# SOME NOTES ON ENGINE ROOM MAINTENANCE AND REFITS OF A CRUISER UNDER TROPICAL WAR CONDITIONS

BY

COMMANDER (E) A. F. SMITH, R.N.

The following notes are based on experience in H.M.S. *Kenya* during the last six months of 1950 and on data compiled from the ship's engine room records of the Second World War. It is thought that they might help operational staffs in getting the most service out of a cruiser without extending the main propulsion plant beyond its limit of reliability and efficiency, and the engine room personnel beyond their endurance.

**Maintenance and Service**

The amount of service that can be obtained from any normal propulsion unit is dependent upon a large number of factors, some of which are the age of the ship, date the ship was last refitted, the extent of the refit and the standard of workmanship, design of the machinery, availability of spare gear, and size and skill of the engine room maintenance staff.

As a general rule greater service can be obtained if ships are kept at sea for a small number of long patrols than for a large number of short periods. Once ships are at sea with all machinery running under proper conditions of lubrication and temperature, very little wear and tear takes place. Raising steam and shutting down, starting and stopping machines or, in other words, large changes in the thermal cycle cause more wear and tear than reasonable steady steaming with everything in use.

**Usage Factor**

To form a comparison of the steaming done in any war year a summary of the days when steam has been put on main engines, *i.e.*, at one hour's notice for steam or less, and the days out of Dockyard Hands has been made. The fraction :—

$$\frac{\text{Days with steam on Main Engines}}{\text{Days out of Dockyard Hands}}$$

has been expressed as a percentage. This has been called the Usage Factor. This Usage Factor is largely a measure of how much the ship has been used at sea or has been available at immediate notice—it is not necessarily the extent it could have been used. It is also a measure of the time when little or no maintenance has been possible. Details are set out in Table I.

An endeavour has been made to establish

(*a*) A maximum *Usage Factor* which could be expected with carefully planned maintenance, and a

(*b*) *Planned Usage Factor* suitable as a basis for operational planning allowing for special operations, casualties, etc.

With a proportionally large maintenance staff one should expect a higher

Usage Factor, and a rough comparative measure of the usefulness of the maintenance staff may be expressed as the fraction

$$\frac{\text{Usage Factor}}{\text{Comparative size of Maintenance Staff}}$$

This expression must be treated with reserve because the Second World War showed that as the war progressed not only did shortages reduce the size of engine room staffs but the average standard of skill was reduced also.

TABLE I

H.M.S. *Kenya*, first commissioned 28th August, 1940

| | 1941 | 1942 | 1943 | 1944 | 1945 | Whole of 1950 | July to Dec., 1950 incl. |
|---|---|---|---|---|---|---|---|
| 1. Dockings ... ... ... | 2 | 2 | 1 | 2 | 1 | 2 | Nil |
| 2. Days in Dockyard at extended notice. | 54 | 124 | 15 | 71 | 226 | 82 | Nil |
| 3. Days out of Dockyard Hands. | 311 | 241 | 350 | 295 | 139 | 283 | 184 |
| 4. Days with steam on Main Engines. | 252 | 160 | 208 | 183 | 78 | 198 | 134 |
| 5. Usage Factor ... ... $\left(\frac{4}{3}\right)$ | 81% | 66% | 59% | 62% | 56% | 70% | 73% |
| ENGINE ROOM MAINTENANCE COMPLEMENT BORNE | | | | | | | |
| 6. C.E.R.A. ... ... ... | 5 | 5 | 4 | 3 | 4 | 3 | 3 |
| 7. E.R.A. ... ... ... | 26 | 23 | 19 | 22 | 21 | 19 | 19 |
| 8. Ch. Mech. and Mech. ... | 4 | 4 | 4 | 6 | 6 | 7 | 7 |
| 9. Total ... ... ... | 35 | 32 | 27 | 31 | 31 | 29 | 29 |
| 10. Comparative size of Maintenance Staffs. | 1 | .91 | .77 | .88 | .88 | .83 | .83 |
| 11. Comparative Usefulness of Maintenance Staff. $\left(\frac{5}{10}\right)$ | 81% | 73% | 77% | 71% | 63% | 84% | 87% |
| 12. Mileage ... ... ... | 66,660 | 45,885 | 54,505 | 58,466 | 27,704 | 47,669 | 35,180 |
| 13. Fuel Oil Used (Tons) ... | 27,247 | 19,833 | 24,726 | 27,057 | 11,534 | 22,682 | 17,192 |

NOTE.—These records have been compiled from *Kenya's* Engine Room Registers. The official instructions are that registers beyond the last commission can be destroyed. If this had been done most of this interesting and valuable data would have been lost and it is strongly recommended that the Fair Engine Room Registers are kept for the life of the ship.

At first it might be thought that " total miles steamed " offers a good comparison between different ships but generally speaking this is not so reliable as the number of days with steam on main engines as there is very little difference in wear and tear for example, whether a cruiser steams at 15 knots or, say, 22 knots. Machinery like feed pumps, forced lubrication pumps, extraction pumps, distilling plant and turbo-generators are for the most part constant-speed machines and as far as they are concerned it does not matter what speed the ship is doing ; it is the running time which counts. Also, for the same distance run the higher-speed ship is able to spend more time in harbour.

**Periodical Maintenance Requirements**

In the Second World War maintenance periods were principally dictated by having to clean boilers internally approximately every 500 hours or at least once a quarter. With the introduction of Admiralty Boiler Compound this period, if the purity of feed water is kept within certain limits, can now be extended to once every twelve months. While this makes ships available for longer periods there are still several features in a cruiser which experience has shown require attention at regular intervals.

After approximately 600-900 hours (approximately six weeks) these less-advertized items are :—

(*a*) Changing one set of distilling plant coils, refitting distiller pump, and descaling brine pipes. Shortage of daywork staff and limited fresh water stowage and distiller plant output makes this operation extremely precarious at sea.

(*b*) Renewal and repair of brickwork, particularly cone bricks.

(*c*) Adjustments to safety valves.

(*d*) Refitting boiler mountings.

(*e*) Remaking steam joints and refitting steam valves.

(*f*) Adjustments and cleaning of steam and water regulators and controllers.

(*g*) Refitting fire and bilge pumps.

Unless these items are attended to regularly they soon affect the overall efficiency of the ship. Many of the items apply to both steam units, but as it is nearly always necessary to keep steam at, say four hours' notice in one unit in operational areas only one unit can be refitted at a time. Such items like boiler brickwork repairs cannot be satisfactorily carried out at less than eight hours' notice ; ten hours is preferable. The work outlined above normally requires five working days with the present complement at the end of every six weeks.

After approximately every 1500-2000 hours (officially once every three months) all boilers require to be cleaned externally. They require to be washed through and inspected internally every 2000 hours. This is to avoid falling off of boiler efficiency, to prevent external corrosion, and to ensure that the internal condition of the boilers is satisfactory. Also a proportion of turbines bearing wear down readings need to be taken. The time required is nine days.

If boilers have steamed with feed water of high salinity it may be necessary to clean some or all of the boilers internally concurrently with external cleaning. Though this is normally unlikely, it is something which must be catered for after six months. Feed tanks and sometimes service fuel oil tanks also need cleaning every six months and the time required will depend very much on the Stoker-mechanic complement. The time required to clean two

boilers internally and all boilers externally (including testing) is 14 days, including time for cooling-off and changing over boilers.

Periodical inspection of machinery must also be carried out if timely forecasts of dockyard repairs are to be made.

A summary of these maintenance requirements is :—

| | *Notice of Steam* | |
|---|---|---|
| | *1st Unit* | *2nd Unit* |
| (*a*) Five days every six weeks ... ... ... | 4 hours | 10 hours |
| (*b*) Nine days every three months ... ... | 4 hours | 12 hours |
| (*c*) Fourteen days every six months ... ... | 8 hours | 24 hours |

**Rest and Recreation**

In planning stand-off periods, rest and recreation for the ship's company is a very important factor. It is an advantage if the maintenance periods follow these rest periods and run consecutively with them. A limited amount of maintenance is, of course, done during these rest periods.

Continuous engine-room watchkeeping in three watches under conditions of high temperature and humidity with periods at damage-control stations is very exhausting and these rest periods are of greater importance in the tropics than in temperate climates.

It is suggested that on an average about four to five days per month in harbour should be allowed in the tropics additional to the maintenance periods.

**A Planned Usage Factor**

Assuming that ships will receive a periodical refit after every 12 months' operational duty the time set aside for maintenance and rest for the twelve months would be :—

| | | *Total in Days* |
|---|---|---|
| *Rest* | $4\frac{1}{2}$ days/month ... ... ... ... ... | 54 |
| *Maintenance* (8 periods) | (*a*) Five days every other six weeks (4 periods) ... | 20 |
| | (*b*) Nine days at end of third and ninth months (two periods) ... ... ... ... ... | 18 |
| | (*c*) Fourteen days at end of sixth and twelfth months (two periods) ... ... ... ... | 28 |
| | Total ... | 120 |

$$\textit{Planned Usage Factor} = \frac{245}{365} = 67\%$$

The second period of 14 days would be the pre-dockyard refit period. This period should be principally employed in progressing inspections and surveys which should have the effect of reducing the size of the Final Supplementary Defect List very considerably.

**Actual Usage Factors**

From Table I it will be seen that :

(*a*) If one ignores the exceptional year 1941 when *Kenya* was new and had a comparatively large maintenance complement, the average Usage Factor for the Second World War years (1942–45) was ... ... ... ... ... ... ... 61%

(*b*) The 1950 Usage Factor was ... ... ... ... ... 70%

(*c*) From July–December, 1950 inclusive the Usage Factor was 73%

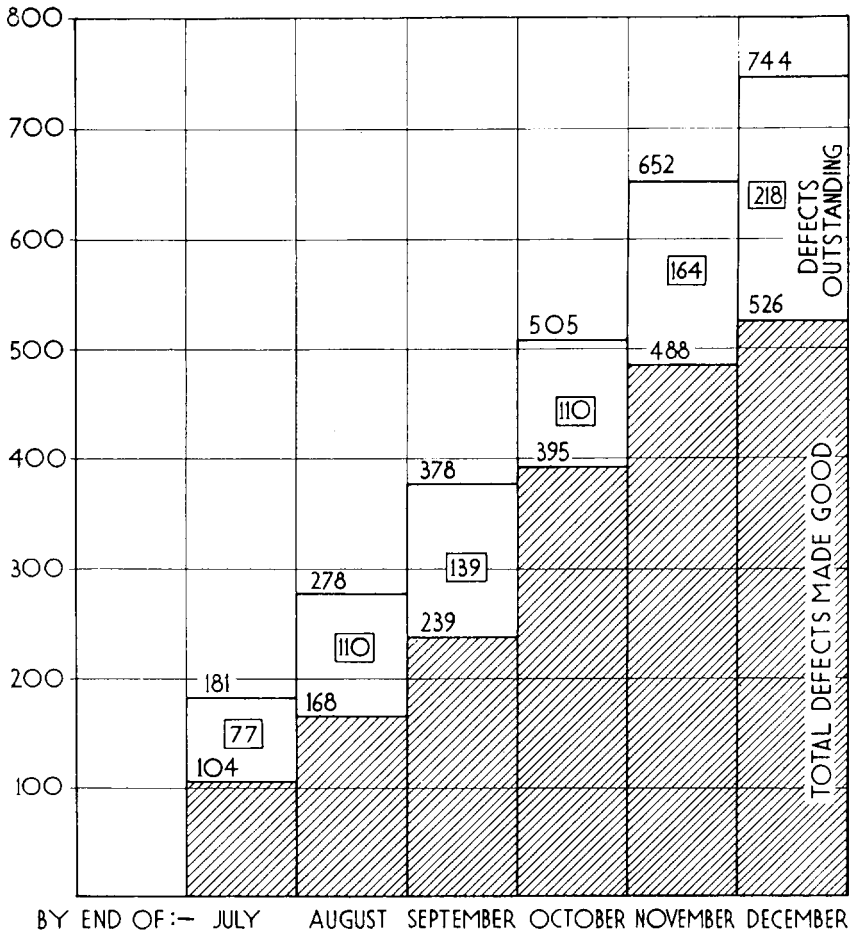
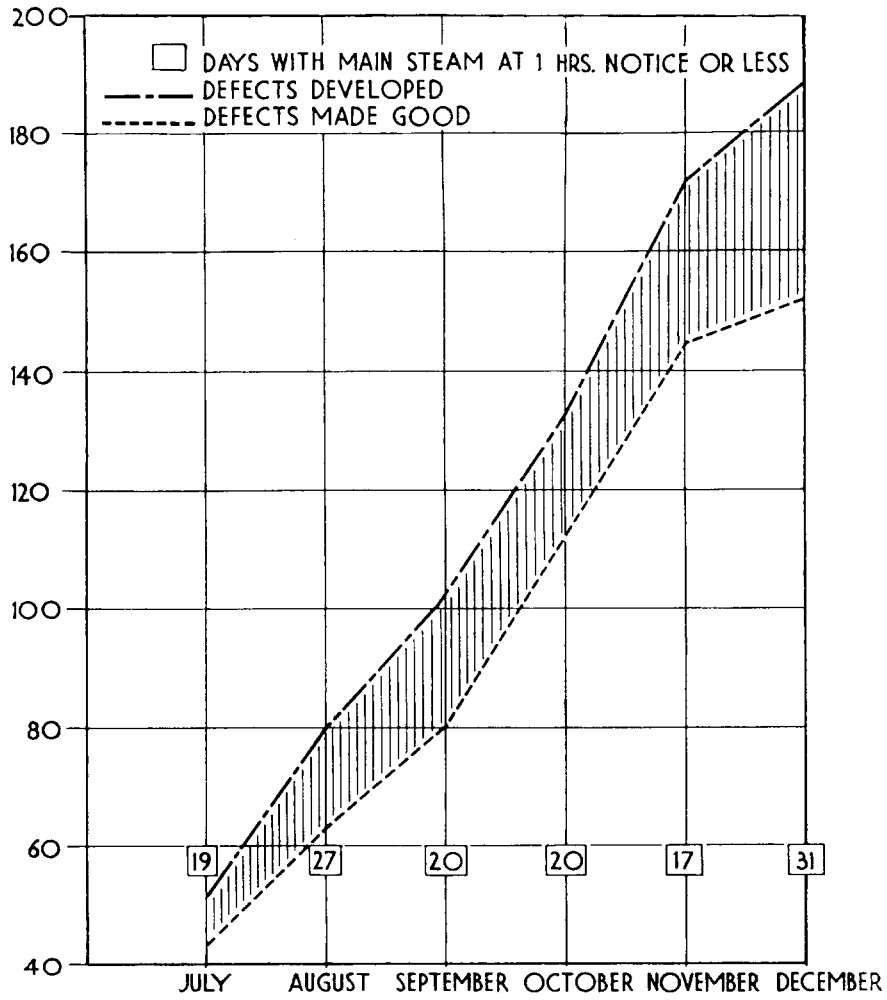



**FIG. 1. TOTAL NUMBER OF ENGINE ROOM DEPARTMENT DEFECTS DEVELOPED AND MADE GOOD SINCE JULY 1950**

With the full knowledge of the maintenance work that is now required, inspections that have become overdue, and the strain that is beginning to be felt by the engine-room personnel it is considered that the Usage Factor for the last six months (73%) is about the maximum one can expect from a ten-year-old ship for such a period. She has had the advantages of (*a*) having previously just completed a dockyard refit and (*b*) the engine-room complement had served in her for twelve months.

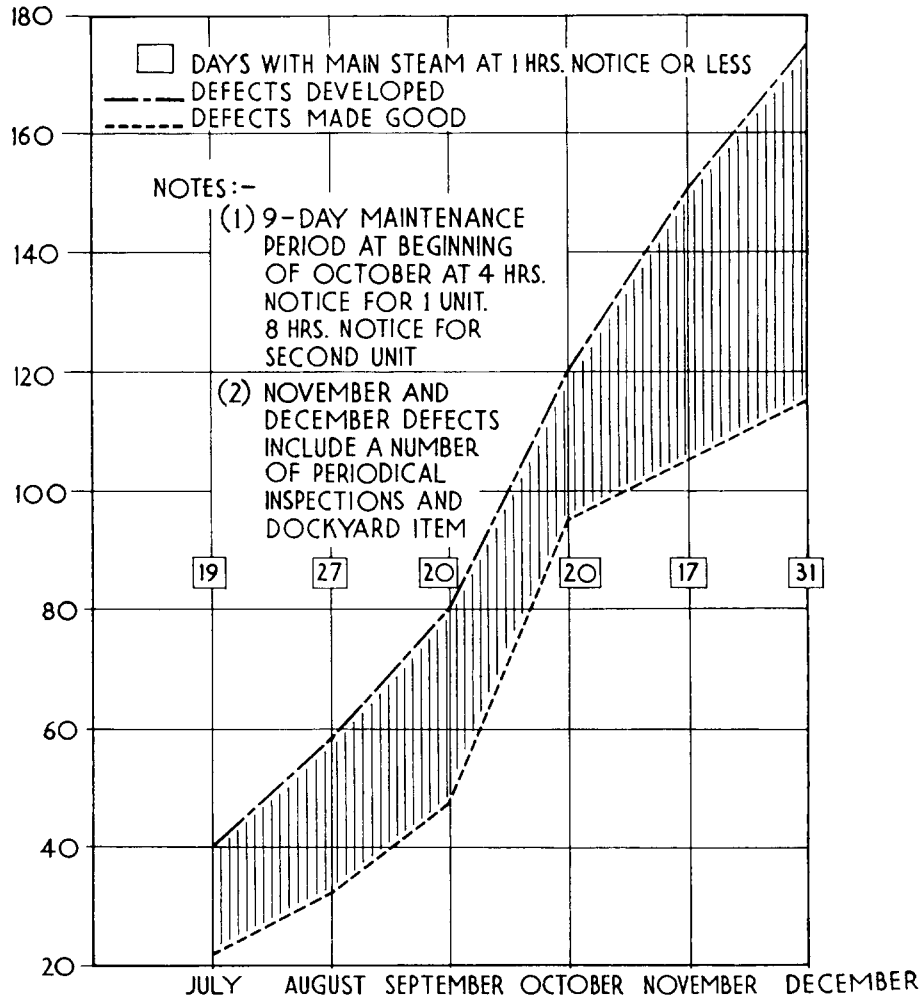
Figures illustrating the defects developed and the extent to which the engine-room staff has been able to compete with the work is illustrated in Figs. I and II. The total number (Fig. I) includes many ventilation defects caused by gun-fire which though temporarily repaired cannot be satisfactorily completed without dockyard assistance. The number of repair items now requiring dockyard attention is steadily growing.

A Usage Factor must generally be less for an old ship than for a new one, because corrosion creeps in with age, materials become crystalline, and much refitting work which with new materials would be simple, after years of service is apt to become complicated by corrosion failures, unforeseen breakages, and necessary renewals. There is also the greater need for inspections to be carried out before the next dockyard refit so that the true condition of the machinery can be assessed.




DEFECTS DEVELOPED AND MADE GOOD IN ENGINE ROOMS SINCE JUNE 1950

FIG. 2.




DEFECTS DEVELOPED AND MADE GOOD IN BOILER ROOMS SINCE JUNE 1950

**Comparison Between Planned and Usage Factors**

In the light of the remarks just made it is considered that without a larger and a more experienced maintenance complement than at present it would be inadvisable to plan for a ten-year-old cruiser anything higher than a Usage Factor of 65–70% over a period of twelve months, but if the suggested maintenance periods are adhered to, particularly in the first six months after a refit, a ship is much more likely to maintain her efficiency throughout the year and be better able to meet unexpected requirements for special operations or take on additional duties caused by casualties to other ships. Experience in July–September, 1950, showed that a much higher Usage Factor is possible for periods of 2–3 months. For example, for the seven weeks 16th July to 5th September, H.M.S. *Kenya* had steam on main engines for 46 days out of 51 (distance steamed 15,777 miles) which is a Usage Factor of 90%, but this cannot be expected to be maintained over a much longer period.

The proposed Planned Usage Factor represents a 6% increase over the average Usage Factor for the years 1942–45. This increase is to some extent a measure of the value of Admiralty Boiler Compound in increasing the operational availability of H.M. ships.

To increase the Usage Factor further there is a need :—

(i) To increase the time between external cleaning of boilers by improved soot removal and blowing arrangements, and to improve design of boiler casings to facilitate cleaning.

(ii) To improve the output of distilling plants and the means of maintaining their outputs over a long period.

(iii) To increase the fresh water stowage. Laundry and modernized bathrooms have increased the fresh water consumption by 30–35% in H.M.S. *Kenya*.

(iv) To improve the design of safety valves, sirens, and steam joints generally.

(v) To improve the quality of boiler brickwork and particularly cone bricks.

(vi) To improve the design and materials used in sea-water and brine pumps, particularly fire and bilge pumps, so as to increase the time required between overhauls.

Perhaps it is of interest to note that it is estimated that the Usage Factor for the R.M.S. *Queen Mary* and *Queen Elizabeth* is 78%.

Sir William Currie in his recent paper " British Shipping " gives the average figures for cargo ships operated by one company as 71 days at sea to every 102 days in harbour, *i.e.*, a Usage Factor of 41%. This low figure is principally due to delays in loading and off-loading.

**Dockyard Refits**

These remarks on usage are based on the assumption that a ship will leave her refitting yard in a very efficient state. The older a ship and the more she is used will mean a corresponding larger number of repair items requiring dockyard assistance. Unless all known defects are made good and efficient at a dockyard refit, ship's staff will be unable to do the work expected of them and operational planning may be seriously dislocated.

One of the major factors deciding the duration of a refit is the condition of a ship's boilers. With a new ship and a good design of boiler there should be little dockyard repair work required in the first four or five years, but after

this the life of the tubes of different boilers in a cruiser is apt to get " out of step". As superheater tubes of Admiralty-type 3-drum boilers have to be renewed after every $4\frac{1}{2}$–$6\frac{1}{2}$ years it means that generally one superheater will require retubing every twelve months, unless more wholesale renewals are carried out, say, every four years ; it is considered that in the long run this would be an advantage from the operational point of view. Generator tubes have a normal life of ten years, so a ten-year-old ship can also expect some generator tube renewals.

Chatham Dockyard, working overtime, retubed the superheaters of one boiler in 39 days. Singapore Dockyard did the same job in 42 days. After retubing, boilers have to be tested, boiled out, cleaned and brickwork completed. This takes about eight days, depending on the success of the initial tests. Steam cannot be raised until boiler cleaning is complete, and this delays the trials of auxiliary machinery in the affected boiler-room, and also the basin trial.

Thus without taking into account possible generator tube renewals and bearing in mind that a fortnight is required for a pre-refit period for de-ammunitioning, cleaning fuel oil tanks for survey and repair, periodical inspections, and external cleaning and testing of boilers before dockyard repair, etc., and another week is required for cleaning up after dockyard work is complete, storing ammunitioning, basin and sea trials and any adjustments required after trials, a period of at least 71 days in the vicinity of a refitting yard, if one boiler is to have its superheaters retubed, is about the minimum one can expect unless a larger-than-normal dockyard labour force is made available. Allowance must also be made for dockyard holidays.

**Comment**

This article forms a good approach to an analysis of the maintenance problem in a particular case and emphasizes clearly the need for regular planned maintenance to improve operational availability.

Comments are invited.