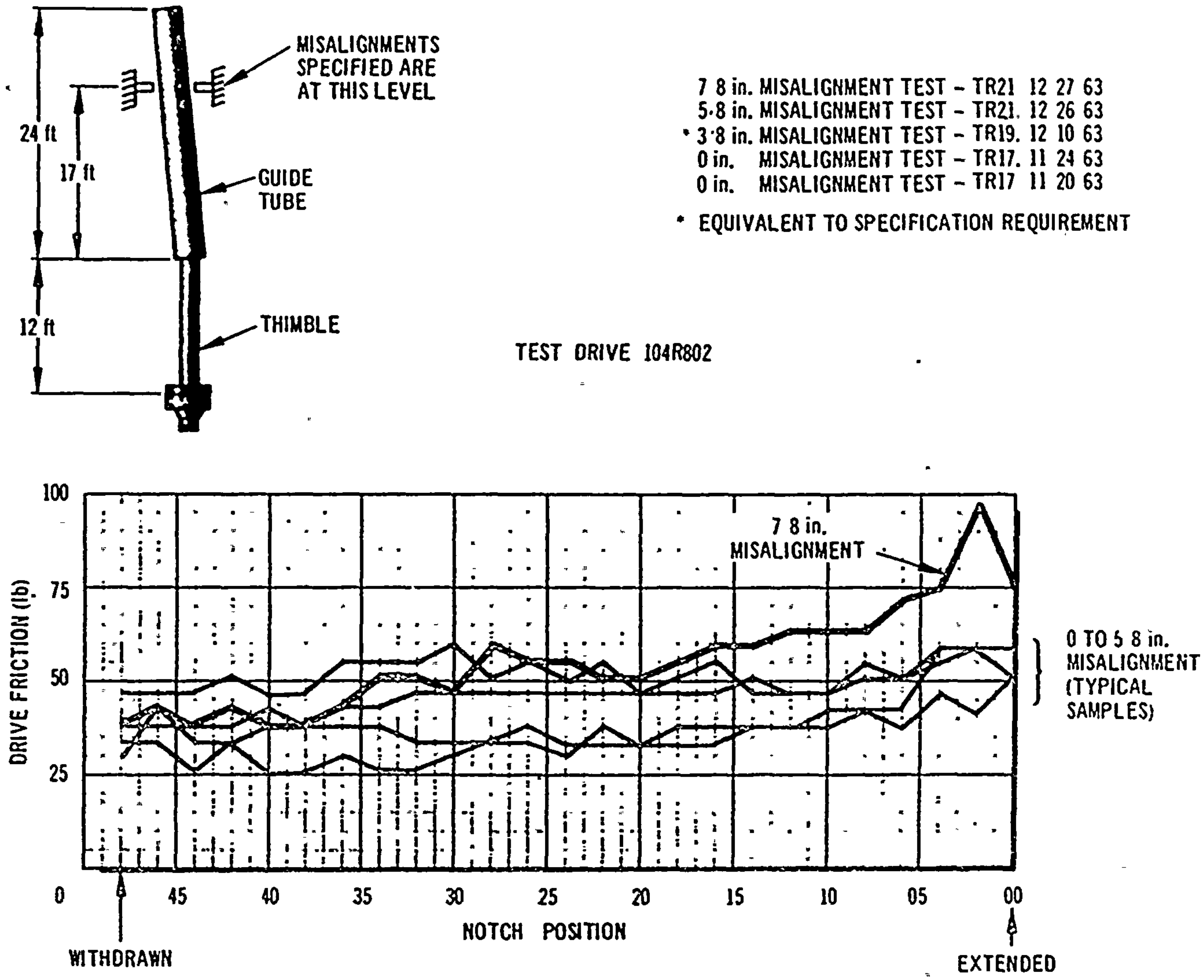


FIGURE 4-4 MISALIGNMENT FRICTION TESTS

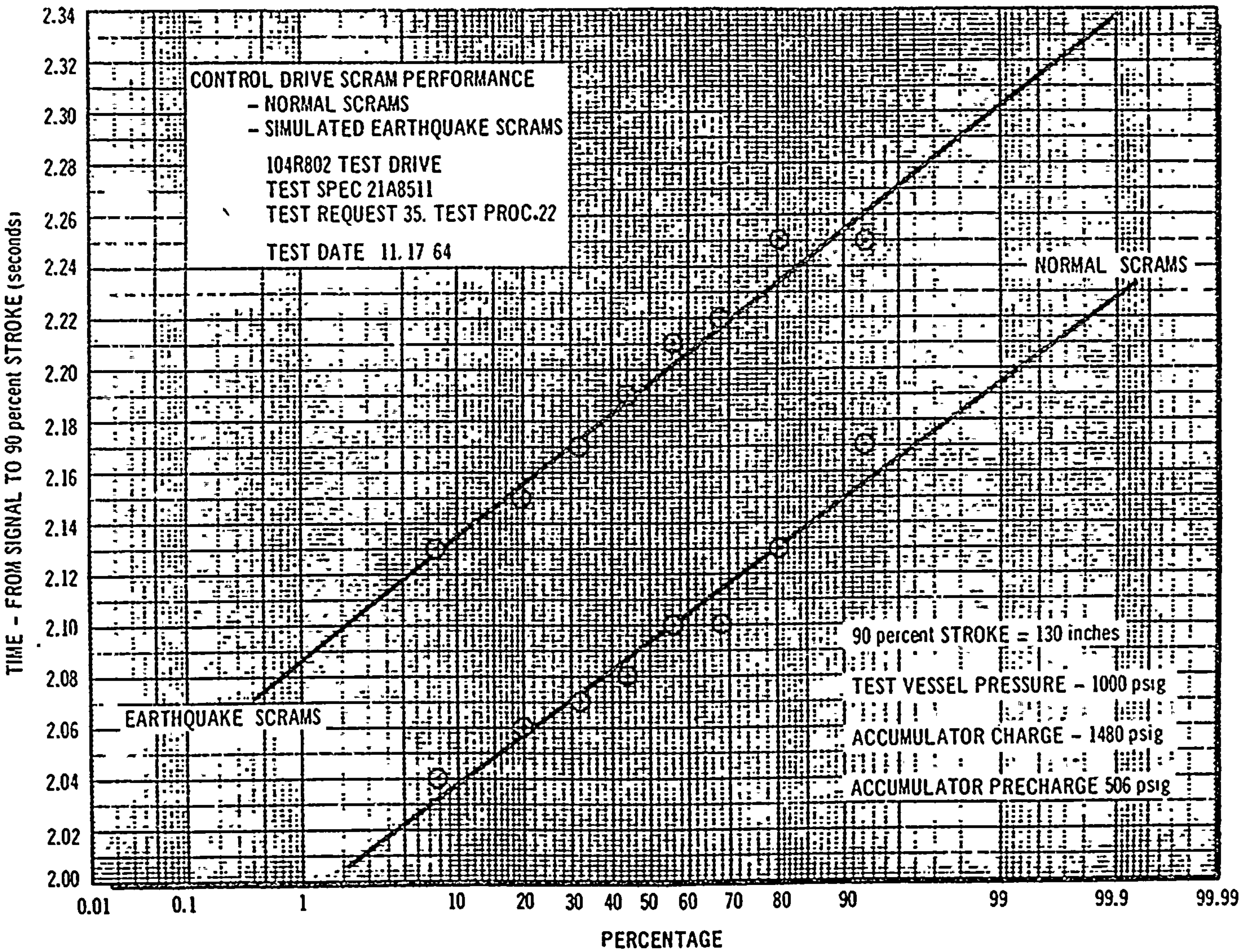


FIGURE 4-5 EARTHQUAKE SCRAM COMPARISON–PROBABILITY PLOT

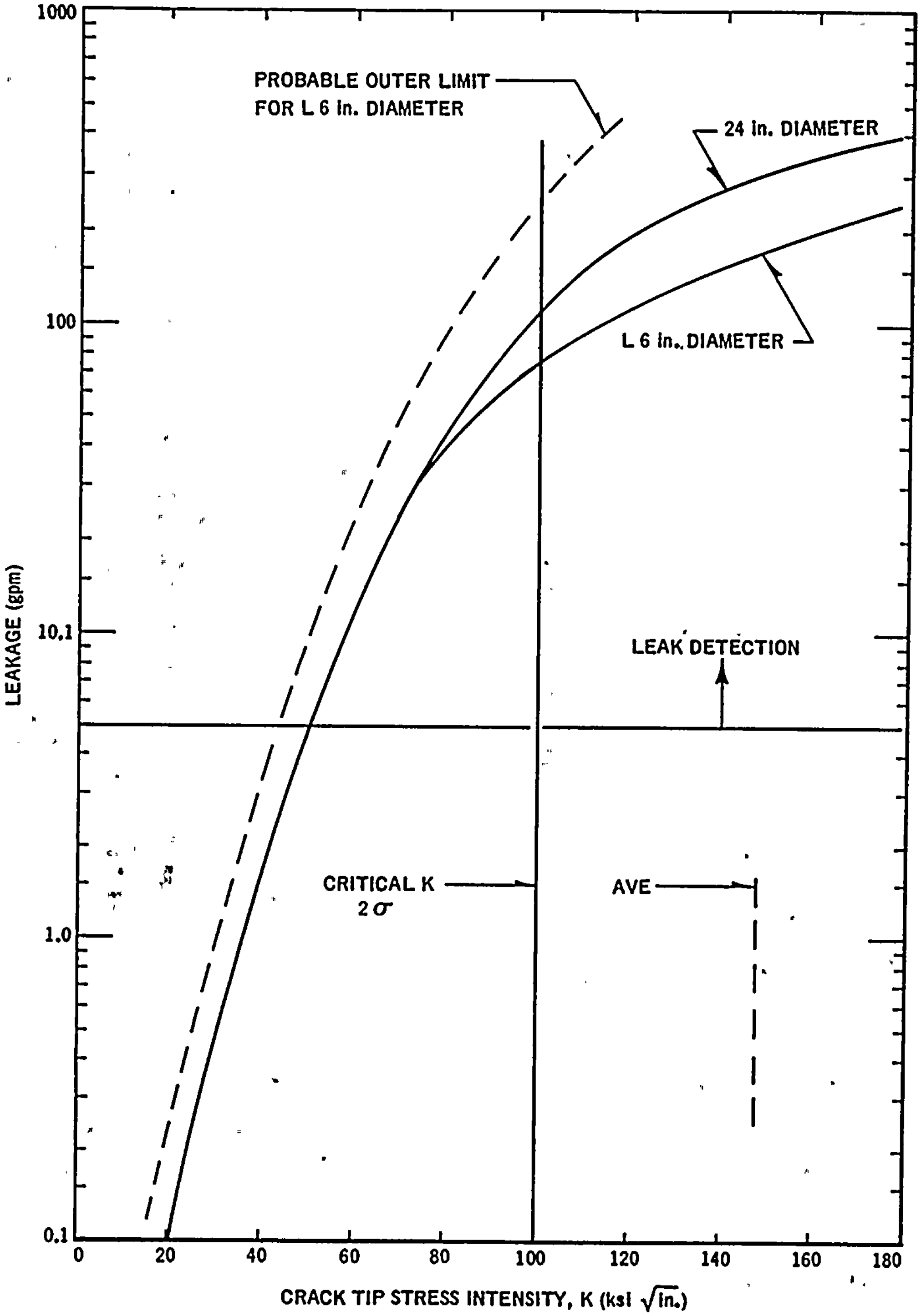


FIGURE ~~6-8~~. CRACK LEAKAGE RATE CORRELATION

4-6

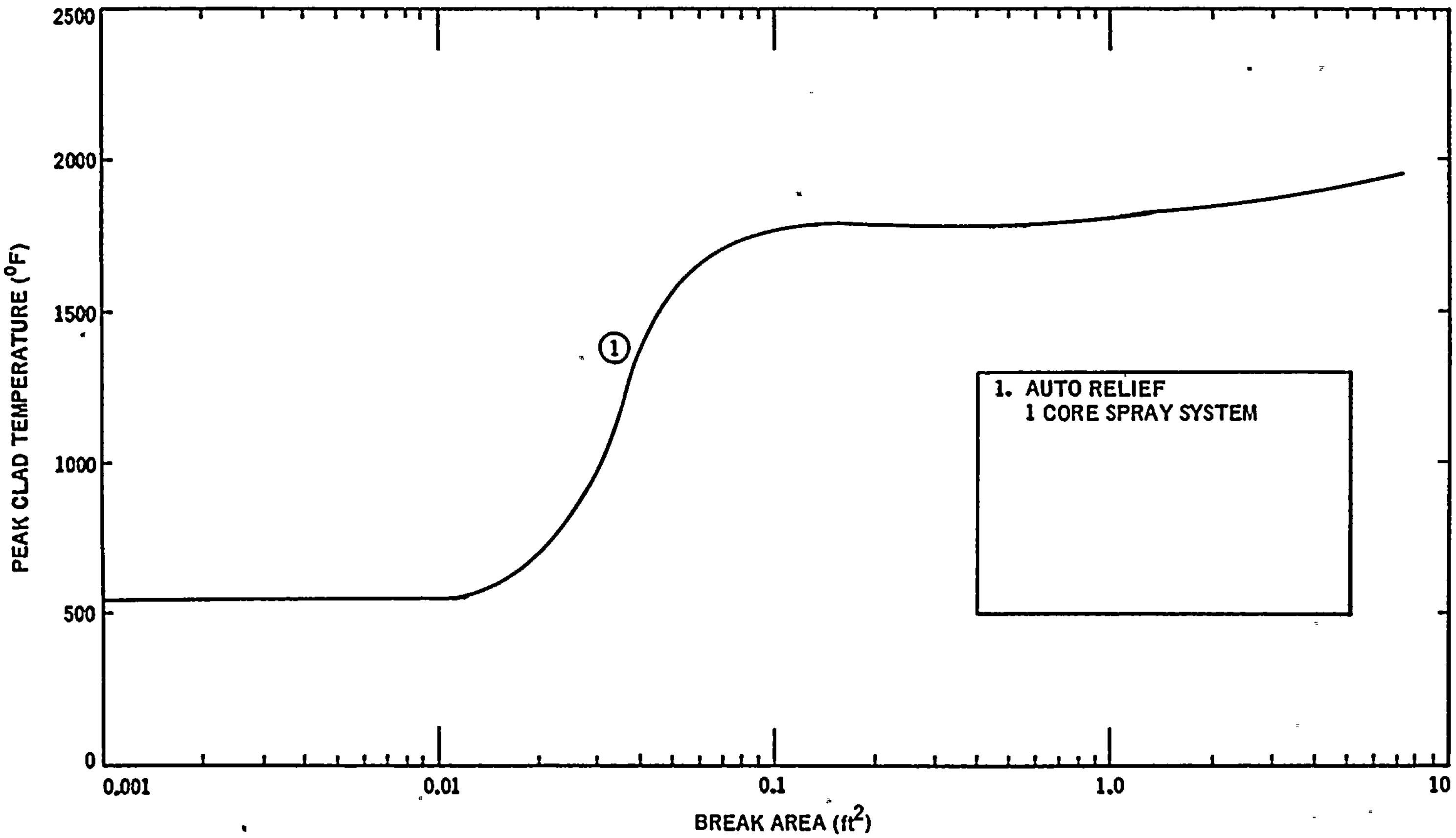


FIGURE 6-7. PEAK CLAD TEMPERATURE VERSUS BREAK SIZE

4-7

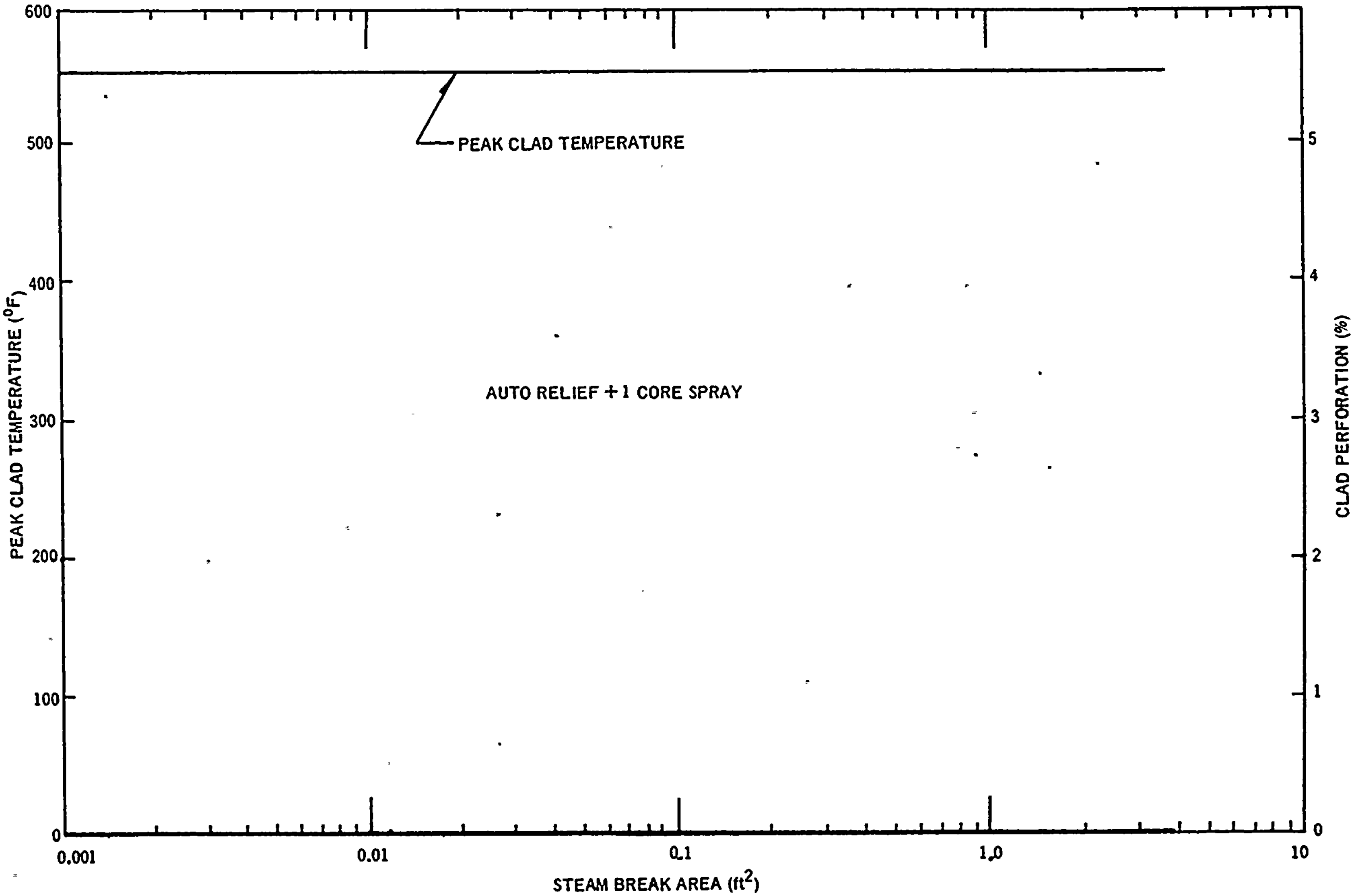


FIGURE4-8 PEAK CLAD TEMPERATURE VERSUS STEAM BREAK AREA

5. SIGNIFICANCE OF RECENT PRIMARY SYSTEM INVESTIGATIONS

It is believed that three separate and distinct conditions have been found which are being satisfactorily resolved before restoring the Station to service:

1. Massive stress corrosion cracking in the upper wall of the west core spray safe end was caused by very high tensile stresses due to the cantilever effect of improperly supported attachment piping in the presence of high oxygen water in the stagnant (closed and inverted) loop at the failure zone. It is obvious that oxygen enriched water existed at the top of the inverted loops in the core spray line safe end zones. It is believed that the low chloride levels in the reactor water preclude chlorides from this source as a corrosive media.

   This situation is being resolved by completely replacing both core spray safe ends, the outboard section of the thermal sleeves, and the immediate external attachment piping section with non-furnace sensitized steel (304ELC) in accordance with the replacement procedure described in the Reactor Primary System Investigation Report dated May 1, 1970.

   All piping systems in the drywell, including the two core spray lines, have been reevaluated and redesigned where necessary to reduce operating stresses to values far below the yield point. Further, all piping expansions will be measured during a hot functional test to be conducted prior to restarting the Reactor, to check the efficacy of the pipe supports, suspension and seismic restraints. Reference points will be established for comparison with future measurements. These stress

reevaluations, including redesign, if necessary, are also being continued for safety-related systems outside the drywell. The results will have been fully evaluated before the Station is restored to service. The closed stagnant loop "effect" in both core spray lines is being eliminated by redesign of the thermal sleeve so as to allow venting of the horizontal pipe section back into the Reactor vessel. An investigation is being made to determine if there are any other potential traps or "dead end" areas in other systems which might give rise to a similar problem. The results will be fully evaluated before the Station is restored to service.

2. The exterior shallow surface indications on other nozzles and brackets (including the guide rod support weld) are believed to be either original forging and/or surface defects ("bark", slag, seams, weld defects) or attack caused by contamination deposited before the vessel was placed in service, which corroded in the presence of moisture during periods of shutdown. In the absence of moisture during reactor operation, there is no reason to believe that exterior corrodant-promoted penetrations will continue.
It is believed that this situation can be satisfactorily resolved, at least for the present, by flapper grinding to whiteness (by PT tests) all such indications on furnace sensitized safe ends, brackets, and the guide rod support weld. The planned surveillance program described in Section 3, above, will provide continuing assurance for the integrity of these components.

3. The sensitized stainless steel piping attached outboard of the east core spray safe end contained 3 "tight" intergranular axial cracks in the base metal zone adjacent to the weld on the internal surface with a maximum depth of .090 inches.

The axial penetrations may have been induced by residual welding stresses in the longitudinal direction, or they could be the result of intergranular corrosion. If welding was responsible, the penetration should not propagate under the low applied operating stresses. If corrosion was responsible, cracks might conceivably have propagated through the pipe wall. However, the propagation would have resulted in a small leak which would have been detected before it became a safety hazard.

The weld area at the joint between the core spray pipe and safe end has some unusual characteristics. The stainless steel pipe is sensitized for a distance of at least one inch from the weld deposit, and the degree of sensitization appears heavier than expected in a normal weld heat affected zone. In addition, sensitization occurred in the pipe immediately adjacent to the weld bead. This is abnormal because the high heat input from welding should produce a solution heat treated zone immediately adjacent to the weld deposit. It appears that the stainless steel pipe was reheated after the initial welding, at a temperature sufficiently high to produce a sensitized structure. Another unusual effect was the recrystallized layer observed on the surface of the core spray pipe. Recrystallization of this surface layer also suggests that the pipe was re-heated. Extensive weld repairs and/or heat-straightening may have caused this condition.

Incidental to this, there is also reported transgranular cracking in the base metal of the thermal sleeve adjacent to the attachment seal weld at the end of the sleeve.
Crud samples analyzed by the AEC showed chloride contamination in the crevice area between the thermal sleeve and the safe end in the east core spray line. There is no apparent source of chlorides in the coolant water, or other Reactor internals.
It is believed that the contamination in the crevice area occurred during construction, and that removal was not accomplished in the restricted crevice area during Reactor cleaning cycles.
Further investigations are being carried out in an attempt to obtain confirmation of the cause of the axial penetrations. The condition, too, is being resolved by complete replacement of the core spray assembly, including the outboard attachment piping. The replacement components will be N.D.T. tested, using PT, RT, and UT where feasible in accordance with ASME III acceptance standards.

PRIMARY CONTAINMENT INTEGRATED LEAK TEST

PRIMARY CONTAINMENT INTEGRATED LEAK RATE TEST

1.0 Introduction

The initial integrated leak rate test was completed August 10, 1969. Initial criticality was September 5, 1969. According to paragraph 4.3.3 d of the Technical Specifications, an integrated leak rate test is due in August, 1970 plus or minus 8 months. This test is in conformance with this specification.

2.0 Scope

The containment tested includes the drywell and pressure suppression chamber, the steam side of the emergency condensers, and collectively, all the penetrations and isolation valves exposed to the free space of these vessels. The reactor was vented to the drywell, therefore, any leakage through isolation valves exposed to the steam space of the reactor is also included in containment leakage.

3.0 Specifications

3.1 Leakage rate tests subsequent to the initial tests shall be performed without preliminary leak detection surveys or leak repairs immediately prior to or during the test, at an initial pressure of approximately 22 psig.

3.2 Leak repairs, if necessary to permit integrated leakage rate testing, shall be preceded by local leakage measurements. The leakage rate difference, prior to and after repair when corrected to P_t shall be added to the final integrated leakage rate result.

3.3 Closure of the containment isolation valves for the purpose of the test shall be accomplished by the means provided for normal operation of the valves.

3.4 The test duration shall not be less than 24 hours for integrated leak rate measurements, but shall be extended to a sufficient period of time to verify, by measuring the quantity of air required to return to the starting point (or other methods of equivalent sensitivity), the validity and accuracy of the leakage rate results.

4.0 Acceptance Criteria

4.1 The allowable operational leak rate $L_{to(22)}$ was established during the initial integrated leak test at 0.87% of the contained volume in 24 hours at 22 psig.

5.0 Test Procedure

5.1 Overall leakage is measured using the reference vessel method. Calibrated resistance temperature sensors and suitably proportioned tubing type reference systems are distributed in the drywell and suppression chamber. Figure 1. A remote sampling system using heated probe extensions outside the vessel supplies a dew point detector. Read out is by means of precision electronic instruments. Test air is supplied through the containment spray system.

5.0 Test Procedures Cont'd.

5.2 Instrumentation penetrations are in the mode for normal operation except that the nitrogen purge for the TIP system is closed and isolated from the drywell. The vent valve outside the inline check is open to assure no inadvertent supply of nitrogen to the drywell.

5.3 The containment spray system isolation valves are open in the normal mode for containment spray system operation. The valves to the air test header are closed and a leak detector tap is open on the air supply side of these valves to prevent inadvertent supply of air to the drywell.

5.4 The core spray system is filled with water as in operations. The condensate fill line (also the supply to the torus makeup) is unwatered and vented. Leakage of water to the environment from this system is monitored and considered in the test results. Since there may be some interchange of water between the reactor vessel and torus, there will be no external manipulation to maintain reactor water level during the 24 hour leak test run nor will there be any addition to or subtraction of water from the system.

5.5 Isolation valves between the reactor vessel and the clean-up system are closed and the system vented. The shutdown cooling system is isolated from the reactor vessel and vented, and the feedwater lines are also isolated and vented just outside of the outer isolation valves. Provision is made to monitor these vents to detect magnitude of leakage. No exact quantitative measurements is applied to these observations. All water loss is included in the gross containment leakage.

6.0 Test Data

6.1 Combined leakage per reference system instruments.

	Date	Time	Drywell Pressure psia	Differential Pressure Drywell to Drywell Reference	Average Drywell Dew Point Temperature °F	Dew Point Saturation Pressure	Average Drywell Temperature °R
Drywell							
Start 22 psig	6/27/70	0030	36.78	.0881	45.3	.1492	523.9
End 22 psig	6/28/70	0030	36.55	.2901	45.0	.1474	523.3
End pump back	6/28/70	0315	36.77	.0943	45.8	.1520	523.6
Torus (Suppression Chamber)							
Start 22 psig	6/27/79	0030	36.75	.0900	51.5	.1881	526.3
End 22 psig	6/28/70	0030	36.51	.3006	51:5	.1881	525.8
End pump back	6/28/70	0315	36.73	.0877	52.0	.1916	525.9

6.0 Test Data Cont'd.

See figure 3 for trend plot of test data.

6.2 Pump back data using displacement gas meter and air tank for supply:

Gas meter input 1912 ft.^{3} @ 22 psig.

7.0 Calculations and Results

7.1 Containment leakage from 00:30, 27 June 1970 through 00:30, 28 June 1970.

$$\text{Leak rate \%} = \left(\frac{100}{P_1}\right)\left[\left(\frac{T_1}{T_2}\right)\left(\Delta P_2 + P_{v2}\right) - \left(\Delta P_1 + P_{v1}\right)\right]$$

Drywell Data

P_1 = 36.78 psia	
T_1 = 523.9 °R	T_2 = 523.3 °R
ΔP_1 = .0881 psia	ΔP_2 = .2901 psia
P_{v1} = .1492 psia	P_{v2} = .1474 psia

% Leakage @ 22 psig = 0.56% in Drywell

P_1 = 36.75 psia	
T_1 = 526.3 °R	T_2 = 525.8
ΔP_1 = .0900	ΔP_2 = .3006
P_{v1} = .1881	P_{v2} = .1881

% Leakage @ 22 psig = 0.57% in Torus

Combined leakage (.61) (.56) + (.34) (.57) = 0.56%

7.2 Pump Back Check

(a) "Net" leakage end of pump back

Drywell

$$(100)\ \frac{(.0943-.0881)}{(36.78)} = .017\%$$

Torus

$$(100)\ \frac{(.0877-.0900)}{36.75} = -.0062$$

Combined

(.61) (.017) + (.39) (-.0062) = .008%
(.00008) (300,400) = 24 ft.^{3} @ 22 psig

7.0 Calculations and Results Cont'd.

7.2 Pump Back Check Cont'd.

(b) Assumed in leakage end of test to end of pump back.

(.0056) (300,400) = 1680 ft.^{3} @ 22 psig per 24 hours end of test to end of pump back 2 hrs. 45 min.

$\left(\frac{2.75}{24}\right)$ (1680) = 192 ft.^{3} @ 22 psig

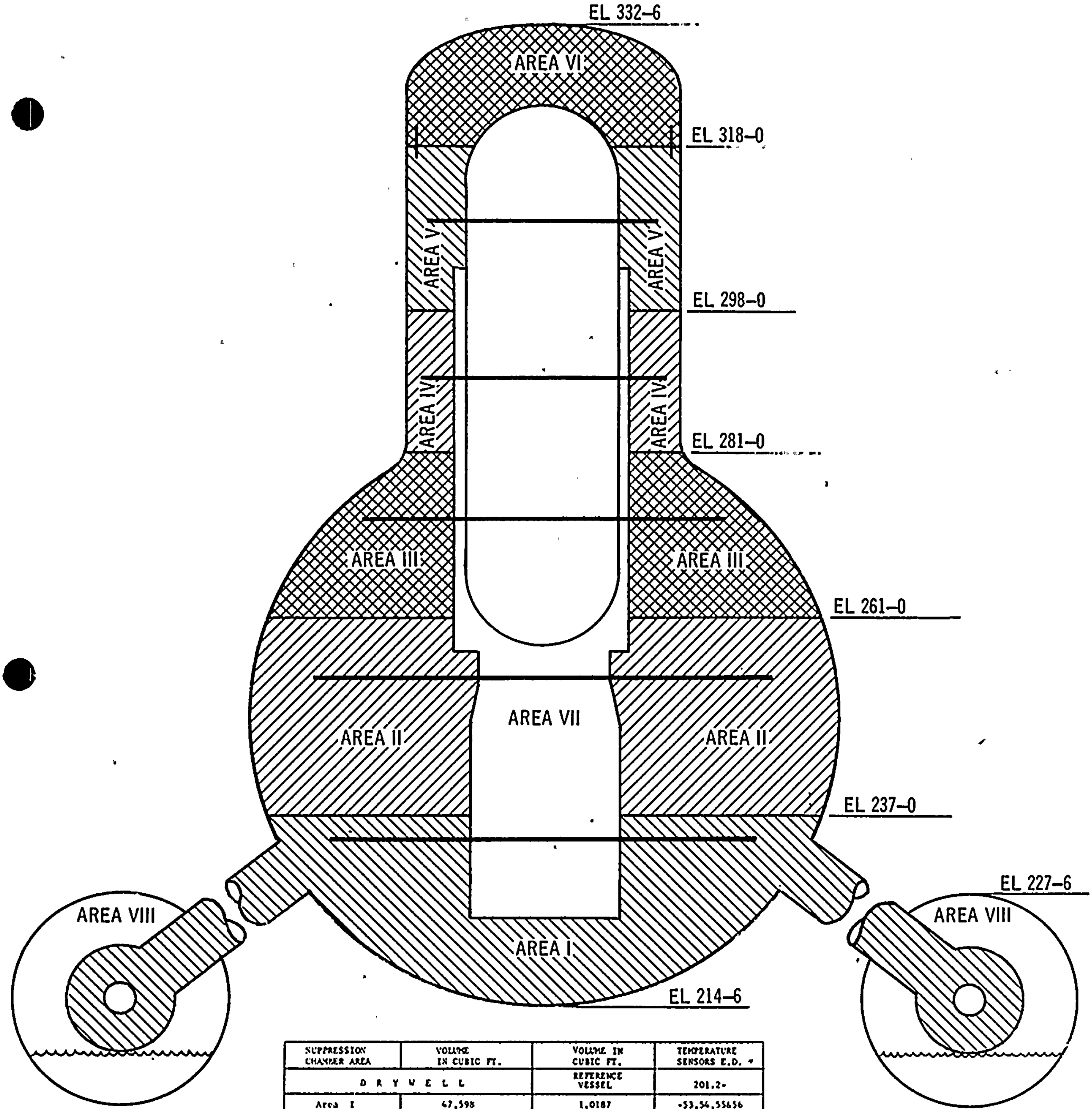
(c) Adjusted pump back leakage.

1912 - 192 + 24 = 1744 ft.^{3} @ 22 psig

$\frac{1744}{300,400}$ = 0.57% of contained volume at 22 psig.

7.3 Leak Test Conclusions

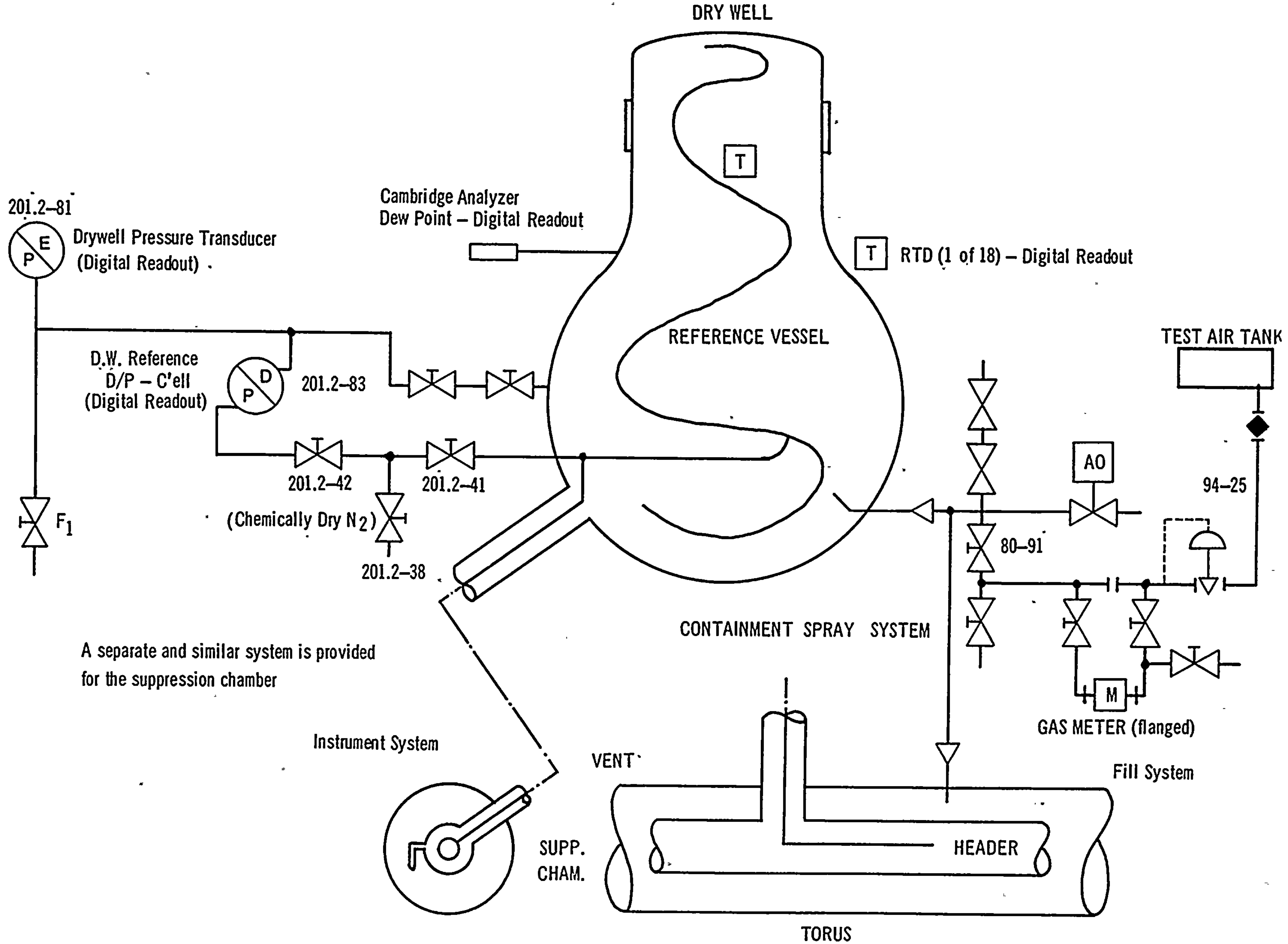
As found on June 28, 1970, the primary containment leakage of 0.56% was well below the allowable operational leak rate [$L_{to(22)}$] of 0.87% as derived from the Technical Specifications and the preoperational leak test of August, 1969.



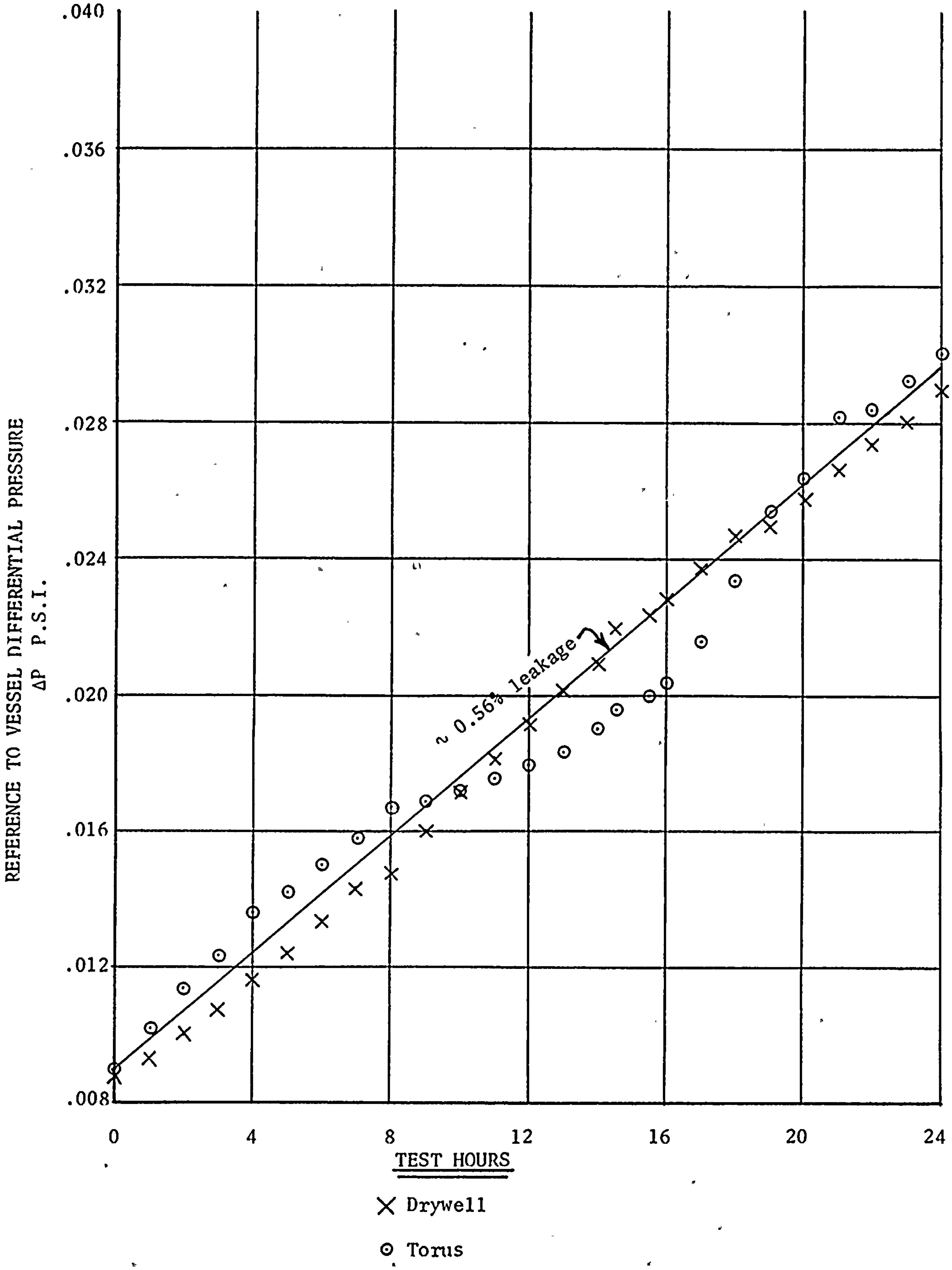
SUPPRESSION CHAMBER AREA	VOLUME IN CUBIC FT.	VOLUME IN CUBIC FT.	TEMPERATURE SENSORS E.D. *
D R Y W E L L		REFERENCE VESSEL	201.2-
Area I	47,598	1.0187	-53,54,55656
Area II	73,128	1.5637	-49,50,31
Area III	33,483	0.7172	-46,47,48
Area IV	6,064	0.1298	-45
Area V	4,289	0.0918	-44
Area VI	7,206	0.1624	-43
Area VII	13,667	0.2926	-52
T O R U S			
Area VIII	117,907	0.4035	-59,60,61662

REFERENCE VESSEL
DISTRIBUTION

FIGURE 1



INSTRUMENT AND
FILL CONNECTIONS
FIGURE 2



Test Data

Figure 3