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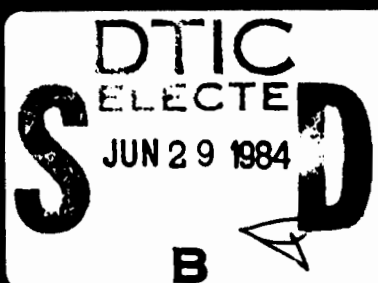
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Watertown Arsenal Laboratory
Report No. WAL 640/141
Problem No. D-13.3

23 November 1944

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WELDING OF ARMOR

Summary of Ballistic Shock Test Results for
1-1/2 Inch Thick Armor "H" Plates Welded with
Austenitic Electrodes and Tested at Aberdeen Proving Ground
During the Period 1 October 1943 through 31 March 1944

OBJECT

To tabulate firing record data for subject plates and to present a comparison of ballistic shock performance of plates made with various materials and welding procedures.

SUMMARY

1. Data from 31 Aberdeen Proving Ground firing records including 19 rolled homogeneous and 12 cast homogeneous armor manually welded "H" plates have been tabulated on the accompanying charts and tables. The small number of plates in this thickness group tested during the six month period, as compared with 172 "H" plates for the period of 1 October 1942 through 31 March 1943 (Report No. WAL 640/84) and 117 "H" plates for the period of 1 April 1943 through 30 September 1943 (Report No. WAL 640/113), limit the use of the present comparison to merely that of substantiating previously established trends.

2. A large difference in average weld metal cracking, which is apparently associated with steel quality (cleanliness and directional properties) is evident for rolled homogeneous armor "H" plates. Other welding procedure variables are not shown to have any large effect on ballistic shock performance.

3. With the exception of one "H" plate, a very marked decrease in the proportion of plate metal cracking was observed for cast armor "H" plates. This is apparently a result of more rigid acceptance testing, including use of fibre fracture test, which has brought about increases in hardenability and better heat-treat practice for cast armor.

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INTRODUCTION

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This is the seventh of a series of reports presenting tabulation of ballistic shock test results and welding procedure variables for "H" plates welded by commercial fabricators. Two of the previous reports, WAL 640/48 and 640/113 deal with "H" plates of 1-1/2 inch thick armor welded with austenitic electrodes and tested at Aberdeen Proving Ground during the periods of 1 October 1942 through 31 March 1943 and 1 April 1943 through 30 September 1943. The present tabulation includes all firing records received by this arsenal for "H" plates of 1-1/2 inch thick armor welded with austenitic electrodes and tested at Aberdeen Proving Ground between 1 October 1943 and 31 March 1944.

Data from 31 firing records are tabulated on the charts of Appendix A. An index of fabricators, armor manufacturers and electrode manufacturers is given in Table I. A summary of current ballistic shock test specification requirements and a key to tabulation methods and symbols used in this report are included in Appendix A.

GENERAL COMMENTS

For the purpose of this report, all cracking, in weld metal or armor plate within one-eighth inch of the edge of the weld is included as weld cracking and the remainder as plate cracking. Impacts striking at a distance (center of impact to center of weld) greater than 2 inches were not included in the averages. The average weld and plate cracking have been tabulated in terms of the severity of the ballistic test (Table II) and the correction used previously (Table III) have been applied in calculating average weld metal cracking throughout this report.

In Tables IV through X changes in the more important variables introduced by welding materials and procedures are compared on the basis of average cracking per round after correcting for ballistic severity. Because of the small number of test results, the comparison will be of value principally in support of trends indicated in the two earlier groups for 1-1/2 inch thick "H" plates welded with austenitic electrodes.

HAND WELDED, ROLLED ARMOR, H PLATES

Fabricators - Table IV

The performance of plates welded by various fabricators is dependent upon the quality of the electrodes and armor as well as the welding procedure and inspection control. Therefore no conclusions are made with regard to the quality of plates welded by each fabricator.

Armor Data - Table V

No correlations have been established between chemical composition or hardness of base metal and average weld metal cracking per round. However, there has been apparent a large difference in average weld metal cracking, between armor types, which may be associated with steel quality. That is, armor types which are usually relatively clean and types which have been cross-rolled consistently perform best from the standpoint of average weld metal cracking per round. The present group of plates, while too small in number to be conclusive, indicates a similar trend.

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Electrodes - Table VI

No correlations have been established between chemical composition or other electrode variables and ballistic cracking.

Joint Design - Table VII

Neither Root gap nor method of plate edge preparation have been established as important variables. A slight trend toward improved ballistic performance for included angles greater than 45° has been established but is not apparent in the present group of plates.

Welding Procedure - Table VIII

No correlation is evident between the total number of passes and ballistic cracking. The use of a combination of beads and weaves in the body of the weld and of multiple beads in the crown have been established as desirable, but the present tabulation does not contribute to this trend. Initial plate temperature varied from 70° to 200°F. No benefit of pre-heating is apparent.

Radiographic Examination - Table IX

It has been established that there is no correlation between results of radiographic examination and ballistic shock test performance. This is because (1) the area most susceptible to radiographic defects is the crossbar and impacts are placed on the leg welds at an average distance of six inches from the crossbar and, (2) the present radiographic standards are very severe and reject plates for defects which do not have a large influence on ballistic performance. Six of the present group of 18 plates failed radiographic examination but the average ballistic cracking was not greatly increased over that of the passing plates.

HAND WELDED, CAST ARMOR, H PLATES

Armor Data - Table X

With the exception of one "H" plate, a tremendous improvement is shown in the amount of plate metal cracking as compared to weld metal cracking during ballistic testing for this group of 12 "H" plates. Two previous tabulations for 1-1/2 inch thick hand welded cast armor plates have shown both weld and plate cracking, but especially plate cracking to be greater for cast than for rolled plates, even though the ballistic test is less severe for cast than for rolled plates. It was concluded that the cast armor plate had not been fully hardened during heat treatment, either due to insufficient hardenability or poor heat treating practice. The welded "H" plate, incorporating notches and high residual stresses, provided a very severe test for inadequately heat-treated armor compositions, and the extensive plate cracking invalidated any attempted comparisons of welding variables.

Recent more rigid acceptance testing including use of fibre fracture test, has effected a considerable improvement in shock resistance of cast armor and this is reflected in the improved performance of the present group of "H" plates. However, the small number of plates in the group does not justify a tabular comparison of welding variables.

TABLE I

Index to PlatesHand Welded, Rolled Armor, H Plates

Chart No.	No. of Plates	Fabricator	Armor Mfr.	Electrode Mfr.
1	1	Buick Youngstown Company	Great Lakes Jones & Laughlin	Crucible
2 - 3	4	Carnegie-Illinois	Carnegie-Illinois	Maurath Arcos
4	1	Chicago Vitreous Enamel Products	Great Lakes Jones & Laughlin	Crucible
5	2	Detroit Tank Arsenal	Carnegie-Illinois	Crucible Metal & Thermit
6	2	Federal Machine & Welder Co.	Republic	Crucible Harnischfeger
7	2	Fisher Tank	Ford Motor	McKay
8	1	Fitzgibbons	Carnegie-Illinois	McKay Harnischfeger
9	1	Holland Furnace	Great Lakes Jones & Laughlin	Crucible
10	1	W. B. Jarvis Company	Great Lakes Jones & Laughlin	Crucible
11	2	Midland Steel	Dominion Foundry	Crucible
12	1	Kalamazoo Stove & Furnace	Great Lakes Jones & Laughlin	Crucible
13	1	Pressed Steel Car Co.	Carnegie-Illinois	Crucible

Hand Welded, Cast 1-1/2 inch Thick Armor, H Plates

1	3	Briggs	American Steel Foundries	Metal & Thermit
2 - 3	3	Chrysler-Plymouth	American Steel Continental	Alloy McKay
4	1	Fitzgibbons	American Steel	Metal & Thermit Harnischfeger
5	1	Midland Steel	American Steel	Crucible
6	1	New York Air Brake Co.	American Steel	Lincoln Harnischfeger
7	2	Pressed Steel Car Co.	Continental Symington Gould	Crucible
8	1	Wehr Steel Co.	Wehr Steel Co.	A. O. Smith

TABLE II

Ballistic Severity Data - 1-1/2 Inch Thick

Vel. f/s	1st Round			2nd Round			3rd Round			4th Round			5th Round			6th Round			7th Round		
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
<u>Rolled H Plates</u>																					
0 - 2"																					
1176-1300	15	17.3	.4	13	16.5	.9	1	19.0	0	1	24.3	0									
1126-1175	2	20.1																			
1075-1125	2	13.1	6.2	2	1.3	0	1	20.5	.8												
1025-1074																					
950-1024																					
Over 2"																					
1176-1300	1	8.3	6.0	1	0	0															
1126-1175																					
1075-1125																					
1025-1074																					
950-1024																					
<u>Cast H Plates</u>																					
0 - 2"																					
1126-1200	1	0	0	1	13.3	0	2	18.0	0	1	0	0									
1076-1125	9	7.0	1.9	7	3.7	2.8	2	.4	.3												
1025-1075	1	0	0	4	4.7	.5	2	8.1	1.1	1	11.5	0									
975-1024																					
900- 974																					
Over 2"																					
1126-1200																					
1076-1125																					
1025-1075	1	0	0				1	0	0												
975-1024																					
900- 974																					

NOTES: A = Number of Rounds

B = Average Weld Cracking

C = Average Plate Cracking

TABLE III

Weld Cracking Corrections for Ballistic Severity

(Center of impact no further than 2 inches
distant from center of weld)

<u>Vel. f/s</u>	<u>1st Round</u>	<u>2nd Round</u>	<u>3rd Round</u>	<u>4th Round</u>
<u>Rolled H Plates</u>				
1176-1300+	-1.0	-3.0	-5.0	-7.0
1126-1175	- .5	-2.5	-4.5	-6.5
1075-1125	0	-2.0	-4.0	-6.0
1025-1074	+ .5	-1.5	-3.5	-5.5
950-1024	+1.0	-1.0	-3.0	-5.0
<u>Cast H Plates</u>				
1126-1200	-1.0	-3.0	-5.0	-7.0
1076-1125	- .5	-2.5	-4.5	-6.5
1025-1075	0	-2.0	-4.0	-6.0
975-1024	+ .5	-1.5	-3.5	-5.5
900- 974	+1.0	-1.0	-3.0	-5.0

NOTE: See Report WML 640/84 for derivation of these corrections.

TABLE IV

Fabricators of Hand Welded 1-1/2" Thick Rolled H Plates

<u>Armor Fabricator</u>	<u>No. of Plates</u>	<u>No. of Rounds</u>	<u>Av. Weld Cracking per Round (Corrected)(inches)</u>	<u>Av. Plate Cracking per Round</u>
Buick Youngstown Co.	1	3	14.5	0
Carnegie-Illinois Steel Corporation	4	6	16.8	0
Chicago Vitreous Enamel Products	1	1	26.3	0
Detroit Tank Arsenal	2	4	15.3	0
Federal Machine & Welder Company	2	3	7.3	5.8
Fisher Tank Division	2	4	14.8	0
Fitzgibbons Boiler Company, Inc.	1	2	15.9	0
Holland Furnace Co.	1	1	16.6	0
W. B. Jarvis Co.	1	2	18.1	2.2
Kalamazoo Stove & Furnace Company	1	2	23.7	0
Midland Steel Products	2	5	10.9	3.3
Pressed Steel Car Co.	1	2	4.2	0

TABLE V

Armor Data for Hand Welded 1-1/2 Inch Thick Rolled Armor H Plates

Manufacturer	Type	Chemical Composition	°F.	Heat Treatment Hold (hrs.)	Quench	Brinell Hardness	No. of Plates	No. of Rounds	Av. Cracking per Round (Corrected)	Weld	Plate
Carnegie-Illinois Steel Corporation	RI	.25 - .29 C									
		1.16 - 1.37 Mn	1562	3/4	Water		8	14	15.7		0
		.19 - .22 Si	1049	1-3/4	Water	F. 263-					
		.012- .029 S				277					
		.010- .019 P				B. 248-					
		.76 - .90 Cr				275					
Dominion Foundry	RV	.19 - .22 Mo									
		.28 C									
		.68 Mn	Not Given	Not Given	Not Given	Not Given	2	5	10.9		3.3
		.29 Si									
		2.11 Cr									
		.77 Ni									
Ford Motor Company	RII	.23 Mo									
		.28 C									
		1.28 Mn	Not Given	Not Given	Not Given	F. 269	2	4	16.8		0
		.26 Si				B. 269					
		.025 S									
		.024 P									
Composite Plates Jones & Laughlin Great Lakes	RIII J.L.	.53 Cr									
		.44 Mo									
		.24 - .27 C									
		1.59 - 1.70 Mn									
		.19 - .21 Si	1650	1/2 to 1-1/4	Water	F. 255-	5	9	17.2		.7
		.015- .024 S	1050			269					
		.013- .022 P	1200	1-1/2 to 3	Air	B. 269					
		.27 . .34 Mo				285					

TABLE V (Cont.)

Manufacturer	Type	Chemical Composition	°F.	Hold (hrs.)	Quench	Brinell Hardness	No. of Plates	No. of Rounds	Av. Cracking per Round (Corrected) Weib	Round Plate
	R IV	.25 - .29 C								
	G.L.	.94 - 1.23 Mn								
		.60 - .82 Si	1650	1/2 to 1-1/4	Water	F. 262				
		.019 - .027 S	1150			277				
		.018 - .027 P	1175	1-1/2 to 3	Air	B. 277				
		.65 - .75 Cr				285				
		.18 - .30 Mo								
		.61 - .12 Zr								
Republic Steel	R I	.264 C								
		1.22 Mn								
		.296 Si	1600	3	Water	F. 255	2	3	6.6	3.7
		.015 S				B. 255				
		.021 P	1200	3-1/2	Air					
		.788 Cr								
		.384 Mo								

TABLE VIa

Electrode Data for Hand Welded 1-1/2 Inch Thick Rolled H Plates

Electrode Manufacturer	Brand	Weld Metal Composition	Coating	No. of Plates	No. of Rounds	Av. Weld Cracking Per Round (Corrected)	Av. Plate Cracking Per Round
Arcos Corp.	Chromang	.065 - .17 C 3.3 - 4.75 Mn .80 Si .03 S .03 P 18.0 - 20.5 Cr 9.0 - 10.7 Ni 1.10 Mo	Lime	2	4	14.7	0
Crucible Steel	Resistal	.11 - .12 C 4.02 - 4.34 Mn .45 - .50 Si 20.05 - 20.76 Cr 9.40 - 10.52 Ni	Titania	1	2	23.8	0
Crucible Steel	Not Given	.26 C 6.33 Mn .81 Si .018 S .044 P 10.50 Ni 12.33 Cr .21 Mo	Not Given	2	5	10.9	3.3
Crucible Steel	Resistal Armorise Mn	.10 - .12 C 3.82 - 4.56 Mn .31 - .58 Si 19.01 - 19.52 Cr 9.70 - 10.70 Ni .77 - .85 Mo	Titania	5	11	10.4	.3

TABLE VIa (Cont.)

Electrode Manufacturer	Brand	Weld Metal Composition			Coating	No. of Plates	No. of Rounds	Av. Weld Cracking Per Round (Corrected)	Av. Plate Cracking Per Round
Crucible Steel	Resistal Mo	.10	-	.11	C	2	4	11.5	.4
		1.74	-	1.86	Mn				
		.19	-	.26	Si				
		19.71	-	20.18	Cr				
		9.98	-	10.35	Ni				
		1.82	-	1.86	Mo				
Harnischfeger	Smootharc AW-3C	.08	-	.12	C	1	1	11.5	7.5
		1.80	-	3.88	Mn				
		.33	-	.58	Si				
		18.4	-	19.7	Cr				
		9.44	-	10.7	Ni				
		.71	-	1.82	Mo				
Maurath, Inc.	Maurath	.08	-	.12	C	2	2	29.4	0
		3.95	-	5.00	Mn				
		.27	-	.58	Si				
		.009	-	.016	S				
		.019	-	.030	P				
		19.52	-	21.70	Cr				
		9.70	-	10.05	Ni				
		.05	-	.20	Mo				
McKay Company	Armorloy	.14	-	.16	C	2	4	14.3	0
		4.32	-	4.58	Mn				
		.30	-	.57	Si				
		.007	-	.023	S				
		.023	-	.024	P				
		16.7	-	17.4	Cr				
		.20	-	.28	Mo				

TABLE VIa (Cont.)

Electrode Manufacturer	Brand	Weld Metal Composition	Coating	No. of Plates	No. of Rounds	Av. Weld Cracking Per Round (Corrected)	Av. Plate Cracking Per Round
Metals and Thermit Corp.	Murex	.09 C 3.89 Mn .59 Si 19.48 Cr 9.47 Ni .78 Mo	Lime	1	2	21.0	0
McKay Harnischfeger Alloy Rods	McKay Armorloy	.12 C 4.5 Mn .80 Si 19.0 Cr 9.2 Ni	Lime	1	2	15.9	0
Composite	Harnischfeger P & H	.10 C 4.0 Mn .30 Si .03 S .03 P 19.0 Cr 9.5 Ni .80 Mo	Lime				
	Alloy Rod Armorarc	.08 C .35 Mn .35 Si .03 S .03 P 19.0 Cr 8.5 Ni	Lime				

TABLE VIb
(Rolled Homogeneous 1-1/2 Inch)

Electrode Type	Weld Analysis	No. of Flates	No. of Rounds	Av. Weld Cracking Per Round (Corrected) (Inches)	Av. Plate Cracking Per Round
Mn-Mo Mod. 18/8	At least 1% Mn and .2% Mo	17	32	13.7	1.2
Mn Mod. 18/8	At least 1% Mn below .2% Mo	2	3	23.4	0

TABLE VII

Joint Design Data for Hand Welded 1-1/2 Inch Thick Rolled "H" Plates

Angle of Bevel	No. of Plates	No. of Rounds	Av. Weld Cracking Per Round (Corrected)	Av. Plate Cracking Per Round
45° DV	10	21	15.1	.9
50° DV	1	2	15.9	0
54° DV	1	1	26.3	0
60° DV	6	9	15.4	1.8
75° DV	1	1	4.2	0

Root Gap (Inches)	No. of Plates	No. of Rounds	Av. Weld Cracking Per Round (Corrected) (Inches)	Av. Plate Cracking Per Round
3/16	6	8	16.9	0
1/4	2	5	10.9	3.3
5/16	11	22	15.5	.4

Plate Preparation	No. of Plates	No. of Rounds	Av. Weld Cracking Per Round (Corrected) (Inches)	Av. Plate Cracking Per Round
Flame Cutting	1	2	15.9	0
Flame Cutting and Grinding	16	28	14.7	.9
Machining	2	5	15.8	.9

TABLE VIII

Welding Procedure for Hand Welded 1-1/2 Inch Rolled "C" Plates

No. of Passes	No. of Plates	No. of Rounds	Av. Weld Cracking Per Round (Corrected)(Inches)	Av. Plate Cracking Per Round
6	2	5	10.9	3.3
8	2	4	14.3	0
10	1	1	26.3	0
11	1	3	14.5	0
12	1	2	23.7	0
14	2	6	16.3	.7
15	2	2	19.7	0
16	2	3	7.3	3.8
17	1	2	15.9	0
18	1	2	4.2	0
20	1	2	20.3	0
28	1	1	35.0	0
34	1	2	9.1	0

Root Deposition Type		No. of Plates	No. of Rounds	Av. Weld Cracking Per Round (Corrected)(Inches)	Av. Plate Cracking Per Round
I	Single bead at root	6	9	18.3	0
II	Two beads at root	13	20	13.8	1.2
Body Deposition					
Type					
I	Layers only	7	14	14.3	1.2
II	Beads only	3	6	16.0	0
III	Layers and beads	9	15	15.0	1.1
Crown Deposition					
Type					
I	Single crown	10	19	15.9	1.1
II and III	Multiple crown	9	16	14.0	.7

Preheat °F.	No. of Plates	No. of Rounds	Av. Weld Cracking Per Round (Corrected)(Inches)	Av. Plate Cracking Per Round
70 - 100	13	22	13.4	0.5
125	1	1	26.3	0
140	1	3	9.5	4.3
150	1	2	18.7	0
200	1	2	18.1	2.1
225	1	3	14.6	0
250	1	2	13.0	1.6

TABLE IX

Radiographic Data for Hand Welded
1-1/2 Inch Thick Rolled "H" Flates

Radiographic Results	No. of Plates	No. of Rounds	Av. Weld Cracking		Av. Plate Cracking Per Round
			Per Round (Corrected)	(Inches)	
Passing	13	24	14.6		.7
Failure	6	11	17.7		1.2

TABLE X

Armor Data for Hand Welded 1-1/2 Inch Thick Cast Armor "H" Plates

Armor Manufacturer	Type	Chemical Composition	Heat Treatment			No. of Plates	No. of Rounds	Av. Weld Cracking Per Round (Corrected)(Inches)	Av. Plate Cracking Per Round
			°F.	Hold (hrs.)	Quench B.H.N.				
American Steel	C IV	.24 - .305 C	1850	6	Air F. 235-	7	19	4.0	.1
		1.31 - 1.45 Mn			252				
		.42 - .45 Si	1250	2	Air B. 238-				
		.024 - .03 S			252				
		.014 - .017 P	1650	4	Water				
		1.21 - 1.35 Cr							
American Steel	C I Con.	.50 - .51 Ni	1200	8	Water	1	2	5.1	0
		.40 - .44 Mo							
Continental Roll & Steel		.32 C	Not Given	Not Given	Not Given	F. 248 B. 248			
Composite		.92 Mn							
		.40 Si							
		.046 S							
		.042 P							
Composite		.50 Cr							
		.51 Ni							
		.52 Mo							
C II A Amer.		.257 C							
		1.54 Mn							
		.52 Si							
		.019 S							
		.019 P							
		.35 Cr							
		.11 Mo							

TABLE X (Cont.)

Armor Manufacturer	Type	Chemical Composition	Heat Treatment		Quench	B.H.N.	No. of Plates	No. of Rounds	Av. Weld Cracking Per Round (Corrected)(Inches)	Av. Plate Cracking Per Round
			°F.	(hrs.)						
American Steel	C-III Amer.	.245 C .97 Mn .45 Si								
Continental Roll & Steel		.028 S .017 P 2.89 Cr .41 Mo	Not Given	Not Given	Not Given	F. 224 B. 224	1	2	0	1.
Composite	C I Con.	.32 C	1650	10	Air					
		.83 Mn				F. 241				
		.30 Si	1550	8	Sol. Oil	B. 248				
		.044 S								
		.048 P								
Continental Roll & Steel Cont'l	C-IV	.51 Cr	1200	12	Water					
		.52 Ni								
		.50 Mo								
		.30 C	1625	3	Air	F. 270	1	2	2.5	1.1
		.36 Si				B. 262				
General Steel Castings		.031 S	1575	3	Sol. Oil					
		.044 P								
		.52 Cr								
		.55 Ni	1225	3	Water					
		.48 Mo								
Composite	C-IV Gen.	.26 - .32 C								
		1.52 - 1.60 Mn				F. 293				
		.43 Si				B. 293				
		.013 - .013 S								
		.012 - .015 P	1650	4	Water					
		.50 - .69 Cr								
		.28 - .33 Mo								

TABLE X (Cont.)

Armor Manufacturer	Type	Chemical Composition		°F.	Heat Treatment		No. of Plates	No. of Rounds	Av. Weld Cracking		Av. Plate Cracking Per Round
					Hold (hrs.)	Quench B.H.N.			Per Round (Corrected)	(Inches)	
Symington Gould	C IV	.27	- .33	C							
		1.38	- 1.57	Mn	1700	5½	Water	F-246-	1	4	10.1
		.46	- .52	Si				278			0
		.020	- .030	S							
		.027	- .036	P	1149	6	Water	B-242-			
		.24	- .32	Cr				285			
			.30	Mo							
Wehr Steel Company	C IV	.29		C							
		.89		Mn	1700	6	Air	P. 255	1	2	7.4
		.43		Si							16.1
		.037		S							
		.026		P	1625	4	Water	B. —			
		.63		Cr							
		.97		Ni	1150	6	Air				
		.41		Mo							

APPENDIX A

1. Key to tabulation method and symbols.
2. Specification requirements for H plates welded with austenitic electrodes.
3. Tabulation of firing record data for subject H plates.

KEY TO TABULATION METHOD AND SYMBOLS

1. Identification of Test

Information in the first column identifies the test.

2. Armor Data

A. Plate Thickness

Plates in this tabulation are of 1-1/2 inch thick homogeneous armor.

B. Type Armor

Armor compositions are typed as follows:

R (Rolled)

	Type	C	Mn	Si	Cr	Mo	<u>Typical Analyses</u>	
							Ni	Zr
I	Mn-Ni-Cr-Mo	.26	1.15	.20	.60	.20	1.00	.002 B added
II	Mn-Cr-Mo	.27	1.30	.25	.55	.42		
III	Mn-Mo	.25	1.60	.22	—	.37		.002 B added
IV	Mn-Cr-Mo-Si	.27	.86	.79	.62	.17		.09
V	Special	(noted in tabulation)						

C (Cast)

I	Mn-Ni-Cr-Mo	.32	.80	.35	.55	.40	.45	
II	Mn-Cr-Mo	.28	1.55	.45	.40	.12		
III	Mn-Mo	.30	1.58	.40	—	.30		
IV	Special	(noted in tabulation)						

C. Carbon Content

Carbon content is listed as given.

D. Brinell Hardness Number (BHN)

The Brinell hardness numbers on both the front and back of plate are tabulated.

E. Process

This refers to the melting practice and is given as basic open hearth (B.O.H.), acid open hearth (A.O.H.), basic electric (B. Elec.), and acid electric (A. Elec.).

F. Heat Treatment

The temperature, time of hold, and type of quench and draw are recorded as given in the firing record.

3. Electrode Data

These data are listed as given in each firing record.

A. Type

Since alloys are sometimes added in the coating, electrodes are typed according to the chemical analysis of the weld metal when given. The types are as follows:

A (Austenitic)

I Mn-Mo Modified 18/8 (Cr-Ni-Fe alloy)
Weld Analysis - at least 1% Mn and .3% Mo.

II Mn Modified 18/8 (Cr-Ni-Fe alloy)
Weld Analysis - at least 1% Mn and less than .3% Mo.

III Mo Modified 18/8 (Cr-Ni-Fe alloy)
Weld Analysis - at least .3% Mo and less than 1% Mn.

B. Current and Polarity

These are to be tabulated as DC straight (str.), DC reversed (rev.) or AC.

4. Joint Design

A. Groove, etc.

This item notes the type of groove - single vee (SV) bevel or double vee (DV) bevel - the included angle, and the width of the root face (RF).

B. Root Gap

This is the distance in inches between the plates as set up for welding.

C. Plate Preparation

This indicates whether the plate edges to be welded together were flame cut, ground, machined, buttered, etc.

5. Welding Procedure

A. Backing

Backing if used, i.e. back-up bar, chill, filler, and spacer strip is noted.

B. Deposition

Figure 1 shows how the weld is broken up into root, body, and crown types. The size electrode is noted with the number of passes, type of passes, and the current and voltage. Passes are divided into two kinds: (a) layer, if the pass bridges the gap; and (b) bead, if the pass does not bridge the gap. SB designates seal bead.

C. Total Welding Time and Interpass Temperature

These are listed as given.

D. Remarks

Any comments on chipping, grinding, and other special techniques used, not noted above but which might affect ballistic properties of welded armor plate, are noted under "remarks."

6. Heat

Preheat and postheat of weldment are tabulated.

7. Ballistic Results

The type projectile used in testing is noted for each plate. Hits, velocity, and location of each, cracking and remarks on cracking, are recorded. Symbols used are as follows:

H.	-	hit
F/S	-	feet per second
L.L.	-	left leg
R.L.	-	right leg
CB.	-	crossbar
LOC.	-	location
R	-	right of
L	-	left of
X	-	on weld
U	-	above
D	-	below
IMP	-	running from or through impact
O	-	not running from or through impact

Types of cracking:

I	-	Weld (includes weld, fusion zone, and heat-affected zone cracking within 1/8 inch from weld)
IV	-	Star plate cracking
V	-	Linear plate cracks

Cracking is measured on the back of the plate.

8. The remarks on cracking and results of radiographic examination are recorded in the last column. P signifies the welded plate passed radiographic inspection, and F that it failed.

SPECIFICATION REQUIREMENTS FOR "H" PLATES
WELDED WITH AUSTENITIC ELECTRODES

Figure 11 shows the construction and intended aiming points for the ballistic shock test plate.

The requirements for the shock test at normal temperature as given by Specification AXS-497, Rev. 3, August, 1942, were as follows:

<u>Armor</u>	<u>Projectile</u>	<u>Striking Velocity</u> <u>(± 25 f/s)</u>	<u>Maximum Allowable Cracking</u> <u>Weld</u>	<u>Plate</u> <u>(inches)</u>
1-1/2" rolled	75 mm. T21	1100	15	8
1-1/2" cast	"	1050	15	8
1" rolled	"	775	18	8

There were no requirements specified for 1/2 inch plate, but for these cold tests the 37 mm. M54 H.E. projectile at 2600 f/s velocity was used. A limit of 12 inches of weld cracking was used as a criterion of acceptability of the welded joint. The limit on plate cracking was 8 inches.

From 3 May 1944 to the present the following requirements have been in effect (as abstracted from Specification AXS-497, Rev. 5, 15 December 1943):

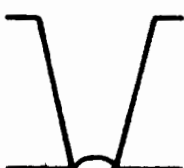
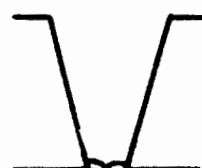
"F-3. Ballistic tests. Test plates required by paragraph F-2a(1)a shall be supported solidly on each of the two sides parallel to the longest welds and with these welds upright. The plate shall be tested for compliance with the requirements of Table II.

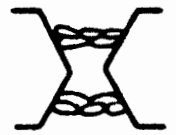
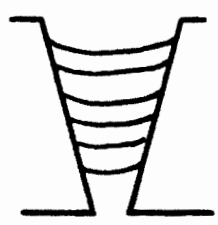
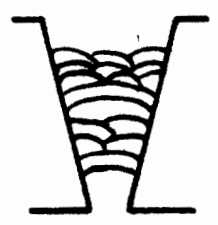
TABLE II

<u>Thickness of</u> <u>shock test</u> <u>plate, inches</u>	<u>Type of</u> <u>homogeneous</u> <u>armor</u>	<u>Projectile</u>	<u>Striking</u> <u>velocity f/s,</u> <u>plus or minus</u> <u>25 f/s</u>	<u>Allowable</u> <u>weld crack-</u> <u>ing, inches,</u> <u>maximum</u>
1-1/2	rolled	75 mm. T21	1200	15
1-1/2	cast	"	1050	10
1	rolled	"	725	17
1	cast	57 mm. T1	975	6
3/4	rolled	"	800	2
1/2	rolled	37 mm. H.E. M54	2525	15

"F-3a. Cracks in the armor parallel to the weld and within 1/8 inch of the edge of the weld shall be considered in the total weld cracking.

"F-3b. All impact velocities specified for cast homogeneous armor are subject to variation depending on the actual armor thickness. This variation shall be based on the velocities specified for testing primary armor and results in velocity of 6 f/s for each increase of 0.01 inch in armor thickness.

Root types	Type I	Type II
Double V bevel	 Single root bead at center of root	 More than one bead at root etc.
Single V bevel	 Single bead bridging root gap	 More than one bead bridging root gap etc.

Body types	Type I	Type II	Type III	Type IV	Type V
Double V bevel	 Layers only	 Beads only	 Layers & beads	Unionmelt	Special
Single V bevel	 Layers only	 Beads only	 Layers & beads	Unionmelt	Special

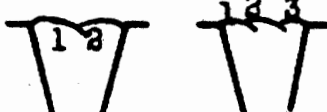
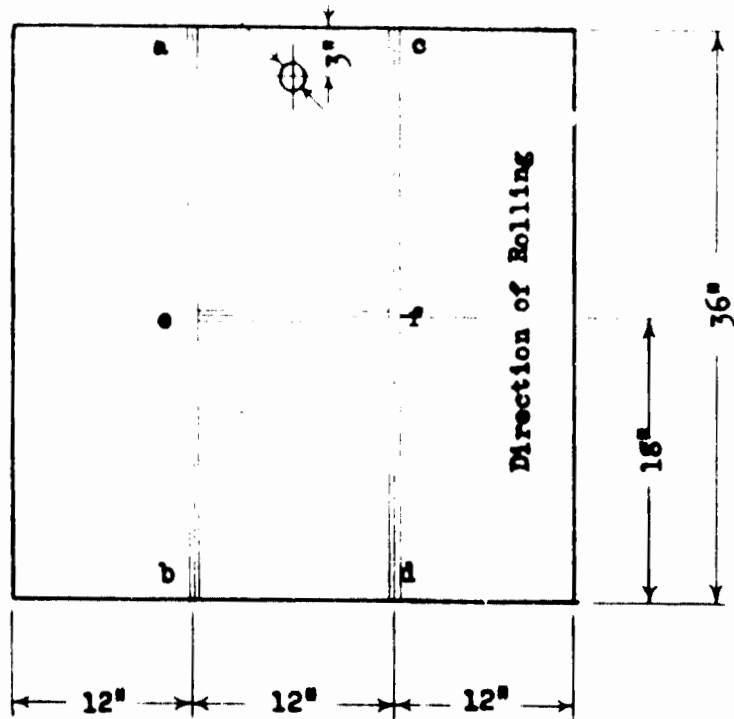
Crown types	Type I	Type II	Type III
Double V & Single V Bevel	 Single Crown Single pass bridges gap	 Multiple Crown Last bead touches parent metal	 Multiple Crown Last bead does not touch parent metal etc.

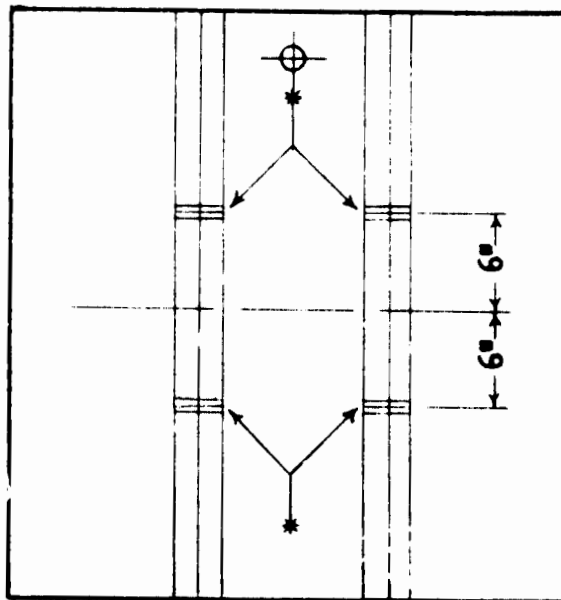
Fig. 1 Weld Metal Deposition Types

2" Dia.

Weld Sequence:
ab, cd, fe.



QUALIFICATION SHOCK TEST PLATE



* Intended Aiming Points

FIG. 11

IDENTIFICATION	ERROR DATA	ELECTRODE DATA	JOINT DESIGN	WELDING PROCEDURE	FRAT	BALLISTIC RESULTS								REMARKS ON CRACKING	
A. FIRING RECORD NO. B. DATE OF TEST C. PLATE NO. D. ARMOR MANUFACTURER E. ELECTRODE MFR. F. ARMOR FABRICATOR	A. PLATE THICKNESS B. TYPE C. CARBON CONTENT D. BHN E. PROCESS F. HEAT TREATMENT TEMP. TIME QUENCH	A. TYPE B. TRADE NAME C. COATING D. CURRENT & POLARITY	A. GROOVE, INCLUDED ANGLE, ROOT FACE B. ROOT GAP C. PLATE PREPARATION	A. BACKING B. DEPOSITION SIZE CL. NO. TYPE AMP. V. 1. ROOT TYPE 2. BODY TYPE 3. GROW TYPE C. TOTAL WELDING TIME & INTER PASS TEMPERATURE D. REMARKS	A. PRE B. POST	#	VEL.	LOCATION OF S	CRACKING	RADIOGRAPHIC RESULTS, ETC.					
							F/S	L.L.	R.L.	C.B.	LOC	TYPE	ARY		
A. AD 948 B. 10/22/43 C. 4-2-TB-1-H-4 D. Carnegie Ill. Steel Corp. E. Maurath Inc. F. Carnegie Ill. Steel Corp.	A. 1-1/2" B. R I 1. 21Mn .20Si .029S .015P .90Cr 1.00Ni .10Mo C. .27C D. Face 286 Back 286 E. B.O.H. F. 1562° F 3/4 hr water 1049° F 1 1/2 hr water	A. A II .06-.12C 3.95-5.00 Mn .27-.56Si .009-.016 S .019-.030 P 19.58-21.70Cr 9.70-10.06Ni .05-.20Mo B. Maurath C. Lime D. DO-REV	A. 60° DV B. 3/16" C. Flame cutting, Grinding.	A. B. 1. I 5/32" 1a 125 21 2. III 3/16" 3a 180 25 1/4" 3a 200 26 5/32" 1a 125 21 1/4" 6b 200 26 3. I 1/4" 1a 220 28 C. 7 hours 8 minutes. 90° F - 220° D. Grinding time 3-3/4 hours.	A. None B. None	1	1185	1"	6"	U	IMP	I	234"	P Moderate amount of slag.	
														78mm Proof projectile 721	
A. A 11289 B. 12/9/43 C. B-5H D. Carnegie Ill. Steel Corp. E. Arcos Corp. F. Carnegie Ill. Steel Corp.	A. 1-1/2" B. R I 1. 37Mn .20Si .024S .019P .76Cr .76Ni .21Mo C. .28C D. Face 248 Back 255 E. B.O.H. F. 1562° F 2 hr water 1196° F 1 1/2 hr water	A. A I .065C 3.3-4.72Mn .80Si .03S max .05P max 18.0-20.5Cr 9.0-10.7Ni 1.10Mo max B. Chromang C. Lime D. DO-REV	A. 60° DV B. 5/16" C. Flame cutting, Grinding.	A. B. 1. I 5/32" 1a 160 20 2. III 1/4" 4a 245 28 5/32" 1a 160 20 1/4" 6b 245 28 3. II 3/16" 6b 220 26 C. 4-1/2 hours 180° F-200° F D. Grinding time 1 hour, Peening 2 hours 15 minutes.	Not given None	1	1801	1"	9"	U	IMP	I	244"	P	
						2	1215	1 1/2"	9 1/2"		D	IMP	I	18 3/4"	484" 721
														78mm Proof projectile 721	
A. A 11286 B. 1/15/44 C. 10-B-5H D. Carnegie Ill. Steel Corp. E. Arcos Corp. F. Carnegie Ill. Steel Corp.	A. 1-1/2" B. R I 1. 31Mn .22Si .012S .010P .88Cr .88Ni .20Mo C. .27C D. Face 255 Back 255 E. Elec. Basic F. 1562° F 2 hr water 1150° F 1 1/2 hr water	A. A I .065-.17C 3.3-4.72Mn .80Si .03S .05P 18.0-20.5Cr 9.0-10.7Ni 1.10Mo max B. Chromang C. Lime D. DO-REV	A. 60° DV B. 5/16" C. Flame cutting, Grinding.	A. B. 1. II 5/32" 3b 185 22 2. II 3/16" 28b 200 27 3. II 3/16" 6b 180 26 C. 6 hours 24 minutes. 185-240° F D. Grinding time 1 hour 15 minutes.	Not given None	1	1196	1"	6"	U	IMP	I	84"	P	
						2	1200	1-3/8"	8 1/2"		D	IMP	I	14 234"	
														78mm Proof projectile 721	
														2.	

IDENTIFICATION	ARMOR DATA	ELECTRODE DATA	JOINT DESIGN	WELDING PROCEDURE	BEAT	BALLISTIC RESULTS								REMARKS ON CRACKING
A. FIRING RECORD NO. B. DATE OF TEST C. PLATE NO. D. ARMOR MANUFACTURER E. ELECTRODE MPER. F. ARMOR FABRICATOR	A. PLATE THICKNESS B. TYPE C. CARBON CONTENT D. MIN E. PROCESS F. HEAT TREATMENT TEMP. TIME QUENCH	A. TYPE B. TRADE NAME C. COATING D. CURRENT & POLARITY	A. GROOVE, INCLUDED ANGLE, ROOT FACE B. ROOT GAP C. PLATE PREPARATION	A. BACKING B. DEPOSITION SIZE EL. NO. TYPE AMP. V. 1. ROOT TYPE 2. ROOT TYPE 3. GROW TYPE C. TOTAL WELDING TIME & INTER PASS TEMPERATURE D. REMARKS	A. PRE B. POST	#	VEL.	LOCATION OF S				CRACKING		RADIOGRAPHIC RESULTS, ETC.
							F/S	L L	R L	C B	LOC.	TYPE	ENT	
A. A 12840 B. 3/7/44 C. 75412 CT-R-R-2 D. Carnegie Ill. Steel Corp. E. Maurath Inc. F. Carnegie Ill. Steel Corp.	A. 1 1/2" B. R I 1.10% .1981 .0228 .016P .87Cr 1.13M1 .22Mo C. .25C D. Face 277 Back 286 E. B.O.H. F. 1582°F 2 hr water 1040°F 1 1/2 hr water	A. A II --- B. Maurath Type 317 C. D. DC-REV	A. 60° DV B. 3/16" C. Flame cutting. Grinding	A. B. 1. II 5/32" 25 170 25 2. II 5/32" 180 185-190 28 3. II 5/32" 80 190 28 C. 8 hours 45 minutes. 101-175°F D. Grinding time 14-1/2 hours.	A. None B. None	1 1	1218		1- 5/8" L 12 1/2"		U IMP	I	30"	F Excessive in- complete fusion and slag.
			</											

IDENTIFICATION	ANODE DATA	ELECTRODE DATA	JOINT DESIGN	WELDING	PROCEDURE	FRAT	BALLISTIC RESULTS								REMARKS ON CRACKING
A. FIRING RECORD NO. B. DATE OF TEST C. PLATE NO. D. ARMOR MANUFACTURER E. ELECTRODE MFG. F. ARMOR FABRICATOR	A. PLATE THICKNESS B. TYPE C. CARBON CONTENT D. SIZE E. PROCESS F. HEAT TREATMENT TEMP. TIME QUENCH	A. TYPE B. TRADE NAME C. COATING D. CURRENT & POLARITY	A. GROOVE, INCLUDED ANGLE, ROOT FACE B. ROOT GAP C. PLATE PREPARATION	A. BACKING B. DEPOSITION SIZE EL. NO. TYPE AMP. V. 1. ROOT TYPE 2. ROOT TYPE 3. GROWN TYPE C. TOTAL WELDING TIME & INTER PASS TEMPERATURE D. REMARKS	A. PRE B. POST PASSES	A. PRE B. POST	WEL.	LOCATION OF S	CRACKING	RADIOGRAPHIC RESULTS, ETC.					
							F/S	L.L.	R.L.	C.B.	LOC.	TYPE	EXT.		
A. A 11504 B. 1/6/44 C. CV-W10 D. Jones & Laughlin Steel Corp. E. Crucible Steel Corp. of Amer. F. Chicago Vitreous Enamel Prods.	A. 1-1/2" B. R III J&L 1.70Mn .20Si .015S .017P .34Mo C. .27C D. Pace 269 Back 285 E. B.O.H. F. 1650°F 1 hr. water 1050°F 3 hrs. air A. 1-1/2" B. R IV GL .90Mn .73Si .023S .087P .65Cr .18Mo .012B .182r C. .28C D. Pace 262 Back 277 E. B.O.H. F. 1650°F 1 hr. water 1050°F 3 hrs. air	A. A I .14C 4.08Mn .54Si 19.08Cr 10.10Ni .84Mo B. Armorigise C. Titania D. DO-REV	A. 54° DV B. 3/16" C. Flame cutting. Grinding.	A. Copper B. 1. I 3/16" 1a 175 27 2. I 3/16" 1a 175 27 1/4" 6a 220 22 3. I 1/4" 2a 220 22 C. 2 hours. 185°F-170°F D. Grinding time 1 hour.	A. 125°F B. None	1	1198	4° R	74° U		IMP	1	274°	P	
								78mm Froo. projectile						221	

4.

IDENTIFICATION	AIRBOR DATA	ELECTRODE DATA	JOINT DESIGN	WELDING PROCEDURE	SEAT	BALLISTIC RESULTS										REMARKS ON CRACKING
A. FIRING RECORD NO. B. DATE OF TEST C. PLATE NO. D. ARMOR MANUFACTURER E. ELECTRODE MPON. F. ARMOR FABRICATOR	A. PLATE THICKNESS B. TYPE C. CARBON CONTENT D. SPS E. PROCESS F. HEAT TREATMENT TEMP. TIME QUENCH	A. TYPE B. TRADE NAME C. COATING D. CURRENT & POLARITY	A. GROOVE, INCLUDED ANGLE, ROOT FACT B. ROOT GAP C. PLATE PREPARATION	A. BACKING B. DEPOSITION SIZE EL. DO. TYPE AND V. 1. ROOT TYPE 2. BODY TYPE 3. GROWN TYPE C. TOTAL WELDING TIME & INTER PASS TEMPERATURE D. REMARKS	A. PRE B. POST	B	VOL.	F/B	L.L.	R.L.	C.B.	LOC.	TYPE	AMP	RADIOGRAPHIC DEFECTS, ETC.	
A. AD 935 B. 10/16/43 C. 44 D. Republic Steel Corp. E. Crucible Steel Co. F. Federal Machine & Welder Co.	A. 1-1/2" B. R I 1. 22mm .296 .0158 .081P .788Cr .91Mn .384 Mo C. .284C D. Face 255 Back 255 E. Elec. Basic F. 1800° F 3 hrs water 1800° F 3 1/2 hr air	A. A I 1. 105-12C 3. 98-4. 50 B. Mn C. .35-.46Si 19.00. 19.70Cr 9.98 10.24Mn .78-.82Mo B. Resistal Armorize Mn C. Titania D. DC-REV	A. 80° DV B. 5/16" C. Flame cutting. Grinding.	A. Copper B. 1. II 5/16" Ra 170 24-25 2. III 1/4" Ra 230 25-26 5/16" Ra 380 27-28 5/16" 4b 380 27-28 3. III 1/4" 4b 280 28-29 5/16" Ra 380 27-28 C. 7 hours 56 minutes. 70°-215°F D. Grinding time 1 hour 52 minutes.	A. None B. None	1	1197		4"	54"		U	INF	I	4-5/8" 2 Small amount of scattered porosity. 9-7/8 1-5/4 18"	
A. AD 935 B. 10/16/43 C. 45 D. Republic Steel Corp. E. Harnischfeger Company F. Federal Machine & Welder Co.	A. 1-1/2" B. R I 1. 22mm .296S .0158 .081P .788Cr .91Mn .384Mo C. .284C D. Face 255 Back 255 E. Elec. Basic F. 1800° F 3 hrs water 1800° F 3 1/2 hr air	A. A I 1. 105-12C 3. 98-4. 50 B. Mn C. .35-.56Si 19.4 19.7Cr 9.44 10.7Mn .71-1.82 Mo B. Smooth Arc AW-3C C. Titania D. DC-REV	A. 80° DV B. 5/16" C. Flame cutting. Grinding.	A. Copper B. 1. II 5/16" 1a 160 22-24 3/16" 1a 185 24-26 2. III 3/16" 1a 185 24-26 1/4" 3a 220 26-28 1/4" 4b 220 26-28 3. III 1/4" 4b 220 26-28 1/4" 5b 220 26-28 C. 5 hours 47 minutes. 100°-215°F D. Grinding time 1 hour 55 min.	A. None B. None	1	1189		2 1/2"	54"		U	INF	I	8 1/2"	
						2	1194		4"	R	54"		D	INF	V	14 1/2"
													O	I	2-5/8" 7-1/2"	
																28-7/8"
																78mm Proof projectile TR1

6.

IDENTIFICATION	ARMOR DATA	ELECTRODE DATA	JOINT DESIGN	WELDING PROCEDURE	HEAT	BALLISTIC RESULTS								REMARKS ON CRACKING		
A. FIRING RECORD NO. B. DATE OF TEST C. PLATE NO. D. ARMOR MANUFACTURER E. ELECTRODE MPAS F. ARMOR FABRICATOR	A. PLATE THICKNESS B. TYPE C. CARBON CONTENT D. S&H E. PROCESS F. HEAT TREATMENT TEMP. TIME QUENCH	A. TYPE B. TRADE NAME C. COATING D. CURRENT & POLARITY	A. GROOVE, INCLUDED ANGLE, ROOT FACE B. ROOT GAP C. PLATE PREPARATION	A. BACKING B. DEPOSITION SIZE EL. NO. TYPE AMP. V. 1. ROOT TYPE 2. ROOT TYPE 3. GROWN TYPE C. TOTAL WELDING TIME & INTER PASS TEMPERATURE D. REMARKS	A. PRE B. POST	#	VEL.	LOCATION OF B				CRACKING				RADIOGRAPHIC RESULTS, ETC.
							F/S	L.L.	R.L.	C.B.	LOC.	TYPE	AMT.			
A. A 10084 B. 11/28/43 C. 13 D. Carnegie-111. Steel Corp. E. McKay Harnischfeger Alloy Rod F. Fitzgibbons Boiler Company Inc.	A. 1-1/2" B. R I 1.19Mn .21Si .024S .018P .81Cr .77Ni .18Mo .08Cu C. .28C D. Face 282 Back 285 E. F. 1850°F 1110°F 2-2/3 hr. water	McKay- A. A II .12C .34Mn .80Si 19.0Cr 9.2Ni B. Armorloy C. Lime D. DO-REV Harnischfeger A. A I .10C 4.02 .30Si .03S .03P 19.0Cr 9.5Ni .80Mo B. P & H C. Lime D. DO-REV Alloy Rod A. A II .08C 4.2Mn .36Si .03S .03P 19.0Cr 8.5Ni B. Armor arc C. Lime D. DO-REV	A. 50° DV B. 3/16" C. Flame cutting.	A. B. 1. II 3/16" 2a 170 22 2. III 1/4" 3a 270 22 1/4" 2b 270 22 5/16" 6b 320 22 3. II 5/16" 4b 320 22 C. 16 hours. Below 250°F D. Grinding time 3.20 hours. Bottom of root bead ground clean.	A. None B. None	1 2	1800 1800		X R	64° 6- 3/8" D	IMP IMP	I I	19 1/2 16 35 1/2	F 2-1/4" cracking at crossbar.		
				</												

IDENTIFICATION	ANODE DATA	ELECTRODE DATA	JOINT DESIGN	WELDING PROCEDURE	SEAT	BALLISTIC RESULTS										REMARKS ON CRACKING
A. FIRING RECORD NO. B. DATE OF TEST C. PLATE NO. D. ANODE MANUFACTURER E. ELECTRODE MFG. F. ANODE FABRICATOR	A. PLATE THICKNESS B. TYPE C. CARBON CONTENT D. MIN E. PROCESS F. HEAT TREATMENT TEMP. TIME QUENCH	A. TYPE B. TRADE NAME C. COATING D. CURRENT & POLARITY	A. GROOVE, INCLUDED ANGLE, ROOT FACE B. ROOT GAP C. PLATE PREPARATION	A. BACKING B. DEPOSITION SIZE EL. NO. TYPE AMP. V. 1. 100% TYPE 2. 50% TYPE 3. 25% TYPE C. TOTAL WELDING TIME & INTER PASS TEMPERATURE D. REMARKS	A. PRE B. POST	#	VEL.	LOCATION OF S				CRACKING				RADIOGRAPHIC RESULTS, ETC.
							F/S	L.L.	B.L.	C.B.	LOC.	TYPE	INT			
A. A 12897 B. 3/21/44 C. HW 4 D. Jones & Laughlin. Great Lakes Steel E. Crucible Steel Co. F. W.B. Jarvis Co.	A. 1-1/2" B. R III JAL 1.58% .19Si .0245 .018P .27% C. .28C D. Face 255 Back 257 E. B.O.H. F. 1650° F 1 1/2 hr water 1800° F 1 1/2 hr air A. 1-1/2" B. R IV GL 1.82% .60Si .0196 .018P .78Cr .18% .08% C. .28C D. Face 260 Back 277 E. B.O.H. F. 1650° F 1 1/2 hr water 1175° F 1 1/2 hr air	A. A I .10C 1.74% .26Si 19.71Cr 10.35Ni 1.82% B. Resistal C. Titania D. DC-REV	A. 45° DV B. 5/16" C. Machining.	A. Copper B. 1. II 3/16" 2a 180 22 2. III 1/4" 2a 225 30 3. I 1/4" 2a 280 32 C. 6 hours. 160°-300° F D. Grinding time 8-1/2 hours.	A. 200° F B. None	1 2	1200 1225	5/8" R	8 1/2" U 10" D	IMP IMP IMP	I V I V	20" 1 20" 3 1/2	44 1/2"	P 3/8" incomplete fusion.		
														78mm Proof projectile TEL		

10.

IDENTIFICATION	ANODE DATA	ELECTRODE DATA	JOINT DESIGN	WELDING PROCEDURE	HEAT	BALLISTIC RESULTS								REMARKS OF CRACKING
A. FILING RECORD NO. B. DATE OF TEST C. PLATE NO. D. ANODE MANUFACTURER E. ELECTRODE SPEC. F. ANODE FABRICATOR	A. PLATE THICKNESS B. TYPE C. CARBON CONTENT D. WMP E. PROCESS F. HEAT TREATMENT TEMP. TIME QUENCH	A. TYPE B. TRADE NAME C. COATING D. CURRENT & POLARITY	A. GROOVE, INCLUDED ANGLE, ROOT FACE B. ROOT GAP C. PLATE PREPARATION	A. BACKING B. DEPOSITION SIZE EL. NO. TYPE AMP. V. 1. ROOT TYPE 2. ROOT TYPE 3. GROW TYPE C. TOTAL WELDING TIME & INTER PASS TEMPERATURE D. REMARKS	A. PRE B. POST	#	VEL.	LOCATION OF B	CRACKING	RADIOGRAPHIC RESULTS, ETC.				
							F/S	L.L.	R.L.	C.B.	LOC.	TYPE	INT.	
A. A 11560 B. 12/30/43 C. GMC 80 D. Dominion Fdry. E. Crucible Steel F. Midland Steel Products.	A. 1-1/2" B. R V C. .032in .2981 D. 11Cr E. .77W1 .22Mo F. .28C	A. A II B. .28C C. .522in D. .8181 E. .0188 F. .044P G. 10.50W1 H. 12.33Cr I. .21Mo	A. 45° DV B. 1/4" C. Flame cutting. Grinding.	A. Copper B. 1. II 3/16" 2a 170 22 2. I 1/4" 2a 250 30 3. I 1/4" 2a 780 30 C. --- 140°-180°F D. Weld ground flush with plate. Preheat 250°F for flame cut. Automatic and hand welding.	A. 250° F B. None	5	1190	3/8"	8 1/2"	U	IMP	I	27"	
						6	1164	1 1/4"	8 1/2"	D	-	-	-	3-3/16" F 4" cracking at crossbar.
														7mm Proof projectile TR1
A. A 11560 B. 12/30/43 C. GMC 81 D. Dominion Fdry. E. Crucible Steel F. Midland Steel Products	A. 1-1/2" B. R V C. .032in .2981 D. 11Cr E. .77W1 .22Mo F. .28C	A. A II B. .28C C. .522in D. .8181 E. .0188 F. .044P G. 12.33Cr H. 10.50W1 I. .21Mo	A. 45° DV B. 1/4" C. Flame cutting. Grinding.	A. Copper B. 1. II 3/16" 2a 170 22 2. I 1/4" 2a 250 30 3. I 1/4" 2a 780 30 C. --- 140°-185°F D. Weld ground flush with plate. Preheat 250°F for flame cut. Automatic and hand welding.	A. 140° B. None	1	1100	1"	8 1/2"	U	IMP	I	8"	F
						2	1099	1 1/4"	8 1/2"	D	-	-	-	
						3	1098	X	8 1/2"	U	IMP	I	20"	
							1178				O	V		
														7mm Proof projectile TR1

IDENTIFICATION	ANODE DATA	ELECTRODE DATA	JOINT DESIGN	WELDING PROCEDURE	SEAT	BALLISTIC RESULTS										REMARKS ON CRACKING
A. FIRING RECORD NO. B. DATE OF TEST C. PLATE NO. D. ANODE MANUFACTURER E. ELECTRODE MFR. F. ANODE FABRICATOR	A. PLATE THICKNESS B. TYPE C. CARBON CONTENT D. SIZE E. PROCESS F. HEAT TREATMENT TEMP. TIME QUENCH	A. TYPE B. TRADE NAME C. COATING D. CURRENT & POLARITY	A. GROOVE, INCLUDED ANGLE, DEG. FACE B. ROOT GAP C. PLATE PREPARATION	A. BACKING B. DEPOSITION SIZE CL. NO. TYPE AMP. V. 1. ROOT TYPE 2. ROOT TYPE 3. GROW TYPE C. TOTAL WELDING TIME & INTER PASS TEMPERATURE D. REMARKS	A. PRE B. POST	#	VEL. F/S	LOCATION OF S				CRACKING		RADIOGRAPHIC RESULTS, ETC.		
								L.L.	R.L.	C.D.	LOC.	TYPE	AMT.			
A. A 11559 B. 12/29/43 C. 850 W5 D. Jones & Laughlin Great Lakes Steel Corp. E. Crucible Steel F. Kalamazoo Stove & Furnace Company.	A. 1-1/2" B. R III JAL 1.032Mn .2181 .0178 .002P .34% C. .24C D. Face 255 Back 269 E. B.O.M. F. 1680° F 1 1/2 hr WQ & temp. A. 1-1/2" B. R IV CL .002Mn .7681 .0196 .002P .68Cr .22% .02Cr C. .28C D. Face 268 Back 285 E. B.O.M. F. 1680° F., WQ, 1180° F 3 hrs. air (tempering)	A. R II .11-.12C 4.08-4.34 Mn .45-.50Si 20.05- 20.78Cr 9.40- 10.52Ni B. Resistal C. Titania D. DO-REV	A. 45° DV B. 5/16" C. Flame cutting. Grinding	A. Copper B. 1. II 3/16" 2a 190 22 2. III 1/4" 2a 225 28 5/16" 2a 220 30 5/16" 4b 280 30 3. I 5/16" 2a 280 30 C. 5 hours. 180° F - 510° F D. Grinding time 18 hours.	A. 150° F B. None	1 2	1231 1186		X 3/4" L	10° U 7 1/2° D	IMP IMP	I I	154° 36 514°	P		

IDENTIFICATION	ANODE DATA	ELECTRODE DATA	JOINT DESIGN	WELDING PROCEDURE	TEST	BALLISTIC RESULTS										REMARKS ON CRACKING
A. FILING RECORD NO. B. DATE OF TEST C. PLATE NO. D. ANODE MANUFACTURER E. ELECTRODE INFO. F. ANODE FABRICATOR	A. PLATE THICKNESS B. TYPE C. CARBON CONTENT D. SIZE E. PROCESS F. HEAT TREATMENT TEMP. TIME QUENCH	A. TYPE B. TRADE NAME C. COATING D. CURRENT & POLARITY	A. GROOVE, INCLUDED ANGLE, ROOT FACE B. ROOT GAP C. PLATE PREPARATION	A. BACKING B. DEPOSITION SIZE EL. NO. TYPE AMP. V. 1. ROOT TYPE 2. ROOT TYPE 3. GROOVE TYPE C. TOTAL WELDING TIME & INTER PASS TEMPERATURE D. REMARKS	A. PRE B. POST	#	VEL. F/S	LOCATION OF D				CRACKING		MAGNIFICATION RESULTS, ETC.		
								L.L.	R.L.	C.B.	LOC.	TYPE	LEN.			
A. AD 917 B. 10/5/45 C. HQ 57 D. Carnegie Steel E. Crucible Steel F. Pressed Steel Car Company.	A. 1-1/2" B. R I 1.10% .1981 .0228 .016P .87Cr 1.13Ni .22Mo C. .25C D. Face 265 Back 275 E. F. 1562° F 1 1/2 hr water	A. A I .11C 1.60% .1981 20.18Cr 9.88Ni 1.62Mo B. Resist 1 (Mc) C. Titania D. AC-STR	A. 75° DV B. 5/16" C. Flame cutting. Grinding.	A. B. 1. II 5/16" 2a 160-170 23-25 2. III 5/16" 1a 170 25 1/4" 2a 250 25 5/16" 2a 300 27 5/16" 4b 300 27 3. II 5/16" 6b 300 27 C. 16 hours. — D. Grinding time 8 hours.	A. 100° F B. None	1	1210		1- 1/8" L	5+ D 5° U	- - IMP I	- - 114"	P	78mm Proj. projectile T81		

19.

IDENTIFICATION	MATERIAL DATA	ELECTRODE DATA	JOINT DESIGN	WELDING PROCEDURE	SEAT	BALLISTIC RESULTS	REMARKS OR CRACKING
A. FIRING RECORD NO. B. DATE OF TEST C. PLATE NO. D. ARMOR MANUFACTURER E. ELECTRODE SPEC. F. ARMOR FABRICATOR	A. TYPE B. TRADE NAME C. CARBON CONTENT D. RHN E. PROCESS F. HEAT TREATMENT TEMP. TIME QUENCH	A. TYPE B. TRADE NAME C. COATING D. CURRENT & POLARITY	A. GROOVE INCLUDED ANGLE, ROOT FACE B. ROOT GAP C. PLATE PREPARATION	A. BACKING B. DEPOSITION SIZE EL. NO. TYPE AMP. V. 1. ROOT TYPE 2. BODY TYPE 3. GROWTH TYPE C. TOTAL WELDING TIME & INTER PASS TEMPERATURE D. REMARKS	A. PAX B. POST	# VEL. LOCATION OF S CRACKING RADIOGRAPHIC RESULTS, ETC.	
						F/S L.L. R.L. C.R. LOC. TYPE AMT	
A. AD 910 B. 9/30/45 C. 54 D. Continental Roll & Steel American Steel Found. E. Alloy Rod. F. Chrysler Plymouth	A. 1-1/2" (1.64") B. C I Con. .82Mn. .40Si .046S. .042P .60Cr. .51Ni .52Mo C. .32C D. Face 248 Back 248 E. Acid O.H. F. --- A. 1-1/2" B. C II A & C 1.54Mn. .62Si .019S. .019P .35Cr. .11Mo C. .287C D. Face 217 Back 217 E. B.O.H. F. ---	A. A II .14C 3.5Mn .75Si .26S. .36P .18Cr 8.25Ni Tr.Mo B. Armoxarc C. Titania D. DC-REV	A. 45° DV B. 1/4" C. Flame cutting.	A. Copper B. 1. II 3/16" 2a 180 28 2. I 1/4" 2a 210 27 5/16" 4a 280 30 3. II 3/16" 4b 180 28 5/16" 2b 280 30 C. 8 hours. D. Grinding time 4 hours.	A. None B. None	1 1172 1- 5/16" R 7 1/2" U - - - 2 1137 1" R 5 1/2" D IMP I 13 1/2"	P Welds are acceptable.
A. AD 910 B. 9/30/45 C. 55 D. American Steel Found. Continental Roll & Steel McWay Company E. McNay Company F. Chrysler Plymouth	A. 1-1/2" B. C IV A .97Mn. .45Si .088S. .017P 2.89Cr. .41Mn C. .245C D. Face 224 Back 224 E. B.O.H. F. --- A. 1-1/2" B. C C I Con. .83Mn. .30Si .044S. .042P .51Cr. .52Ni .50Mo C. .52C D. Face 241 Back 248 E. Acid O.H. F. 1650°F 10 hrs air 1550°F 6 hrs oil 1800°F 12 hrs water	A. A II .18C 3.75Mn .70Si 19.25Cr 9.10Ni B. Armoxloy C. Lime D. DC-REV	A. 45° DV B. 1/4" C. Flame cutting.	A. Copper B. 1. II 3/16" 2a 180 28 2. I 1/4" 2a 210 27 5/16" 4a 280 30 3. II 5/16" 2b 280 30 3/16" 4b 180 28 C. 6 hours D. Grinding time 4 hours.	A. None B. None	1 1087 1- 7/8" R 7 1/2" U - - - 2 1068 1 1/2" R 3 1/2" U IMP I 4 3 1058 2 1/2" R 5 1/2" D - - - 2 1/2"	P Welds are acceptable.
						75mm Proof projectile TEI	2.

IDENTIFICATION	ARMOR DATA	ELECTRODE DATA	JOINT DESIGN	WELDING PROCEDURE	SEAT	BALLISTIC RESULTS								REMARKS ON CRACKING
A. FIRING RECORD NO. B. DATE OF TEST C. PLATE NO. D. ARMOR MANUFACTURER E. ELECTRODE MPAS. F. ARMOR FABRICATOR	A. PLATE THICKNESS B. TYPE C. CARBON CONTENT D. SIZE E. PROCESS F. HEAT TREATMENT TEMP. TIME QUENCH	A. TYPE B. TRADE NAME C. COATING D. CURRENT & POLARITY	A. GROOVE, INCLUDED ANGLE, ROOT FACE B. ROOT GAP C. PLATE PREPARATION	A. BACKING B. DEPOSITION SIZE EL. NO. TYPE AMP. V. 1. ROOT TYPE 2. BODY TYPE 3. GROWN TYPE C. TOTAL WELDING TIME & INTER PASS TEMPERATURE D. REMARKS	A. PRE B. POST	#	VEL.	LOCATION OF B	CRACKING	RADIOGRAPHIC RESULTS, ETC.				
						F/B	L.L.	R.L.	C.B.	LOC.	TYPE	ART		
A. A 11350 B. 12/27/43 C. FOB 14 D. American Steel Foundry E. Metal & Thermit. F. Harnischfeger Alloy Rod. F. Fitzgibbon Boiler Company, Inc.	A. 1-1/2" B. C IV 1.30Mn.43Si .014P.1.26Cr .15Ni.42Mo C. .305C D. Face 248 E. -- F. 1850° 6 hrs. 1250° 2 hrs. 1650° 4 hrs. 1200° 8 1/2 hrs.	Metal & Thermit. A. A I .07-.17C 3.3-4.75Mn .80Si 18.0-20.5Cr 9.0-10.7Ni 0.0-1.10Mo B. Murex C. Lime D. DC-REV Harnischfeger A. A I .10C4.0Mn .30Si .035.03P 19.0Cr 9.5Ni .80Mo B. PAN C. Lime D. DC-REV Alloy Rod A. A II .08C 3.5Mn .35Si .035.03P 19.0Cr 8.5Ni B. Armorarc C. Lime D. DC-REV	A. 45° DV B. 3/16" C. Flame cutting	A. B. 1. II 3/16" 2a 160 22 2. III 1/4" 4a 250 22 3. II 1/4" 8b 280 22 3. II 5/16" 4b 380 22 C. 27 hours. Below 250°F D. Grinding time 4 hours. Bottom of root bead ground clean.	A. 200° B. None	1	1106	1" 8 1/2"	L U	IMP I	19 1/2"	F		
						2	1110	7/8" 2 1/2"	L D		IMP I	2-5/8"	Total of 3 1/2" of cracking at intersections of x-bar and leg welds. 21-2/3"	
													75mm Proof projectile 121	

IDENTIFICATION	ANODE DATA	ELECTRODE DATA	JOINT DESIGN	WELDING PROCEDURE	SEAT	BALLISTIC RESULTS										REMARKS ON CRACKING
A. FILING RECORD NO. B. DATE OF TEST C. PLATE NO. D. ANODE MANUFACTURER E. ELECTRODE SPEC. F. ANODE FABRICATOR	A. PLATE THICKNESS B. TYPE C. CARBON CONTENT D. SIZE E. PROCESS F. HEAT TREATMENT TEMP. TIME QUENCH	A. TYPE B. TRADE NAME C. COATING D. CURRENT & POLARITY	A. GROOVE, INCLUDED ANGLE, ROOT FACE B. ROOT GAP C. PLATE PREPARATION	A. BACKING B. DEPOSITION SIZE CL. NO. TYPE AND V. 1. ROD TYPE 2. ROOT TYPE 3. GROW TYPE C. TOTAL WELDING TIME & INTER PASS TEMPERATURE D. REMARKS	A. PRE B. POST	#	VEL.	LOCATION OF #			CRACKING			RADIOGRAPHIC RESULTS, ETC.		
F/S	L.L.	R.L.	C.D.	LOC.	TYPE	ANY										
A. A 11884 B. 1/4/44 C. A 85 D. American Steel Foundry E. Crucible Steel Co. F. Midland Steel Products	A. 1-1/2" (1.50) B. Cast IV 1.45% C, .45% Si 1.35% Cr, .60% Mn .40% Mo C. .30C D. Face 235 Back 240 E. Not given F. 1850° F 6 hrs air 1255° F 2 hrs air 1650° F 4 hrs water 1250° F 6 hrs water draw	A. A I .105C 3.92% Mn .32% Si 19.92% Cr 9.71% Ni .82% Mo B. Grade V C. Not given D. AC	A. 45° DV B. 1/4" C. Flame cutting.	A. Copper B. 1. II 3/16" 2a 175-190 22 2. I 1/4" 2a 260 23 5/16" 2a 375 24 3/8" 2a 475 24 3. I 3/8" 2a 475 24 C. --- 110° - 2 20° F D. Not given	A. None B. None	1	1097	5/8"	9 1/4"	R	U	IMP	I	1 1/2"	P	
						2	1098	I	8 1/4"	B	-	-	-	-	5/8"	
						3	1136	1- 3/8"	L	U	-	-	-	-	Cast plate is sound. Welds are acceptable.	
						4	1195	3/8"	L	7 1/4"	D	-	-	-		
															2-1/8"	
								75mm Proof	projectile					121		

IDENTIFICATION	ANODE DATA	ELECTRODE DATA	JOINT DESIGN	WELDING PROCEDURE	SEAT	BALLISTIC RESULTS								REMARKS ON CRACKING
A. FIRING RECORD NO. B. DATE OF TEST C. PLATE NO. D. ANODE MANUFACTURER E. ELECTRODE MFG. F. ANODE FABRICATOR	A. PLATE THICKNESS B. TYPE C. CARBON CONTENT D. SIZE E. PROCESS F. HEAT TREATMENT TEMP. TIME QUENCH	A. TYPE B. TRADE NAME C. COATING D. CURRENT & POLARITY	A. GROOVE, INCLUDED ANGLE, ROOT FACE B. ROOT GAP C. PLATE PREPARATION	WELDING	A. PRE B. POST	#	VEL.	LOCATION OF #				CRACKING		RADIOGRAPHIC RESULTS, ETC.
				PROCEDURE				F/S	L.L.	R.L.	C.B.	LOC.	TYPE	
A. A 11349 B. 12/27/43 C. NYAB 49 D. American Steel Foundries E. Lincoln Elec. Hardischfeger F. New York Air Brake Co.	A. 1-1/2" (1.56") B. Cast IV 1.25% .4381 .05% .014P 1.20Cr .51Ni .42Mn C. .305C D. --- E. Elec. Acid F. 1850° F 6 hrs air 1250° F 2 hrs air 1650° F 4 hrs water 1200° F 8 1/2 hrs water	A. A II .10C 4.00Mn .50Si 19.60Cr 9.25Ni B. Armorweld P & H C. Not given D. DC-REV	A. 45° EV B. 1/4" C. Flame cutting. Grinding.	A. B. 1. II 3/16" 2a 200 26 2. III 5/32" 1a 200 26 3/16" 7b 200 26 3. II 1/4" 2b 300 30 3/16" 2b 200 26 C. 10 hours. 150°-175° F D. Grinding time 7 hours.	A. None B. None	1 2	1118 1106	1" L	104" L 84" D	U IMP IMP	I I	1-1/8" 1-3/8" 2 1/4"	P Numerous surface depressions and markings present on weld surface.	
							76mm Proof	proof	projectile	TE1				

6.

IDENTIFICATION	ANNOX DATA	ELECTRODE DATA	JOINT DESIGN	WELDING PROCEDURE	SEAT	BALLISTIC RESULTS	REMARKS ON CRACKING
A. FIRING RECORD NO. B. DATE OF TEST C. PLATE NO. D. ANNOX MANUFACTURER E. ELECTRODE MPNo. F. ANNOX FABRICATOR	A. PLATE THICKNESS B. TYPE C. CARBON CONTENT D. BHN E. PROCESS F. HEAT TREATMENT TEMP. TIME QUENCH	A. TYPE B. TRADE NAME C. COATING D. CURRENT & POLARITY	A. GROOVE, INCLUDED ANGLE, ROOT FACE B. ROOT GAP C. PLATE PREPARATION	A. BACKING PASSES B. DEPOSITION SIZE EL. NO. TYPE AMP V. 1. ROOT TYPE 2. BODY TYPE 3. GROWN TYPE C. TOTAL WELDING TIME & INTER PASS TEMPERATURE D. REMARKS	A. PRE B. POST	# VEL. LOCATION OF S CRACKING RADIOPHOTOGRAPHIC RESULTS ETC.	
						F/B L.L. R.L. C.B. LOC. TYPE AMT	
A. AD 917 B. 10/5/43 C. M2 69 D. Continental Roll & Steel General Steel Castings. E. Crucible Steel F. Pressed Steel Car Company	A. 1-1/2" B. Cast IV CRS 1.18% Mn .0313% C .02Cr .56Mn .48Mo .30C C. .30C D. Face 270 Back 262 E. Not given F. 1625°F 3 hrs air 1575°F 2 hrs sol oil 1225°F 3 hrs water Ar 1-1/2" B. Cast IV CGT 1.52-1.60% Mn .43Si .012-.014S .012-.016P .50-.69Cr .28-.33Mo C. .28-.32C D. Face 265 Back 265 E. Not given F. 1650°F 4 hrs water	A. A I .085C 4.14mm .23Si 19.70Cr 9.90Ni .72Mo B. Resistal (m) C. Titania D. DC-REV	A. 75° DV B. 3/16" C. Flame cutting Grinding	A. B. 1. II 5/32" 2a 130 -140 25 2. I 5/32" 2a 140 25 3. I 3/16" 2a 170 25 C. 29 hours. — D. Grinding time 10 hours.	A. 100° F B. None	1 1A 2-3/8" L 9+° D 2 1052 +° L 2 1051 14° R 5-7/8" U IMP I 5° V 2-1/8" 7-1/8"	P
A. AD 940 B. 10/18/43 C. M2 49 D. Symington Gould E. Crucible Steel F. Pressed Steel Car Company	A. 1-1/2" (1.52) B. Cast IV 1.38-1.57% Mn .48-.52Si .080-.080S .027-.030P .24-.32Cr .30Mo C. .27-.32C D. Face 248-270 Back 248 265 E. Not given F. 1700°F 8½ hr water 1140°F 6 hr water	A. A I .11C 1.82mm .19Si 20.18Cr 9.90Ni 1.62Mo B. Resistal C. Titania D. DC-REV	A. 75° DV B. 5/16" C. Flame cutting Grinding	A. B. 1. I 5/16" 2a 170 28 2. III 1/4" 2a 280 28 5/16" 2a 300 30 3. II 5/16" 4b 300 30 C. 15 hours. — D. Grinding time 5-1/2 hours.	A. None B. None	1 1080 5/8" L 14+° D 2 1084 5/8" R 15° U IMP I 13+° 3 1087 X 14-5/8" D IMP I 16+° 4 1048 +° L 14+° U IMP I 11+°	F Weld is not acceptable due to cracking in x-bar. Small amount of porosity throughout the weld. B type shrinkage.
						75mm Proof projectile T21	7.

[illegible]