

BOILER TUBE FAILURE IN A DESTROYER.

The following report of a tube failure in a boiler of an intermediate destroyer is a good example of how such a report should be made. It is clear, comprehensive and no relevant details have been omitted, though some incorrect deductions seem to have been drawn from the facts. All engineer officers should realise that it is essential for the good of the service that the real cause of tube failure should be ascertained and reported. After such a failure the most strenuous endeavour should be made to find out and record all relevant facts and to obtain corroboration of all evidence, particularly as regards the water levels. Much may be learnt from the readings of the main feed tanks during the period before the failure. Only by finding out the cause of all tube failures is it possible to locate weaknesses in design which may exist and to distinguish between failures due to faulty material and those due to bad operation.

From : The Commanding Officer, H.M.S.....

Date : 13th January, 1945. No. 01/234.

To : Captain (D),.....Destroyer Flotilla,
H.M.S.....

Failure in Number One Boiler.

Report of failure in Number One Boiler is submitted herewith.

2. I consider that Stoker Petty Officer....., and Leading Stoker....., who were on watch in Number One Boiler Room, failed in their duty in that for a short period they cannot have noticed the level of water in the boiler ; and further, that....., Engine Room Artificer 4th Class, on watch in the engine room, should have suspected that something was wrong when he saw that the amount of feed water showing in the tank did not become less after the reduction in speed at 0842, and also when it was necessary to keep the two main feed pumps running for so long.

3. I propose reprimanding these ratings, as in spite of the serious consequences of their mistake I feel that a more severe punishment, such as disrating, would not be in the interest of the service.

4. All three ratings fully realise the seriousness of the accident, as indeed do all the engine room personnel on board. All three ratings are for these days experienced in their duties and the regrettable occurrence will have furthered their knowledge.

5. I most deeply regret that the operational efficiency of H.M. Ship under my command should have been adversely affected in circumstances which I consider should have been prevented.

6. Further, I regret that the accident should have occurred in a department of which Lieutenant (E)....., is head, as I am very confident of the ability of this Officer, and he naturally feels this accident most deeply.

(Signed).....

Lieutenant-Commander-in-Command.

Enclosure :—

Report of Failure (Commanding Officer,
H.M.S.....'s,
No. 12/345)—7 sheets.

No. 12/345.

H.M.S.

13th January, 1945

SIR,

I regret to have to report the failure of 3 in number tubes in No. 1 Boiler of H.M.S. on 8th January, 1945. The tubes in question are :—

| | | | |
|------|-----|-----|-----|
| R.H. | ... | B47 | B64 |
| L.H. | ... | D88 | |

In addition to the above tubes which burst, there are, as far as can be seen, about 90 in number of A and B rows, 150 in number of C, D and E rows, and a number of outer rows considerably distorted. As far as can be seen the superheater tubes are not distorted.

2. At 0822 on 8th January, 1945, the ship was taking up station at 28 knots. Between 0822 and 0838 there were 8 revolution telegraph orders passed, reducing speed down to 23 knots. At approximately 0850 the E.R.A. of the watch found he was losing vacuum. This time would be about the time when the casualty occurred in the boiler room.

3. *Conditions prevailing at the time of Casualty.*

Engine Room

Speed 216 revolutions.

1 Main feed pump feeding both boilers.

2 Air ejectors in use.

2 Extractor pumps running.

No. 1 Boiler Room (Controlling boiler room).

2 Forced draught fans (3 nozzles open).

2 Auxiliary feed pumps jogging.

6 Sprayers at 140 lb. oil pressure.

No. 2 Boiler Room.

2 Forced draught fans (3 nozzles open).

2 Auxiliary feed pumps jogging.

7 Sprayers at 110 lb. oil pressure.

4. *Action of Engine Room and Boiler Room personnel from time of going on watch to time of casualty.*

(a) *E.R.A. of the Watch.*

0822 Started 2nd main feed pump when revolutions were increased above 250.

When ship was doing 286 revolutions noted feed tanks were full—main and reserve.

0842 After reducing to 216 revolutions rang up No. 1 Boiler Room and informed Stoker Petty Officer that he was going to stop 2nd feed pump. Was told not to stop pump as the feed level was a bit low.

0852 Rang up again after about 10 minutes and asked if it was all right to stop pump now. Reply was—"Have 2½-3 in. showing, all right to stop 2nd pump."
Stopped 2nd feed pump.

0856 About 4 to 5 minutes later vacuum began to drop. Rang up gear room for C.E.R.A. and rang up Engineer Officer. Speeded up main circulating engines. Checked up on air ejectors and feed tanks. Feed tanks were still showing "full." Rang up bridge and reported that he would have to ease down. Eased down on main engines.

(b) *S.P.O. of No. 1 Boiler Room.*

Took over watch with 3 sprayers on at 120 lb. pressure. Main feed check partly shut (boiler had been feeding high during time of leaving harbour, with small boiler output).

0820 About 20 minutes after going on watch sprayers in use were 7, at 140 lb. pressure.
Auxiliary feed pumps were started jogging as water level appeared a bit low.

0835 About 15 minutes before casualty occurred E.R.A. rang up about stopping 2nd main feed pump and was told not to stop it yet as feed level was a bit low.

0845-

0850 Number of sprayers reduced to 6 at 140 lb. after about 15 to 20 minutes.

E.R.A. again rang up about stopping main feed pump and was told it was all right to do so.

0855 Shortly after 2nd main feed pump had been stopped (about (approx.) 5 minutes) the tube burst. It was like a soot blowing noise, but much louder.

Then S.P.O. shut off emergency oil cut-off.

Speeded up fans. Shut off air flaps and main feed check valve. Rang up stop on telegraph and rang up engine room that tube had burst. Told stoker to open up auxiliary feed pump discharge to feed heater (this for the benefit of No. 2 boiler).

Leading Stoker shut right hand main stop and auxiliary stop valve (valve had closed itself). Stoker shut left hand main stop valve and opened auxiliary feed pump discharge to feed heater.

Notes.—(i) Time taken to shut off oil fuel—About 1 sec.

Time taken to shut stops—About 1½ min.

Time taken for steam to disappear—About 10 min.

(ii) Gauge glasses and automatic feed regulator were blown through, and float level operated by Leading Stoker at 0805 and again at 0830.

R.H. gauge glass was quite satisfactory.

L.H. gauge glass blew through satisfactorily, but water was slow in finding its level.

Automatic feed regulator was satisfactory.

(iii) Feed pressure was 410 lb., feed check piston pressure 395 lb. continuously whilst main feed pumps were running.

- (iv) No steam appeared in the boiler room after the tubes burst.
 (v) Safety valve was not eased because steam pressure dropped to a safe pressure very quickly and it was not considered necessary.

(b) *S.P.O. of No. 2 Boiler Room.*

0805 On taking over watch had 5 sprayers on at 100 lb. pressure.
 After 15 min., 6 at 100 lb.

0830 —

0835 25 to 30 min. after going on watch, 7 sprayers at 110 lb. pressure.

0845 —

0855 After about 15 to 20 min. put on another sprayer, making 8 at about 220 lb. Feed water began to drop. Put both auxiliary feed pumps on the boiler, taking suction from overflow and reserve feed tank (reserve feed tank was being run down to overflow). Auxiliary feed pumps going at full output. Water level was maintained at about 5 in.

0850 —

0900 About 5 to 6 min. later reduced to 5 sprayers at 80 lb.
 About 2 min. later shut down to 3 sprayers at 80 lb.
 Auxiliary feed pumps doing 15 S.P.M. on one pump: 7-8 S.P.M. on the other pump.
 Steam pressure rapidly rose and 1 sprayer at 80 lb. was left on.

(c) *Action taken by C.E.R.A.* Checked up on feed tanks, which showed "Full" in both. Air ejectors; gland steam; main circulators, and extractor pumps.

Then noticed oil fuel pressure in No. 1 Boiler Room was gone, so told stoker to get oil fuel transfer pump under way to feed No. 1.

5. *Action taken by the Engineer Officer.*

Informed at about 0855 that E.R.A. was losing vacuum.

In Engine Room about 0857.

State of machinery on arrival:—

Main engines turning at about 160 revolutions.

1 main feed pump in use.

2 extractor pumps in use.

Vacuum 22 in.

Steam 200 lb.

Main feed tank about 2 tons water.

Overflow tank about 5 tons water.

Condenser at normal level.

Shut down on throttles.

Questioned E.R.A. of the Watch about level of water in overflow tank and told him to run down from reserves, and shut off supplementary valves on overflow tank. Told stoker to tell boiler rooms to get auxiliary feed pumps on to overflow tank suction, and told E.R.A. to stand by to shut down main feed pump. Told C.E.R.A. to check float control valves on closed feed system. Told E.R.A. to open supplementary valves on overflow tank. Water level in tanks then became 5 in main, 2 in overflow tank. Vacuum started to drop so shut supplementary valves on overflow tank. By this time the true state of affairs was appreciated and the E.R.A. was told to shut main bulkheads to No. 1 Boiler Room.

Approx.

0905 Reported to the Captain that No. 1 Boiler Room was out of action for the time being, and that steam would be available shortly in No. 2.

Told to obey revolution counter, which was then at 86 revolutions, and to report when higher revolutions would be available.

Returned to Engine Room and started main engines.

By this time overflow tank had about 5 tons of water and main feed tank about 4 tons.

Reported to Captain ready to proceed on one boiler—by 'phone.

Reported estimated damage to Captain and that time required to effect repairs to boiler would be about 36 hours.

Ran fan in No. 1 Boiler Room at slow speed to cool boiler down.

1400 Entered furnace and surveyed damage.

Reported to Captain that damage was greater than anticipated and that it was considered that when tubes were plugged boiler should not be used except in an emergency.

Ran boiler down to overflow tank and to bilge.

Extent of damage :—

Two in number B row tubes burst towards the superheater.

Estimated considerable distortion of :—

50 in number A and B row tubes.

60 in number C D and E row tubes.

No sign of burning of tubes apparent.

Gave orders to cut out 1 burst tube. One A row had to be cut out to do this.

9.1.45.

0200 Entered boiler. Top and bottom drums.

No sign of oil was to be seen.

General condition was good.

Gauge glasses were renewed. Packing was found in tube glass at the bottom of left hand gauge glass. A 48 and B 47 right hand side were cut out and examined. Tubes showed hard black scale deposit on top side of tube, which looked as if it might have been oil carbonised on the tube or black lead, or perhaps burnt soot. No sign of other pitting was found on either side of the tubes removed.

A 48, B 47, B 64 were plugged and an air pressure test applied. It was then discovered that D 88 on the left hand side was punctured also. This tube was also plugged. Boiler was then again air-pressure tested and various tubes showed leaks at the tube plate.

These tubes were rolled and again air pressure tested to 50 lb., and appeared satisfactory.

Boiler was then sighted, washed through and pumped up. Lime was added and boiler was closed up.

Steam was then raised, using a 300-lb. sprayer at 70 lb. oil pressure. Steam showed after 2½ hours and was raised to 75 lb. Water leaked from several tubes at top drum.

Boiler was then allowed to lose steam and additional water was pumped in to make up for loss.

Steam was raised a second time and pressure taken up to 175 lb. Estimated loss of water about $1\frac{1}{2}$ tons per hour.

Considered boiler could be used under these conditions in an emergency, and this fact was reported to the Captain.

Boiler was left banked between 10 and 50 lb. during last 6 hours before entering harbour.

Water tests were taken about 2 hours after boiler was run down to overflow tank.

Tests were :—

| | |
|--------------------------|------------------------|
| Main feed tank | 0·2 grains per gallon. |
| Overflow tank | 1·5 grains per gallon. |
| Reserve feed tank | 0·2 grains per gallon. |
| No. 2 boiler | 4·0 grains per gallon. |

6. *Action on return to Harbour.*

On return to harbour a thorough internal and external examination was carried out.

Remaining lengths of A 48 and B 47 tubes right hand side, and A 64 and B 64 right hand side, and A 56, B 56, C 88, D 88, E 89 left hand side, were cut out for examination.

Result of Examination.

(i) *External—*

(a) Damage was more extensive than at first estimated. About 90 in number A and B rows ; 150 in number C, D and E rows were badly distorted. Several F rows badly distorted and resting on superheater.

(b) Casings not distorted or damaged.

(c) Brickwork. Cones worn, remainder in satisfactory condition.

(d) Tubes covered with caked soot and fine sulphur deposit round bottoms of tubes on outside tubes.

Inside tubes covered with an improperly burned oil deposit with patches of flake.

Deposit of clinker round superheater supports.

(ii) *Internal.*

(a) Scattered slight pitting in steam and water drums, of no appreciable depth. Slight red deposit in superheater headers.

(b) Internal gear in satisfactory condition.

(c) No sign of oil was seen in steam or water drums, or in tubes.

(d) Plugged tubes were sighted when removed and were clear of obstruction.

Other Examinations carried out.

Covers were removed from all feed water tanks, and gearing room and boiler room observation tanks. No sign of oil was present.

Drain filter tanks examined. No sign of oil.

Condenser sight glasses examined. No sign of oil.

Note.—Impermeators on pumps are operated only by the Chief Engine Room Artificer.

Saturated exhaust is always put through drain cooler.

| | | |
|------------------------------|-----|---|
| Main feed check valve ... | ... | } Examined and found to be satisfactory. |
| Automatic feed regulator ... | ... | |
| Gauge glass mountings ... | ... | |
| Safety valve casing gear ... | ... | |

Leading Stoker was examined for proficiency in testing gauge mountings, and was satisfactory.

7. Detailed Examination of Burst Tubes.

Right hand side. B 47 (removed after casualty occurred).

Position of fracture 30 in. from top drum on outboard side of tube, i.e., towards superheater.

Type of fracture—Burst. Length $4\frac{3}{4}$ in. ; Width $3\frac{1}{8}$ in.

Thickness of tube : 0.126 in.

No evidence of scab or other pitting.

No obvious signs of burning of tube.

Partially burnt oily deposit on outside of tube.

Black scale on outboard side of tube internally.

B 64 (removed on return to harbour).

Position of fracture, 31 in. from top drum on outboard side of tube.

Type of fracture : Burst. Length $6\frac{1}{8}$ in. ; width $3\frac{1}{2}$ in.

Thickness of tube : 0.129.

No evidence of scab or other pitting.

Slight signs of burning.

Left hand side.

D 88 (removed on return to harbour).

Position of fracture ; 16 in. from top drum on inboard side of tube, i.e., towards furnace.

Type of fracture : Burst. Length 3 in. approx. Width 3 in. approx.

Thickness of tube : 0.127.

No evidence of pitting internally.

Partially burnt oil deposit externally.

Tube appeared burnt on outboard side of tube at position of fracture.

Top end of tube was bent at fracture approximately 60° to mean axis, in towards superheater.

8. Previous Treatment of Boilers since last Boiler Clean on 17th October, 1944.

Boilers have steamed for short periods only at high powers. 300 revolutions have been used, but only for short periods.

On one occasion $28\frac{1}{2}$ knots was used for 8 hours. Steaming during this time was quite comfortable. No undue pressures or temperatures were experienced.

A full power run of two hours was carried out on 7th January, 1945. The results were satisfactory. An examination of tubes from the outside was made by the Engineer Officer on completion, after entering harbour. No distortion could be seen in either boiler.

Boilers had steamed 720 hours.

Stoker Petty Officer did some patching of brickwork in No. 1 boiler between 0200 and 0500 on 8th January, 1945. He was told to have a look along the tubes and reported no obvious distortion of tubes.

Salinity Records.

Daily record of salinity is kept.

Highest reading recorded : 4 grains per gallon in No. 1.

9. *Explanation of Failure.*

From investigation carried out there must have been a shortage of water between 0800 and time of stopping 2nd main feed pump. Two main feed pumps were in use and reduction in speed was slow. When the Engine Room Artificer rang up the Boiler Room to stop the 2nd feed pump, i.e., at 23 knots, there should have been no need to keep the pump running. (The water in main and overflow tanks showed a full reading, when they should have shown a reduction of about 4 tons from the reading at 28 knots.) Pumps were discharging at 410 lb./sq. in.

Reading of feed tanks at the time of the loss of vacuum according to the Chief Engine Room Artificer and the Engine Room Artificer of the Watch showed both tanks full.

When the Engineer Officer appeared, which was approximately two minutes after the arrival of Chief Engine Room Artificer..... the main feed tank was very low, as was also the overflow tank. (A loss of 19 to 20 tons of water in two minutes.) The total amount of water which would escape through the three burst tubes is estimated to be approximately 2.02 tons per minute. When the ship is under way condensers suck in air through supplementary valves at between 2 to 3 tons level. Assuming overflow had been full, the time taken to start losing vacuum would have been 6 to 7 minutes from time of casualty.

The Engine Room Artificer states that both feed tanks were full. It is considered that the reading of overflow tank must have been false at this time, and probably at times between 28 knots and the arrival of the Engineer Officer. (The float in the overflow tank stuck on one previous occasion, and was examined.)

(Signed).....
Lieutenant-Commander-in-Command.

H.M.S..... FAILURE IN NO. 1 BOILER.

(Commanding Officer H.M.S.....'s No. 01/234.)

13.1.45.

II.

The Commodore Commanding Destroyers,

(Copy to H.M.S.....)

Forwarded concurring generally.

2. With reference to paragraphs 2, 3 and 4 of 's No. 01/234 of 13th January, 1945, I have instructed the Commanding Officer of H.M.S., to take disciplinary action accordingly.

3. The boiler has been examined by the Flotilla Engineer Officer and the Flotilla Boilermaker C.E.R.A., whose detailed report is attached.

(Signed).....

CAPTAIN (D).

— FLOTILLA,
15th January, 1945.

Report of Examination of No. 1 Boiler of H.M.S. by Flotilla Boilermaker C.E.R.A.—12th January, 1945.

1. *External.*

(a) *Right hand.*

- B47 Tube split away from furnace about $\frac{2}{3}$ of the way from bottom drum.
 A48 Tube cut out to facilitate the removal of B47.
 B46 This tube bent towards the furnace, the split being on the side remote from the furnace. These tubes were plugged.
 A1 to A3 ... These tubes distorted, bending towards outer casing.
 A15 to A39 Tubes distorted ranging to E row.
 A40 to A64 Tubes badly distorted, extending to E row. C to E row tubes touching one another.
 E and E1 rows Tubes distorted to such an extent as to be touching the superheater tubes. Vision for further observation being obstructed by superheater supports.
 F121 to F125 Badly distorted, resting against superheater tubes. Further distortion of tubes extends for as far as can be seen. Further distortion of generator tubes was noticed along the whole length of the boiler, sufficient to prevent saws from being inserted.

(b) *Left hand.*

- A1 to A51 ... Slight distortion, no general tendency, $\frac{2}{3}$ of the way up the tube front water drum.
 A52 to A66 ... Tubes badly distorted, extending to E row. C to E row tubes nesting.
 D88 A56, B56, C88 and E89 tubes were removed to expose D88 which was seen to be split $\frac{1}{2}$ of the way from the steam drum, on the fire side. This tube had been plugged.
 E and E1 rows Tubes distorted towards the superheaters.
 A71 and A72 Badly distorted towards the furnace.
 F row ... Tubes distorted towards the furnace, a number of tubes nesting against the superheater tubes. Further observation impeded by superheater brackets.
 F to U rows... Distortion of tubes, the general tendency being towards the furnace.

- (c) There was no obvious discoloration of tubes to indicate the loss of water.

There was a sticky form of scale on the tubes from half-way along the boiler to the back on the furnace side, right and left hand sides indicating fuel not being burnt correctly.

The scale on the outer casing side was of a hard cement-like nature, this being due to the water forming with the soot.

Sliding feet were free to move.

2. *Internal.*

Boiler was opened, condition being good.

No signs of oil in the steam or water drums, condition of internal gear good.

In the vicinity of the plugged tubes there was a white deposit easily removable. As lime is known to have been added when the boiler was refilled with water after the tubes were plugged, this was probably a lime deposit.

There was a black scale of a shiny appearance in the tops of the tubes visible from the steam drum. Owing to the lack of oil indication in the steam and water drums this would not appear to be an oil scale.

At the lower ends of the tubes, visible from the water drums, there was a light brown deposit in the generator tubes, easily removable and crumbling on touch.

From A to E rows, especially in the fire row tubes, this brown scale was of a harder nature and not easily removable.

3. It was noted that F 107 tube had been plugged when the A to E rows were renewed on a previous occasion.

4. No. 2 boiler was inspected externally, and as far as could be seen was in good condition, with no tube distortion.

5. A test of water from No. 1 boiler before opening out, and from No. 2 boiler while at W, but shut down, was taken.

Results :—

No. 1 Boiler : Alkaline. Salinity NIL.

No. 2 Boiler : Slightly alkaline. Salinity 2.4 grains per gallon.

(Signed).....

C.E.R.A.

Flotilla Boilermaker.

II.

Despite the lack of characteristic discoloration of the tubes, vide 1 (c) above, it is considered that primarily this boiler must have been short of water to cause tube failure. It is possible that severe nesting existed in the case of one or more of the tubes which eventually burst, leading to local overheating which, aggravated by the effects of a shortage of water, terminated in the bursting of the first tube. This would, of course, immediately increase the loss of water so that other failures and distortion would very rapidly follow.

I consider this boiler to be unfit for use in its present condition, except in dire emergency to save the ship from total loss.

(Signed).....

ACT. COMMANDER (E),

FLOTILLA ENGINEER OFFICER.

H.M.S.....FAILURE IN No. 1 BOILER.
 (.....No. 01/234 of 13th January, 1945)

III.

THE COMMANDER-IN-CHIEF,
 (Copy to :—The Captain (D),Flotilla)
 (H.M.S.)

Forwarded, concurring in the action taken. All destroyers have been informed of this accident and its consequences upon the fighting efficiency of the Flotilla. It is hoped the lesson has been learned.

(Signed).....
 COMMODORE (D),

H.M.S.....
 19th January, 1945.

FAILURE IN No. 1 BOILER.
 (Commanding Officer, H.M.S.....'s letter
 No. 01/234, dated 13th January, 1945)

IV.

Secretary of the Admiralty,
 (Copy to : Commodore (D),
 Captain (D),....., Destroyer Flotilla)
 Forwarded concurring.

(Signed).....
 FOR ADMIRAL,
 COMMANDER-IN-CHIEF.

.....,
 1st February, 1945.

H.M.S.....
*Failure in No. 1 Boiler
 Report.*

Noted.

2. Blame for the accident is directly due to Stoker Petty Officer, and Leading Stoker....., in charge of the boiler room and water tender respectively, in that having taken over the watch with the main feed check valve partially closed to prevent the boiler from filling up whilst on low load they failed to open it when speed was increased.

Referring to paragraph 4 (b) of the enclosure to C.O., 's report, Note (iii), the high piston pressure indicates that the feed check valve was probably open to the full extent allowed by the position of the hand control.

3. The disciplinary action taken against these two ratings is concurred in.

4. Apart from the fact that he was slow to appreciate the cause of the trouble, of which there were indications that would be obvious to a more experienced man, no blame can be attributed to E.R.A., 4th Class. Having regard to his limited experience this rating is not considered deserving of censure.

5. The attention of the E.O. H.M.S., should be invited to the instructions contained in E.M., Article 234, paragraph 7.

6. It is proposed to inform C.-in-C....., accordingly and that during the forthcoming refit of H.M.S..... arrangements should be made for No. 1 boiler to be thoroughly examined by Dockyard officers, with particular reference to the condition of the steam drum tube plate as regards distortion and ovality of tube holes. The bore of the main feed check valve piston chamber should be examined for wear, and piston clearance verified.

The result of this examination is to be reported, stating the extent of repairs necessary to render the boiler fully serviceable.

ENGINEER-IN-CHIEF.

March, 1945.