O T T A W A August 5th, 1942.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1278.

Examination of Shell Q.F., H.E., 40 mm. Mark IIT.

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Source of Material and Object of Investigation:

On July 17th, 1942, these laboratories received from the Inspection Board of the United Kingdom and Canada, 70 Lyon Street, Ottawa, Ontario, 6 shell (40 mm.) bodies for Q.F., H.E. 40 mm. Mark IIT shells.

These shells were made from "Ledloy" steel, which is free machining leaded steel. There were longitudinal marks on the surface of these shells (see Figure 1). It was

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

requested that it be determined whether or not these marks were true rokes or some type of segregation in the steel. These shells were accompanied by a letter (file No. 4/4/1/ WSL4/6) dated July 15th, 1942, and signed by Mr. M. W. Hollands, for the Inspector-General. The work was done under Analysis Requisition No. O.T. 3085.

Macroscopic Examination:

The defects referred to appear as longitudinal lines on the surface of the shell. Most of them appear on the outside surface but some are found on the inside surface as well.

In Figure 1, which is a photograph, about natural size, one of these lines may be seen. Figures 2 and 3 are photographs of these defects at 20 diameters.

Rings were cut from the shells and squeezed so that the lines on the outside of the shell would open up into cracks, if they were going to.

Figure 4 is a photograph of one of these cracks developing. It started at one of the lines on the side of the shell.

To compare the behaviour of the steel that showed these markings with the behaviour of the steel that did not, two rings, of exactly the same dimensions, were obtained; one from a shell in which no markings could be found and one from a shell exhibiting these markings. The original inside diameters of both these rings were 1.08 inch. The ring from the good shell was compressed 0.23 inch before cracks appeared, while the ring from the shell showing the lines could only be

(Macroscopic Examination, cont'd) -

compressed 0.18 inch before a crack developed.

One of these cracked surfaces was photographed to show the appearance of the fractured surface where the crack started. This photograph was taken at a magnification of 40 diameters. The line that was on the surface of the shell, when broken open, appears to be a line of bright-walled holes. This is shown in Figure 5.

The surfaces on which these lines appeared were tested for segregations of both sulphur and lead. A standard sulphur print was made for sulphur segregation. This is shown in Figure 6. The same surface was then printed for lead segregation. This print is shown in Figure 7.

The procedure for making this lead print is as follows:

Materials required:

(1) Saturated solution of ammonium acetate in water.
(2) Concentrated ammonium hydroxide.
(3) H_2S generator.
(4) Saturated solution of tartaric acid in water.
(5) Smooth white blotting paper or "ditto" paper.

Printing Solution:

4 parts ammonium acetate.
1 part NH_4OH.
1 part H_2O.

Fixing Solution:

Water, saturated with H_2S.

Clearing Solution:

1 part saturated tartaric acid solution.
1 part water..
Saturate with H_2S.

Drying Solution:

4 parts methyl alcohol.
1 part water.

(Continued on next page)

(Macroscopic Examination, cont'd) -

Preparation of Specimen:

(1) Grind surface smooth.
(2) Swab with concentrated HNO_3 and wash with water.

Printing Procedure:

1. Soak a piece of "ditto" paper in printing solution, remove excess moisture with blotting paper and apply to surface of specimen.

2. Strip after one minute and develop in a stream of H_2S gas.

3. Transfer to fixing solution for 1 minute.

4. Transfer to clearing solution for from three to five minutes to remove iron stains.

5. Put it back into fixing solution for a short length of time.

6. Transfer to drying solution and then dry quickly.

Microscopic Examination:

Figure 8 is a photomicrograph at 100 diameters showing a cross-section of one of these cracks or marks.

Figure 9 is a photomicrograph at 100 diameters giving a longitudinal view of the same crack as shown in Figure 8. Note material in crack. This is also shown in Figure 10.

The metal structure in the neighbourhood of this crack is shown in Figure 11. Note also the presence of some distortion. This is due to the machining of the shell. In preparing the specimen, not enough surface metal was removed to get below the distortion due to machining.

Chemical Analysis:

		Per cent
Carbon	-	0.40
Manganese	-	1.24
Silicon	-	0.22
Sulphur	-	0.034
Phosphorus	-	0.026
Lead	-	0.24

Discussion:

It will be noted that the marks on the surface of the shells are associated with both lead and sulphur segregations. (See Figures 6 and 7). It will also be noted that these marks can be the starting point of a failure under the conditions of testing employed in this investigation. (See Figure 4).

The depth of these marks in the finished shell will vary. Two of the marks examined extended to a depth of 0.0025 inch and 0.009 inch respectively.

Conclusions:

These marks would not appear to be true "Rokes", but are rather some type of defect caused by the segregation of both lead and sulphur in steel.

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HVK:GHB.

Figure 1.

Photograph, actual size, showing crack developing during squeeze test.

Figure 2.

Photograph, $\frac{3}{4}$ actual size, showing shell and lines on surface.

Figure 3.

Photographs of marks on surface of shell, X20.

Figure 4.

Photograph, X40, showing appearance of fracture where a surface crack was opened up during squeeze test, Note appearance of shing holes.

Figure 5.

Figure 6.

Sulphur print on segment of shell surface

Figure 8.

Figure 7.

Lead print on same surface as sulphur print in Fig. 6.

Figure 9.

Photomicrograph, X100 unetched, showing cross-section through one of the marks.

Figure 10.

Photomicrograph, X100 unetched, showing longitudinal view of one of the same marks as shown in Figure 8.

Figure 11.

Photomicrograph, X500 picral etch, showing a section of the crack shown in Figure 9. (Note that this particular portion of the crack is filled with some substance).

Photomicrograph, X100 picral etch, same as shown in Figure 9.

HVK:GHB.