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EXAMINATION OF MODIFIED CRS-1

Furnished By

The Rustless Iron Corporation of America

To determine its

Suitability for use After Welding without Subsequent Heat Treatment

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Metallurgical and Testing Division,
U. S. Naval Gun Factory,
January 26, 1934.

SUITABILITY OF MODIFIED 18-8 FOR WELDING APPLICATIONS.

Data contained in report number 115 and a letter, dated November 9, 1933, both received from the Rustless Iron Corporation of America indicated that a modified 18-8 alloy has been developed which maintains its corrosion resistance after welding without subsequent anneal. This latter feature merits the application of this alloy to intricate welded shapes, such as the change proposed for gasolene storage tanks to conform to the shape of the vessel's hull, thus utilizing storage space.

A concise statement of the application of this alloy is contained in a quotation from paragraph 2 of the letter referred to above:

"This modified CRS alloy has been developed in an endeavor to produce a metal which can be welded and put into service without subsequent annealing, and which will not suffer loss of corrosion resistance as the result of this omission of the annealing operation. - - - It may be used for Navy purposes wherever grades CRS-1 or CRS-1a are now specified, and in addition, it may be fabricated by welding at the Navy Yards or on board ship and placed in service without any heat treatment subsequent to welding. - - -"

The Bureau of Ordnance has requested the Naval Gun Factory laboratory to determine the degree of susceptibility of the Rustless Iron Corporation plates to intergranular corrosion after welding but without subsequent heat treatment.

Material -

The following CRS plates were received from the Rustless Iron Corporation for test purposes:

Plate	a	-	0.5	inches	thick
"	b	-	.12	"	"
"	c	-	.18	"	"
"	d	-	.5	"	"

Plate "a" was received in the welded state, plates "b" and "c" were welded by the Naval Gun Factory (V-type electric weld, using coated electrodes), and plate "d" is being held in reserve.

Analysis -

[illegible] analysis of samples taken from plate [illegible]

	C	Si	S	P	Mn	Ni	Cr	Cu	Mo
Parent metal	0.05	0.36	0.006	0.027	0.41	7.62	18.91	0.12	none
Weld metal	.06	.17	.005	.012	.34	8.26	18.89	.10	"

The Rustless Iron Corporation states that the other plates were made from the same heat of steel.

Physical Properties -

The tensile properties of both the parent (base) and welded metal for all three plates are given below:

	Yield point: lbs/sq. in.	Ult. tensile: lbs/sq. in.	Elongation: % in 1"	Elongation: % in 2"	Reduction area, %
Plate "a", parent	62,600	102,200		35.5	49.0
" " , "	63,400	104,400		36.2	50.5
" " , weld	62,100	92,100	32.0	23.5	33.2
" " , "	62,100	91,100	29.0	22.3	29.8
Plate "b", parent	53,900	97,000		48.0	51.6
" " , "	52,100	96,300		46.3	48.7
" " , weld	52,700	91,400	41.5	33.8	33.8
" " , "	51,000	91,700	40.0	33.5	38.7
Plate "c", parent	51,200	93,100		46.0	49.5
" " , "	52,400	94,300		48.0	51.4
" " , weld	54,200	93,200		32.0	38.8
" " , "	44,000	83,700		31.0	40.0

Corrosion Tests -

1. Salt Spray Test.

Two specimens were taken from each welded plate (samples were 2 inches square, beveled on two adjacent sides, with the weld running diagonally) and exposed to the salt spray test for 48 hours. All six specimens appeared entirely satisfactory after the exposure.

2. Nitric acid test.

Welded specimens 2 inches long selected transverse to the weld from all three plates were subjected to a 48 hour boiling period under standard conditions. The results, expressed in inches penetration per month, are given below:

Plate	Density	Sq. in. Area	Inches penetration per month
"a" - 1	7.94	4.04	0.00107
2	7.94	4.03	.00103
3	7.95	4.04	.00105
"b" - 1	7.97	1.786	.00109
2	7.97	1.967	.00111
"c" - 1	7.97	2.43	.00151
2	7.97	2.[illegible]3	.00146
3	7.96	[illegible]	.00147

The above values are well within the specifications. There was no local attack at or bordering on the edges of the welds either on those specimens or in other tests of specimens from these welds which were tested with the original surfaces intact.

3. Cupro-Sulphuric Acid Test.

Test specimens cut transverse to and thru the weld were removed from each welded plate and boiled 48 hours in a 10 per cent copper sulphate - 10 per cent sulphuric acid solution with a reflux condenser. Several samples cut from plate "b" were exposed to this test for 200 hours. None of these specimens showed any indication of intergranular attack after being twisted thru 180 degrees.

Microscopical Examination -

The parent metal and welds of all three plates were studied microscopically and found to be similar. The micrographs which accompany this report were taken from plate "a". One sample was taken in the parent metal far removed from any heat effect of the welding operation. A second sample was a cross-section thru the weld.

The polished but unetched specimens showed numerous small non-metallic inclusions distributed thruout the welded zone. The inclusions in the parent metal were larger in size but not nearly as plentiful.

1. Electrolytic etching.

This etchant consisted of a 10 per cent hydrochloric acid, alcoholic solution. The specimen was made the anode.

Figure 1 shows the structure of the parent metal remote from the weld, unaffected by the heat of the weld, showing elongated ferrite.

The ferrite areas just outside the weld junction in the parent metal are shown in figure 2. These areas do not appear to be as plentiful as the ferrite shown in figure 1, but both show the elongated shape conferred upon them during rolling.

The junction of the weld and parent metal is shown in figure 3. The parent metal exhibits the characteristic directional areas of ferrite, whereas the ferrite in the weld is dendritically arranged.

2. Aqua regia glycol etch.

Figure 4 shows the somewhat angular austenitic grains of the parent metal. The deeply etched ferrite areas are very prominent.

The structure represented in figure 5, taken very near the weld junction in the parent metal, is very similar to that shown in figure 4. It can be observed, however, that in figure 5 the ferrite streaks are discontinuous, moreso than in figure 4, and that the ferrite extends from one austenitic grain into another.

The grain boundaries shown in the weld junction in figure 6 are not distinctly developed. The weld material can be recognized by the haphazard arrangement of the ferrite.

The structure of the weld itself is shown in figure 7. The austenite has a distinctly dendritic appearance and the ferritic areas appear to occur at the interdendritic areas.

No carbides were actually detected in these structures. There was some evidence that some carbide particles were associated with the ferrite.

<u>Conclusions</u> -

It has been found that in three thicknesses of plate, welded under several conditions, the welded area is as nearly immune as the unwelded metal from attack by sea water spray and from exposure to the severly corrosive tests used to disclose susceptibility to intergranular corrosion.

No evidence of even the least degree of increased susceptibility to intergranular corrosion in the vicinity of the weld has been found.

The use of CRS-1 of the composition and condition of the metal on which these welds were made is recommended for corrosion-resisting steel construction where welds are to be made.

In order to secure immunity to intergranular corrosion it is necessary to accept a low proof stress material. This is true whether material of the sort covered by this report be used or regular CRS-1 welded and subsequently heated and quenched. In some designs an advantage will lie with this special material in that only the part adjacent to the welds will be softened. In most, if not in all, cases the omission of the heat treatment after welding will be of great advantage. In many applications the use of this material will enable designs to be executed which could not be performed by the older method since heat treatment after welding is often impossible.

Submitted:

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Approved and forwarded:

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Figure 3.
Weld junction. Ferrite areas in parent metal directional while those in the weld are influenced by the dendrites.

Electrolytically etched. X 500

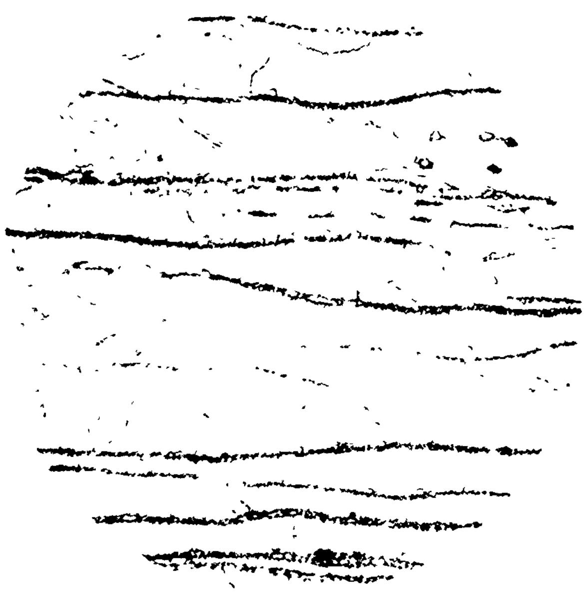

Figure 4.
Austenite grains in parent metal showing strain lines from rolling, ferrite streaks deeply etched.

Aqua regia glycol reagent. X 500

Plate 2.

Figure 5.
Austenitic grains in parent metal adjacent to the weld showing strain lines, also ferrite not as plentiful as shown in figure 4.

Aqua regia glycol reagent. X 500

Figure 6.
Weld junction etched with aqua regia glycol reagent. The ferrite areas are quite predominant and the austenitic grains are practically invisible.

X 500

Plate 3.

F'gure 7.
Weld metal. The ferrite occurs in the inter-dendritic areas. Austenite grain boundaries not developed.

Aqua regia glycol reagent. X 500

Plate 4.