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STURGEON BAY, WISCONSIN 54235

SUBMERGED ARC WELDING

INVESTIGATION OF TUBULAR ELECTRODES DESIGNED FOR SUBMERGED ARC WELDING APPLICATIONS

FINAL REPORT

JULY, 1985

Under

P.O. Number: POM 69068-R

PROJECT MANAGER:

R.A. Whannell

PRINCIPAL INVESTIGATORS:

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SECTION 1

FOREWORD

FOREWORD

The purpose of this report is to describe the methods used to weld the test samples and to present the results of the physical and metallurgical tests performed in this research and development program. This report covers the investigation of the operating characteristics of tubular welding electrodes designed for Submerged Arc Welding applications. The effort of this program was directed toward comparing the relative merits of tubular submerged arc welding electrodes as opposed to solid submerged arc welding electrodes.

The Submerged Arc Welding Process (SAW) using conventional electrodes (solid wire) enjoys a prominent niche, as a welding process, due to high filler wire deposition rates and excellent quality of the deposited weld metal. The Submerged Arc Welding Process is limited to the flat position for butt welds and the horizontal position for fillet welds. These limitations have not detracted from the popularity of the process as a fabricating tool. The process is normally used with mechanized welding equipment; however, it can be used as a manual process.

In recent years electrode manufacturers have developed tubular electrodes designed for submerged arc welding applications. This "new generation" of electrodes promises several areas of improvement over the solid electrodes that may have significant economic impact on welding costs. In addition, electrode chemistry may be altered to improve the physical properties of weld metal deposits to suit individual welding requirements.

This project was initiated by the SP-7 Welding Panel of the Ship Production Committee; a committee of the Society of Naval Architects and Marine Engineers. A special thank you is due this group who served as technical advisors in the preparation of inquiries and evaluation of subcontract proposals. Their comments and criticisms helped to make this a more valuable project.

This effort was financed largely by government funds supplied jointly by the U.S. Maritime Administration and the U. S. Navy through a cost-sharing contract between Newport News Shipbuilding, Bay Shipbuilding and the Maritime Administration.

SECTION 2

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Newport News Shipbuilding
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Newport News, VA 23607

Also, appreciation is expressed to the following people at Bay Shipbuilding Corp. for their continued support of our efforts on the SP-7 welding panel to reduce welding costs:

Mr. George K. Geiger - President
Mr. Bruce C. Shaw - Director of Operations

In the performance of this project two outside agencies were employed for physical, metallurgical and corrosion testing of welds. Acknowledgment is due for their dedication and personal efforts:

1. Northeast Wisconsin Technical Institute, Green Bay Campus
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Mr. Richard Krause, Metallurgist

Mr. Alan J. Wos, Q.A. Consultant

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   120 South Riverside Plaza
   Chicago, IL 60606

   Mr. D. B. Peterson - Manager - Welding Processes - Industrial Gasses Department

   Mr. W. T. (Tom) Bean - Sales Representative - Welding Products Department

   Mr. Jack Gruselle - Green Bay Welding Supply

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4. Alloy Rods Inc.
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   Mr. Joseph L. Scott - Manager, New Market Development

   Ms. Shirly Bollinger - New Market Development

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VOLUME 1

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SECTION 4

INTRODUCTION

INTRODUCTION

The primary objective of this project was to evaluate the operating characteristics of flux core and metal core electrodes designed for use with the Submerged Arc Welding Process. These electrodes have been described, in vendor literature, as the "new generation" of submerged arc welding electrodes that can be tailored to suit almost all base metal chemistries, thus capable of producing superior weld metal deposits. In view of the fact that shipbuilding and ship related steel fabrication utilizes the Submerged Arc Welding Process, it was determined that these electrodes were worthy of investigation. In the initial investigation of these electrodes, we discovered that availability of tubular flux core and/or metal core electrodes designed for submerged arc welding were not readily available. Several major electrode manufacturers do not make this type of electrode due to lack of demand by steel fabricators. In addition, electrode manufacturers have found that fabricated electrodes have a tendency to develop deposit inconsistencies due to the difficulty in maintaining the elements in the flux powder homogeneously and eliminating hydrogen in the powder deposit. These problems have been solved by some electrode manufacturers; however, not all manufacturers have opted to develop this technology into a new product line.

SECTION 5

PROCESS DESCRIPTION

THE SUBMERGED-ARC PROCESS

Submerged-arc welding differs from other arc welding processes in that a blanket of fusible, granular material - commonly called flux - is used for shielding the arc and the molten metal. The arc is struck between the workpiece and the bare wire” electrode, the tip of which is submerged in the flux. Since the arc is completely covered by the flux, it is not visible and the weld is run without the flash, spatter, and sparks that characterize the open-arc processes. The nature of the flux is such that very-little smoke or visible fumes are developed.

THE MECHANICS OF FLUX SHIELDING

The process is either semiautomatic or full automatic, with electrode fed mechanically to the welding gun, head, or heads. In semiautomatic welding, the welder moves the gun, usually equipped with a flux-feeding device, along the joint. Flux feed may be by gravity flow through a nozzle concentric” with the electrode from a small hopper atop the gun, or it may be through a concentric nozzle tube-connected to an air-pressurized flux tank. Flux may also be applied in advance of the welding operation or ahead of the arc from a hopper run along the joint. In fully automatic submerged-arc welding, flux is fed continuously to the joint ahead of or concentric to the arc, and full-automatic installations are commonly equipped with vacuum systems to pick up the unfused flux left by the welding head or heads for cleaning and reuse.

During welding, the heat of the arc melts some of the flux along with the tip of the electrode. The tip of the electrode and the welding zone are always surrounded and shielded by molten flux, surmounted by a layer of unfused flux. The electrode is held a short distance above the workpiece, and the arc is between the electrode and the workpiece. As the electrode progresses along the joint, the lighter molten flux rises above the molten metal in the form of a slag. The weld metal, having a higher melting (freezing) point, solidifies while the slag above it is still molten. The slag then freezes over the newly solidified weld metal, continuing to protect the metal from contamination while it is very hot and reactive with atmospheric oxygen and nitrogen. Upon cooling and removal of any unmelted flux for reuse, the slag is readily peeled from the weld.

There are two general types of submerged-arc fluxes, bonded and fused. In the bonded fluxes, the finely ground chemicals are mixed, treated with a bonding agent and manufactured into a granular aggregate. The deoxidizers are incorporated in the flux. The fused fluxes are a form of” glass resulting from fusing the various chemicals and then grinding the glass to a granular form. Fluxes are available that add alloying elements to the weld metal, enabling alloy weld metal to be made with mild steel electrode. -

ADVANTAGES OF THE PROCESS

High currents can be used in submerged-arc welding and extremely high heat developed. Because the current is applied to the electrode a short distance above its tip, relatively high amperages can be used on small diameter electrodes. This results in extremely high current densities on relatively small cross sections of electrode. Currents as high as 600 amperes can be carried on electrodes as small as 5/64 in., giving a density in the order of 100,000 amperes per square inch - six to ten times that carried on stick electrodes.

Because of the high current density, the melt-off rate is much higher for a given electrode diameter than with stick-electrode welding. The melt-off rate is affected by the electrode material, the flux, type of current, polarity, and length of wire beyond the point of electrical contact in the gun or head.

The insulating blanket of flux above the arc prevents rapid escape of heat and concentrates it in the welding zone. Not only are the electrode and base metal melted rapidly, but the fusion is deep into the base metal. The deep penetration allows the use of small welding grooves, thus minimizing the amount of filler metal per foot of joint and permitting fast welding speeds. Fast welding, in turn, minimizes the total heat input into the assembly and, thus, tends to prevent problems of heat distortion. Even relatively thick joints can be welded in one pass by the submerged arc process.

Welds made under the protective layer of flux have good ductility, impact resistance and uniformity in bead appearance. Mechanical properties at least equal to those of the base metal are consistently obtained. In single-pass welds, the fused base material is large compared to the amount of filler metal used. Thus, in such welds the base metal may greatly influence the chemical and mechanical properties of the weld. For this reason, it is sometimes unnecessary to use electrodes of the same composition as the base metal for welding many of the low-pass welds are less affected by the base metal and depend to a greater extent on the composition of the electrode, the activity of the flux, and the welding. conditions.

Through regulation of current, voltage, and travel speed, the operator can exercise close control over penetration to provide any depth ranging from deep and narrow with high-crown reinforcement, to wide, nearly flat beads with shallow penetration. Beads with deep penetration may contain on the order of" 70% melted base metal, while shallow beads may contain as little as 10% base metal. In some instances, the deep penetration properties of the submerged arc welding process can be used " to eliminate and reduce the expense of edge preparation.

Multiple electrodes may be used, two side by side or two or more in tandem, to cover a large surface area or to increase welding speed. If shallow penetration is desired with multiple electrodes, one electrode can be grounded through the other (instead of through the workpiece) so that the arc-does not penetrate deeply.

Deposition rates are high - up to ten times those of stick electrode welding.

Submerged-arc welding may be done with either DC or AC power. Direct current gives better control of bead shape, penetration, and welding speed, and arc starting is easier with. it. Bead shape is usually best with DC reverse polarity (electrode positive), which also provides maximum penetration. Highest deposition rates and minimum penetration are obtained with DC straight polarity. Alternating current minimizes arc blow and gives penetration between that of DCRP and DCSP.

APPLICATIONS AND ECONOMIES

With proper selection of equipment, submerged-arc is widely applicable to the welding requirements of industry. It can be used with all types of joints, and permits welding a full range of carbon and low-alloy steels, from 16-gage sheet to the thickest plate. It is also applicable to some high-alloy, heat-treated, and stainless steels, and is a favored process for rebuilding and hardsurfacing. Any degree of mechanization can be used - from the hand-held semi-automatic gun to boom or track-carried and fixture-held multiple welding heads.

The high quality of submerged-arc welds, the high deposition rates, the deep penetration, the adaptability of the process to full mechanization, and the comfort characteristics (no glare, sparks, spatter, smoke, or excessive heat radiation) make it a perferred process in steel fabrication. It is used extensively in ship and barge building, railroad car building, pipe manufacture, and in fabricating structural beams, girders, and columns where long welds are required. Automatic submerged-arc installations are also key features of the welding areas of plants turning out mass-produced assemblies joined with repetitive short welds.

The high deposition rates attained with submerged-arc are chiefly responsible for the economies achieved with the process. The cost reductions when changing from the manual shielded metal-arc process to submerged-arc are frequently dramatic. Thus, a hand-held submerged-arc gun with mechanized travel may reduce welding costs more than 50%; with fully automatic multiarc equipment, it is not unusual for the costs to be approximately 10 percent of those attained with. stick-electrode welding.

Factors other than deposition rates enter into the reduction of welding costs. Continuous electrode feed from coils, ranging in weight from 60 to 1,000 pounds, contributes to a high operating factor. Where the deep-penetration characteristics of the process permit the elimination or reduction of joint preparation, expense is lessened. After the weld has been run, cleaning costs are minimized because of the elimination of spatter by the protective flux.

When submerged-arc equipment is operated properly, the weld beads are smooth and uniform, so that grinding or machining is rarely required. Since the rapid heat input of the process minimizes distortion, the costs for straightening finished assemblies are reduced, especially if a carefully. planned welding sequence has been followed. Submerged-arc welding, in fact, often allows the premachining of parts, further adding to fabrication cost savings.

A limitation of submerged-arc welding is-that imposed by the force of gravity. In most instances, the joint must be positioned flat or horizontal to hold the granular flux. To deal with this problem, weldment positioners are used to turn assemblies to present joints flat or horizontal - or the assemblies may be turned or rotated by a crane. Substantial capital investments in positioning and fixturing equipment in order to use submerged-arc welding to the fullest extent, and thus gain full advantage of the deposition rate, have proved their worth in numerous industries. Special fixturing and tooling have been developed for the retention of flux and molten metal in some applications, so that “three-o’clock” and even vertical-up welding is possible.

Although they are not truly limitations, problems can arise in the use of submerged-arc resulting from improper joint preparation and improper procedures. Thus, "flash-through" of the arc, burn-through, and weld porosity result from such factors as improper procedures, poor fitup and joint contaminants.

SECTION 6

SUBMERGED ARC WELDING EQUIPMENT

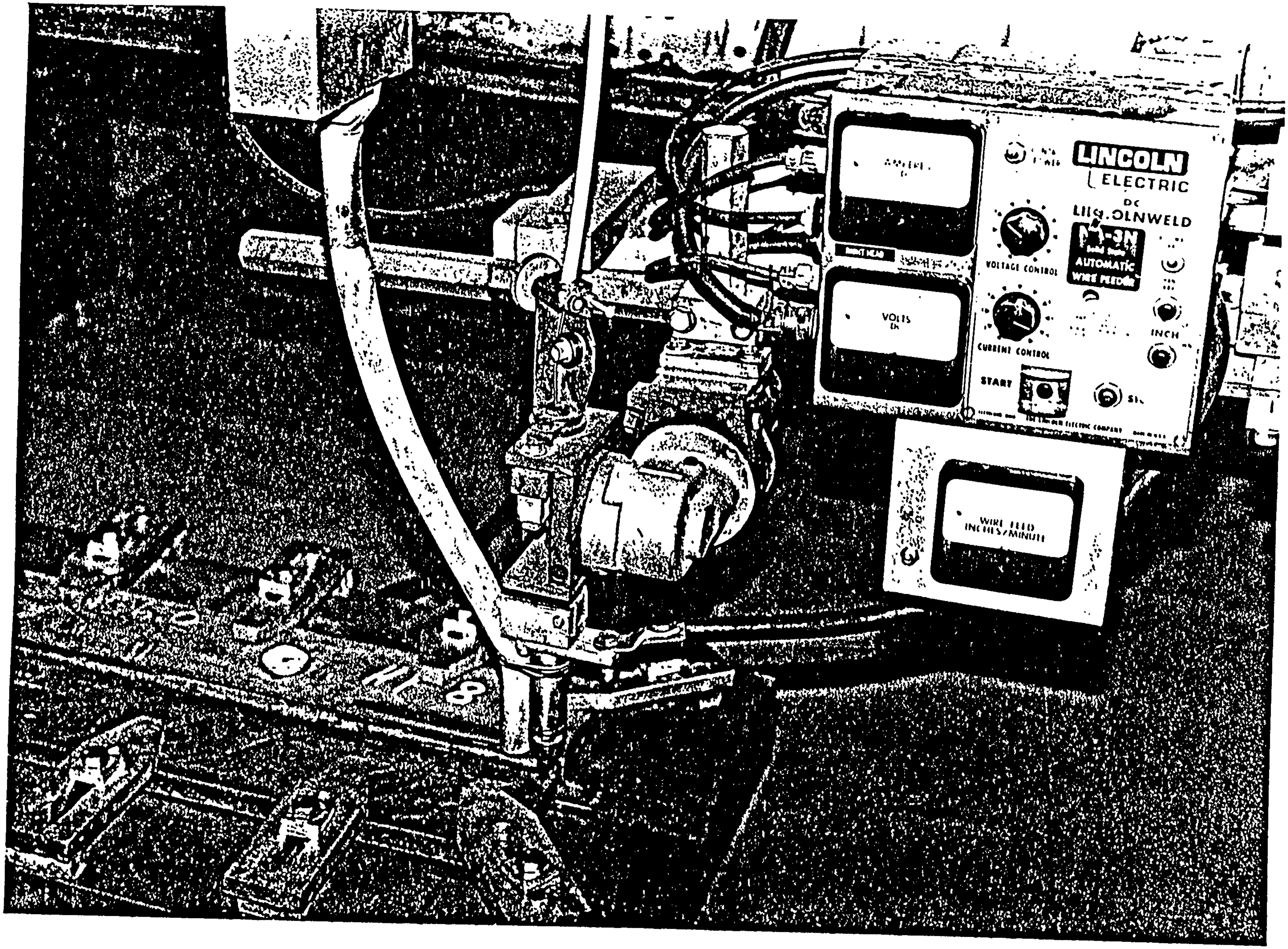
SUBMERGED ARC WELDING EQUIPMENT

The power source used in this program was a Lincoln DC-1500 three phase rectifier type, set in the Constant Voltage control mode. This power source has input line voltage compensation which will maintain constant secondary output up to a ±10% line fluctuation value. It is also equipped with an SCR-type control circuit which provides precise control of voltage and amperage setting as well . as having excellent starting characteristics needed for submerged arc welding.

Control was provided by a Lincoln NA-3 solid state wire feeder-head equipped with an optional start control board, and full metering capabilities for Voltage, Amperage and Wire Feed Speed in inches per minute. The control head was set for reverse polarity operation (electrode +) in the constant voltage mode. The head was coupled to a Lincoln wire feed motor and gear box to which a mechanical wire straightener and Lincoln model K-148 torch were attached. This torch has a tang contact system which provides positive electrical contact at the nozzle of the assembly.

All meters were calibrated at the start of the program and were checked at 90 day intervals. The wire feed speed meter was also verified on each pass by the use of a Lincoln hand held digital wire feed speed meter.

Only one correction was made during the length of the program. This was to the amperage meter to correct a 20 to 25 amp error on April 25, 1985. There were only three procedures run subsequent to this date: HY-8-AC1, HY-8-AC-HHI-1 and HY-O-AC-1. Because the program was dependent on all electrodes operating at the exact same amperage there may be a 4 to 5 percent difference due to meter drift on these procedures.



LINCOLN NA-3 HEAD AND K-148 TORCH MOUNTING

SECTION 7

BASE MATERIALS WELDED

BASE MATERIALS WELDED

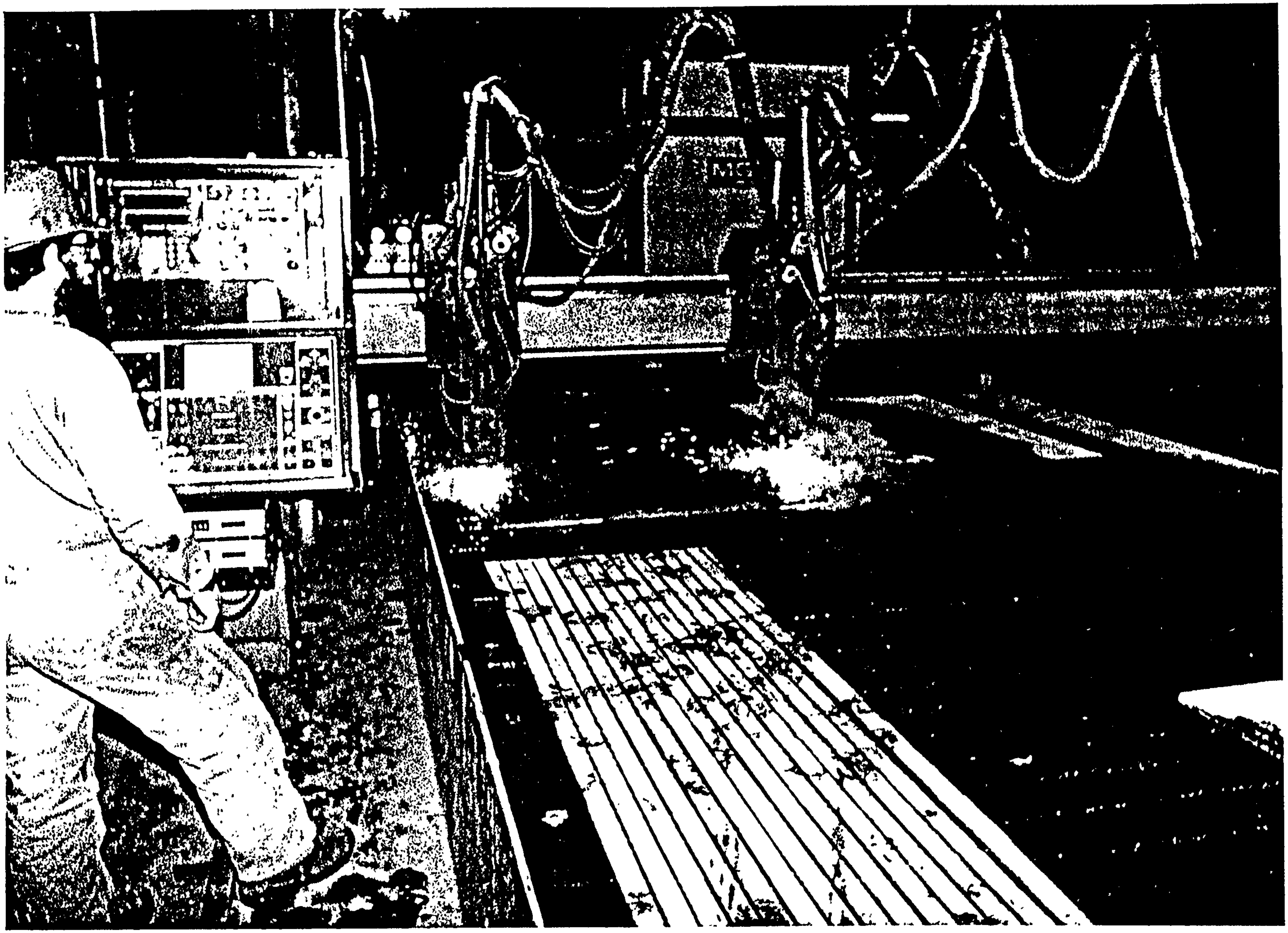
The specific steels selected for this program cover the shipbuilding industry as a whole, both commercial and military. They were selected to reflect the current technological level in steels on the higher end of the spectrum in tensile strength and impact resistance or corrosion resistance requirements.

American Bureau of Shipping steel EH-36 was selected to represent typical steels used in commercial construction applications where higher strength or impact resistance is required.

A 316L stainless steel was selected to represent applications where corrosion resistance is a primary concern.

TWO grades of steel were selected to represent military applications, HY-80 and HY-1OO conforming to MIL-S-16216 J.

The physical test reports on these materials are included for comparison purposes and information.



PLASMA CUTTING OF TEST MATERIAL

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REPORT OF TESTS AND ANALYSES

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SOLD TO: SEE BELOW
STH STEEL CORP-SHIP DIV-BEAUMONT

SHIP TO: BETH STEEL CORP
SHIP DIV BEAUMONT YD
BEAUMONT TX

SERIAL NUMBER	PAT. NO	HEAT NUMBER	SIZE AND QUANTITY NO PCS	THICKNESS INCHES	WIDTH OR DIA. INCHES	LENGTH INCHES	WEIGHT POUNDS	YIELD POINT PSI	TENSILE STRENGTH PSI	ELONG IN	
PLATES - ABS GR EH36 REV 1980 S.010 MAX SPCL TESTS - SEE MI && NORMALIZED FLATTENED TO STD TOL											
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				N 1650 DEG F 36 MIN				57600	84400		
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TOP CENTER THRU THICKNESS
BOTTOM CENTER THRU THICKNESS

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10117		803N76631			1.000	V	FULL	L	-40	94	96	98	-				

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176631	.18	1.42	.014	.008	.269	.016	.16	.19	.053	.034					

THAT THE ABOVE RESULTS ARE A TRUE AND CORRECT COPY
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SERIAL NUMBER	PAT. NO.	HEAT NUMBER	NO. PCS.	THICKNESS	WIDTH OR DIA.	LENGTH	WEIGHT	YIELD KSI	TENSILE STRENGTH KSI	ELONG. IN.	ELONG. %
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3378 MIL-S-22698B GR DH36 CL U
TS & TEST PCS NORM AT 1650 DEG & HELD 1/2 HR PER INCH OF THICKNESS
PVNSTLHSNJ
AB/DH36
PAINT 1 END BLUE/WHITE/GREEN

SERIAL NUMBER	PAT. NO.	HEAT NUMBER	NO. PCS.	THICKNESS	WIDTH OR DIA.	LENGTH	WEIGHT	YIELD KSI	TENSILE STRENGTH KSI	ELONG. IN.	ELONG. %
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								63.9	84.1	8	20
								60.5	83.4	8	28
		431P4011	1	1/ 4	96	360	2450				
								62.2	85.5	8	19

TESTED IN ACCORDANCE WITH THE REQUIREMENTS OF ABS RULES.

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PVN
Q. A. APPROVED
PRESSURE VESSEL-NUCLEAR STEELS INC.
Date 5-10-82
By [signature]

HEAT NUMBER	C	Mn	P	S	Si	Cu	Ni	Cr	Mo	V	Cb	N	Al
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431P4011	.16	1.41	.018	.023	.240	.04	.02	.15	.073		.049		

C. B. [signature]

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I certify that the above results are a true and correct copy of records prepared and main- [signature]

D. JOB, CONTRACT NO.

P.O. DATE	PURCHASE ORDER NO.		
	4234		
SHIPPERS NO.		MILL ORDER NO.	INVOICE NO.
75531	06/23/83	EA76535	163-15167
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Q. A. APPROVED
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Date 3/30/84
By BS

ARMOR PLATE HY80 MIL-S-16216J - DESCALE, 1 COAT PAINT ULTRASONIC TEST FOR SOUNDNESS & GAUGE

PLATES
01 MILL CERTIFIED T/R 3 T/R TO SLD TO ATTN ? LANZA

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226-223 BHN (3000) KG

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FULL SIZE TRANS V NOTCH CHARPY IMPACT TEST 10X10MM MADE AT 0 [illegible]. F. [illegible] . -[illegible].0-095.0 FT. LBS.
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Meredith Corp./PVN Steels Ref # 812
Bay Shipbuilding PO# 163719

1 Pc. 1" x 96" x 120"

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. PLATES
. C1 MILL CERTIFIED T/R 3 T/R TO SLD TO ATTN B LANZA

ITEM NO.	THICKNESS OR SECTION	WIDTH, DIA. OR FT. WT.	LENGTH	QUANTITY	WEIGHT	HEAT NO.	TEST OR PIECE IDENTITY	YIELD PT. PSI	TENSILE STR. PSI	ELONGATION % IN 8"	ELONGATION % IN 2"	% RED. OF AREA
01	1/4	96	396	1	2695	4W1258	0366343 TT	92200	105300		26.0	
							TB	90500	104000		24.0	
	FINAL HEAT	TREAT:AUST	1680 DEG F 18	MIN	WTR QUENCH	TMPR	1310 DEG F	40 MIN				
01	1/4	96	396	1	2695	4W1258	0366345 TT	89000	104200		28.0	
							TB	89000	104200		2[illegible].0	
	FINAL HEAT	TREAT:AUST	1660 DEG F 28	MIN	WTR QUENCH	TMPR	1310 DEG F	40 MIN				
01	1/4	96	396	1	2695	4W1258	03663589 TB	91800	104900		22.0	
							TT	95200	106000		25.0	
	FINAL HEAT	TREAT:AUST	1660 DEG F 23	MIN	WTR QUENCH	TMPR	1310 DEG F	40 MIN				
								END OF DATA				

Meredith Corp./PVN Steels Ref # 812

Bay Shipbuilding PO# 163719

1 Pc. 1/4" x 96" x 24"

YIELD STR. @ .2% OFFSET

HEAT NO.	TYPE	C	MN	P	S	SI	CU	NI	CR	MO	SN	AL	N	V	B	TI	CB	CO
4W1258	HEAT	14	27	005	009	25	05	241	131	33				01		003		
4W1258	CHK	14	27	006	008	26	05	239	132	32				006		003		
4W1258	CHK	15	27	004	007	26	05	238	131	32				01		002		
END OF DATA																		

UNLESS OTHERWISE SPECIFI RECORDS ARE AVAILABLE CO ERING HEAT NUMBER OF MAT USED, PROCESSING OF PLAT DIMENSIONAL CONTROL EMP ED, ULTRASONIC TESTING, GAUGING AND HEAT TREATME

000 0772 (REV. 7-78)

Test Report

REQ JOB. CONTRACT NO	P.O. DATE	PURCHASE ORDER NO
		4553 11/23/83

SHIPPERS NO.	MILL ORDER NO	INVOICE NO.
75073 01/31/84	EA94060	163-34763
VEHICLE IDENTITY 57407		160

VENDOR
MON VALLEY WORKS
HOMESTEAD, PA. 15120

SOLD TO
Meredith Corp./PVN Steels
460 Hillside Avenue
Hillside, NJ 07205

SHIP TO
Meredith Corp./PVN Steels
460 Hillside Avenue
Hillside, NJ 07205

THIS IS TO CERTIFY THAT TH PRODUCT DESCRIBED HEREIN W MFGD., SAMPLED, TESTED, AN OR INSPD. IN ACCORDANCE WI THE SPECIFICATION AND FUL- FILLS REQUIREMENTS IN SUCH RESPECTS.

EO

PREPARED BY THE OFFICE O
C.E. CHURCHILL, MGR. Q.A

DATE C2/01/84

SPEC & INSP. ARMOR PLATE HY100 MIL-S-16216J - DESCALE, 1 COAT PAINT, ULTRASONI C TEST FOR SOUNDNESS & GAUGE

Meredith Corp./PVN Steels Ref # 812

PLATES
01 MILL CERTIFIED T/R

Bay Shipbuilding PO# 163719 1 Pc. 1" x 90" x 120"

ITEM NO.	THICKNESS OR SECTION	WIDTH, DIA. OR FT. WT.	LENGTH	QUANTITY	WEIGHT	HEAT NO	TEST OR PIECE IDENTITY	YIELD PT PSI	TENSILE STR. PSI	ELONGATION % IN 8"	ELONGATION % IN 2"	% RED. OF AREA
02	1.0000	90	480	1	12252	2W0001	0402444 TT	111500	122200		40.0	62.0
							TB	110700	121700		38.0	58.0
							241-241	BHN (3000) KG				

FULL SIZE TRANS V NOTCH CHARPY IMPACT TEST 10X10 MM MADE AT -120 DEG. F. 073.0-069.0-069.0 FT. LBS.
FULL SIZE TRANS V NOTCH CHARPY IMPACT TEST 10X10 MM MADE AT 0 DEG. F. 088.0-089.0-094.0 FT. LBS.
FULL SIZE TRANS V NOTCH CHARPY IMPACT TEST 10X10 MM MADE AT -120 DEG. F. 068.0-066.0-064.0 FT. LBS.
FULL SIZE TRANS V NOTCH CHARPY IMPACT TEST 10X10 MM MADE AT 0 DEG. F. 096.0-091.0-096.0 FT. LBS.

FINAL HEAT TREAT: AUST 1660 DEG F 70 MIN WTR QUENCH TMPR 1200 DEG F 75 MIN

PVN
PRESSURE VESSEL-NUCLEAR STEELS INC.
Q. A. APPROVED
Date 3/30/84
By HU

YIELD STR. @ .2% OFFSET

HEAT NO.	TYPE	C	MN	P	S	SI	CU	NI	CR	MO	SN	AL	N	V	B	TI	CB	CO
2W0001	HEAT	15	27	010	011	24	07	263	147	43				01		01		
2W0001	CHK	15	28	010	010	23	07	261	151	37				01		002		
2W0001	CHK	16	28	009	009	24	07	265	152	42				01		003		

UNLESS OTHERWISE SPECIFIE RECORDS ARE AVAILABLE COV ERING HEAT NUMBER OF MAT. USED, PROCESSING OF PLATE DIMENSIONAL CONTROL EMPLO ED, ULTRASONIC TESTING, GAUGING AND HEAT TREATMEN

00 0772 (REV 7-78) Test Report

JOB CONTRACT NO.	P O DATE	PURCHASE ORDER NO		
		3269 08/31/81		
	SHIPPERS NO		MILL ORDER NO	INVOICE NO
	75661 12/14/81		EA39325	163-19168
	VEHICLE IDENTITY	CS1406		160

VENDOR: HOMESTEAD WORKS
HOMESTEAD, PA. 15120

SOLD TO:
Meredith Corp./PVN Steels
460 Hillside Avenue
Hillside, NJ 07205

SHIP TO:
Meredith Corp./PVN Steels
460 Hillside Avenue
Hillside, NJ 07205

WE HEREBY CERTIFY THAT THE CHEMICAL ANALYSES AND/OR TEST RESULTS SHOWN IN THIS REPORT ARE CORRECT AS CONTAINED IN THE RECORDS OF THE COMPANY

A.J. JOSEPH, CH. MET.

DATE 12/14/81

SPEC. & DISP. ARMOR PLATE HY100 MIL-S-16216H - DESCALE & 1 COAT PAINT

Meredith Corp./PVN Steels Ref # 812

PLATES
01 MILL CERTIFIED T/R TO SOLD TO ATTN D LANZA

Bay Shipbuilding PO# 163719 1 Pc. 1/4" x 90" x 26"

23

ITEM NO	MATERIAL DESCRIPTION THICKNESS OR SECTION	WIDTH DIA OR FT WT	LENGTH	QUANTITY	WEIGHT	HEAT NO	TEST OR PIECE IDENTITY	YIELD PT PSI	TENSILE STR PSI	ELONGATION % IN 8	ELONGATION % IN 2	% RED OF AREA
01	1/4	90	348	1	2221	73B625	0165290A TC	112900	124600		20.0	
							WC	117800	128400		17.C	

FINAL HEAT TREAT:AUST 1680 DEG F 18 MIN WTR QUENCH TMPR 1220 DEG F 40 MIN

YIELD STR. @ .2% OFFSET

Q. A. APPROVED
PVN
PRESSURE VESSEL NUCLEAR STEELS INC.
Date 3/30/84
By JJS

HEAT NO	TYPE	C	MN	P	S	SI	CU	NI	CR	MO	SN	AL	N	V	B	TI	CB	CO
73B625	HEAT	20	29	009	019	27	03	245	163	46				02		003		
73B625	CHK	19	29	008	019	26	03	243	162	45				002		003		
73B625	CHK	19	28	007	019	25	03	245	163	45				002		002		

UNLESS OTHERWISE SPECIFIE
RECORDS ARE AVAILABLE COV
ERING HEAT NUMBER OF MAT.
USED, PROCESSING OF PLATE
DIMENSIONAL CONTROL EMPLO
ED, ULTRASONIC TESTING,
[illegible]

SECTION 8

ELECTRODE/FLUX - DESIGNATION CODES

6/5/85

MARAD PROJECT 3205 - CORED S.A.W. ELECTRODES

MATERIAL

EH-36

Plate Code	Wire	Flux
EH-6-CS	Linde 36	Linde 20 (Solid Wire)
EH-6-FC	Speed Alloy 70-S	Linde 80

316L Stainless

Plate Code	Wire	Flux
SS-L-CS	Linde 316L	Linde 80 (Solid Wire)
SS-L-FC	In-Flux 316L G/S	Oerlikon OP-76

HY-80

Plate Code	Wire	Flux
HY-8-CS	Linde 95	Linde 709-5 (Solid Wire)
HY-8-FC	Speed Alloy 90-S	Linde 80
HY-8-MC	Metal Core 100S-2	Oerlikon OP 121 tt
HY-8-AC	Alloy Cored 100S-1	Oerlikon OP 121tt
HY-8-AC-HHI	High Heat Input - Alloy Cored 100S-1	
HY-8-AC-1	Reformulation - Alloy Cored 100S-1	
HY-8-AC-HHI-1	High Heat Input - Reformulated A.C. 100S-1	

HY-100

Plate Code	Wire	Flux
HY-0-CS	Linde 120	Linde 709-5 (Solid Wire)
HY-0-AC	Alloy Cored 120S-1	Oerlikon OP 121tt
HY-0-AC-1	Reformulation - Alloy Cored 120S-1	

8/22/85

TRADE NAMES BY MANUFACTURER

MARAD PROJECT 3205 - FLUX CORED S.A.W. R&D ELECTRODES

SOLID WIRES/CONTROL	FLUX	BASE MATERIAL	PLATE CODE
LINDE			
Linde 36	Linde 20	EH-36	EH-6-CS
Linde 95	Linde 709-5	HY-80	HY-8-CS
Linde 120	Linde 709-5	HY-100	HY-0-CS
Linde 316L	Linde 80	316L	SS-L-CS

METAL CORE WIRES	FLUX	BASE MATERIALS	PLATE CODE
TELEDYNE MCKAY			
Speed Alloy 70-S	Linde 80	EH-36	EH-6-FC
Speed Alloy 90-S	Linde 80	HY-80	HY-8-FC
Speed Alloy 110-S	Linde 80	HY-100	HY-0-FC
In-Flux 316L G/S	Oerlikon OP-76	316L	SS-L-FC
ALLOY RODS			
Alloy Cored 100S-1	Oerlikon OP 121 tt*	HY-80	HY-8-AC
Alloy Cored 120S-1	Oerlikon OP 121 tt*	HY-100	HY-0-AC
TRI-MARK			
Metal Core 100S-2	Oerlikon OP 121 tt*	HY-80	HY-8-MC

*(German Made Flux)

SECTION 9

WELD JOINT DESIGN AND PROCEDURE LIMITS

WELDING PROCEDURE SPECIFICATION

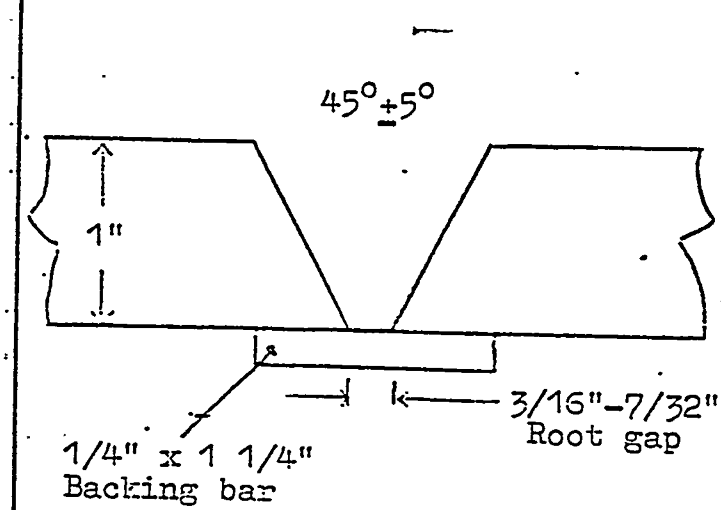
BAY SHIPBUILDING CORP.

Department of
Welding Engineering

BASE MATERIAL ABS EH-36
ELECTRODE CLASS EH-14
STICKOUT 1"
PULARITY Reverse
MODE Constant Voltage

PREHEAT TEMP. 50°F MINIMUM
INTERPASS TEMP. 400°F MAXIMUM
TRAVEL SPEED 18 I.P.M.

JOINT FIT UP TOLERANCES



WELD LAYER(S)	PROCESS	FILLER METAL CLASS	FILLER METAL DIA.	CURRENT TYPE POLAR.	CURRENT AMPERAGE	VOLTAGE	TRAVEL SPEED
1 - 4	S.A.W.	EH-14	3/32"	Reverse	350	30	18
5-Face	S.A.W.	EH-14	3/32"	Reverse	500	32	18

BASE METAL PREPARATION — EDGES OF SURFACES TO BE WELDED SHALL BE PREPARED BY SHEARING, MACHINING, GRINDING OR THERMAL CUTTING, AND FREE OF ALL FOREIGN MATERIAL SUCH AS OIL, GREASE AND EXCESSIVE SCALE OR RUST.

WELD LAYER METAL DEPOSIT APPEARANCE — UNDERCUTTING ON SIDE WALLS OF GROOVE OR ADJOINING BASE METAL SHALL NOT BE PERMITTED.

WELDING PROCEDURE SPECIFICATION

BAY SHIPBUILDING CORP.
Department of
Welding Engineering

BASE MATERIAL 316L

ELECTRODE CLASS 316L

STICKOUT 1"

POLARITY Reverse

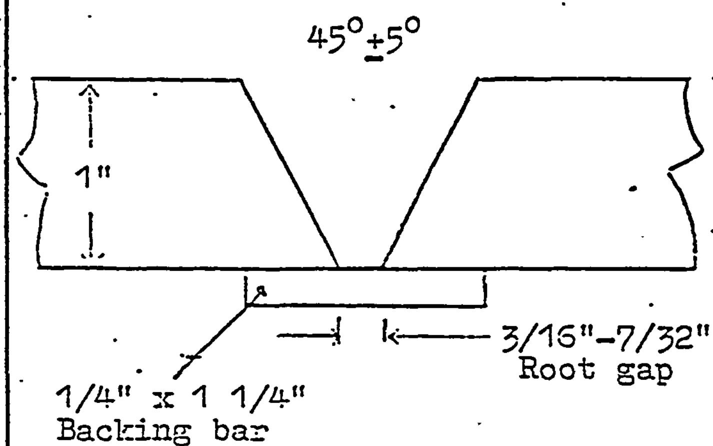
MODE Constant Voltage

PREHEAT TEMP. 150°F MINIMUM

INTERPASS TEMP. 350°F MAXIMUM

TRAVEL SPEED 12 I.P.M.

JOINT FIT UP TOLERANCES



WELD LAYER(S)	PROCESS	FILLER METAL CLASS	FILLER METAL DIA.	CURRENT TYPE POLAR.	CURRENT AMPERAGE	VOLTAGE	TRAVEL SPEED
1-Face	S.A.W.	316L	3/32"	Reverse	350	30	12

BASE METAL PREPARATION — EDGES OF SURFACES TO BE WELDED SHALL BE PREPARED BY SHEARING, MACHINING, GRINDING OR THERMAL CUTTING, AND FREE OF ALL FOREIGN MATERIAL SUCH AS OIL, GREASE AND EXCESSIVE SCALE OR RUST.

WELD LAYER METAL DEPOSIT APPEARANCE — UNDERCUTTING ON SIDE WALLS OF GROOVE OR ADJOINING BASE METAL SHALL NOT BE PERMITTED.

WELDING PROCEDURE SPECIFICATION

BAY SHIPBUILDING CORP.

Department of
Welding Engineering

BASE MATERIAL HY-80

ELECTRODE CLASS 100S-1

STICKOUT 1"

POLARITY Reverse

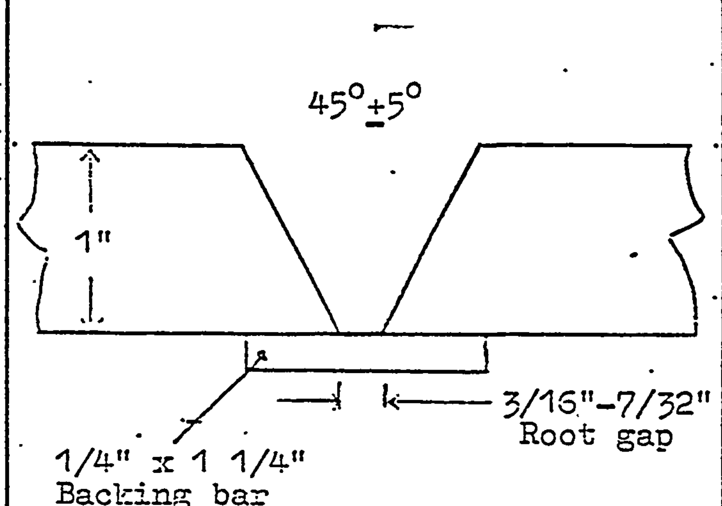
MODE Constant Voltage

PREHEAT TEMP. 200°F MINIMUM

INTERPASS TEMP. 400°F MAXIMUM

TRAVEL SPEED 18 I.P.M.

JOINT FIT UP TOLERANCES



WELD LAYER(S)	PROCESS	FILLER METAL CLASS	FILLER METAL DIA.	CURRENT TYPE POLAR.	CURRENT AMPERAGE	VOLTAGE	TRAVEL SPEED
1 - 4	S.A.W.	100S-1	3/32"	Reverse	350	30	18
5-Face	S.A.W.	100S-1	3/32"	Reverse	500	32	18

BASE METAL PREPARATION — EDGES OF SURFACES TO BE WELDED SHALL BE PREPARED BY SHEARING, MACHINING, GRINDING OR THERMAL CUTTING, AND FREE OF ALL FOREIGN MATERIAL SUCH AS OIL, GREASE AND EXCESSIVE SCALE OR RUST.

WELD LAYER METAL DEPOSIT APPEARANCE — UNDERCUTTING ON SIDE WALLS OF GROOVE OR ADJOINING BASE METAL SHALL NOT BE PERMITTED.

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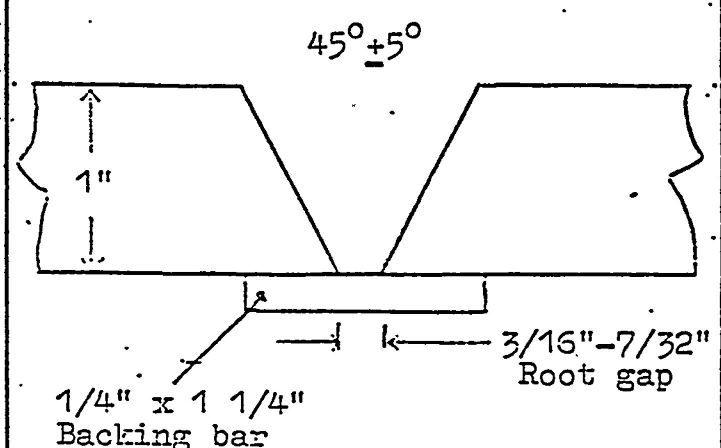
BAY SHIPBUILDING CORP.
Department of
Welding Engineering

WELDING PROCEDURE SPECIFICATION

BASE MATERIAL HY-100
ELECTRODE CLASS 120S-1
STICKOUT 1"
POLARITY Reverse
MODE Constant Voltage

PREHEAT TEMP. 200°F MINIMUM
INTERPASS TEMP. 400°F MAXIMUM
TRAVEL SPEED 18 I.P.M.

JOINT FIT UP TOLERANCES



WELD LAYER(S)	PROCESS	FILLER METAL		CURRENT		VOLTAGE	TRAVEL SPEED
		CLASS	DIA.	TYPE POLAR.	AMPERAGE		
1 - 4	S.A.W.	120S-1	3/32"	Reverse	350	30	18
5-Face	S.A.W.	120S-1	3/32"	Reverse	500	32	18

BASE METAL PREPARATION — EDGES OF SURFACES TO BE WELDED SHALL BE PREPARED BY SHEARING, MACHINING, GRINDING OR THERMAL CUTTING, AND FREE OF ALL FOREIGN MATERIAL SUCH AS OIL, GREASE AND EXCESSIVE SCALE OR RUST.

WELD LAYER METAL DEPOSIT APPEARANCE — UNDERCUTTING ON SIDE WALLS OF GROOVE OR ADJOINING BASE METAL SHALL NOT BE PERMITTED.

SECTION 10

WELD TOOLING

WELD TOOLING

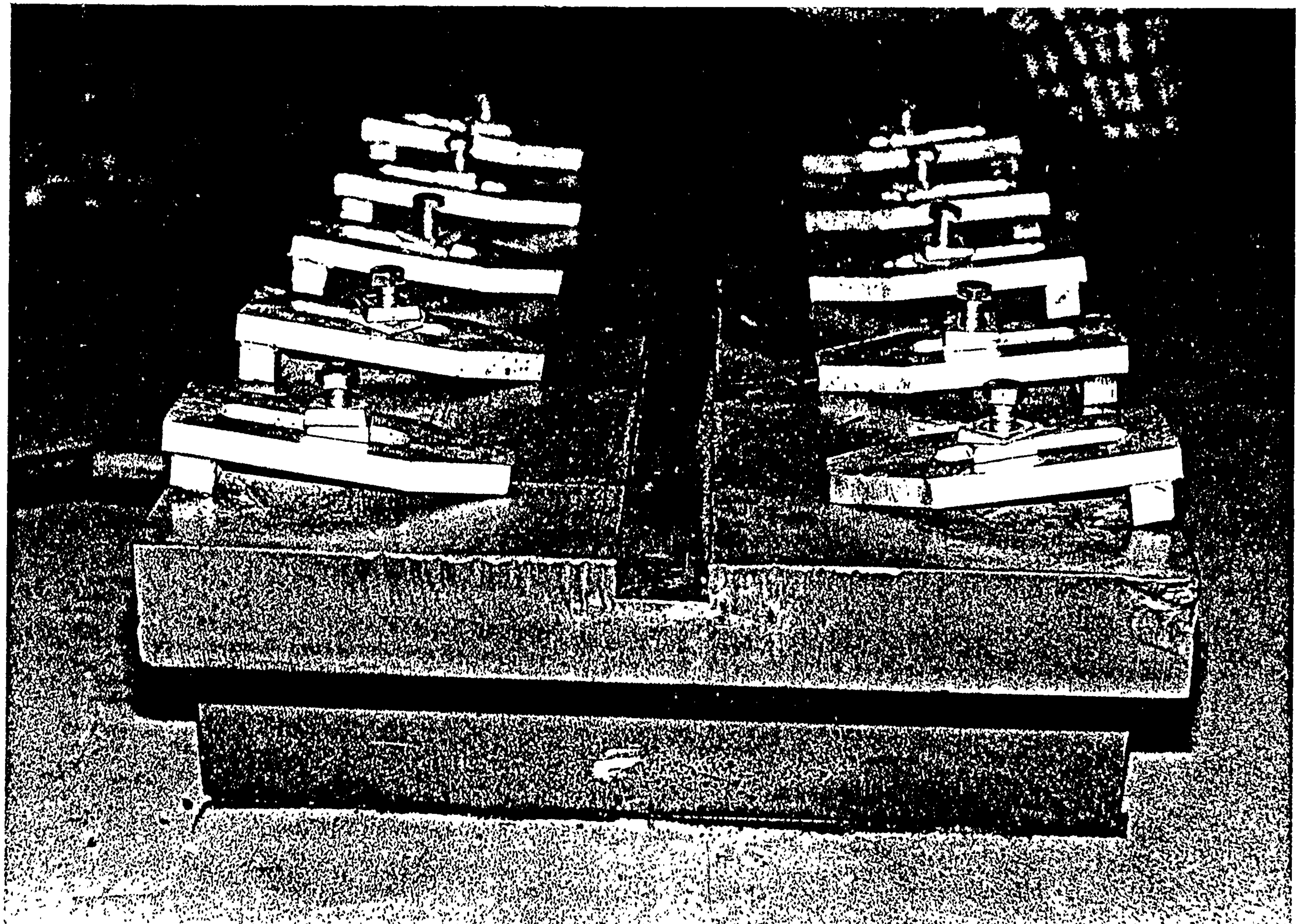
The hold down fixture used in this program was fabricated from a piece of 3" x 24" x 42" ABS Grade A plate steel. A 1" x 2" slot was milled in the fixture to allow a relief for the backing bars on procedure test plates. Ten 3/4" high strength (H.S.) bolts with dogs were used to clamp the plate in place and prevent rotational distortion. Three 3/4" x 8" x 24" strong backs were welded to the underside of the fixture to provide a high level of restraint to simulate job site conditions common to shipbuilding fabrications.

The side beam carriage was a Pandjiris model VSC-40-12 mounted on a Pandjiris model PBT-15/144 side beam. The travel mechanism was a Pandjiris tachometer control type which is solid state controlled to regulate travel speeds precisely regardless of differing resistance on the carriage guide rollers or cable rack.

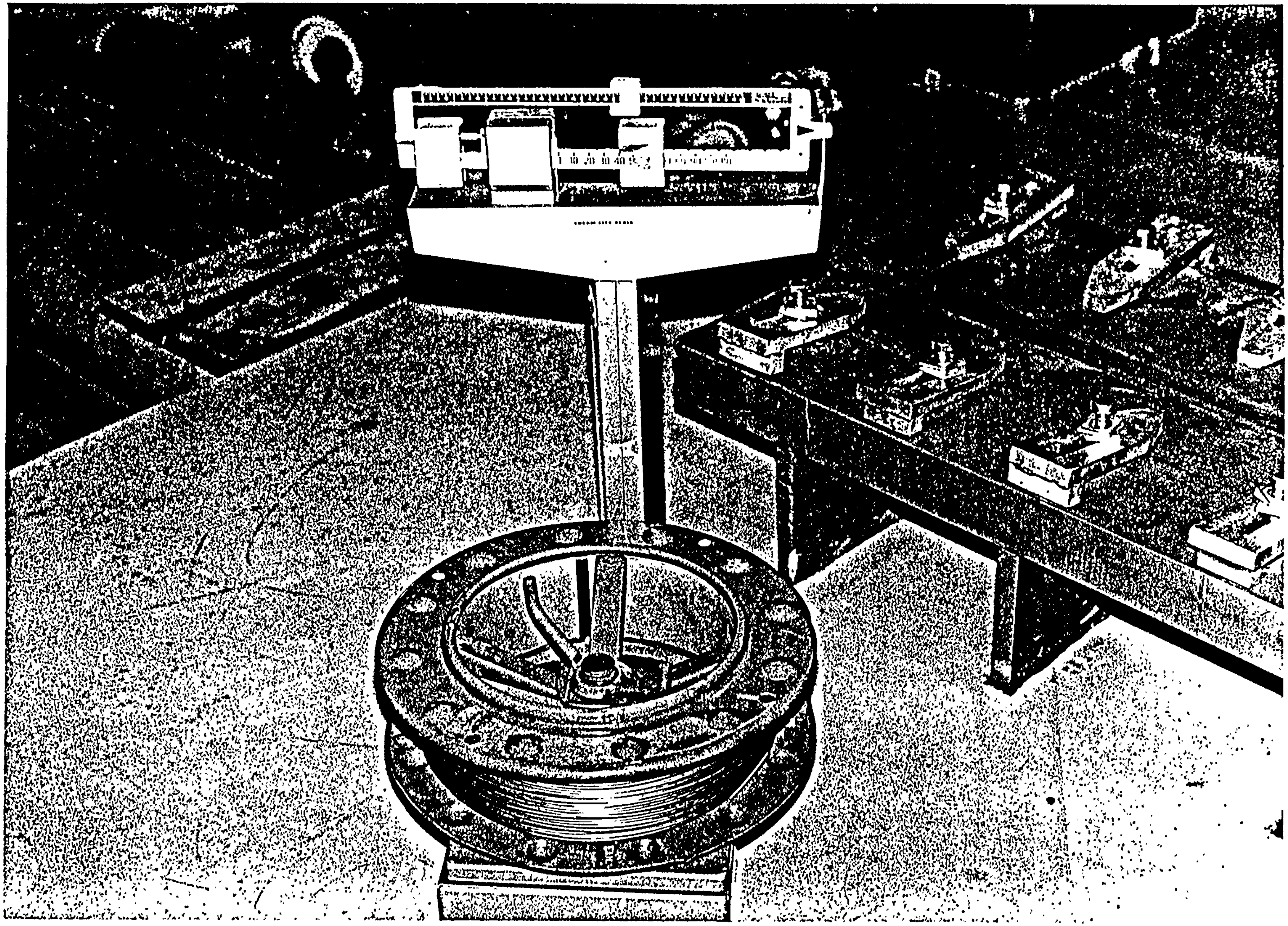
The voltage and wire feed speed settings were frequently double checked using a Lincoln Voltage Indicator, No. M-12421, and a Lincoln Wire Speed Meter, No. M-13367.

The scale used for all weight measurements on test plates and wire spools was a Detecto Model 4570. It has a 130 lb. capacity with a ½ ounce accuracy.

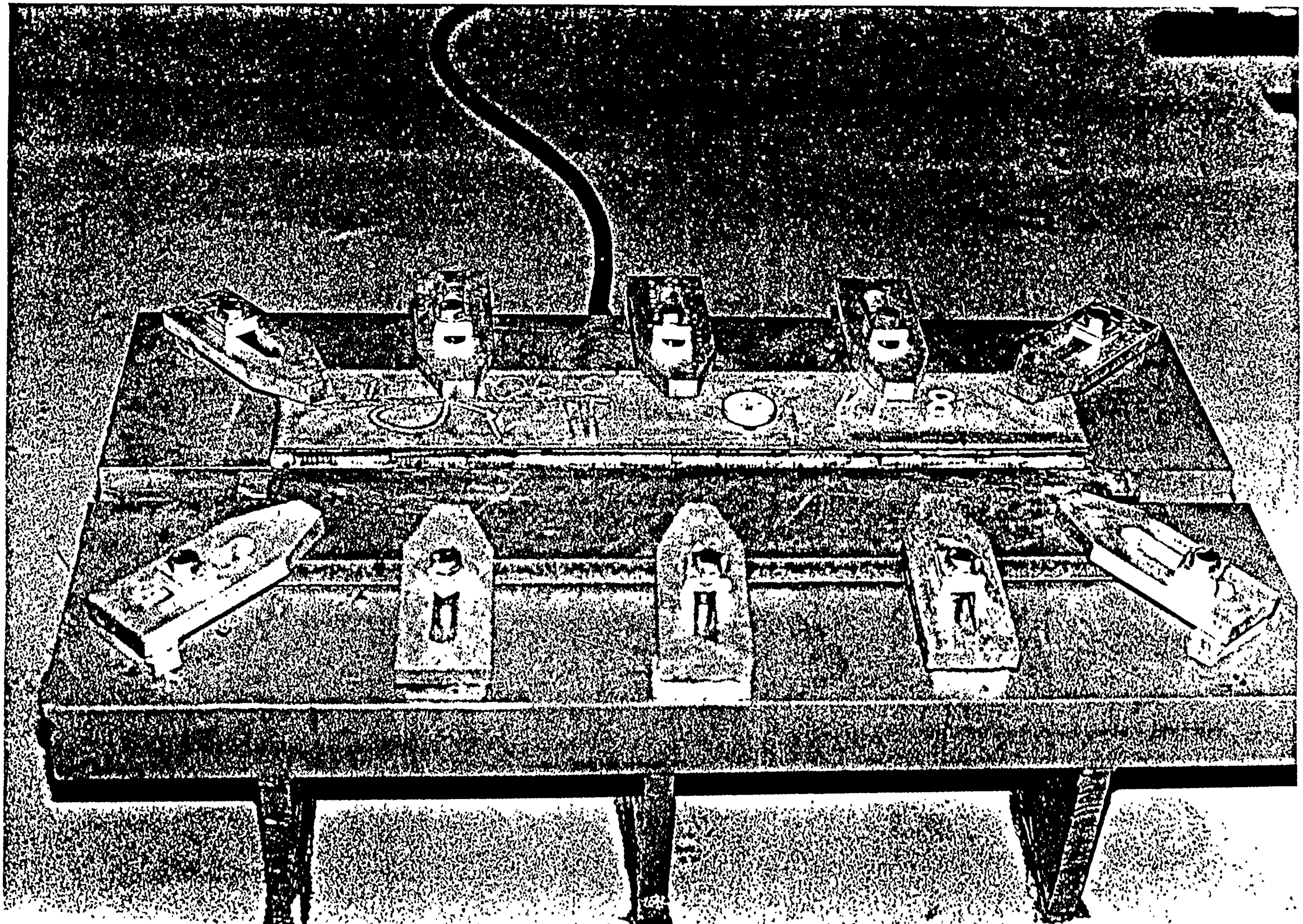
Preheat and Interpass temperatures were verified by a Pacific Transducer Corporation surface thermometer, model PTC-313F.



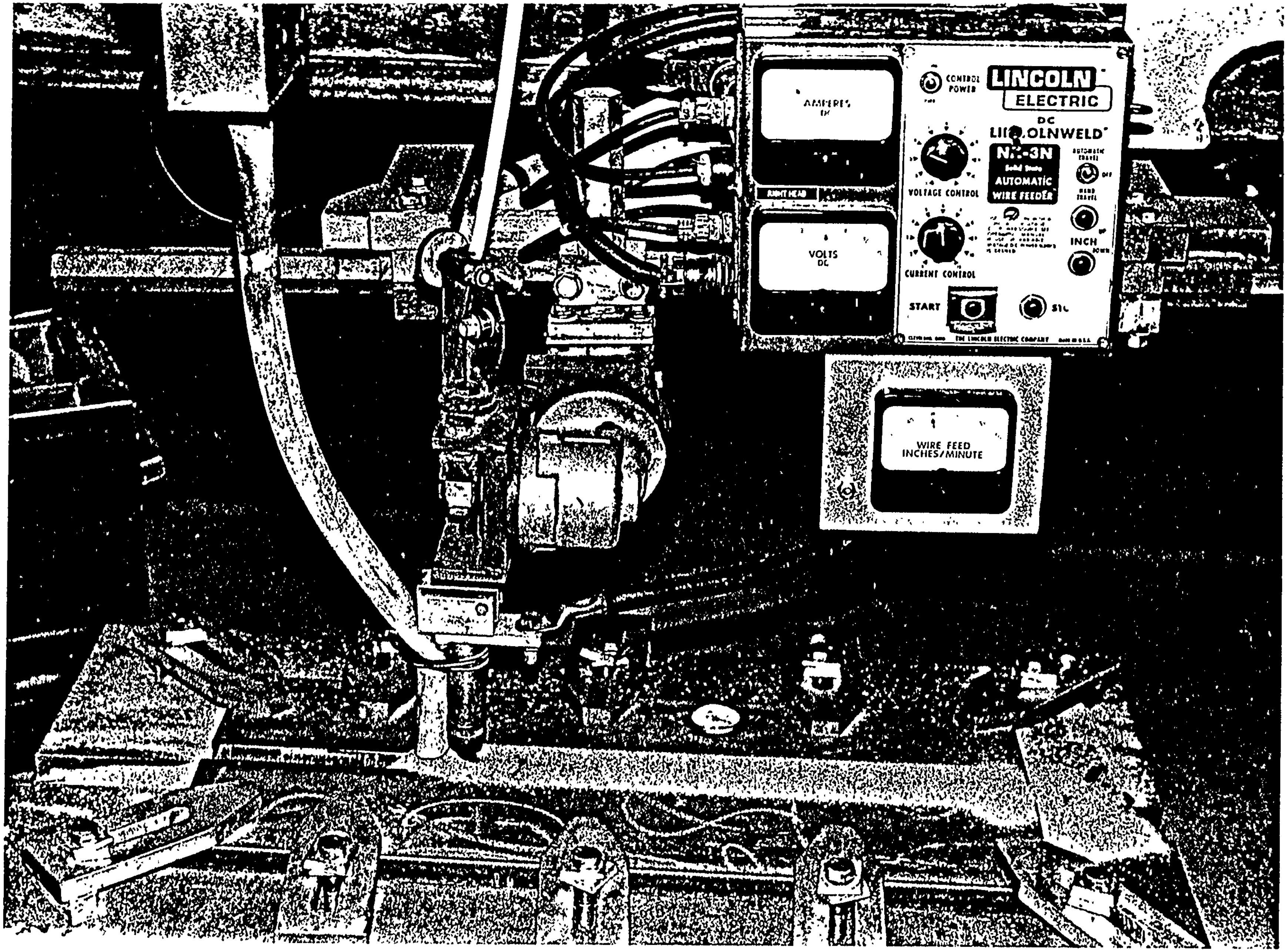
HOLD DOWN FIXTURE (3" x 24" x 42")



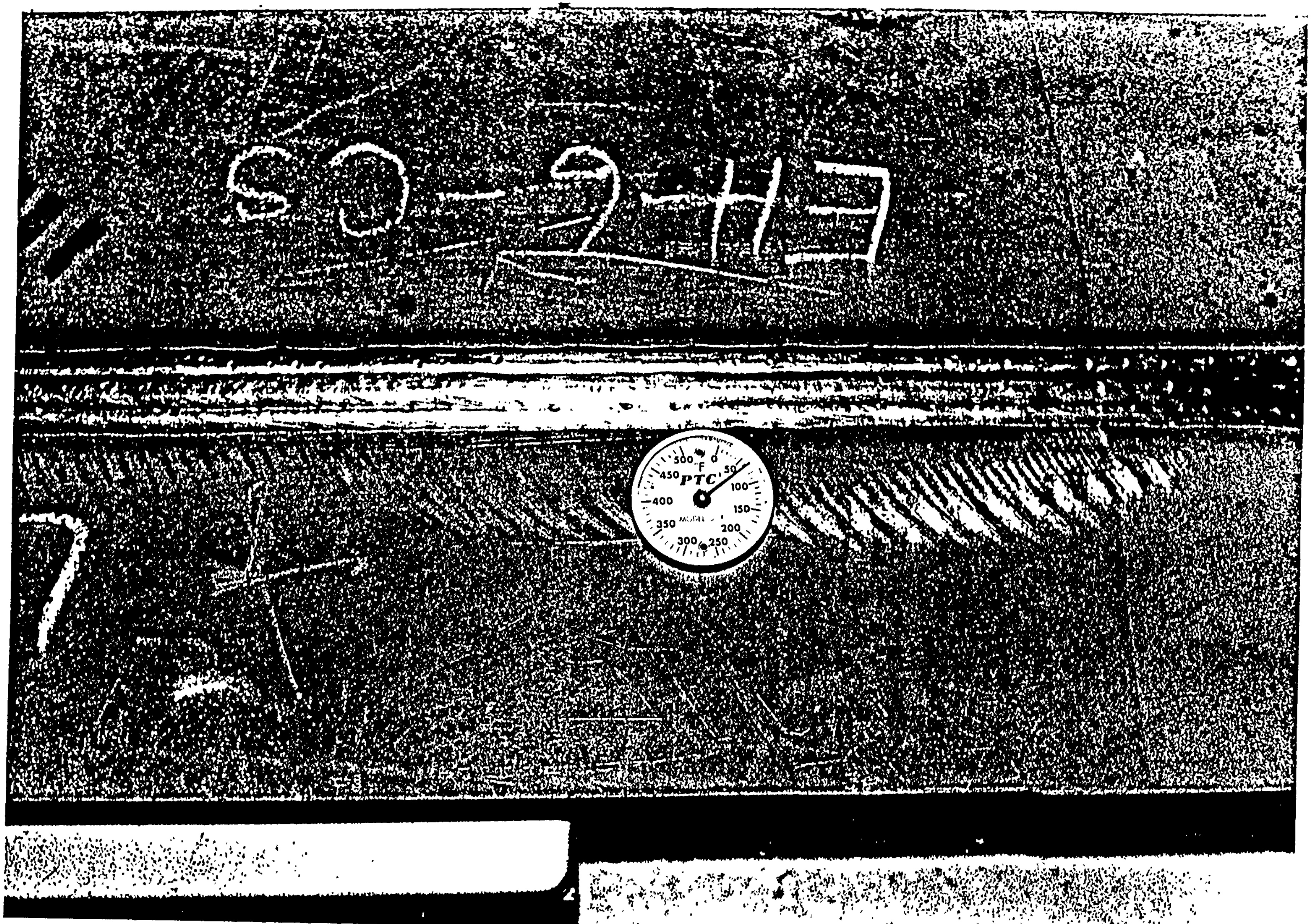
ELECTRODE SPOOL BEING WEIGHED PRIOR TO WELD OPERATION



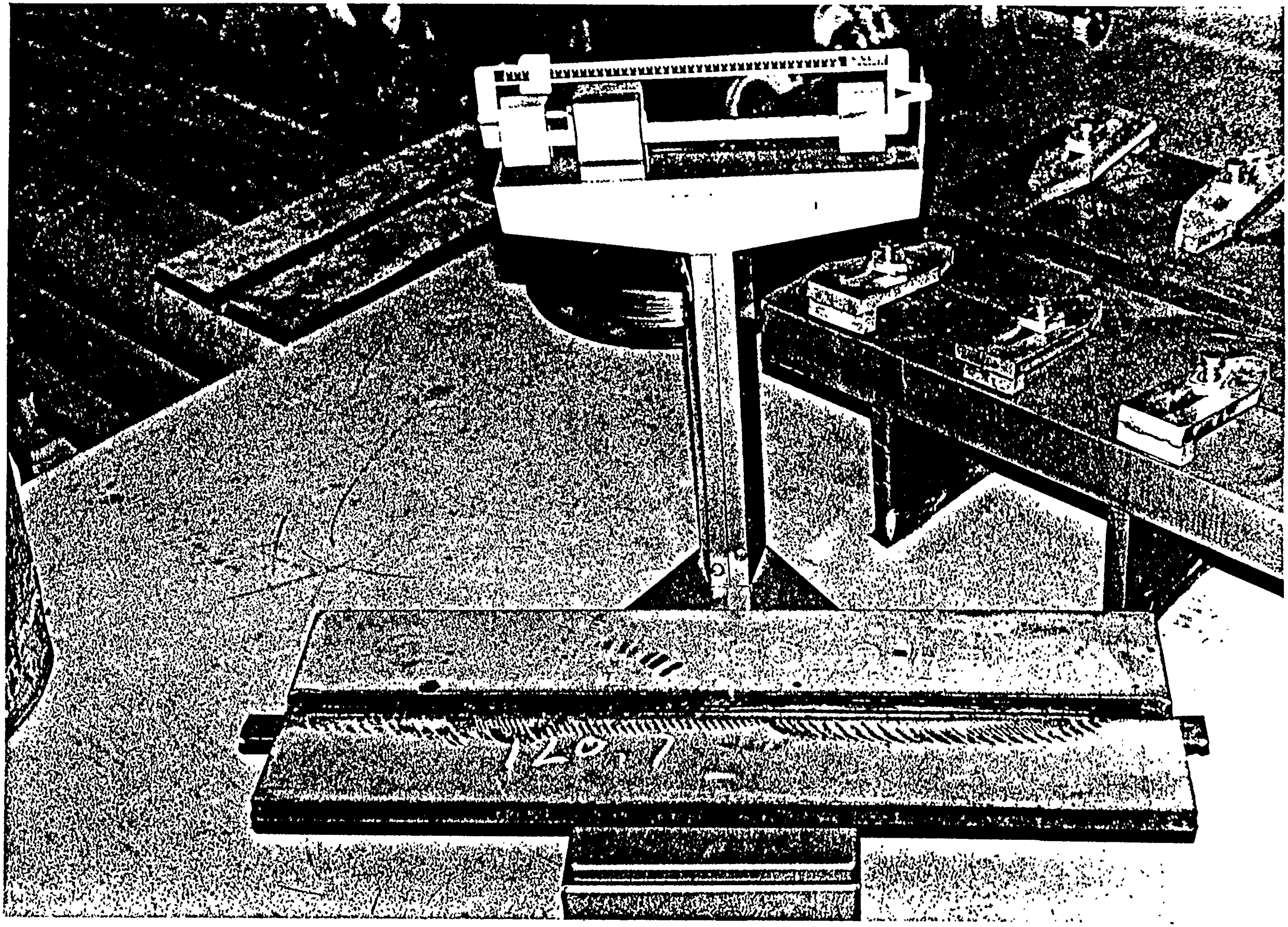
HY-80 MATERIAL READY FOR WELD SEQUENCE



DEPOSITING ROOT PASS



COMPLETED EH-6-CS PROCEDURE SHOWING P.T.C. SURFACE THERMOMETER



COMPLETED EH-6-CS PROCEDURE ON DETECTO SCALE

SECTION 11

PROCEDURE TEST RECORDS

TEST PLATE PROCEDURE MARAD 3205

INSTRUCTIONS TO OPERATOR

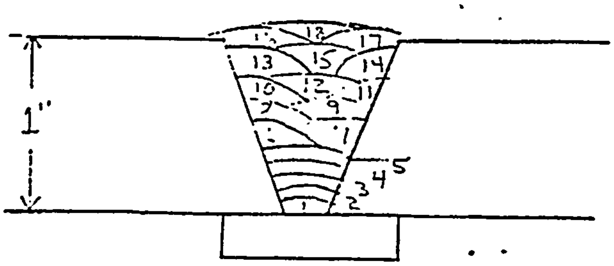
1. Weigh Test Plate after fit up and wire brushing.
2. Weigh Wire Spool Assy. (Keep all wire clippings).
3. Bolt plate down and preheat - check with thermometer.
4. Weld at root pass settings specified.
5. Check Volts, Amps, wire feed speed (WFS), and Time.
6. Check Interpass Temperature and record.
7. Repeat 4,5,6 thru pass #4.
8. Reweigh Test Plate and Wire Spool and record.
9. Re-install in fixture and preheat.
10. Deposit fill passes as required.
11. Monitor Volts, Amperage and Wire Feed Speeds and record for all passes. (Verify W.F.S with hand meter.)
12. Record time in seconds for all passes.
13. Use sheetmetal template to set Electrical Stick Out (E.S.O.) for each pass.
14. Monitor Interpass temperatures. Do not exceed maximum specified temperatures.
15. Record any observations or comments that pertain to the wire-flux combination in use.
16. After plate cools to ambient temperature, remove for final weight and stamping operations prior to mechanical testing.
17. Clean spatter and remove backing bar by milling prior to releasing plate for radiographic testing.

PROCEDURE TEST RECORD

Plate Code EH-6-CS

Date 6-6-84
Operator H. Phillips
Recorder B. Halverson

Pass No.	Voltage	Amperage	Wire Feed Speed (Inches)	Travel Speed (Inches)	Elapsed Time (Seconds)	Heat Input K.J.P.I.
R1	30	350	66	18	103	35
R2	30	350	66	18	103	35
R3	30	350	66	18	103	35
R4	30	350	66	18	102	35
F5	32	500	105	18	103	53.3
F6	32	500	105	18	103	53.3
F7	32	500	105	18	104	53.3
F8	32	500	105	18	103	53.3
F9	32	500	105	18	103	53.3
F10	32	500	105	18	102	53.3
F11	32	500	105	18	102	53.3
F12	32	500	105	18	102	53.3
F13	32	500	105	18	102	53.3
F14	32	500	105	18	105	53.3
F15	32	500	105	18	102	53.3
F16	32	500	105	18	103	53.3
F17	32	500	105	18	102	53.3
F18	32	500	105	18	101	53.3



Weights

Test Plate Asssembly

Start 114-14 Root 115-9 End 120-7

Deposited Metal 11oz-Root

89oz-Fill

Electrode Spool

Start 75-3 Root 74-7 End 69-7

Expended Electrode 12oz Root

92oz Fill

PROCEDURE TEST RECORD

Plate Code EH-6-FC

Date 6-12-84
Operator T. Madsen
Recorder B. Halverson

Pass No.	Voltage	Amperage	Wire Feed Speed (Inches)	Travel Speed (Inches)	Elapsed Time (Seconds)	Heat Input K.J.P.I.
R1	30	350	75	18	101	35
R2	30	350	75	18	102	35
R3	30	350	75	18	102	35
R4	30	350	75	18	101	35
F5	32	500	143	18	100	53.3
F6	32	500	142	18	100	53.3
F7	32	500	142	18	99	53.3
F8	32	500	142	18	98	53.3
F9	32	500	142	18	99	53.3
F10	32	500	142	18	100	53.3
F11	32	500	143	18	100	53.3
F12	32	500	142	18	99	53.3
F13	32	500	143	18	100	53.3
F14	32	500	143	18	100	53.3
F15	32	500	144	18	98	53.3
F16						
F17						
F18						

Weights

Test Plate Asssembly

Start 114-12 Root 115-6 End 119-8

Deposited Metal 10oz -Root

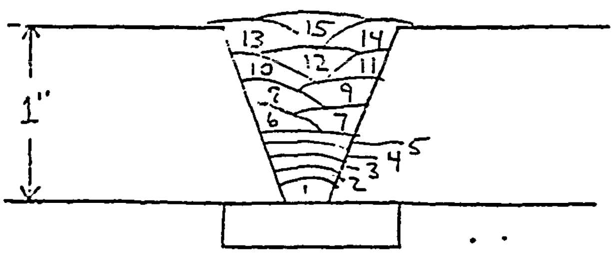
66oz -Fill

Electrode Spool

Start 75-10 Root 74-13 End 70-7

Expended Electrode 13oz Root

83oz Fill



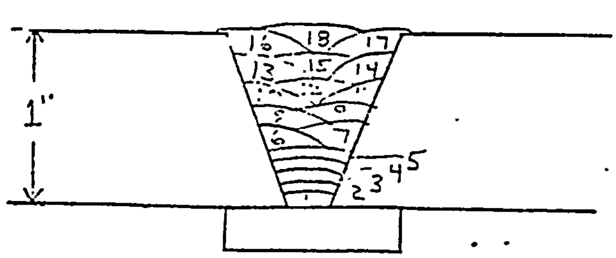
WELDING SEQUENCE

PROCEDURE TEST RECORD

Plate Code SS-L-CS

Date 9-5-84
Operator H. Phillips
Recorder B. Halverson

Pass No.	Voltage	Amperage	Wire Feed Speed (Inches)	Travel Speed (Inches)	Elapsed Time (Seconds)	Heat Input K.J.P.I.
R1	30	350	88	12	108	52.5
R2	30	350	88	12	125	52.5
R3	30	350	88	12	123	52.5
R4	30	350	88	12	120	52.5
F5	30	350	88	12	125	52.5
F6	30	350	88	12	120	52.5
F7	30	350	88	12	121	52.5
F8	30	350	88	12	122	52.5
F9	30	350	88	12	120	52.5
F10	30	350	88	12	122	52.5
F11	30	350	88	12	124	52.5
F12	30	350	88	12	120	52.5
F13	30	350	88	12	121	52.5
F14	30	350	88	12	120	52.5
F15	30	350	88	12	120	52.5
F16	30	350	88	12	123	52.5
F17	30	350	88	12	120	52.5
F18	30	350	88	12	120	52.5



Weights

Test Plate Asssembly

Start 107-3 Root ______ End 113-0

Deposited Metal ____ -Root

93 -Fill

Electrode Spool

Start 57-14 Root ______ End 51-6

Expended Electrode ______ Root

104 Fill

PROCEDURE TEST RECORD

Plate Code SS-L-FC

Date 8-27-84
Operator T. Madsen
Recorder B. Halverson

Pass No.	Voltage	Amperage	Wire Feed Speed (Inches)	Travel Speed (Inches)	Elapsed Time (Seconds)	Heat Input K.J.P.I
R1	30	350	132	12	122	52.5
R2	30	350	132	12	123	52.5
R3	30	350	132	12	126	52.5
R4	30	350	132	12	120	52.5
F5	30	350	132	12	119	52.5
F6	30	350	132	12	121	52.5
F7	30	350	132	12	121	52.5
F8	30	350	132	12	123	52.5
F9	30	350	132	12	122	52.5
F10	30	350	132	12	122	52.5
F11	30	350	132	12	122	52.5
F12	30	350	132	12	120	52.5
F13	30	350	132	12	118	52.5
F14	30	350	132	12	118	52.5
F15	30	350	132	12	117	52.5
F16	30	350	132	12	118	52.5
F17						
F18						

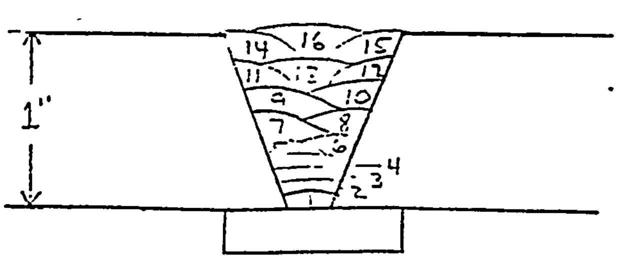
Weights

Test Plate Asssembly

Start 107-0 Root ______ End 113-8

Deposited Metal ____ -Root

104oz Fill



Electrode Spool

Start 59-13 Root ______ End 53-3

Expended Electrode ______ Root

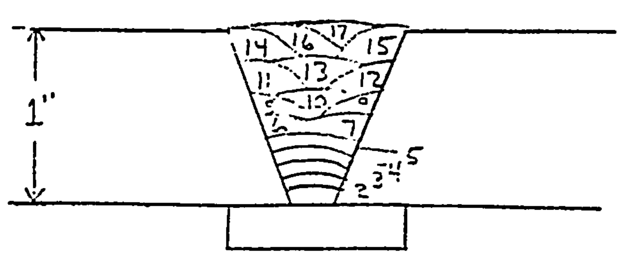
104oz Fill

PROCEDURE TEST RECORD

Plate Code HY-8-CS

Date 6-14-84
Operator T. Madsen
Recorder B. Halverson

Pass No.	Voltage	Amperage	Wire Feed Speed (Inches)	Travel Speed (Inches)	Elapsed Time (Seconds)	Heat Input K.J.P.I.
R1	30	350	74	18	88	35.0
R2	30	350	74	18	88	35.0
R3	30	350	74	18	89	35.0
R4	30	350	74	18	90	35.0
F5	32	500	116	18	90	53.3
F6	32	500	117	18	89	53.3
F7	32	500	117	18	90	53.3
F8	32	500	117	18	90	53.3
F9	32	500	117	18	90	53.3
F10	32	500	117	18	89	53.3
F11	32	500	117	18	90	53.3
F12	32	500	117	18	88	53.3
F13	32	500	117	18	87	53.3
F14	32	500	117	18	87	53.3
F15	32	500	117	18	86	53.3
F16	32	500	117	18	87	53.3
F17	32	500	117	18	86	53.3
F18						



Weights

Test Plate Asssembly

Start 106-0 Root 106-12 End 110-15

Deposited Metal 12 -Root

67 -Fill

Electrode Spool

Start 45-11 Root 44-13 End 40-8

Expended Electrode 14 Root

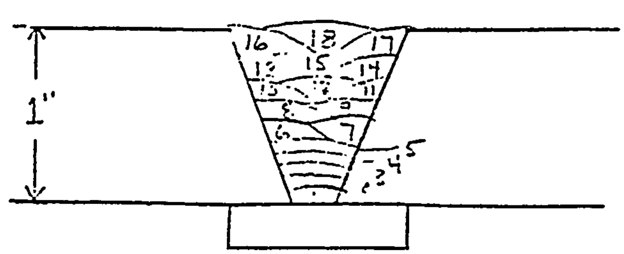
69 Fill

PROCEDURE TEST RECORD

Plate Code HY-8 FC

Date 7-12-84
Operator H. Phillips
Recorder B. Halverson

Pass No.	Voltage	Amperage	Wire Feed Speed (Inches)	Travel Speed (Inches)	Elapsed Time (Seconds)	Heat Input K.J.P.I.
R1	30	350	77	18	90	35.0
R2	30	350	77	18	90	35.0
R3	30	350	77	18	90	35.0
R4	30	350	77	18	91	35.0
F5	32	500	135	18	90	53.3
F6	32	500	135	18	90	53.3
F7	32	500	135	18	89	53.3
F8	32	500	135	18	90	53.3
F9	32	500	135	18	90	53.3
F10	32	500	136	18	89	53.3
F11	32	500	136	18	89	53.3
F12	32	500	136	18	90	53.3
F13	32	500	136	18	88	53.3
F14	32	500	135	18	89	53.3
F15	32	500	136	18	91	53.3
F16	32	500	137	18	91	53.3
F17	32	500	136	18	90	53.3
F18	32	500	137	18	89	53.3



Weights

Test Plate Asssembly

Start 104-12 Root 105-7 End 110-9

Deposited Metal 11 -Root

82 -Fill

Electrode Spool

Start 72-9 Root 71-12 End 66-6

Expended Electrode 13 Root

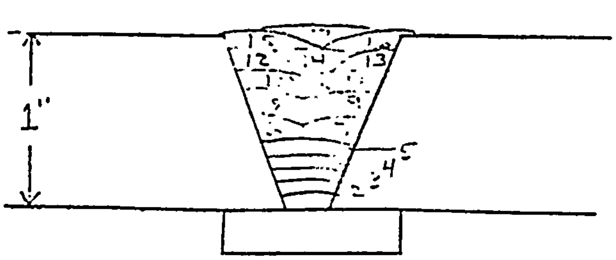
86 Fill

PROCEDURE TEST RECORD

Plate Code HY-8-MC

Date 6-14-84
Operator T. Madsen
Recorder B. Halverson

Pass No.	Voltage	Amperage	Wire Feed Speed (Inches)	Travel Speed (Inches)	Elapsed Time (Seconds)	Heat Input K.J.P.I.
R1	30	350	82	18	90	35.0
R2	30	350	81	18	90	35.0
R3	30	350	82	18	90	35.0
R4	30	350	82	18	90	35.0
F5	32	500	140	18	90	53.3
F6	32	500	140	18	90	53.3
F7	32	500	140	18	90	53.3
F8	32	500	140	18	90	53.3
F9	32	500	140	18	90	53.3
F10	32	500	140	18	90	53.3
F11	32	500	140	18	90	53.3
F12	32	500	140	18	90	53.3
F13	32	500	140	18	90	53.3
F14	32	500	140	18	90	53.3
F15	32	500	140	18	90	53.3
F16	32	500	140	18	90	53.3
F17	32	500	140	18	90	53.3
F18						



Weights

Test Plate Asssembly

Start 107-15 Root 108-14 End 113-6

Deposited Metal 15 -Root

72 -Fill

Electrode Spool

Start 74-15 Root 73-13 End 69-2

Expended Electrode 18 Root

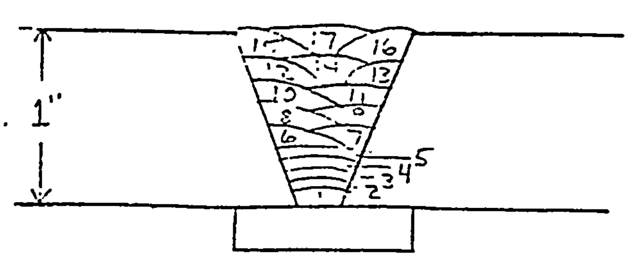
75 Fill

PROCEDURE TEST RECORD

Plate Code HY-8-AC

Date 7-26-84
Operator H. Phillips
Recorder B. Halverson

Pass No.	Voltage	Amperage	Wire Feed Speed (Inches)	Travel Speed (Inches)	Elapsed Time (Seconds)	Heat Input K.J.P.I.
R1	30	350	90	18	91	35.0
R2	30	350	90	18	91	35.0
R3	30	350	90	18	95	35.0
R4	30	350	90	18	96	35.0
F5	32	500	156	18	92	53.3
F6	32	500	157	18	91	53.3
F7	32	500	156	18	92	53.3
F8	32	500	156	18	91	53.3
F9	32	500	157	18	94	53.3
F10	32	500	157	18	91	53.3
F11	32	500	156	18	94	53.3
F12	32	500	157	18	94	53.3
F13	32	500	157	18	94	53.3
F14	32	500	157	18	94	53.3
F15	32	500	156	18	98	53.3
F16	32	500	156	18	94	53.3
F17	32	500	156	18	94	53.3
F18						



Weights

Test Plate Asssembly

Start 105-12 Root 106-11 End 112-1

Deposited Metal 15 -Root

86 -Fill

Electrode Spool

Start 74-4 Root 73-4 End 67-11

Expended Electrode 16 Root

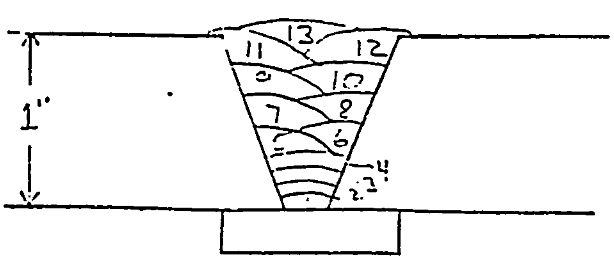
8[illegible] Fill

PROCEDURE TEST RECORD

Plate Code HY-8-AC-HHI

Date 7-27-84
Operator H. Phillips
Recorder B. Halverson

Pass No.	Voltage	Amperage	Wire Feed Speed (Inches)	Travel Speed (Inches)	Elapsed Time (Seconds)	Heat Input K.J.P.I.
R1	30	350	84	18	90	35.0
R2	30	350	84	18	91	35.0
R3	30	350	84	18	91	35.0
R4	30	350	84	18	91	35.0
F5	32	500	149	10	129	96.0
F6	32	500	154	10	129	96.0
F7	32	500	154	10	129	96.0
F8	32	500	154	10	129	96.0
F9	32	500	154	10	132	96.0
F10	32	500	154	10	135	96.0
F11	32	500	154	10	129	96.0
F12	32	500	154	10	130	96.0
F13	32	500	154	10	130	96.0
F14						
F15						
F16						
F17						
F18						



Weights

Test Plate Asssembly

Start 105-9 Root 106-6 End 111-11

Deposited Metal 13 -Root

85 -Fill

Electrode Spool

Start 67-7 Root 66-9 End 61-3

Expended Electrode 14 Root

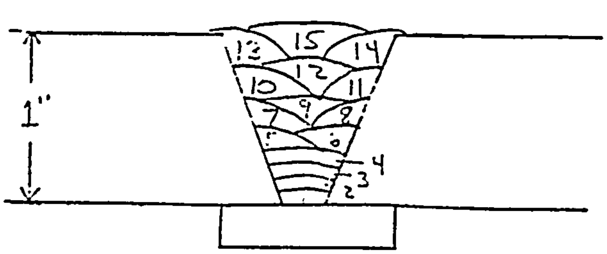
86 Fill

PROCEDURE TEST RECORD

Plate Code HY-8-AC-1

Date 5-2-85
Operator H. Phillips
Recorder B. Halverson

Pass No.	Voltage	Amperage	Wire Feed Speed (Inches)	Travel Speed (Inches)	Elapsed Time (Seconds)	Heat Input K.J.P.I.
R1	30	350	90	18	97	35.0
R2	30	350	90	18	96	35.0
R3	30	350	90	18	98	35.0
R4	30	350	90	18	100	35.0
F5	32	500	156	18	100	53.3
F6	32	500	156	18	100	53.3
F7	32	500	156	18	100	53.3
F8	32	500	156	18	103	53.3
F9	32	500	156	18	100	53.3
F10	32	500	156	18	101	53.3
F11	32	500	156	18	100	53.3
F12	32	500	156	18	94	53.3
F13	32	500	156	18	105	53.3
F14	32	500	156	18	97	53.3
F15	32	500	156	18	103	53.3
F16						
F17						
F18						



WELDING SEQUENCE

Weights

Test Plate Asssembly

Start 105-10 Root 106-8 End 111-12

Deposited Metal 12 -Root

84 -Fill

Electrode Spool

Start 55-6 Root 54-9 End 49-3

Expended Electrode 13 Root

86 Fill

PROCEDURE TEST RECORD

Plate Code HY-8-AC-HHI-1

Date 5-2-85
Operator H. Phillips
Recorder R. Miller

Pass No.	Voltage	Amperage	Wire Feed Speed (Inches)	Travel Speed (Inches)	Elapsed Time (Seconds)	Heat Input K.J.P.I.
R1	30	350	90	18	95	35.0
R2	30	350	90	18	100	35.0
R3	30	350	90	18	95	35.0
R4	30	350	90	18	91	35.0
F5	32	500	156	10	170	96.0
F6	32	500	156	10	169	96.0
F7	32	500	156	10	169	96.0
F8	32	500	156	10	200	96.0
F9	32	500	156	10	211	96.0
F10	32	500	156	10	239	96.0
F11	32	500	156	10	255	96.0
F12	32	500	156	10	247	96.0
F13						
F14						
F15						
F16						
F17						
F18						

Weights

Test Plate Asssembly

Start 106-6 Root 107-3 End 113-12

Deposited Metal 13 -Root

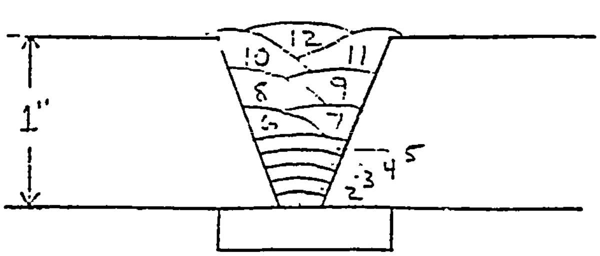
105 -Fill

Electrode Spool

Start 48-12 Root 47-14 End 41-4

Expended Electrode 14 Root

106 Fill



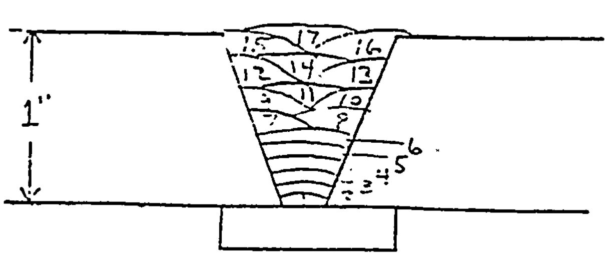
WELDING SEQUENCE

PROCEDURE TEST RECORD

Plate Code HY-0-CS

Date 7-3-84
Operator J. Dart
Recorder B. Halverson

Pass No.	Voltage	Amperage	Wire Feed Speed (Inches)	Travel Speed (Inches)	Elapsed Time (Seconds)	Heat Input K.J.P.I.
R1	30	350	66	18	90	35.0
R2	30	350	67	18	90	35.0
R3	30	350	68	18	90	35.0
R4	30	350	68	18	90	35.0
F5	32	500	112	18	90	53.3
F6	32	500	112	18	90	53.3
F7	32	500	112	18	90	53.3
F8	32	500	113	18	90	53.3
F9	32	500	112	18	90	53.3
F10	32	500	112	18	90	53.3
F11	32	500	113	18	88	53.3
F12	32	500	113	18	90	53.3
F13	32	500	112	18	88	53.3
F14	32	500	113	18	90	53.3
F15	32	500	112	18	90	53.3
F16	32	500	112	18	88	53.3
F17	32	500	112	18	89	53.3
F18						



Weights

Test Plate Asssembly

Start 105-14 Root 106-10 End 110-14

Deposited Metal 12 -Root

68 -Fill

Electrode Spool

Start 47-0 Root 46-3 End 41-15

Expended Electrode 13 Root

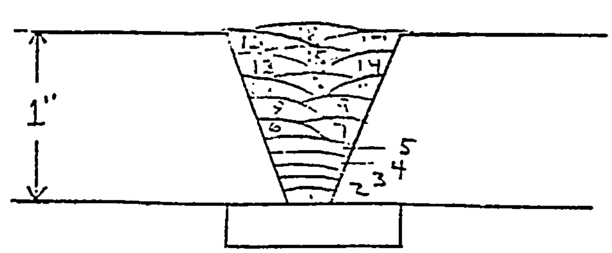
68 Fill

PROCEDURE TEST RECORD

Plate Code HY-0-FC

Date 7-9-84
Operator J. Dart
Recorder B. Halverson

Pass No.	Voltage	Amperage	Wire Feed Speed (Inches)	Travel Speed (Inches)	Elapsed Time (Seconds)	Heat Input K.J.P.I.
R1	30	350	75	18	90	35.0
R2	30	350	75	18	90	35.0
R3	30	350	75	18	90	35.0
R4	30	350	75	18	90	35.0
F5	32	500	134	18	90	53.3
F6	32	500	134	18	89	53.3
F7	32	500	133	18	89	53.3
F8	32	500	133	18	90	53.3
F9	32	500	133	18	90	53.3
F10	32	500	133	18	90	53.3
F11	32	500	133	18	89	53.3
F12	32	500	133	18	90	53.3
F13	32	500	133	18	90	53.3
F14	32	500	133	18	89	53.3
F15	32	500	134	18	90	53.3
F16	32	500	134	18	90	53.3
F17	32	500	133	18	89	53.3
F18	32	500	133	18	89	53.3



Weights

Test Plate Asssembly

Start 105-4 Root 106-0 End 110-10

Deposited Metal 12 -Root

74 -Fill

Electrode Spool

Start 74-12 Root 73-15 End 69-2

Expended Electrode 13 Root

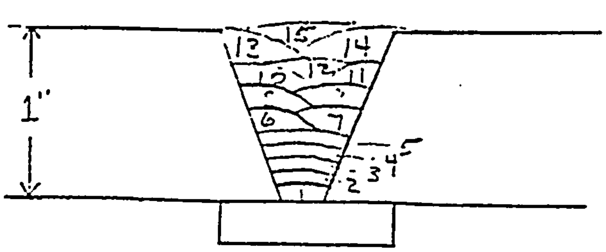
77 Fill

PROCEDURE TEST RECORD

Plate Code HY-0-AC

Date 9-6-84
Operator H. Phillips
Recorder B. Halverson

Pass No.	Voltage	Amperage	Wire Feed Speed (Inches)	Travel Speed (Inches)	Elapsed Time (Seconds)	Heat Input K.J.P.I.
R1	30	350	72	18	93	35.0
R2	30	350	72	18	94	35.0
R3	30	350	72	18	106	35.0
R4	30	350	72	18	107	35.0
F5	32	500	135	18	97	53.3
F6	32	500	135	18	94	53.3
F7	32	500	135	18	94	53.3
F8	32	500	135	18	93	53.3
F9	32	500	135	18	110	53.3
F10	32	500	135	18	108	53.3
F11	32	500	135	18	111	53.3
F12	32	500	135	18	95	53.3
F13	32	500	135	18	94	53.3
F14	32	500	135	18	91	53.3
F15	32	500	135	18	101	53.3
F16						
F17						
F18						



Weights
Test Plate Asssembly

Start 104-12 Root 105-9 End 110-9

Deposited Metal 13 -Root

80 -Fill

Electrode Spool

Start 66-11 Root 65-13 End 60-11

Expended Electrode 14 Root

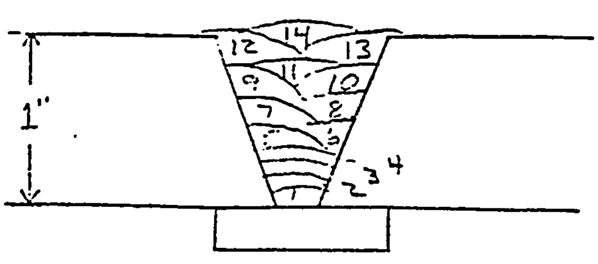
82 Fill

PROCEDURE TEST RECORD

Plate Code HY-0-AC-1

Date 4-29-85
Operator H. Phillips
Recorder B. Halverson

Pass No.	Voltage	Amperage	Wire Feed Speed (Inches)	Travel Speed (Inches)	Elapsed Time (Seconds)	Heat Input K.J.P.I.
R1	30	350	72	18	97	35
R2	30	350	72	18	103	35
R3	30	350	72	18	103	35
R4	30	350	73	18	102	35
F5	32	500	135	18	105	53.3
F6	32	500	135	18	107	53.3
F7	32	500	135	18	107	53.3
F8	32	500	135	18	105	53.3
F9	32	500	135	18	101	53.3
F10	32	500	135	18	113	53.3
F11	32	500	135	18	110	53.3
F12	32	500	135	18	107	53.3
F13	32	500	135	18	110	53.3
F14	32	500	135	18	110	53.3
F15						
F16						
F17						
F18						



Weights

Test Plate Asssembly

Start 104-2 Root 105-0 End 110-13

Deposited Metal 14 -Root

93 -Fill

Electrode Spool

Start 72-4 Root 71-5 End 65-6

Expended Electrode 15 Root

95 Fill

SECTION 12

WELD TEST RESULTS

WELD TESTING

The finished procedure plates were visually inspected for deficiencies before they were released for testing. After the backing bars were milled off they were radiographically tested using either Iridium (IR) 192 or a 300KV x-ray tube.

The first and second procedure plates run with solid 316L wire were rejected for cracking in the center of the weld. This cracking was eliminated on the third procedure plate by reducing the parameter settings to 30 volts and 350 amps at 12 I.P.M.. It should be noted that satisfactory plates were produced by the cored 316L wire at higher parameter settings.

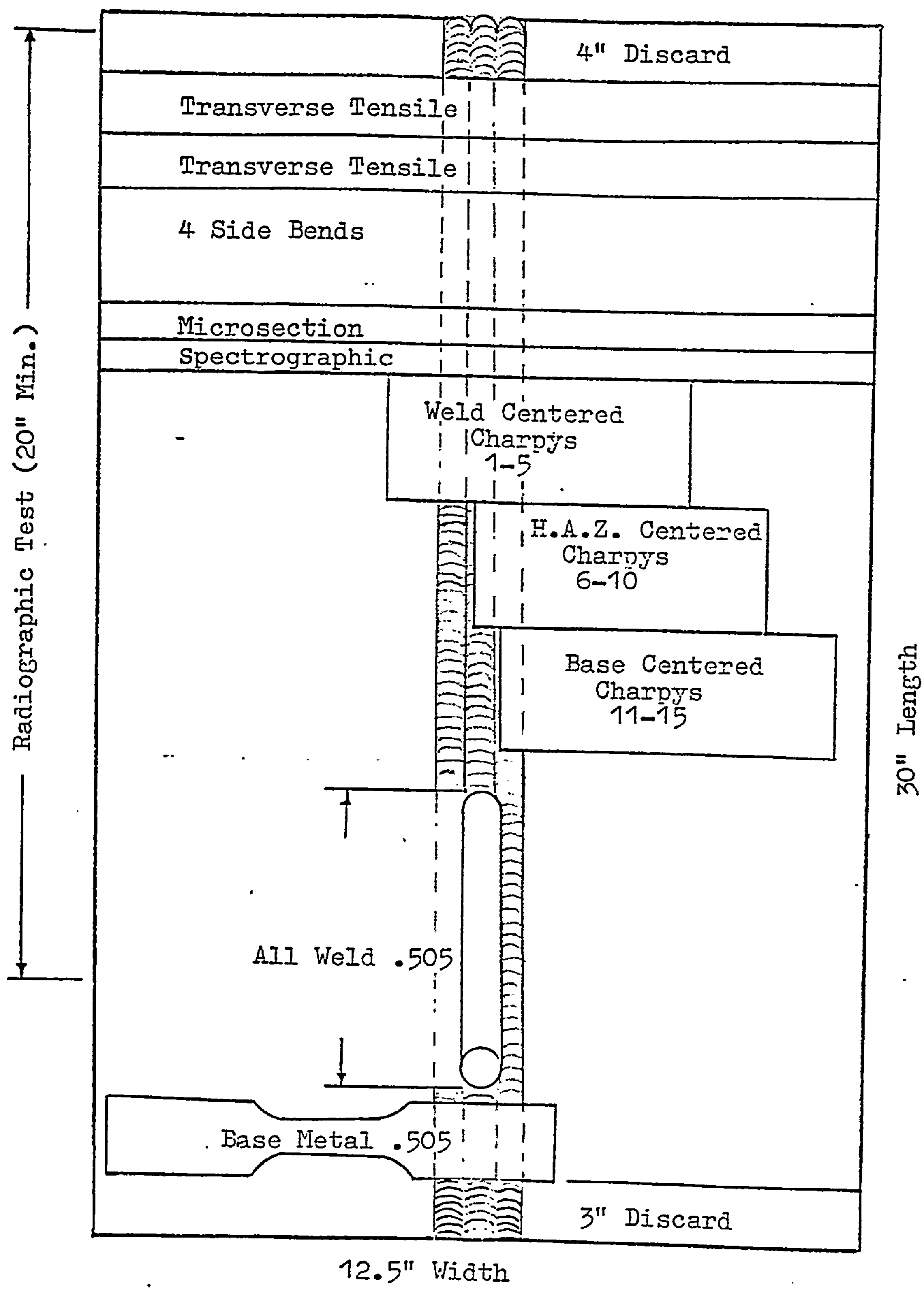
All other procedure plates were found to be satisfactory by radiographic testing.

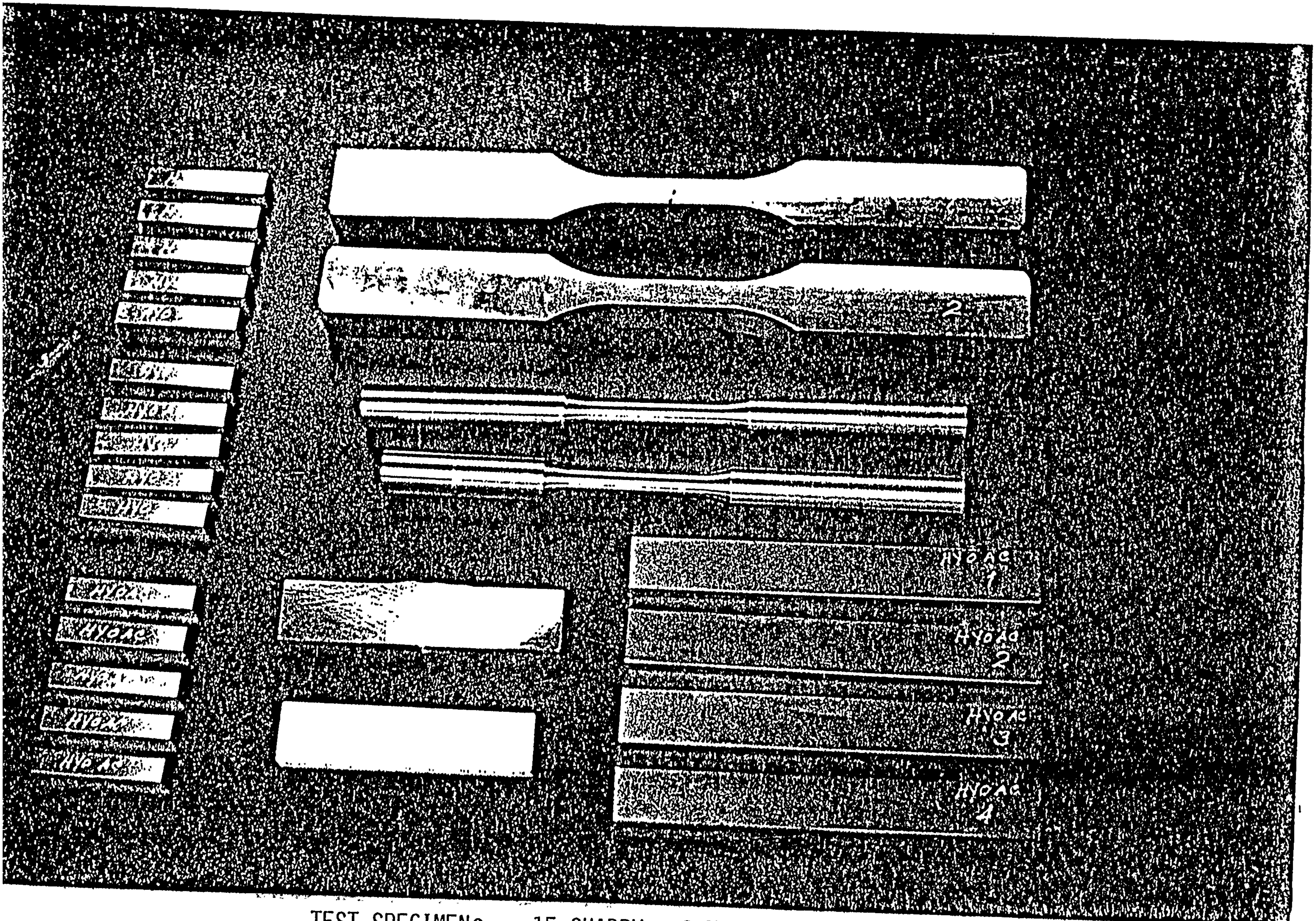
Mechanical test specimens were then removed from the plates in the order depicted in Fig. 1. All removal was accomplished using a band saw to eliminate heat input effects associated with thermal cutting processes.

Mechanical tests on EH-36 and 316L stainless were prepared and tested in accordance with the ABS Rules for Building and Classing Steel Vessels 1984. Specifications used for testing HY-80 and HY-100 was MIL-STD-418C.

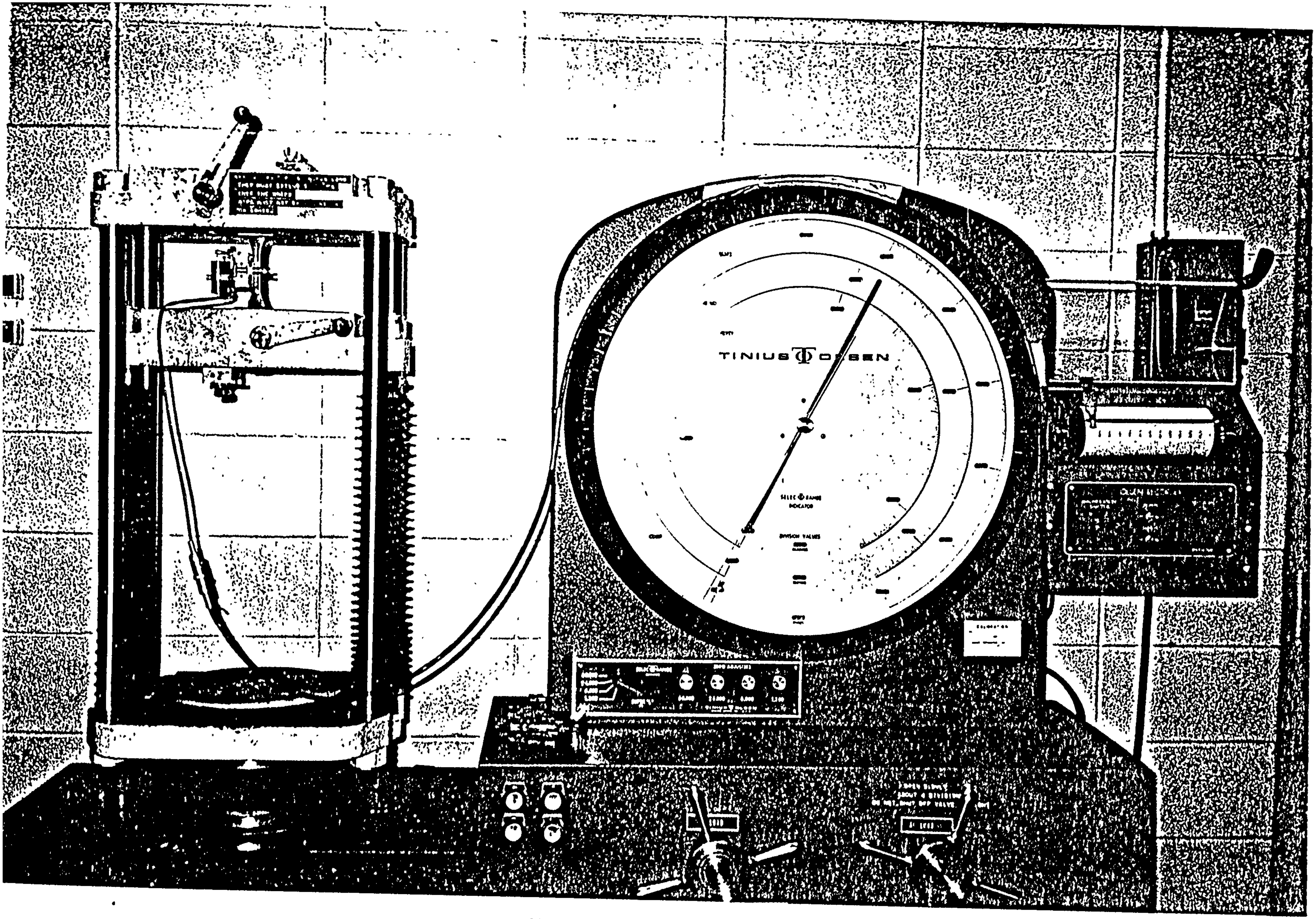
Charpy tests were run with a variation in that 5 samples were tested at each location. To eliminate scatter, the highest and lowest values were not included in the average ft. lbs. reported in this report. All actual values are included in Appendix B.

FIGURE 1

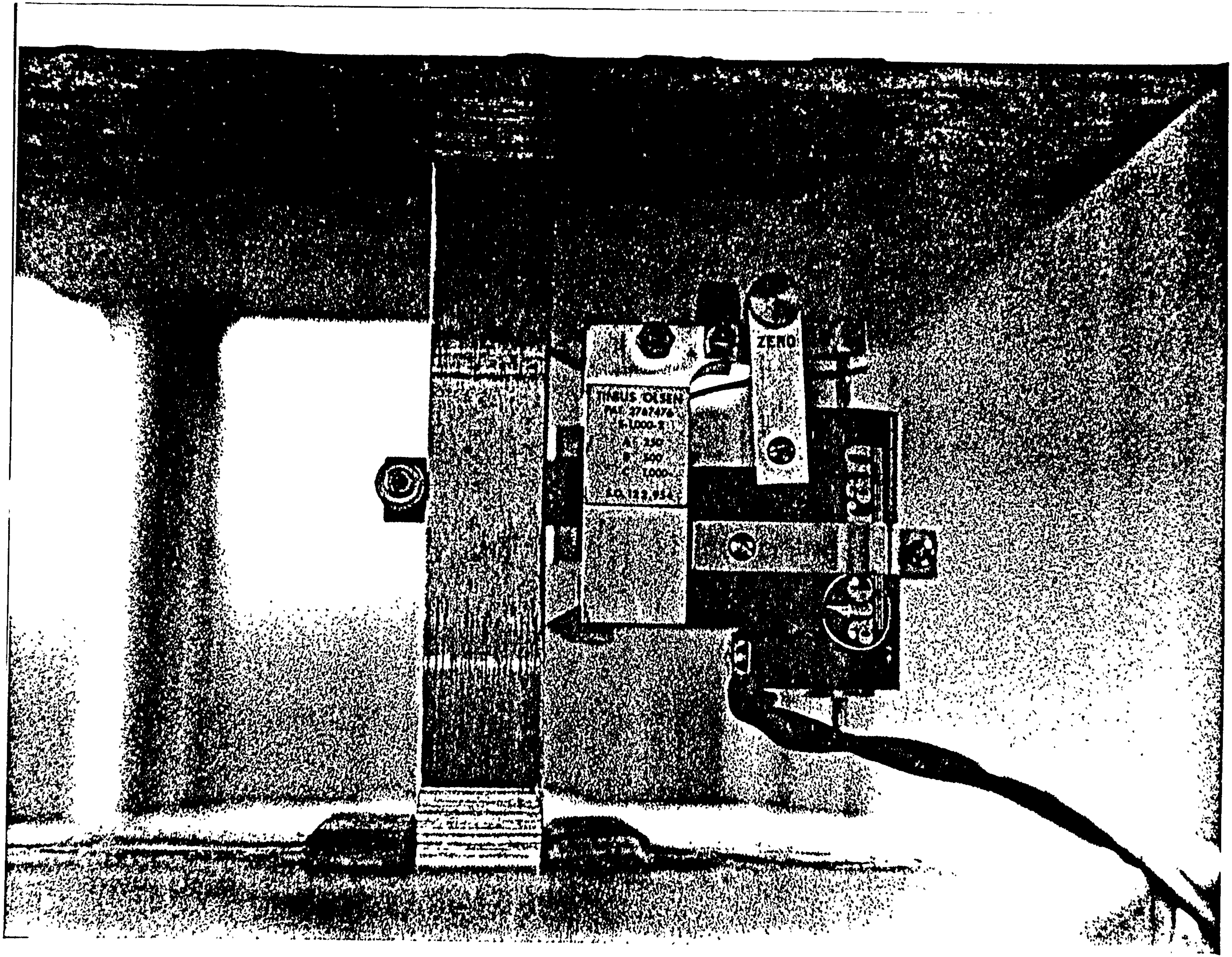

4" Discard
Transverse Tensile
Transverse Tensile
4 Side Bends
Microsection
Spectrographic
Weld Centered Charpys 1-5
H.A.Z. Centered Charpys 6-10
Base Centered Charpys 11-15
All Weld .505
Base Metal .505
3" Discard
Radiographic Test (20" Min.)
30" Length
12.5" Width



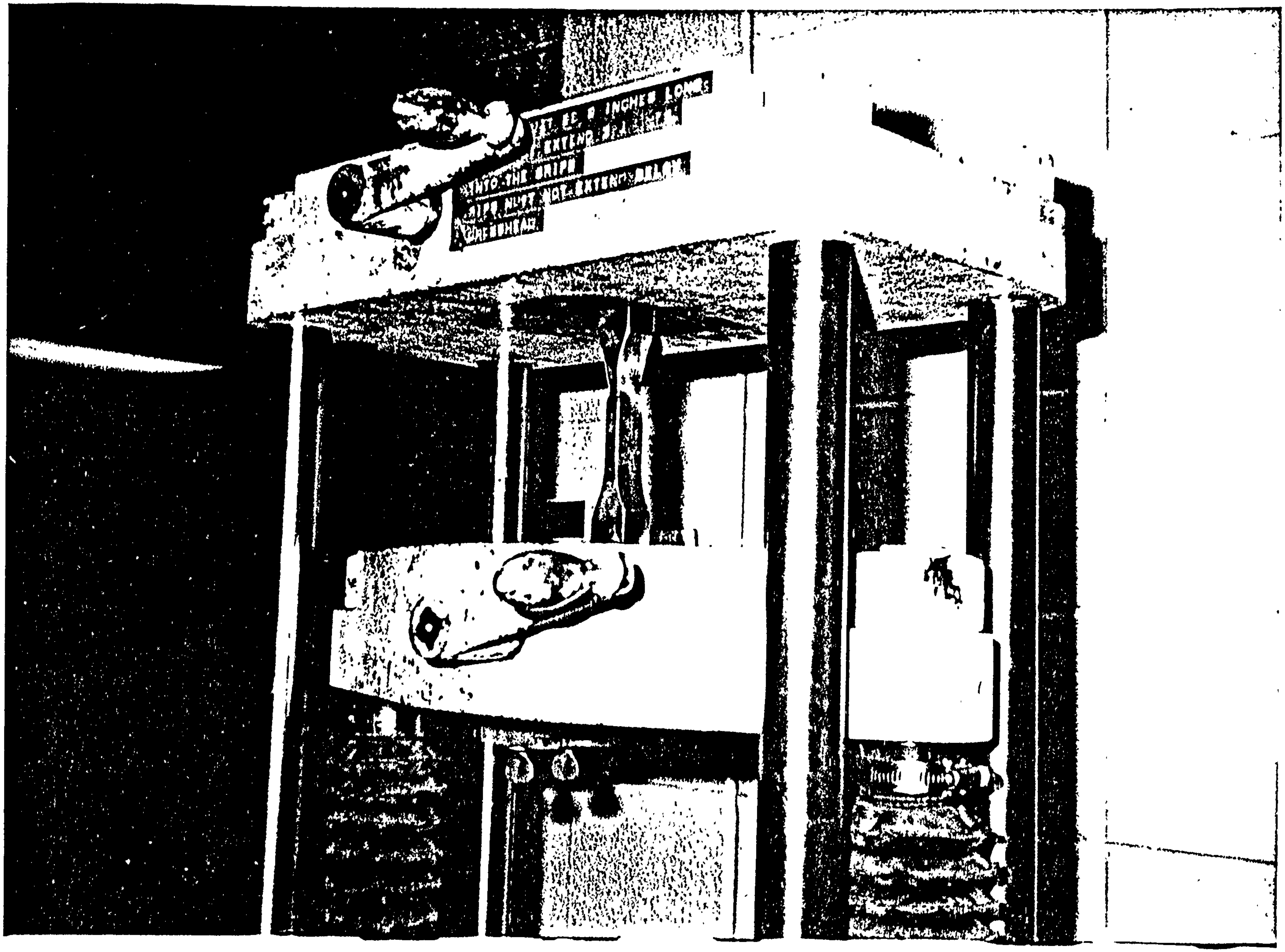
TEST SPECIMENS - 15 CHARPY - 2 TRANS. TENSILE - ALL WELD .505 - BASE .505
MICROSECTION - SPECTROGRAPHIC - 4 SIDE BENDS



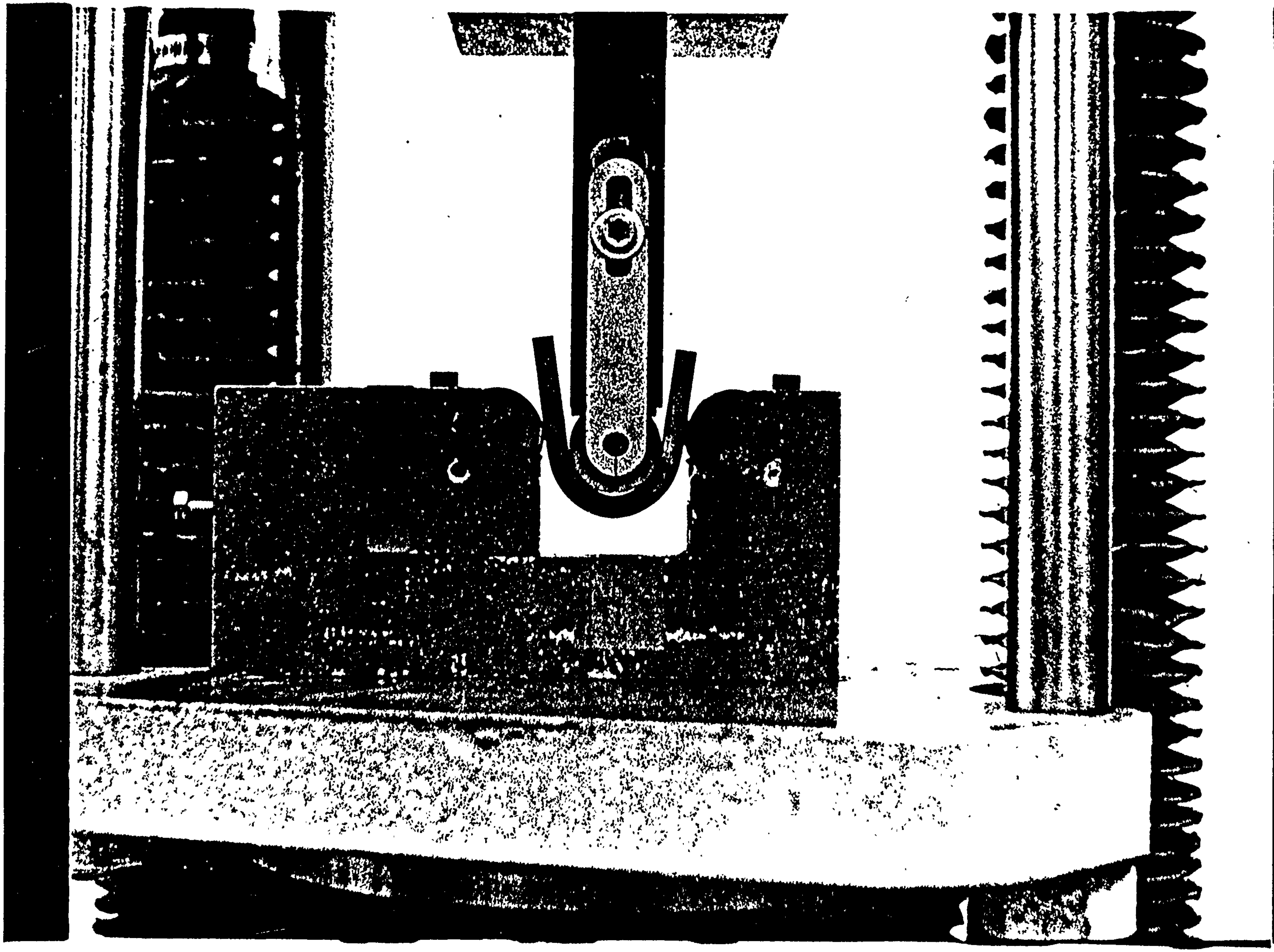
TENSILE TEST IN PROGRESS



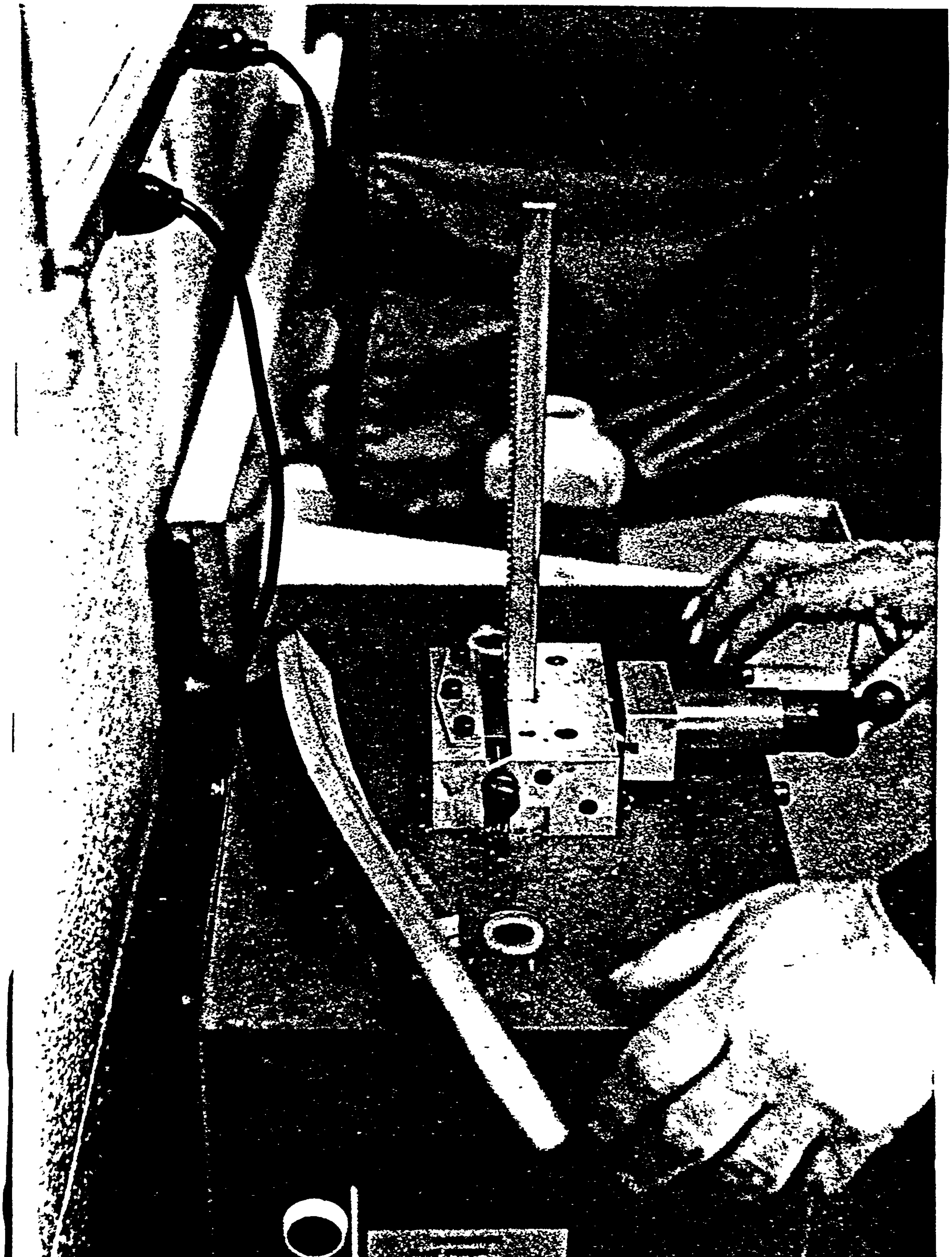
TINIUS OLSEN EXTENSOMETER IN USE TO DETERMINE YIELD POINT



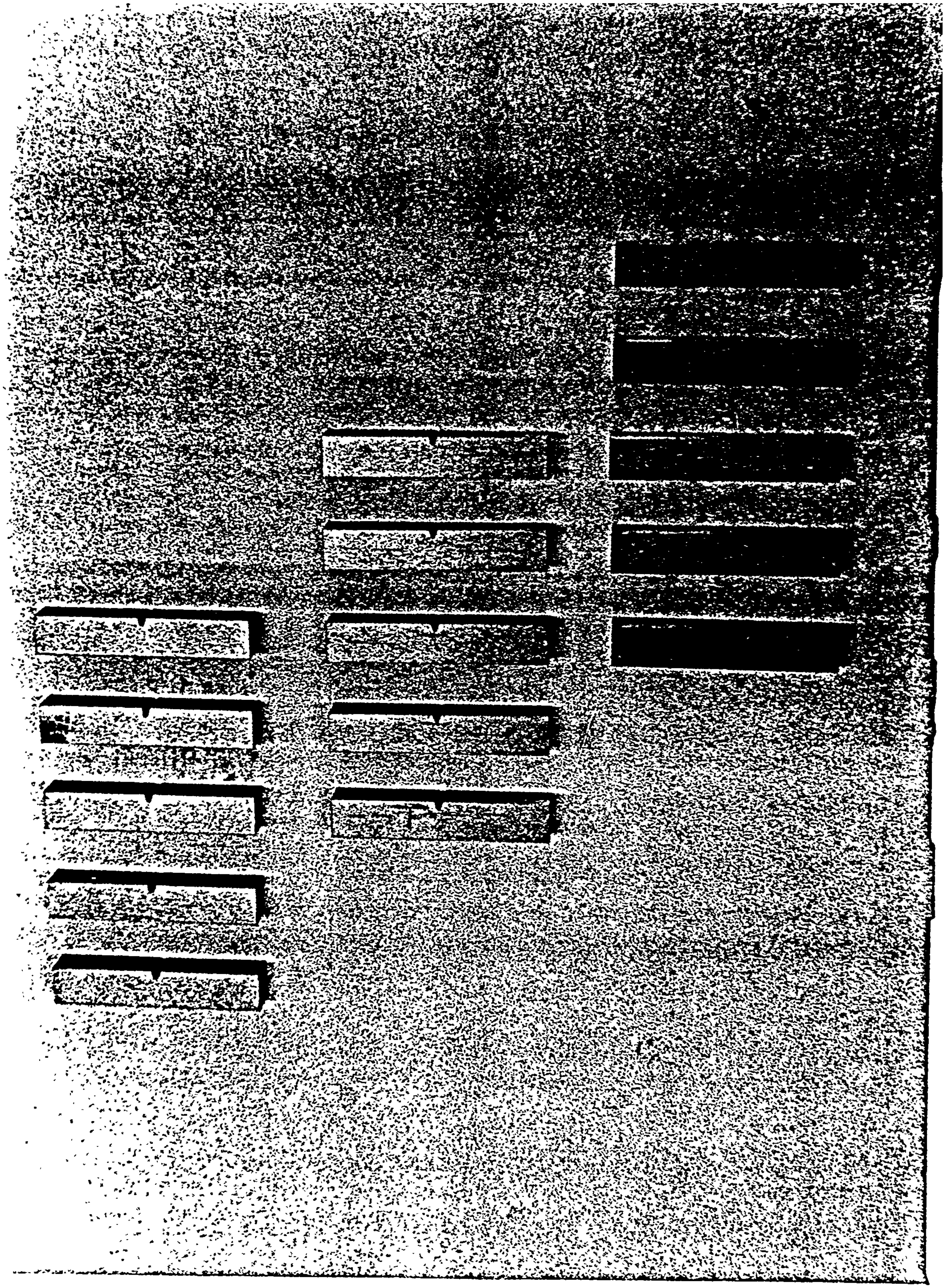
TRANSVERSE TENSILE SPECIMEN AT ULTIMATE LOAD



180° SIDE BEND TEST IN PROGRESS

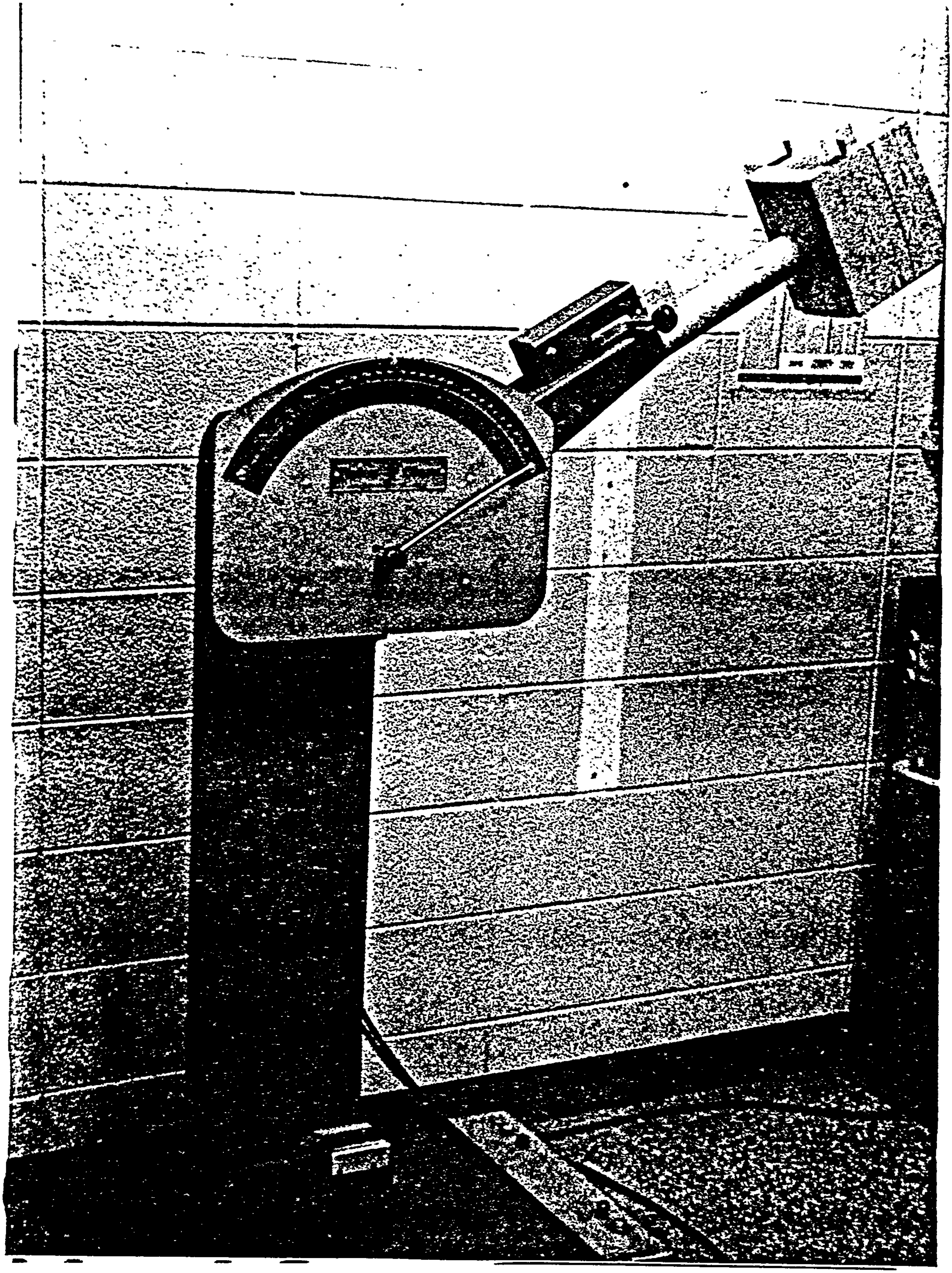


NOTCHING OF CHARPY TEST SPECIMEN

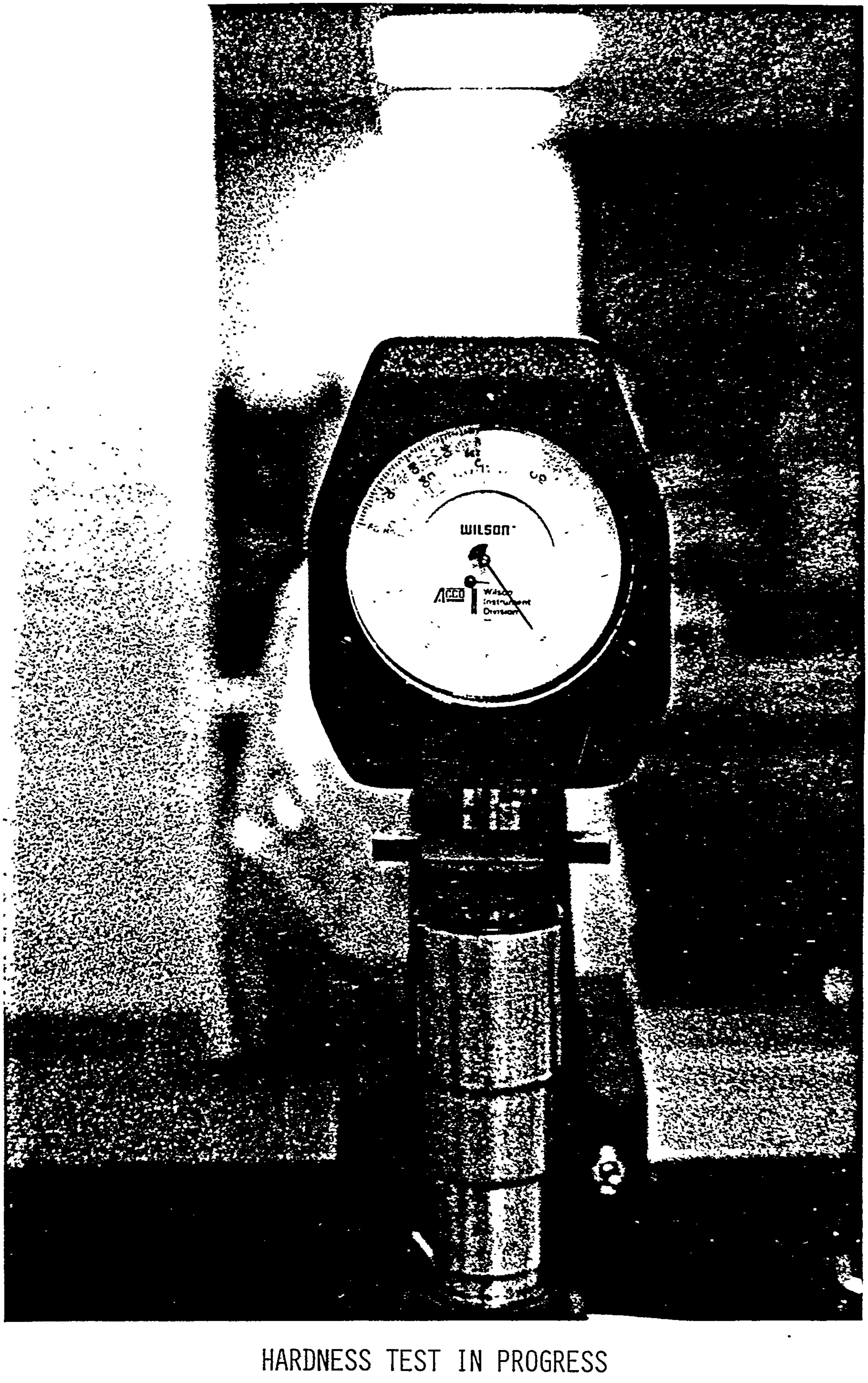


NOTCHED CHARPY TESTS

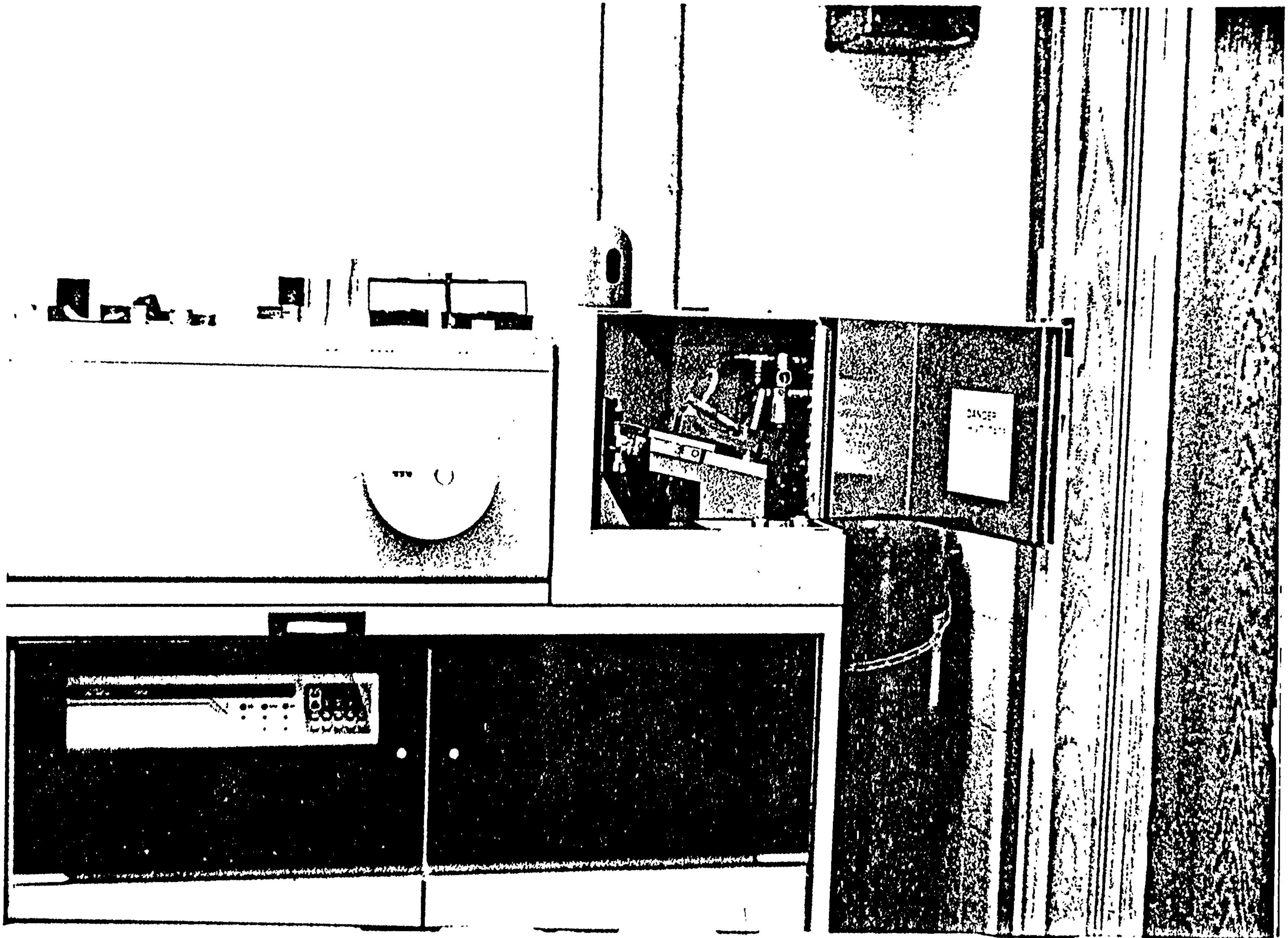
CHARPY SPECIMENS BEING CHILLED TO -60°F



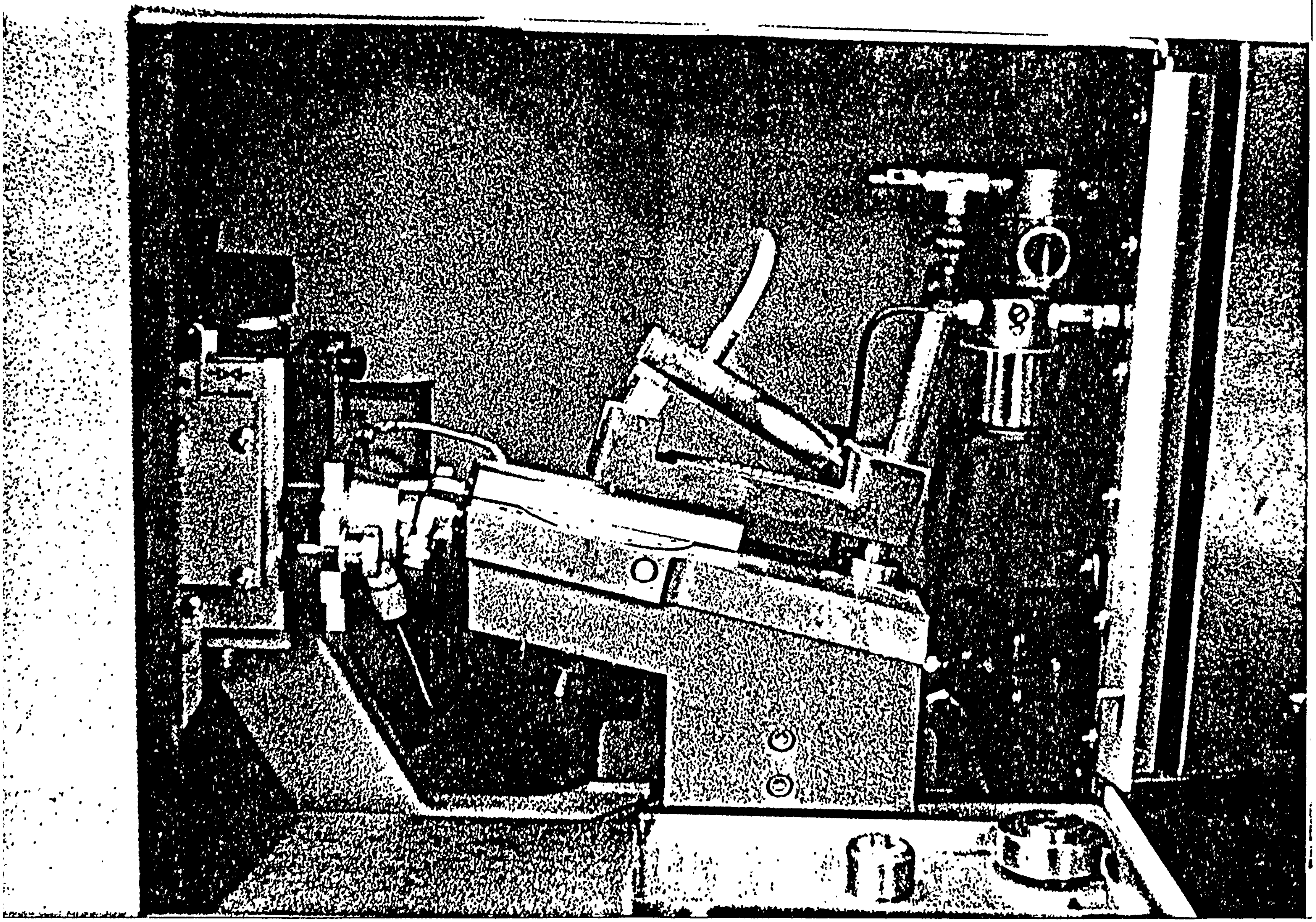
TINIUS OLSEN CHARPY TESTER AFTER FREE SWING DROP



HARDNESS TEST IN PROGRESS



SPECTROGRAPHIC TEST - JARREL ASH MODEL



SPECTROGRAPHIC TEST CHAMBER

Code (EH-6-CS)

Electrode Linde 36

Flux Linde 20

Physical Test Summary

Tensile Test	No.	Yield PSI	Ult. Tensile	%Elong	Fracture Location
Transverse Weld	1	58,008	81,108	17	Base
Transverse Weld	2	56,199	79,776	18	Base
All Weld (.505)		55,500	83,500	32	Weld
Base Plate (.505)		62,871	78,712	26	Base

180° Bend Tests	No.	Result
Trans. Side Bend	1	Passed
Trans. Side Bend	2	Passed
Trans. Side Bend	3	Passed
Trans. Side Bend	4	Passed

Charpy Impact Tests	Weld	H.A.Z.	Base
Average at -40 °F (Ft.Lbs)*	13.1	33.8	103

*Test temperature/A.B.S. rules should have been -22°F. for automatic applications. Lower temperature resulted in lower Charpy Impact Test Values.

Hardness Survey	Weld	H.A.Z.	Base
Average R30N	27.9	38.0	25.7

Spectrographic Deposit Analysis

C	MN	P	S	SI	NI	CR
<.108	.814	.010	.021	.767	.186	<.050

MO	V	CO	W	TI	CU	AL
.026	.007	<.015	.015	<.016	.038	<.016

Note: Actual test data and explanation of test procedures are contained in appendix.

Code (EH 6 FC)

Electrode McKay Speed Alloy 70-S

Flux Linde 80

Physical Test Summary

Tensile Test	No.	Yield PSI	Ult. Tensile	%Elong	Fracture Location
Transverse Weld	1	57,453	86,749	28	Base
Transverse Weld	2	56,352	85,655	28	Base
All Weld (.505)		52,763	83,919	32	Weld
Base Plate (.505)		77,114	92,039	27	Base

180° Bend Tests	No.	Result
Trans. Side Bend	1	Passed
Trans. Side Bend	2	Passed
Trans. Side Bend	3	Passed
Trans. Side Bend	4	Passed

Charpy Impact Tests	Weld	H.A.Z.	Base
Average at -40 °F (Ft.Lbs) *	73.0	106.3	125.3

*ABS Rules Specify -22°F. Test Temperature for automatic applications, -40° for manual applications.

Hardness Survey	Weld	H.A.Z.	Base
Average R30N	37.3	43.8	25.7

Spectrographic Deposit Analysis

C	MN	P	S	SI	NI	CR
.115	1.34	.016	.016	.412	.303	.063
MO	**V**	**CO**	**W**	**TI**	**CU**	**AL**
.029	.024	.015	.028	<.016	<.027	<.016

Note: Actual test data and explanation of test procedures are contained in appendix.

Code (SS L CS)

Electrode Linde 316L

Flux Linde 80

Physical Test Summary

Tensile Test	No.	Yield PSI	Ult. Tensile	%Elong	Fracture Location
Transverse Weld	1	54,602	83,368	22	C.L. Weld
Transverse Weld	2	55,851	86,170	37	C.L. Weld
All Weld (.505)		52,272	87,121	51	Weld
Base Plate (.505)		58,823	85,294	32	Base

180° Bend Tests	No.	Result
Trans. Side Bend	1	Passed
Trans. Side Bend	2	Passed
Trans. Side Bend	3	Passed
Trans. Side Bend	4	Passed

Charpy Impact Tests	Weld	H.A.Z.	Base
Average at ______°F (Ft.Lbs)	N/A		

Hardness Survey	Weld	H.A.Z.	Base
Average R30N	35.6	34.5	26.5

Spectrographic Deposit Analysis

C	MN	P	S	SI	NI	CR
<.039	1.58	.020	.020	.973	12.4	16.9
MO	**V**	**CO**	**W**	**TI**	**CU**	**AL**
2.32	N/A	N/A	N/A	N/A	0	N/A

Note: Actual test data and explanation of test procedures are contained in appendix.

Code (SS L FC)

Electrode McKay Influx 316L G/S

Flux Oerlikon OP-76

Physical Test Summary

Tensile Test	No.	Yield PSI	Ult. Tensile	%Elong	Fracture Location
Transverse Weld	1	56,113	86,131	42	C.L. Weld
Transverse Weld	2	55,963	85,321	38	C.L. Weld
All Weld (.505)		50,000	85,750	53	Weld
Base Plate (.505)		58,750	80,500	41	Base

180° Bend Tests	No.	Result
Trans. Side Bend	1	Passed
Trans. Side Bend	2	Passed
Trans. Side Bend	3	Passed
Trans. Side Bend	4	Passed

Charpy Impact Tests	Weld	H.A.Z.	Base
Average at ______°F (Ft.Lbs)		N/A	

Hardness Survey	Weld	H.A.Z.	Base
Average R30N	35	34.0	26.7

Spectrographic Deposit Analysis

C	MN	P	S	SI	NI	CR
<.039	1.93	.015	.018	.531	13.0	17.8

MO	V	CO	W	TI	CU	AL
2.57	N/A	N/A	N/A	N/A	0	N/A

Note: Actual test data and explanation of test procedures are contained in appendix.

Code (HY8CS)

Electrode Linde 95

Flux Linde 709-5

Physical Test Summary

Tensile Test	No.	Yield PSI	Ult. Tensile	%Elong	Fracture Location
Transverse Weld	1	89,843	111,718	20	Base
Transverse Weld	2	91,324	113,013	21	Base
All Weld (.505)		89,847	109,340	26	Weld
Base Plate (.505)		91,414	109,848	21	Base

180° Bend Tests	No.	Result
Trans. Side Bend	1	Passed
Trans. Side Bend	2	Passed
Trans. Side Bend	3	Passed
Trans. Side Bend	4	Passed

Charpy Impact Tests	Weld	H.A.Z.	Base
Average at -60° °F (Ft.Lbs)	37.0	125.6	138.3

Hardness Survey	Weld	E.A.Z.	Base
Average R30N	43.1	57.75	41.0

Spectrographic Deposit Analysis

C	MN	P	S	SI	NI	CR
<.108	1.06	.012	.009	.418	2.13	.509
MO	V	CO	W	TI	CU	AL
.359	.007	.020	.019	<.016	.030	<.016

Note: Actual test data and explanation of test procedures are contained in appendix.

Code (HY8FC)

Electrode McKay Speed Alloy 90-S

Flux Linde 80

Physical Test Summary

Tensile Test	No.	Yield PSI	Ult. Tensile	%Elong	Fracture Location
Transverse Weld	1	91,379	113,448	24	Base
Transverse Weld	2	89,431	111,818	21	Base
All Weld (.505)		88,190	107,035	26	Weld
Base Plate (.505)		109,848	119,444	20	Base

180° Bend Tests	No.	Result
Trans. Side Bend	1	Passed
Trans. Side Bend	2	Passed
Trans. Side Bend	3	Passed
Trans. Side Bend	4	Passed

Charpy Impact Tests	Weld	H.A.Z.	Base
Average at .60° °F (Ft.Lbs)	48.3	141.0	135.0

Hardness Survey	Weld	H.A.Z.	Base
Average R30N	47	52.5	41.8

Spectrographic Deposit Analysis

C	MN	P	S	SI	NI	CR
<.108	1:18	.016	.018	.382	2.15	.273
MO	V	CO	W	TI	CU	AL
.253	.018	.020	.008	<.016	.047	<.016

Note: Actual test data and explanation of test procedures are contained in appendix.

Code (HY8MC)

Electrode Tri Mark MC 100 S-2

Flux Oerlikon OP121tt(G)

Physical Test Summary

Tensile Test	No.	Yield PSI	Ult. Tensile	%Elong	Fracture Location
Transverse Weld	1	84,600	106,800	25	Base
Transverse Weld	2	86,262	107,777	26	Base
All Weld (.505)		85,786	105,837	29	Weld
Base Plate (.505)		94,191	106,060	25	Base

180° Bend Tests	No.	Result
Trans. Side Bend	1	Passed
Trans. Side Bend	2	Passed
Trans. Side Bend	3	Passed
Trans. Side Bend	4	Passed

Charpy Impact Tests	Weld	H.A.Z.	Base
Average at -60°F (Ft.Lbs)	54.6	141.6	149.3

Hardness Survey	Weld	H.A.Z.	Base
Average R30N	43.3	56.25	41.7

Spectrographic Deposit Analysis

C	MN	P	S	SI	NI	CR
<.108	1.21	.016	.012	.352	2.16	.380

MO	V	CO	W	TI	CU	AL
.240	.016	.021	.018	<.016	<.027	<.016

Note: Actual test data and explanation of test procedures are contained in appendix.

Code (HY8AC)

Electrode Alloy Rods 100S - 1

Flux Oerliknon OP121tt (G)

Physical Test Summary

Tensile Test	No.	Yield PSI	Ult. Tensile	%Elong	Fracture Location
Transverse Weld	1	86,009	96,330	8	C.L. Weld
Transverse Weld	2	80,156	95,179	8	C.L. Weld
All Weld (.505)		88,383	108,585	26	Weld
Base Plate (.505)		82,564	93,589	21	Base

180° Bend Tests	No.	Result
Trans. Side Bend	1	Fractured along Fusion Line
Trans. Side Bend	2	Fractured along Fusion Line
Trans. Side Bend	3	Fractured along Fusion Line
Trans. Side Bend	4	Fractured along Fusion Line

Charpy Impact Tests	Weld	H.A.Z.	Base
Average at -6f °F (Ft.Lbs)	17.6	118.3	145.0

Hardness Survey	Weld	H.A.Z.	Base
Average R30N	35.5	58.0	42.2

Spectrographic Deposit Analysis

C	MN	P	S	SI	NI	CR
<.108	.964	.015	.019	.105	>2.22	.213
MO	V	co	W	TI	CU	AL
.379	.016	.021	.021	<.016	.029	<.016

Note: Actual test data and explanation of test procedures are contained in appendix.

Code (HY 8 AC HHI)

Electrode Alloy Rods 100S-1

Flux Oerlikon OP121tt(G)

Physical Test Summary

Tensile Test	No.	Yield PSI	Ult. Tensile	%Elong	Fracture Location
Transverse Weld	1	80,393	96,270	9	C.L. Weld
Transverse Weld	2	79,016	94,779	9	C.L. Weld
All Weld (.505)		85,678	106,281	27	Weld
Base Plate (.505)		84,079	95,024	19	Base

180° Bend Tests	No.	Result
Trans. Side Bend	1	Fractured at Center of Weld
Trans. Side Bend	2	Fractured along Fusion Line
Trans. Side Bend	3	Fractured at Center of Weld
Trans. Side Bend	4	Fractured at Center and F.L.

Charpy Impact Tests	Weld	H.A.Z.	Base
Average at -60 °F (Ft.Lbs)	15.6	50.3	150.0

Hardness Survey	Weld	H.A.Z.	Base
Average R30N	38.5	56.25	39.0

Spectrographic Deposit Analysis

C	MN	P	S	SI	NI	CR
<.108	.910	.014	.019	.106	> 2.22	.253

MO	V	CO	W	TI	CU	AL
.379	.015	.022	.017	<.016	.031	<.016

Note: Actual test data and explanation of test procedures are contained in appendix.

Code (HY 8 AC-1)

Electrode Alloy Rods 100S-1

Flux Oerlikon OP 121tt(G)

Physical Test Summary

Tensile Test	No.	Yield PSI	Ult. Tensile	%Elong	Fracture Location
Transverse Weld	1	92,602	111,030	19.6	C.L. Weld
Transverse Weld	2	91,428	110,950	23.4	Base
All Weld (.505)		93,216	97,740	8.1	Weld
Base Plate (.505)		86,432	104,010	27.9	Base

180° Bend Tests	No.	Result
Trans. Side Bend	1	Passed
Trans. Side Bend	2	Passed
Trans. Side Bend	3	Passed
Trans. Side Bend	4	Passed

Charpy Impact Tests	Weld	H.A.Z.	Base
Average at -60 °F (Ft.Lbs)	55.6	64.3	143.3

Hardness Survey	Weld	H.A.Z.	Base
Average R30N	45.7	56.5	40.0

Spectrographic Deposit Analysis

C	MN	P	S	SI	NI	CR
<.108	1.65	.013	.011	.270	>2.22	.491

MO	V	CO	W	TI	CU	AL
.432	.013	<.015	<.008	<.016	.029	.016

Note: Actual test data and explanation of test procedures are contained in appendix.

Code (HY 8 AC HHI-1)

Electrode AlloY Rods 100S-1

Flux Oerlikon OP121 tt(G)

Physical Test summary

Tensile Test	No.	yield PSI	Ult. Tensile	%Elong	Fracture Location
Transverse Weld	1	85,075	107,970	23,4	C.L. Weld
Transverse Weld	2	84,661	108,570	20.3	C-L. Weld
All Weld (.505)		83,100	110,330	25.0	Weld
Base Plate (.505)		89,800	108,160	28.0	Base

180° Bend Tests	No.	Result
Trans. Side Bend	1	Passed
Trans. Side Bend	2	passed
Trans. Side Bend	3	Passed
Trans. Side Bend	4	Passed

Charpy Impact Tests	Weld	H.A.z.	Base
Average at -60° °F (Ft.Lbs)	32.6	141.0	85.3

Hardness Survey	Weld	H.A.z.	Base
Average R30N	41.5	55	40.5

Spectrographic Deposit Analysis

C	MN	P	S	SI	NI	CR
<.108	1.26	.019	.012	.250	>2.22	.397
MO	**V**	**CO**	**W**	**TI**	**CU**	**AL**
.355	.014	<.015	.010	<.016	.040	<.016

Note: Actual test data and explanation of test procedures are contained in appendix.

code(HY O CS)

Electrode Linde 120

Flux Linde 709-5

Physical Test Summary

Tensile Test	No.	Yield PSI	Ult. Tensile	%Elong	Fracture Location
Transverse Weld	1	103,954	123,587	21	Base
Transverse Weld	2	102,435	118,194	NA*	C.L. Weld
*Retest	3	104,225	123,802	17	Base
All Weld (.505)		111,940	123,383	22	Weld
Base Plate (.505)	1	105,000	126,000	18.5	Base

180° Bend Tests	No.	Result
Trans. Side Bend	1	Passed
Trans. Side Bend	2	Passed
Trans. Side Bend	3	Passed
Trans. Side Bend	4	Passed

Charpy Impact Tests	Weld	H.A.Z.	Base
Average at -60 °F (Ft.Lbs)	38*	123.3	129

*Linde has developed a new flux (651-VF) to meet Charpy impact requirements of 45 ft. lbs. @ -60°F to have it included on the U.S. Navy Quality Products List (QPL).

Hardness Survey	Weld	H.A.Z.	Base
Average R30N	48.72	57.75	45.8

Spactrographic Deposit Analysis

C	MN	P	S	SI	NI	CR
<.108	1.16	.020	.012	.431	>2.22	.599
MO	**V**	**CO**	**W**	**TI**	**CU**	**AL**
.440	.007	.063	.019	<.016	.033	<.016

Note: Actual test data and explanation of test procedures are contained in appendix.

Code (HY-0 FC)

Electrode McKay Speed Alloy 110-S

Flux Linde 80

Physical Test Summary

Tensile Test	No.	Yield PSI	Ult. Tensile	%Elong	Fracture Location
Transverse Weld	1	103,879	125.431	19	Base
Transverse Weld	2	106,388	123,611	19	Base
All Weld (.505)		113,451	124,365	24	Weld
Base Plate (.505)		124,875	135,074	18	Base

180° Bend Tests	No.	Result
Trans. Side Bend	1	Passed
Trans. Side Bend	2	Fractured at Corner N/A - Retest*
Trans. Side Bend	3	Passed
Trans. Side Bend	4	Fractured - L.O.F. in Root - Retest*

*4 Sidebends Retested - All Passed

Charpy Impact Tests	Weld	H.A.Z.	Base
Average at -60 °F (Ft.Lbs)	24.6	121.6	129.6

Hardness Survey	Weld	H.A.Z.	Base
Average R30N	52.5	56.0	46.3

Spectrographic Deposit Analysis

C	MN	P	S	SI	NI	CR
<.108	>1.65	.023	.020	.409	>2.22	.363
MO	**V**	**CO**	**W**	**TI**	**CU**	**AL**
.441	.022	.024	.019	<.016	.042	<.016

Note: Actual test data and explanation of test procedures are contained in appendix.

Code (HY 0 AC)

Electrode Alloy Rods Mil-120S-1

Flux Oerlikon OP121tt(G)

Physical Test Summary

Tensile Test	No.	Yield PSI	Ult. Tensile	%Elong	Fracture Location
Transverse Weld	1	102,702	123,198	21	Base
Transverse Weld	2	110,011	122,022	23	Base
All Weld (.505)		109,547	122,864	22	Weld
Base Plate (.505)		105,500	124,000	21	Base

180° Bend Tests	No.	Result
Trans. Side Bend	1	Passed
Trans. Side Bend	2	Fractured along Fusion Line
Trans. Side Bend	3	Fractured along Fusion Line
Trans. Side Bend	4	Passed

Charpy Impact Tests	Weld	H.A.Z.	Base
Average at -60 °F (Ft.Lbs)	37.0	106.0	137.6

Hardness Survey	Weld	H.A.Z.	Base
Average R30N	47.0	54.0	45.8

Spectrographic Deposit Analysis

C	MN	P	S	SI	NI	CR
<.108	>1.65	.021	.013	.261	>2.22	.567
MO	**V**	**CO**	**W**	**TI**	**CU**	**AL**
.434	.016	.028	.032	<.016	.034	.019

Note: Actual test data and explanation of test procedures are contained in appendix.

Code (HY 0 AC-1)

Electrode Alloy Rods 120S-1

Flux Oerlikon OP 121tt(G)

Physical Test Summary

Tensile Test	No.	Yield PSI	Ult. Tensile	%Elong	Fracture Location
Transverse Weld	1	102,974	123,650	19.9	C.L. Weld
Transverse Weld	2	104,166	122,930	20.9	C.L. Weld
All Weld (.505)		105,223	122,840	21,5	Weld
Base Plate (.505)		114,141	124,050	22.0	Base

180° Bend Tests	No.	Result
Trans. Side Bend	1	Passed
Trans. Side Bend	2	Passed
Trans. Side Bend	3	Passed
Trans. Side Bend	4	Passed

Charpy Impact Tests	Weld	H.A.Z.	Base
Average at -60 °F (Ft.Lbs)	55	57.6	130.6 (Ft.lbs)

Hardness Survey	Weld	H.A.Z.	Base
Average R30N	47.5	53.0	43.0

Spectrographic Deposit Analysis

C	MN	P	S	SI	NI	CR
<.108	>1.65	.013	.011	.270	>2.22	.491

MO	V	CO	W	TI	CU	AL
432	.013	<.015	<.008	<.016	.029	.016

Note: Actual test data and explanation of test procedures are contained in appendix.

SECTION 13

EVALUATION OF TEST RESULTS

* See Footnote

*FOOTNOTE

Due to the late arrival of the "AC" reformulated electrode and project schedule restraints, an equal number of photomicrographs were not produced for test samples HY-8-AC-1, HY-8-AC-HHI-1 and HY-0-AC-1. A limited number of photomicrographs were produced and evaluated in the Anderson Laboratories Reports on the above weld test samples.

July 31, 1985

Bay Shipbuilding Corp.   B023
605 North 3rd Ave.
Sturgeon Bay, WI 54235-2324
Attn: Mr. Bruce Halverson

Dear Mr. Halverson:

we have completed our evaluation of the weld samples identified as EH6CS and EH6FC submitted to us on your Job #3205-204. The objective of this investigation was to compare the inclusion level in the weld filler material, the heat affected zone (HAZ) and the level of segregation in the weld filler material of the two samples.

A metallographic examination was conducted on two transverse sections (with respect to the length of the weld seam) of approximately one square centimeter in area removed from each of the samples. One section contained filler metal, HAZ and base material from an area near the middle of the plate. The other section contained only filler metal.

An inclusion rating was then conducted on the sections of weld filler metal. The inclusion rating per ASTM E45 method A (worst field reported) was limited to the D category (globular oxides) of inclusion-because of the morphology of the inclusions found in the welds. The inclusion rating for sample EH6CS was D1 heavy and D4 thin (see Photograph #l) and the inclusion rating for sample EH6FC was DO heavy and D2 thin (see photograph +2).

An examination of the etched sections of both samples revealed that the filler metal of the HY6CS sample (see photograph #3) exhibited less severe segregation than the filler metal of the EH6FC sample (see photograph #4). The HAZ of the welds were then examined and no significant metallurgical defects were found. The width of the HAZ of the welds was then estimated by taking ten readings along lines normal to the tangent of the base metal/filler metal interface. The results of these measurements are as follows:

Sample EH6CS-
.06, .06, .06, .05, .06, .05, .06, .06, .06, .06 in.
Average: .06 in.

Sample EH6FC-
.06, .05, .06, .06, .06, .06, .06, .05, .05, .06 in.
Average: .06 in.

CONCLUSION:

Neither of the samples exhibited any significant metallurgical defects in the HAZ's. Sample EH6CS had a higher level of inclusions than sample EH6FC. However, sample EH6CS exhibited less severe segregation in the weld filler metal than sample EH6FC. The width of the HAZ's of both samples were found to be similar.

Very truly yours,

ANDERSON LABORATORIES, INC.

Ralph B. Meyer

Ralph B. Meyer, Manager

RBM/trs
M5-562

July 31, 1985

Bay Shipbuilding Corp. B023
605 North 3rd Ave.
Sturgeon Bay, WI 54235-2324
Attn: Mr. Bruce Halverson

Dear Mr. Halverson:

We have completed our evaluation of the weld samples identified as SSLCS and SSLFC submitted to us on your Job #3205-204. The objective of this report is to compare the inclusion level in the weld filler material, the heat affected zone (HAZ) and the level of segregation in the weld filler material of the two samples.

A metallographic examination was conducted on two transverse sections (with respect to the length of the weld seam), approximately one square centimeter in area, removed from each of the samples. One section contained filler metal, HAZ and base material from an area near the middle of the plate. The other section contained only filler metal.

An inclusion rating was then conducted on the sections of weld filler metal. The inclusion rating per ASTM E45 method A (worst field reported) was limited to the D category (globular oxides) of inclusion because of the morphology of the inclusions found in the welds. The inclusion rating for sample SSLCS was D2 heavy and D4 thin (see photograph #l) and the inclusion rating for sample SSLFC was DO heavy and D1 thin (see photograph #2).

An examination of the etched sections of both samples revealed that the filler metal of the SSLCS sample (see photograph #3) exhibited large islands of segregated material while smaller islands of segregated material were observed in the filler metal of the SSLFC sample (see photograph #4). The HAZ of the welds were then examined and no significant metallurgical defects were found. The width of the HAZ of the welds was then estimated by taking ten readings along lines normal to the tangent of the base metal/filler metal interface. The results of these measurements are as follows:

SSLCS sample-
.011, .012, .014, .024, .026, .019, .015, .009,
.015, .014 in. Average: .016 in.

SSLFC sample-
.006, .011, .014, .005, .012, .008, .007, .015, .005, .006 in.   Average: .009 in.

CONCLUSION:

Neither of the two samples exhibited any significant metallurgical defects in the heat affected zones. Sample SSLCS exhibited a significantly higher level of inclusions than sample SSLFC and also exhibited larger islands of segregation in the filler material. The width of the HAZ of sample SSLCS was considerably greater than that found in sample SSLFC.

Very truly yours,

ANDERSON LABORATORIES, INC.

Ralph B. Meyer

Ralph B. Meyer, Manager

RBM/trs
M5-562

July 30, 1985

Bay Shipbuilding Corp. B023
605 North 3rd Ave.
Sturgeon Bay, WI 54235-2324
Attn Mr. Bruce Halverson

Dear Mr. Halverson:

We have completed our evaluation of the weld samples identified as HY8CS, HY8AC1, HY8MC, HY8AC, HY8FC, HY8HHI1 and HY8ACHHI recently submitted to us (Reference Job #3205-204). The objective of this investigation was to compare the inclusion level in the weld filler material, the heat affected zone (HAZ) and the level of segregation in the weld filler material of the samples.

A metallographic examination was conducted on two transverse sections (with respect to the length of the weld seam) of approximately one square centimeter in area removed from each of the samples. One section contained filler metal, HAZ and base material from an area near the middle of the plate. The other section contained only filler metal.

An inclusion rating was then conducted on the sections of weld filler metal. The inclusion rating per ASTM E45 method A (worst field reported) was limited to the D category (globular oxides) of inclusion because of the morphology of the inclusions found in the welds. All samples except HY8AC and HY8ACHHI exhibited levels of inclusions lower than or equal to 1 (see photographs #l, #2, #3, #6 and #7). The samples which exhibited low levels of inclusions did exhibit relatively uniformly distributed small inclusions which were resolvable at magnifications of 400 diameters or greater. Samples HY8AC1, HY8MC, HY8Fc and HY8HHI1 exhibited marginally lower concentrations of small inclusions than sample HY8CS. The inclusion rating of sample HY8AC was D2 heavy and D2 thin (see photograph #4). The HY8AC sample also contained one large inclusion which was probably slag (see photograph #5). The inclusion rating of sample HY8ACHHI was D2 heavy and D3 thin (see photograph #8).

An examination of the etched sections revealed that the segregation in the filler metals of samples HY8AC, HY8HHI1 and HY8ACHHI was less severe than that found in sample HY8CS (see photographs #9, #10, #11 and #12). Samples HY8AC1, HY8BK2 and HY8FC exhibited segregation in the weld filler metal which was similar to that found in sample HY8CS. The HAZ of the welds were then examined and no significant metallurgical defects were found. The width of the HAZ of the welds was then estimated by taking ten readings along lines normal to the tangent of the base metal/filler metal interface. The results of these measurements are as follows:

Sample HY8CS-
.09, .09, .10, .09, .08, .07, .06, .08, .09, .10 in.
Average: .09 in.

Sample HY8AC1-
.12, .10, .09, .09, .08, .08, .07, .07, .06, .06 in.
Average: .08 in.

Sample HY8MC-
.13, .12, .12, .10, .10, .08, .07, .06, .06, .05 in.
Average: .09 in.

Sample HY8AC-
.08, .07, .07, .07, .07, .10, .11, .11, .12, .12 in.
Average: .09 in.

Sample HY8FC-
.08, .08, .07, .08, .07, .06, .06, .06, ,.09, .08 in.
Average: .07 in.

Sample HY8HHI1-
.16, .12, .12, .13, .13, .14, .15, .15, .14, .13 in.
Average: .14 in.

Sample HY8ACHHI-
.08, .09, .10, .10, .09, .08, .09, .08, .09, .11 in.
Average: .09 in.

SUMMARY : The following table is a comparison of the inclusion level, segregation and width of HAZ'S of samples HY8AC! HY*MC, HY*AC, HY*FC, HY*HHIl and HY8ACHHI to sample HY8CS.

Sample ID	Inclusion level	Segregation of weld	Width of HAZ
HY8CS	---------	--------	.09 in.
HY8AC1	Marginally cleaner	Equal	.08 in.
HY8MC	Marginally cleaner	Equal	.09 in.
HY8AC	Dirtier	Less	.09 in-.
HY8FC	Marginally cleaner	Equal	.07 in.
HY8HHI1	Marginally cleaner	Less	.14 in.
HY8ACHHI	Dirtier	Less	.09 in.

Conclusion:

None of the samples exhibited any significant metallurgical defects in the HAZ. Samples HY8AC and HY8ACHHI exhibited inclusion levels which were greater than sample HY8CS while the remainder of the samples exhibited inclusion levels which were marginally lower than that found in sample HY8CS. The severity of the segregation found in the filler material of samples HY8AC, HY8HHIl an HY8ACHHI was less than the segregation found in sample HY8CS and the remainder of the samples exhibited segregation similar to that found in sample HY8CS. The widths of the HAZ'S of samples HY8ACL and HY8FC were smaller than sample HY8CS while the the width of the HAZ of sample HY8HHIl was larger. The other samples had widths similar to sample HY8CS.

Very truly yours,

ANDERSON LABORATORIES, INC.

Ralph B. Meyer

Ralph B. Meyer, Manager

RBM/trs
M5-562

July 31, 1985

Bay Shipbuilding Corp. B023
605 North 3rd Ave.
Sturgeon Bay, WI 54235-2324
Attn: Mr. Bruce Halverson

Dear Mr. Halverson:

We have completed our evaluation of the weld samples identified as HYOCS, HYOAC, HYOAC1, and HYOFC submitted to us on your Job #3205-204. The objective of this investigation was to compare the inclusion level in the weld filler material, the heat affected zone (HAZ) and the level of segregation in the weld filler material of the samples.

A metallographic examination was conducted on two transverse sections (with respect to the length of the weld seam) approximately one square centimeter in area removed from each of the samples. One section contained filler metal, HAZ and base material from an area near the middle of the plate. The other section contained only filler metal.

An inclusion rating was then conducted on the sections of weld filler metal. The inclusion rating per ASTM E45 method A was limited to the D category (globular oxides) of inclusions because of the morphology of the inclusions found in the samples. All of the samples exhibited an inclusion level less than or equal to 1. All of the samples exhibited relatively uniform concentrations of small inclusions which were resolvable at a magnification of 400 diameters or greater (see photographs #1, #2, #3 and #4). Samples HYOAC and HYOAC1 exhibited a lower concentration of small inclusions than sample HYOCS while sample HYOFC exhibited a similar concentration of small inclusions when compared to sample HYOCS.

An examination of the etched sections of the samples revealed that the degree of segregation in the weld filler metal of all of the samples was similar. The HAZ'S of the welds were then examined and no significant metallurgical defects were found. The width of the HAZ'S of the welds was then estimated by taking ten readings along lines normal to the tangent of the base metal/filler metal interface. The results of these measurements are as follows:

HYOCS sample-
.08, .06, .07, .07, .08, .07, .09, .07, .07, .09 in.
Average: .08 in.

HYOAC sample-
.10, .10, .10, .07, .06, .06, .06, .07, .07, .08 in.
Average: .08 in.

HYOAC1 sample-
.14, .15, .13, .13, .13, .12, .13, .13, .13, .13 in.
Average: .13 in.

HYOFC sample-
.07, .08, .10, .11, .07, .06, .06, .06, .07, .08 in.
Average: .08 in.

CONCLUSION:

All of the samples exhibited low inclusion levels when rated per ASTM E45. However, samples HYOAC and HYOAC1 exhibited marginally lower concentrations of small inclusions than sample HYOCS while sample HYOFC exhibited approximately the same concentration of small inclusions as sample HYOCS. The severity of segregation in the weld filler metals present in all of the samples was also found to be similar. No significant metallurgical defects were found in the HAZ of any of the samples and the width of the HAZ'S of all samples except HYOAC1 were found to be similar. The width of the HAZ of sample HYOAC1 was found to be greater than sample HYOCS.

Very truly yours,

ANDERSON LABORATORIES, INC.

Ralph B. Meyer

Ralph B. Meyer, Manager

RBM/trs
M5-562

CONCLUSIONS

The following is a comparison of operating characteristics between solid electrodes and the new family of flux core - metal core electrodes designed for submerged arc welding:

The flux core type electrodes investigated in this project demonstrated several areas of improvement related to ease of operation. Flux core electrode types were easier to cut to renew the electrode end prior to starting a weld. This was particularlY true in regard to the higher strength electrodes. The high strength solid electrodes are a problem to cut using bolt cutters and if proper care is not used in this operation, the electrode may be dislodged from the contact tine inside the submerged arc welding head. When the above condition exists, an attempt to restart the arc results in no contact, thus no arc start: or accidental contact inside of the head, destroying the tine. Destruction of the contact tine usually results in an erratic short arc initiation and the introduction of foreign material from the tine being introduced into the weld puddle, thus causing a serious weld defect. Failure of the arc to initiate on contact with the work piece can also result in mis-alignment of the electrode in relation to the desired arc path, thus resulting in poor weld bead placement. This can be particularly damaging to weld quality in multipass welds of long duration.

Another improvement noted in using the flux core electrode is arc initiation. Arc initiation is exceptionally smooth and consistent; during the life of this project the flux core type electrode far out-performed the solid electrodes in this respect. Formultipass welds on heavy steel plate this ease of starting is extremely important. Again weld bead placement, due to the nature of the process, is obscured from the operator’s view until the solidified flux can be removed from the weld deposit. If the arc initiation is poor or causes the welding head to be pushed off the joint, the operator will not be able to correct this misalignment until he has deposited 12″ to 18″ inches of weld. Poor arc starting is responsible for many submerged arc welding defects that can be extremely costly to repair.

The flux core type electrodes, because of their design, are much easier to straighten prior to entry into the weld pool. The cast and helix of solid spooled sub arc electrode influences the amount of pressure required to straighten the electrode prior to welding. The cast and helix of solid sub arc wires does change significantly between the top layers on a spool and the bottom layers. This change, particularly on higher strength solid electrodes will cause the electrode to change the location of the weld pool. This change can be significant in width in relation to the weld bead placement. The obvious advantage of the flux core type electrodes is the relative ease of straightening due to the lower columnar strength of the electrode sheath. In this investigation we found that repeatable control of the electrode location, in maintaining alignment on straight multipass welds, was excellent with the flux core type electrodes.

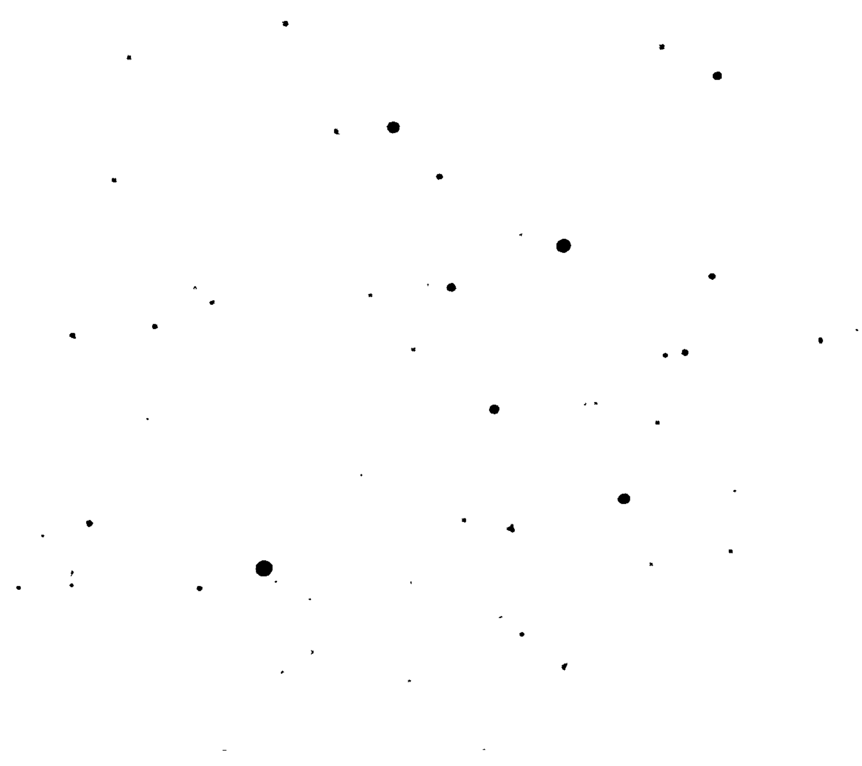
In regard to horizontal fillet welding with the flux core electrodes, our investigation showed better arc initiation and a more uniform fillet bead shape. The fillet welds were produced using a “Lincoln Electric Co.” hand held submerged arc welding package. The fillet weld cross-sectional etched samples proved that the solid sub arc electrodes produce a much deeper penetration at the root of the weld faying surfaces. The flux core electrodes do not have the deep penetrating capability of the solid electrodes; however both types produce satisfactory root penetration. The fillet weld break tests indicated that the flux core electrodes produce fillet welds that exhibit less porosity in the root of the weld than the solid electrodes. Producing fillet welds over mill scale or primed plate (weld through primers) indicated that the flux core electrodes and the solid electrodes will not tolerate excessive mill scale or uncontrolled amounts of primer on the faying surfaces to be joined. Weld through primers cannot exceed a combined thickness of over 2 roils on faying surfaces without serious porosity developing in the root of the weld and also porosity that is visible on the surface of the fillet welds. Mill scale is not as devastating to weld quality in fillet welds as compared to excessive weld through primer when millage of the primer thickness is not scrupulously controlled.

MARAD 3205 PROGRAM - DEPOSITION/EFFICIENCY RESULTS

Plate Code	Dep/Eff @ 350 Amps	Dep/Eff @ 500 Amps
A.B.S EH-36		
EH-6-CS	6.02 lbs.hr/91.66%	12.21 lbs.hr/96.73%
EH-6-FC	5.54 lbs.hr/76.92%	13.58 lbs.hr/94.28%
316L STAINLESS		
SS-L-CS	9.63 lbs.hr/89.42%	--------------
SS-L-FC	12.11 lbs.hr/100%	--------------
HY-80		
HY-8-CS	7.60 lbs.hr/85.71%	13.12 lbs.hr/97.10%
HY-8-FC	6.85 lbs.hr/84.61%	14.70 lbs.hr/95.34%
HY-8-MC	9.37 lbs.hr/83.33%	13.84 lbs.hr/96.00%
HY-8-AC	9.04 lbs.hr/93.75%	15.95 lbs.hr/96.62%
*HY-8-AC-1	6.90 lbs.hr/92.30%	17.08 lbs.hr/97.67%
HY-100		
HY-0-CS	7.50 lbs.hr/92.30%	13.15 lbs.hr/100%
HY-0-FC	7.50 lbs.hr/92.30%	13.27 lbs.hr/96.10%
HY-0-AC	7.31 lbs.hr/92.85%	16.54 lbs.hr/97.56%
*HY-0-AC-1	7.77 lbs.hr/93.33%	19.46 lbs.hr/97.89%

* Reformulation

Bay Shipbuilding Corp.
Sample SSLCS
Photograph #1



M5-562-1 Magnification: 100 Diameters Etch: None

The photomicrograph shows the worst area of inclusions found in the weld filler metal of the sample.

Bay Shipbuilding Corp.
Sample SSLFC
Photograph #2

M5-562-2 Magnification: 100 Diameters Etch: None

The photomicrograph shows the worst area of inclusions found in the weld filler metal of the sample.

Bay Shipbuilding Corp.
Sample SSLCS
Photograph #3

M5-562-1   Magnification: 12.5 Diameters   Etch: 10% Oxalic electrolytic

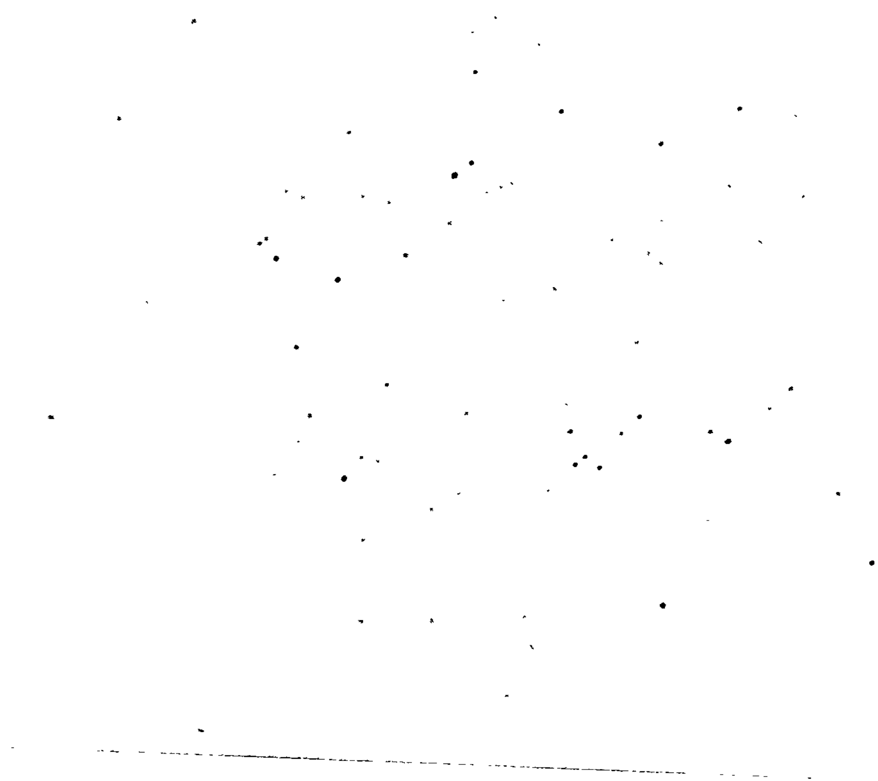
The photomacrograph shows the typical structure found in the weld filler metal.

Bay Shipbuilding Corp.
Sample SSLFC
Photograph #4

M5-562-2 Magnification: 12.5 Diameters Etch: 10% Oxalic electrolytic

The photomacrograph shows the typical structure found in the weld filler metal.

Bay Shipbuilding Corp.
Sample HYOCS
Photograph #1



M5-562-3 Magnification: 400 Diameters Etch: None

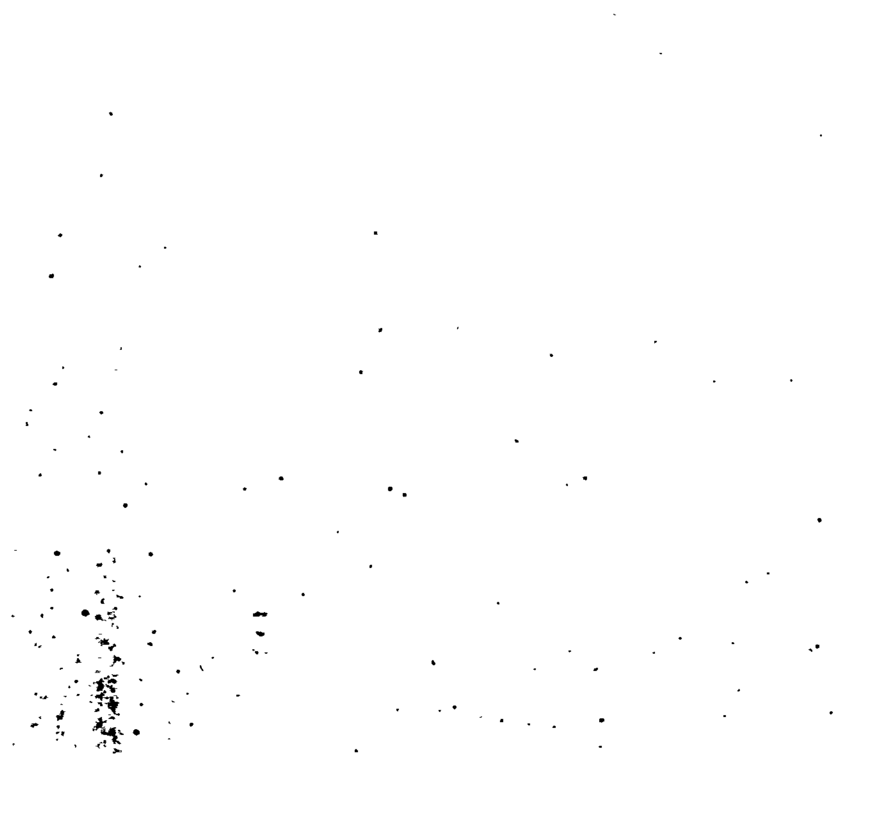
The photomicrograph shows the typical level of small inclusions found in the sample.

Bay Shipbuilding Corp.
Sample HYOAC
Photograph #2

M5-562-4 Magnification: 400 Diameters Etch: None

The photomicrograph shows the typical level of small inclusions found in the sample.

Bay Shipbuilding Corp.
Sample HYOAC1
Photograph #3



M5-562-5 Magnification: 400 Diameters Etch: None

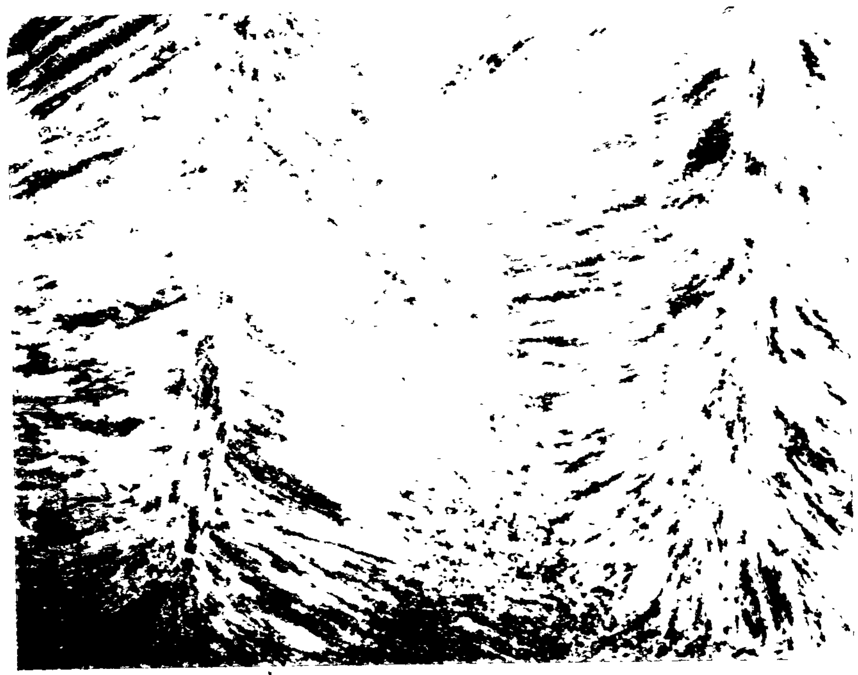
The photomicrograph shows the typical level of small inclusions found in the sample.

Bay Shipbuilding Corp.
Sample HYOFC
Photograph #4

M5-562-6 Magnification: 400 Diameters Etch: None

The photomicrograph shows the typical level of small inclusions found in the sample.

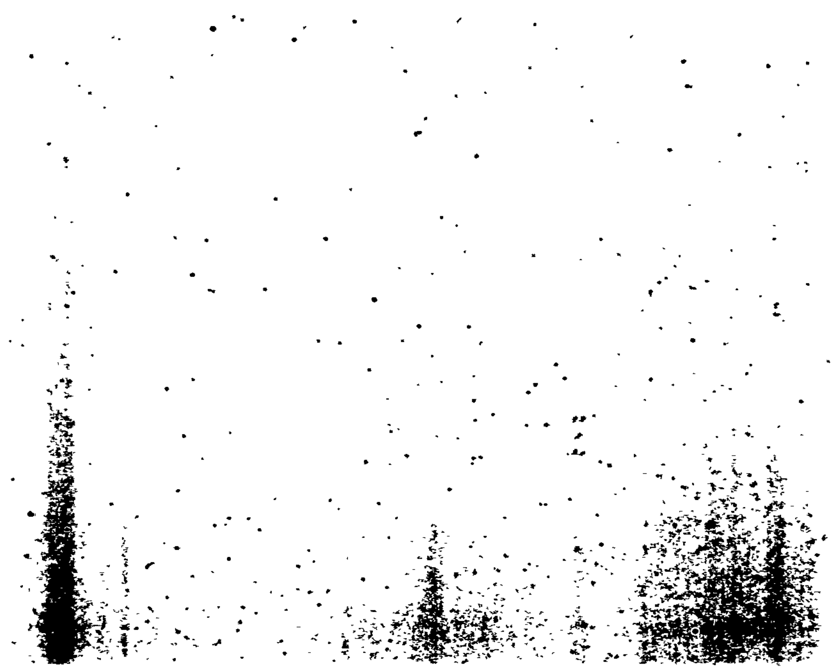
Bay Shipbuilding Inc.
Sample HY8CS
Photograph #9



M5-562-7 Magnification: 10 Diameters Etch: 2% Nital

The photomicrograph shows the typical severity of segregation found in the weld filler metal of the sample.

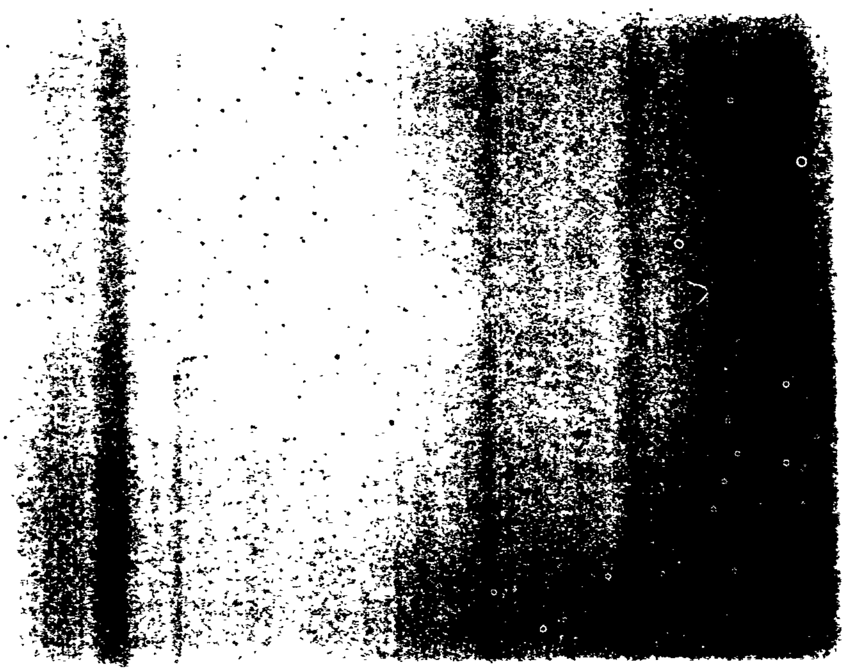
Bay Shipbuilding Inc.
Sample HY8CS
Photograph #1



M5-562-7 Magnification: 400 Diameters Etch: None

The photomicrograph shows the typical level of inclusions found in the sample.

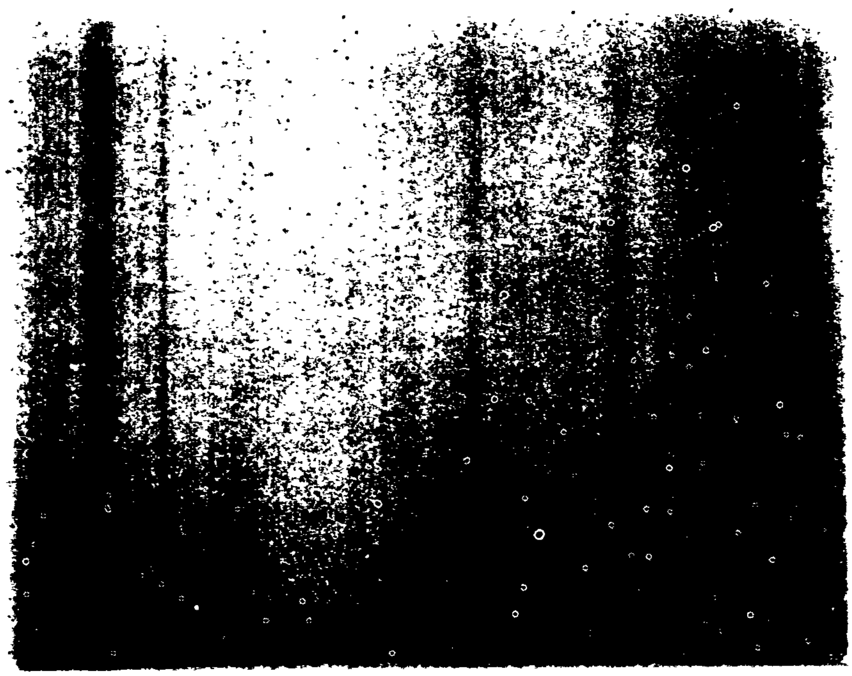
Bay Shipbuilding Inc.
Sample HY8AC1
Photograph #2



M5-562-8 Magnification: 400 Diameters Etch: None

The photomicrograph shows the typical level of inclusions found in the sample.

Bay Shipbuilding Inc.
Sample HY8MC
Photograph #3



M5-562-9 Magnification: 400 Diameters Etch: None

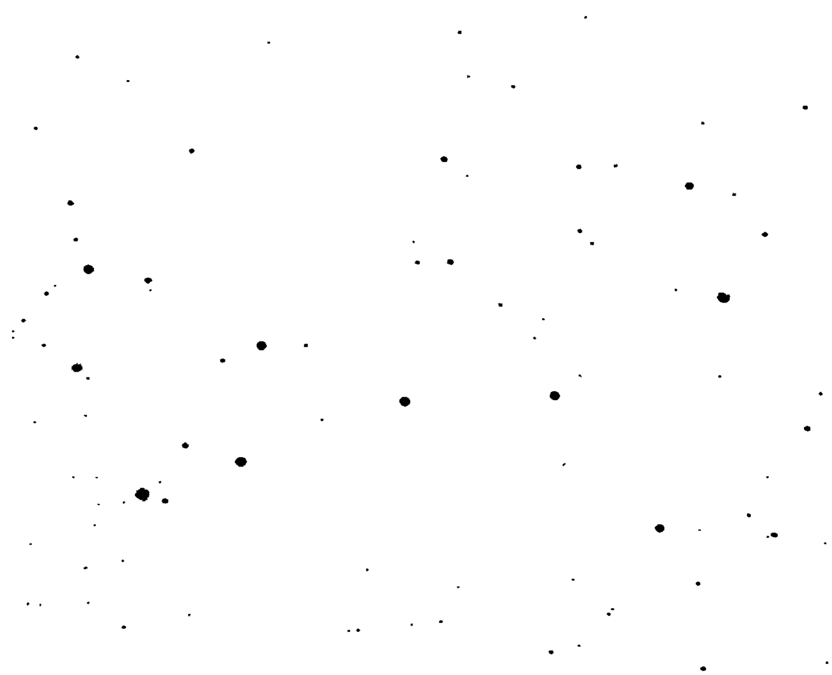
The photomicrograph shows the typical level of inclusions found in the sample.

Bay Shipbuilding Inc.
Sample HY8AC
Photograph #5

M5-562-10 Magnification: 100 Diameters Etch: None

The photomicrograph shows the large inclusion found in the sample. The inclusion was .021 in. long and .008 in. wide.

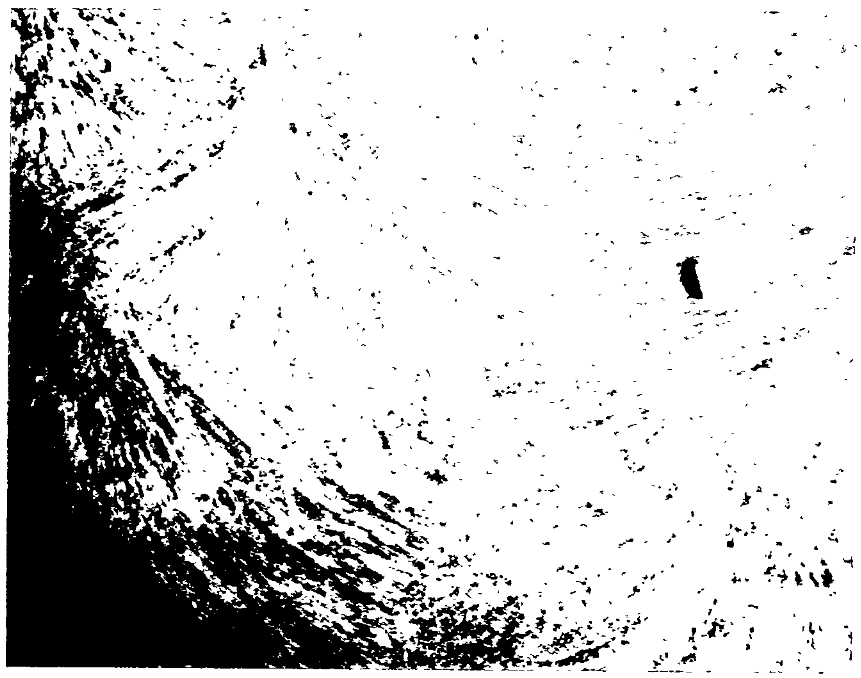
Bay Shipbuilding Inc.
Sample HY8AC
Photograph #4



M5-562-10   Magnification: 100 Diameters   Etch: None

The photomicrograph shows the worst field of inclusions found in the sample.

Bay Shipbuilding Inc.
Sample HY8AC
Photograph #10



M5-562-10   Magnification: 10 Diameters   Etch: 2% Nital

The photomicrograph shows the typical severity of segregation found in the weld filler metal of the sample.

Bay Shipbuilding Inc.
Sample HY8FC
Photograph #6

M5-562-11   Magnification: 400 Diameters   Etch: None

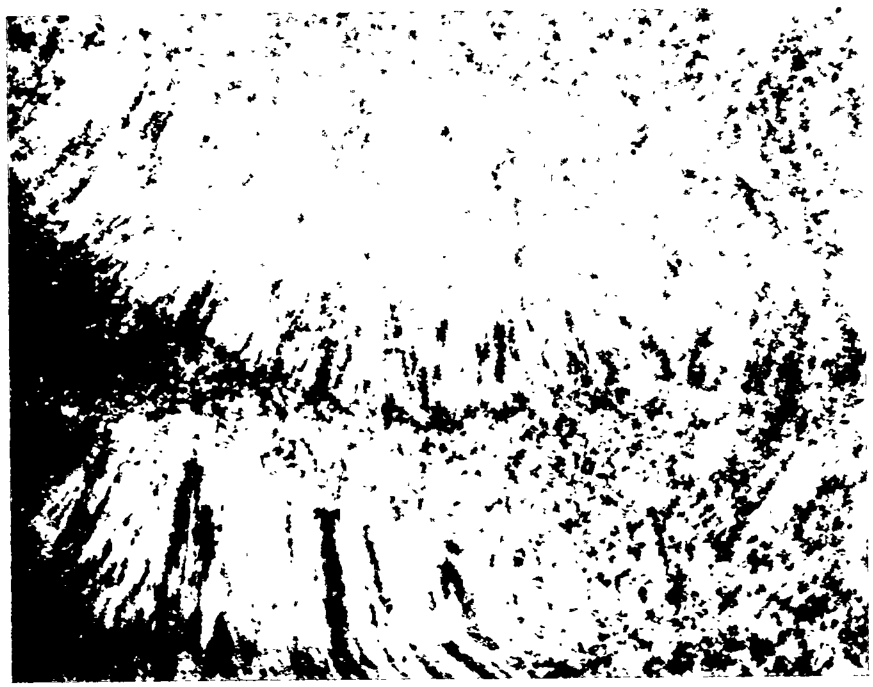
The photomicrograph shows the typical level of inclusions found in the sample.

Bay Shipbuilding Inc.
Sample HY8HHI1
Photograph #7

MS-562-12   Magnification: 400 Diameters   Etch: None

The photomicrograph shows the typical level of inclusions found in the sample.

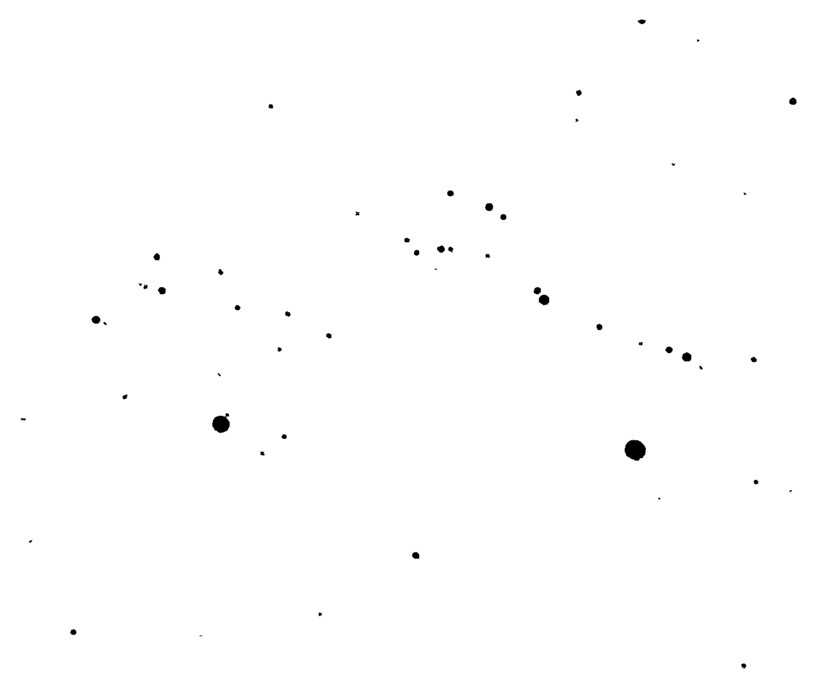
Bay Shipbuilding Inc.
Sample HY8HHI1
Photograph #11



M5-562-12 Magnification: 10 Diameters Etch: 2% Nital

The photomicrograph shows the typical severity of segregation found in the weld filler metal of the sample.

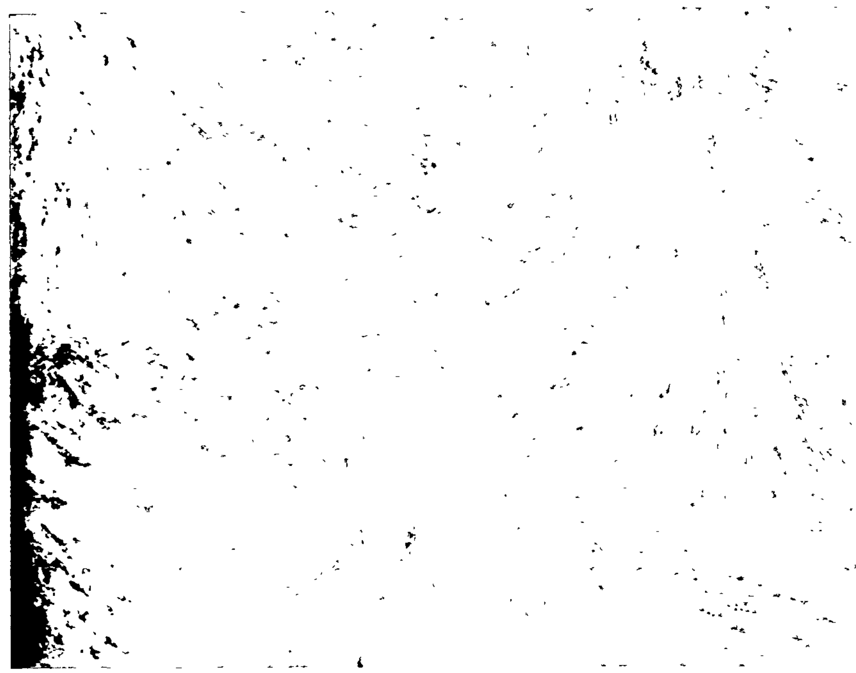
Bay Shipbuilding Inc.
Sample HY8ACHHI
Photograph #8



M5-562-13   Magnification: 100 Diameters   Etch: None

The photomicrograph shows the worst field of inclusions found in the sample.

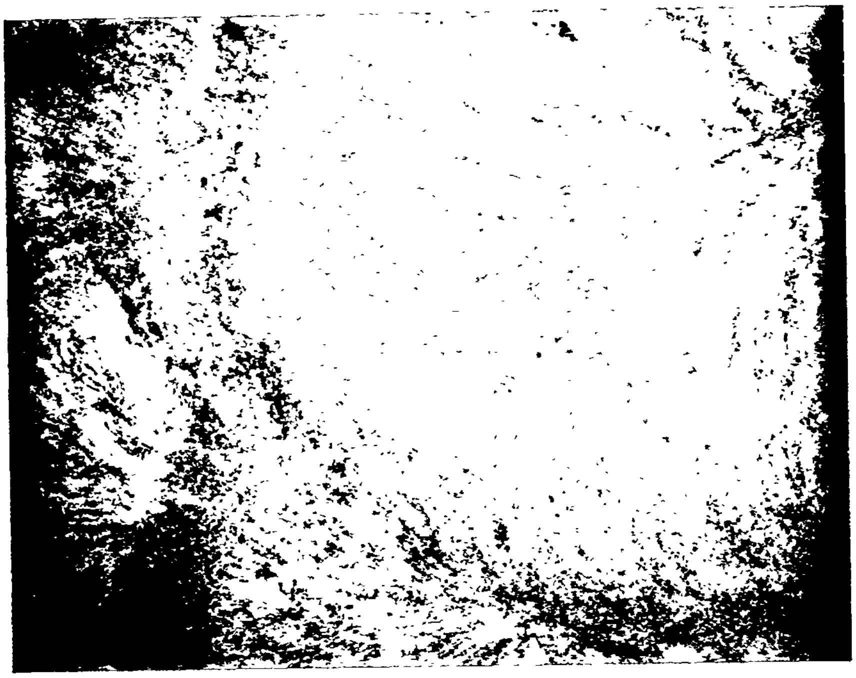
Bay Shipbuilding Inc.
Sample HY8ACHHI
Photograph #12



M5-562-13 Magnification: 10 Diameters Etch: 2% Nital

The photomicrograph shows the typical severity of segregation found in the weld filler metal of the sample.

Bay Shipbuilding Corp.
Sample EH6CS
Photograph #3



M5-562-14   Magnification: 10 Diameters   Etch: 2% Nital

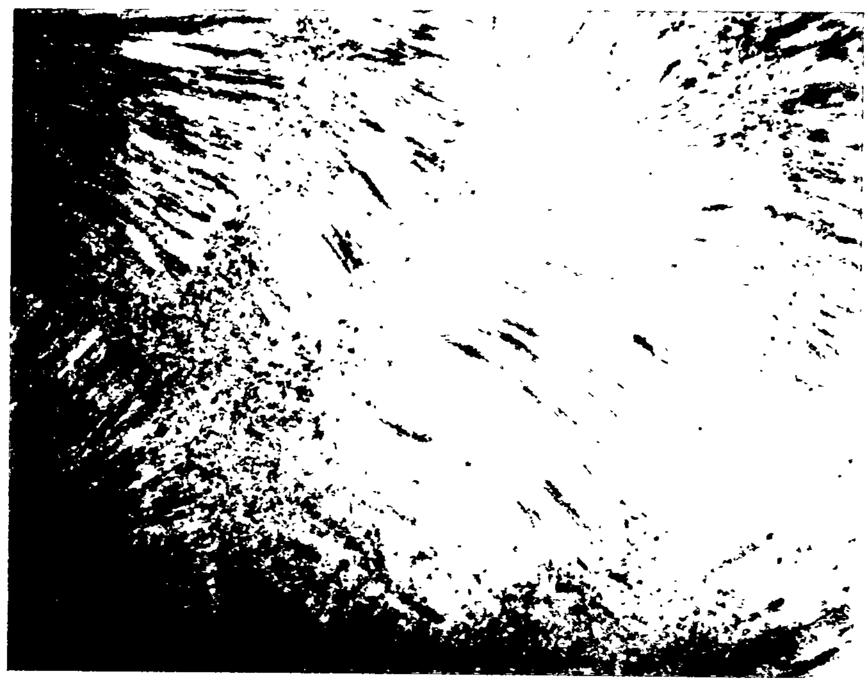
The photomicrograph shows the typical severity of the segregation found in the filler metal of the sample.

Bay Shipbuilding Corp.
Sample EH6CS
Photograph #1

M5-562-14 Magnification: 100 Diameters Etch: None

The photomicrograph shows the worst field of inclusions found in the sample.

Bay Shipbuilding Corp.
Sample EH6FC
Photograph #4



M5-562-15 Magnification: 10 Diameters Etch: 2% Nital

The photomicrograph shows the typical severity of the segregation found in the filler metal of the sample.

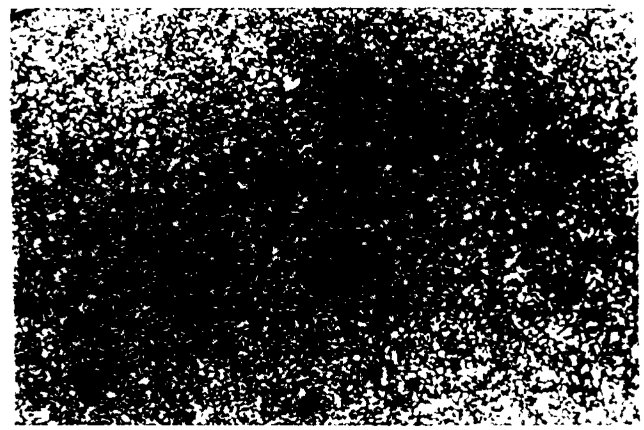
Bay Shipbuilding Corp.
Sample EH6FC
Photograph #2

M5-562-15 Magnification: 100 Diameters Etch: None

The photomicrograph shows the worst field of inclusions found in the sample.

2-2

WELD METAL - LARGE GRAIN STRUCTURE



WELD METAL - FINE GRAIN STRUCTURE

2-4

WELD METAL AT FUSION LINE

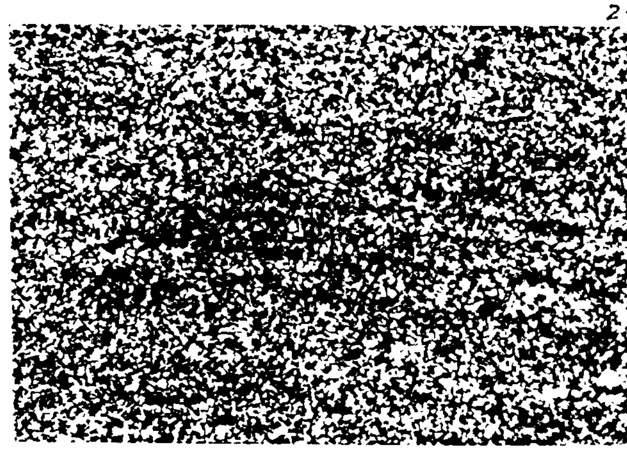
2-5

BASE METAL H.A.Z. - LARGE GRAIN

2-6

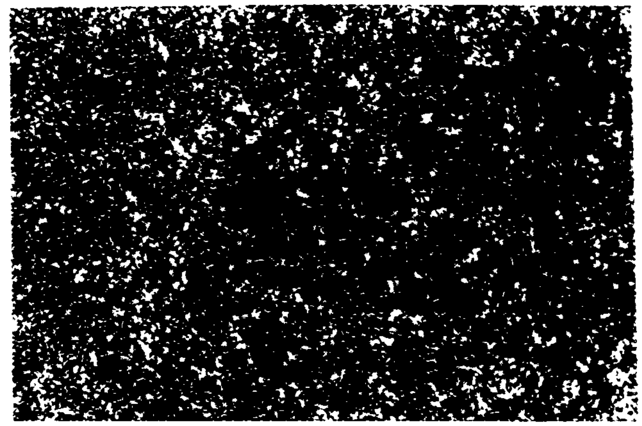
BASE METAL H.A.Z. - FINE GRAIN

2-7



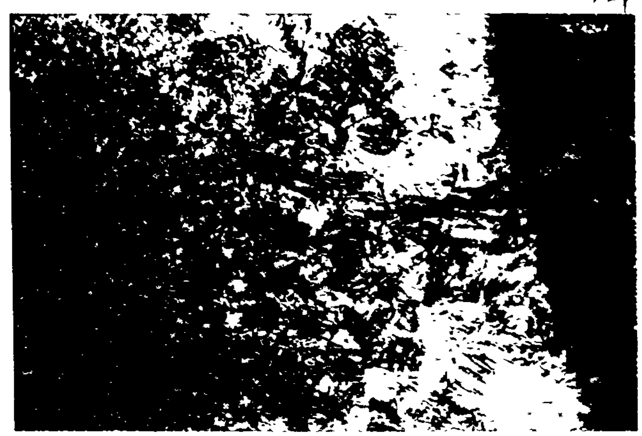
BASE METAL AWAY FROM H.A.Z.

WELD METAL - LARGE GRAIN STRUCTURE

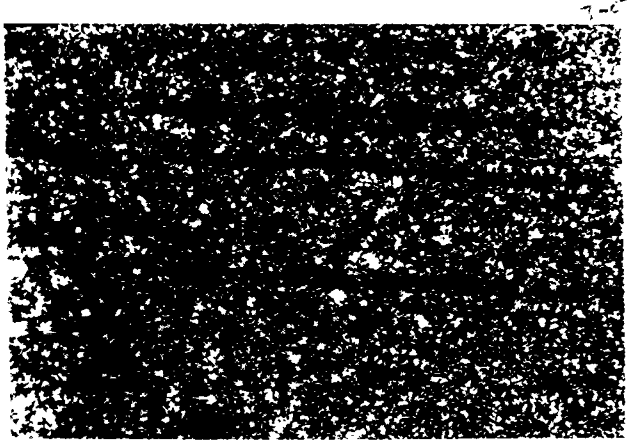


WELD METAL - FINE GRAIN STRUCTURE

WELD METAL AT FUSION LINE



BASE METAL H.A.Z. - LARGE GRAIN



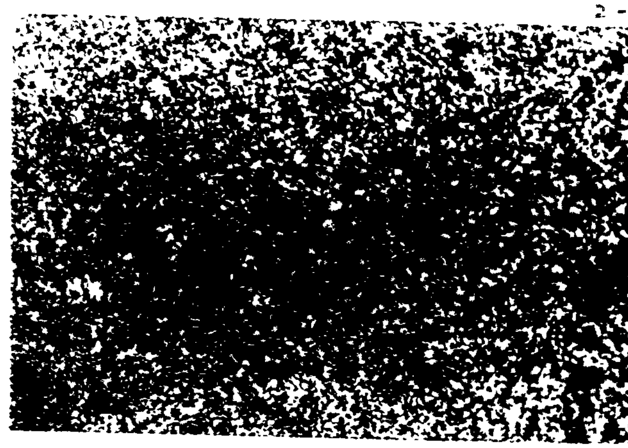
BASE METAL H.A.Z. - FINE GRAIN

BASE METAL AWAY FROM H.A.Z.

2-8

WELD METAL - LARGE GRAIN STRUCTURE

2-9

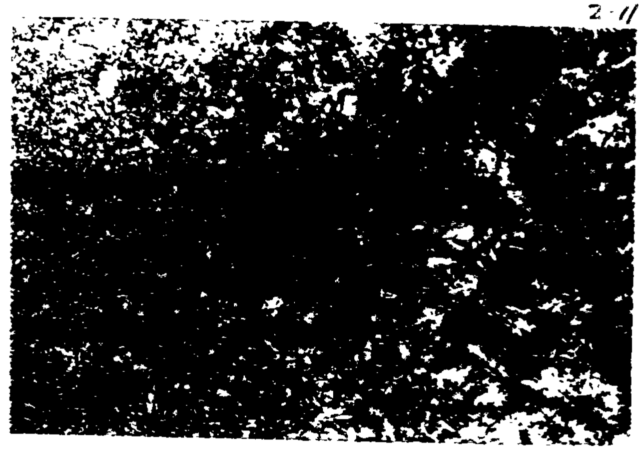


WELD METAL - FINE GRAIN STRUCTURE

2-10

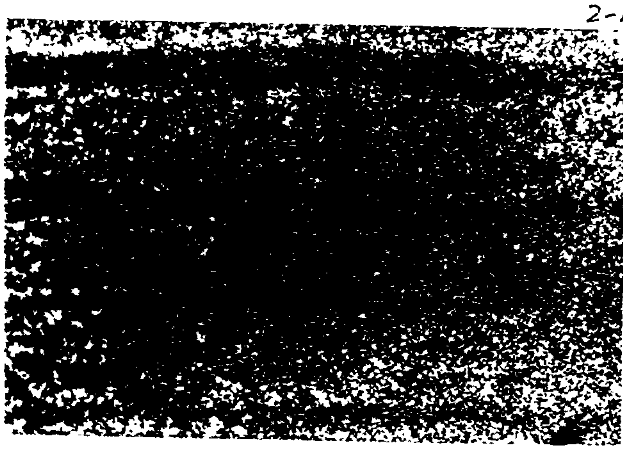
WELD METAL AT FUSION LINE

2-11



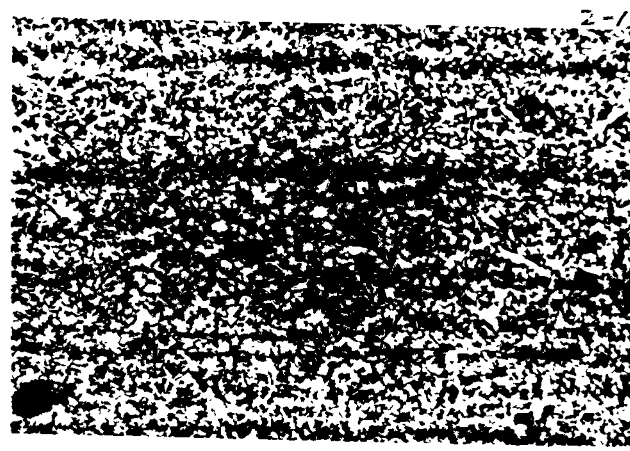
BASE METAL H.A.Z. - LARGE GRAIN

2-12

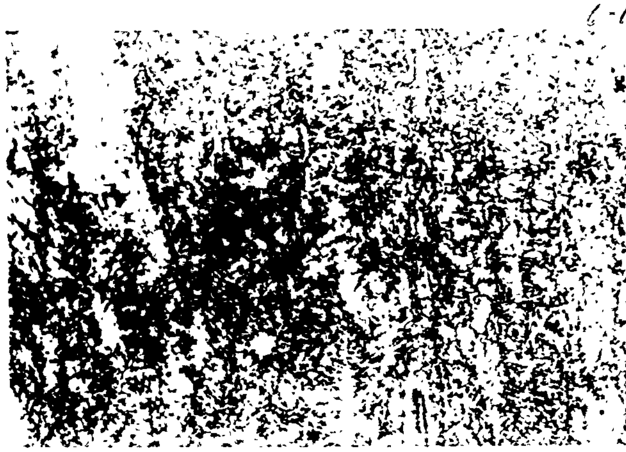


BASE METAL H.A.Z. - FINE GRAIN

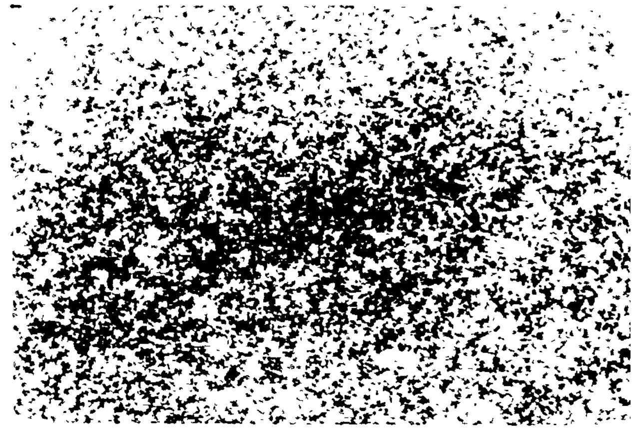
2-13



BASE METAL AWAY FROM H.A.Z.



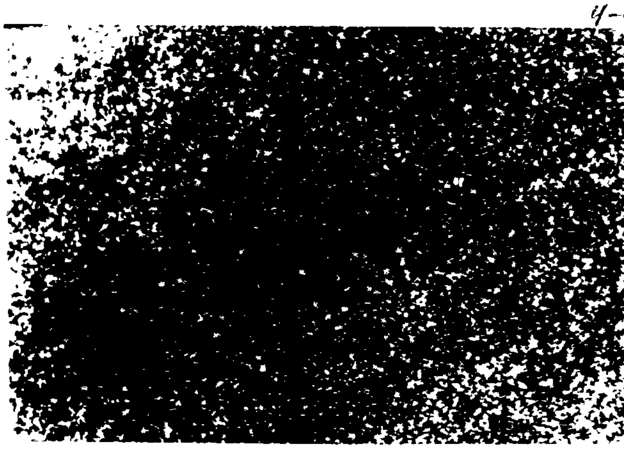
WELD METAL - LARGE GRAIN STRUCTURE



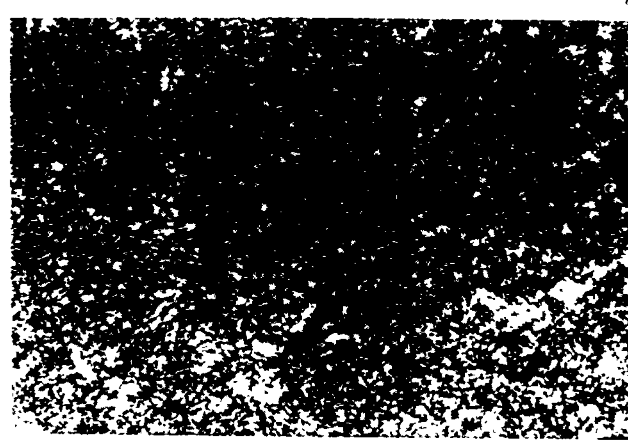
WELD METAL - FINE GRAIN STRUCTURE

WELD METAL AT FUSION LINE

BASE METAL H.A.Z. - LARGE GRAIN

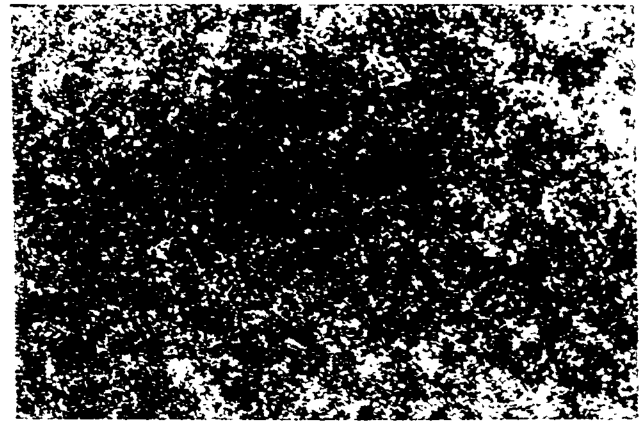


BASE METAL H.A.Z. - FINE GRAIN

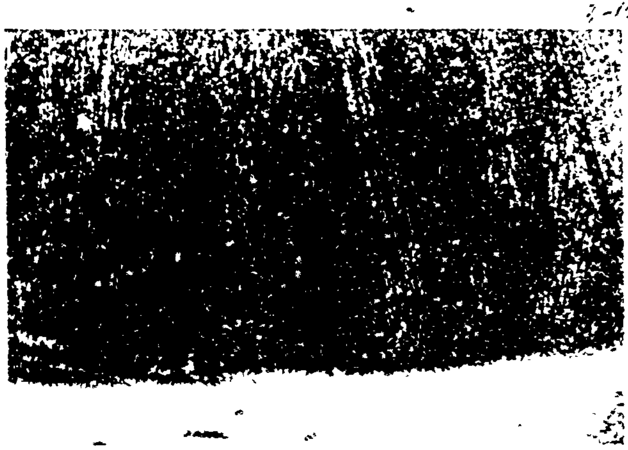


BASE METAL AWAY FROM H.A.Z.

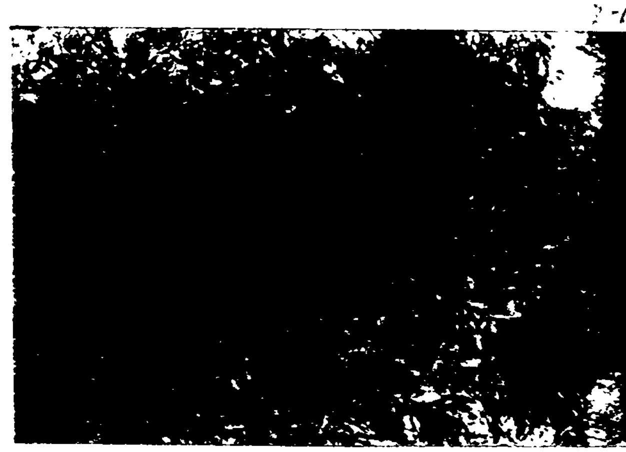
WELD METAL - LARGE GRAIN STRUCTURE



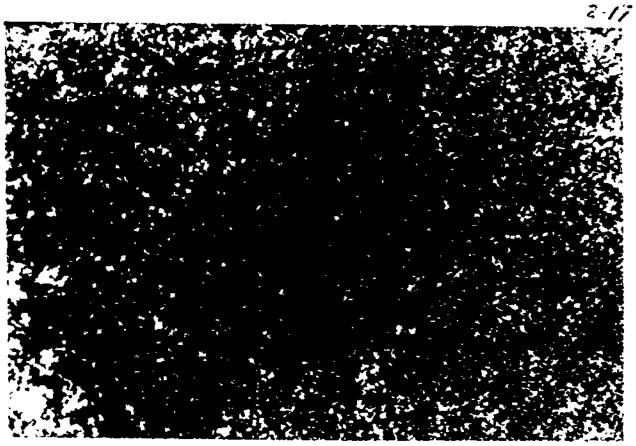
WELD METAL - FINE GRAIN STRUCTURE



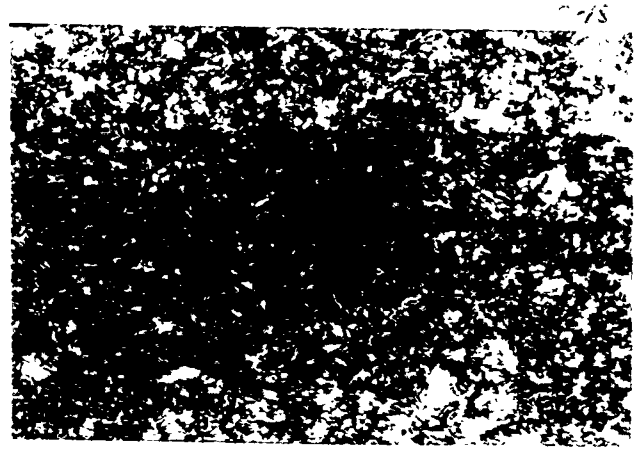
WELD METAL AT FUSION LINE



BASE METAL H.A.Z. - LARGE GRAIN

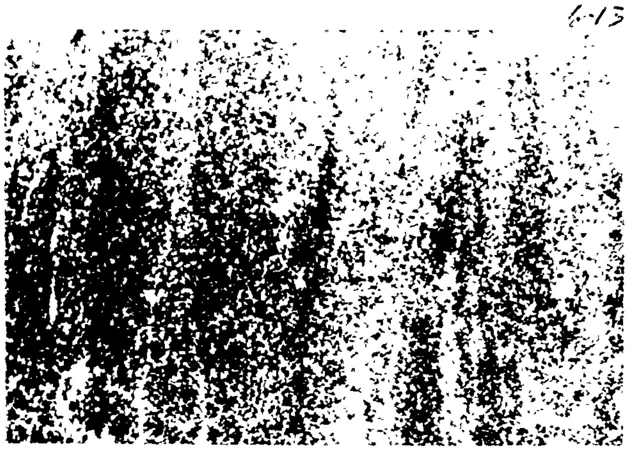


BASE METAL H.A.Z. - FINE GRAIN



BASE METAL AWAY FROM H.A.Z.

6-13

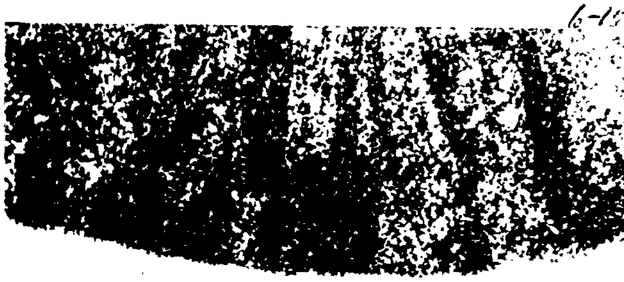


WELD METAL - LARGE GRAIN STRUCTURE

6-14

WELD METAL - FINE GRAIN STRUCTURE

6-15

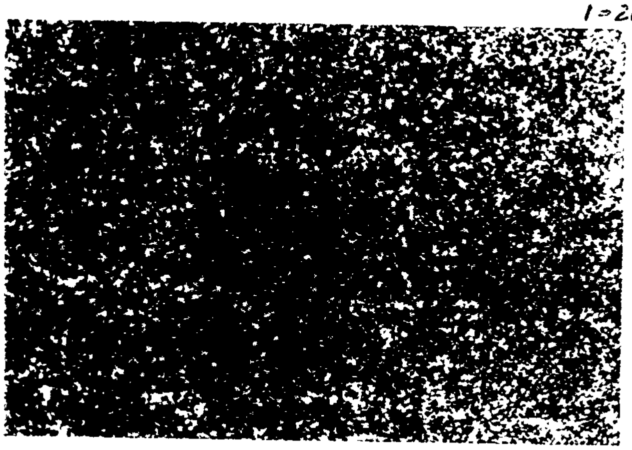


WELD METAL AT FUSION LINE

1-19

BASE METAL H.A.Z. - LARGE GRAIN

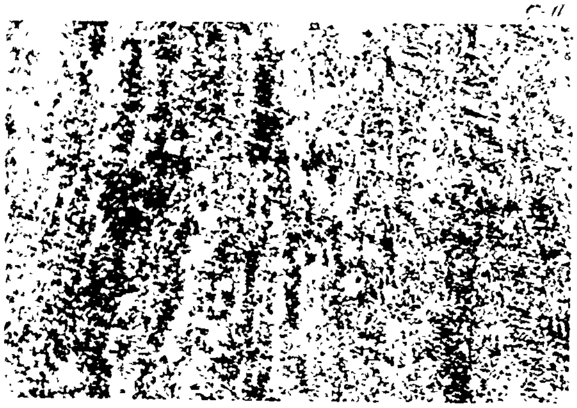
1-20



BASE METAL H.A.Z. - FINE GRAIN

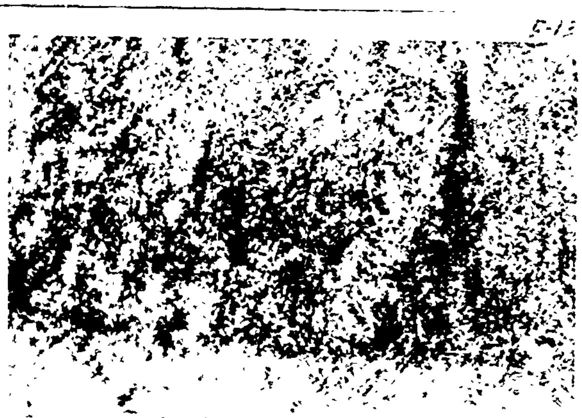
1-21

BASE METAL AWAY FROM H.A.Z.



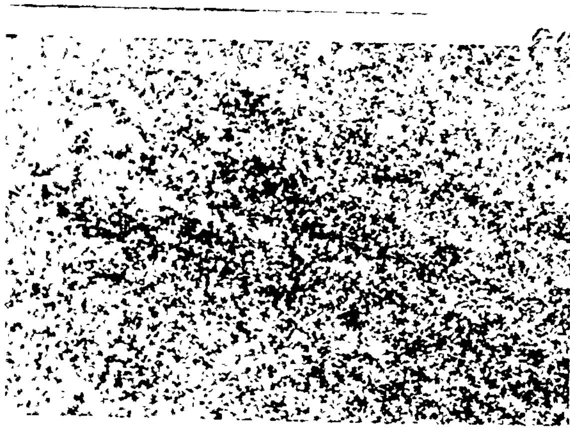
WELD METAL - LARGE GRAIN STRUCTURE

WELD METAL - FINE GRAIN STRUCTURE



WELD METAL AT FUSION LINE

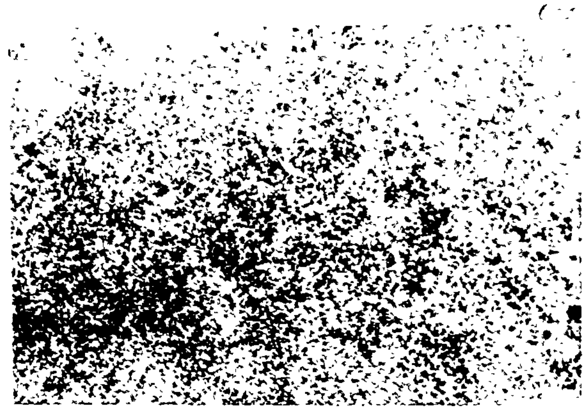
BASE METAL H.A.Z. - LARGE GRAIN



BASE METAL H.A.Z. - FINE GRAIN

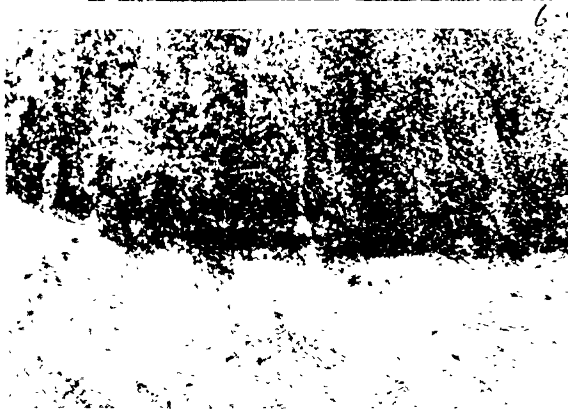
BASE METAL AWAY FROM H.A.Z.

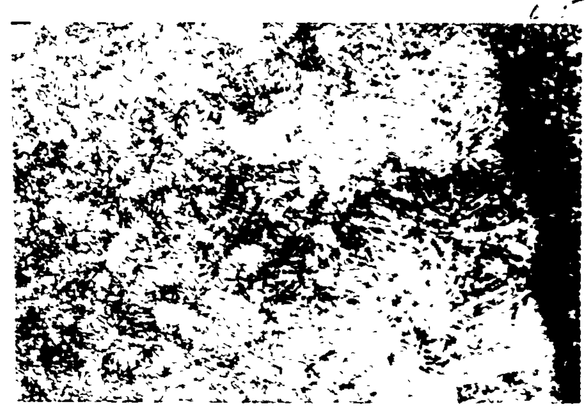
HY-8-AC-HHI



WELD METAL - LARGE GRAIN STRUCTURE

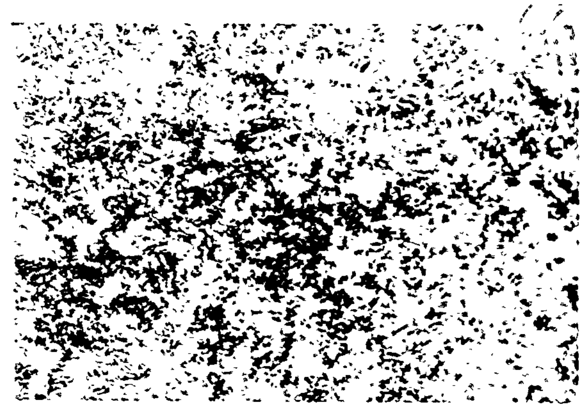
WELD METAL - FINE GRAIN STRUCTURE





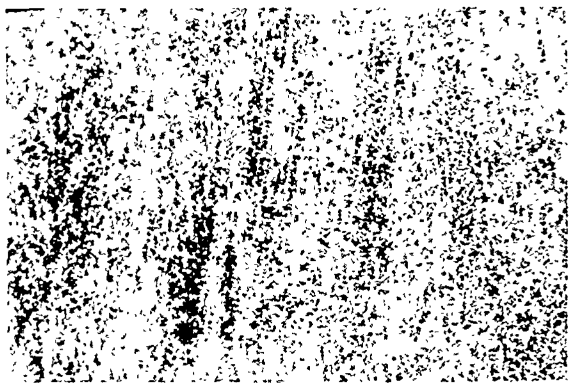
WELD METAL AT FUSION LINE

BASE METAL H.A.Z. - LARGE GRAIN

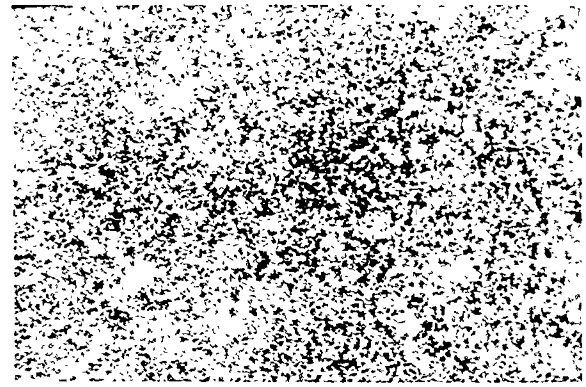


BASE METAL H.A.Z. - FINE GRAIN

BASE METAL AWAY FROM H.A.Z.



WELD METAL - LARGE GRAIN STRUCTURE

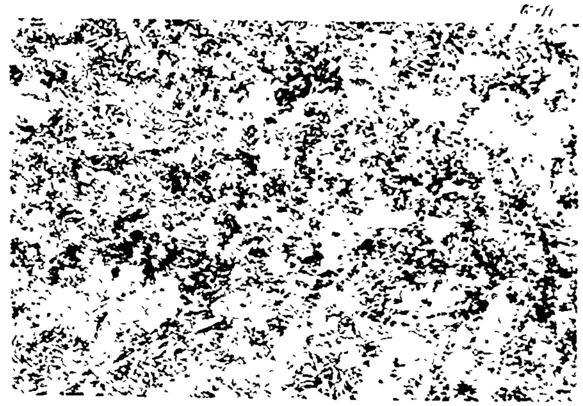


WELD METAL - FINE GRAIN STRUCTURE

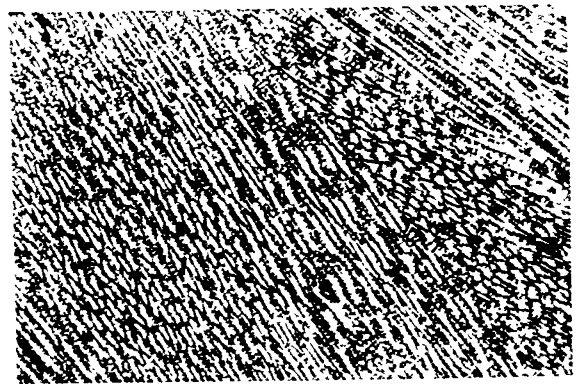
WELD METAL AT FUSION LINE

BASE METAL H.A.Z. - LARGE GRAIN

BASE METAL H.A.Z. - FINE GRAIN



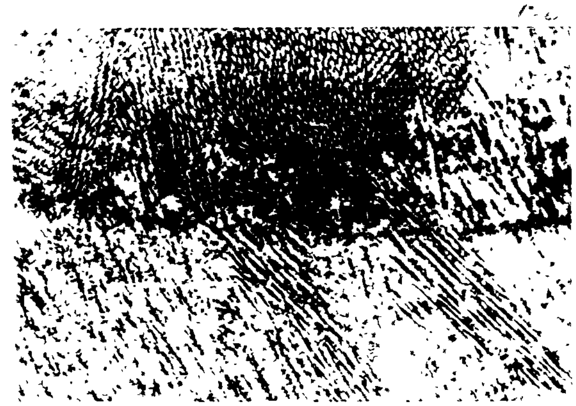
BASE METAL AWAY FROM H.A.Z.



WELD METAL - LARGE GRAIN STRUCTURE

4-8

WELD METAL AT FUSION LINE



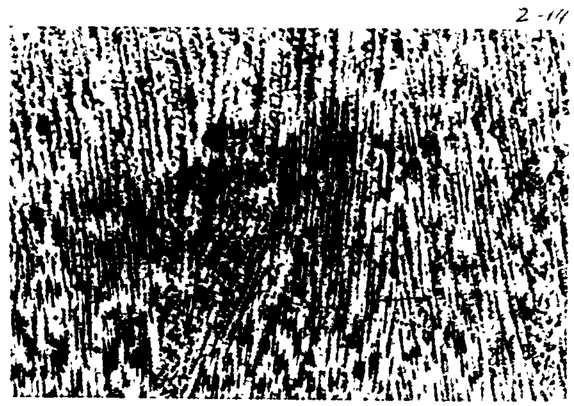
BASE METAL H.A.Z. LARGE GRAIN

4-4

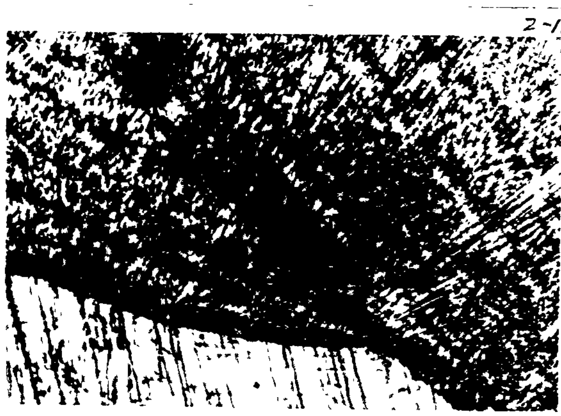
BASE METAL H.A.Z.

4-10

BASE METAL AWAY FROM H.A.Z.

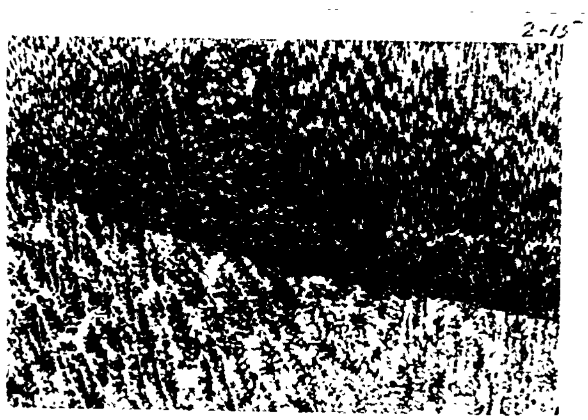


WELD METAL - LARGE GRAIN STRUCTURE



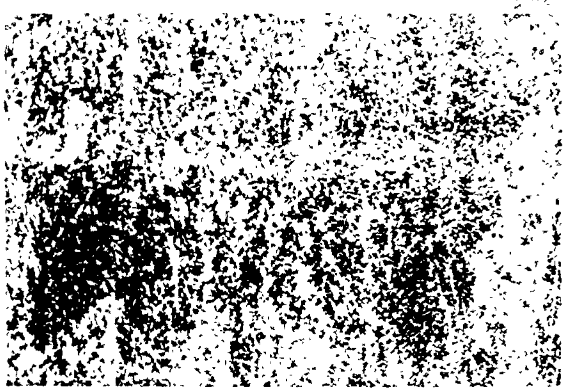
WELD METAL AT FUSION LINE

BASE METAL H.A.Z. LARGE GRAIN



BASE METAL H.A.Z.

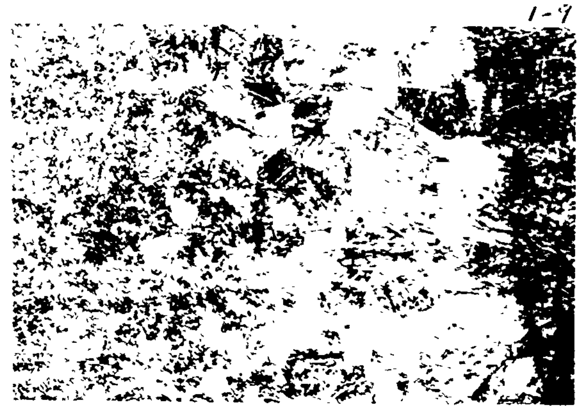
BASE METAL AWAY FROM H.A.Z.



WELD METAL - LARGE GRAIN STRUCTURE

WELD METAL - FINE GRAIN STRUCTURE

WELD METAL AT FUSION LINE



BASE METAL H.A.Z. - LARGE GRAIN

BASE METAL H.A.Z. - FINE GRAIN

BASE METAL AWAY FROM H.A.Z.

HY-0-CS

SECTION 14

SUMMARY

SUMMARY

The most significant result in regard to the data gathered in this project was an improvement in the weld metal charpy impact results using fabricated electrodes on HY-80 and HY-100 steel test samples as opposed to the solid electrode Charpy impact values. It should be-noted that the solid electrode manufacturer (Linde) has developed a new flux (651 VF) to meet the new U.S.N.-Q.P.L. requirement for higher impact strength on HY type steel.

Another significant result-noted when comparing solid vs. flux core type electrodes is the improved deposition rates of the flux core electrodes as measured at the same amperage and voltage. In the lower amperage range, used for root passes against the backing bar (350 amps), the overall average of the deposition improvement was 3.5% of all samples tested. At the manufacturer's recommended welding amperage (500 amps), the average improvement in deposition rates was 19% of all samples tested. We feel that this is a significant improvement that demonstrates an economic advantage in favor of the flux core type electrodes.

Electrode cost comparison for the high strength type electrodes is also a very significant factor that impacts operating costs. Flux core - metal core fabricated electrodes for HY-80 and HY-100 submerged arc welding applications are as much as 50% lower in price/lb. than the solid electrodes designed for the same applications. In some cases, fabricated electrodes are designed for gas shielded flux core welding as well as submerged arc welding applications. This latter item is, in itself, important by allowing a manufacturer to reduce electrode inventories.

In conclusion, we feel that this investigation has produced conclusive data that fabricated electrodes have several advantages in operating characteristics that improve weld quality and at the same time, reduce costs. There is one area, however, that must be addressed in this final conclusion. A point to consider is the difference in the penetrating capabilities of the two electrode types. If a weld joint design requires a deep penetrating arc, the solid electrode has a definite advantage over the fabricated electrodes. The type of joint design that requires a deep penetrating arc is a square butt joint, without edge preparation, welded from two sides. For this type weld joint design we recommend the solid electrodes be used. For all other submerged arc welding, we recommend strong consideration be given to the use of fabricated electrodes.

SECTION 15

REFERENCES

REFERENCES

1. 12TH Edition - Procedure Handbook of Arc Welding, Lincoln Electric Company

SECTION 16

APPENDIX A - TENSILE TEST FORMS

Work No. EH 6 CS

Test Samples prepared by:

Contractor_________

NWTI X

NORTHEAST WISCONSIN TECHNICAL INSTITUTE
Trades and Industry Division
2740 West Mason Street, Green Bay, WI 54303

White-Company
Yellow-NWTI
Pink-Performer

TENSILE TEST WORKSHEET

ITEM	DIAMETER OR THICKNESS	WIDTH	CSA	YIELD LOAD	ULTIMATE LOAD	YIELD STRENGTH	TENSILE STRENGTH	GAGE LENGTH	ELONG.	% ELONG.	[redacted]
TEN. 1	.863	.565	.487	28,250	39500	58,008	81,108	2"	.351	17	
TEN. 2	.861	.572	.492	27,650	39 250	56,199	79,776	2"	.365	18	
BASE	.505	/	.200	11,100	16700	55,500	83,500	2"	.648	32	
WELD	.507	/	.202	12,700	15900	62,871	78,712	2"	.534	26	

Test Performed by: John W [illegible] Date: 8/22/84

Witnessed by: [illegible] Date: 8/22/84

Work No. EH 6 FC

Test Samples prepared by:

Contractor ________

NWTI X

NORTHEAST WISCONSIN TECHNICAL INSTITUTE
Trades and Industry Division
2740 West Mason Street, Green Bay, WI 54303

White-Company
Yellow-NWTI
Pink-Performer

TENSILE TEST WORKSHEET

ITEM	DIAMETER OR THICKNESS	WIDTH	CSA	YIELD LOAD	ULTIMATE LOAD	YIELD STRENGTH	TENSILE STRENGTH	GAGE LENGTH	ELONG.	% ELONG.	HARDNESS
TEN. 1	.856	.565	.483	27750	41900	57,453	86,749	2"	.573	28	
TEN. 2	.863	.566	.488	27500	41800	56,352	85,655	2"	.568	28	
BASE	.504		.199	10500	16700	52,763	83,919	2"	.645	32	
WELD	.507		.201	15,500	18500	77,114	92,039	2"	.544	27	

Test Performed by: John M. K[illegible] Date: 8/21/84

Witnessed by: Bruce [illegible] Date: 8/21/84

Work No. SS L CS

Test Samples prepared by:

Contractor________

NWTI X

NORTHEAST WISCONSIN TECHNICAL INSTITUTE
Trades and Industry Division
2740 West Mason Street, Green Bay, WI 54303

White-Company
Yellow-NWTI
Pink-Performer

TENSILE TEST WORKSHEET

ITEM	DIAMETER OR THICKNESS	WIDTH	CSA	YIELD LOAD	ULTIMATE LOAD	YIELD STRENGTH	TENSILE STRENGTH	GAGE LENGTH	ELONG.	% ELONG.	HARDNESS
TEN 1	.832	.575	.478	26,100	39,850	54,602	83,368	2"	.443	22	
TEN 2	.832	.565	.470	26,250	40,500	55,851	86,170	2"	.740	.37	
Base	.503		.198	10,350	17,250	52,272	87,121	2"	1.030	51	
Weld	.510		.204	12,000	17,400	58,823	85,294	2"	.659	32	

Test Performed by: ______________ Date: 9/29/84

Witnessed by: ______________ Date: 9/29/84

Work No. SS L FC

Test Samples prepared by:

Contractor________

NWTI X

NORTHEAST WISCONSIN TECHNICAL INSTITUTE
Trades and Industry Division
2740 West Mason Street, Green Bay, WI 54303

White-Company
Yellow-NWTI
Pink-Performer

TENSILE TEST WORKSHEET

ITEM	DIAMETER OR THICKNESS	WIDTH	CSA	YIELD LOAD	ULTIMATE LOAD	YIELD STRENGTH	TENSILE STRENGTH	GAGE LENGTH	ELONG.	% ELONG.	HARDNESS
TEN 1	.873	.628	.548	30,750	47,200	56,113	86,131	2"	.846	42	
TEN 2	.870	.627	.545	30,500	46,500	55,963	85,321	2"	.766	38	
Base	.505		.200	10,000	17,150	50,000	85,750	2"	1.067	53	
Weld	.505		.200	11,750	16,100	58,750	80,500	2"	.835	41	

Test Performed by: John W Ki[illegible] Date: 9/29/84

Witnessed by: Bruce Hal[illegible] Date: 9/29/84

Work No. HY 8 CS

Test Samples prepared by:

Contractor__________

NWTI X

NORTHEAST WISCONSIN TECHNICAL INSTITUTE
Trades and Industry Division
2740 West Mason Street, Green Bay, WI 54303

White-Company
Yellow-NWTI
Pink-Performer

TENSILE TEST WORKSHEET

ITEM	DIAMETER OR THICKNESS	WIDTH	CSA	YIELD LOAD	ULTIMATE LOAD	YIELD STRENGTH	TENSILE STRENGTH	GAGE LENGTH	ELONG.	% ELONG.	HARDNESS
TEN-1	.875	.513	.448	40 250	50,050	89,843	111,718	2"	.418	20	
TEN-2	.876	.500	.438	40,000	49,500	91,324	113,013	2"	.432	21	
BASE	.502		.197	17.700	21.540	89,847	109,340	2"	.520	26	
WELD	.503		.198	18 100	21.750	91,414	109,848	2"	.437	21	

Test Performed by: John W King Date: 8/21/84

Witnessed by: Bruce [illegible] Date: 8/21/84

Work No. HY8FC

Test Samples prepared by:

Contractor ________

NWTI X

NORTHEAST WISCONSIN TECHNICAL INSTITUTE
Trades and Industry Division
2740 West Mason Street, Green Bay, WI 54303

White-Company
Yellow-NWTI
Pink-Performer

TENSILE TEST WORKSHEET

ITEM	DIAMETER OR THICKNESS	WIDTH	CSA	YIELD LOAD	ULTIMATE LOAD	YIELD STRENGTH	TENSILE STRENGTH	GAGE LENGTH	ELONG.	% ELONG.	[redacted]
TEN 1	.869	.501	.435	39,750	49350	91,379	113,448	2"	.483	24	Base
TEN 2	.871	.506	.440	39,350	49200	89,431	111,818	2"	.431	21	Base
BASE	.504		.199	17,550	21300	88,190	107,035	2"	.531	26	
WELD	.503		.198	21,750	23650	109,848	119,444	2"	.415	20	

Test Performed by: John W King Date: 8/22/84

Witnessed by: Bruce [illegible] Date: 8/22/84

Work No. HY 8 MC

Test Samples prepared by:

Contractor ________

NWTI X

NORTHEAST WISCONSIN TECHNICAL INSTITUTE
Trades and Industry Division
2740 West Mason Street, Green Bay, WI 54303

White-Company
Yellow-NWTI
Pink-Performer

TENSILE TEST WORKSHEET

ITEM	DIAMETER OR THICKNESS	WIDTH	CSA	YIELD LOAD	ULTIMATE LOAD	YIELD STRENGTH	TENSILE STRENGTH	GAGE LENGTH	ELONG.	% ELONG.	Fracture Location
TEN 1	.881	.568	.500	42 300	53 400	84,600	106,800	2"	.519	25	Base
TEN 2	.870	.570	.495	42 700	53 350	86,262	107,777	2"	.532	26	Base
BASE	.502		.197	16 900	20850	85,786	105,837	2"	.582	29	Weld
WELD	.503		.198	18 650	21000	94,191	106,060	2"	.511	25	Base

Test Performed by: John W King Date: 8/22/84

Witnessed by: Bruce [illegible] Date: 8/22/84

Work No. HY 8 AC

Test Samples prepared by:

Contractor________

NWTI X

NORTHEAST WISCONSIN TECHNICAL INSTITUTE
Trades and Industry Division
2740 West Mason Street, Green Bay, WI 54303

White-Company
Yellow-NWTI
Pink-Performer

TENSILE TEST WORKSHEET

ITEM	DIAMETER OR THICKNESS	WIDTH	CSA	YIELD LOAD	ULTIMATE LOAD	YIELD STRENGTH	TENSILE STRENGTH	GAGE LENGTH	ELONG.	% ELONG.	[redacted]
TEN. -1	.878	.497	.436	37500	42000	86,009	96,330	2"	.169	08	Weld
TEN. -2	.875	.510	.446	35750	42450	80,156	95,179	2"	.177	08	Weld
BASE	.502	/	.198	17500	21500	88,383	108,585	2"	.532	26	
WELD	.498	/	.195	16100	18250	82,564	93,589	2"	.430	21	

Test Performed by: John M. K[illegible] Date: 8/21/84

Witnessed by: Bruce [illegible] Date: 8/21/84

Work No. HY8-AGH/4I

Test Samples prepared by:

Contractor ________

NWTI X

NORTHEAST WISCONSIN TECHNICAL INSTITUTE
Trades and Industry Division
2740 West Mason Street, Green Bay, WI 54303

White-Company
Yellow-NWTI
Pink-Performer

TENSILE TEST WORKSHEET

ITEM	DIAMETER OR THICKNESS	WIDTH	CSA	YIELD LOAD	ULTIMATE LOAD	YIELD STRENGTH	TENSILE STRENGTH	GAGE LENGTH	ELONG.	% ELONG.	HARDNESS
TEN 1	.880	.564	.496	39,875	47750	80,393	96,270	2"	.185	09	
TEN 2	.885	.563	.498	39,350	47200	79,016	94,779	2"	.198	09	
BASE	.504		.199	17,050	21,150	85,678	106,281	2"	.549	27	
WELD	.506		.201	16,900	19,100	84,079	95,024	2"	.387	19	

Test Performed by: John W. Kin[illegible] Date: 8/22/84

Witnessed by: Bruce Hat[illegible] Date: 8/22/84

Hy-8-AC-1
Murad Proj. 3205

Work No. ___________

Test Samples prepared by:

Contractor___________

NWTI ___X___

NORTHEAST WISCONSIN TECHNICAL INSTITUTE
Trades and Industry Division
2740 West Mason Street, Green Bay, WI 54303

White-Company
Yellow-NWTI
Pink-Performer

TENSILE TEST WORKSHEET

ITEM	DIAMETER OR THICKNESS	WIDTH	CSA	YIELD LOAD	ULTIMATE LOAD	YIELD STRENGTH	TENSILE STRENGTH	GAGE LENGTH	ELONG.	% ELONG.	HARDNESS
t#1	.983	.372	.3657	33,800	40,600	92,602	111,030	2	.392	19.6	
t#2	.981	.379	.3718	33,920	41,250	91,428	110,950	2	.468	23.4	
505 Weld	.504	—	.1995	18,550	19,500	93,216	97,740	2	.162	8.1	
505 Par	.504	—	.1995	17,200	20,750	86,432	104,010	2	.557	27.9	

Test Performed by: A Ruppradt

Date: May 15 1985

Witnessed by: Bruce Halverson

Date: 5-15-85

HY-8-HHF-1
Marad Proj 3205

Work No. ________

Test Samples prepared by:

Contractor________

NWTI __X__

NORTHEAST WISCONSIN TECHNICAL INSTITUTE
Trades and Industry Division
2740 West Mason Street, Green Bay, WI 54303

White-Company
Yellow-NWTI
Pink-Performer

TENSILE TEST WORKSHEET

ITEM	DIAMETER OR THICKNESS	WIDTH	CSA	YIELD LOAD	ULTIMATE LOAD	YIELD STRENGTH	TENSILE STRENGTH	GAGE LENGTH	ELONG.	% ELONG.	HARDNESS
+#1	.972	.384	.3732	31,750	40,300	85,075	107,970	2	.468	23.4	
+#2	.965	.377	.3638	30,800	39,500	84,661	108,570	2	.406	20.3	
505 Weld	.505	—	.2003	16,620	22,100	83,100	110,330	2	.500	25.0	
505 Par	.506	—	.2011	18,050	21,750	89,800	108,160	2	.566	28.3	

Test Performed by: [illegible] Date: May 15 1985

Witnessed by: [illegible] Date: 5-15-85

Work No. HY-O CS

Test Samples prepared by:

Contractor__________

NWTI X

NORTHEAST WISCONSIN TECHNICAL INSTITUTE
Trades and Industry Division
2740 West Mason Street, Green Bay, WI 54303

White-Company
Yellow-NWTI
Pink-Performer

TENSILE TEST WORKSHEET

ITEM	DIAMETER OR THICKNESS	WIDTH	CSA	YIELD LOAD	ULTIMATE LOAD	YIELD STRENGTH	TENSILE STRENGTH	GAGE LENGTH	ELONG.	% ELONG.	HARDNESS
Ten. 1	.875	.405	.354	36,800	43750	103,954	123,587	2"	.421	21	BASE
Ten. 2	.874	.400	.349	35,750	41250	102,435	118,194	2"	* .177	*Retest	= broke at 2" gage mark
Base	.506		.201	22500	24800	111,940	123,383	2"	.444	22	
Weld	.505		.200	21000	25200	105,000	126,000	2	.370	18.5	

Test Performed by: John M. [illegible] Date: 8/21/84

Witnessed by: Bruce [illegible] Date: 8/21/84

Work No. HY 0 CS

Test Samples prepared by:

Contractor ________

NWTI X

NORTHEAST WISCONSIN TECHNICAL INSTITUTE
Trades and Industry Division
2740 West Mason Street, Green Bay, WI 54303

White-Company
Yellow-NWTI
Pink-Performer

TENSILE TEST WORKSHEET

ITEM	DIAMETER OR THICKNESS	WIDTH	CSA	YIELD LOAD	ULTIMATE LOAD	YIELD STRENGTH	TENSILE STRENGTH	GAGE LENGTH	ELONG.	% ELONG.	HARDNESS
Retest											
TEN 3	.876	.406	.355	37,000	43,950	104,225	123,802	2"	.345	17	

Test Performed by: [illegible] Date: 9/29/84

Witnessed by: [illegible] Date: 9/29/84

Work No. HY-0-FC

Test Samples prepared by:

Contractor_________

NWTI X

NORTHEAST WISCONSIN TECHNICAL INSTITUTE
Trades and Industry Division
2740 West Mason Street, Green Bay, WI 54303

White-Company
Yellow-NWTI
Pink-Performer

TENSILE TEST WORKSHEET

ITEM	DIAMETER OR THICKNESS	WIDTH	CSA	YIELD LOAD	ULTIMATE LOAD	YIELD STRENGTH	TENSILE STRENGTH	GAGE LENGTH	ELONG.	% ELONG.	Fracture Location
TEN 1	.871	.400	.348	36,150	43,650	103,879	125,431	2"	.387	19	Base
TEN 2	.875	.412	.360	38,300	44,500	106,388	123,611	2"	.385	19	Base
BASE	.501		.197	22,350	24500	113,451	124,365	2"	.489	24	W
WELD	.506		.201	25,100	27150	124,875	135,074	2"	.378	18	B

Test Performed by: John W Kim Date: 8/22/84

Witnessed by: Bruce Halverson Date: 8/22/84

Work No. HY 0 AC

Test Samples prepared by:

Contractor

NWTI X

NORTHEAST WISCONSIN TECHNICAL INSTITUTE
Trades and Industry Division
2740 West Mason Street, Green Bay, WI 54303

White-Company
Yellow-NWTI
Pink-Performer

TENSILE TEST WORKSHEET

ITEM	DIAMETER OR THICKNESS	WIDTH	CSA	YIELD LOAD	ULTIMATE LOAD	YIELD STRENGTH	TENSILE STRENGTH	GAGE LENGTH	ELONG.	% ELONG.	HARDNESS
TEN 1	.877	.507	.444	45,600	54,700	102,702	123,198	2"	.438	21	
TEN 2	.891	.500	.445	44,950	54,300	101,011	122,022	2"	.470	23	
Base	.504		.199	21,800	24,450	109,547	122,864	2"	.442	22	
Weld	.505		.200	21,100	24,800	105,500	124,000	2"	.431	21	

Test Performed by: John W King

Date: 9/29/84

Witnessed by: Bruce [illegible]

Date: 9/29/84

HY-O-AC-1
Marad Project 3205
Work No. ______

Test Samples prepared by:

Contractor ______

NWTI X

NORTHEAST WISCONSIN TECHNICAL INSTITUTE
Trades and Industry Division
2740 West Mason Street, Green Bay, WI 54303

White-Company
Yellow-NWTI
Pink-Performer

TENSILE TEST WORKSHEET

ITEM	DIAMETER OR THICKNESS	WIDTH	CSA	YIELD LOAD	ULTIMATE LOAD	YIELD STRENGTH	TENSILE STRENGTH	GAGE LENGTH	ELONG.	% ELONG.	HARDNESS
T#1	.941	.376	.3538	36,350	43,750	102,974	123,650	2	.398	19.9	
T#2	.941	.370	.3482	36,250	42,800	104,166	122,930	2	.418	20.9	
505 weld	.507	—	.2019	21,150	24,800	105,223	122,840	2	.430	21.5	
505 Par	.503	—	.1987	22,600	24,650	114,141	124,050	2	.441	22.0	

Test Performed by: [signature]
Date: May 15 1985

Witnessed by: Bruce Halverson
Date: 5-15-85

APPENDIX B - CHARPY TEST FORMS

APPENDIX B - Charpy Tests

Note:

Equipment used to notch the specimens was a Blacks Equipment Limited notch cutter, Type CNB-14 - Serial NO. 82643B.

The chiller was manufactured by F.T.S., Multi-Cool, Stone Ridge, NY 12484.

Temperature verification was obtained with an Omega 450 AKT, Thermocouple Thermometer Type K, Serial NO. 456853 - Calibration Date: April 1, 1984.

ARMY MATERIALS AND MECHANICS RESEARCH CENTER

Watertown, Massachusetts 02172

Date of Test: 2 November 1984

TABLE

COMPARISON TESTS ON CHARPY IMPACT MACHINES

Facility: Northeast Wisconsin Technical Institute
Marinette, WI 54143

Make of Machine: Tinius Olsen   Serial No. 135330

	AMMRC (ft-lb)	(ft-lb)	Variation Actual		Variation Allowed
High Energy	68	69.8	2.6	%	±5.0%
Low Energy	11.3	10.8	-.5	ft-lb	±1.0 ft-lb

XMR Form 105
Rev 1 Apr 81

IMPACT MATERIAL TEST FORM

TESTING AGENT: N.W.T.I.
DATE: Nov. 9, 1984
TESTED FOR: Bay Shipbuilding Corp.
MATERIAL TYPE: EH 36
SPECIMEN ID#: EH 6 CS
TESTING TEMPERATURE: - 40° F.
MEDIUM: Methanol Anhydrous CH3OH
TYPE OF NOTCH: Charpy V Notch

WISCONSIN STATE WELD
TESTING LAB #3
1601 University Drive
Marinette, WI 54143

TESTING MACHINE MODEL #: 74 Univ. Tinius Olsen
SERIAL NUMBER: 135330

SPECIMEN ID#		FT.-LB. ENERGY	
All Weld	1	16	H
	2	8	L
	3	15	
	4	9.5	
	5	15	
H.A.Z.	6	15	
	7	10	L
	8	14.5	
	9	112	H
	10	72	
Base	11	168	
	12	173	H
	13	69	
	14	66	L
	15	72	

AVERAGE SPECIMENS 1 TO 5 13.1 Ft. lbs.

AVERAGE SPECIMENS 6 TO 10 33.8 Ft. lbs.

AVERAGE SPECIMENS 11 TO 15 103 Ft. lbs.

AVERAGE SPECIMENS ___ TO ___ ______

TESTING AGENT SIGNATURE: Malcolm Schreiner
DATE: 11/9/84

IMPACT MATERIAL TEST FORM

TESTING AGENT: N.W.T.I.
DATE: Nov. 9, 1984
TESTED FOR: Bay Shipbuilding Corp.
MATERIAL TYPE: EH 36
SPECIMEN ID#: EH 6 FC
TESTING TEMPERATURE: - 40° F.
MEDIUM: Methanol Anhydrous CH3OH
TYPE OF NOTCH: Charpy V Notch

WISCONSIN STATE WELD
TESTING LAB #3
1601 University Drive
Marinette, WI 54143

TESTING MACHINE MODEL #: 74 Univ. Tinius Olsen
SERIAL NUMBER: 135330

SPECIMEN ID#		FT.-LB. ENERGY	
All Weld	1	64	L
	2	75	
	3	68	
	4	76	
" "	5	77	H
H.A.Z.	6	134	H
	7	120	
	8	84	
	9	115	
	10	53	L
Base	11	132	
	12	113	L
	13	116	
	14	157	H
	15	128	

AVERAGE SPECIMENS 1 TO 5 73 Ft. Lbs.

AVERAGE SPECIMENS 6 TO 10 106.3 Ft. Lbs.

AVERAGE SPECIMENS 11 TO 15 125.3 Ft. Lbs.

AVERAGE SPECIMENS ___ TO ___ ______

TESTING AGENT SIGNATURE: Malcolm Schroeder
DATE: 11/9/84

IMPACT MATERIAL TEST FORM

TESTING AGENT: N.W.T.I.
DATE: Nov. 9, 1984
TESTED FOR: Bay Shipbuilding Corp.
MATERIAL TYPE: HY 100
SPECIMEN ID#: HY 0 CS
TESTING TEMPERATURE: - 60° F.
MEDIUM: Methanol Anhydrous CH3OH
TYPE OF NOTCH: Charpy V Notch

WISCONSIN STATE WELD
TESTING LAB #3
1601 University Drive
Marinette, WI 54143

TESTING MACHINE MODEL #: 74 Univ. Tinius Olsen
SERIAL NUMBER: 135330

SPECIMEN ID#		FT.-LB. ENERGY	
All Weld	1	30	
	2	38	
	3	33	L
	4	44	H
	5	37	
H.A.Z.	6	118	L
	7	123	
	8	126	H
	9	126	
	10	121	
Base	11	130	
	12	129	
	13	127	L
	14	128	
	15	131	H

AVERAGE SPECIMENS 1 TO 5 33 Ft. Lbs.

AVERAGE SPECIMENS 6 TO 10 123.3 Ft. Lbs.

AVERAGE SPECIMENS 11 TO 15 129 Ft. Lbs.

AVERAGE SPECIMENS ___ TO ___ ______

TESTING AGENT SIGNATURE: Malcolm Schreiner
DATE: 11/9/84

IMPACT MATERIAL TEST FORM

TESTING AGENT: N.W.T.I.
DATE: Nov. 9, 1984
TESTED FOR: Bay Shipbuilding Corp.
MATERIAL TYPE: HY 100
SPECIMEN ID#: HY 0 AC
TESTING TEMPERATURE: - 60° F.
MEDIUM: Methanol Anhydrous CH3OH
TYPE OF NOTCH: Charpy V Notch

WISCONSIN STATE WELD
TESTING LAB #3
1601 University Drive
Marinette, WI 54143

TESTING MACHINE MODEL #: 74 Univ. Tinius Olsen
SERIAL NUMBER: 135330

SPECIMEN ID#		FT.-LB. ENERGY	
All Weld	1	53	H
	2	34	
	3	33	L
	4	42	
	5	35	
H.A.Z.	6	53	L
	7	118	
	8	144	H
	9	82	
	10	118	
Base	11	150	H
	12	139	
	13	140	
	14	134	
	15	125	L

AVERAGE SPECIMENS 1 TO 5 37 Ft. Lbs.

AVERAGE SPECIMENS 6 TO 10 106 Ft. Lbs.

AVERAGE SPECIMENS 11 TO 15 137.6 Ft. Lbs.

AVERAGE SPECIMENS ___ TO ___ ___

TESTING AGENT SIGNATURE: Malcolm Schreiner
DATE: 11/9/84

IMPACT MATERIAL TEST FORM

TESTING AGENT: N.W.T.I.
DATE: Nov. 9, 1984
TESTED FOR: Bay Shipbuilding Corp.
MATERIAL TYPE: HY 100
SPECIMEN ID#: HY 0 FC
TESTING TEMPERATURE: - 60° F.
MEDIUM: Methanol Anhydrous CH3OH
TYPE OF NOTCH: Charpy V Notch

WISCONSIN STATE WELD
TESTING LAB #3
1601 University Drive
Marinette, WI 54143

TESTING MACHINE MODEL #: 74 Univ. Tinius Olsen
SERIAL NUMBER: 135330

SPECIMEN ID#		FT.-LB. ENERGY	
All Weld	1	25	
	2	26	H
	3	25	
	4	24	
	5	24	L
H.A.Z.	6	120	
	7	121	
	8	124	
	9	124	H
	10	118	L
Base	11	135	H
	12	128	L
	13	129	
	14	130	
	15	130	

AVERAGE SPECIMENS 1 TO 5 24.6 Ft. Lbs.

AVERAGE SPECIMENS 6 TO 10 121.6 Ft. Lbs.

AVERAGE SPECIMENS 11 TO 15 129.6 Ft. Lbs.

AVERAGE SPECIMENS ___ TO ___ ___

TESTING AGENT SIGNATURE: Malcolm Schreiner
DATE: 11/9/84

IMPACT MATERIAL TEST FORM

TESTING AGENT: N.W.T.I.
DATE: Nov. 9, 1984
TESTED FOR: Bay Shipbuilding Corp.
MATERIAL TYPE: HY 80
SPECIMEN ID#: HY 8 CS
TESTING TEMPERATURE: - 60° F.
MEDIUM: Methanol Anhydrous CH3OH
TYPE OF NOTCH: Charpy V Notch

WISCONSIN STATE WELD
TESTING LAB #3
1601 University Drive
Marinette, WI 54143

TESTING MACHINE MODEL #: 74 Univ. Tinius Olsen
SERIAL NUMBER: 135330

SPECIMEN ID#		FT.-LB. ENERGY	
All Weld	1	41	H
	2	40	
	3	33	L
	4	34	
	5	37	
H.A.Z.	6	128	H
	7	121	L
	8	124	
	9	127	
	10	126	
Base	11	140	
	12	138	
	13	144	H
	14	134	L
	15	137	

AVERAGE SPECIMENS 1 TO 5 37 Ft. Lbs.

AVERAGE SPECIMENS 6 TO 10 125.6 Ft. Lbs.

AVERAGE SPECIMENS 11 TO 15 138.3 Ft. Lbs.

AVERAGE SPECIMENS ___ TO ___ ___

TESTING AGENT SIGNATURE: Malcolm Schreiner
DATE: 11/9/84

IMPACT MATERIAL TEST FORM

TESTING AGENT: N.W.T.I.
DATE: May 3, 1985
TESTED FOR: Bay Shipbuilding Corp.
MATERIAL TYPE: HY 80
SPECIMEN ID#: HY8 AC-1
TESTING TEMPERATURE: -60F
MEDIUM: Methanol Anhydrous CH3OH
TYPE OF NOTCH: Charpy V Notch

WISCONSIN STATE WELD
TESTING LAB #3
1601 University Drive
Marinette, WI 54143

TESTING MACHINE MODEL #: 74 Univ. Tinius Olsen
SERIAL NUMBER: 135330

SPECIMEN ID#		FT.-LB. ENERGY	
All Weld	1	54	
	2	50	
	3	67	H
	4	44	L
	5	63	
H.A.Z.	6	40	L
	7	65	
	8	58	
	9	70	
	10	90	H
Base	11	142	
	12	147	
	13	141	
	14	135	L
	15	152	H

AVERAGE SPECIMENS 1 TO 5 55.6 Ft. lbs.

AVERAGE SPECIMENS 6 TO 10 64.3 Ft. lbs.

AVERAGE SPECIMENS 11 TO 15 143.3 Ft. lbs.

AVERAGE SPECIMENS ___ TO ___ ______

TESTING AGENT SIGNATURE: ______
DATE: ______

IMPACT MATERIAL TEST FORM

TESTING AGENT: N.W.T.I.
DATE: Nov. 9, 1984
TESTED FOR: Bay Shipbuilding Corp.
MATERIAL TYPE: HY 80
SPECIMEN ID#: HY 8 AC HHT
TESTING TEMPERATURE: - 60° F.
MEDIUM: Methanol Anhydrous CH3OH
TYPE OF NOTCH: Charpy V Notch

WISCONSIN STATE WELD
TESTING LAB #3
1601 University Drive
Marinette, WI 54143

TESTING MACHINE MODEL #: 74 Univ. Tinius Olsen
SERIAL NUMBER: 135330

SPECIMEN ID#		FT.-LB. ENERGY	
All Weld	1	19	H
	2	15	
	3	15	
	4	17	
	5	12.5	L
H.A.Z.	6	47	
	7	47	
	8	33	L
	9	82	H
	10	57	
Base	11	152	
	12	138	L
	13	166	H
	14	146	
	15	152	

AVERAGE SPECIMENS 1 TO 5 15.6 Ft. Lbs.

AVERAGE SPECIMENS 6 TO 10 50.3 Ft. Lbs.

AVERAGE SPECIMENS 11 TO 15 150 Ft. Lbs.

AVERAGE SPECIMENS ___ TO ___ ___

TESTING AGENT SIGNATURE: Malcolm Sobczak
DATE: 11/9/84

IMPACT MATERIAL TEST FORM

TESTING AGENT: N.W.T.I.
DATE: May 3, 1985
TESTED FOR: Bay Shipbuilding Corp.
MATERIAL TYPE: HY80
SPECIMEN ID#: HY8 HHI-1
TESTING TEMPERATURE: -60F
MEDIUM: Methanol Anhydrous CH3OH
TYPE OF NOTCH: Charpy V Notch

WISCONSIN STATE WELD
TESTING LAB #3
1601 University Drive
Marinette, WI 54143

TESTING MACHINE MODEL #: 74 Univ. Tinius Olsen
SERIAL NUMBER: 135330

SPECIMEN ID#		FT.-LB. ENERGY	
All Weld	1	30	
	2	28	L
	3	37	H
	4	35	
	5	33	
H.A.Z.	6	138	
	7	136	L
	8	147	H
	9	145	
	10	140	
Base	11	73	L
	12	98	H
	13	77	
	14	94	
	15	85	

AVERAGE SPECIMENS 1 TO 5 32.6 Ft. lbs.

AVERAGE SPECIMENS 6 TO 10 141.0 Ft. lbs.

AVERAGE SPECIMENS 11 TO 15 85.3 Ft. lbs.

AVERAGE SPECIMENS ___ TO ___ ___

TESTING AGENT SIGNATURE: ___
DATE: ___

IMPACT MATERIAL TEST FORM

TESTING AGENT: N.W.T.I.
DATE: Nov. 9, 1984
TESTED FOR: Bay Shipbuilding Corp.
MATERIAL TYPE: HY 80
SPECIMEN ID#: HY 8 AC
TESTING TEMPERATURE: - 60° F.
MEDIUM: Methanol Anhydrous CH_3OH
TYPE OF NOTCH: Charpy V Notch

WISCONSIN STATE WELD
TESTING LAB #3
1601 University Drive
Marinette, WI 54143

TESTING MACHINE MODEL #: 74 Univ. Tinius Olsen
SERIAL NUMBER: 135330

SPECIMEN ID#		FT.-LB. ENERGY	
All Weld	1	21	H
	2	16	
	3	12	L
	4	18	
" "	5	19	
H.A.Z.	6	105	
	7	142	
	8	92	L
	9	108	
	10	154	H
Base	11	140	
	12	142	
	13	150	H
	14	144	
	15	132	L

AVERAGE SPECIMENS 1 TO 5 17.6 Ft. Lbs.

AVERAGE SPECIMENS 6 TO 10 118.3 Ft. Lbs.

AVERAGE SPECIMENS 11 TO 15 145 Ft. Lbs.

AVERAGE SPECIMENS ___ TO ___ ______

TESTING AGENT SIGNATURE: Malcolm M. Schreiner
DATE: 11/9/84

IMPACT MATERIAL TEST FORM

TESTING AGENT: N.W.T.I.
DATE: Nov. 9, 1984
TESTED FOR: Bay Shipbuilding Corp.
MATERIAL TYPE: HY 80
SPECIMEN ID#: HY 8 MC
TESTING TEMPERATURE: - 60° F.
MEDIUM: Methanol Anhydrous CH3OH
TYPE OF NOTCH: Charpy V Notch

WISCONSIN STATE WELD
TESTING LAB #3
1601 University Drive
Marinette, WI 54143

TESTING MACHINE MODEL #: 74 Univ. Tinius Olsen
SERIAL NUMBER: 135330

SPECIMEN ID#		FT.-LB. ENERGY	
All Weld	1	61	H
	2	49	
	3	50	
	4	40	
	5	56	
H.A.Z.	6	146	H
	7	141	
	8	145	
	9	136	L
	10	139	
Base	11	151	
	12	134	L
	13	148	
	14	149	
	15	152	H

AVERAGE SPECIMENS 1 TO 5 54.6 Ft. Lbs.

AVERAGE SPECIMENS 6 TO 10 141.6 Ft. Lbs.

AVERAGE SPECIMENS 11 TO 15 149.3 Ft. Lbs.

AVERAGE SPECIMENS ___ TO ___ ______

TESTING AGENT SIGNATURE: Malcolm Adjusnier
DATE: 11/19/84

IMPACT MATERIAL TEST FORM

TESTING AGENT: N.W.T.I.
DATE: May 3, 1985
TESTED FOR: Bay Shipbuilding Corp.
MATERIAL TYPE: HY 100
SPECIMEN ID#: HY0 AC 1
TESTING TEMPERATURE: -60F
MEDIUM: Methanol Anhydrous CH3OH
TYPE OF NOTCH: Charpy V Notch

WISCONSIN STATE WELD
TESTING LAB #3
1601 University Drive
Marinette, WI 54143

TESTING MACHINE MODEL #: 74 Univ. Tinius Olsen
SERIAL NUMBER: 135330

SPECIMEN ID#		FT.-LB. ENERGY	
All Weld	1	55	
	2	50	
	3	60	
	4	63	H
	5	48	L
H.A.Z.	6	55	
	7	58	
	8	60	
	9	77	H
	10	54	L
Base	11	129	L
	12	135	H
	13	131	
	14	131	
	15	130	

AVERAGE SPECIMENS 1 TO 5 55.0 Ft. lbs.

AVERAGE SPECIMENS 6 TO 10 57.6 Ft. lbs.

AVERAGE SPECIMENS 11 TO 15 130.6 Ft. lbs.

AVERAGE SPECIMENS ___ TO ___ ______

TESTING AGENT SIGNATURE: ______
DATE: ______

APPENDIX C - HARDNESS TEST FORMS

Hardness Data Explanation

I. Test Equipment

The tester used consists of a Wilson Rockwell Twin Testor, Model 3TY-a-Rb, serial #279. The machine was serviced 6-28-84 to ASTM-E 18 standards.

II. Data Sheet Explanation

The data sheets contain the following data:

Weld sample number, date of the test, Rockwell test block data, machine test data, weld sample base metal hardness, and a graph of the hardness data vs position of the test. All hardness data was run on the superficial scale R30N. This scale allows a smaller test dent so readings could be taken closer together.

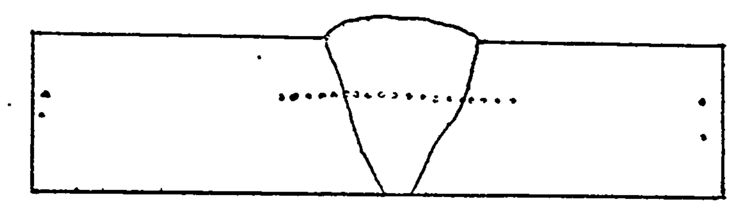
111. Sample Test Procedure

1. The weld test samples were etched with appropriate etch solution to relieve the welded area and the base metal-weld boundary.

2. A series of three tests were run on the test.block . to determine the operational accuracy of the hardness tester.

3. To establish base metal hardness, hardness tests were taken on the ends of the sample away from the heat effected area. Three readings were taken and averaged.

4. A series of about 20 single tests were run across the weld to establish a hardness profile of the welded area. This series was started about 3/8″ from the weld boundary and ended about 3/8″ in the base metal on the opposite side. Tests were taken at about 1/16″ increments. Since the exact placements could not be accomplished, the increment distances vary slightly.



5. The test dents were counted to determine the division line between the base metal and the weld pool. These boundaries are marked on the hardness graph.

6. Any samples showing inconsistent data were retested.

7. After all samples were tested, the Rockwell test block was retested to determine machine accuracy.

IV. Test Results and Explanation

The hardness value of the standard test block and the "machine test" show good correlation. The hardness of the test block recorded is R30N 47.0± 1.0 and the machine test averaged R30N 46.8. Tests run on the test block after weld sample testing again show good consistency with an average of R30N 46.7.

The first and last hardness tests on the "series" show good correlation with that of the base metal average. In all cases the HY and EH steel samples show that there are hardened areas in the heat affected zones next to the weld pool . The maximum hardness in these areas was probably not determined in all cases. However, the data does show substantial increase over the base metal hardness.

The–hardness of the "weld metals" of sample Hy-8-Ac shows a value slightly lower than that of the base metal. Samples Hy-O-CS, Hy-O-FC, Hy-8-FC, EH-6-FC, and EH-6-CS show a hardness that is slightly harder than the base metal average. Weld samples Hy-O-AC, Hy-8-MC, Hy-8-cs, and Hy-8-AC-HHI show a hardness about even with that of

continued

the base metal. Both stainless steel samples show a "weld metal" that is about 10 R30N points higher than that of the base metal.

Signed: Quentin Ruprecht Date: November 6, 1984

HARDNESS DATA

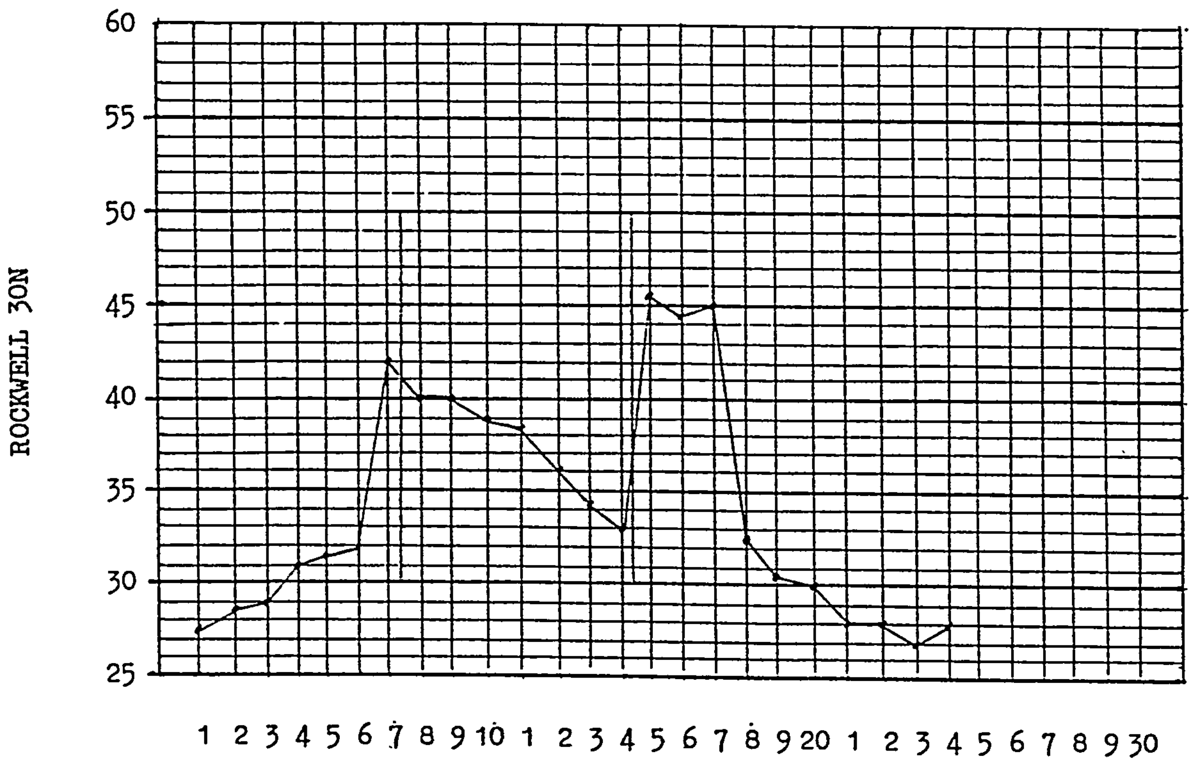
SAMPLE NUMBER EH-6-FC DATE OCTOBER 3,1984

ROCKWELL TEST BLOCK 71R05358 R30N 47.0 ± 1.0

MACHINE TEST AVERAGE 46.5, 47.5, 46.5 = 46.8

TEST	R30N	TEST	R30N	TEST	R30N
1	27.5	11	38.5	21	28.0
2	28.5	12	36.0	22	28.0
3	29.0	13	34.5	23	27.0
4	31.0	14	33.0	24	28.0
5	31.5	15	45.5	25	
6	32.0	16	44.5	26	
7	42.0	17	45.0	27	
8	40.0	18	32.5	28	
9	40.0	19	30.5	29	
10	39.0	20	30.0	30	

BASE METAL HARDNESS R30N 26.0, 25.0, 26.0 = 25.7



TEST NUMBER

APPROXIMATELY 1/16" INCREMENTS

MARAD PROJECT 3205

HARDNESS DATA

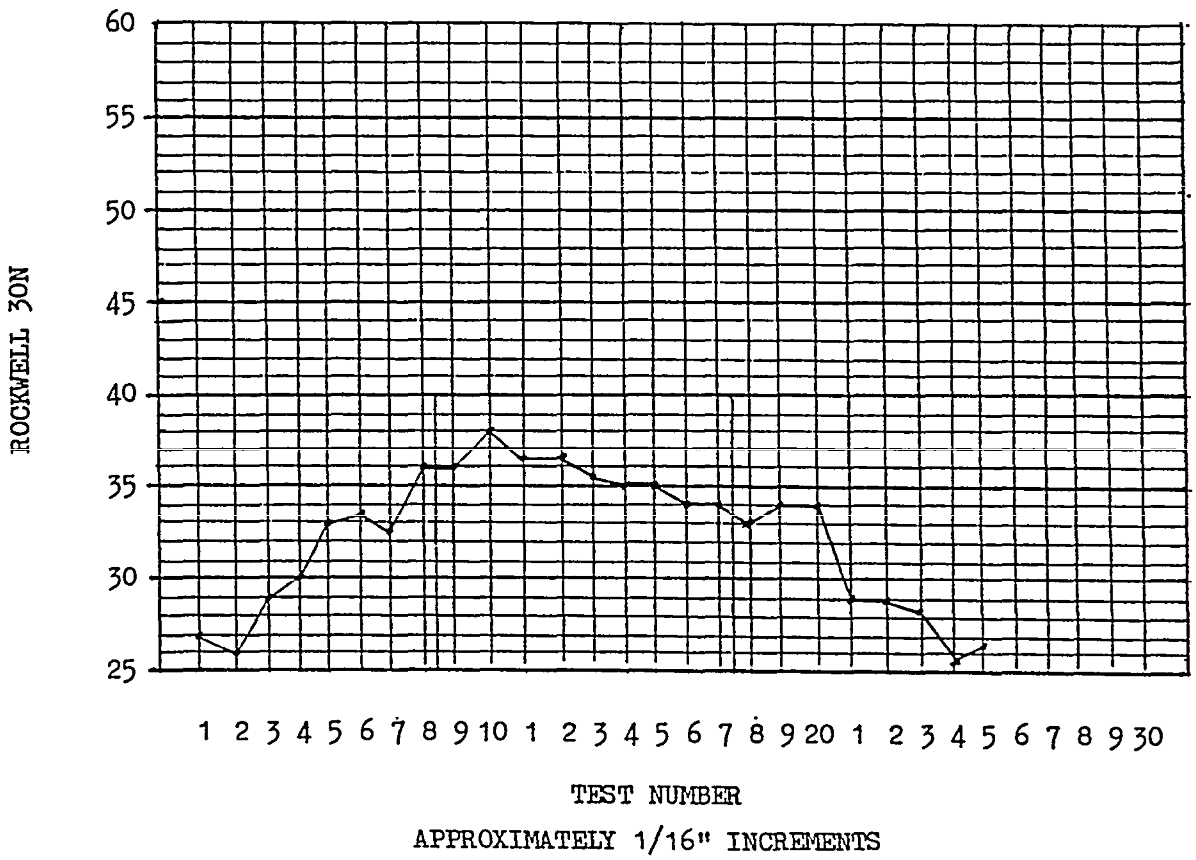
SAMPLE NUMBER SS-L-CS DATE OCTOBER 3,1984

ROCKWELL TEST BLOCK 71R05358 R30N 47.0 ± 1.0

MACHINE TEST AVERAGE 46.5, 47.5, 46.5 = 46.8

TEST	R30N	TEST	R30N	TEST	R30N
1	27.0	11	36.5	21	29.0
2	26.0	12	36.5	22	29.0
3	29.0	13	35.5	23	28.5
4	30.0	14	35.0	24	25.5
5	33.0	15	35.0	25	26.5
6	33.5	16	34.0	26	
7	32.5	17	34.0	27	
8	36.0	18	33.0	28	
9	36.0	19	34.0	29	
10	38.0	20	34.0	30	

BASE METAL HARDNESS R30N 26.0, 27.0, 26.5 = 26.5



MARAD PROJECT 3205

HARDNESS DATA

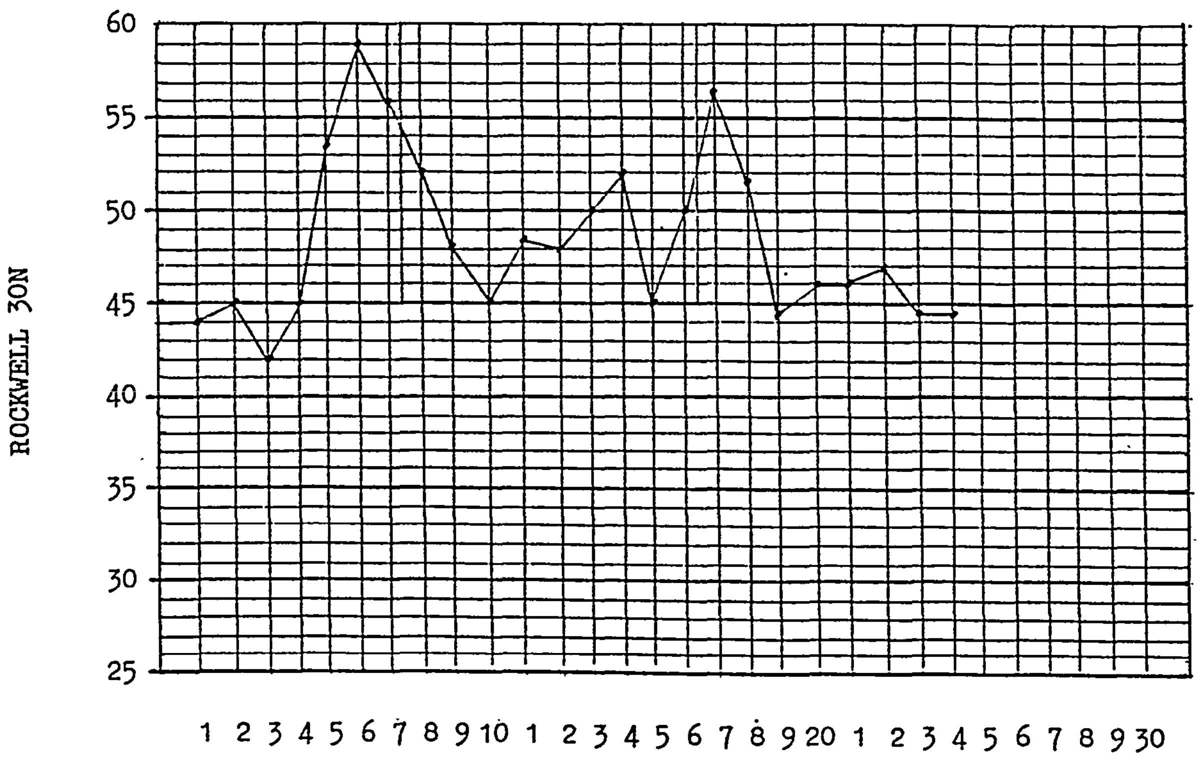
SAMPLE NUMBER HY-O-CS DATE OCTOBER 3,1984

ROCKWELL TEST BLOCK 71R05358 R30N 47.0 ± 1.0

MACHINE TEST AVERAGE 46.5, 47.5, 46.5 = 46.8

TEST	R30N	TEST	R30N	TEST	R30N
1	44.0	11	48.5	21	46.0
2	45.0	12	48.0	22	47.0
3	42.0	13	50.0	23	44.5
4	45.0	14	52.0	24	44.5
5	53.5	15	45.0	25	
6	59.0	16	50.0	26	
7	56.0	17	56.5	27	
8	52.0	18	51.5	28	
9	48.0	19	44.5	29	
10	45.0	20	46.0	30	

BASE METAL HARDNESS R30N 47.0,44.0,46.5 = 45.8



TEST NUMBER

APPROXIMATELY 1/16" INCREMENTS

MARAD PROJECT 3205

HARDNESS DATA

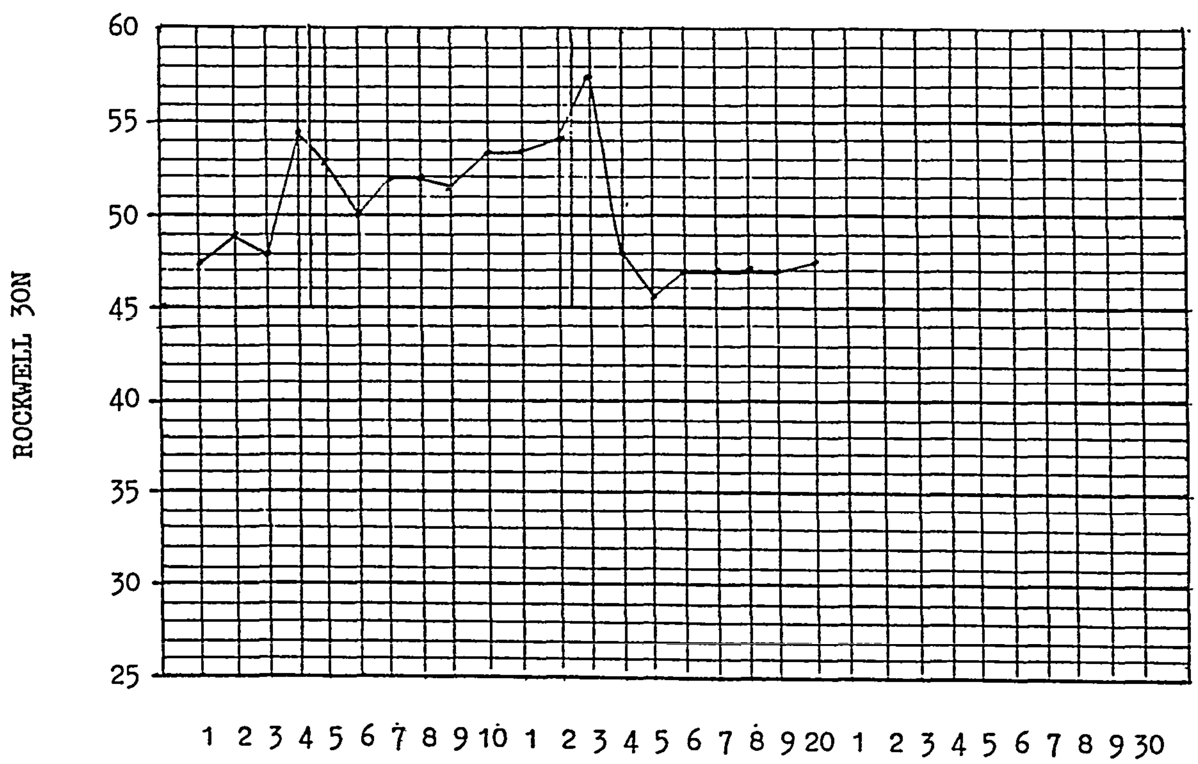
SAMPLE NUMBER HY-0-FC DATE OCTOBER 3,1984

ROCKWELL TEST BLOCK 71R05358 R30N 47.0 ± 1.0

MACHINE TEST AVERAGE 46.5, 47.5, 46.5 = 46.8

TEST	R30N	TEST	R30N	TEST	R30N
1	47.5	11	53.5	21	
2	49.0	12	54.0	22	
3	48.0	13	57.5	23	
4	54.5	14	48.0	24	
5	53.0	15	45.5	25	
6	50.0	16	47.0	26	
7	52.0	17	47.0	27	
8	52.0	18	47.0	28	
9	51.5	19	47.0	29	
10	53.5	20	47.5	30	

BASE METAL HARDNESS R30N 48.0, 46.0, 45.0 = 46.3



TEST NUMBER

APPROXIMATELY 1/16" INCREMENTS

MARAD PROJECT 3205

HARDNESS DATA

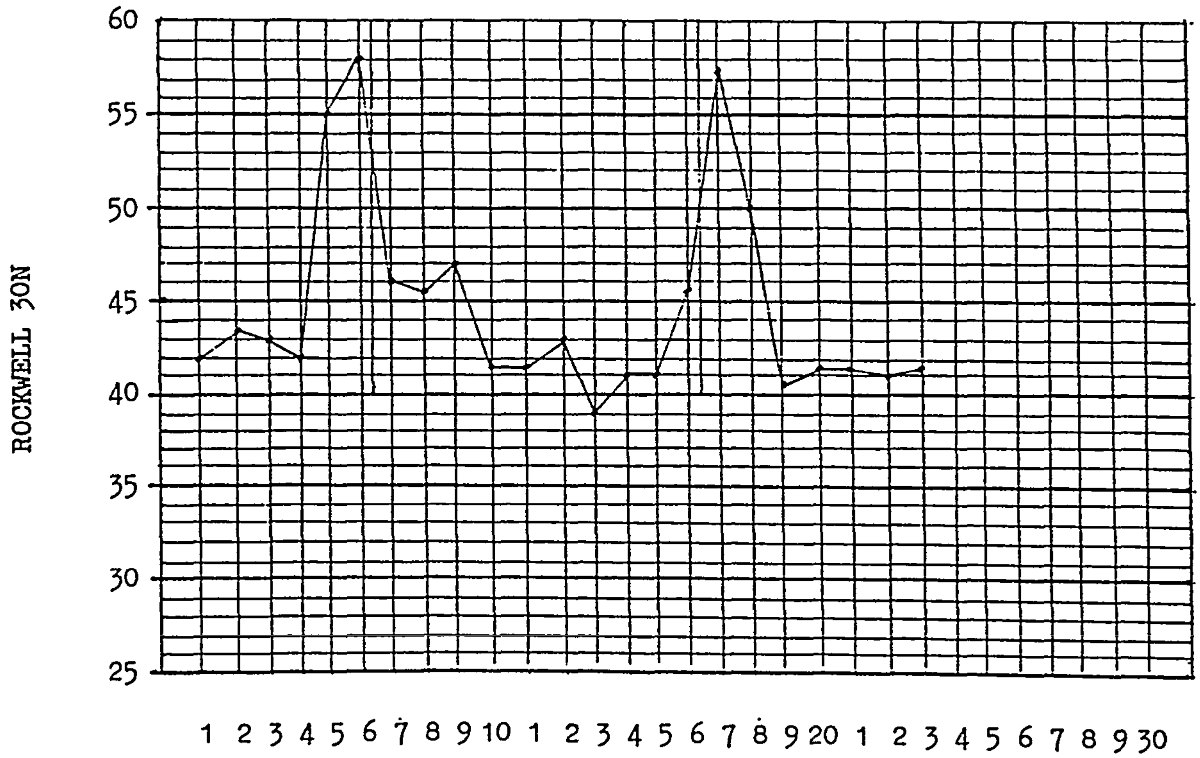
SAMPLE NUMBER HY-8-CS DATE OCTOBER 3,1984

ROCKWELL TEST BLOCK 71R05358 R30N 47.0 ± 1.0

MACHINE TEST AVERAGE 46.5, 47.5, 46.5 = 46.8

TEST	R30N	TEST	R30N	TEST	R30N
1	42.0	11	41.5	21	41.5
2	43.5	12	43.0	22	41.0
3	43.0	13	39.0	23	41.5
4	42.0	14	41.0	24	
5	55.0	15	41.0	25	
6	58.0	16	45.5	26	
7	46.0	17	57.5	27	
8	45.5	18	50.0	28	
9	47.0	19	40.5	29	
10	41.5	20	41.5	30	

BASE METAL HARDNESS R30N 42.0, 41.0, 40.0 = 41.0



TEST NUMBER

APPROXIMATELY 1/16" INCREMENTS

MARAD PROJECT 3205

HARDNESS DATA

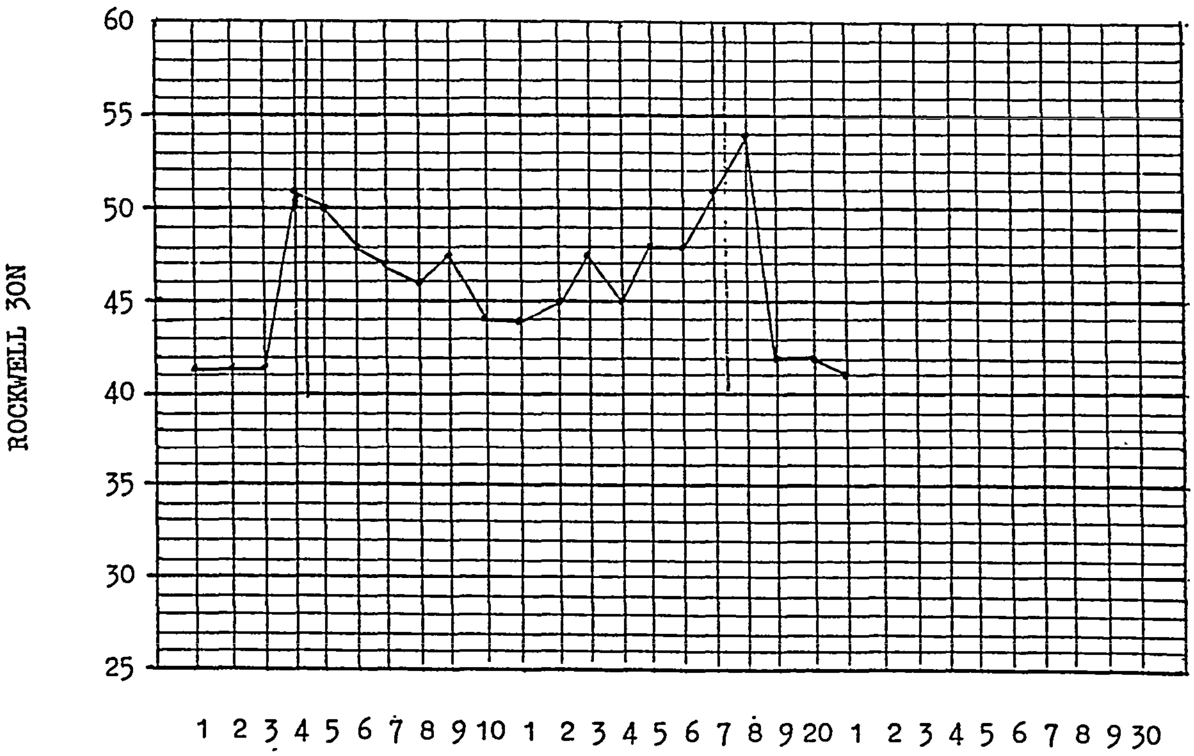
SAMPLE NUMBER HY-8-FC DATE OCTOBER 3,1984

ROCKWELL TEST BLOCK 71R05358 R30N 47.0 ± 1.0

MACHINE TEST AVERAGE 46.5, 47.5, 46.5 = 46.8

TEST	R30N	TEST	R30N	TEST	R30N
1	41.5	11	44.0	21	42.0
2	41.5	12	45.0	22	41.0
3	41.5	13	47.5	23	
4	51.0	14	45.0	24	
5	50.0	15	48.0	25	
6	48.0	16	48.0	26	
7	47.0	17	51.0	27	
8	46.0	18	54.0	28	
9	47.5	19	42.0	29	
10	44.0	20	42.5	30	

BASE METAL HARDNESS R30N 42.0, 42.0, 41.5 = 41.8



TEST NUMBER

APPROXIMATELY 1/16" INCREMENTS

MARAD PROJECT 3205

HARDNESS DATA

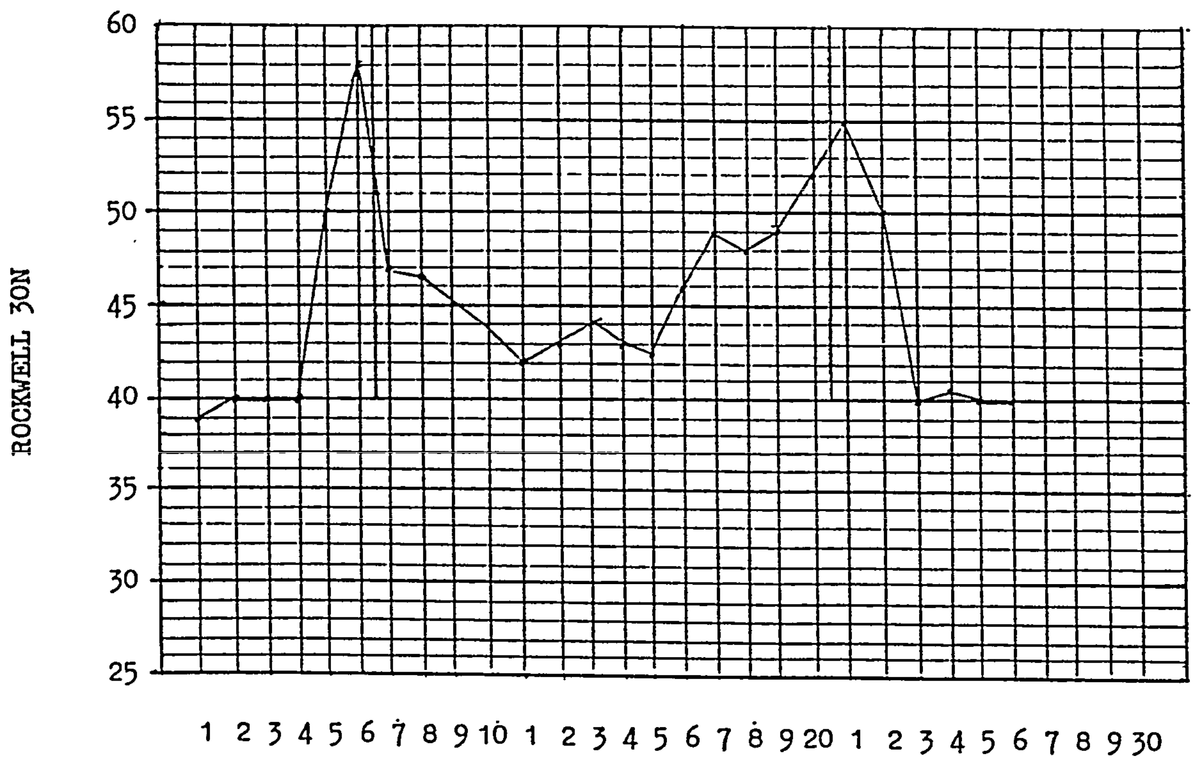
SAMPLE NUMBER Hy-8-AC-1 DATE May 9, 1985

ROCKWELL TEST BLOCK 71R05358 R30N 47.0 ± 1.0

MACHINE TEST AVERAGE R30N 47.1, 46.9, 46.5 = 46.8

TEST	R30N	TEST	R30N	TEST	R30N
1	39.0	11	42.0	21	55.0
2	40.0	12	43.0	22	50.0
3	40.0	13	44.0	23	40.0
4	40.0	14	43.0	24	40.5
5	50.0	15	42.5	25	40.0
6	58.0	16	46.0	26	40.0
7	47.0	17	49.0	27	
8	46.5	18	48.0	28	
9	45.0	19	49.0	29	
10	44.0	20	52.0	30	

BASE METAL HARDNESS R30N 40.0, 39.0, 41.0 = 40.0



TEST NUMBER

APPROXIMATELY 1/16" INCREMENTS

MARAD PROJECT 3205

HARDNESS DATA

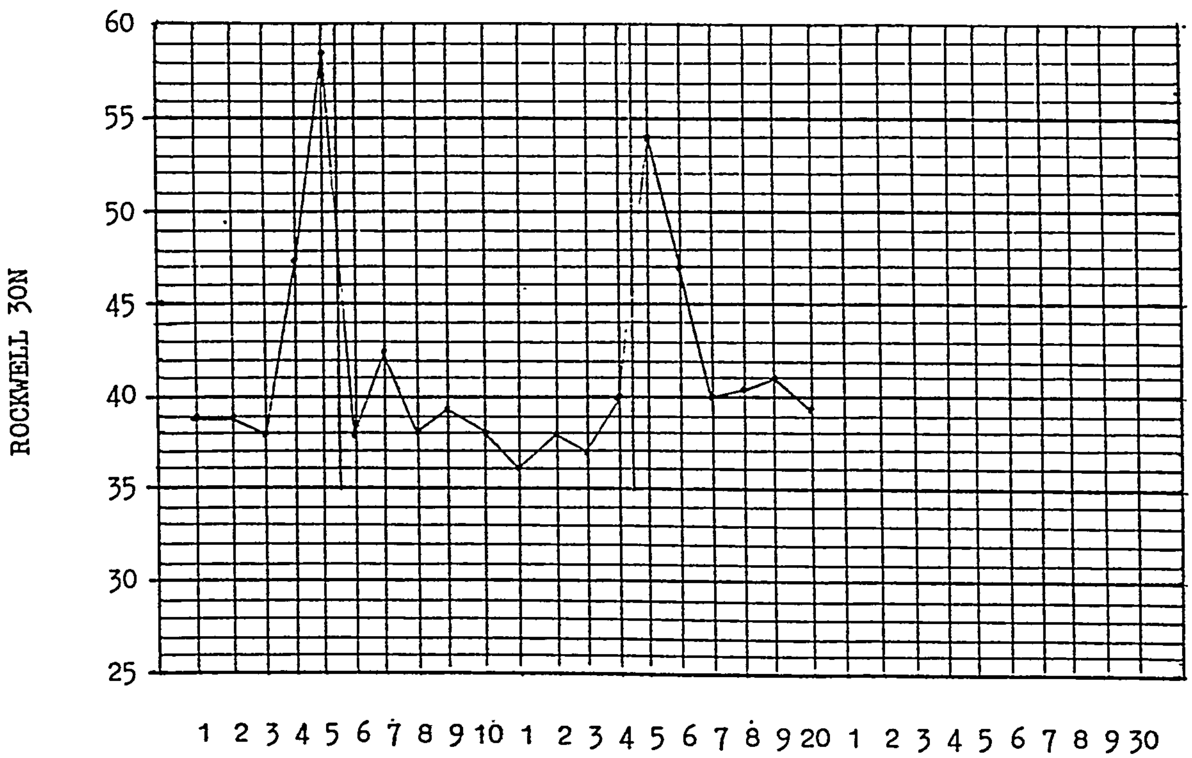
SAMPLE NUMBER HY-8-AC-HHI DATE OCTOBER 3,1984

ROCKWELL TEST BLOCK 71R05358 R30N 47.0 ± 1.0

MACHINE TEST AVERAGE 46.5, 47.5, 46.5 = 46.8

TEST	R30N	TEST	R30N	TEST	R30N
1	39.0	11	36.0	21	
2	39.0	12	38.0	22	
3	38.0	13	37.0	23	
4	47.5	14	40.0	24	
5	58.5	15	54.0	25	
6	38.0	16	47.0	26	
7	42.5	17	40.0	27	
8	38.0	18	40.5	28	
9	39.5	19	41.0	29	
10	38.0	20	39.5	30	

BASE METAL HARDNESS R30N 39.0, 36.0, 42.0 = 39.0



TEST NUMBER

APPROXIMATELY 1/16" INCREMENTS

MARAD PROJECT 5205

HARDNESS DATA

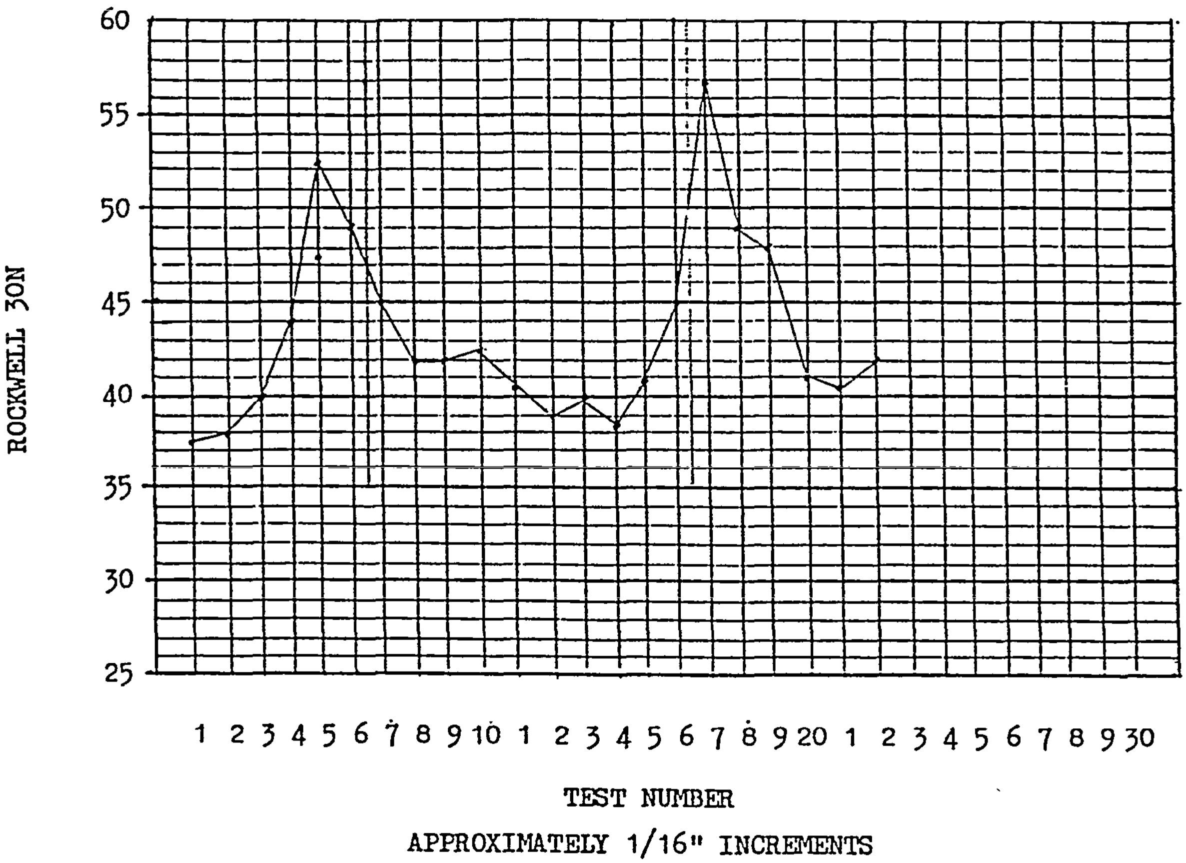
SAMPLE NUMBER Hy-8-HHI-1 DATE May 9, 1985

ROCKWELL TEST BLOCK 71R05358 R30N 47.0 ± 1.0

MACHINE TEST AVERAGE R30N 47.1, 46.9, 46.5 = 46.8

TEST	R30N	TEST	R30N	TEST	R30N
1	37.5	11	40.5	21	40.5
2	38.0	12	39.0	22	42.0
3	40.0	13	40.0	23	
4	44.0	14	38.5	24	
5	52.5	15	41.0	25	
6	49.0	16	45.0	26	
7	45.0	17	57.0	27	
8	42.0	18	49.0	28	
9	42.0	19	48.0	29	
10	42.5	20	41.0	30	

BASE METAL HARDNESS R30N 39, 42, 40.5 = 40.5



MARAD PROJECT 3205

HARDNESS DATA

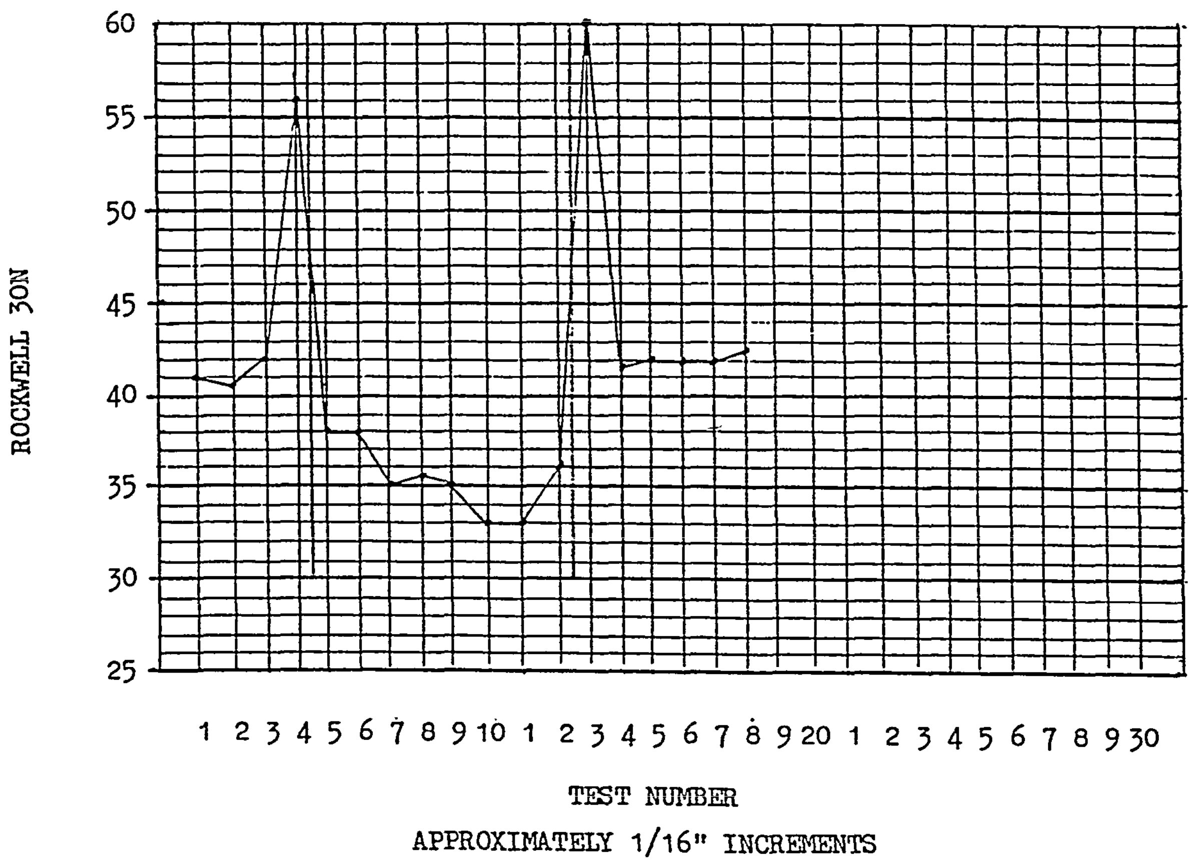
SAMPLE NUMBER HY-8-AC DATE OCTOBER 3,1984

ROCKWELL TEST BLOCK 71R05358 R30N 47.0 ± 1.0

MACHINE TEST AVERAGE 46.5, 47.5, 46.5 = 46.8

TEST	R30N	TEST	R30N	TEST	R30N
1	41.0	11	33.0	21	
2	40.5	12	36.0	22	
3	42.0	13	60.0	23	
4	56.0	14	41.5	24	
5	38.0	15	42.0	25	
6	38.0	16	42.0	26	
7	35.0	17	42.0	27	
8	35.5	18	42.5	28	
9	35.0	19		29	
10	33.0	20		30	

BASE METAL HARDNESS R30N 42.5, 41.5, 42.5 = 42.2



MARAD PROJECT 3205

HARDNESS DATA

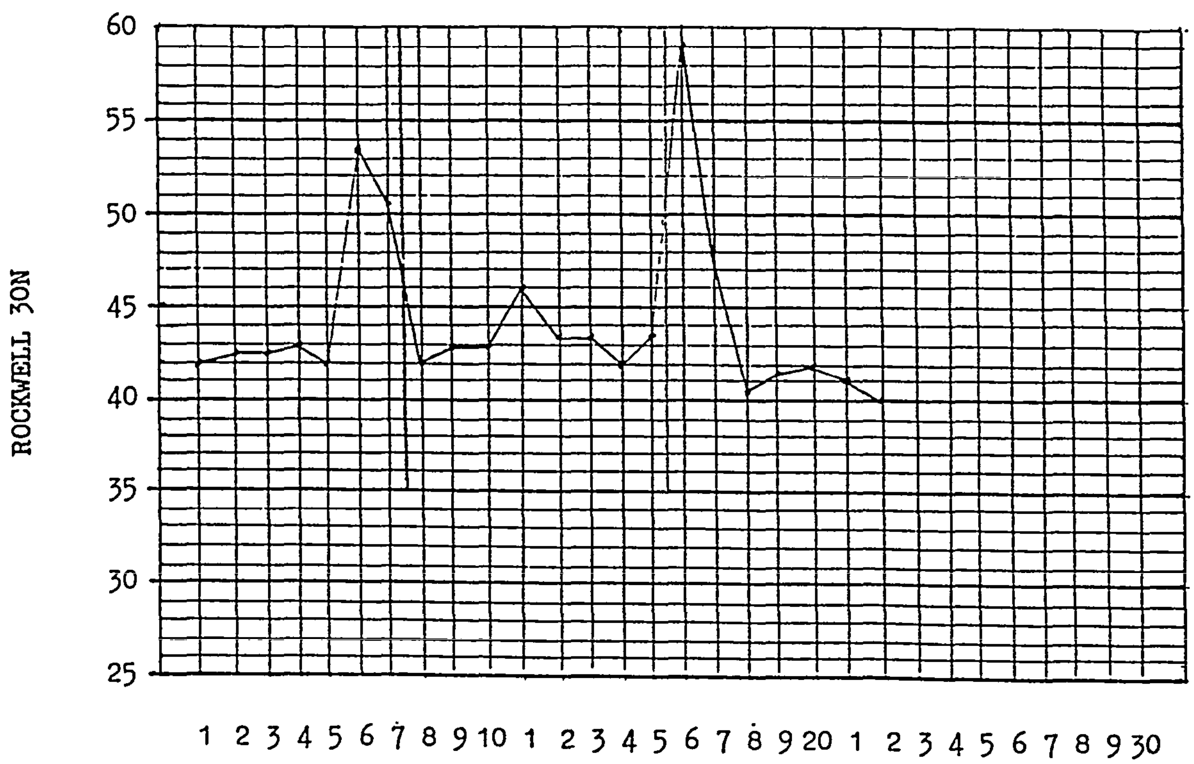
SAMPLE NUMBER HY-8-MC DATE OCTOBER 3,1984

ROCKWELL TEST BLOCK 71R05358 R30N 47.0 ± 1.0

MACHINE TEST AVERAGE 46.5, 47.5, 46.5 = 46.8

TEST	R30N	TEST	R30N	TEST	R30N
1	42.0	11	46.0	21	41.0
2	42.5	12	43.5	22	40.0
3	42.5	13	43.5	23	
4	43.0	14	42.0	24	
5	42.0	15	43.5	25	
6	53.5	16	59.0	26	
7	50.5	17	48.0	27	
8	42.0	18	40.5	28	
9	43.0	19	41.5	29	
10	43.0	20	42.0	30	

BASE METAL HARDNESS R30N 43.0, 41.0, 41.0 = 41.7



TEST NUMBER

APPROXIMATELY 1/16" INCREMENTS

MARAD PROJECT 3205

HARDNESS DATA

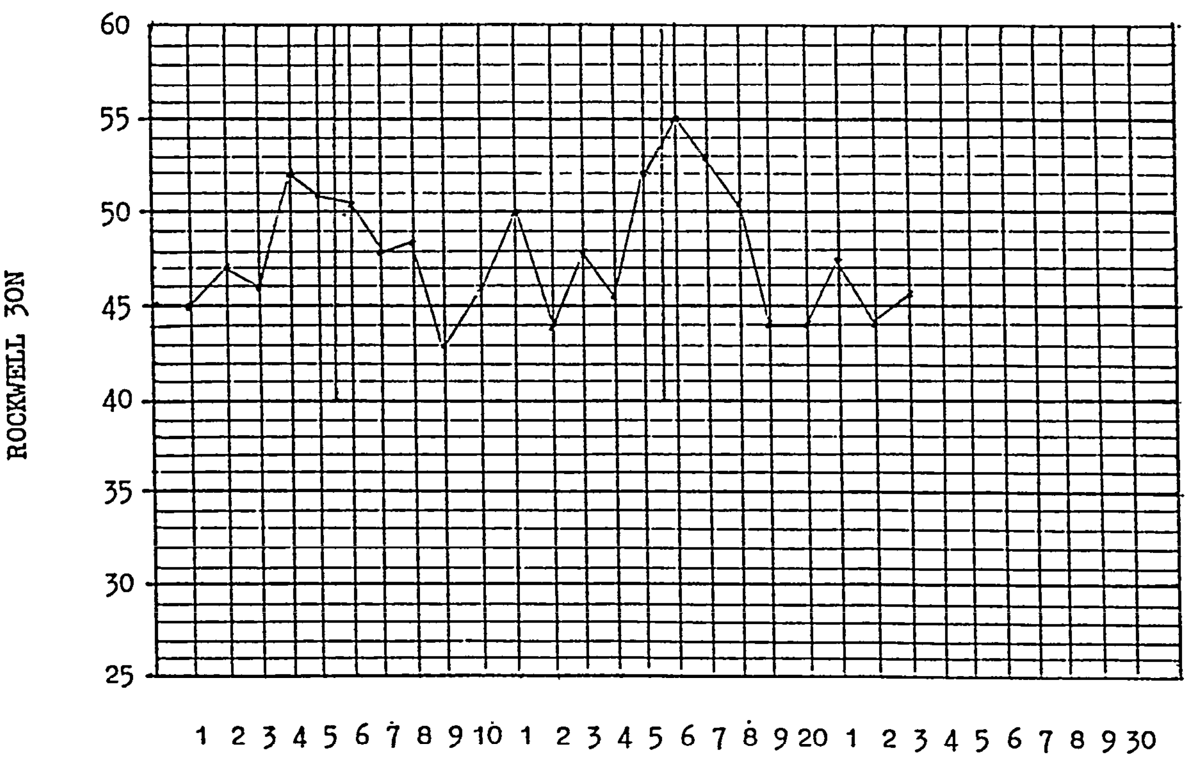
SAMPLE NUMBER. Hy-O-AC-1 DATE May 9, 1985

ROCKWELL TEST BLOCK 71R05358 R30N 47.0 ± 1.0

MACHINE TEST AVERAGE R30N 47.1, 46.9, 46.5 = 46.8

TEST	R30N	TEST	R30N	TEST	R30N
1	45.0	11	50.0	21	47.5
2	47.0	12	44.0	22	44.0
3	46.0	13	48.0	23	46.5
4	52.0	14	45.5	24	
5	51.0	15	52.0	25	
6	50.5	16	55.0	26	
7	48.0	17	53.0	27	
8	48.5	18	50.5	28	
9	43.0	19	44.0	29	
10	46.0	20	44.0	30	

BASE METAL HARDNESS R30N 43.0, 41.0, 45.0 = 43.0



TEST NUMBER

APPROXIMATELY 1/16" INCREMENTS

APPENDIX D - SPECTROGRAPHIC FORMS

MARAD PROJECT 3205

Spectrographic Data
Explanation and Results

I. Spectrographic apparatus:

The spectrometer used for this data was a Jarrell-Ash Atomcomp Model 750 direct reading vacuum unit. The spark stand consists of an electronic controlled wave source. A Digital PDP 8-a computer analyzed the results. Argon gas of 99.96% purity was used in the spark chamber.

II. Test procedure.

1. The spark chamber was cleaned before testing.

2. The spectrometer electrical components were warmed up with at least 16 burns prior to standardization.

3. The spectrometer was standardized by:

   a. Setting the optical monitor to maximum peak value.

   b. Working standards were burnt to standardize each element in the appropriate matrix.

c. An analytical standard was burnt to determine the accuracy of the standardization.

4. Each sample was freshly ground before testing

5. Four burns were run on each sample. The results of each burn were averaged by the computer. The burns on the base metal were taken at each end and on both sides of the sample. The burns of the weld metal were taken in the center of the weld pool and on both sides of the sample.

6. A set of three or four samples were run consecutively on a standardization.

7. A final test was run on the same analytical standard to verify the accuracy of the spectrometer operation.

111. Explanation of the data sheets.

This is the explanation of the major data lines, starting at the top of the data pages.

1. Line one contains the project title, the sample name, and the placement of the burns.

2. There is a set of two or four burns listed with the burn number, time, and date of test. Next are two “IS” numbers that represent the intensity of the iron count and the operation of the electronics. Also, listed is a line of

element symbols and the “intensity ratio” value of that element. The symbols < or > in front of the element value represents the value as being “less than” or “greater than” that capable of being determined by the matrix. Ratio value between the different burns should not vary by large amounts. However, small variation is to be expected. The “average” line represents the average of the burn ratios printed out in percent concentration. These percent concentration numbers are then the approximate amount of element in the sample. Even though there are four burns averaged”, these percentages can only represent a close approximation of the exact amounts.

IV. Observations of the weld sample test data.

The following observations are by sample sets.

1. Samples Hy-8-CS, Hy-8-FC, Hy-8-AC-HHI, Hy-8-MC, dated 9-15-84 and sample Hy-8-AC, dated 9-19-84.

   a. The average percent values of the NBS standard 1261, before sample burning, show expected correlation with the accepted percentages.

   b. The NBS analytical standard burns before and after show expected correlation. Most elements obtained a difference of only ± several hundredths of 1%. Tungsten, however, varies the most and does tend to drift on this machine.

c. The base metal burns of all tested samples show good consistency and within expected variations.

d. Carbon content of all weld metals is less than 0.108% concentration.

e. The weld materials tested show concentration values with significant differences in the elements of MN, S1, CR, and MO. The remaining elements tested show minor percentage difference.

2. Weld samples Hy-O-CS, Hy-O-FC, and Hy-O-AC, dated 9-22-84.

a. The average percent values of the NBS analytical standard 1261, before sample testing, show expected correlation with the accepted values.

b. The NBS analytical standard burns, before and after, show expected correlation. Most elements obtained a difference of only ± several hundredths of 1%.

c. The base metal burns of all tested samples show good consistency and within expected variations.

d. All weld metals tested show a carbon content of less than 0.108% concentration.

e. The weld metals tested show significant differences in the elements MN, S1, CR, and minor differences in the remaining elements.

3. Weld samples EH-6-CS, EH-6-FC, dated 9-19-84.

   a. The average percent values of the NBS analytical standard burns, before sample testing, show expected correlation with the accepted values.

   b. The NBS analytical standard burns before and after samples show expected correlation. Most elements obtained a difference of only ± several hundredths of 1%.

   c. The base metal burns of all tested samples show good consistency and within expected variances.

   d. The carbon content of the weld metal of sample EH-6-CS has a value less than 0.108%, while sample EH-6-FS has a content slightly more than 0.108%.

   e. The weld metals of the two samples have a significant difference in elements of MN, SI, NI, while remaining elements show minor variances.

4. Weld samples SS-L-CS and SS-L-FC, dated 9-20-84.

   a. The MBH analytical standard 12851-G burns, before sample burning, show expected correlation with the accepted values. The element copper cannot be determined by this matrix as there is insufficient programming data.

b. The MBH analytical standard burns before and after sample sample burning show expected correlation. Most elements obtained a difference of only + several hundredths of 1%. Chromium and molybdenum obtained difference in ± several tenths of 1%.

c. The base metal burns show good consistency between the two samples.

d. The weld metals of the two samples show carbon content as being less than 0.039%. Manganese in the “FC” weld metal is somewhat higher than that of the “CS” weld metal. Silicon, however, is less in the “FC” weld metal. The remaining elements tested show similar contents.

e. The weld metals and base metals of the two samples are very similar in composition to each other with only minor differences in the major-alloying elements of MN, CR, NI, and MO.

Signed: Quentin Ruprecht Date: November 6, 1984.

MARAD PROJECT 3205

Spectrographic Data

5. Weld samples Hy-8-AC-1, HY-8-HH-1, and Hy-O-AC-l.

   a. The average percent values of the NBS analytical standard burns, before sample testing, show expected correlation with the accepted values.

   b. The NBS analytical standard burns before and after samples show expected correlation. Most elements obtained a difference of only ± several hundredths of 1%.

   c. The base metal burns of all tested samples show good consistency and within expected variances.

   d. The carbon content of the weld sample for Hy-O-AC-1, Hy-8-HHI-1, and Hy-8-AC-l has a value less than 0.108% and is considerably less than the base metals.

   e. The weld metal of all samples has a significant difference in elements MN, and CR, compared to the base metal.

Signed: Quentin Ruprecht Date: May 29, 1985.

U.S. Department of Commerce
Rogers C. B. Morton,
Secretary
National Bureau of Standards
Ernest Ambler, Acting Director

National Bureau of Standards

Certificate of Analysis

Standard Reference Material 1261

AISI 4340 Steel

This standard is in the form of disks 31 mm (1 1/4 in) in diameter and 19 mm (3/4 in) thick, generally for use in optical emission and x-ray spectrometric analysis.[a]

Element	Percent, by weight	Element	Percent, by weight
Carbon	0.38_2	Aluminum (total)	0.02_1
Manganese	.66	Niobium	.022
Phosphorus	.015	Tantalum	.020
Sulfur	.017	Boron	.0005
Silicon	.223	Lead	$.00002_5$
Copper	.042	Zirconium	.009
Nickel	1.99	Antimony	.0042
Chromium	0.69_0	Bismuth	.0004
Vanadium	.011	Silver	.0004
Molybdenum	.19	Calcium	$.00002_8$
Tungsten	.017	Magnesium	.00018
Cobalt	.030	Selenium	.004
Titanium	.020	Tellurium	.0006
Arsenic	.017	Cerium	.0014
Tin	.010	Lanthanum	.0004
		Neodymium	$.0002_9$

[a] This material also is available in the form of chips, SRM 361, for use in chemical methods of analysis; rods, SRM 1095, 6.4 mm (1/4 in) in diameter and 102 mm (4 in) long for the determination of gases in metals by vacuum fusion and neutron activation methods of analysis; and rods, SRM 661, 3.2 mm (1/8 in) in diameter and 51 mm (2 in) long for application in microchemical methods of analysis such as electron probe microanalysis, spark source mass spectrometric analysis, and laser probe analysis.

CERTIFICATION: The value listed for a certified element is the present best estimate of the "true" value based on the results of the analytical program. The value listed is not expected to deviate from the "true" value by more than ±1 in the last significant figure reported; for a subscript figure, the deviation is not expected to be more than ±5. Based on the results of homogeneity testing, maximum variations within and among samples are estimated to be less than the uncertainty figures given above.

The overall direction and coordination of the technical measurements at NBS leading to certification were performed under the direction of K. F. J. Heinrich, O. Menis, B. F. Scribner, J. I. Shultz, and J. L. Weber, Jr.

The technical and support aspects involved in the preparation, certification, and issuance of this Standard Reference Material were coordinated through the Office of Standard Reference Materials by R. E. Michaelis.

Washington, D.C. 20234
January 8, 1976
(Originally issued July 26, 1970
with revisions August 16, 1972, and
attachment February 24, 1975)

J. Paul Cali, Chief
Office of Standard Reference Materials

(over)

PLANNING, PREPARATION, TESTING, ANALYSIS: This standard is one of five replacements for the original eight 1100 series iron and steel SRM's. Material from the same melt is available in a variety of forms to serve in checking methods of analysis and in calibrating instrumental techniques.

The material for this standard was vacuum meIted and cast at the Carpenter Technology Corporation, Reading, Pennsylvania, under a contract with the National Bureau of Standards. The contract was made possible by a grant from the American Iron and Steel Institute.

The ingots were processed by Carpenter Technology Corporation to provide material of the highest possible homogeneity. Following acceptance of the composition based on NBS analyses, selectcd portions of the ingot material were extensively tested for homogeneity at NBS by J. R; Baldwin, D. M. Bouchette, S. D. Rasberry, and J. L. Weher, Jr. Only that material meeting a critical evaluation was processed to the final sizes.

Chemical analyses for certification were made on composite samples representative of the ac cepted lot of material.

Cooperative analyses for certification were performed in the analytical laboratories of BethIehem Steel Corporation, Sparrows Point Plant, Maryland, R. H. Rouse; Carpenter Technology Corporation, Research and Development Center, Reading, Pennsylvania, E. J. Cramer; The Timken Rollcr Bearing Company, Steel & Tube Division, Canton, Ohio, R. G. Cover; United States Steel Corporation, Applied Research Laboratory, Monroeville, Pennsylvania, L. Melnick; and Gary Steel Works, Gary, Indiana, E. H. Shipley.

Analyses were performed in the Analytical Chemistry Division of the National Bureau of Standards by the following: R. Alvarez, J. R. Baldwin, D. A. Becker, R. K. Bell, R. W. Burke, B. S. Carpenter, E. L. Garner, T. E. Gills, C. J. Lutz, L. A. Machlan, E. J. Maienthal, J. McKay, L. J. Moore, C. W. Mueller, T. J. Murphy, P. J. Paulsen, T. C. Rains, S. D. Rasberry, T. A. Rush, K. M. Sappcnficld, B.A. Thompson, S. A. Wicks, and J. Wing.

ADDITIONAL INFORMATION ON THE C0MPOSIT10N: Certification is made only for the elements indicated. The five replacements, however, contain a graded series for 40 elcments and nformation on thc elements not certified may be of importance in the use of the material. Although these arc not certified, values arc presented in the following tablc for the remaining elements.

Value from a single method of analysis:

Elcment	Percent. bv weight	Element	Percent. by weight
Gold	(<0.00005)	Oxygcn	(0.0009)
Zinc	(.0001)	Hydrogcn	(<.0005)
Praseoymium	(.00014)	Strontium	(<.0005)
Hafnium	(.0002)	Iron (by diffcrcncc)	(95.6)
Nitrogen	(.0037)		

[a]Dash indicates "'not detected ." Value in parenthesis following the dash is the conservative "upper limit" of detcctlon.

Approxinmate value from heat analysis:

Germanium [0.006]

MBH ANALYTICAL LTD.
HOLLAND HOUSE · QUEENS ROAD · BARNET · HERTS EN5 4DJ · ENGLAND Tel: 01-441 2024

CERTIFIED REFERENCE MATERIALS

CERTIFICATE OF ANALYSIS

MATERIAL: 18/8 STAINLESS STEEL

Standard Reference	C	Si	S		P	Mn	Ni	Cr	Co	Mo	Nb	Cu				
13 W																
12838 D	...	1.05	...		...	1.35	10.00	18.00	...	1.98	0.86	...				
12839 G	...	1.00	...		...	0.98	9.96	16.24	...	3.39	0.40	...				
15072 G	0.064	1.03	0.008		0.054	1.26	7.46	16.10	...	1.99	1.00	1.10				
12851 F	0.14	1.08	0.028		0.031	1.22	10.08	18.38	0.038	3.63	0.26	0.08				
12852 B	0.15	1.09	0.053		...	1.29	10.04	18.46	0.12	2.00	1.11	...				
12851 G	0.12	1.08	0.03		0.023	1.22	10.00	18.32	0.043	3.50	0.24	0.055				
12852 C	0.15	1.16	0.062		...	1.24	10.00	18.42	0.098	2.00	1.17	...				
		G1														

MANUFACTURED BY: WILLAN METALS LTD, ROTHERHAM

ANALYSED BY: WILLAN METALS LTD, ROTHERHAM

0/ MARAD PROJECT 3205 SAMPLE EH-6-CS WELD METAL

6-13

0
EGRGRGRGRAC
E
G

BURN # 1 LOFE 5:43 9:19:84
R

IS	IS
11897	9343

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.1304	.1199	.0544	.0825	.0823	.1403	.0772	.0422	.0709	.0526	.0386	.0560	.0186	.4328	0

G

BURN # 2 LOFE 5:44 9:19:84
R

IS	IS
12064	9344

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.1317	.1198	.0535	.0816	.0837	.1393	.0786	.0424	.0744	.0531	.0366	.0560	.0187	.4607	0

G

BURN # 3 LOFE 5:45 9:19:84
R

IS	IS
12142	9344

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.1292	.1202	.0536	.0813	.0819	.1392	.0774	.0419	.0713	.0523	.0368	.0553	.0185	.4313	0

G

BURN # 4 LOFE 5:45 9:19:84
R

IS	IS
12098	9341

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.1469	.1259	.0542	.0776	.0786	.1433	.0859	.0453	.0901	.0531	.0361	.0563	.0180	.5291	0

A

AVERAGE LOFE 5:46 9:19:84
C

IS	IS
12050	9343

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL
< .108	.814	.010	.021	.767	.186	< .050	.026	.007	< .015	.015	< .016	.038	< .016

*

0/ MARAD PROJECT 3205 SAMPLE EH-6-CS BASE METAL

6-12

O
EGRGRGRGRAC
E
G

BURN # 1 LOFE 5:37 9:19:84
R

IS	IS
12229	9350

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.2784	.1806	.0638	.0602	.0311	.1804	.1311	.0649	.1990	.0554	.0401	.0657	.0114	1.645	0

G

BURN # 2 LOFE 5:38 9:19:84
R

IS	IS
12261	9347

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.2575	.1777	.0630	.0595	.0305	.1807	.1310	.0643	.1954	.0551	.0412	.0638	.0113	1.640	0

G

BURN # 3 LOFE 5:39 9:19:84
R

IS	IS
12439	9347

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.2569	.1812	.0642	.0622	.0309	.1819	.1336	.0648	.1983	.0545	.0419	.0645	.0113	1.557	0

G

BURN # 4 LOFE 5:40 9:19:84
R

IS	IS
12477	9346

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.2620	.1827	.0640	.0579	.0310	.1815	.1340	.0648	.1996	.0543	.0406	.0643	.0113	1.573	0

A

AVERAGE LOFE 5:41 9:19:84
C

IS	IS
12351	9347

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL
.203	1.37	.018	.013	.242	.388	.192	.061	.035	.016	.028	< .016	< .027	.029

*

0/ MARAD PROJECT 3205 SAMPLE EH-6-FC WELD METAL
U
EGRGRGRGRAC
E
G

6-15

BURN # 1 LOFE 5:52 9:19:84
R

IS	IS													
12457	9343													
C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.1686	.1748	.0623	.0678	.0494	.1622	.0818	.0429	.1480	.0529	.0410	.0830	.0108	.6062	0

G

BURN # 2 LOFE 5:53 9:19:84
R

IS	IS													
12530	9343													
C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.1828	.1816	.0622	.0665	.0503	.1667	.0877	.0452	.1557	.0535	.0421	.0796	.0113	.6813	0

G

BURN # 3 LOFE 5:54 9:19:84
R

IS	IS													
12730	9341													
C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.1675	.1746	.0614	.0680	.0492	.1605	.0800	.0426	.1476	.0540	.0405	.0826	.0108	.6138	0

G

BURN # 4 LOFE 5:55 9:19:84
R

IS	IS													
12626	9340													
C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.1860	.1795	.0615	.0653	.0489	.1663	.0907	.0469	.1570	.0540	.0407	.0786	.0120	.7047	0

A

AVERAGE LOFE 5:55 9:19:84
C

IS	IS												
12586	9342												
C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL
.115	1.34	.016	.016	.412	.303	.063	.029	.024	.015	.028 <	.016 <	.027 <	.016

*

0/ MARAD PROJECT 3205 SAMPLE EH-6-FC BASE METAL
0
EGRGRGRGRAC
E
G

BURN # 1 LOFE 5:48 9:19:84
R

IS	IS
12586	9349

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.2566	.1819	.0630	.0601	.0310	.1807	.1292	.0645	.1986	.0555	.0406	.0644	.0114	1.554	0

G

BURN # 2 LOFE 5:48 9:19:84
R

IS	IS
12569	9341

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.2618	.1815	.0639	.0599	.0309	.1815	.1313	.0645	.1979	.0550	.0415	.0637	.0113	1.582	0

G

BURN # 3 LOFE 5:49 9:19:84
R

IS	IS
12566	9341

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.2644	.1817	.0654	.0579	.0310	.1843	.1336	.0651	.1985	.0547	.0448	.0645	.0114	1.618	0

G

BURN # 4 LOFE 5:50 9:19:84
R

IS	IS
12650	9341

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.2598	.1833	.0665	.0664	.0311	.1849	.1341	.0654	.2002	.0546	.0446	.0645	.0114	1.617	0

A

AVERAGE LOFE 5:51 9:19:84
C

IS	IS
12593	9343

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL
.200	1.38	.018	.014	.243	.397	.191	.062	.035	.017	.034 <	.016 <	.027	.029

*

0/ MARAD PROJECT 3205 SAMPLE SS-L-CS WELD METAL C-21
0
EGRGRGRGRAC
E
G

BURN # 1 STFE 5:59 9:20:84
R

IS	IS									
7748	9333									
C	MN	P	S	SI	CR	NI	MO	CU	XX	YY
.0865	.2723	.1144	.0914	.1413	5.632	1.370	13.18	.0474	0	0

G

BURN # 2 STFE 6:00 9:20:84
R

IS	IS									
7766	9333									
C	MN	P	S	SI	CR	NI	MO	CU	XX	YY
.0828	.2721	.1131	.0908	.1411	5.643	1.360	13.02	.0483	0	0

G

BURN # 3 STFE 6:02 9:20:84
R

IS	IS									
7597	9333									
C	MN	P	S	SI	CR	NI	MO	CU	XX	YY
.1079	.2738	.1118	.0928	.1415	5.662	1.348	12.80	.0463	0	0

G

BURN # 4 STFE 6:03 9:20:84
R

IS	IS									
7721	9334									
C	MN	P	S	SI	CR	NI	MO	CU	XX	YY
.0882	.2717	.1190	.0885	.1361	5.723	1.373	12.97	.0508	0	0

A

AVERAGE STFE 6:04 9:20:84
C

IS	IS							
7708	9333							
C	MN	P	S	SI	CR	NI	MO	CU
< .039	1.58	.020	.020	.973	16.9	12.4	2.32	0

*

0/ MARAD PROJECT 3205 SAMPLE SS-L-CS BASE METAL

c-20

0
EGRGRGRGRAC
E
G

BURN # 1 STFE 5:55 9:20:84
R

IS	IS									
8004	9333									
C	MN	P	S	SI	CR	NI	MO	CU	XX	YY
.0828	.2472	.1332	.0508	.0701	5.503	1.304	12.83	.0640	0	0

G

BURN # 2 STFE 5:56 9:20:84
R

IS	IS									
7966	9337									
C	MN	P	S	SI	CR	NI	MO	CU	XX	YY
.0822	.2499	.1357	.0503	.0709	5.567	1.305	12.62	.0639	0	0

G

BURN # 3 STFE 5:57 9:20:84
R

IS	IS									
8116	9339									
C	MN	P	S	SI	CR	NI	MO	CU	XX	YY
.0839	.2488	.1358	.0515	.0700	5.629	1.314	12.38	.0643	0	0

G

BURN # 4 STFE 5:58 9:20:84
R

IS	IS									
8178	9334									
C	MN	P	S	SI	CR	NI	MO	CU	XX	YY
.0910	.2481	.1357	.0518	.0701	5.598	1.311	12.41	.0653	0	0

A

AVERAGE STFE 5:59 9:20:84
C

IS	IS							
8066	9336							
C	MN	P	S	SI	CR	NI	MO	CU
< .039	1.40	.029	< .012	.451	16.7	11.7	2.23	0

*

0/ MARAD PROJECT 3205 SAMPLE SS-L-FC WELD METAL

C-23

0
EGRGRGRGRAC
E
G

BURN # 1 STFE 6:09 9:20:84
R

IS	IS									
7898	9333									
C	MN	P	S	SI	CR	NI	MO	CU	XX	YY
.0929	.3178	.1039	.0804	.0770	5.943	1.406	14.14	.0394	0	0

G

BURN # 2 STFE 6:10 9:20:84
R

IS	IS									
7372	9333									
C	MN	P	S	SI	CR	NI	MO	CU	XX	YY
.1077	.3218	.1062	.0865	.0836	6.063	1.425	14.13	.0399	0	0

G

BURN # 3 STFE 6:11 9:20:84
R

IS	IS									
7083	9334									
C	MN	P	S	SI	CR	NI	MO	CU	XX	YY
.1053	.3223	.1053	.0892	.0865	6.051	1.431	14.51	.0401	0	0

G

BURN # 4 STFE 6:12 9:20:84
R

IS	IS									
8123	9333									
C	MN	P	S	SI	CR	NI	MO	CU	XX	YY
.0873	.3185	.1003	.0800	.0777	5.857	1.385	14.21	.0395	0	0

A

AVERAGE STFE 6:13 9:20:84
C

	IS	IS							
	7619	9333							
	C	MN	P	S	SI	CR	NI	MO	CU
<	.039	1.93	.015	.018	.531	17.8	13.0	2.57	0

*

0/ MARAD PROJECT 3205 SAMPLE SS-L-FC BASE METAL C-22
0
EGRGRGRGRAC
E
G

BURN # 1 STFE 6:04 9:20:84
R

IS	IS									
8265	9331									
C	MN	P	S	SI	CR	NI	MO	CU	XX	YY
.0845	.2492	.1437	.0538	.0701	5.696	1.338	12.37	.0656	0	0

G

BURN # 2 STFE 6:05 9:20:84
R

IS	IS									
8273	9333									
C	MN	P	S	SI	CR	NI	MO	CU	XX	YY
.0832	.2472	.1415	.0538	.0699	5.586	1.332	12.67	.0664	0	0

G

BURN # 3 STFE 6:06 9:20:84
R

IS	IS									
8291	9332									
C	MN	P	S	SI	CR	NI	MO	CU	XX	YY
.0852	.2498	.1439	.0539	.0703	5.527	1.341	12.93	.0660	0	0

G

BURN # 4 STFE 6:07 9:20:84
R

IS	IS									
8284	9332									
C	MN	P	S	SI	CR	NI	MO	CU	XX	YY
.0824	.2469	.1421	.0538	.0700	5.531	1.321	12.99	.0651	0	0

A

AVERAGE STFE 6:07 9:20:84
C

IS	IS							
8278	9332							
C	MN	P	S	SI	CR	NI	MO	CU
< .039	1.40	.033	< .012	.449	16.7	12.0	2.27	0

*

C-24

QEGRGRAC
Q

*0/ MARAD PROJECT 3205 MBH ANALYTICAL STANDARD 12851 G
Q
EGRGRAC
E
G

BURN # 1 STFE 6:15 9:20:84
R

IS	IS									
7881	9333									
C	MN	P	S	SI	CR	NI	MO	CU	XX	YY
.2053	.2238	.1453	.1858	.1511	5.963	1.284	19.44	.0425	0	0

G

BURN # 2 STFE 6:15 9:20:84
R

IS	IS									
7965	9333									
C	MN	P	S	SI	CR	NI	MO	CU	XX	YY
.2054	.2232	.1468	.1905	.1507	5.922	1.283	19.58	.0427	0	0

A

AVERAGE STFE 6:16 9:20:84
C

IS	IS							
7923	9333							
C	MN	P	S	SI	CR	NI	MO	CU
.094	1.22	.034	.036	1.05	17.7	11.4	3.65	0

*

210

0/ MARAD PROJECT 3205 MBH ANALYTICAL STANDARD 12851 G c-19
O
EGRGRAC
E
G

BURN # 1 STFE 5:51 9:20:84
R

IS	IS									
7592	9334									
C	MN	P	S	SI	CR	NI	MO	CU	XX	YY
.2135	.2248	.1442	.1939	.1531	6.182	1.289	18.96	.0428	0	0

G

BURN # 2 STFE 5:52 9:20:84
R

IS	IS									
7413	9333									
C	MN	P	S	SI	CR	NI	MO	CU	XX	YY
.2034	.2254	.1365	.1878	.1536	5.999	1.247	18.97	.0410	0	0

A

AVERAGE STFE 5:53 9:20:84
C

IS	IS							
7502	9333							
C	MN	P	S	SI	CR	NI	MO	CU
.096	1.23	.032	.037	1.07	18.2	11.2	3.54	0

*

QEGRGRGRGRAC
Q

*

D-3

0/ MARAD PROJECT 3205 SAMPLE HY-8-CS WELD METAL

0
EGRGRGRGRAC
E
G

BURN # 1 LOFE 12:09 9:15:84
R

IS	IS
12089	9329

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.1322	.1513	.0566	.0487	.0509	.3943	.2223	.2398	.0737	.0606	.0360	.0888	.0158	.8231	0

G

BURN # 2 LOFE 12:10 9:15:84
R

IS	IS
12095	9329

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.1483	.1431	.0580	.0504	.0499	.4134	.2614	.2471	.0770	.0628	.0383	.0871	.0168	.9143	0

G

BURN # 3 LOFE 12:11 9:15:84
R

IS	IS
11930	9326

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.1250	.1545	.0553	.0474	.0514	.3887	.2137	.2388	.0735	.0598	.0331	.0877	.0161	.8018	0

G

BURN # 4 LOFE 12:12 9:15:84
R

IS	IS
11781	9326

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.1387	.1489	.0546	.0481	.0508	.3976	.2445	.2436	.0758	.0609	.0315	.0877	.0169	.8553	0

A

AVERAGE LOFE 12:13 9:15:84
C

IS	IS
11974	9328

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL
< .108	1.06	.012	.009	.418	2.13	.509	.359	.007	.020	.019	< .016	.030	< .016

*

D/ MARAD PROJECT 3205 SAMPLE HY-8-CS BASE METAL
0
EGRGRGRGRAC
E
G

BURN # 1 LOFE 12:05 9:15:84
R

IS	IS
11289	9333

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.2389	.0674	.0578	.0574	.0355	.4803	.6119	.2925	.1014	.0674	.0339	.0976	.0206	2.110	0

G

BURN # 2 LOFE 12:06 9:15:84
R

IS	IS
11178	9332

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.2353	.0673	.0573	.0571	.0353	.4778	.6091	.2883	.1010	.0674	.0339	.0961	.0205	2.184	0

G

BURN # 3 LOFE 12:06 9:15:84
R

IS	IS
11511	9332

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.2335	.0670	.0583	.0568	.0350	.4801	.6022	.2855	.1002	.0678	.0355	.0956	.0208	2.151	0

G

BURN # 4 LOFE 12:07 9:15:84
R

IS	IS
11595	9331

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.2353	.0680	.0592	.0602	.0359	.4830	.6028	.2936	.1013	.0688	.0363	.0982	.0220	2.160	0

A

AVERAGE LOFE 12:08 9:15:84
C

IS	IS
11393	9332

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL
.174	.297	.014	.013	.280	> 2.22	> 1.45	.446	.013	.027	.020	< .016	.052	.040

*

D-5

0/ MARAD PROJECT 3205 SAMPLE HY-8-FC WELD METAL
0
EGRGRGRGRAC
E
G

BURN # 1 LOFE 12:18 9:15:84
R

IS	IS
11940	9328

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.1658	.1671	.0620	.0726	.0472	.3956	.1256	.1752	.1272	.0612	.0329	.0922	.0191	.8233	0

G

BURN # 2 LOFE 12:19 9:15:84
R

IS	IS
11844	9327

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.1715	.1608	.0610	.0705	.0455	.4055	.1673	.1873	.1257	.0610	.0320	.0943	.0190	.8941	0

G

BURN # 3 LOFE 12:20 9:15:84
R

IS	IS
11854	9329

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.1664	.1686	.0607	.0718	.0475	.3906	.1285	.1752	.1286	.0597	.0299	.0914	.0192	.8208	0

G

BURN # 4 LOFE 12:21 9:15:84
R

IS	IS
11860	9327

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.1755	.1548	.0605	.0710	.0465	.4106	.1937	.1964	.1234	.0623	.0320	.0943	.0223	.9326	0

A

AVERAGE LOFE 12:22 9:15:84
C

IS	IS
11875	9328

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL
< .108	1.18	.016	.018	.382	2.15	.273	.253	.018	.020	.008	< .016	.047	< .016

*

D-4

0/ MARAD PROJECT 3205 SAMPLE HY-8-FC BASE METAL
0
EGRGRGRGRAC
E
G

BURN # 1 LOFE 12:14 9:15:84
R

IS	IS
11338	9327

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.2336	.0677	.0580	.0586	.0355	.4822	.6064	.2930	.1014	.0684	.0335	.0980	.0208	2.143	0

G

BURN # 2 LOFE 12:15 9:15:84
R

IS	IS
11374	9330

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.2376	.0681	.0581	.0587	.0360	.4848	.5990	.2950	.1016	.0692	.0333	.0980	.0210	2.117	0

G

BURN # 3 LOFE 12:16 9:15:84
R

IS	IS
11543	9330

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.2329	.0675	.0580	.0586	.0353	.4784	.5957	.2896	.1009	.0688	.0339	.0969	.0207	2.187	0

G

BURN # 4 LOFE 12:17 9:15:84
R

IS	IS
11681	9327

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.2321	.0675	.0578	.0557	.0354	.4794	.5848	.2886	.1002	.0699	.0343	.0966	.0209	2.166	0

A

AVERAGE LOFE 12:17 9:15:84
C

IS	IS
11484	9328

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL
.172	.299	.014	.013	.281	> 2.22	> 1.45	.448	.013	.028	.016	< .016	.051	.040

*

0/ MARAD PROJECT 3205   SAMPLE HY-8-MC WELD METAL D-9
0
EGRGRGRGRAC
E
G

BURN # 1 LOFE 12:37 9:15:84
R

IS	IS
12025	9324

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.1153	.1808	.0610	.0557	.0444	.3920	.1376	.1573	.1169	.0610	.0338	.0986	.0146	.9904	0

G

BURN # 2 LOFE 12:38 9:15:84
R

IS	IS
11914	9323

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.1368	.1570	.0605	.0555	.0431	.4080	.2258	.1858	.1131	.0629	.0342	.1013	.0158	1.167	0

G

BURN # 3 LOFE 12:39 9:15:84
R

IS	IS
11989	9323

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.1385	.1605	.0603	.0558	.0428	.4054	.2118	.1830	.1142	.0625	.0337	.1018	.0165	1.158	0

G

BURN # 4 LOFE 12:40 9:15:84
R

IS	IS
12163	9321

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.1288	.1660	.0621	.0566	.0435	.4028	.1885	.1756	.1144	.0624	.0364	.0997	.0155	1.078	0

A

AVERAGE LOFE 12:41 9:15:84
C

IS	IS
12023	9323

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL
< .108	1.21	.016	.012	.352	2.16	.380	.240	.016	.021	.018	< .016	< .027	< .016

*

0/ MARAD PROJECT 3205   SAMPLE HY-8-MC BASE METAL D-8
0
EGRGRGRGRAC
E
G

BURN # 1 LOFE 12:33 9:15:84
R

IS	IS
11319	9322

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.2111	.0660	.0570	.0522	.0339	.4672	.5942	.2793	.0990	.0676	.0350	.0937	.0201	2.152	0

G

BURN # 2 LOFE 12:34 9:15:84
R

IS	IS
11530	9323

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.2168	.0662	.0591	.0542	.0342	.4753	.5875	.2840	.0992	.0689	.0381	.0950	.0205	2.145	0

G

BURN # 3 LOFE 12:35 9:15:84
R

IS	IS
11546	9323

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.2169	.0670	.0590	.0570	.0347	.4770	.5932	.2878	.1001	.0690	.0372	.0959	.0207	2.148	0

G

BURN # 4 LOFE 12:35 9:15:84
R

IS	IS
11816	9323

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.2257	.0659	.0603	.0553	.0340	.4793	.5770	.2806	.0981	.0697	.0406	.0945	.0209	2.127	0

A

AVERAGE LOFE 12:36 9:15:84
C

IS	IS
11553	9323

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL
.156	.286	.015	.012	.269	> 2.22	> 1.45	.433	.012	.028	.030	< .016	.049	.040

*

6-17

0/ MARAD PROJECT 3205 SAMPLE HY-8-AC WELD METAL
0
EGRGRGRGRAC
E
G

BURN # 1 LOFE 6:04 9:19:84
R

IS	IS
11902	9342

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.1071	.1383	.0604	.0753	.0157	.4185	.1222	.2509	.1164	.0584	.0385	.0872	.0158	.7641	0

G

BURN # 2 LOFE 6:04 9:19:84
R

IS	IS
11850	9338

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.1143	.1357	.0602	.0728	.0160	.4238	.1571	.2578	.1159	.0586	.0381	.0884	.0161	.7803	0

G

BURN # 3 LOFE 6:05 9:19:84
R

IS	IS
11893	9338

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.1123	.1397	.0603	.0753	.0159	.4165	.1214	.2517	.1161	.0584	.0384	.0869	.0161	.7557	0

G

BURN # 4 LOFE 6:06 9:19:84
R

IS	IS
11948	9339

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.1182	.1357	.0605	.0735	.0160	.4254	.1606	.2553	.1153	.0597	.0399	.0853	.0177	.7705	0

A

AVERAGE LOFE 6:07 9:19:84
C

IS	IS
11898	9339

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL
< .108	.964	.015	.019	.105	> 2.22	.213	.379	.016	.021	.021	< .016	.029	< .016

*

B-16

0/ MARAD PROJECT 3205 SAMPLE HY-8-AC BASE METAL
n
FGRGRGRGRAC
E
G

BURN # 1 LOFE 5:57 9:19:84
R

IS	IS													
11818	9341													
C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.2369	.0666	.0635	.0579	.0348	.5000	.6597	.2901	.1015	.0658	.0443	.0949	.0212	2.060	0

G

BURN # 2 LOFE 5:58 9:19:84
R

IS	IS													
11811	9337													
C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.2319	.0663	.0627	.0571	.0345	.4944	.6526	.2871	.1009	.0660	.0439	.0942	.0210	2.024	0

G

BURN # 3 LOFE 5:59 9:19:84
R

IS	IS													
11690	9340													
C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.2306	.0666	.0616	.0545	.0346	.4937	.6559	.2860	.1013	.0656	.0429	.0940	.0217	2.055	0

G

BURN # 4 LOFE 6:00 9:19:84
R

IS	IS													
11801	9337													
C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.2333	.0667	.0625	.0566	.0349	.4966	.6612	.2902	.1015	.0657	.0430	.0947	.0214	2.069	0

A

AVERAGE LOFE 6:01 9:19:84
C

IS	IS												
11780	9339												
C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL
.172	.297	.017	.012	.277 >	2.22 >	1.45	.442	.013	.028	.036 <	.016	.051	.040

*

0/ MARAD PROJECT 3205   SAMPLE HY-8-AC-HHT   WELD METAL

D-7

O
EGRGRGRGRAC
E
G

BURN # 1   LOFE   12:28   9:15:84
R

IS	IS
11844	9325

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.1146	.1328	.0595	.0764	.0150	.4126	.1264	.2508	.1120	.0621	.0355	.0948	.0161	.7795	0

G

BURN # 2   LOFE   12:29   9:15:84
R

IS	IS
11772	9325

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.1201	.1342	.0580	.0735	.0167	.4189	.1570	.2552	.1147	.0628	.0341	.0927	.0164	.8255	0

G

BURN # 3   LOFE   12:30   9:15:84
R

IS	IS
11919	9326

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.1102	.1320	.0586	.0753	.0143	.4093	.1271	.2518	.1117	.0622	.0341	.0838	.0162	.7428	0

G

BURN # 4   LOFE   12:31   9:15:84
R

IS	IS
11663	9325

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.1222	.1350	.0572	.0718	.0185	.4203	.1763	.2546	.1164	.0625	.0327	.0958	.0173	.8721	0

A

AVERAGE   LOFE   12:32   9:15:84
C

IS	IS
11799	9325

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL
< .108	.910	.014	.019	.106	> 2.22	.253	.379	.015	.022	.017	< .016	.031	< .016

*

D-6

0/ MARAD PROJECT 3205 SAMPLE HY-8-AC-HHT BASE METAL

0
EGRGRGRGRAC
E
G

BURN # 1 LOFE 12:24 9:15:84

R

IS	IS
11461	9326

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.2164	.0660	.0582	.0541	.0339	.4731	.5813	.2807	.0986	.0690	.0362	.0953	.0205	2.196	0

G

BURN # 2 LOFE 12:25 9:15:84

R

IS	IS
11354	9327

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.2226	.0660	.0578	.0535	.0339	.4714	.6069	.2815	.0997	.0670	.0348	.0947	.0203	2.324	0

G

BURN # 3 LOFE 12:26 9:15:84

R

IS	IS
11427	9327

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.2240	.0665	.0580	.0551	.0344	.4710	.6015	.2833	.1002	.0677	.0353	.0955	.0210	2.277	0

G

BURN # 4 LOFE 12:27 9:15:84

R

IS	IS
11567	9325

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.2114	.0659	.0579	.0528	.0338	.4698	.5939	.2781	.0989	.0679	.0366	.0939	.0202	2.118	0

A

AVERAGE LOFE 12:27 9:15:84

C

IS	IS
11452	9326

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL
.156	.284	.014	.011	.267 >	2.22 >	1.45	.429	.012	.027	.023 <	.016	.049	.042

*

0/ MARAD PROJECT 3205 SAMPLE HY-8-AC-1 WELD METAL
0
EGRGRGRGRAC
E
G

BURN # 1 LOFE 4:20 5:16:85
R

IS	IS
12204	9331

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.1277	.1947	.0563	.0546	.0364	.4054	.1605	.2542	.1142	.0601	.0274	.0987	.0175	1.028	0

G

BURN # 2 LOFE 4:21 5:16:85
R

IS	IS
11907	9331

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.1340	.1871	.0544	.0542	.0375	.4088	.1989	.2625	.1142	.0590	.0248	.1036	.0170	1.140	0

G

BURN # 3 LOFE 4:22 5:16:85
R

IS	IS
11714	9330

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.1277	.1928	.0543	.0540	.0371	.3987	.1719	.2565	.1149	.0583	.0242	.1007	.0166	1.051	0

G

BURN # 4 LOFE 4:22 5:16:85
R

IS	IS
11879	9331

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.1352	.1866	.0547	.0556	.0373	.4080	.1943	.2646	.1137	.0594	.0255	.1034	.0208	1.121	0

A

AVERAGE LOFE 4:23 5:16:85
C

IS	IS
11926	9331

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL
< .108	1.29	.019	.013	.254	> 2.22	.337	.385	.013	< .015	.012	< .016	.043	< .016

*

0/ MARAD PROJECT 3205 SAMPLE HY-8-AC-1 BASE METAL
0
EGRGRGRGRAC
E
G

BURN # 1 LOFE 4:16 5:16:85
R

IS	IS
12089	9330

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.2626	.0717	.0524	.0598	.0396	.4775	.6003	.3009	.0964	.0677	.0325	.0989	.0204	2.087	0

G

BURN # 2 LOFE 4:16 5:16:85
R

IS	IS
12049	9332

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.2493	.0710	.0512	.0544	.0390	.4715	.5850	.2935	.0951	.0681	.0320	.0968	.0220	2.101	0

G

BURN # 3 LOFE 4:18 5:16:85
R

IS	IS
12233	9328

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.2319	.0708	.0526	.0583	.0387	.4720	.5837	.2953	.0952	.0685	.0342	.0977	.0203	2.149	0

G

BURN # 4 LOFE 4:18 5:16:85
R

IS	IS
11777	9332

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.2247	.0706	.0498	.0542	.0381	.4600	.5895	.2886	.0947	.0672	.0306	.0960	.0204	2.231	0

A

AVERAGE LOFE 4:19 5:16:85
C

IS	IS
12037	9330

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL
.175	.275	.016	.014	.269 >	2.22 >	1.45	.448	.010	.020	.042 <	.016	.056	.039

*

0/ MARAD PROJECT 3205 SAMPLE HY-8-HHI-1 WELD METAL
O
EGRGRGRGRAC
E
G

BURN # 1 LOFE 4:11 5:16:85
R

IS	IS													
11940	9331													
C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.1260	.1929	.0555	.0492	.0367	.3862	.1866	.2396	.1173	.0581	.0237	.0998	.0173	1.093	0

G

BURN # 2 LOFE 4:12 5:16:85
R

IS	IS													
11831	9332													
C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.1400	.1808	.0531	.0518	.0368	.3998	.2234	.2474	.1133	.0587	.0236	.1016	.0170	1.140	0

G

BURN # 3 LOFE 4:13 5:16:85
R

IS	IS													
12031	9331													
C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.1258	.1936	.0564	.0485	.0362	.3865	.1855	.2356	.1174	.0581	.0245	.0999	.0170	1.083	0

G

BURN # 4 LOFE 4:14 5:16:85
R

IS	IS													
12365	9331													
C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.1445	.1803	.0559	.0542	.0367	.4095	.2149	.2477	.1118	.0603	.0284	.1013	.0184	1.115	0

A

AVERAGE LOFE 4:15 5:16:85
C

IS	IS												
12042	9331												
C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL
< .108	1.26	.019	.012	.250	> 2.22	.397	.355	.014	< .015	.010	< .016	.040	< .016

*

0/ MARAD PROJECT 3205 SAMPLE HY-8-HHI-1 BASE METAL
0
EGRGRGRGRAC
E
G

BURN # 1 LOFE 4:07 5:16:85
R

IS	IS
11384	9327

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.2344	.0720	.0453	.0511	.0399	.4496	.6102	.2959	.0967	.0649	.0220	.0975	.0191	2.196	0

G

BURN # 2 LOFE 4:08 5:16:85
R

IS	IS
11343	9331

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.2355	.0718	.0466	.0525	.0397	.4541	.6073	.2955	.0964	.0654	.0239	.0972	.0193	2.193	0

G

BURN # 3 LOFE 4:08 5:16:85
R

IS	IS
11188	9331

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.2375	.0720	.0467	.0550	.0396	.4523	.6059	.2940	.0962	.0653	.0240	.0971	.0192	2.218	0

G

BURN # 4 LOFE 4:09 5:16:85
R

IS	IS
11243	9331

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.2420	.0720	.0463	.0519	.0398	.4516	.6147	.2967	.0969	.0649	.0230	.0976	.0191	2.176	0

A

AVERAGE LOFE 4:10 5:16:85
C

IS	IS
11289	9330

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL
.170	.283	.011	.012	.275 >	2.22 >	1.45	.450	.010	.017 <	.008 <	.016	.048	.041

*

0/ MARAD PROJECT 3205 SAMPLE HY-O-CS WELD METAL

E-27

0
EGRGRGRGRAC
E
G

BURN # 1 LOFE 9:50 9:22:84
R

IS	IS
11161	9350

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.1243	.1676	.0655	.0559	.0523	.4586	.2632	.2868	.0766	.1012	.0400	.0861	.0146	.8269	0

G

BURN # 2 LOFE 9:51 9:22:84
R

IS	IS
11450	9348

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.1506	.1472	.0675	.0558	.0484	.4631	.3458	.2808	.0779	.0941	.0456	.0879	.0203	.9641	0

G

BURN # 3 LOFE 9:52 9:22:84
R

IS	IS
11387	9347

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.1264	.1670	.0683	.0575	.0518	.4648	.2649	.2883	.0768	.0998	.0464	.0869	.0150	.8222	0

G

BURN # 4 LOFE 9:53 9:22:84
R

IS	IS
11223	9347

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.1314	.1620	.0672	.0558	.0511	.4628	.2937	.2868	.0781	.0972	.0437	.0885	.0163	.8574	0

A

AVERAGE LOFE 9:54 9:22:84
C

IS	IS
11305	9348

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL
< .108	1.16	.020	.012	.431	> 2.22	.599	.440	.007	.063	.019	< .016	.033	< .016

*

0/ MARAD PROJECT 3205 SAMPLE HY-0-CS BASE METAL

E-26

0
EGRGRGRGRAC
E
G

BURN # 1 LOFE 9:46 9:22:84
R

IS	IS													
10762	9352													
C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.2118	.0689	.0636	.0559	.0306	.4501	.6390	.2616	.0846	.0690	.0378	.0920	.0252	1.847	0

G

BURN # 2 LOFE 9:47 9:22:84
R

IS	IS													
10659	9349													
C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.2198	.0692	.0638	.0552	.0311	.4526	.6451	.2653	.0848	.0689	.0381	.0923	.0253	1.839	0

G

BURN # 3 LOFE 9:48 9:22:84
R

IS	IS													
10738	9348													
C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.2190	.0688	.0643	.0539	.0307	.4515	.6416	.2614	.0845	.0690	.0394	.0918	.0265	1.804	0

G

BURN # 4 LOFE 9:48 9:22:84
R

IS	IS													
11052	9348													
C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.2268	.0689	.0664	.0540	.0308	.4600	.6472	.2646	.0844	.0693	.0440	.0920	.0262	1.789	0

A

AVERAGE LOFE 9:49 9:22:84
C

IS	IS												
10803	9349												
C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL
.156	.310	.018	.011	.245	> 2.22	> 1.45	.399	.009	.032 <	.008 <	.016	.077	.035

*

E-29

0/ MARAD PROJECT 3205 SAMPLE HY-0-FC WELD METAL
0
EGRGRGRGRAC
E
G

BURN # 1 LOFE 9:59 9:22:84
R

IS	IS
11646	9347

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.1409	.2217	.0710	.0818	.0498	.4786	.1869	.2873	.1423	.0611	.0434	.1054	.0175	.9682	0

G

BURN # 2 LOFE 9:59 9:22:84
R

IS	IS
11517	9347

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.1460	.2189	.0705	.0796	.0471	.4784	.2171	.2877	.1402	.0614	.0444	.1071	.0181	.9994	0

G

BURN # 3 LOFE 10:00 9:22:84
R

IS	IS
11646	9344

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.1416	.2281	.0703	.0817	.0493	.4785	.1848	.2873	.1435	.0611	.0430	.1060	.0179	.9675	0

G

BURN # 4 LOFE 10:01 9:22:84
R

IS	IS
11632	9344

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.1478	.2170	.0702	.0803	.0478	.4745	.2204	.2831	.1396	.0618	.0439	.1071	.0200	.9876	0

A

AVERAGE LOFE 10:02 9:22:84
C

IS	IS
11610	9345

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL
< .108	> 1.65	.023	.020	.409	> 2.22	.363	.441	.022	.024	.019	< .016	.042	< .016

*

E-28

D/ MARAD PROJECT 3205 SAMPLE HY-O-FC BASE METAL
O
EGRGRGRGRAC
E
G

BURN # 1 LOFE 9:54 9:22:84
R

IS	IS													
11286	9349													
C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.2173	.0685	.0676	.0541	.0303	.4593	.6427	.2597	.0839	.0694	.0474	.0911	.0254	1.833	0

G

BURN # 2 LOFE 9:55 9:22:84
R

IS	IS													
11355	9351													
C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.2153	.0682	.0677	.0525	.0300	.4581	.6476	.2580	.0841	.0689	.0482	.0910	.0254	1.807	0

G

BURN # 3 LOFE 9:56 9:22:84
R

IS	IS													
11308	9352													
C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.2206	.0687	.0688	.0551	.0305	.4637	.6560	.2637	.0847	.0688	.0496	.0919	.0256	1.806	0

G

BURN # 4 LOFE 9:57 9:22:84
R

IS	IS													
11264	9348													
C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.2211	.0688	.0680	.0549	.0305	.4607	.6510	.2621	.0845	.0688	.0471	.0912	.0256	1.772	0

A

AVERAGE LOFE 9:58 9:22:84
C

IS	IS												
11303	9350												
C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL
.155	.306	.021	.011	.241 >	2.22 >	1.45	.395	.009	.032	.031 <	.016	.075	.034

*

E-31

```
 0/  MARAD PROJECT 3205   SAMPLE HY-O-AC   WELD METAL
0
EGRGRGRGRAC
E
G

BURN # 1  LOFE      10:07   9:22:84
R
   IS      IS
 11530    9340
   C       MN      P       S       SI      NI      CR      MO      V       CO      W       TI      CU      AL       YY
 .1231   .2194   .0688   .0594   .0327   .5078   .2768   .2823   .1181   .0648   .0499   .1076   .0165   1.189      0
G

BURN # 2  LOFE      10:08   9:22:84
R
   IS      IS
 11452    9343
   C       MN      P       S       SI      NI      CR      MO      V       CO      W       TI      CU      AL       YY
 .1199   .2186   .0670   .0592   .0326   .5003   .2731   .2848   .1183   .0647   .0467   .1104   .0162   1.175      0
G

BURN # 3  LOFE      10:09   9:22:84
R
   IS      IS
 11515    9343
   C       MN      P       S       SI      NI      CR      MO      V       CO      W       TI      CU      AL       YY
 .1211   .2173   .0680   .0592   .0327   .5060   .2788   .2826   .1175   .0649   .0485   .1091   .0171   1.193      0
G

BURN # 4  LOFE      10:10   9:22:84
R
   IS      IS
 11447    9342
   C       MN      P       S       SI      NI      CR      MO      V       CO      W       TI      CU      AL       YY
 .1234   .2138   .0679   .0584   .0319   .5012   .2917   .2806   .1176   .0650   .0480   .1077   .0174   1.169      0
A

AVERAGE   LOFE      10:11   9:22:84
C
   IS      IS
 11486    9342
   C       MN      P       S       SI      NI      CR      MO      V       CO      W       TI      CU      AL
< .108 > 1.65    .021    .013    .261 > 2.22    .567    .434    .016    .028    .032 < .016    .034    .019

*
```

E-30

0/ MARAD PROJECT 3205 SAMPLE HY-0-AC BASE METAL
0
EGRGRGRGRAC
E
G

BURN # 1 LOFE 10:03 9:22:84
R

IS	IS
11254	9343

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.2304	.0689	.0712	.0571	.0305	.4687	.6510	.2626	.0846	.0696	.0541	.0922	.0259	1.817	0

G

BURN # 2 LOFE 10:04 9:22:84
R

IS	IS
11105	9343

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.2280	.0694	.0693	.0565	.0310	.4654	.6563	.2656	.0853	.0692	.0485	.0927	.0265	1.794	0

G

BURN # 3 LOFE 10:04 9:22:84
R

IS	IS
11203	9343

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.2029	.0677	.0678	.0519	.0297	.4533	.6472	.2578	.0841	.0686	.0486	.0912	.0250	1.879	0

G

BURN # 4 LOFE 10:05 9:22:84
R

IS	IS
11291	9341

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.2089	.0680	.0690	.0532	.0298	.4604	.6533	.2578	.0841	.0688	.0522	.0906	.0256	1.805	0

A

AVERAGE LOFE 10:06 9:22:84
C

IS	IS
11213	9342

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL
.154	.306	.022	.011	.240	> 2.22	> 1.45	.395	.009	.032	.039	< .016	.076	.035

*

0/ MARAD PROJECT 3205 SAMPLE HY-0-AC-1 WELD METAL
0
EGRGRGRGRAC
E
G

BURN # 1 LOFE 4:02 5:16:85
R

IS	IS
11998	9332

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.1266	.2555	.0491	.0517	.0393	.4440	.2195	.2849	.1149	.0607	.0227	.1089	.0145	1.118	0

G

BURN # 2 LOFE 4:03 5:16:85
R

IS	IS
11788	9332

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.1335	.2420	.0486	.0511	.0389	.4441	.2419	.2888	.1115	.0612	.0220	.1101	.0148	1.186	0

G

BURN # 3 LOFE 4:04 5:16:85
R

IS	IS
11834	9331

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.1110	.2561	.0485	.0500	.0397	.4390	.2230	.2830	.1156	.0601	.0217	.1082	.0154	1.091	0

G

BURN # 4 LOFE 4:04 5:16:85
R

IS	IS
11623	9327

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.1317	.2300	.0480	.0501	.0383	.4377	.2618	.2862	.1092	.0624	.0219	.1056	.0157	1.168	0

A

AVERAGE LOFE 4:05 5:16:85
C

IS	IS
11811	9330

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL
< .108 >	1.65	.013	.011	.270 >	2.22	.491	.432	.013 <	.015 <	.008 <	.016	.029	.016

*

```
 0/  HARAD PROJECT  3205   SAMPLE HY-0-AC-1  BASE METAL
0
EGRGRGRGRAC
E
G

BURN # 1  LOFE      3:58   5:16:85
R
   IS      IS
 11609   9333
   C      MN      P      S      SI      NI      CR      MO      V       CO      W       TI      CU      AL      YY
 .2360  .0731  .0511  .0511  .0359  .4264  .5895  .2736  .0761  .0694  .0232  .0930  .0247  1.905      0
G

BURN # 2  LOFE      3:59   5:16:85
R
   IS      IS
 11683   9332
   C      MN      P      S      SI      NI      CR      MO      V       CO      W       TI      CU      AL      YY
 .2211  .0723  .0509  .0467  .0352  .4236  .5987  .2705  .0759  .0684  .0235  .0931  .0243  1.898      0
G

BURN # 3  LOFE      3:59   5:16:85
R
   IS      IS
 11752   9333
   C      MN      P      S      SI      NI      CR      MO      V       CO      W       TI      CU      AL      YY
 .2223  .0731  .0511  .0496  .0354  .4220  .6094  .2711  .0763  .0680  .0227  .0931  .0247  1.891      0
G

BURN # 4  LOFE      4:00   5:16:85
R
   IS      IS
 11632   9331
   C      MN      P      S      SI      NI      CR      MO      V       CO      W       TI      CU      AL      YY
 .2280  .0736  .0518  .0503  .0358  .4267  .6162  .2740  .0768  .0678  .0240  .0940  .0260  1.841      0
A

AVERAGE   LOFE      4:01   5:16:85
C
   IS      IS
 11669   9332
   C      MN      P      S      SI      NI      CR      MO      V       CO      W       TI      CU      AL
  .160   .292   .015   .011   .242 > 2.22 > 1.45   .408   .006   .020 < .008 < .016   .076   .033

*
```

0/ MARAD PROJECT 3205 NBS SAMPLE 1261
0
EGRGRAC
E
G

BURN # 1 LOFE 12:01 9:15:84
R

IS	IS
11532	9331

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.4357	.1074	.0632	.0745	.0290	.3823	.3048	.1455	.1108	.0845	.0383	.2987	.0190	1.505	0

G

BURN # 2 LOFE 12:01 9:15:84
R

IS	IS
11106	9335

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.4337	.1087	.0613	.0723	.0294	.3742	.3048	.1468	.1126	.0845	.0334	.3202	.0185	1.481	0

A

AVERAGE LOFE 12:02 9:15:84
C

IS	IS
11319	9333

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL
.379	.673	.017	.018	.224	1.94	.708	.193	.015	.044	.023	.025	.041	.025

*

QEGRGRGRGRAC
Q

*

D-10

QEGRGRAC
Q

*0/ MARAD PROJECT 3205 NBS SAMPLE 1261
O
EGRGRAC
E
G

BURN # 1 LOFE 12:42 9:15:84
R

IS	IS
11736	9317

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.4347	.1078	.0648	.0759	.0289	.3839	.3004	.1480	.1112	.0854	.0400	.3136	.0192	1.502	0

G

BURN # 2 LOFE 12:42 9:15:84
R

IS	IS
11819	9321

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.4342	.1073	.0654	.0765	.0288	.3849	.2968	.1471	.1102	.0862	.0423	.3109	.0191	1.499	0

A

AVERAGE LOFE 12:43 9:15:84
C

IS	IS
11777	9319

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL
.379	.669	.020	.019	.220	1.99	.691	.195	.015	.045	.042	.025	.043	.025

*

0/ MARAD PROJECT 3205 NBS SAMPLE 1261

B-11

0
EGRGRAC
E
G

BURN # 1 LOFE 5:31 9:19:84
R

IS	IS
11480	9348

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.4269	.1061	.0631	.0733	.0287	.3854	.3219	.1455	.1102	.0813	.0389	.2990	.0188	1.461	.0001

G

BURN # 2 LOFE 5:33 9:19:84
R

IS	IS
11540	9350

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.4401	.1069	.0646	.0746	.0289	.3885	.3272	.1479	.1113	.0811	.0400	.3153	.0190	1.394	.0000

A

AVERAGE LOFE 5:33 9:19:84
C

IS	IS
11510	9349

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL
.380	.673	.018	.018	.223	1.98	.716	.194	.015	.044	.023	.026	.040	.025

*

QEGRGRGRGRAC
Q

*

B-18

QEGRGRAC
Q

*0/ NBS SAMPLE 1261
Q
EGRGRAC
E
G

BURN # 1 LOFE 6:08 9:19:84
R

IS	IS													
11814	9334													
C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.4388	.1078	.0675	.0778	.0288	.3950	.3254	.1483	.1112	.0819	.0464	.3155	.0192	1.446	0

G

BURN # 2 LOFE 6:09 9:19:84
R

IS	IS													
11930	9333													
C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.4366	.1080	.0683	.0727	.0208	.3961	.3353	.1482	.1118	.0806	.0471	.3131	.0192	1.432	0

A

AVERAGE LOFE 6:10 9:19:84
C

IS	IS												
11872	9333												
C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL
.384	.687	.021	.019	.223	2.06	.732	.196	.015	.044	.047	.026	.042	.025

*

E-32

QEGRGRAC
Q

*O/MARAD PROJECT 3205 NBS SAMPLE 1261.
O
EGRGRAC
E
G

BURN # 1 LOFE 10:12 9:22:84
R

IS	IS													
11376	9343													
C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.4399	.1086	.0716	.0778	.0277	.3999	.3416	.1472	.1134	.0804	.0537	.3131	.0189	1.442	0

G

BURN # 2 LOFE 10:13 9:22:84
R

IS	IS													
11202	9343													
C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.4377	.1084	.0720	.0777	.0278	.3987	.3389	.1470	.1131	.0811	.0567	.3128	.0188	1.435	0

A

AVERAGE LOFE 10:13 9:22:84
C

IS	IS												
11289	9343												
C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL
.381	.676	.024	.019	.217	2.09	.726	.196	.015	.045	.051	.025	.044	.026

*

0/ MARAD PROJECT 3205 NBS SAMPLE 1261 E-25
0
EGRGRAC
E
G

BURN # 1 LOFE 9:43 9:22:84
R

IS	IS
11001	9353

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.4246	.1082	.0649	.0737	.0279	.3851	.3286	.1439	.1130	.0820	.0425	.3108	.0185	1.488	0

G

BURN # 2 LOFE 9:44 9:22:84
R

IS	IS
10973	9353

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.4300	.1092	.0652	.0739	.0282	.3838	.3316	.1457	.1145	.0819	.0414	.3248	.0187	1.442	0

A

AVERAGE LOFE 9:44 9:22:84
C

IS	IS
10987	9353

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL
.368	.678	.019	.018	.220	1.95	.699	.192	.015	.046	.014	.025	.043	.026

*

QEGRGRGRGRAC
Q

*

O/ MARAD PROJECT 3205 NBS SAMPLE 1261
O
EGRGRGRGRAC
E
G

BURN # 1 LOFE 4:24 5:16:85
R

IS	IS
11769	9327

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.4480	.1176	.0553	.0750	.0324	.3632	.3154	.1479	.1097	.0840	.0308	.3400	.0177	1.505	0

G

BURN # 2 LOFE 4:25 5:16:85
R

IS	IS
11552	9330

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.4429	.1171	.0552	.0723	.0322	.3619	.3129	.1474	.1097	.0847	.0306	.3334	.0177	1.498	0

G

BURN # 3 LOFE 4:26 5:16:85
R

IS	IS
11676	9329

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.4396	.1169	.0547	.0706	.0321	.3601	.3099	.1462	.1094	.0855	.0303	.3284	.0176	1.506	0

G

BURN # 4 LOFE 4:27 5:16:85
R

IS	IS
11661	9331

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL	YY
.4445	.1184	.0553	.0736	.0328	.3624	.3130	.1472	.1102	.0854	.0310	.3368	.0177	1.527	0

A

AVERAGE LOFE 4:28 5:16:85
C

IS	IS
11664	9329

C	MN	P	S	SI	NI	CR	MO	V	CO	W	TI	CU	AL
.378	.670	.019	.020	.217	2.05	.705	.192	.013	.035	.035	.024	.041	.025

*

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 0/   MARAD PROJECT  3205    NBS SAMPLE  1261
0
EGRGRAC
E
G

BURN # 1  LOFE       3:53   5:16:85
R
   IS      IS
 11912    9331
   C      MN      F       S       SI      NI      CR      MO      V       CO      W       TI      CU      AL      YY
 .4368   .1166   .0529   .0647   .0322   .3590   .3110   .1456   .1090   .0844   .0277   .3295   .0177   1.517     0
G

BURN # 2  LOFE       3:54   5:16:85
R
   IS      IS
 11899    9331
   C      MN      F       S       SI      NI      CR      MO      V       CO      W       TI      CU      AL      YY
 .4507   .1177   .0546   .0704   .0324   .3628   .3143   .1481   .1102   .0846   .0292   .3403   .0180   1.451     0
A

AVERAGE   LOFE       3:55   5:16:85
C
   IS      IS
 11905    9331
   C      MN      F       S       SI      NI      CR      MO      V       CO      W       TI      CU      AL
  .378    .667    .018    .018    .217    2.04    .704    .191    .012    .035    .025    .024    .042    .024

*


 QEGRGRGRGRAC
Q

*
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