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FINAL REPORT

ON

EVALUATION OF SHIP WELDING PROCEDURES BY DIRECT EXPLOSION TESTING

BY

G. S. MIKHALAPOV
Metallurgical Research and Development Company, Inc.
Under Bureau of Ships Contract NObs-53383
(Index No. NS-011-067)

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Dear Sir:

Herewith is a copy of the second Report on the investigations using the "Direct Explosion High-Energy Loading Test", by G. S. Mikhalapov. These investigations are being conducted at the request of the Ship Structure Committee. This Report, together with the first Report (SSC-43, March 15, 1951), covers the work done up to January 1951.

Any questions, comments, criticisms or other matters pertaining to the Report should be addressed to the Secretary, Ship Structure Committee.

This Report is being distributed to those individuals and agencies associated with the work reported. It is hoped that the information presented will prove useful.

Yours sincerely,

K. K. COWART
Rear Admiral, U. S. Coast Guard
Chairman, Ship Structure Committee

PREFACE

The Navy Department through the Bureau of Ships is distributing this report for the SHIP STRUCTURE COMMITTEE to those agencies and individuals who were actively associated with the research work. This report represents results of part of the research program conducted under the Ship Structure Committee's directive "to improve the hull structures of ships by an extension of knowledge pertaining to design, materials and methods of fabrication".

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ON

EVALUATION OF SHIP WELDING PROCEDURES

BY

DIRECT EXPLOSION TESTING

COVERING WORK PERFORMED

UNDER

DEPARTMENT OF THE NAVY-BUREAU OF SHIPS

CONTRACT NObs-53383

WITH

METALLURGICAL RESEARCH & DEVELOPMENT
COMPANY, INC.

(INDEX NO. NS-011-067)

FOREWORD

The research described in this report was sponsored and financed by the Ship Structure Committee and carried out under Contract NObs-53383 with the Bureau of Ships, Department of the Navy. The work was conducted under the general supervision and direction of the Ship Structure Sub-Committee.

The author wishes to express his appreciation to Dr. Finn Jonassen, Technical Director, Committee on Ship Steel; Capt. R. H. Lambert, USN, and Messrs. C. A. Loomis and E. M. MacCutcheon of the Bureau of Ships for their assistance and advice.

The views and opinions expressed in this report are those of the author and do not necessarily represent the views of either the Ship Structure Committee, the Committee on Ship Steel, or of the Department of the Navy.

G. S. Mikhalapov

EVALUATION OF SHIP WELDING PROCEDURES
BY DIRECT EXPLOSION TESTING

BY

G. S. MIKHALAPOV

METALLURGICAL RESEARCH & DEVELOPMENT COMPANY, INC.

Bureau of Ships Contract NObs-53383

Index No.NS-011-067

INTRODUCTION

The investigation described in this report is a direct continuation of work conducted for the Ship Structure Committee under Bureau of Ships Contract NObs-50464 and described in report SSC-43. (1)

It will be remembered that the latter investigation was undertaken primarily in an attempt to obtain an indication of whether the type of welding electrodes used in joining ship plate had an appreciable effect on the notch toughness of the finished joint, and that the data obtained strongly suggested that this was the case. Specifically they indicated that the use of the low hydrogen, low alloy electrode AWS type E-10016 noticeably improved performance of joints of ship plate, as compared to the performance when the joints were welded with E-6010 electrodes; the improvement was far greater in case of a fully killed steel than in case of a semi-killed steel. It also suggested that joints made by multi-pass submerged arc process are greatly superior to those made with E-6010 electrodes. A number of questions immediately arise concerning the probable causes of these improvements in performance, for instance, whether the reduction of hydrogen in the arc atmosphere or the alloy content of E-10016 electrode are of greater importance and whether improvement produced by the multi-pass submerged arc process would be exhibited if more common two-pass procedure was used. In addition other pertinent questions arise concerning the relative effects of other variables in welding procedures, such as interpass temperatures, preheat, peening, stress relief, etc.

Accordingly, the Ship Structure Committee directed further exploration of the relative effects of different welding procedures on the notch toughness of the welded joint as determined by the direct explosion test as follows:

1) Determine notch toughness of welded joints of a semi-killed and of a fully killed steel when welded with -

   a) Class E-7016 electrodes.

   b) Submerged arc process, using two passes, one from each side.

2) Obtain a general indication of the relative effects on the notch toughness of welded joints of a fully killed steel, of the following factors:

   a) preheat of 150° F.

   b) interpass temperature

   c) low temperature stress relief

   d) peening of all weld passes

METHOD OF INVESTIGATION

In order to permit a direct comparison with the results of the previous investigation of ship plate, the plates used were taken from the same two heats of A.B.S. Class B and Class C steel used in the previous investigation. The mechanical properties and chemical analyses of these steels are described in Report SSC-43 (1) and are reproduced for convenience below in Table I. It will be remembered that the Class B steel is semi-killed while the Class C steel is silicon-killed with aluminum added for fine grain.

TABLE I

Composition and mechanical properties of the 1" thick ship plate used.

Code	AQ	AP
Ladle Analysis	ABS Class B*	ABS Class C**
C	.16%	.16%
Mn	.71	.72
Si	.05	.22
P	.010	.015
S	.030	.033
Average Mechanical Properties		
Y.P., psi	35,200	40,200
T.S., psi	60,900	69,800
El.,% in 8"	27.6	24.0

The joint preparation was in general similar to that used in the previous investigation, as follows:

Joint 1. Manual Weld. 60° double V, 5/32" root opening, 0 root face, root pass made with 5/32" electrode, chipped out to sound metal and welded with 3 passes on each side using 1/4" electrode. A total of seven passes.

Joint 2. Submerged arc weld. 90° double V, 5/16" root face, 0 root opening welded with Linde Grade 70-12X200 melt and, 3 passes of 1/8" electrode Linde No. 36 from each side for a total of six passes:

Joint 3. Submerged arc weld. 90° double V, 5/16" root face, 0 root opening welded with Linde Grade 70-12X200 melt and, 1 pass of 3/16" electrode Linde No. 36 from each side for a total of two passes.

A complete series of 15 specimens were made on both AQ or semi-killed, and on AP or fully killed steels using Grade E-7016 electrodes, Harnischfeger type 70-LA-2, with an interpass temperature of 200 - 225° F, a condition identical to

* Bethlehem Steel Co.
** Lukens Steel Co.

one used in previous investigations. In addition a complete series of 15 specimens were made on AQ or semi-killed steel by the 2-pass submerged arc process with an interpass temperature again held at 200 - 225° F.

18 sets, of 3 specimens each, were prepared on type AP or fully killed steel using E-7016 electrodes, E-6010 electrodes, and 2 pass and 6 pass submerged arc process, and the following conditions of preheat, interpass temperatures and post-weld treatment:

A- Items 7,8,16,21 - No preheat & 70° F interpass temperature - No post-weld treatment.

B- " 9,10,17,22 - 150° F preheat & 150° F interpass temperature - No post-weld treatment.

C*- " 11,18,23 - 150°F preheat & Maximum interpass** temperature - No post-weld treatment.

D- " 12,13,19,24 - No preheat & 70° F interpass temperature - low temperature stress relief.

E*- " 14,20,25 - No preheat & 70° F interpass temperature - every pass peened while hot.

F- Item 15 - Submerged arc 6 pass, using Linde No. 40 rod (2% Mn. & .5% Mo) and 150° interpass temperature. No post-weld treatment.

G- " 26 - Manual weld with E-10016 electrode. No preheat & 70° interpass temperature. Complete thermal stress relief at 1150° F., furnace cooled.

Low temperature stress relief was performed by representatives of the Linde Air Products Co. and consisted of heating two broad bands, one on each side of the weld to approximately 400° F. while keeping the weld itself under 100°F. Because of desirability of stress relieving a full size weldment, items 12, 19, 24 were each fabricated by joining two pieces 18" x 54" to form a 36" x 54" weldment which was then stress relieved. The three specimens were oxygen cut from this weldment.

* Not attempted on welds of joint No. 3 type.
** Next pass started as soon as possible after previous pass completed, so that the interpass temperature reaches a maximum value.

All specimens were radiographed and four specimens were found to exhibit lack of root penetration. These specimens were discarded and new specimens were prepared in their stead. All specimens made of semi-killed steel with type E-7016 electrodes exhibited varying degrees of porosity. Of these, five specimens were considered as having an excessive amount of porosity, while the porosity of the remaining 10 were considered to be within acceptable limits.

Peening consisted of three to five passes over each layer of welded metal immediately after its deposition, using a medium weight (#3) chipping hammer and a tool having an approximately rectangular face 5/16" x 3/4".

The eighteen sets of three identical specimens welded with conditions A to E were all tested at 10°F while the two sets welded with conditions G and H were tested at -40° F in an endeavor to obtain an approximate indication of the relative merits of the procedures they represented. The method of testing of these specimens is given in Table II.

TABLE II

Method of testing 3 identical specimens at one temperature.

Submerged Arc Specimens:

1st Specimen		2nd Specimen		3rd Specimen
380g.	(if no fracture	500g.	(if no fracture	560g.
			(if fractured	440g.
	(if fractured	260g.	(if no fracture	320g.
			(if fractured	200g.

E-7016 specimen

1st Specimen		2nd Specimen		3rd Specimen
320g.	(if no fracture	440g.	(if no fracture	500g.
			(if fractured	380g.
	(if fractured	200g.	(if no fracture	260g.
			(if fractured	140g.

E-6010 specimen

1st Specimen		2nd Specimen		3rd Specimen
240g.	(if no fracture	320g.	(if no fracture	360g.
			(if fractured	280g.
	(if fractured	160g.	(if no fracture	200g.
			(if fractured	120g.

In order to minimize the effect of the location of each specimen in the original 220" x 72" steel plates on the results of the tests, an attempt was made to secure random selections of the three specimens comprising each welding condition to be studied, as follows: 96 specimens were prepared from two Lukens Steel Plates 220" x 72" and marked consecutively as indicated on Figure 1 and 2. Seventeen sets of 3 numbers each were then selected at random from the 96 numbers, each set constituting an item of welding conditions.

Exception was made of the specimens intended for low temperature stress relief treatment, which had to be made for 3 consecutive specimens, since it appeared doubtful that complete stress relief could be accomplished on 18" x 18" specimens. However, in one welding condition (Item P-13, 6 pass union melt) stress relief was attempted on 18" x 18" specimens.

DISCUSSION OF RESULTS

The results of the investigation are reported in tabular form in Table III and in graph form in Figure 3. In accordance with previous analyses, fracture is said to have occurred when the crack length exceeds 9 inches. For purposes of comparison some of the data reported previously (1) are reproduced on Figure 3. Figures 4 and 5 show the relation between applied energy and deformation produced at room temperature for the Class B and Class C steels respectively, using data reported herein and previous results; these further confirm similar relations reported before (1).

In examining Figure 3 it will be seen that little difference in performance exists between E-10016 and E-7016 electrodes when used for joining fully-killed steel, whereas on semi-killed steel, E-7016 electrode appears to actually out perform E-10016 electrode at temperatures below 40°F. It would thus appear that the main benefit of this type of electrode is derived from the type of coating used rather than from the alloy content of the weld metal.

On examining the relative performances of 2 and 6-pass union melt welds the two pass appears on the first glance to be superior to the 6-pass at 10° F.

TABLE III

Summary of Performance of pilot tests at 10°F - based on tests of 3 identical specimens made from 1" fully killed steel with various welding procedures.

Item No.	Welding Procedure	Highest Charge No Fracture	Lowest Charge Fracture
AP-7	2-Pass U.M. - 70° Int.T.	380	440
9	" " 150° Prht.& Int.T.	380	440
12	" " 70° Int. T.-LTSR	200	260
8	6-Pass U.M. - 70° Int. T.	200	260
10	" " 150° Prht.& Int.T.	380	440
11	" " 150° Prht.-Max.Int. T.	380	440
13	" " 70° Int. T.-LTSR	-	200
14	" " " " " Peened	120	200
21	E-7016 - 70° Int. T.	320	380
22	" 150° Prht.& Intp.T.	260	320
23	" 150° Prht.-Max.Intp.T.	380	440
24	" 70° Int. T.-LTSR	200	260
25	" " " " Peened	-	140
16	E-6010 - 70° Intp. T.	-	120
17	" 150° Prht.& Intp. T.	-	120
18	" 150° Prht.-Max.Intp. T.	120	160
19	" 70° Intp. T.-LTSR	-	120
20	" " " " Peened	120	160
	Tested at -40° F.		
AP 15	6-Pass U.M. .5% Mo Rod-150° Prht. & Int. T.	120	160
26	E-10016-70% Intp.T-1150° Th.S.R.	200	240

This is hard to understand unless the cooling rate of the two-pass weld is substantially lower than that of the 6-pass, even though the interpass temperature of the 6-pass weld was maintained at 200-225° F. Even then the effect of the cooling rate must be far greater than could be expected in low carbon steel. There is however another possible explanation. Referring to report SSC-43 it will be seen that the low performance of the 6-pass union melt at 10° F was established on the basis of fracture of one specimen only (Q-3-12) which fractured at 320 gms. However, the X-ray of this specimen showed incomplete root penetration for about 4 inches in the middle of the specimen, and it is possible that this defect lowered the performance of the specimen even though the fracture did not follow the path of the defect.

Additional data will have to be obtained before the relative merits of 2 and 6 pass union melt welds can be evaluated accurately. However in any case the performance of two pass union melt joints of 1" thick mild steel plate did not appear to be inferior to that of six pass union melt. Furthermore performance of 1" thick plate of semi-killed steel when welded with 2 pass union melt is very much better than when welded with any of the manual electrodes tested.

In analyzing the results of the pilot tests it becomes apparent that evaluation based on performance of only three specimens is not very satisfactory. Actually only one specimen is tested at anywhere near a critical charge and accordingly evaluation of a particular condition studied is based on performance of only one specimen.

In reviewing these pilot series as a whole the first and probably most important observation is that none of the variations of preheat and interpass temperatures and of post weld treatments tried, (with possible exception of furnace stress relief) have resulted in any significant improvement in performance. Furthermore several of the procedures tried resulted in actual deterioration of performance.

Another significant trend which appears reasonably consistent is the dependence of performance of the finished joint on the rate of cooling of the weld. With one exception factors which could be reasonably expected to slow down cooling of the weld improve the performance, while those which speed up the cooling affect the performance adversely.

One exception is the case of joints welded with E-7016 electrodes and with 150° preheat and interpass temperature, which appear to be inferior to similar joints welded without preheat and with 70° interpass temperature, and also inferior to E-7016 welds made with 150° preheat and maximum interpass temperature and to E-7016 welds made with 200-225° interpass temperature. In other words performances of 70° interpass and 150° interpass temperature welds appear to be reversed.

Another unexpected result is the relatively poor performance of unionmelt and E-7016 joints treated after welding by the low temperature stress relief method and by peening. Although it is possible that these treatments are of little benefit to a welded joint it is hard to rationalize any possibility of their detrimental effect. However it must be noted that in case of peened welds all passes including the last were peened and a possibility thus exists that the last pass could have been appreciably work hardened if the peening has been unduly severe. It must be also noted that since the low temperature stress relieved specimens were fabricated by welding together two plates 18" x 54" into a 36" x 54" weldment, they were subjected to greater restraint during welding which might have affected adversely the properties of the weld even though the residual stresses were subsequently relieved by the treatment. Tests will be made on joints of which all passes except the last were peened.

The fact that both peening and low temperature stress relief appear to have little if any effect on E-6010 welds may possibly be explained by the fact that at 10° F these welds fail with very low energy absorption and with no detectable plastic flow and any deterioration of performance is harder to detect at that low level.

As could be expected specimens stress relieved at 1150° F performed in a superior manner at -40° F though their performance at that temperature was still only half as good as that of prime plate. Nevertheless this still represents a 100% improvement over non-furnace-stress-relieved welds.

CONCLUSIONS

The following tentative conclusions appear to be pertinent on the basis of the data obtained to date.

1) Notch sensitivity of welded joints made with type E-7016 electrodes appears to be no greater than that of welded joint made with E-10016 electrodes.

2) Notch sensitivity of welded joints made with 2-pass union melt process appears to be no greater than that of welded joint made with 6-pass union melt process.

3) Data obtained with the pilot tests appear to be inconclusive and additional tests appear to be necessary before valid conclusions can be drawn from them.

4) The performance of welded joints of ship-quality steel is significantly affected by many of the possible variables in the methods of fabrication, such as type of electrode, joint design, welding procedure, etc.

5) The data reported herein further substantiate the relationship between applied charge and depth of the resulting dish reported in SSC-43.

REFERENCES

(1) G.S.Mikhalapov, "Evaluation ... Test," Ship Structure Committee Report SSC-43, March 15, 1951.

APPENDIX

Performance of 1" thick Welded Steel Plate (AP-Fully killed, similar to ABS Class C. Steel; AQ-semi-killed, ABS Class B Steel)

Spec. No.	Welding Procedure	Temp. °F.	Charge Gms.	Depth of Dish, inch	Extent of Fracture
AQ-5-4-	2-pass U.M. - 200° F Intp. T.	69	300	1.93	None
13	" " " " "	70	420	2.42	"
9	" " " " "	70	500	2.68	"
14	" " " " "	68	540	-	2 pieces
15	" " " " "	69	580	-	3 "
7	" " " " "	12	180	1.14	None
3	" " " " "	14	260	1.65	"
1	" " " " "	12	340	2.02	"
6	" " " " "	12	420	2.25	"
8	" " " " "	12	500	2.50	"
10	" " " " "	-40	40	.01	"
12	" " " " "	-38	60	.02	"
5	" " " " "	-44	60	-	Fine crack, back only
11	" " " " "	-40	80	-	4 pieces
2	" " " " "	-40	100	-	5 "
AQ-6-9	E-7016 - 200° F Intp. T.	69	320	2.04	None
5	" " " "	68	330	2.09	"
11	" " " "	69	350	2.16	"
14*	" " " "	69	350	-	2 pieces
15	" " " "	69	380	-	3 "
6	" " " "	12	160	.97	None
13*	" " " "	12	200	-	5 pieces
2*	" " " "	14	240	-	4 "
1	" " " "	-40	60	.03	None
10	" " " "	-40	80	-	36" crack, back only
3**	" " " "	72	280	1.83	None
12**	" " " "	72	280	1.84	"
4**	" " " "	72	280	1.80	"
7**	" " " "	71	320	1.98	"
8**	" " " "	71	320	-	2 pieces

* Specimen exhibited maximum acceptable porosity

** " " unacceptable "

Spec. No.	Welding Procedure	Temp. °F.	Charge Gms.	Depth of Dish, inch	Extent of Fracture
AP-6-1	E-7016 - 200° F Intp. T.	69	380	–	2 pieces
9	" " " "	70	440	2.23	None
11	" " " "	68	440	2.27	"
6*	" " " "	69	470	–	2 pieces
10*	" " " "	69	500	–	2 "
14	" " " "	9	320	1.71	None
15	" " " "	9	360	1.90	"
7	" " " "	12	380	1.93	"
2	" " " "	13	400	2.04	"
4	" " " "	9	400	–	3 pieces
3	" " " "	-40	60	.06	None
12	" " " "	-41	80	.04	"
5	" " " "	-38	80	–	crack, back only
8	" " " "	-41	80	–	" " "
13	" " " "	-42	100	–	4 pieces
AP-7-13	2-pass U.M. - 70° Intp. T.	10	380	1.90	None
74	" " " " " "	10	440	–	3 pieces
26	" " " " " "	9	500	–	6 "
8-86	6- " " " " "	10	200	–	None
25	" " " " " "	10	240	–	5 pieces
92	" " " " " "	11	380	–	7 "
9-32	2- " " 150° Prht.& Intp.T.	9	380	1.87	None
55	" " " " " " "	10	440	–	8 pieces
28	" " " " " "	9	500	–	7 "
10-57	6- " " " " "	11	380	1.82	None
7	" " " " " "	10	440	–	8 pieces
18	" " " " " "	10	500	–	7 "
11-47	" " " " " Max.Intp.T.	11	380	1.88	None
63	" " " " " " " "	10	440	–	4 pieces
89	" " " " " " " "	11	500	–	7 "
12-3	2- " " 70° Intp.T.-LTSR	11	200	–	None
1	" " " " " " "	10	260	–	7 pieces
2	" " " " " " "	10	380	–	7 "
13-5	6- " " " " " "	10	200	–	5 "
72	" " " " " " "	10	260	–	5 "
59	" " " " " " "	10	380	–	5 "
14-51	" " " " " "Peened	11	200	–	18" crack-back only
29	" " " " " " "	9	260	–	4 pieces
78	" " " " " " "	10	380	–	7 "
15-4	6- " " -.5 Mc.rod-150° F. Intp.T.	-40	120	.49	None
79	" " " " " " " "	-40	160	–	4 pieces
67	" " " " " " " "	-40	200	–	5 "

* Specimen exhibited maximum acceptable porosity

Spec. No.	Welding Procedure	Temp. °F.	Charge Gms.	Depth of Dish, inch	Extent of Fracture
AP-16-82	E-6010 - 70° F. Intp. T.	11	120	-	4" crack-back
70	" " " "	10	160	-	4 pieces
53	" " " "	9	240	-	5 "
17-9	" 150° Prht.& Intp.T.	11	120	-	3 "
39	" " " " "	10	160	-	4 "
6	" " " " "	10	240	-	5 "
18-60	" " " Max. " "	11	120	.56	None
88	" " " " " "	10	160	-	4 pieces
1	" " " " " "	10	240	-	4 "
19-1	" 70° F Intp.T.LTSR	11	120	-	2 "
2	" " " " "	11	160	-	4 "
3	" " " " "	10	240	-	6 "
20-9	" " " " Peened	11	120	.60	None
66	" " " " "	10	160	-	4 pieces
24	" " " " "	10	240	-	6 "
21-17	E-7016 " " "	10	320	1.69	none
65	" " " "	10	380	-	6 pieces
41	" " " "	11	440	-	6 "
22-40	" 150° Prht.& Intp.T.	10	200	-	None
64	" " " " "	11	240	-	"
56	" " " " "	11	320	-	4 pieces
23-81	" " " Max. " "	10	320	1.67	None
48	" " " " " "	9	380	1.84	None
10	" " " " " "	9	440	-	7 pieces
24-1	" 70° Intp.T.-LTSR	11	200	-	None
2	" " " " "	11	260	-	6 pieces
3	" " " " "	10	320	-	6 "
25-84	" " " " Peened	8	140	-	3 "
44	" " " " "	9	200	-	4 "
27	" " " " "	9	320	-	5 "
26-37	E-10016" " " 1150°Th.S.R.	-40	200	.96	None
49	" " " " " "	-40	240	-	7 pieces
95	" " " " " "	-40	280	-	9 "

CENTER OF INGOT — BOTTOM OF INGOT

P-26-49	P-16-53	P-10-57	P-19-61	P-21-65	P- -69	P- -73	P-19-77	P-23-81	P- -85	P-11-89	P-24-93
P- -50	P-12-54	P-12-58	P- -62	P-20-66	P-16-70	P-7-74	P-14-78	P-16-82	P-8-86	P- -90	P- -94
P-14-51	P-9-55	P-13-59	P-11-63	P-15-67	P- -71	P-19-75	P-15-79	P- -83	P- -87	P- -91	P-26-95
P- -52	P-22-56	P-18-60	P-22-64	P- -68	P-13-72	P- -76	P- -80	P-25-84	P-18-88	P-8-92	P- -96

48 SPECIMENS - 18"X18"

AP (CLASS C) STEEL

FIG. 1

TOP OF INGOT — BOTTOM OF INGOT

P-18-1	P-13-5	P-17-9	P-7-13	P-21-17	P- -21	P-8-25	P-14-29	P- -33	P-26-37	P-21-41	P- -45
P- -2	P-17-6	P-23-10	P-24-14	P-10-18	P- -22	P-7-26	P- -30	P- -34	P- -38	P- -42	P- -46
P- -3	P-10-7	P- -11	P- -15	P-20-19	P- -23	P-25-27	P- -31	P- -35	P-17-39	P- -43	P-11-47
P-15-4	P-24-8	P- -12	P- -16	P-12-20	P-20-24	P-9-28	P-9-32	P- -36	P-22-40	P-25-44	P-23-48

48 SPECIMENS - 18"X 18"

AP (CLASS C) STEEL

FIG. 2

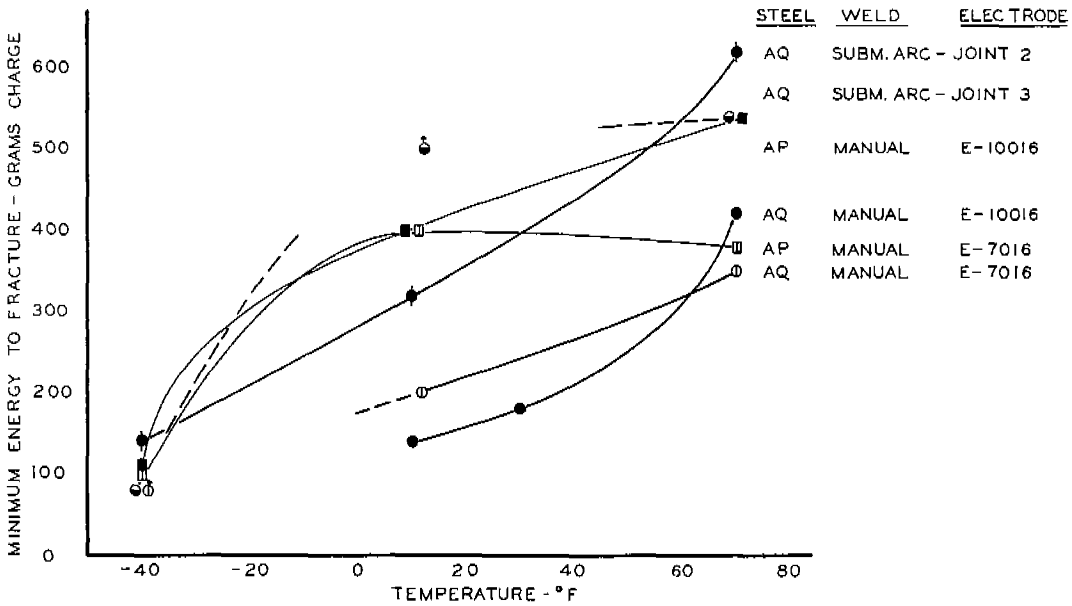

FIG. 3. EFFECT OF TEMPERATURE ON MINIMUM ENERGY TO FRACTURE WELDED SHIP PLATE ONE INCH THICK

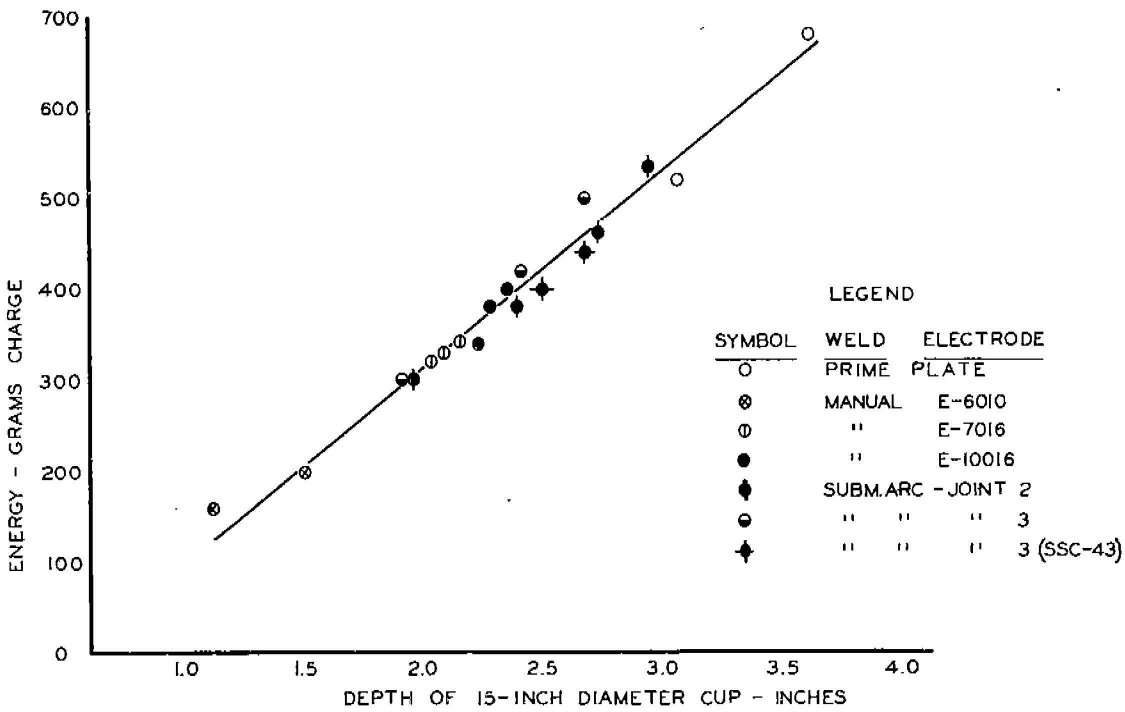

FIG. 4. EFFECT OF APPLIED ENERGY ON SPECIMEN DEFORMATION - ROOM TEMPERATURE TESTS ON AQ (CLASS B) STEEL

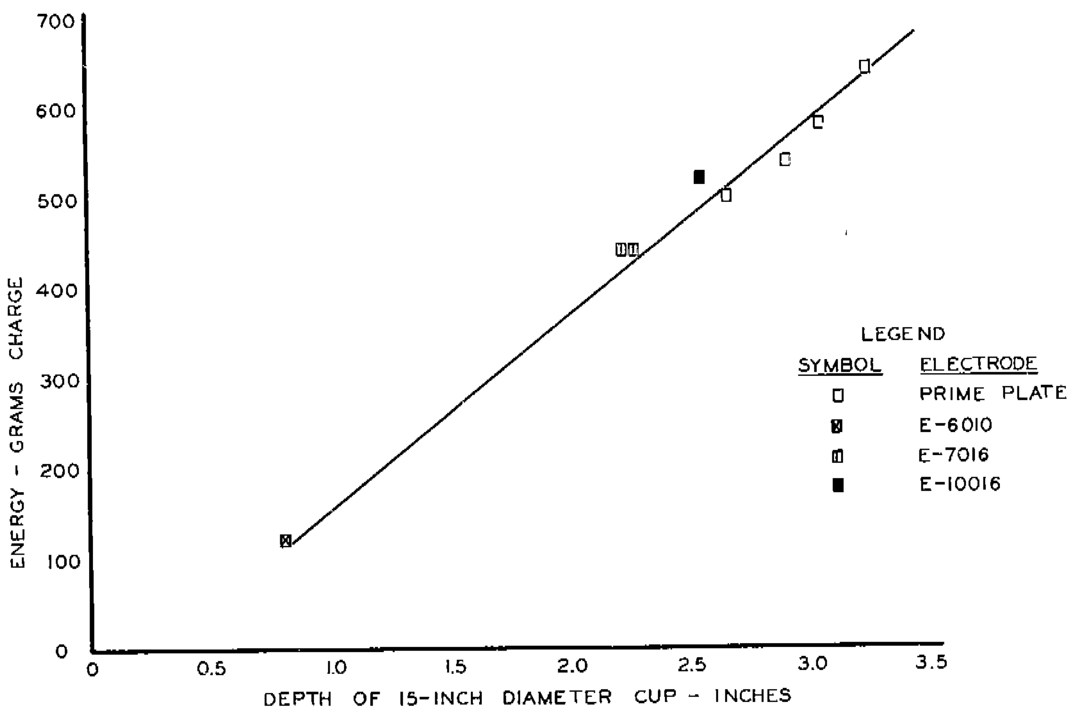

FIG. 5. EFFECT OF APPLIED ENERGY ON SPECIMEN DEFORMATION - ROOM TEMPERATURE TESTS ON AP (CLASS C) STEEL