O T T A W A August 14th, 1941.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1066.

An Examination of
Steel Ship-Plate for Destroyers.

BUREAU OF MINES
DIVISION OF METALLIC MINERALS
ORE DRESSING AND
METALLURGICAL LABORATORIES

CANADA
DEPARTMENT
OF
MINES AND RESOURCES
MINES AND GEOLOGY BRANCH

O T T A W A   August 14th, 1941.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1066.

An Examination of
Steel Ship-Plate for Destroyers.

Origin of Request:

In a letter dated August 2nd, 1941, Lieut. Commander C. E. Olive, R.C.N.V.R., of the Naval Service, Department of National Defence, Ottawa, Ontario, requested that an examination of some steel be carried out in order to determine its suitability for use in destroyer construction. The following pieces of steel, all of which were reported to

(Origin of Request, cont'd) -

be from the same sheet, were submitted along with the letter:

Three tensile test pieces,

Three bend test pieces, and

Three pieces 12 in. x 6 in. x $\frac{1}{4}$ in. thick.

Canadian and American naval specifications were also enclosed, in order that a comparison might be made.

Physical Tests:

Test pieces were machined to dimensions specified in Appendix "G" of the Department of National Defence specifications for tests of materials used in a destroyer of the TRIBAL class. Impact tests were included for additional information. An unnotched test piece, $\frac{1}{2}$ x $\frac{1}{2}$ x 3 inches in size, was used.

	Test Piece - No. 1	No. 2	No. 3
Elastic limit, p.s.i. (Using 2 in. extensometer, test pieces received being too short for an 8 in. extensometer.)	-	-	40,000
0.1 per cent proof stress, p.s.i., (2 in. extensometer)	-	-	48,300
Yield by drop of beam, p.s.i. -	47,550	47,900	47,700
Ultimate tensile strength, p.s.i. -	67,500	66,300	67,700
Elongation in 2 in., per cent -	50.0	50.5	51.0
" " 8 " , " " -	27.0	26.0	26.0
Reduction of area, per cent -	50.4	53.9	52.0
Impact, longitudinal, ft. lb. -	84.5	83.0	84.5
" , transverse, " " -	84.0	83.5	83.5

Bend test, 180° on a diameter $2\frac{1}{2}$ times plate thickness - O.K.
" " , " " " " equal to " " - O.K.
" " , " " " " of half of " " - Small surface checks.

Tensile test fractures showed a laminated structure. (See Figure 1).

(Figure 1 on next page)

(Physical Tests, cont'd) -

Figure 1.

Actual size.

FRACTURE AFTER TENSILE TEST.

Hardness Test:

137 Brinell hardness number.

Chemical Analysis:

		Per cent
Carbon	-	0.13
Silicon	-	0.17
Manganese	-	0.73
Nickel	-	None
Chromium	-	"
Vanadium	-	"
Copper	-	0.26
Aluminium	-	Trace
Molybdenum	-	None
Sulphur	-	0.025
Phosphorus	-	0.013

Microstructure:

Long stringers of silicate-type slag inclusions are shown in Figures 2 and 3. These account for the laminated structure of the tensile test fracture. Fine-grained ferrite (white) is shown in Figure 4. Inclusions or "dirt" in this

(Microstructure, cont'd) -

steel occur in much greater than average amounts.

Figure 2.

X100, unetched.

LONGITUDINAL SECTION.

Figure 3.

X100, unetched.

TRANSVERSE SECTION.

Figure 4.

X100, nital etch.

LONGITUDINAL SECTION.

-

Discussion:

Chemical analysis of the plate examined conforms to S.A.E. X1015 steel, which is a soft, low-strength, high-ductility material. Entrained slag and oxides have resulted in a laminated structure. This condition does not disqualify the material for use where static loading is encountered.

Elongated inclusions in steel containing 0.30 to 0.70 per cent carbon have been proven to be connected with:

(1) Lowered resistance to projectiles.
(2) Lowered fatigue properties.
(3) Lowered impact resistance.

In a low-carbon steel, however, the effects of elongated inclusions are much less pronounced. Certain types of slag inclusions improve the welding properties of mild steel and wrought iron.

It would be advisable to obtain photomicrographs of each heat and thus record the type and distribution of inclusions, with a view to setting up some standard for microstructure. Many consumers of steel have already done this and thereby maintain a more uniform quality of manufactured article.

Comparison with Specifications.

	Tensile strength	Yield point	Elong. in 2 ins., per cent	Elong. in 2 ins., per cent	Carbon content, per cent
R.C.N. Grade "D"	37-44 tons sq.in.	17 tons min.	-	17.0	0.30 (max.)
R.C.N. Grade "H.S.T.U."	32-36 tons sq.in.	-	-	18.0	0.30 (max.)
U.S.N. Grade "M" (Spec. 4855)	60,000 p.s.i. min.	37,000 p.s.i. min.	23.0	25.0	0.31 (max.)
Plate examined	67,000 p.s.i.	47,700 p.s.i.	50.0	26.0	0.13

(Continued on next page)

(Discussion, cont'd) -

The plate submitted for examination does not meet the tensile strength requirements for R. C. N. Grade "D" or R. C. N. Grade "H. S. T. U." steel ship plate. It does, however, meet the tensile strength requirements for U. S. N. Grade "M" steel ship plate.

In order to meet Grade "D" class of ship plate, it would be necessary to change the composition of the steel. An increase in carbon would raise the tensile strength and lower the elongation properties. Manganese in amounts over 1.00 per cent will increase the tensile strength without appreciably lowering ductility or weldability.

In recommending an analysis to be adopted for Grade "D" steel ship plate, availability of material must be considered. It is assumed that U. S. N. Grade "High Tensile" is now being made; therefore, since this material meets R. C. N. Grade "D" requirements, it could be adopted for Canadian use. Specifications for this material include:

U.S.N. Grade HT Steel Ship Plate.

(1)	Tensile strength	-	90,000 p.s.i., min.
(2)	Yield point	-	50,000 p.s.i., min.
(3)	Elongation in 8 inches (for plate under 15.3 pounds per sq.ft.)	-	20 per cent min.
(4)	Carbon	-	0.18 per cent, max.
(5)	Manganese	-	1.45 " "
(6)	Vanadium	-	0.08 - 0.14 per cent.

Thickness of plate will have some effect on physical properties. Thin plate, having been worked more, will have greater strength per square inch than thick plate. Some cognizance of this should be taken in the R. C. N. specifications.

Conclusions:

1. The steel examined corresponds to S. A. E. X1015.

2. It does not meet the tensile strength requirements for R. C. N. Grades "D" or "H.S.T.U." steel ship-plate.

3. It meets the tensile and elongation requirements for U. S. N. Grade "Medium" ship-plate.

4. In order to meet the U. S. N. "High Tensile" or R. C. N. Grade "D" requirements, a low-carbon, low-alloy steel is required. Medium manganese steel is probably the most readily available steel in this classification.

5. Entrained "dirt" or slag and oxides are fairly high in the steel examined. Microstructure standards should be set up to help control the quality of the steel purchased.

HHF:GB.

oooooooooooo
oooooo
oo