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O T T A W A January 24th, 1944.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1580.

Examination of a Cracked Piston Head
from a Canso Aircraft Oleo Leg.

(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

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Origin of Material and Object of Investigation:

On January 8th, 1944, the Department of National Defence, Air Services, Ottawa, submitted a broken piston head from a Canso aircraft oleo leg, P.N.R. 93. Accompanying correspondence stated that the plane, after test flights on December 28th and 29th, 1943, was stored in the open, that it was towed into the flight hangar on the afternoon of December 20th, and that failure occurred while it was sitting in the hangar.

It was stated that these piston heads are made from ½-inch-wall tubing which is received from Cleveland, that they are fully machined and ground by Canadian Vickers Limited, and that the material is presumed to be SAE X4130 or its National Emergency equivalent.

A letter (File No. 938 HK-1-5 AMAE DAI), dated January 6th, 1944, signed by Wing Commander A. J. Smith for Chief of Air Staff, requested that an examination be made

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

and a report submitted.

A copy of Drawing No. 8103, showing the position of the broken piston head, was also received.

General Examination:

The broken piston head was examined visually and representative photographs taken (see Figure 1). An interesting detail of the break may be seen. The dark zone extending about half way through the wall from the outside is evidence that a crack existed in the part before failure occurred.

Mechanical Testing:

Three micro tensile bars were prepared for the Hounsfield tensometer. These were cut in the longitudinal direction of the tubing. Vickers hardness numbers were also determined. These data are presented in Table I.

TABLE I. - MECHANICAL PROPERTIES.

	Bar No. 1	Bar No. 2	Bar No. 3	Specified
Ultimate tensile strength, p.s.i. -	214,000	213,000	216,000	201,600 min.
Yield strength, p.s.i.	200,000	200,000	200,000	Not specified.
Elongation, per cent	18	18	18	" "
Reduction in area, per cent -	52	50	52	" "
Vickers hardness number -	- 454 (Rockwell 'C' 43)			

Microscopic Examination:

A specimen was prepared for microscopic examination. Figure 2 is a photomicrograph taken at 100 diameters to show the unetched appearance of the surface of this specimen. Note the inclusions. Figure 3 is a photomicrograph taken at a magnification of 1000 diameters to show the structure developed

(Microscopic Examination, cont'd) -

by etching in 2 per cent nital. This is a normal structure for tempered martensite.

Chemical Analysis:

A sample was obtained for chemical analysis. Special precautions were observed to avoid contamination from the chromium plating on the outside surface. The results are given in Table II

TABLE II. - CHEMICAL ANALYSIS.

	Obtained	Specified, SAE X4130
	- Per cent -	
Carbon	0.37	0.28-0.33
Silicon	0.28	0.20-0.35
Manganese	0.77	0.40-0.60
Nickel	0.22	-
Chromium	1.18	0.80-1.10
Molybdenum	0.23	0.15-0.25
Sulphur	0.018	0.04 max.
Phosphorus	0.026	0.04 max.

This is in accordance with the chemical specifications for SAE 4132 steel.

Discussion of Results:

Visual Examination -

It is evident, from the appearance of the fractured surface, that there was a crack in the piston head before complete failure took place, probably before it was installed in the aircraft. This crack could have been caused either by quenching or by welding (it is understood from the drawing that there is welding done on this part in the vicinity of the failure).

Three ways in which the crack could have been produced are suggested:

(1) The stresses set up during welding might have been sufficient to produce the crack.

(2) It is stated in Drawing No. 8103 that the parts are heat-treated after welding. Then, if the stresses caused by

(Discussion of Results, cont'd) -

welding were not high enough to produce a crack, they still might have been high enough for the cumulative effect of these stresses plus the stresses caused by thermal shock of putting in a hot heat-treating furnace to produce a crack.

(3) The crack might have been produced by the stresses set up during quenching.

Of these three causes, the most likely is the third. If the crack had been present before or during heating for quenching, the surfaces of the crack might have been scaled, unless a controlled-atmosphere furnace was used. It is, therefore, more likely that the crack was formed during quenching.

Another possibility is that this is not a quenching crack at all but, rather, a fatigue crack. However, in view of the fact that the 'plane made only two flights before failure this might not be very probable.

Mechanical Tests -

It is evident, from the mechanical properties of the steel, that the heat treatment produced the required tensile strength.

Microscopic Examination -

The steel is not as clean as some steels examined by these Laboratories. However, it is not thought that it is sufficiently dirty to cause failure. The microstructure shows that the heat treatment was satisfactory.

Chemical Analysis -

The chemical analysis is that of a 4132 steel, not a 4130. This means that the carbon content is a little higher and would have the tendency to make the steel more susceptible

(Discussion of Results, cont'd) -

to cracking from sudden changes in temperature. However, it is considered a very remote possibility that an increase of 0.04 per cent in the carbon content above the maximum specified, in the range of 0.3 to 0.4 per cent carbon, would be sufficient to have a marked effect on the sensitivity of the steel to cracks from thermal stresses.

CONCLUSIONS:

1. The steel was properly heat-treated to produce the required mechanical properties and the proper microstructure.

2. The steel appeared to be of an acceptable quality.

3. The failure started at a crack produced at some stage in the manufacture of the part.

Recommendation:

It is recommended that adequate magnaflux inspection be used to detect cracked parts before chromium plating.

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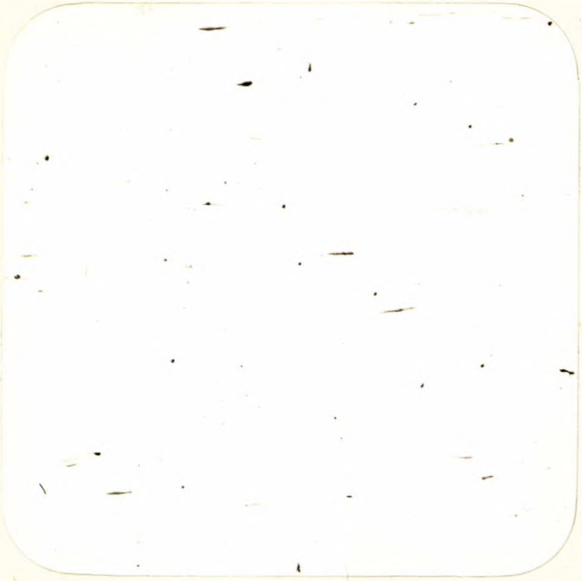
Figure 1.

PHOTOGRAPH, ABOUT ½ ACTUAL SIZE, SHOWING FRACTURED PORTION OF PISTON HEAD.

Note the presence of two distinct zones in the fracture, indicating that failure took place in two stages.

Figure 2.



X100, unetched.

PHOTOMICROGRAPH, SHOWING INCLUSIONS.

Figure 3.

X1000, etched in 2 per cent nital.

PHOTOMICROGRAPH, SHOWING STRUCTURE.

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