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O T T A W A November 2nd, 1944.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1732.

Metallurgical Examination of Track Link Connectors.

(Copy No. 10.)

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Abstract

The early failure of the track link couplings was found to be caused by quenching cracks. Recommendations as to changes in material and heat treatment are made.

Origin of Material and Object of Investigation:

Under date of October 13th, 1944, Col. J. L. McAvity, Director of Development of Vehicles and Small Arms, Department of National Defence, Army, Ottawa, Ontario, submitted several case-hardened track link connectors and a specimen of the bar stock from which they were machined. In a covering letter (file HQS 8928-11-61 (DVA)), Colonel McAvity requested a metallurgical examination to determine cause of failure, and also recommendations as to changes in material and heat treatment. Of the couplings submitted, one had failed at an early mileage and two had not been in service.

Chemical Analysis:

Chemical analysis of the broken coupling was found to be as follows:

	As Found	SAE 1112 Specification
	- Per Cent -	
Carbon -	0.10	0.08-0.13
Manganese -	0.85	0.60-0.90
Silicon -	0.01	-
Phosphorus -	0.072	0.09-0.13
Sulphur -	0.229	0.16-0.26

Mechanical Properties of Bar Stock:

Two standard tensile specimens were machined from the sample of bar stock supplied. Mechanical properties are shown in Table I.

Table I.

	No. 1	No. 2
Maximum stress, p.s.i. -	86,200	86,200
0.1 per cent proof stress, p.s.i. -	79,000	79,000
Elongation in 2 inches, per cent -	18.0	17.5
Reduction in area, per cent -	51	49

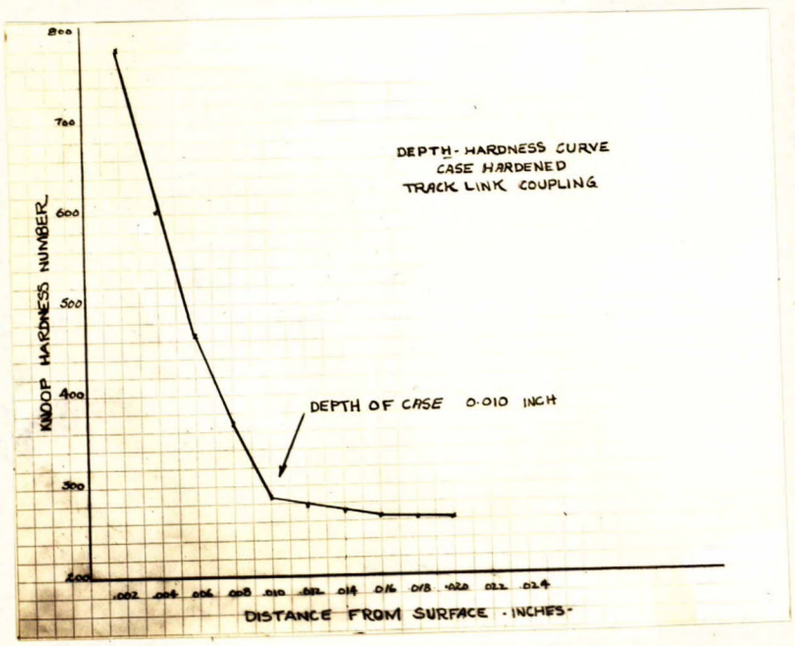
Hardness Survey:

To determine the depth of carbon case, a Tukon hardness tester was used. The curve in Figure 1 shows the hardness of the metal in relation to the distance from the surface. The case depth is 0.010 inch.

(Continued on next page)

(Hardness Survey, cont'd) -

Figure 1.



The "Knoop" hardness values of 780 at the surface and 256 in the core correspond, respectively, to approximately 750 and 230 Vickers.

Microscopic Examination:

Microscopic examination of the metal adjacent to the fracture disclosed a microstructure typical of a case-hardened part (i.e., a core structure of low-carbon martensite and ferrite and a higher-carbon martensitic case). The case depth varied from 0.006 to 0.010 inch.

At the change of section and shoulder (see arrows, Figure 2), small surface cracks were observed in both the failed and the unused connectors. In the unused parts the cracks are small (see Figure 3). In the part that failed, the cracks have widened considerably (see Figure 4).

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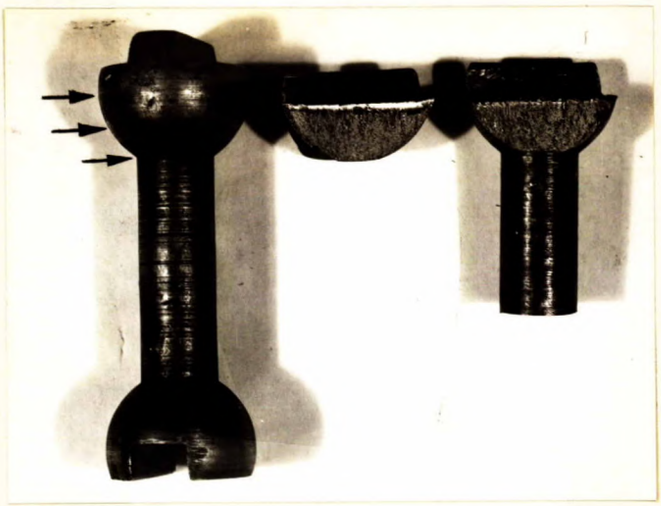
(Microscopic Examination, cont'd) -

Figure 2.



PHOTOGRAPH OF TRACK LINK COUPLINGS,
SHOWING NATURE OF FRACTURE.

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Figure 3.

X500, etched in 2 per cent nital.

TRACK LINK CONNECTOR WHICH
HAS NOT BEEN IN SERVICE.

White arrow points to quenching crack.

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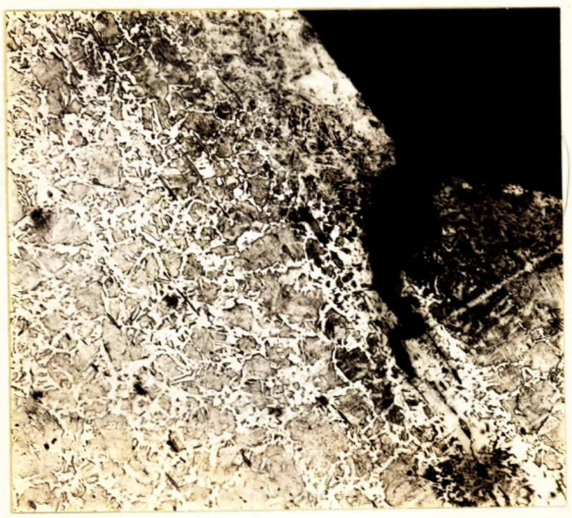
(Continued on next page)

(Microscopic Examination, cont'd) -

Figure 4.



X100, etched in 2 per cent nital.

TRACK LINK CONNECTOR WHICH
FAILED IN SERVICE.

Note crack in fillet (sharp change of section).

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Discussion:

The track link connectors have been made from free-machining steel having a chemical composition corresponding to SAE 1112 specifications. A high surface hardness has been obtained by case-hardening in a cyanide bath and then quenching.

Tensile tests of the core material gave results which are normal for steel of this chemical analysis and core hardness. The hardness values of surface and core indicate that the connectors have been water-quenched.

Microscopic cracks located as shown in Figure 2 are the obvious cause of failure. When the track link connectors are subjected to alternating stresses in service these cracks increase in size and the result is early failure.

Quenching cracks originate during the quenching

(Discussion, cont'd) -

operation due to the fact that with the change in microstructure during rapid cooling there is a change in volume of the metal. This change is not uniform throughout the section and may cause excessive internal stress. The condition is aggravated by sharp changes in section (such as at the head of the track link connectors) and by a too severe quench.

It may be possible to eliminate the formation of these cracks by:

(1) Increasing the radius of the fillet at the shoulder.

(2) Using an oil rather than a water quench. (It should be noted that a milder quenching medium will lower the surface hardness somewhat.)

(3) A stress-relieving draw at about 300° F. immediately after quenching.

Previous experience with tank track parts that are subject to severe wear as well as considerable stress has shown that more satisfactory service can be obtained by using a homogeneously hardened part. If difficulties in machining are not encountered, a steel of suitable hardenability, such as either NE 8650 or SAE 4140, subsequently oil-quenched and drawn to a hardness of Rockwell 'C' 45 ±3, is to be recommended.

Conclusions:

1. The track link connectors have been made by case-hardening and quenching free-machining bar stock of a chemical composition corresponding to SAE 1112 specification.

2. Mechanical properties of the unheat-treated bar stock are satisfactory for SAE 1112 hot-rolled steel.

3. Early failure was caused by the presence of

(Conclusions, cont'd) -

quenching cracks produced during the heat-treating operation.

Recommendations:

1. If machining difficulties are not encountered a higher-carbon, homogeneously hardened connector will give more satisfactory service. After machining, the connector should be oil-quenched and drawn to a hardness of Rockwell 'C' 45 ±3.

2. It may be possible to eliminate the quenching cracks in case-hardened connectors by:

(a) Increasing the radius of the fillet at the head.

(b) Using a less severe quenching medium.

(c) Giving them a stress-relieving draw at 300° F.

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