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WATERTOWN ARSENAL LABORATORY

MEMORANDUM REPORT

NO. WAL 710/656

Metallurgical Examination of Fourteen 5/16 Inch Rolled Homogeneous Armor Plates Manufactured by Great Lakes Steel Corporation

BY

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DATE 14 June 1944

WATERTOWN ARSENAL
WATERTOWN, MASS.

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Final Report on Problem B-4.38

14 June 1944

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ABSTRACT

Metallurgical examination, including Brinell hardness surveys, fracture tests for steel soundness and fibre, and macroetch tests was conducted on each of the fourteen plates furnished by Great Lakes Steel Corporation. Microscopic examination was made on six plates and chemical analyses were taken of two. All plates except two were fibroue. Plates 17 and 19 revealed traces of crystallinity at hardnesses of 388 and 375 respectively.

1. As requested by the Ordnance Research Center, APG 470.5/5865 - Wtn 470.5/8122, metallurgical examination has been completed on sections from fourteen (14) 5/16 inch rolled homogeneous armor plates manufactured by the Great Lakes Steel Corporation and tested at Aberdeen as a part of the effect of hardness program. Ballistic results will be reported in Armor Test Report No. AD-510 of the Ordnance Research Center.

2. Metallurgical examination included the following tests:

a. Brinell hardness surveys.

b. Fracture test for steel soundness.

c. Fracture test for response to heat treatment.

d. Macroetch tests.

e. Chemical analyses.

f. Microscopic examination.

c. Fracture test for response to heat treatment.

Sections the same size as above were notched transversely to a depth of $\frac{1}{8}$ inch from each side and broken rapidly under a drop weight mechanism. The sample broken in one direction was as-received, whereas the second sample, taken in the opposite rolling direction, was tempered at 1050°F. Because of cross sectional rolling it was difficult to distinguish the directional properties. The tempered sections were fibrous whereas two of the sections in the as-received heat treated condition revealed traces of crystallinity at high hardness.

Table II

Plate No.	Steel Soundness Tests		Fibre Test	
	Longitudinal	Transverse	Tempered	As-Received
15	B	B	Fibrous	Fibrous
17	B	B	Fibrous	Fibrous - Trace Crystallinity (High Hardness)
19	B	B	Fibrous	Fibrous - Trace Crystallinity (High Hardness)
21	B	B	Fibrous	Fibrous
25	D	B	Fibrous	Fibrous
27	B	D	Fibrous	Fibrous
28	D	B	Fibrous	Fibrous
124	B	B	Fibrous	Fibrous
147	B	B	Fibrous	Fibrous
148	B	D	Fibrous	Fibrous
149	D	B	Fibrous	Fibrous
150	B	C	Fibrous	Fibrous
151	B	B	Fibrous	Fibrous
152	B	B	Fibrous	Fibrous

d. Macroetch tests.

Macroetching of a section from each plate revealed no undesirable segregation in thirteen of the plates. In plate 27, centerline segregation was pronounced and exhibited what would seem to be microscopically stringer-like nonmetallic inclusions. However, when a section of the same plate was examined under the microscope centerline segregation was apparent but only slightly and the inclusions were of a small silicate type.

e. Chemical analyses.

Chemical analyses obtained on two plates were as follows:

Chemical Composition

Plate No.	C	Mn	Si	S	P	Ni	Cr	Mo	V	B	Zr
27	.31	1.48	.29	.027	.025	Nil	.55	.26	Nil	.0023	Nil
148	.31	1.49	.29	.030	.025	Nil	.56	.26	Nil	.0022	Nil

f. Microscopic examination.

A section from plates 15, 17, 27, 28, 147, and 152 was examined for nonmetallic distribution, microstructure, and depth of decarburization.

Plates 15, 17, and 28 had a fairly high concentration of sulphide and small fine oxide-silicate nonmetallic inclusions, the latter in the majority, as illustrated in Figure 1-A. Plates 147 and 152 exhibited a higher nonmetallic content with fine elongated complex silicate-oxides and sulphides. Plate 27 was fairly clean with slight centerline segregation of fine silicate inclusions.

The microstructure of all plates was a tempered martensite; decarburization was negligible in all cases.

4. The microstructure, revealing a tempered martensite, indicates all plates were satisfactorily heat treated. The traces of crystallinity observed in plates 17 and 19 are probably a function of the high hardness and therefore, not attributed to improper heat treatment. The inferior steel soundness of some of the plates, as recorded in Table II, may not cause adverse ballistic behavior; the ballistic results being a function of the respective hardnesses of the plates.

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APPROVED:

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GREAT LAKES STEEL CORPORATION 5/16 INCH ROLLED ARMOR

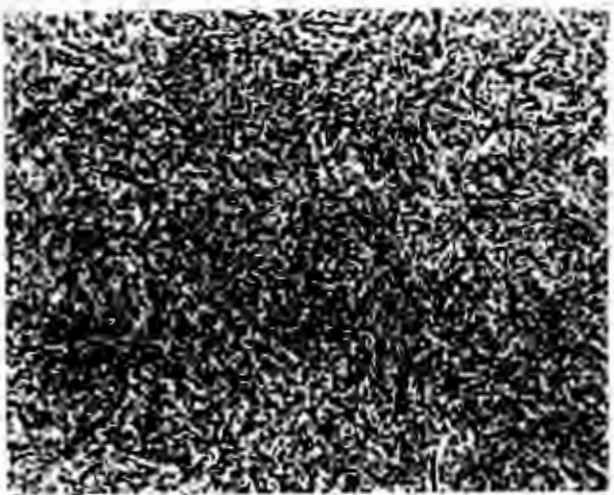
TYPICAL MICROSTRUCTURES

X100 Unetched

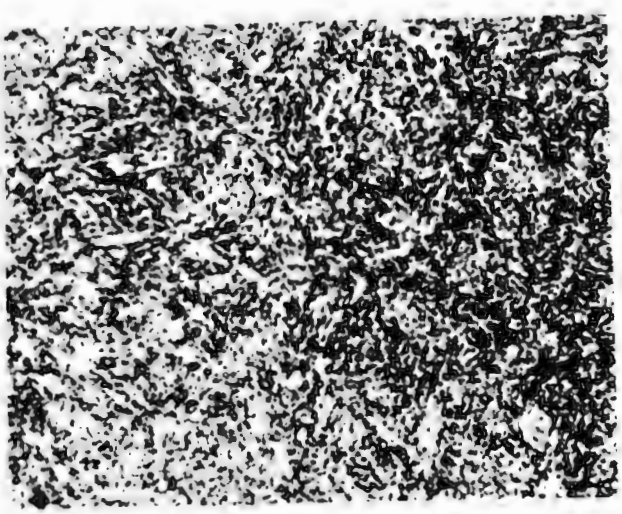
A - Plate 28. Fine complex silicate-oxide inclusions.

B - Plate 152. Fine complex silicate-oxides and sulphide inclusions.

X1000 Picral



C - Plate 147. Tempered martensite at a Brinell hardness of 444.



D - Plate 152. Tempered martensite at a Brinell hardness of 309.

FIGURE 1.