File.

FILE COPY

OTTAWA April 16, 1945.

REPORT

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1837.

Metallurgical Examination of Broken Bogie Pin from 20-Ton Transporter.

(Copy No. 10.)

Bureau of Mines
Division of Metallic
Minerals
-
Physical Metallurgy
Research Laboratories

CANADA
DEPARTMENT
OF
MINES AND RESOURCES
Mines and Geology Branch

O T T A W A April 16, 1945.

REPORT

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1837.

Metallurgical Examination of Broken Bogie Pin from 20-Ton Transporter.

Source of Material and Object of Investigation:

On April 6, 1945, one broken bogie pin from a 20-ton transporter (Dwg. A-307386) was received, for metallurgical examination, from the Division of Metallurgy, Army Engineering Design Branch, Department of Munitions and Supply, Ottawa, Ontario. The covering Requisition No. 691 (A.E.D.B. Lot No. 584, Report 13, Test No. 72), dated April 7, 1945, requested that the cause of failure be determined and that an appropriate grade of steel be specified to prevent future failures of this part. Figures 1 and 2 show the broken pin as received.

(Continued on next page)

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

Figure 1.

Figure 2.

Note fracture at oil hole.

BROKEN BOGIE PIN FROM 20-TON TRANSPORTER.

(Approximately $\frac{5}{8}$ full size).

-

Visual Examination:

Visual examination revealed that the fracture had occurred at right angles to the longitudinal axis at the horizontal portion of the oil hole. (See Figure 2).

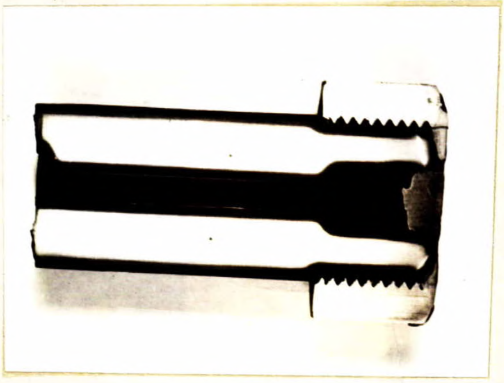
A longitudinal section was made of the pin (see Figure 3), consisting of a nut threaded on to a bolt. An oil hole, which was subsequently plugged, was drilled axially through the centre of the bolt and out at one side, at right angles to the axis.

On etching the section in 2 per cent nital, a very thick case (approximately 50 thousandths of an inch) was revealed, extending along both the inner and outer walls of the bolt.

(Continued on next page)

(Visual Examination, cont'd) -

Figure 3.



LONGITUDINAL SECTION (Nital Etch).

Note decarburization adjacent to oil hole.

(Approximately ¾ full size).

-

Hardness Tests:

Hardness tests made on the core and case gave the following readings:

		HARDNESS
Case	-	60 to 63.5, Rockwell "C".
Core	-	90 to 92, Rockwell "B".

Chemical Analysis:

The results of the chemical analysis made on the bolt are as follows:

		Per Cent
Carbon	-	0.31
Manganese	-	0.55
Silicon	-	0.09
Sulphur	-	0.035
Phosphorus	-	0.025
Nickel, chromium, molybdenum, and vanadium	-	Nil.

-

Microscopic Examination:

Figure 4 is a photomicrograph, taken at X500 magnification, showing the structure of the core, consisting of fine pearlite and ferrite.

Figure 5 shows the microstructure of the case, at X1000 magnification, consisting of fine martensite and carbides.

Figure 6, taken at X500 magnification, shows the typical microstructure of the zone intermediate between the case and the core. The structure consists of ferrite, martensite and troostite.

Figure 7 (X500 magnification) shows the extent of decarburization of the case adjacent to the oil hole. The thickness of the decarburized area is approximately 2/1000 inch.

Discussion:

The chemical analysis, macro-examination and hardness tests show that the bolt portion of the pin was made from SAE 1030 steel and had been case-carburized. Previous to carburizing, an oil hole had been drilled for purposes of lubrication. When it was decided that this lubrication was unnecessary the oil hole was plugged.

The position of the fracture at the horizontal case-hardened oil hole lends itself to the opinion that failure has occurred because of faulty design, since a hole drilled at right angles to the body of the pin and then carburized would act as a source of very high stress concentration and would render the part extremely susceptible to fatigue failure.

The decarburized surface extending along the oil hole, shown in Figure 7 and also evident in the macrophotograph in Figure 3, was probably caused by faulty carburizing

(Discussion, cont'd) -

procedure. Such a condition is most undesirable, since the fatigue property of the steel is seriously reduced.

Hence, failure may be directly attributed to faulty design and was probably hastened by improper carburizing conditions. It is therefore thought that a solid pin made of the same steel, that is, SAE 1030, and correctly carburized to give a case hardness of approximately 60 Rockwell "C", would probably satisfy the requirements.

Another alternative would be to employ homogeneous pins, hardened throughout, made of either SAE 9255 or NE 8650 steels. The chemical limits of these steels are as follows:

		SAE 9255	NE 8650
		- (Per	Cent) -
Carbon	-	0.50-0.60	0.48-0.53
Manganese	-	0.60-0.90	0.75-1.00
Silicon	-	1.80-2.20	0.20-0.35
Sulphur	-	0.05 max.	0.04 max.
Phosphorus	-	0.04 max.	0.04 max.
Nickel	-		0.40-0.70
Chromium	-		0.40-0.60
Molybdenum	-		0.15-0.25

The SAE 9255 steel can be heat treated to 42-48 Rockwell "C", by quenching in oil from 1650° F. followed by a draw at 950° F.

The NE 8650 steel can be given the same hardness by quenching in oil from 1500° F., followed by drawing at 800° F. The complete physical properties resulting from this heat treatment are as follows:

Yield point, p.s.i.	Tensile strength, p.s.i.	Elongation, per cent in 2 inches	Reduction in area, per cent	Brinell hardness, number	Izod impact, ft-lb.
206,500	228,000	10.0	37.3	444	10-12

CONCLUSIONS:

1. The bogie pin was made by threading a nut onto a case-hardened bolt through which an oil hole had been previously drilled.

2. The bolt was made from SAE 1030 steel.

3. Failure was thought to have resulted from poor design and improper case-hardening.

Recommendations:

1. It is recommended that a solid pin be made of the same material (SAE 1030) but be correctly case-hardened, to 60 Rockwell " C", so as to prevent decarburization.

2. An alternative to the above case-hardened pin would be a homogeneous pin made of either SAE 9255 or NE 8650 steel, hardened throughout to a hardness of approximately 445 Brinell.

oooooooooooo
oooooo
oo

AF:GHB.

Figure 4.

X500, nital etch.

MICROSTRUCTURE OF CORE.

Fine pearlite and ferrite.

Figure 5.

X1000, nital etch.

MICROSTRUCTURE OF CASE.

Fine martensite and carbides.

Figure 6.

X500, nital etch.

INTERMEDIATE ZONE.

Martensite, troostite, and ferrite.

Figure 7.

X500, nital etch.

DECARBURIZED CASE ADJACENT TO OIL HOLE.

The white constituent is ferrite.

AF:GHB.