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November 15th, 1944.

REPORT

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1745.

Investigation of Chassis Frame Side
Rails of Armoured Truck.

(Copy No. 44.)

BUREAU OF MINES
DIVISION OF METALLIC
MINERALS
Physical Metallurgy
Research Laboratories

DEPARTMENT
OF
MINES AND RESOURCES
Mines and Geology Branch

O T T A W A November 15th, 1944.

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Abstract

Metallurgical examination has shown that the chassis frame side rails have failed in fatigue. The better performance of one frame is attributed to freedom from decarburization, also slightly higher tensile strength may have been a helping factor.

Origin of Material and Object of Investigation:

On October 10th, 1944, the Inspection Board of United Kingdom and Canada, Ottawa, Ontario, submitted (with Requisition O.T. 4288) two (2) parts of a truck chassis which had failed at a number of places, in the web of the chassis. In a covering letter (File 12/4/16), Mr. J. M. Gilmartin, I.O.M., for Inspector of Materials, requested a complete investigation of the chemical and physical properties of the material and an opinion on the cause of failure. Also supplied were drawings which gave the following specifications for the

(Origin of Material and Object of Investigation, cont'd) -

part:

- (1) Hot-rolled pickled steel.
- (2) Minimum yield point, 41,000 p.s.i.
- (3) Elongation, 35-45 per cent in 2 inches.

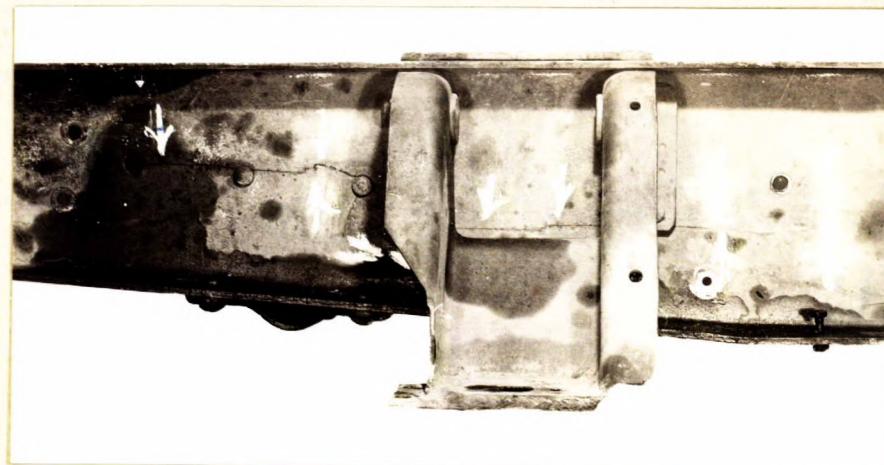
In connection with the same investigation the Army Engineering Design Branch of the Department of Munitions and Supply, Ottawa, submitted portions of another chassis frame which had failed in the same manner (Requisition No. 676, A.E.D.B. Lot No. 569, Report No. 51, Test No. 1, Nov. 9, 1944).

It was reported that failure occurred in the frame received from the I. B. U. K. & C. (designated No. 1 in this report) at approximately 4,700 miles, while that from the A. E. D. B. (No. 2 herein) failed at approximately 8,000 miles.

Microscopic Examination:

As shown in Figures 1 and 2, failure occurred specifically in the web of the chassis, with cracks originating at the rivet holes.

Figure 1.



RIGHT FRAME SECTION OF CHASSIS.

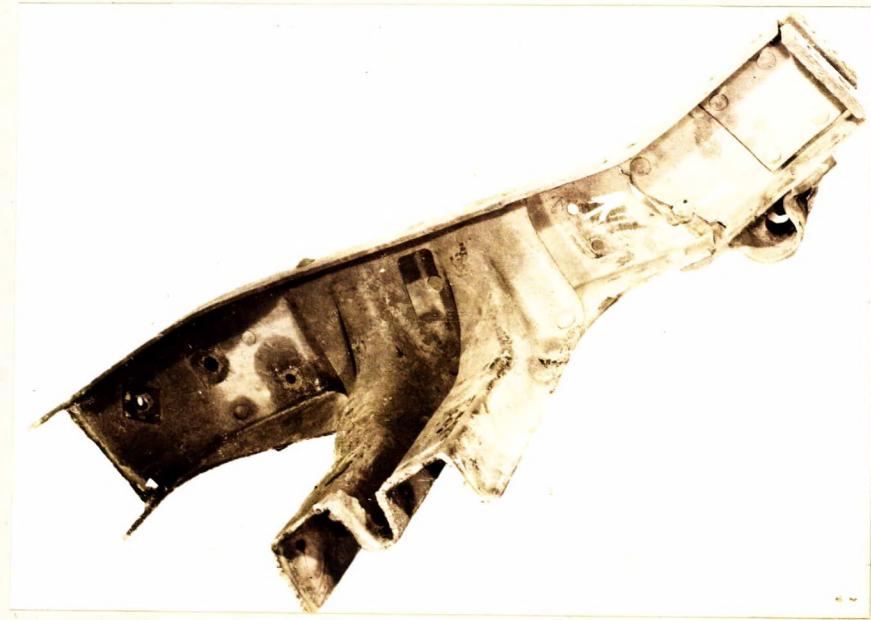
Arrows indicate crack.

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(Microscopic Examination, cont'd) -

Figure 2.



LEFT FRONT SECTION OF CHASSIS.

Arrows indicate point of failure.

Chemical Analysis:

TABLE I.

	Carbon, per cent	Manganese, per cent	Silicon, per cent	Phosphorus, per cent	Sulphur per cent
*No. 1	- 0.30	0.29	Trace.	0.010	0.036
**No. 2	- 0.24	0.40	Trace.	0.006	0.038

* Submitted by Inspection Board of United Kingdom and Canada.

** Submitted by Army Engineering Design Branch, Department of Munitions and Supply.

Mechanical Properties:

Tensile tests on standard flat specimens gave the following results:

(Continued on next page)

(Mechanical Properties, cont'd) -

TABLE II.

	Maximum stress, p.s.i.	Yield strength, p.s.i.	Elongation, per cent in 2 inches
No. 1 -	56,500	36,800	33.5
No. 2 -	62,400	38,600	34.0

Hardness:

TABLE III.

Frame No.	Across Section	On Surface
1 -	110-125 Vickers, 10-kg. load.	95 Brinell, 5,000-kg. load.
2 -	149-156 "	108-110 "

McQuaid-Ehn Grain Size:

Frame No. 1, 1-3.

Frame No. 2, 1-2.

Microscopic Examination:

Microscopic examination revealed in both frames a microstructure typical of hot-rolled mild steel. A difference in the dispersion of the pearlite indicated a difference in cooling rate, which substantiates the variation in hardness values. The microstructure at the surface of both frames is significant. No. 1 has been almost completely decarburized to a depth of 0.013-0.019 inch; No. 2 does not appear to be decarburized at all. Figures 3 and 4 illustrate these microstructures. Careful examination of the metal adjacent to the rivet holes disclosed small fatigue cracks in both frames (see Figure 5).

Figure 3.

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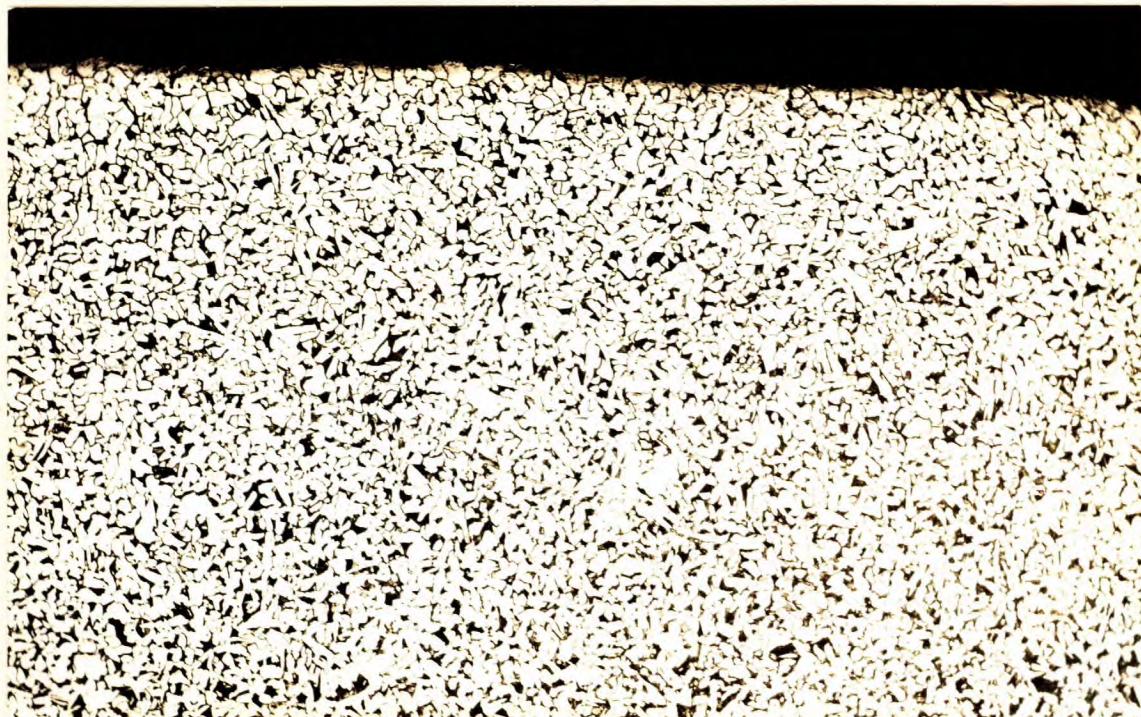


X100, etched in 2 per cent nital.

CHASSIS FRAME NO. 1.

Note decarburized surface, and core
microstructure of pearlite and ferrite.

Figure 4.



X100, etched in 2 per cent nital.

CHASSIS FRAME NO. 2.

Note freedom from decarburization. Finer
dispersion of pearlite indicated faster
cooling rate, which explains higher hardness.

Figure 5.



X250, lightly etched in
2 per cent nital.

FATIGUE CRACK AT SURFACE OF RIVET HOLE.

Discussion:

Numerous cracks originating at the rivet holes, and microscopic fatigue cracks at the same location, indicate clearly that both chassis frames failed in fatigue, i.e., they have been subjected to alternating stresses which are greater than the endurance limit of the steel.

In considering fatigue failures of this type, there are two main factors involved:

- (1) The resistance to alternating stress varies directly as the tensile strength.
- (2) The condition of the surface of the metal and the location of sharp changes of section and notches. (Softer materials are less affected by notches, as they yield to even out stress.)

The mechanical properties of the two frames are similar. The slightly higher hardness and tensile strength of Frame No. 2 would suggest slightly better performance when subjected to alternating stress. The only departure from specification is the low yield of both frames. No great

(Discussion, cont'd) -

significance is attached to this low yield value, as yield values have no direct correlation with fatigue resistance. It is a recognized fact that there is no deformation in fatigue failures and that fatigue strength is a ratio of the ultimate.

Of considerable significance is the fact that the less satisfactory frame (No. 1) is decarburized to a depth of 0.013-0.019 inch. It is a well known fact that surface decarburization lowers the endurance limit and consequently impairs the resistance to fatigue-type stress.

In general, it may be stated that freedom from decarburization, and higher tensile strength up to the point where notch sensitivity becomes a limiting factor, will mean better fatigue resistance for the frames. However, it is notable that higher tensile strength of the body material will not necessarily raise the endurance limit if the part is extensively decarburized.

Conclusions:

1. Both frames failed as the result of fatigue.
2. The better performance of one frame is explainable by:
 - (a) The extensive decarburization of the less satisfactory frame.
 - (b) The slightly higher tensile strength of the satisfactory frame.

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