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Report No. 642/117

# ARC WELDING OF ARMOR

## Summary of Ballistic Tests of Welded "H" Plates in Rolled and Cast Homogeneous Armor Plate at Sub-Zero Temperatures at Camp Shilo, Canada, during the Winter of 1942 - 1943



By

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WATERTOWN ARSENAL
WATERTOWN, MASS.

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Report No. 642/117
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## OBJECT

To summarize the results of ballistic shock tests of welded armor "H" plates made at Camp Shilo under sub-zero temperature conditions and to compare these results with the ballistic shock performance of several welded plates which were withheld from test at Camp Shilo and tested at Aberdeen Proving Ground under normal temperature conditions.

## SUMMARY

The trends indicated by the results of the tests included in this report appear to be approximately as follows:

1. The chances for successful shock performance of production welded armor H plates at sub-zero temperatures are:

| | | |
|---|---|---|
| a. | Manually welded | 34% (1 out of 3) |
| | (1) Multiple bead surface layer | 41% (2 out of 5) |
| | (2) Single pass surface layer | 24% (1 out of 4) |
| b. | Unionmelt welded | 0% |

2. With the radiographic standards in use when these tests were made the radiographic test was consistent with the ballistic shock test in 45% of the cases involved. Of the plates which passed the X-ray test, 30% passed the shock test.

3. Radiographic standards for welds in sub-zero temperature service probably should be higher than those for welds in service at normal temperature.

4. While the plates manually welded with the manganese modified electrode show a slightly higher percentage of passing (35%) than do the plates welded with the molybdenum modified electrode (28%), this difference is considered insufficient to indicate superiority of performance of one type over the other.





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APPROVED:

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## INTRODUCTION

The summaries included in this report were presented at meetings of the Electrode and Homogeneous Armor Fabricators' Groups of the Subcommittee on Welding of Armor in Chicago on 5 June 1943 as requested by the Tank-Automotive Center, Armor and Welding Unit, by telephone on 27 May 1943. These summaries are intended to point out the trends indicated by the results of the tests for the purpose of suggesting methods and materials to be used in future tests of this sort.

## MATERIALS AND TEST PROCEDURE

The tests covered by this report were made on welded H plates of the type shown by Figure 2, Specification AXS-497, Revision 3, August, 1942. The tests at sub-zero temperatures were made at Camp Shilo, Canada, during the winter of 1942-1943, all test plates being stored out of doors prior to and during the actual firing test. Plates were tested with front face normal to line of fire at 100-yd. range and supported at both vertical edges of the plate as is done at Aberdeen Proving Ground. All projectiles fired in these tests were at temperatures of 50° F. to 75° F. at the time of firing and the guns were operated from inside a building heated to ordinary room temperature.

The majority of the plates tested at Camp Shilo, as shown by Tables I to VI inclusive, were of 1/2", 1" and 1-1/2" rolled and 1-1/2" cast homogeneous armor manually welded with commercial brands of manganese modified and molybdenum modified stainless steel electrodes. A number of plates in the 1/2" and 1-1/2" thickness were welded by the Unionmelt process (Table VII). One set of four plates of 1-1/2" rolled homogeneous armor was welded with a ferritic alloy electrode (Table IV). Several other plates welded with certain experimental electrodes and tested at Camp Shilo are not included in this report.

As may be noted in Tables I to VII inclusive, certain H plates were withheld from test at Camp Shilo for test at Aberdeen Proving Ground under normal temperature conditions. The results of these tests are shown in Table VIII.

The data included in Tables I to VII were taken from the following A.P.G. Firing Records:

| 1/2" Rolled Plate | 1" Rolled Plate | 1-1/2" Rolled Plate | 1-1/2" Cast Plate |
|---|---|---|---|
| AD-2138 | AD-2142 | AD-2123 | AD-2130 |
| 2140 | 2143 | 2124 | 2131 |
| 2145 | | 2125 | 2132 |
| 2146 | | 2126 | 2133 |
| | | 2127 | 2134 |
| | | 2128 | 2136 |
| | | 2135 | 2137 |
| | | 2139 | |

The number and types of welded plates involved in the summaries of this report are as follows:

Plates Tested at Sub-Zero Temperatures

| Armor | Ferritic Elec. | Mo Mod. Elec. | Mn Mod. Elec. | Unionmelt |
|---|---|---|---|---|
| 1/2" Rolled | - | 8 | 8 | 10 |
| 1" Rolled | - | 6 | 7 | -- |
| 1-1/2" Rolled | 2 | 18 | 14 | 12 |
| 1-1/2" Cast | - | 14 | 18 | 3 |

Plates Tested at Normal Temperatures

| | | | | |
|---|---|---|---|---|
| 1/2" Rolled | - | 1 | - | 4 |
| 1" Rolled | - | 4 | 3 | - |
| 1-1/2" Rolled | 2 | - | 1 | - |
| 1-1/2" Cast | - | 1 | - | - |

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

| Armor | Projectile | Striking Velocity (± 25 f/s) | Maximum Allowable Cracking (inches) Weld | Plate |
|---|---|---|---|---|
| 1-1/2" Rolled | 75 mm. T21 | 1100 | 15 | 8 |
| 1-1/2" Cast | " | 1050 | 15 | 8 |
| 1" Rolled | " | 775 | 18 | 8 |

There are 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 as indicated above.

While the specification (AXS-497, Rev. 3) does not clearly specify the difference between a fair and an unfair hit, it has been found that a satisfactory welded joint is not affected when the center of impact is 2 inches or more away from the center of the weld. This principle has been followed in designating the fair and unfair hits in Tables I to VIII. Also, the weld cracking specified in the tables for each round includes the cracking which occurred in the weld metal, the fusion zone, and the heat-affected zone. The amount of plate cracking is noted under Remarks. All of these references are to cracking which occurred on the back face of the plate and are given as recorded in the firing records.

From the WAS-2 Forms of the firing records, the following heat analyses of armor plate used were taken:

| Manufacturer | Thickness | C | Mn | Si | P | S | Cr | Mo | Ni | Va | Cu | Zr |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| J & L | 1/2" R* | .22 | 1.27 | .22 | .019 | .016 | -- | .43 | -- | -- | -- | -- |
| Gr. Lakes | " | .28 | .78 | .72 | .019 | .025 | .61 | .17 | -- | -- | -- | .08 |
| Dom. Fdry. | " | .25 | .80 | .31 | .022 | .023 | .93 | .25 | .65 | -- | -- | -- |
| J & L | 1" R* | .27 | 1.56 | .18 | .01 | .02 | -- | .39 | -- | -- | -- | -- |
| Gr. Lakes | " | .29 | .95 | .72 | .02 | .025 | .60 | .15 | -- | -- | -- | .10 |
| Republic | " | .28 | .90 | .25 | .025 | .022 | .72 | .38 | .83 | -- | -- | -- |
| J & L | 1-1/2" R* | .27 | 1.59 | .25 | .02 | .016 | -- | .41 | -- | -- | -- | -- |
| Gr. Lakes | " | .29 | .95 | .72 | .023 | .025 | .64 | .16 | -- | -- | -- | .10 |
| Republic | " | .27 | .92 | .29 | .02 | .017 | 1.04 | .66 | 1.21 | -- | -- | -- |
| " | " | .25 | .85 | .20 | .016 | .02 | .65 | .48 | .92 | -- | -- | -- |
| Carnegie | " | .26 | .95 | .20 | .018 | .023 | .55 | .40 | 1.05 | -- | -- | -- |
| Dom. Fdry. | " | .28 | .68 | .43 | .028 | .025 | 2.28 | .31 | .71 | -- | -- | -- |
| Ford | " | .26 | 1.35 | .21 | .013 | .02 | .54 | .45 | .03 | -- | -- | -- |
| Amer. Steel | 1-1/2" C* | .28 | 1.56 | .47 | .017 | .021 | .37 | .15 | -- | -- | -- | -- |
| Continental | " | .27 | .77 | .35 | .04 | .04 | .52 | .40 | .55 | -- | -- | -- |
| Ford | " | .26 | 1.10 | .49 | .016 | .02 | .50 | .29 | -- | -- | -- | -- |
| Ord. St. Fdry. | " | .28 | 1.47 | .48 | .024 | .022 | -- | .39 | -- | -- | -- | -- |
| Sym. Gould | " | .25 | .98 | .35 | .032 | .016 | .45 | .46 | .56 | -- | -- | -- |

* R - Rolled plate - C - Cast plate

From the WAS-2 forms of the firing records, the following data on weld metal compositions used (pad analysis)+ were taken:

| Manufacturer | Brand | C | Mn | Si | Ni | Cr | Mo | S | P |
|---|---|---|---|---|---|---|---|---|---|
| Alloy Rods | Armorarc A | .13 | 2.0 | .70 | 10.5 | 21.0 | 2.75 | .03 | .04 |
| " " | " | .17 | 1.5 | .30 | 10.8 | 18.3 | 2.0 | .01 | .035 |
| Crucible | Armorize | .08 | 1.65 | .29 | 10.5 | 18.5 | 2.0 | -- | -- |
| Harnischfeger | AW-3 | .12 | 1.60 | .56 | 10.9 | 19.3 | 2.1 | -- | -- |
| Page Steel | ----- | .13 | 1.82 | .40 | 11.5 | 19.2 | 2.5 | .013 | -- |
| Reid Avery | Raco | .09 | 1.79 | .035 | 10.1 | 19.3 | 1.24 | .004 | .051 |
| Alloy Rods | Armorarc B | .08 | 3.60 | .035 | 10.2 | 19.4 | .012 | .005 | .019 |
| " " | " | .09 | 3.75 | .38 | 11.2 | 19.4 | -- | .01 | .036 |
| " " | " | .13 | 4.5 | .70 | 10.5 | 21.0 | -- | .03 | .03 |
| McKay | Armorloy | .08 | 4.1 | .63 | 8.9 | 19.1 | -- | .02 | .02 |
| " | " | .11 | 4.7 | .65 | 9.7 | 18.0 | .07 | .025 | .025 |
| " | Armorloy A5 | .10 | 3.7 | 1.13 | 10.2 | 18.1 | .47 | -- | -- |
| A. O. Smith | SW-101 | .12 | .54 | .21 | 1.72 | .38 | .77 | Va = .12 | |
| Unionmelt | #42 | .22 | 3.7 | .50 | 11.9 | 9.9 | .08 | .025 | .035 |

+ Pad analysis: Analysis of that portion of a pad deposited by the electrode which contains no material from the plate metal upon which the pad was deposited.

## DISCUSSION

The welded H plates tested on this cold test program were welded by fabricators experienced in welding H plates. The welding procedures used were those then being currently used in production which has been approved by ballistic tests of welded H plates at normal temperatures.

Plates Tested at Sub-Zero Temperatures (Tables I to VII)

Of the 136 welded H plates covered by this report, 120 plates were tested at sub-zero temperatures. Of these 120 plates, 35 were of 1-1/2" thick cast homogeneous armor, 10 of which failed in the armor plate instead of the welded joint (NWT - No Weld Test). Of the 85 rolled homogeneous armor plates, 7 plates failed in the armor instead of the welded joint. Thus, only 103 welded plates can be considered as indicating weld performance at sub-zero temperatures.

Of these 103 plates, 78 were acceptable and 24 plates were rejectable according to the X-ray standards then in use by Aberdeen Proving Ground (November and December, 1942) and one plate was not X-rayed. Twenty-four of the 78 acceptable plates, and 2 of the 24 rejectable plates passed the shock test, together with the one plate which was not X-rayed (Summary F). Thus, a total of 27 plates were acceptable and 76 plates were not acceptable on the basis of the shock test at sub-zero temperatures.

If, however, the 25 Unionmelt plates are eliminated, the manually welded plates show 27 plates to be acceptable and 51 plates not acceptable in the shock test, or a passing percentage of 34-2/3%. If only the manually welded 1/2" and 1-1/2" thicknesses are considered (since all 1" plate welds failed in shock), the passing percentage is about 41%.

With reference to X-ray examination of welds in armor and correlation with the results of the ballistic shock test of welded H plates, it may be noted from the preceding paragraph that the shock performance of 46 plates (24 plates passing and 22 plates failing) was consistent with, and the shock performance of 56 plates was not consistent with the radiographic test results. Of this latter group, 2 plates failing the X-ray test passed the shock test, whereas 54 plates passed X-ray and failed in shock. These data suggest two significant ideas:

1. The X-ray test used was not unduly restrictive as far as shock performance of welded joints at sub-zero temperatures is concerned because, if acceptance had been based on X-ray examination alone, only 2 plates would have been rejected which actually did pass the shock test.

2. Radiographic standards of acceptance for welds in armor to serve at sub-zero temperatures must be higher than the standards used for acceptance of welds serving at normal temperatures.

The superior shock performance of those double V welds in which the surface layer was deposited in several passes or beads is noticeable (Summary G). Eliminating the 15 plates with this type of surface layer, which failed in the armor plate, 14 out of 34 plates in this group passed the shock test. The group with the surface layer deposited in a single pass included 30 plates of which 7 plates passed the shock test and there was one failure of the armor. The net result is 41% passing for the multiple bead surface layer, and 24% passing for the single pass surface layer - nearly a 2 to 1 superiority.

The 1/2" plates and the Unionmelt welds are not included in this comparison because of the fact that the 1/2" plates were welded with a single V joint and the Unionmelt welds all have a single pass surface layer. It is also recognized that other factors such as angle of bevel, root gap, and amount of surface reinforcement of the weld on the tension side of the plate, as well as weld metal defects, might have some effect on shock performance. However, these factors are disregarded because the majority of plates in both thicknesses (1" and 1-1/2") were welded using a fixed bevel and root gap (see Tables I to VII) and data are not available as to amount of weld reinforcement present on each welded joint. The significance of weld metal defects is indicated by the fact that with either type of surface layer deposition, approximately the same number of welds passed the X-ray test and failed the shock test (18 plates with multiple bead surface layer and 20 plates with the single pass surface layer). Thus, it would appear that, other factors being equal in form and amount, the success or failure of these double V welds appears to be noticeably concerned with the method of surface layer deposition and this connection is believed significant.

With reference to the plate manually welded with modified austenitic electrode, the weld performance in the shock test was as follows:

| | Mo Mod. | | | Mn Mod. | | |
|---|---|---|---|---|---|---|
| Armor | Passing | Failing | Plate Failure | Passing | Failing | Plate Failure |
| 1/2" R* | 2 | 6 | - | 4 | 4 | - |
| 1" R* | - | 4 | 2 | - | 5 | 2 |
| 1-1/2" R* | 8 | 7 | 3 | 5 | 9 | - |
| 1-1/2" C* | - | 8 | 6 | 6 | 9 | 3 |
| TOTALS | 10 | 25 | 11 | 15 | 27 | 5 |
| Passing Shock Test | | 28% | | | 35% | |

* R - Rolled - C - Cast

While the weight of the evidence indicates a slight superiority of the Mn modified electrode, the difference is small, and for all practical purposes it can be said that, as far as these tests are concerned, there is no significant superiority of one type of electrode over the other.

It is evident from these tests that the chances for successful performance of welded H plates under ballistic impact at sub-zero temperatures are about 1 to 2 with the armor compositions and methods of welding which were being used in the production of armored vehicles during the Fall of 1942. While no attempt has been made in this report to discuss the types of failures which occurred in these welded joints, it is believed that a majority were associated with either the fusion zone or heat-affected zone of the joint. A detailed metallurgical investigation of this phase of the study is now underway at the U. S. Steel Corporation Laboratories, Kearny, New Jersey, under the direction of the National Research Council.

Plates Tested at Normal Temperatures (Table VIII)

The ballistic tests of Unionmelt welded 1/2" plate at normal temperature (+70° F., Table VIII) indicate acceptability (3 passed, 1 failed). This is in startling contrast to the general low temperature result shown by Table VII, and is somewhat complicated by the fact that the welds of three plates were originally unacceptable on radiographic examination before undergoing the low temperatures of Camp Shilo.

Of the seven 1" plates tested at normal temperature, 3 passed the ballistic test, whereas none of the 1" plates tested at low temperature (Table II) were acceptable. All of these 7 plates failed the radiographic test on return to Aberdeen Proving Ground, whereas 3 of the plates were originally acceptable. Two of the 3 plates passing the ballistic test at Aberdeen were originally acceptable radiographically (see Table VIII).

The 4 welded plates of 1-1/2" armor, of which one was a cast plate, tested at Aberdeen at normal temperature were generally acceptable ballistically. Two of the 3 plates of rolled armor were ferritically welded. These were part of the original set of 4 (Table IV) in which the crossbar of the H was welded leaving a gap at each end. These gaps were later filled up with austenitic stainless weld metal. These 4 ferritically welded plates exhibited satisfactory ballistic shock performance at both normal and sub-zero temperatures.

## TABLES OF FIRING DATA (I - VIII)

(Nomenclature - AXS 770)

| Symbol | Interpretation |
|---|---|
| Fabricator | Company which welded the H plate. |
| Armor Mfgr. | Company which produced the armor used for the H plate. |
| C | Carbon content of the armor plate used - ladle analysis. |
| Electrode | Manufacturer or Brand designation of welding electrode used. |
| SV | Single V joint with angle of V as specified. |
| DV | Double V joint with angle of V on each side of the plate as specified. |
| Joint Gap | Space separating the plate edges as specified. Sometimes designated as "plate separation" or "root gap." |
| L | Layers each deposited in a single pass and spread from side to side of the joint groove. |
| B | Layers each consisting of several individual beads or passes. |
| L & B | Single pass layers alternated with layers of individual beads. |
| SB | Seal bead. Bead deposited on the back of a single V joint after the weld in the V has been either partially or wholly completed. |
| RD | Round. Each shot fired is considered a round. |
| f/s | Feet per second velicity of projectile at the muzzle of the gun. |
| Wld. Ck. | Cracking in the weld metal, fusion zone, and heat-affected zone on the back of the plate caused by the particular round specified. |
| Plate Temp. | Degrees Fahrenheit temperature of test plate at time of firing. |
| F | Failed the required test. |
| P | Passed the required test. |
| Bal. | Ballistic Shock Test. |
| CB | Under Remarks refers to crossbar of the H. |
| NWT | No Weld Test. Indicates failure of the armor plate instead of the weld. |

TABLE V

COLD TESTS OF WELDED ARMOR - CAMP SHILO - 1942/1943

1/2" ROLLED HOMOGENEOUS PLATE

Moly. Mod. Austenitic 18/8 Electrode

| Fabricator | Armor Mfr. | C | Electrode | Joint Bevel | Joint Gap | Weld Deposit Body | Weld Deposit Surface | Shock Test Rd. | Shock Test Vel.f/s | Shock Test Wld.Gx. | Test Plate Temp. | X-ray | Bal. | Firing Record | Plate No. | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Yellow Truck | J & L | 0.22 | Harn. AW-3 | 45° SY | 3/16" | L | B 1SB | 1° | 2600 | — | -19° | F | | ADE145 | C12 | |
| | | | | | | | | 2° | 2600 | — | | | | | | |
| | | | | | | | | 4 rds. at 2600 | | | | | F | | | None fair, no cracks |
| " | " | " | " | " | " | " | " | 1° | 2600 | — | -17° | F | | " | C11 | |
| | | | | | | | | 2 rds. at 2600 | | | | | | | | None fair, no cracks |
| | | | | | | | | 4 | 2600 | 9-1/2 | | | F | | | |
| | | | | | | | | 2 rds. at 2600 | | | | | | | | Not fair, no further cracks |
| | One plate held for A. F. O. test | | | | | | | | | | | | | | | |
| Yellow Truck | Great Lakes | 0.28 | Harn. AW-3 | 45° SY | 3/16° | L | B 1SB | 2 rds. at 2600 | | | -21° | F | | ADE146 | C17 | Not fair. 4° weld crack |
| | | | | | | | | 3 | 2600 | 25 | | | F | | | Plate cracked 12° |
| " | " | " | " | " | " | " | " | 1° | 2600 | 20 | -20° | F | F | " | C18 | |
| | | | | | | | | 2 rds. at 2600 | | | | | | | | Not fair, no further cracking |
| " | " | " | " | " | " | " | " | 1° | 2600 | — | | F | | " | C19 | |
| | | | | | | | | 2 | 2600 | 25-1/2 | -15° | | F | | | Plate cracked 18° |
| Hamilton Bridge | Dom. Fdry. | 0.25 | Harn. AW-3 | 60° SY | 1/16° | L | L 1SB | 1 | 2600 | 18 | -8° | F | F | ADE136 | 2 | Plate cracked 12° |
| | | | | | | | | 2° | 2600 | — | | | | | | Plate cracked 13-3/4° more |
| " | " | " | " | " | " | " | " | 1° | 2600 | — | -13° | F | | " | 3 | |
| | | | | | | | | 2 | 2600 | 46 | | | F | | | Broke in 2 pieces |
| " | " | " | " | " | " | " | " | 1° | 2600 | 12 | -16° | F | F | " | 4 | Plate cracked 16° |

Manganese Mod. Austenitic 18/8 Electrode

| Fabricator | Armor Mfr. | C | Electrode | Joint Bevel | Joint Gap | Weld Deposit Body | Weld Deposit Surface | Shock Test Rd. | Shock Test Vel.f/s | Shock Test Wld.Gx. | Test Plate Temp. | X-ray | Bal. | Firing Record | Plate No. | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Yellow Truck | J & L | 0.22 | McKay | 45° SY | 3/16° | L | B 1SB | 1° | 2600 | — | -15° | F | | ADE145 | C14 | |
| | | | | | | | | 2 | 2600 | 13 | | | F | | | |
| | | | | | | | | 3 | 2600 | 2-1/2 | | | | | | |
| | | | | | | | | 4° | 2600 | 4 | | | | | | |
| " | " | " | " | " | " | " | " | 1 | 2600 | 4-1/2 | -19° | F | F | " | C15 | |
| | | | | | | | | 2° | 2600 | — | | | | | | |
| | | | | | | | | 3 | 2600 | — | | | | | | |
| | | | | | | | | 4 | 2600 | 19-1/2 | | | | | | |
| " | " | " | " | " | " | " | " | | 2600 | — | -18° | F | | " | C16 | 4 rds., none fair, no cracks |
| | | | | | | | | 5 | 2600 | 26-3/4 | | | F | | | |
| Yellow Truck | Great Lakes | 0.28 | McKay | 45° SY | 3/16° | L | B 1SB | 1° | 2600 | 17 | -17° | F | F | ADE146 | C20 | |
| | | | | | | | | 2° | 2600 | 13 | | | | | | Plate cracked 3° |
| | | | | | | | | 2 rds. at 2600 | | | | | | | | Not fair. Plate cracked 3° more |
| " | " | " | " | " | " | " | " | 1 | 2600 | 12-1/2 | -20° | F | F | " | C21 | |
| | | | | | | | | 2° | 2600 | 40-1/2 | | | | | | Broke in 2 pieces |
| " | " | " | " | " | " | " | " | 1 | 2600 | 13-1/2 | -14° | F | (F) | " | C22 | |
| | | | | | | | | 2 rds.at 2600 | | 11 | | | | | | Not fair. Plate cracked 2° |
| Int. Harv. Canada | Dom. Fdry. | 0.25 | Lincoln | 34° SY | 1/16° | L | L | 1 | 2600 | 30-3/4 | -14° | F | F | ADE140 | 7 | Broke in 2 pieces |
| " | " | " | " | " | " | " | " | 1 | 2600 | 22 | -15° | F | F | " | 8 | |
| | | | | | | | | 2 | 2600 | 30-1/2 | | | | | | |

I

" - NOT FAIR BUT - OUTSIDE 2° LIMIT

TABLE II

COLD TESTS OF WELDED ARMOR - CAMP SHILO - 1942/1941

1" ROLLED HOMOGENEOUS PLATE

Molybdenum Mod. Austenitic 18/8 Electrode

| Fabricator | Armor Mfr. | C | Electrode | Joint Bevel | Joint Gap | Weld Body | Weld Deposit Surface | Shock Test RD. | Shock Test Vel.f/s | Shock Test Wld.Ck. | Test Plate Temp. | X-ray | Bal. | Firing Record | Plate No. | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ternstedt | J & L | 0.27 | Alloy Rods | 60°DV | 3/16" | L | L | 1 | 778 | 29-1/2 | -15° | F | F | AD2143 | TH-67 | Plate cracked 1-1/4" |
| " | " | " | " | " | " | " | " | | | 6-1/2 | -16° | F | | " | TH-69 | Passed X-ray after CB was repaired |
| | | | | | | | | 1° | 697 | 17-1/4 | | | F | | | Crk in CB before test. Plate cracked 5" |
| | Two plates held for A. F. G. test | | | | | | | | | | | | | | | |
| Cadillac | Great Lakes | 0.2% | Page | 60°DV | 3/16" | L | B | 1° | 774 | | -17° | F | | AD2142 | 97 | Failed X-ray after repairs |
| | | | | | | | | 2° | 775 | 8-1/2 | | | | | | Plate cracked 8-1/2" |
| | | | | | | | | 3 | 782 | 9-3/4 | | | BWT | | | Broke in 2 pieces |
| " | " | " | " | " | " | " | " | 1° | 775 | | -16 | F | | " | 99 | Passed X-ray after repairs |
| | | | | | | | | 2° | 775 | 11-1/2 | | | | | | Plate cracked 14" |
| | | | | | | | | 3° | 775 | | | | BWT | | | |
| | One plate held for A. F. G. test | | | | | | | | | | | | | | | |
| Cadillac | Republic | 0.2% | Page | 60°DV | 3/16" | L | B | 1 | 809 | 30-1/2 | -17° | F | F | AD2142 | 91 | Failed X-ray after repairs |
| " | " | " | " | " | " | " | " | 1 | 775 | 36 | -11° | F | F | " | 95 | Failed X-ray after repairs |
| | | | | | | | | | | | | | | | | Broke in 2 pieces |
| | One plate held for A. F. G. test | | | | | | | | | | | | | | | |

Manganese Mod. Austenitic 18/8 Electrode

| Fabricator | Armor Mfr. | C | Electrode | Joint Bevel | Joint Gap | Weld Body | Weld Deposit Surface | Shock Test RD. | Shock Test Vel.f/s | Shock Test Wld.Ck. | Test Plate Temp. | X-ray | Bal. | Firing Record | Plate No. | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ternstedt | J & L | 0.27 | Alloy Rods | 60°DV | 3/16" | L | L | 1 | 782 | 22-1/2 | -15° | F | F | AD2143 | TH-68 | |
| " | " | " | " | " | " | " | " | 1 | 797 | 43 | -15° | F | F | " | TH-72 | Broke in 2 pieces |
| | Two plates held for A. F. G. test | | | | | | | | | | | | | | | |
| Cadillac | Great Lakes | 0.2% | McKay | 60°DV | 3/16" | L | B | 1 | 784 | 32 | -17° | F | F | AD2142 | 96 | Passed X-ray after repairs |
| | | | | | | | | | | | | | | | | Broke in 2 pieces |
| " | " | " | " | " | " | " | " | 1 | 784 | 11 | -18° | F | | " | 98 | Failed X-ray after repairs |
| | | | | | | | | 2 | 760 | 13-1/2 | | | BWT | | | Plate cracked 15" |
| | | | | | | | | | | | | | | | | Plate cracked 8-3/4" more |
| " | " | " | " | " | " | " | " | 1 | 775 | 14 | -18° | F | | " | .00 | Passed X-ray after repairs |
| | | | | | | | | | | | | | | | | Back spall in plate |
| | | | | | | | | 2 | 775 | 20-1/4 | | | BWT | | | Piece punched out |
| Cadillac | Republic | 0.2% | McKay | 60°DV | 3/16" | L | B | 1 | 773 | 26 | -19° | F | F | AD2142 | 92 | Passed X-ray after repairs |
| " | " | " | " | " | " | " | " | 1 | 804 | 24 | -19° | F | F | " | 94 | Passed X-ray after repairs |
| | One plate held for A. F. G. test | | | | | | | | | | | | | | | |

II

* - NOT MAIR HIT - OUTSIDE 2° LIMIT

TABLE III

COLD TESTS OF WELDED ARMOR - CAMP SHILO - 1942/1943

1-1/2" ROLLED HOMOGENEOUS PLATE

Molybdenum Mod. Austenitic 18/8 Electrode

| Fabricator | Armor Mfr. | C | Electrode | Joint Bevel | Joint Gap | Weld Body | Weld Deposit Surface | RD. | Shock Test Vel. f/s | Shock Test Wld. Gr. | Test Plate Temp. | X-ray | Bal. | Firing Record | Plate No. | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Fisher | J & L | 0.27 | Raco | 45°DV | 5/16" | L | L | 1 | 1100 | --- | -27° | P | P | AD2135 | CTF-13 | |
| | | | | | | | | 2 | 1101 | 17 | | | | | | |
| " | " | " | " | " | " | " | " | 1 | 1094 | --- | -15° | P | P | " | CTF-15 | Passed X-ray after repairs |
| | | | | | | | | 2 | 1121 | 30-1/2 | | | | | | Plate cracked 7" |
| " | " | " | " | " | " | " | " | 1 | 1110 | 36 | -15° | P | P | " | CTF-14 | Broke in 2 pieces |
| Fisher | Republic | 0.27 | Raco | 45°DV | 5/16" | L | L | 1 | 1100 | 23 | -30° | P | P | AD2128 | CTF-6 | Plate cracked 4" |
| | | | | | | | | 2 | 1098 | 10 | | | | | | Plate cracked 2-1/4" more |
| " | " | " | " | " | " | " | " | 1 | 1108 | 20 | -19° | P | P | " | CTF-4 | Plate cracked 2" |
| | | | | | | | | 2* | 1107 | --- | | | | | | Plate cracked 2" more |
| | | | | | | | | 3 | 1095 | 9 | | | | | | |
| " | " | " | " | " | " | " | " | 1 | 1094 | 14 | -21° | P | P | " | CTF-5 | Plate cracked 5-1/2" |
| | | | | | | | | 2* | 1102 | 16-1/2 | | | | | | |
| Fisher | Great Lakes | 0.29 | Raco | 45°DV | 5/16" | L | L | 1 | 1085 | 6<br>37-1/2 | +24° | P | P | AD2126 | CTF-19 | Crack in CH before test |
| " | " | " | " | " | " | " | " | 1 | 1098 | 36 | -15° | P | P | " | CTF-21 | Broke in 2 pieces |
| " | " | " | " | " | " | " | " | 1 | 806 | 14 | -15° | P | P | " | CTF-20 | |
| | | | | | | | | 2 | 910 | 23 | | | | | | |
| Ford | Ford | 0.26 | Crucible | 45°DV | 3/16" | L | B | 1 | 1085 | 12 | -20° | P | P | AD2123 | W-65 | Plate cracked 1/2" |
| | | | | | | | | 2 | 1105 | 21 | | | | | | Plate cracked 5" more |
| " | " | " | " | " | " | " | " | 1 | 1104 | 13-1/4 | -17° | P | P | " | W-64 | |
| | | | | | | | | 2 | 1093 | 3-3/4 | | | | | | Plate cracked 7-1/2" |
| Ford (Cont.) | Ford | 0.26 | Crucible | 45°DV | 3/16" | L | B | 1 | 725 | --- | -16° | P | | AD2123 | W-63 | |
| | | | | | | | | 2* | 868 | --- | | | | | | |
| | | | | | | | | 3 | 994 | --- | | | | | | |
| | | | | | | | | 4 | 1113 | 11-1/2 | | | P | | | |
| | | | | | | | | 5* | 1145 | --- | | | | | | |
| | | | | | | | | 6 | 1154 | 29 | | | | | | |
| Midland | Carnegie | 0.27 | Crucible | 45°DV | 5/16" | L & B | B | 1 | 1099 | 11-1/4 | -24° | P | P | AD2124 | CH-38 | Plate cracked 2-3/4" |
| | | | | | | | | 2 | 1099 | 10 | | | | | | Plate cracked 3-1/4" more |
| " | " | " | " | " | " | " | " | 1* | 1109 | --- | -19° | P | | " | CH-39 | Hit 2-1/2" from left leg weld |
| | | | | | | | | | | | | | | | | No cracks |
| | | | | | | | | 2 | 1093 | 16-1/2 | | | (P) | | | Hit on right leg weld |
| | | | | | | | | | | | | | | | | Crack in right leg weld |
| | | | | | | | | 3 | 1093 | 1 | | | | | | |
| | | | | | | | | 4 | 1123 | 18-1/2 | | | | | | Plate in 2 pieces |
| " | " | " | " | " | " | " | " | 1 | 1100 | --- | -25° | P | P | " | CH-41 | |
| | | | | | | | | 2 | 1084 | --- | | | | | | |
| G.M.C. Canada | Dominion Foundry | | Harn. AWSA | DV | 1/4" | L & B | B | 1 | 1090 | 11 | -19° | P | NVT | AD2125 | GMC-6 | Broke in 2 pieces |
| " | " | | " | " | " | " | " | 1 | 799 | 5-1/4 | -19° | P | NVT | " | GMC-5 | 11-3/4" plate crack |
| | | | | | | | | 2 | 814 | 1-3/8 | | | | | | |
| | | | | | | | | 3 | 902 | 8-1/2 | | | | | | Broke in 2 pieces |
| " | " | | " | " | " | " | " | | | | | P | | | | | Crack in CH before test |
| | | | | | | | | 1 | 1089 | 16-1/2 | -22° | | NVT | " | GMC-7 | 24" plate crack |

* - NOT MAIN HIT - OUTSIDE 2" LIMIT

## TABLE IV

### COLD TESTS OF WELDED ARMOR - CAMP SHILO - 1942/1943

### 1-1/2" ROLLED HOMOGENEOUS PLATE

#### Manganese Mod. Austenitic 18/8 Electrode

| Fabricator | Armor Mfr. | C | Electrode | Joint Bevel | Joint Gap | Weld Deposit Body | Weld Deposit Surface | RD. | Shock Test Vel.f/s | Shock Test Weld.Cr. | Test Plate Temp. | X-ray | Bal. | Firing Record | Plate No. | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Fisher | J & L | 0.27 | Alloy Rode | 45° DV | 5/16" | L | L | 1 | 1097 | 27-1/2 | -19° | P | P | AD2135 | CTF-11 | Passed X-ray after repairs |
| " | " | " | " | " | " | " | " | 1 | 793 | 24 | -15° | P | P | " | CTF-12 | |
| | One plate held for A.P.G. test | | | | | | | | | | | | | | | |
| Fisher | Republic | 0.25 | Alloy Rode | 45° DV | 5/16" | L | B | 1 | 1097 | 9-1/2 | -18° | P | P | AD2126 | CTF-1A | |
| | | | | | | | | 2* | 1097 | 21 | | | | | | Back spall |
| " | " | " | " | " | " | " | " | 1 | 1110 | 23 | -25° | P | P | " | CTF-2A | Passed X-ray after repairs |
| | | | | | | | | 2 | 1088 | 1-1/2 | | | | | | Plate cracked 3-1/4" |
| " | " | " | " | " | " | " | " | 1 | 1091 | 10 | -19° | P | P | " | CTF-3A | Passed X-ray after repairs |
| | | | | | | | | 2* | 1089 | 29 | | | | | | |
| Fisher | Great Lakes | 0.29 | Alloy Rods | 45° DV | 5/16" | L | L | 1 | 1102 | 22-1/4 | +24° | P | P | AD2126 | CTF-15 | |
| " | " | " | " | " | " | " | " | 1 | 1094 | 37 | -18° | P | P | " | CTF-16 | |
| | | | | | | | | 2* | 1095 | 31 | | | | | | |
| " | " | " | " | " | " | " | " | 1 | 817 | 48 | -15° | P | P | " | CTF-17 | Broke in 2 pieces |
| Ford | Ford | 0.26 | McKay | 45° DV | 3/16" | L | B | 1 | 1091 | 32-3/4 | -17° | P | P | AD2123 | W-53 | |
| | | | | | | | | 2 | 1094 | 16 | | | | | | Broke in 2 pieces |
| " | " | " | " | " | " | " | " | | | 12 | | P | | " | W-66 | Crack in CB before test |
| | | | | | | | | 1 | 1099 | 29 | -16° | | P | | | |
| " | " | " | " | " | " | " | " | 1 | 891 | 10-1/2 | | P | | " | W-61 | |
| | | | | | | | | 2 | 928 | 20 | -16° | | P | | | |
| Midland | Carnegie | 0.27 | McKay | 45° DV | 5/16" | L & B | B | 1 | 1098 | | -24° | P | P | AD2124 | CB-40 | |
| | | | | | | | | 2 | 1093 | 17-1/2 | | | | | | |
| | | | | | | | | 3 | 1095 | 1/2 | | | | | | |
| | | | | | | | | 4 | 1097 | 36-1/4 | | | | | | Broke in 2 pieces |
| " | " | " | " | " | " | " | " | 1 | 1111 | | -16° | P | P | " | CB-42 | |
| | | | | | | | | 2 | 1113 | 5-3/4 | | | | | | Plate cracked 2-3/4" |
| | | | | | | | | 3* | 1099 | | | | | | | Plate cracked 1-7/8" more |
| | | | | | | | | 4 | 1095 | 9-1/4 | | | | | | Plate cracked 9" more |
| | | | | | | | | 5 | 1105 | 29 | | | | | | |
| " | " | " | " | " | " | " | " | 1* | 1092 | | -18° | P | | " | CB-43 | |
| | | | | | | | | 2 | 1121 | 7 | | | P | | | Plate cracked 1-1/2" |
| | | | | | | | | 3 | 1156 | 27-1/4 | | | | | | Plate cracked 4-1/4" more |

### FERRITIC WELDS

### 1-1/2" ROLLED HOMOGENEOUS PLATE

| Fabricator | Armor Mfr. | C | Electrode | Joint Bevel | Joint Gap | Weld Deposit Body | Weld Deposit Surface | RD. | Shock Test Vel.f/s | Shock Test Weld.Cr. | Test Plate Temp. | X-ray | Bal. | Firing Record | Plate No. | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A. O. Smith | Carnegie | 0.24 | SW101 | 13/15° DV | 3/8" | L | B | 1 | 1097 | 13-1/4 | -20° | P | P | AD2139 | 29391 | No postheat treatment |
| | | | | | | | | 2 | 1094 | 9-1/4 | | | | | | Two gaps in crossbar welded with austenitic electrode |
| " | " | " | " | " | " | " | " | 1 | 1100 | | -19° | P | P | " | 29393 | No postheat treatment |
| | | | | | | | | 2 | 1100 | | | | | | | Two gaps in crossbar welded with austenitic electrode |
| | | | | | | | | 3* | 1149 | | | | | | | |
| | | | | | | | | 4 | 1199 | 1-3/4 | | | | | | |
| | | | | | | | | 5 | 1251 | 49 | | | | | | Broke in 2 pieces |
| | Two plates held for A. P. G. test | | | | | | | | | | | | | | | |

* - NOT FAIR HIT - OUTSIDE 2" LIMIT

TABLE V

COLD TESTS OF WELDED ARMOR - CAMP SHILO - 1942/1943

1-1/2" CAST HOMOGENEOUS PLATE

Molybdenum Mod. Austenitic 18/8 Electrode

| Fabricator | Armor Mfr. | C | Electrode | Joint Bevel | Joint Gap | Weld Deposit Body | Weld Deposit Surface | Shock Test RD. | Shock Test Vel. f/s | Shock Test Weld Cr. | Test Plate Temp. | X-ray | Bal. | Firing Record | Plate No. | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Baldwin | Sym. Gould | 0.25 | Alloy Rods | DV | 3/16" | L | B | 1" | 897 | --- | -19° | None | NWT | AD2134 | 35 | Plate cracked 3¼" |
| " | " | " | " | " | " | " | " | 1 | 906 | --- | -21° | None | NWT | " | 36 | Plate cracked 20-1/2" |
| | | | | | | | | 2 | 914 | --- | | | | | Two more hits at 955 and 1002 broke up the plate |
| | One plate held for A. P. G. test | | | | | | | | | | | | | | | |
| Briggs | American | 0.28 | Crucible | 45° DV | 5/16" | L | L | 1 | 800 | 36 | -24° | P | F | AD2131 | M-33 | Broke in 2 pieces |
| " | " | " | " | " | " | " | " | 1 | 808 | 7-1/2 | -20° | P | F | " | M-38 | Plate cracked 6" |
| | | | | | | | | 2 | 904 | 9-1/2 | | | | | | Plate cracked 6-1/4" more |
| " | " | " | " | " | " | " | " | 1 | 904 | 25-1/2 | -26° | P | F | " | M-37 | Plate cracked 15-3/4" |
| Chrysler | Continental | 0.27 | Crucible | 45° DV | 3/16" | L & B | B | 1 | 805 | — | -25° | P | | AD2136 | CP-49 | |
| | | | | | | | | 2 | 900 | 5-3/4 | | | NWT | | | Plate cracked 5-1/4" |
| | | | | | | | | 3 | 1004 | 2 | | | | | | Plate cracked 32-3/4" more |
| " | " | " | " | " | " | " | " | 1* | 802 | 11 | -20° | P | NWT | " | CP-51 | Passed X-ray after repairs. |
| | | | | | | | | 2 | 907 | 2-3/4 | | | | | | Plate cracked 38-3/4" Plate broke up |
| " | " | " | " | " | " | " | " | 1 | 800 | | -27° | P | NWT | " | CP-50 | Broke in 2 pieces |
| Int. Harv. | Ord. St. Fdry. | 0.28 | Alloy Rods | 45° DV | 5/16" | L & B | B | 1 | 806 | 5 6 | -20° | P | F | AD2137 | 42 | Crack in CB before test |
| | | | | | | | | 2 | 901 | 3 | | | | | | Piece broke out |
| " | " | " | " | " | " | " | " | 1* | 885 | 11 | -19° | P | F | " | 43 | Crossbar cracked |
| | | | | | | | | 2* | 938 | — | | | | | | |
| | | | | | | | | 3 | 938 | — | | | | | | |
| | | | | | | | | 4 | 938 | 1-3/4 | | | | | | |
| | | | | | | | | 5 | 1050 | 12-1/4 | | | | | | Plate cracked 19" |
| Int. Harv. (Cont.) | Ord. St. Fdry. | 0.28 | Alloy Rods | 45° DV | 5/16" | L & B | B | 1 | 924 | 8-1/2 | -19° | P | NWT | AD2137 | 44 | Broke in 3 pieces |
| Ford | Ford | 0.26 | Crucible | 45° DV | 3/16" | L | B | 1 | 1017 | 26-1/2 | +24° | P | F | AD2132 | M-54 | Plate cracked 5-3/4" |
| " | " | " | " | " | " | " | " | | | 4 | | | | | | Crack in CB before test |
| | | | | | | | | 1* | 773 | 10 | -22* | P | F | " | M-62 | Plate cracked 25" |
| | | | | | | | | 2 | 800 | 5 | | | | | | Plate cracked 3" more |
| " | " | " | " | " | " | " | " | | | 7 | | | | | | Crack in CB before test |
| | | | | | | | | 1 | 849 | 16-1/2 | -22° | P | | " | M-52 | Plate cracked 2" |
| | | | | | | | | 2 | 906 | 19 | | | F | | | Plate cracked 10-1/4" more |

* - NOT FAIR HIT - OUTSIDE 2" LIMIT

## TABLE VI

### COLD TESTS OF WELDED ARMOR - CAMP SHILO - 1942/1941

### 1-1/2" CAST HOMOGENEOUS PLATE

### Manganese Mod. Austenitic 18/8 Electrode

| Fabricator | Armor Mfr. | Armor C | Electrode | Joint Bevel | Joint Gap | Weld Body | Weld Deposit Surface | Shock Test RD. | Shock Test Vel. f/s | Shock Test Weld, In. | Test Plate Temp. | X-ray | Bal. | Firing Record | Plate No. | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Baldwin | Sym. Gould | 0.25 | Alloy Rods | DV | 3/16" | L | B | 1 | 900 | 4 | -21° | None | P | AD2134 | 39 | |
| | | | | | | | | 2 | 950 | 4-1/2 | | | | | | Plate cracked 7" |
| | | | | | | | | 3 | 1000 | 6 | | | | | | Plate cracked 10" more |
| | | | | | | | | 4 | 1050 | 5-1/2 | | | | | | Plate cracked 13" more |
| " | " | " | " | " | " | " | " | 1 | 818 | — | -19° | P | P | " | 40 | |
| | | | | | | | | 2 | 896 | — | | | | | | |
| | | | | | | | | 3* | 1002 | — | | | | | | |
| | | | | | | | | 4 | 1048 | 9 | | | | | | Plate cracked 16" |
| " | " | " | " | " | " | " | " | 1 | 809 | — | -20° | P | WT | " | 38 | Plate cracked 12" |
| | | | | | | | | 2 | 815 | 1-1/2 | | | | | | |
| | | | | | | | | 3 | 811 | | | | | | | Piece broke out |
| Briggs | American | 0.28 | McKay | 45° DV | 5/16" | L | L | 1 | 912 | — | -28° | P | P | AD2131 | M-36 | |
| | | | | | | | | 2* | 908 | — | | | | | | Plate cracked 28-3/4" |
| | | | | | | | | 3 | 902 | — | | | | | | Plate cracked 11-3/4" more |
| " | " | " | " | " | " | " | " | 1 | 907 | 5-1/2 | -29° | P | | " | M-35 | Plate cracked 6" |
| | | | | | | | | 2 | 1000 | 4-1/2 | | | WT | | | Plate cracked 34-1/2" more |
| | | | | | | | | 1* | 822 | — | -20° | P | | " | M-34 | |
| | | | | | | | | 2* | 823 | — | | | | | | |
| | | | | | | | | 3 | 920 | — | | | P | | | |
| | | | | | | | | 4 | 1001 | 18-1/4 | | | | | | Plate cracked 25-1/2" |
| Fisher | Gen. Steel | | Alloy Rods | 45° DV | 5/16" | L | L | 1 | 1094 | 17-1/4 | +24° | P | P | AD2130 | OTF26 | |
| | | | | | | | | 2 | 1117 | 16-3/4 | | | | | | |
| " | " | | " | " | " | " | " | 1* | 805 | 12 | -29° | P | P | " | OTF28 | |
| | | | | | | | | 2 | 903 | 8 | | | | | | Plate cracked 1-3/8" |
| | | | | | | | | 3 | 1001 | 30 | | | | | | |
| Fisher (Cont.) | Gen. Steel | | Alloy Rods | 45° DV | 5/16" | L | L | 1* | 819 | 11 | -20° | P | P | AD2130 | OTF27 | |
| | | | | | | | | 2 | 909 | 21 | | | | | | Plate cracked 2" |
| | | | | | | | | | | 6 | | | | | | Left leg crack before test |
| Chrysler | Coctia-ental | 0.27 | McKay | 45° DV | 3/16" | L & B | B | 1 | 809 | 14 | -20° | P | P | AD2136 | CR-47 | Passed X-ray after repairs |
| | | | | | | | | 2 | 911 | 2 | | | | | | Plate cracked 44-3/4" |
| " | " | " | " | " | " | " | " | 1 | 810 | 23 | -25° | P | P | " | CR-48 | Passed X-ray after repairs |
| | | | | | | | | 2 | 905 | 13 | | | | | | Plate cracked 8-1/4". Broke in 3 pieces |
| " | " | " | " | " | " | " | " | 1 | 1101 | 20-1/2 | +24° | P | P | " | CR-46 | Passed X-ray after repairs |
| | | | | | | | | 2 | 1059 | — | | | | | | Plate cracked 26-1/4" |
| Int. Harv. | Ord. Dpt. | St. 0.28 | McKay | 45° DV | 5/16" | L & B | B | 1 | 1025 | 4-1/4 | -20° | P | WT | AD2137 | 40 | Plate cracked badly |
| | | | | | | | | 2 | 1050 | — | | | | | | Plate broke 5 pieces |
| " | " | " | " | " | " | " | " | 1* | 909 | — | -20° | P | | " | 41 | |
| | | | | | | | | 2 | 1017 | 1-3/4 | | | | | | |
| | | | | | | | | 3 | 1040 | — | | | P | | | Plate cracked 7" |
| | | | | | | | | 4 | 1095 | 12-1/4 | | | | | | Plate cracked 15-1/2" more |
| " | " | " | " | " | " | " | " | 1* | 779 | — | -22° | P | | " | 39 | |
| | | | | | | | | 2 | 899 | 7-1/2 | | | P | | | Plate cracked 11-1/2" |
| Ford | Ford | 0.26 | McKay | 45° DV | 3/16" | L | B | | | 3 | | P | | | | Crack in CB before test |
| | | | | | | | | 1 | 1049 | 12-1/2 | +24° | | | AD2132 | M-49 | |
| | | | | | | | | 2* | 1053 | 1-1/2 | | | P | | | Plate cracked 19-1/2" |
| | | | | | | | | | | 9-1/2 | | | | | | Crack in CB before test |
| " | " | " | " | " | " | " | " | 1 | 786 | 3 | -20° | | | " | M-67 | Plate cracked 2-5/8" |
| | | | | | | | | 2 | 898 | 11-3/4 | | | P | | | Plate cracked 30-3/4" more |
| | | | | | | | | | | 7-3/8 | | P | | | | Crack in CB before test |
| " | " | " | " | " | " | " | " | 1* | 812 | 4 | -20° | | | " | M-51 | |
| | | | | | | | | 2 | 900 | 16-1/2 | | | P | | | |

* - NOT FAIR HIT - OUTSIDE 2" LIMIT

VI

TABLE VII

COLD TESTS OF WELDED ARMOR - CAMP SHILO - 1942/1943

1/2" ROLLED HOMOGENEOUS PLATE

Unionmelt

| Fabricator | Armor Mfr. | C | Electrode Rod | Electrode Melt | Joint Bevel | Joint Gap | Weld Deposit Body | Weld Deposit Surface | Shock Test RD. | Shock Test Vel.f/s | Shock Test Weld.Cr. | Test Plate Temp. | X-ray | Bal. | Firing Record | Plate No. | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Yellow Truck | J & L | 0.22 | 36 Ferritic | 20 | 45° SV | 1/16" | 1L | 1SB | 1° | 2600 | — | -17° | P | | AD2145 | C-2 | |
| | | | | | | | | | 2 | 2600 | 10 | | | (F) | | | Plate cracked 10" |
| | | | | | | | | | 3° | 2600 | — | | | | | | |
| | | | | | | | | | 4° | 2600 | 22-1/2 | | | | | | |
| " | " | " | " | " | " | " | " | " | 1° | 2600 | 17 | -17° | P | P | " | C-3 | |
| | | | | | | | | | 2° | 2600 | — | | | | | | |
| | | | | | | | | | 3 | 2600 | 23 | | | | | | Plate cracked 8-1/2" |
| | Two plates held for A. F. C. test | | | | | | | | | | | | | | | | |
| Yellow Truck | J & L | 0.22 | 42 | 80 | 45° SV | 1/16" | 1L | 1SB | 1 | 2600 | 16 | -20° | P | P | AD2145 | C-5 | Plate cracked 13" |
| | | | | | | | | | 2° | 2600 | — | | | | | | Plate cracked 6" more |
| | | | | | | | | | 3° | 2600 | | | | | | | Plate cracked 12" more |
| " | " | " | " | " | " | " | " | " | 1° | 2600 | — | -17° | P | | " | C-7 | |
| | | | | | | | | | 2° | 2600 | 14-1/2 | | | P | | | Plate cracked 1-3/4" |
| | | | | | | | | | 3° | 2600 | 6-1/2 | | | | | | Plate cracked 2" more |
| | One plate held for A. F. C. test | | | | | | | | | | | | | | | | |
| Yellow Truck | Great Lakes | 0.28 | 42 | 80 | 45° SV | 1/16" | 1L | 1SB | 1 | 2600 | 52-1/2 | -20° | P | P | AD2146 | C-8 | |
| | | | | | | | | | 1° | 2600 | | | | | | | No cracks |
| | | | | | | | | | 2° | 2600 | | | | | | | No cracks |
| " | " | " | " | " | " | " | " | " | 3° | 2600 | 13-1/2 | -20° | P | P | " | C-9 | |
| | | | | | | | | | 4 | 2600 | 46-1/2 | | | | | | Broke in 2 pieces |
| | One plate held for A. F. C. test | | | | | | | | | | | | | | | | |
| Int. Harv. Canada | Dom. Fdry. | | Ferritic | | 34° SV | 0 | 1L | 1SB | 1 | 2600 | 21 | -18° | P | P | AD2140 | 13 | |
| " | " | | " | | " | " | " | " | 1 | 2600 | 27-1/2 | -15° | P | P | " | 15 | Plate cracked badly |
| " | " | | " | | " | " | " | " | 1 | 2636 | 31 | -11° | P | P | " | 16 | " " " |
| " | " | | " | | " | " | " | " | 1 | 2632 | 34-1/2 | -13° | P | P | " | 18 | Broke in 2 pieces |

1-1/2" ROLLED HOMOGENEOUS PLATE

Unionmelt

| Fabricator | Armor Mfr. | C | Electrode Rod | Electrode Melt | Joint Bevel | Joint Gap | Hand Layers | RD. | Shock Test Vel.f/s | Shock Test Weld.Cr. | Test Plate Temp. | X-ray | Bal. | Firing Record | Plate No. | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Fisher | J & L | 0.27 | #42 | S020XD | 45° DV | 5/16" | 3 | 1 | 1087 | 36 | -17° | P | P | AD2135 | UOTF-4 | Broke in 2 pieces |
| " | " | " | " | " | " | " | 3 | 1° | 651 | 35 | -13° | P | P | " | UOTF-5 | |
| " | " | " | " | " | " | " | 3 | 1 | 1086 | 36 | +20° | P | P | " | UOTF-6 | Broke in 2 pieces |
| Fisher | Republic | 0.25 | #42 | S020XD | 45° DV | 5/16" | 3 | 1 | 823 | 36 | -15° | P | P | AD2128 | UOTF-1A | Broke in 2 pieces |
| " | " | " | " | " | " | " | 4 | 1 | 1089 | 45 | -19° | P | P | " | UOTF-2A | Failed X-ray after repairs |
| | | | | | | | | | | | | | | | | Broke in 2 pieces |
| " | " | " | " | " | " | " | 4 | 1 | 1082 | 36 | +24° | P | P | " | UOTF-3A | Passed X-ray after repairs |
| | | | | | | | | | | | | | | | | Broke in 2 pieces |
| Fisher | Gr. Lakes | 0.29 | #42 | S020XD | 45° DV | 5/16" | 3 | 1 | 704 | 36 | -13° | P | P | AD2126 | UOTF-7 | Passed X-ray after repairs |
| | | | | | | | | | | | | | | | | Broke in 2 pieces |
| " | " | " | " | " | " | " | 3 | 1 | 772 | 36 | -13° | P | P | " | UOTF-8 | Broke in 2 pieces |
| " | " | " | " | " | " | " | 3 | 1° | 1098 | 36 | -17° | P | P | " | UOTF-9 | Broke in 2 pieces |
| Briggs | Carnegie | 0.27 | #42 | — | 45° DV | 1/4" | 4 | 1 | 1098 | 36 | -21° | P | P | AD2127 | UM-32 | Broke in 2 pieces |
| " | " | " | " | | " | " | 4 | 1 | 1096 | 12 | -18° | P | (F) | " | UM-31 | Plate cracked 5/8" |
| | | | | | | | 4 | 2 | 1128 | 30 | | | | | | Broke in 2 pieces |
| " | " | " | " | | " | " | 4 | 1° | 1110 | — | +20° | P | | " | UM-30 | |
| | | | | | | | 4 | 2 | 1083 | 36 | | | P | | | Broke in 2 pieces |

1-1/2" CAST HOMOGENEOUS PLATE

| Fabricator | Armor Mfr. | C | Electrode Rod | Electrode Melt | Joint Bevel | Joint Gap | Hand Layers | RD. | Shock Test Vel.f/s | Shock Test Weld.Cr. | Test Plate Temp. | X-ray | Bal. | Firing Record | Plate No. | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Midland | Contia-ental | 0.27 | #42 | #80 | 45° DV | 1/4" | 4 | 1 | 865 | 36 | -22° | P | P | AD2133 | CC-1 | Broke in 2 pieces |
| " | " | " | " | " | " | " | 4 | 1 | 1057 | 9-1/2 | +24° | P | PWT | " | CC-2 | Broke in 4 pieces |
| " | " | " | " | " | " | " | 4 | 1 | 800 | 36 | -20° | P | P | " | CC-3 | Broke in 2 pieces |

* - NOT FAIR HIT - OUTSIDE 2" LIMIT

## TABLE VIII

TESTS AT NORMAL TEMPERATURE - ABERDEEN PROVING GROUND - 1943

WELDED ARMOR H PLATES FROM CAMP SHILO (See Tables 1 - 11)

| Fabricator | Armor | Rd. | Shock Test Vel.f/s | Weld Gr. | Test Plate Temp. | X-ray | Bal. | Firing Record | Plate No. | Electrode | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 1/2" Rolled Homogeneous Plate | | | | | | |
| Yellow Truck | J & L | 1* | 2600 | — | +70° | P | | AD-507 | C-13 | No Mod. | Originally acceptable. |
| | | 2* | " | — | | | | | | | |
| | | 3 | " | — | | | P | | | | |
| | | 4 | " | 10 | | | | | | | |
| | | 5 | " | 2 | | | | | | | |
| Yellow Truck | J & L | 1* | 2600 | — | +70° | F | | AD-507 | C-1 | Unionmelt Ferritic | Excessive cracks in crossbar. Originally acceptable. |
| | | 2* | " | — | | | | | | | |
| | | 3 | " | 8 | | | | | | | |
| | | 4 | " | 7-3/4 | | | F | | | | |
| Yellow Truck | J & L | 1* | 2600 | 12 | +70° | F | F | AD-507 | C-4 | Unionmelt Ferritic | Excessive cracks and porosity in crossbar. Originally unacceptable. |
| | | 2 | " | — | | | | | | | |
| | | 3 | " | 11-1/2 | | | | | | | |
| Yellow Truck | J & L | 1 | 2600 | 4 | +70° | F | F | AD-507 | C-6 | Unionmelt Austenitic | Excessive amount of incomplete penetration. Originally unacceptable. |
| | | 2 | " | — | | | | | | | |
| | | 3* | " | — | | | | | | | |
| | | 4* | " | — | | | | | | | |
| | | 5 | " | 4 | | | | | | | |
| Yellow Truck | Great Lakes | 1 | 2600 | 8 | +70° | F | F | AD-507 | C-10 | Unionmelt Austenitic | Excessive amount of incomplete penetration. Originally unacceptable due to lack of penetration. |
| | | 2 | " | 9-1/2 | | | | | | | |
| | | 3 | " | 26-1/2 | | | | | | | |
| | | | | | 1" Rolled Homogeneous Plate | | | | | | |
| Ternstedt | J & L | 1 | 775 | 16 | +70° | F | F | AD-507 | TH-71 | No Mod. | Excessive cracks in crossbar. Originally acceptable with small cracks in crossbar. |
| | | 2 | 774 | 19-1/4 | | | | | | | |
| Ternstedt | J & L | | | 6-1/4 | +70° | F | | AD-507 | TH-73 | No Mod. | Excessive cracks in crossbar. Originally acceptable. Repairs are evident. |
| | | 1 | 768 | 20-3/4 | | | F | | | | |
| Ternstedt | J & L | 1 | 769 | 13-3/4 | +70° | F | F | AD-507 | TH-66 | No Mod. | Excessive cracks in crossbar. Originally rejectable. 3" plate crack. |
| | | 2 | 772 | 15-1/2 | | | | | | | |
| | | 3 | 775 | 30-3/4 | | | | | | | |
| Ternstedt | J & L | 1 | 789 | 20-1/2 | +70° | F | F | AD-507 | TH-70 | No Mod. | Excessive cracks in crossbar. Originally rejectable. |
| Cadillac | Great Lakes | 1 | 785 | 21 | +70° | F | F | AD-507 | 101 | No Mod. | Excessive cracks in crossbar. Originally rejectable because of cracks. 2" plate crack. |
| Cadillac | Republic | 1* | 772 | — | +70° | F | | AD-507 | 93 | No Mod. | Excessive cracks in crossbar. Originally rejectable. |
| | | 2 | 774 | 23 | | | F | | | | |
| Cadillac | Republic | 1 | 772 | 11-1/2 | +70° | F | F | AD-507 | 90 | No Mod. | Unsoundness. Scattered cracks. Originally acceptable. 3-1/2" plate crack. 3" plate crack. |
| | | 2 | 773 | 8-1/4 | | | | | | | |
| | | | | | 1-1/2" Rolled Homogeneous Plate | | | | | | |
| Fisher | J & L | 1 | 953 | 7-1/2 | +65° | F | | AD-507 | OTP-10 | No Mod. | Excessive cracks in crossbar. Originally acceptable. |
| | | 2 | 1095 | 4 | | | F | | | | |
| | | 3 | 1101 | 21-1/2 | | | | | | | |
| A. O. Smith | Carnegie | 1 | 1105 | — | +65° | F | F | AD-507 | 29390 | SW-101 Ferritic | Originally acceptable after repairs of cracks. |
| | | 2 | 1094 | 3/4 | | | | | | | |
| | | 3 | 1131 | 1 | | | | | | | |
| | | 4 | 1201 | 18 | | | | | | | |
| A. O. Smith | Carnegie | 1 | 1109 | 4-1/2 | +65° | F | F | AD-507 | 29392 | SW-101 Ferritic | Excessive cracks in crossbar. Originally acceptable. The firing record refers to the shock performance as unsatisfactory. |
| | | 2 | 1145 | 16 | | | | | | | |
| | | 3 | 1152 | 1-1/2 | | | | | | | |
| | | 4 | 1179 | 33 | | | | | | | |
| | | | | | 1-1/2" Cast Homogeneous Plate | | | | | | |
| Baldwin | Sym.-Gould | 1 | 1077 | 12-1/2 | +70° | F | F | AD-507 | 37 | No Mod. | Originally acceptable. |
| | | 2 | 1072 | 4 | | | | | | | |
| | | 3 | 1056 | 19 | | | | | | | |

* - NOT FAIR HIT - OUTSIDE 2° LIMIT

## SUMMARY A

## COLD TESTS

## 1/2" ROLLED HOMOGENEOUS ARMOR

### Molybdenum Modified 18/8

| Fabricator | Armor | Electrode | Gap | Body | Surface | Hits | X-ray | Bal. |
|---|---|---|---|---|---|---|---|---|
| Yellow Trk. | J & L | Harn. | 3/16" | L | B | 6 | F | P |
| | | | | | | 6 | P | P |
| Yellow Trk. | Gr. Lakes | Harn. | 3/16" | L | B | 3 | P | F |
| | | | | | | 3 | P | F |
| | | | | | | 2 | P | F |
| Ham. Bridge | Dom. Fdry. | Harn. | 1/16" | L | L | 2 | F | F |
| | | | | | | 2 | P | F |
| | | | | | | 1 | P | F |

8 plates tested - 2 plates satisfactory

### Manganese Modified 18/8

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Yellow Trk. | J & L | McKay | 3/16" | L | B | 4 | P | P |
| | | | | | | 4 | P | P |
| | | | | | | 5 | P | P |
| Yellow Trk. | Gr. Lakes | McKay | 3/16" | L | B | 4 | P | F |
| | | | | | | 2 | P | F |
| | | | | | | 3 | P | (P) |
| Int. Harv. Canada | Dom. Fdry. | Lincoln | 1/16" | L | L | 1 | F | F |
| | | | | | | 2 | F | F |

8 plates tested - 4 plates satisfactory

FOOTNOTE:

L - Layers each weaved across the groove in deposition.
B - Several individual beads per layer.
L & B - Woven layers alternated with layers of individual beads.

## SUMMARY B

## COLD TESTS

## 1" ROLLED HOMOGENEOUS ARMOR

### Molybdenum Modified 18/8

| Fabricator | Armor | Electrode | Gap | Body | Surface | Hits | X-ray | Bal. |
|---|---|---|---|---|---|---|---|---|
| Ternstedt | J & L | Alloy Rods | 3/16" | L | L | 1 | P | F |
| | | | | | | 1 | P | F |
| Cadillac | Gr. Lakes | Page | 3/16" | L | B | 3 | F | NWT |
| | | | | | | 3 | P | NWT |
| Cadillac | Republic | Page | 3/16" | L | B | 1 | F | F |
| | | | | | | 1 | F | F |

6 plates tested with 2 plate failures - none were satisfactory.

### Manganese Modified 18/8

| Ternstedt | J & L | Alloy Rods | 3/16" | L | L | 1 | P | F |
|---|---|---|---|---|---|---|---|---|
| | | | | | | 1 | P | F |
| Cadillac | Gr. Lakes | McKay | 3/16" | L | B | 1 | P | F |
| | | | | | | 2 | F | NWT |
| | | | | | | 2 | P | NWT |
| Cadillac | Republic | McKay | 3/16" | L | B | 1 | P | F |
| | | | | | | 1 | P | F |

7 plates tested with 2 plate failures - none were satisfactory

FOOTNOTE:

L - Layers each weaved across the groove in deposition.
B - Several individual beads per layer.
L & B - Woven layers alternated with layers of individual beads.

## SUMMARY C

## COLD TESTS

## 1-1/2" ROLLED HOMOGENEOUS ARMOR

### Molybdenum Modified 18/8

| Fabricator | Armor | Electrode | Gap | Body | Surface | Hits | X-ray | Bal. |
|---|---|---|---|---|---|---|---|---|
| Fisher | J & L | Raco | 5/16" | L | L | 2 | P | P |
| | | | | | | 2 | P | P |
| | | | | | | 1 | P | F |
| Fisher | Republic | Raco | 5/16" | L | L | 2 | P | F |
| | | | | | | 3 | P | F |
| | | | | | | 2 | P | P |
| Fisher | Gr. Lakes | Raco | 5/16" | L | L | 1 | P | F |
| | | | | | | 1 | P | F |
| | | | | | | 2 | P | F |
| Ford | Ford | Crucible | 3/16" | L | B | 2 | P | P |
| | | | | | | 2 | P | P |
| | | | | | | 6 | P | P |
| Midland | Carnegie | Crucible | 5/16" | L & B | B | 2 | P | P |
| | | | | | | 4 | P | (F) |
| | | | | | | 2 | P | P |
| Gen. Motors Canada | Dom. Fdry. | Harn. | 1/4" | L & B | B | 1 | P | NWT |
| | | | | | | 3 | P | NWT |
| | | | | | | 1 | F | NWT |

18 plates tested - 8 plates satisfactory

### Manganese Modified 18/8

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Fisher | J & L | Alloy Rods | 5/16" | L | L | 1 | P | F |
| | | | | | | 1 | F | F |
| Fisher | Republic | Alloy Rods | 5/16" | L | L | 2 | F | P |
| | | | | | | 2 | P | F |
| | | | | | | 2 | P | P |
| Fisher | Gr. Lakes | Alloy Rods | 5/16" | L | L | 1 | P | F |
| | | | | | | 2 | P | F |
| | | | | | | 1 | F | F |
| Ford | Ford | McKay | 3/16" | L | B | 2 | P | F |
| | | | | | | 1 | P | F |
| | | | | | | 2 | P | F |
| Midland | Carnegie | McKay | 5/16" | L & B | B | 4 | P | P |
| | | | | | | 5 | P | P |
| | | | | | | 3 | P | P |

14 plates tested - 5 plates satisfactory

## SUMMARY C (Cont.)

Ferritic - A. O. Smith SW-101

| Fabricator | Armor | Electrode | Gap | Body | Surface | Hits | X-ray | Bal. |
|---|---|---|---|---|---|---|---|---|
| A.O.Smith | Carnegie | SW-101 | 3/8" | L | B | 2 | P | P |
| | | | | | | 5 | P | P |

2 plates tested - 2 plates satisfactory

FOOTNOTE:

L - Layers each weaved across the groove in deposition.
B - Several individual beads per layer.
L & B - Woven layers alternated with layers of individual beads.

## SUMMARY D

## COLD TESTS

## 1-1/2" CAST HOMOGENEOUS ARMOR

### Molybdenum Modified 18/8

| Fabricator | Armor | Electrode | Gap | Body | Surface | Hits | X-ray | Bal. |
|---|---|---|---|---|---|---|---|---|
| Baldwin | Sym. Gould | Alloy Rods | 3/16" | L | B | 1 | - | NWT |
| | | | | | | 4 | - | NWT |
| Briggs | Am. St. Fdry. | Crucible | 5/16" | L | L | 1 | P | F |
| | | | | | | 2 | P | F |
| | | | | | | 1 | P | F |
| Chrysler | Continental | Crucible | 3/16" | L & B | B | 3 | P | NWT |
| | | | | | | 2 | P | NWT |
| | | | | | | 1 | P | NWT |
| Int. Harv. | Ord. St. Fdry. | Alloy Rods | 5/16" | L & B | B | 2 | P | F |
| | | | | | | 5 | P | F |
| | | | | | | 1 | P | NWT |
| Ford | Ford | Crucible | 3/16" | L | B | 1 | P | F |
| | | | | | | 2 | P | F |
| | | | | | | 2 | P | F |

14 plates tested with 6 plate failures - none were satisfactory.

### Manganese Modified 18/8

| Fabricator | Armor | Electrode | Gap | Body | Surface | Hits | X-ray | Bal. |
|---|---|---|---|---|---|---|---|---|
| Baldwin | Sym. Gould | Alloy Rods | 3/16" | L | B | 4 | - | P |
| | | | | | | 4 | P | P |
| | | | | | | 3 | P | NWT |
| Briggs | Am. St. Fdry. | McKay | 5/16" | L | L | 3 | P | P |
| | | | | | | 2 | P | NWT |
| | | | | | | 4 | P | P |
| Fisher | Gen. Steel | Alloy Rods | 5/16" | L | L | 2 | P | F |
| | | | | | | 3 | P | F |
| | | | | | | 2 | P | F |
| Chrysler | Continental | McKay | 3/16" | L | B | 2 | P | F |
| | | | | | | 2 | P | F |
| | | | | | | 2 | P | F |
| Int. Harv. | Ord. St. Fdry. | McKay | 5/16" | L & B | B | 2 | P | NWT |
| | | | | | | 4 | P | P |
| | | | | | | 2 | P | P |
| Ford | Ford | McKay | 3/16" | L | B | 2 | P | F |
| | | | | | | 2 | P | F |
| | | | | | | 2 | P | F |

18 plates tested with 3 plate failures - 6 plates satisfactory.

FOOTNOTE:

L - Layers each weaved across the groove in deposition.
B - Several individual beads per layer.
L & B - Woven layers alternated with layers of individual beads.

## SUMMARY E

## COLD TESTS

## UNION-MELT

### 1/2" Rolled Homogeneous Armor

| Fabricator | Armor | Rod | Melt | Gap | Hand Layers | Hits | X-ray | Bal. |
|---|---|---|---|---|---|---|---|---|
| Yellow Trk. | J & L | #36 | #20 | 1/16" | 1SB | 4 | P | (F) |
| | | | | | | 3 | P | F |
| Yellow Trk. | J & L | #42 | #80 | 1/16" | 1SB | 3 | F | F |
| | | | | | | 3 | F | F |
| Yellow Trk. | Gr. Lakes | #42 | #80 | 1/16" | 1SB | 1 | F | F |
| | | | | | | 4 | F | F |
| Int. Harv. Canada | Dom. Fdry. | #40 | | 0 | --- | 1 | F | F |
| | | | | | | 1 | F | F |
| | | | | | | 1 | F | F |
| | | | | | | 1 | F | F |

10 plates tested - 6 ferritic and 4 austenitic - none were satisfactory.

### 1-1/2" Rolled Homogeneous Armor

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Fisher | J & L | #42 | 8020 XD | 5/16" | 3 | 1 | F | F |
| | | | | | | 1 | F | F |
| | | | | | | 1 | F | F |
| Fisher | Republic | #42 | 8020 XD | 5/16" | 3 | 1 | F | F |
| | | | | | | 1 | F | F |
| | | | | | | 1 | P | F |
| Fisher | Gr. Lakes | #42 | 8020 XD | 5/16" | 3 | 1 | P | F |
| | | | | | | 1 | F | F |
| | | | | | | 1 | P | F |
| Briggs | Carnegie | #42 | | 1/4" | 4 | 1 | P | F |
| | | | | | | 2 | P | (F) |
| | | | | | | 2 | F | F |

### 1-1/2" Cast Homogeneous Armor

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Midland | Continental | #42 | #80 | 1/4" | 4 | 1 | P | F |
| | | | | | | 1 | P | NWT |
| | | | | | | 1 | P | F |

15 plates tested with 1 plate failure - none were satisfactory.

FOOTNOTE:

L - Layers each weaved across the groove in deposition.
B - Several individual beads per layer.
L & B - Woven layers alternated with layers of individual beads.

## SUMMARY F

## COLD TESTS

### Radiographic vs. Ballistic Shock Test

| Armor | Electrode Type | Agreement P - X-ray P - Bal. | Agreement F - X-ray F - Bal. | Disagreement F - X-ray P - Bal. | Disagreement P - X-ray F - Bal. | PLATE Failure | Remarks |
|---|---|---|---|---|---|---|---|
| 1/2" R | Mo Mod. | 1 | 1 | 1 | 5 | -- | |
| | Mn Mod. | 4 | 2 | -- | 2 | | |
| | Unionmelt Ferritic | -- | 4 | -- | -- | -- | |
| | Unionmelt | -- | 4 | -- | 2 | -- | |
| 1" R | Mo Mod. | -- | 2 | -- | 2 | 2 | |
| | Mn Mod. | -- | -- | -- | 5 | 2 | |
| 1½" R | Mo Mod. | 8 | -- | -- | 7 | 3 | |
| | Mn Mod. | 4 | 2 | 1 | 7 | -- | |
| | Unionmelt Ferritic | -- | 7 | -- | 5 | -- | |
| | Manual | 2 | -- | -- | -- | -- | |
| 1½" C | Mo Mod. | -- | -- | -- | 8 | 6* | |
| | Mn Mod. | 5 | -- | -- | 9 | 3 | 1 - No X-ray Passed Bal. |
| | Unionmelt | -- | -- | -- | 2 | 1 | |
| TOTALS | | 24 | 22 | 2 | 54 | 17 | 1 - No X-ray Passed Bal. |

* Two of these were not X-rayed

## SUMMARY G

## COLD TESTS

### Weld Deposition vs. Ballistic Shock Performance

### 1" and 1-1/2" Plate (Manual Welds Only)

| Armor | Electrode Type | Ballistic Passing: Body in Layers Surf. Layers | Ballistic Passing: Body in Layers Surf. Beads | Ballistic Passing: Body - Layers and Beads Surf. Layers | Ballistic Passing: Body - Layers and Beads Surf. Beads | Ballistic Failing: Body in Layers Surf. Layers | Ballistic Failing: Body in Layers Surf. Beads | Ballistic Failing: Body - Layers and Beads Surf. Layers | Ballistic Failing: Body - Layers and Beads Surf. Beads |
|---|---|---|---|---|---|---|---|---|---|
| 1" R | Mo Mod. | — | — | — | — | 2 | 2 & 2 NWT | — | — |
| | Mn Mod. | — | — | — | — | | | | |
| | Mn Mod. | — | — | — | — | 2 | 3 & 2 NWT | — | — |
| 1½" R | Mo Mod. | 3 | 3 | — | 2 | 6 | — | — | 1 & 3 NWT |
| | Mn Mod. | 2* | — | — | 3 | 6 | 3 | — | — |
| | Ferritic | — | 2 | — | — | — | — | — | — |
| 1½" C | Mo Mod. | — | — | — | — | 3 | 3 & 2 NWT | — | 2 & 4 NWT |
| | Mn Mod. | 2 | 2** | — | 2 | 3 & 1 NWT | 6 & 1 NWT | — | 1 NWT |
| TOTALS | | 7 | 7 | — | 7 | 22 & 1 NWT | 17 & 7 NWT | — | 3 & 8 NWT |

* One failed X-ray
** One not X-rayed

## SUMMARY H

## COLD TESTS

### Weld Failures vs. Armor Failures (Manual Welds Only)

| Armor Mfgr. | Armor | Electrode Type | Ballistic Shock Weld Passed | Ballistic Shock Weld Failed | Armor Failures | Remarks |
|---|---|---|---|---|---|---|
| J & L | 1/2" R | Mo Mod. | 2 | -- | -- | These data do not include the Unionmelt welds. Of the 25 Unionmelt plates, one 1-1/2" cast plate gave a plate failure as shown in SUMMARY E. Otherwise, all Unionmelt welds failed the ballistic shock test. |
| | | Mn Mod | 3 | -- | -- | |
| | 1" R | Mo Mod. | -- | 2 | -- | |
| | | Mn Mod. | -- | 2 | -- | |
| | 1½" R | Mo Mod. | 2 | 1 | -- | |
| | | Mn Mod. | -- | 2 | -- | |
| Great Lakes | 1/2" R | Mo Mod. | -- | 3 | -- | |
| | | Mn Mod | 1 | 2 | -- | |
| | 1" R | Mo Mod. | -- | -- | 2 | |
| | | Mn Mod. | -- | 1 | 2 | |
| | 1½" R | Mo Mod. | -- | 3 | -- | |
| | | Mn Mod | -- | 3 | -- | |
| Republic | 1" R | Mo Mod. | -- | 2 | -- | |
| | | Mn Mod. | -- | 2 | -- | |
| | 1½" R | Mo Mod. | 1 | 2 | -- | |
| | | Mn Mod. | 2 | 1 | -- | |
| Dom. Fdry. | 1/2" R | Mo Mod. | -- | 3 | -- | |
| | | Mn Mod. | -- | 2 | -- | |
| | 1½" R | Mo Mod. | -- | -- | 3 | |
| | | Mn Mod. | -- | -- | -- | |
| Ford | 1½" R | Mo Mod. | 3 | -- | -- | |
| | | Mn Mod. | -- | 3 | -- | |
| Carnegie | 1½" R | Mo Mod. | 2 | 1 | -- | |
| | | Mn Mod. | 3 | -- | -- | |
| | | Ferritic | 2 | -- | -- | |
| Conti-nental | 1½" C | Mo Mod. | -- | -- | 3 | |
| | | Mn Mod. | -- | 3 | -- | |
| Amer. Steel | 1½" C | Mo Mod. | -- | 3 | -- | |
| | | Mn Mod. | 2 | -- | 1 | |
| Gen. Steel | 1½" C | Mo Mod. | -- | -- | -- | |
| | | Mn Mod. | -- | 3 | -- | |
| Ord. St. Fdry. | 1½" C | Mo Mod. | -- | 2 | 1 | |
| | | Mn Mod. | 2 | -- | 1 | |
| Ford | 1½" C | Mo Mod. | -- | 3 | -- | |
| | | Mn Mod. | -- | 3 | -- | |
| Sym. Gould | 1½" C | Mo Mod. | -- | -- | 2 | |
| | | Mn Mod. | 2 | -- | 1 | |
| TOTALS | | | 27 | 52 | 16 | |

RESTRICTED

ATI- 39488

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ABSTRACT:

Results of ballistic shock tests of welded armor "H" plates made under sub-zero temperature conditions are presented and compared with the performance of several welded plates tested under normal temperature conditions. The chances for successful shock performance of production welded plates at sub-zero temperatures are: a) manually welded, 34%; (1) multiple bead surface layer, 41%, and (2) single pass surface layer, 24%; b) unionmelt welded, 0%. The radiographic test was consistent with the ballistic shock test in 45% of the cases involved. Of the plates which passed the X-ray test, 30% passed the shock test. Radiographic standards for welds in sub-zero temperature service should probably be higher than those for welds in service at normal temperature. While 35% of the plates manually welded with the manganese modified electrode and 28% with molybdenum modified electrode passed, this difference is considered insufficient to indicate superiority of performance of the one type.

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