File.

FILE COPY

O T T A W A April 8th, 1944.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1623.

Examination of Steel Bolts Used in Snowmobile Track.

(Copy No. 10.)

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 April 8th, 1944.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1623.

Examination of Steel Bolts Used in Snowmobile Track.

Origin of Material and Object of Investigation:

On March 24th, 1944, the Division of Metallurgy, Army Engineering Design Branch, Department of Munitions and Supply, Ottawa, Ontario, submitted six (6) bolts for metallurgical examination. It was desired to determine the quality of bolts used in the track of the Snowmobile CDWG. A-39572. The material had been obtained through Mr. W. S. Washburn, Automotive Design, Army Engineering Design Branch, from Messrs. Farand and Delorme, Montreal, Quebec.

The request for this work is entitled Requisition No. 638, A.E.D.B. Lot No. 530, Report No. 107 "D" Test No. 11. Three of the six bolts submitted were unused. The heads of the remainder had failed in service.

These bolts were reported to have been made from SAE 1035 steel, quenched and drawn to a Brinell of 200-260, as specified on Drawing A-39572.

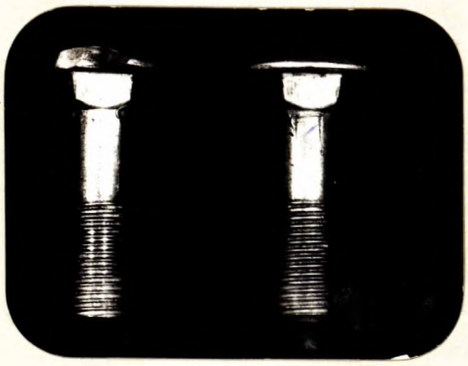
1623
12cc
J.W.M.

Macroscopic Examination:

Specimens of broken and unused bolts are shown in Figure 1. Magnafluxing revealed large cracks in the remaining part of the head of the broken bolt, but there was no evidence of cracks in the neck or shaft.

One bolt was sectioned longitudinally and macro-etched with 50 per cent HCl for 20 minutes, to determine the character of grain flow and the internal condition of the metal. The etched surface is shown in Figure 2.

Figure 1.



BOLTS AS RECEIVED.
(Actual size).

Figure 2.

MACRO-ETCHED SURFACE.

Chemical Analysis:

		As Found	Specification for SAE 1035 Steel
Carbon	-	0.36	0.32-0.38
Manganese	-	0.41	0.60-0.90
Silicon	-	0.21	--
Phosphorus	-	0.009	0.040 max.
Sulphur	-	0.040	0.050 max.

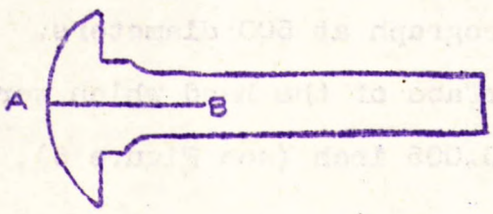
Hardness Survey:

Two bolts (one broken and one unused) were sectioned longitudinally and Vickers hardness readings were taken along the line A-B as shown in Figure 3.

(Continued on next page)

(Hardness Survey, cont'd) -

Figure 3.



Hardness values were plotted against the distances from the surface (A) at which they were taken. Values taken from this curve are shown in Table II.

TABLE II.

VICKERS HARDNESS NUMBERS (10-kg. load).

Bolt No.	Distance from the surface (A), inches										
	.02	.03	.04	.05	.06	.07	.08	.09	.10	.15	.20	.25
1 (Broken)	516	495	474	458	450	444	438	430	424	394	344	310
2 (Unbroken)	490	490	490	474	458	440	426	412	398	342	312	312

Vickers readings taken on a broken bolt in the metal adjacent to cracks were 500-502 V.H.N.

Grain Size:

The grain size, as determined by McQuaid-Ehn test, is 5 (A.S.T.M.). See Figure 4.

Microscopic Examination:

Bolts were split longitudinally for microscopic examination. The microstructure across these sections was heterogeneous, being composed of martensite and ferrite in the thicker parts, the amount of ferrite decreasing toward the

(Microscopic Examination, cont'd) -

surface. In the head, and particularly in the zone where cracking occurred, the microstructure was composed of martensite with troostite at the grain boundaries, as shown in Figure 5, a photomicrograph at 500 diameters. There were some areas at the surface of the head which were decarburized to a depth of 0.004-0.005 inch (see Figure 6).

Discussion:

The chemical composition of the bolts meets the SAE 1035 specification, with the exception of the manganese content which is low (see Table I).

The presence of cracks in the broken heads and the nature of the fracture indicate that the metal failed by cracking rather than by shearing.

Hardness surveys clearly show that the hardness is above that specified (200-260 Brinell). Readings taken at close proximity to cracks varied from 490 to 502 Vickers (460 Brinell). The decrease in hardness toward the thicker section is normal for shallow hardening steels such as SAE 1035.

The high hardness values show that the bolts after quenching have not been properly drawn to obtain the specified hardness. Indeed, with this hardness it is quite likely that they have not been drawn at all. Without this necessary toughening and stress-relieving treatment, the failure of the bolt heads is explainable.

The microstructure was heterogeneous (martensite and troostite), which further substantiates this evidence. Had the bolts been drawn at a suitable temperature (about 800° F.), the troostite structure would have transformed and a uniform tempered structure would have resulted.

The amount of decarburization is small and is not

(Discussion, cont'd) -

likely to have influence on the behaviour of the bolt in service (unless it is considered that failure was occurring due to fatigue).

CONCLUSIONS:

1. The chemical composition of the bolts meets the SAE 1035 specification, with the exception of the manganese content which is 0.41 per cent. This low manganese content would tend to lessen the hardenability somewhat.

2. The internal condition of the metal is favourable, being free from segregation, pipe, or large inclusions.

3. The grain size is 5 (A.S.T.M.).

4. The hardness is 310-516 Vickers (307-477 Brinell) and is not in agreement with the specified 200-260 Brinell.

5. The cause for failure is high hardness and lack of toughness. A proper draw would definitely improve performance.

oooooooooooo
oooooo
oo

IHM:GHB.

Figure 4.

X100, etched in 2 per cent nital.

GRAIN SIZE, 5(A.S.T.M.).

—

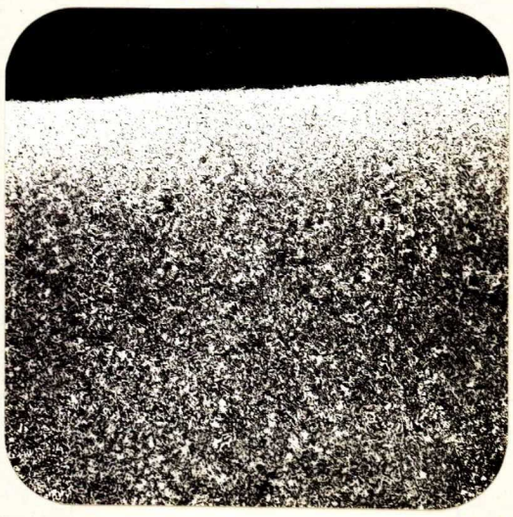
Figure 5.

X500, etched in 2 per cent nital.

MARTENSITE AND TROOSTITE.

—

Figure 6.



X100, etched in 2 per cent nital.

DECARBURIZATION.

—

IHM:GHB.