FAILURE OF MARINE BOILER TUBE : A CASE HISTORY

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ABSTRACT

An interesting case of marine boiler tube failure is described. As a result of local overheating, a ballooning burst occurred in a boiler tube. Evidence showed that a temperature of over 1600°F (871°C) had been reached before rupture. The presence of a thin film of copper arising from the auxiliary equipments of the boiler, caused pittings in the metal. Failure was thus attributed to local overheating accelerated by an inner deposit of heat insulating scale.

INTRODUCTION

When marine boiler tubes fail suddenly, they can cause not only damage to the ships concerned but also endanger life. Though the incidence of such failure is not high, they require to be investigated whenever they occur so that the cause of the occurrence is traced and remedies are adopted for prevention of recurrence of such failures. It is the object of the present paper to describe in detail the history of a case of such failure and trace the causes which led to the failure.

Report from the Ship

The ship reported that the main boiler was damaged by a burst tube which had as a result opened out like a balloon. At the time of the burst the boiler was steaming at a load of 250 lbs/sq. inch. The boiler was of the Admiralty 3 drum water tube type. In such a boiler, water tubes are numbered from the burner end. The rows are lettered alphabetically from the flame onwards. The burst tube was in the A row, thirtyfourth from the burner end, and was on the right hand side of the boiler. In addition to the burst tube, there were several other tubes in row A which had suffered lesser damage, such as cracks and pittings. The split tube was facing the fire and was consequently at a high heat input zone.

Results of Visual Examination

The length of the tube measured approximately 236.22 cm. (93″) and the burst was located at a distance of about 79·75 cm. (31″) from the water drum end of the tube. A photograph of the tube where the burst had occurred was taken and this is shown in Fig(1).

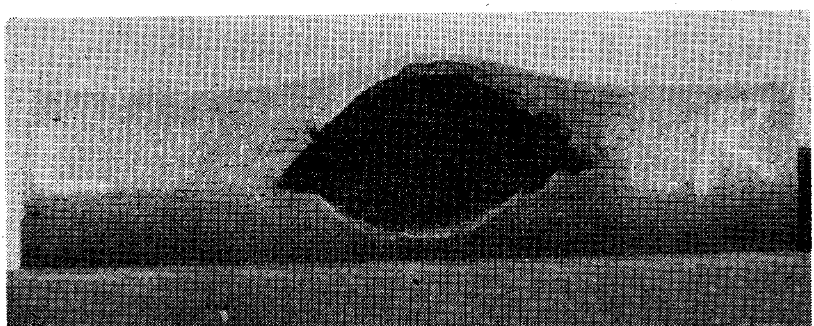

Fig. 1. *The tube showing the burst.*

The following facts emerged as a result of close visual examination:—

(*a*) Some amount of stretching and thinning of the wall near the burst had taken place. The normal wall thickness was 0·307 cm (0·121″), while near the fringe of the burst it had been reduced to 0·285 cm (0·112″).

(*b*) A few pits were observed on the inner surface and the parting line of the burst contained two such pits, 1·25 cm. from one another. Fig. (2).

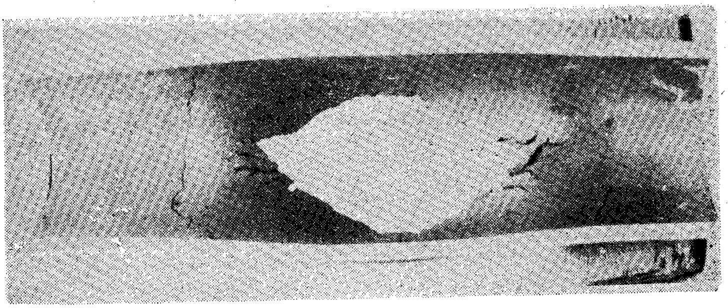

FIG. 2. *Inner water side of the tube showing pits and cracks.*

(*c*) A thick black deposit (Fig. 3) was seen adhering to the inner surface. Where the deposit had flaked off, a thin film of metallic copper could be observed. There is no doubt the copper has emanated from the auxiliary equipments of the boiler. The importance of copper arises from the fact that being cathodic to iron, its presence can lead to the pitting of the tube.

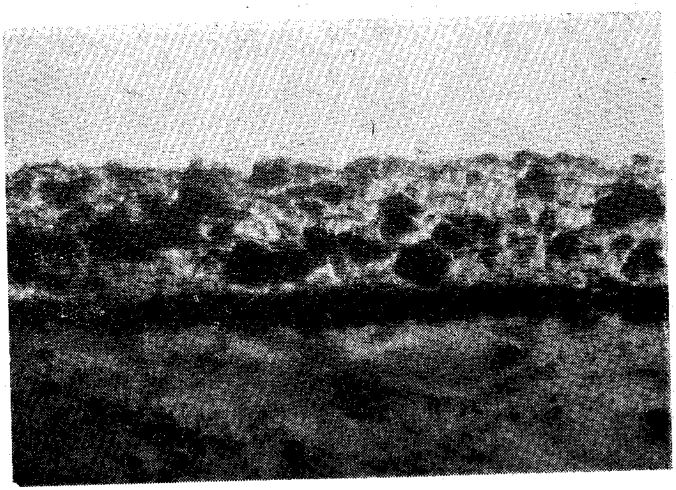

FIG. 3. *Showing black deposit on the inner surface of the tube.*

Results of Chemical Analysis

The analysis of the tube turning and the black deposit on the inner wall gave the following results:—

Tube

Carbon	0·16%
Silicon	Less than 0·1%
Manganese	0·45%

Deposit

Fe_3O_4 δ°4 and some tarry material.

The above results show that the tube had been manufactured from mild steel conforming to B. S. Specn. 971 : 1950—EN3A. The black deposit is a mixture of magnetic oxide of iron and tarry material.

Results of Micro-Examination

Micro examination was carried out using Vickers Projection Microscope. For this purpose, small samples were cut from areas A, B and C indicated in line sketches (Fig. 4 and 5).

Line sketch (Fig. 4) shows the following:—

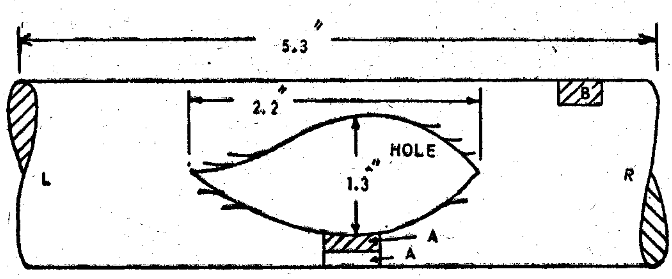

FIG. 4. Line Sketch

The fractured portion of the tube was examined under stereo microscope. It was observed that the cracks were generally circumferential. No visible cracks were seen beyond 1/2" from the fractured end. There was evidence of bulging without any cracks, that is, the metal had become ductile.

Line sketch (Fig. 5) shows the position of specimen C which was about 3·5 inches away from the water drum end.

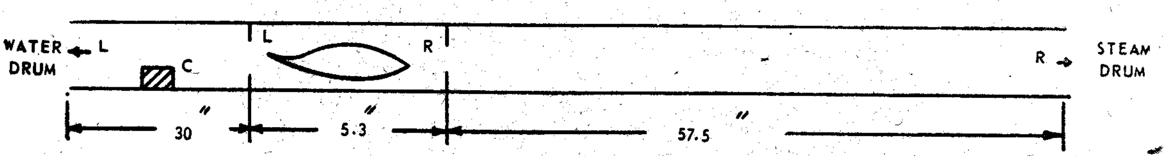

FIG. 5. Line Sketch

Area A

It was obvious that the metal had been heated to about 1650°F before being rapidly quenched by the tremendous flow of steam and water through the burst. Typical microstructure of two areas of specimen A are shown in Fig. 6 and Fig. 7, which show that the crack tended to follow the grain boundaries. A few tips of the crack enter into the grains also. The grain size is coarse revealing Widmanstatten structure.

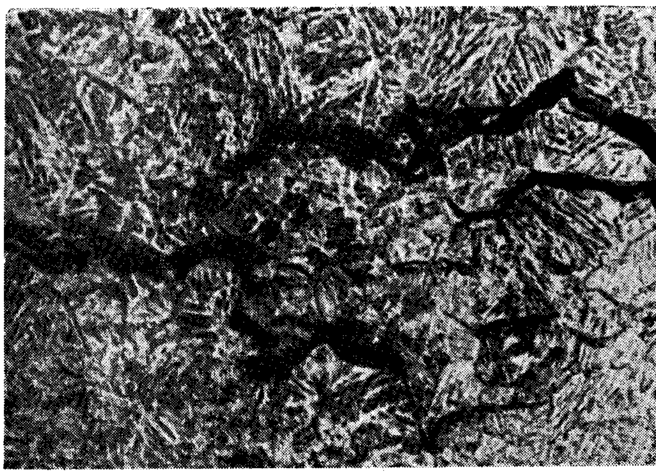

FIG. 6. *Microphotograph showing Widmanstätten structure and some cracks entering the grains*

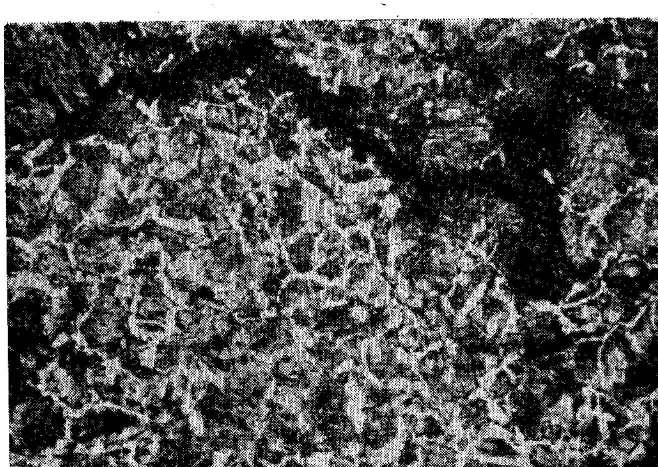

FIG. 7. *Shows Widmanstätten structure as in Fig. 6*

Area B

The sample was polished and examined along the cross-section. The thickness of the deposit was found to be 0·051 cm (0·02″).

Area C

Normal structure of fine grains of ferrite and pearlite was revealed (Fig. 8).

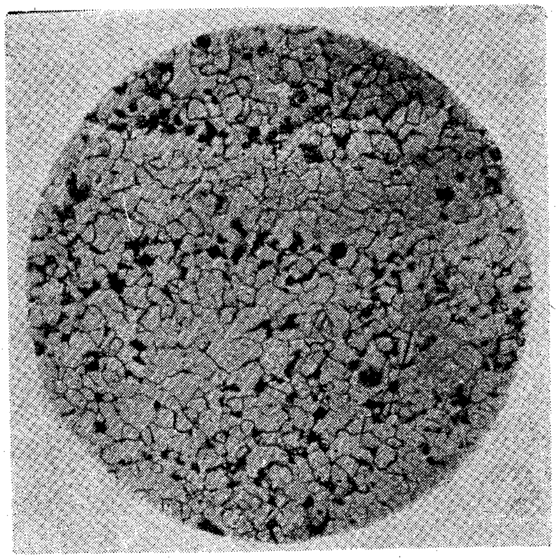

FIG. 8. *Showing fine grains of ferrite and pearlite.*

Analysis of Evidence

From the results presented above it is possible to trace sequentially the following events, ultimately leading to the burst of the tube.

(*a*) Excess overheating of the tube, facing the fire, occurred. This was locally accelerated by the internal deposit of heat insulating material (Fig. 3).

(*b*) At about 1650°F, when the metal possesses great ductility, a gentle bulging took place. When the wall became too thin to withstand the internal water pressure, the rupture occurred.

(*c*) At the time of rupture, the flow of steam and water effectively quenched the over heated metal, as is evident from the Widmanstatten Structure (Fig. 6 and 7).

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