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OTTAWA June 16th, 1942.

REPORT

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1242.

(M. & S. No. 8/D)

Examination of Broken Companion Flange
from Ram Tank.

(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 May 26th, 1942, Mr. L. D. Tatley, of the Army Engineering Design Branch of the Department of Munitions and Supply, Ottawa, Ontario, submitted a broken companion flange from a Ram tank in England (see Figure 1). In his letter of May 23rd, covering this work, Mr. Tatley requested an opinion as to why it broke. He also stated that this failure appeared to be an isolated case.

There are evidently no specifications available for

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

this part. It is stated, however, that this is a rather highly stressed part of the transmission of the Ram tank.

Visual Examination:

Figure 1 is a picture of the partsas received, showing the type of fracture and the general shape of the part.

Microscopic Examination:

A section of the hub was etched in hot 38% HCl, 12% H_2SO_4. The resulting structure is shown in Figure 2. A sulphur print was made of this same surface. Figure 3 is a photograph of this sulphur print. Note that both Figures 2 and 3 show the lines of forging to be perpendicular to the direction of fracture.

Chemical Analysis:

The steel in this hub was analysed chemically and found to be of the following composition:

		Per cent
Carbon	-	0.42
Manganese	-	1.44
Silicon	-	0.22
Sulphur	-	0.11
Phosphorus	-	0.017
Nickel	-	Trace
Chromium	-	Nil
Molybdenum	-	Nil
Copper	-	Nil

Physical Tests:

Tensile properties were determined from a bar of 0.282 in. diameter. The elongation was determined on a one-inch gauge length, which is four times the square root of the area.

Impact properties were determined on a standard

(Physical Tests, cont'd) -

10 mm. square Charpy bar with a 45° izod notch, broken between 40 mm. supports.

The results of these tests are reported below:

Ultimate tensile strength, p.s.i.	-	108,000
Yield strength, p.s.i.	-	70,100
Elongation, per cent	-	28
Reduction in area, per cent	-	57.5
Charpy impact, foot pounds	-	87
Hardness, V. P. N.	-	226

Microscopic Examination:

Figure 4 is a photomicrograph, at 250 diameters, of the steel in the polished condition, before etching. Note the cluster of sulphide inclusions.

Figure 5 shows the etched structure at 500 diameters.

Discussion of Results:

A visual examination of the fracture indicates a failure due to fatigue. It also appeared that the inside corner where the hub joins the flange is cut very sharp. Such a sharp change in direction could cause a high concentration of stresses and could result in a fatigue failure.

The sulphur print, Figure 3, indicates a good distribution of the sulphides. This, combined with the high manganese (1.44%), could be a reason why the high sulphur (0.11%) has not caused the steel to become brittle.

As will be seen from Figure 4, there are a great number of sulphide inclusions in the steel. Inclusions behave in very much the same way as do sharp corners in affecting the fatigue resistance of the steel. Their edges are regions of high stress concentrations and are often

(Discussion of Results, cont'd) -

found to be the starting points of cracks.

Therefore, in this part we have two conditions that could lower the fatigue limit of the steel. The first is a sharp corner due to machining and the second is a large number of inclusions due to high sulphur content. Both conditions should be avoided where the frequency of stress reversals is high.

Conclusions:

This part failed due to fatigue, probably caused by a lowering of the fatigue limit by a large number of inclusions and/or poor machining practice.

Recommendations:

1. Efforts should be made to obtain a steel with a maximum of 0.05% S.

2. Care should be exercised to avoid any sharp corners. Even a radius of 0.05 in. would be helpful.

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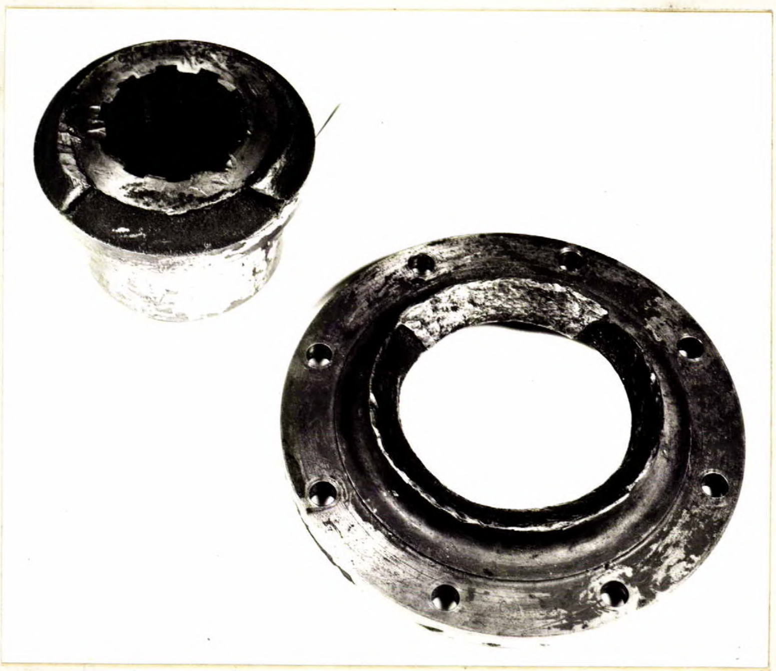
HVK:GHB.

Figure 1.



Photograph, ¼ size, of broken parts of companion flange.

Figure 2.

Macro-etch of section of hub of broken flange.

Natural size.

Figure 3.

Photograph of sulphur print taken from section of hub.

Natural size.

Figure 4.

Photomicrograph, X250, polished to show inclusions.

Figure 5.

Photomicrograph, X500, picral etch.

HVK:GHB.