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O T T A W A November 10th, 1944.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1736.

Investigation of Defective Boiler Tubes from S.S. "Kitsilano Park".

(Copy No. 10.)

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Origin of Request and Object of Investigation:

On November 1st, 1944, a section of defective tubing from the starboard boiler of the S.S. "Kitsilano Park" and a sample of scale taken from the boiler tubes were received from Mr. F. A. Willsher, Chairman of the Board of Steamship Inspection, Department of Transport, Ottawa, Ontario. In an accompanying letter, File No. 9562-2289, it was requested that an investigation be carried out to determine, if possible, the cause of failure.

Tests Performed:

1. Pieces from the unbulged part of the tube were given the tensile strength, elongation and bend tests.
2. The sample of scale was tested for oil and other constituents.
3. Samples of metal taken from the bulged and unbulged parts of the tube were examined under the microscope in the unetched and etched conditions.

Mechanical Properties:

Tensile strength, p.s.i.	-	51,400
Elongation, per cent in 2 inches	-	38
Bend test	-	No fracture. After the usual bend test, further pressure was exerted until the ends of the specimen were brought together. Even then no fracture occurred.

Analysis of Scale:

Analysis of Scale from Interior of Tube -

	Weight, per cent
Oil (extracted with ethyl ether)	1.7
The oil was dark brown and viscous and resembled mineral lubricating oil. The amount obtained was too small for analysis.	
Carbonaceous material (including oil)	14.8
Iron oxide (Fe_2O_3)	7.5
Aluminium oxide (Al_2O_3)	2.4
Silica (SiO_2)	9.6
Lime (CaO)	26.8
Magnesia (MgO)	9.1
Sulphate (SO_4)	7.8
Phosphate (PO_4)	0.9
Carbon dioxide (CO_2)	17.5
Loss on ignition	37.0
Moisture at 105° C.	0.7
" over 105° C.	4.0

(Continued on next page)

(Analysis of Scale, cont'd) -

Nature of Scale from Exterior of Tube -

This scale was attracted by a magnet, indicating the presence of magnetic oxide of iron.

Microscopic Examination:

Examination of metal from the unbulged part of the tube showed a normal grain structure with a small amount of pearlite present. Figure 1 is typical of the metal near the inside surface of the tube and Figure 2 is typical of the metal near the outside surface. Examination of metal from the bulged part of the tube showed a normal grain structure with a somewhat greater amount of pearlite. It still would be considered to have a low carbon content. Figure 3 is typical of the metal near the inside surface and Figure 4 is typical of the metal near the outside surface. There was no indication of defects, such as cracks or an excessive amount of inclusions, in the metal from the bulged part.

Discussion of Results:

1. On the basis of the mechanical tests and the microscopic examination, the metal in the tube does not appear to be at fault.

2. The scale on the inside of the tube is a typical boiler scale as far as the non-carbonaceous constituents are concerned. It contains about 40 per cent calcium carbonate, 11 per cent calcium sulphate, a considerable amount of silicate and magnesium, and smaller amounts of iron oxide, alumina and phosphate. However, the scale also contains 14 per cent of carbonaceous material, including 1.7 per cent of oil. A larger amount of oil probably was present at one

(Discussion of Results, cont'd) -

time but during the operation of the boiler most of it underwent chemical change on account of the high temperature involved.

3. It is believed that the failure of the boiler tube took place in the following manner:

(a) A film consisting of inorganic and carbonaceous materials was deposited upon the inside surface of the tube.

(b) Due to the poor thermal conductivity of this film, the temperature of the tube became excessively high at that point.

(c) A certain amount of iron was oxidized on the outside of the tube, thus reducing the thickness of the metal at that point.

(d) Due to both the decrease in thickness of the metal and the excessive temperature, the tube was unable to withstand the internal pressure and a bulge was produced.

Conclusion:

Without definite information regarding the circumstances under which the defects were produced in the tubes (i.e., water analysis, water treatment, heating technique, etc.), it is impossible to give definite recommendations. However, the general statement can be made that, assuming proper heating conditions, the defects in the tube probably would not have occurred if certain constituents had not been present in the water and if oil and other carbonaceous material had not been present in the tube.

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Figure 1.

X250, nital etch.

TYPICAL OF METAL
NEAR INSIDE SURFACE.

Figure 2.

X250, nital etch.

TYPICAL OF METAL
NEAR OUTSIDE SURFACE.

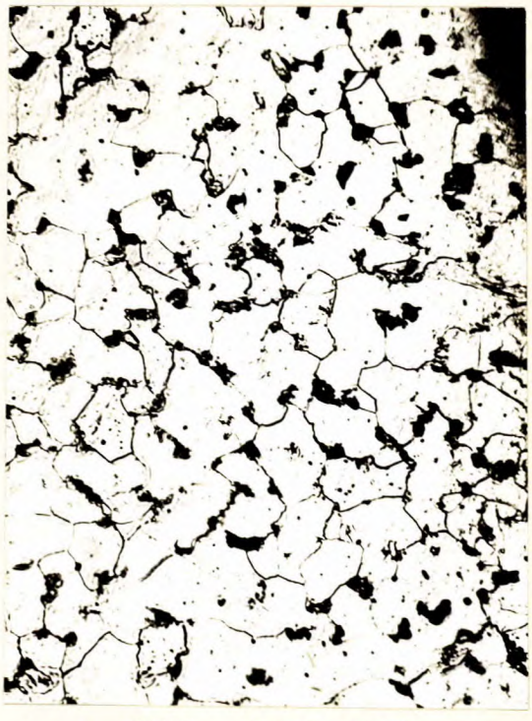
UNBULGED PART OF TUBE.

Figure 3.

X250, nital etch.

TYPICAL OF METAL
NEAR INSIDE SURFACE.

Figure 4.



X250, nital etch.

TYPICAL OF METAL
NEAR OUTSIDE SURFACE.

BULGED PART OF TUBE.

RRR:GHB.