THE TYPE 42 MACHINERY INSTALLATION DESIGN

BY

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The following article is the substance of a presentation given by the Author to the Director of Warship Design, members of the Ship Department Directing Staff and Yarrow-Admiralty Research Department at Vickers Shipbuilding Works, Barrow-in-Furness, in November, 1970. The Author was from March, 1969 to April, 1971, the Head of Section 144 of the Frigate and Destroyer Group in the Directorate of Warship Design.

In reading this article, reference can be made to two previous articles which referred to the Type 42 Destroyer. They were both written by the Author's predecessor, Commander E. R. Chapman, Royal Navy, and can be found in Vol. 18, No. 2, under the titles 'Type 42 Destroyer—Philosophy of the Marine Engineering Design' and 'The Frigate and Destroyer Group—Section 144'.

History of the Design

The early work by the Ship Department Project Group on the Type 42 machinery installation was completed and reported in December, 1966. At this time the machinery layout consisted of two engine rooms separated from a single auxiliary machinery and fuel working space by a deep fuel tank; in addition, a Diesel generator compartment was sited on 1 Deck.

At the beginning of 1967, a contract was placed with Y-ARD for a feasibility study on the lines recommended in the Project Group report. In March of that year it was finally decided that the propulsion machinery was to consist of the COGOG arrangement of one Olympus and one Tyne gas turbine per shaft.

In August, 1967, Y-ARD started work on a 1/12th scale model of the machinery spaces. The aim of this model was to develop the installation by siting all items of equipment, including their electrical ancillaries, major pipe systems and the main cable runs. A large number of equipments and some systems were still in the development stage at this time and full details of many of them, including their sizes, were not available throughout the whole period Y-ARD worked on their model.

By November, 1967, the three Ship Department Sections concerned had taken over the project and by this time a number of major changes had been made to the original design. These changes had been brought about by the need to keep the total ship cost below a certain limit. As far as the machinery installation was concerned the changes were as follows:

Firstly, the machinery space layout now consisted of four machinery spaces: two engine rooms and two auxiliary machinery rooms. The Diesel generators were sited in the latter and the need for a separate compartment on 1 Deck was abolished.

Secondly, a double-bottom stowage for fuel was introduced, approximately half of which became a water displacement system.

Apart from moving the bulkhead between the two engine rooms by six inches, the overall dimensions of the machinery spaces have not changed since that date. At about this time Y-ARD published their Feasibility Study report and subsequently made a plea for more space, but it was never possible to quantify the problem sufficiently to make a valid case to increase size and thereby cost.

The Y.205 contract was placed with Y-ARD in December, 1967, for the production of the Class Marine Engineering Specification and Guidance Drawings.

Within six months tenders had been invited for the First of Class using embryo guidance drawings, a technical description of the installation and an equipment schedule. The order was placed with Vickers Shipbuilding Works in November, 1968, when a little more information was available.

Y-ARD delivered their 1/12th scale model to Vickers in two halves in December, 1968, and February, 1969, and Vickers, who had ordered the basic structure of their 1/6th scale model in January started to develop the installation in April of last year.

The aim of this larger model was to develop fully the layout of all equipments, all pipe systems of 1 inch outside diameter (including lagging) and above, and all major cable runs. Its scope was naturally much greater than that of the Y-ARD model. The use of this 1/6th scale model as a design tool has been successful, each system having been fully developed in the model from only an initial diagrammatic drawing. The model contract is in the process of being extended to include a proportion of the smaller bore pipework and minor cables.

The Class Marine Engineering Specification was first issued in May, 1969, although extracts from it had been passed to Vickers as and when available.

Eighteen months later we had completed the first phase of final model approval. This phase was concerned with the approval of seatings, mountings, equipment layouts, pipe systems of 1 inch outside diameter (including lagging) and above, major cable runs, floorplates and gratings. The remaining phases of final model approval are explained later.

Staff Requirements

So much for the history. Now we turn to the shortcomings that have arisen in the design and to do this we must first discuss our design philosophy.

The design philosophy was based on the Staff Requirements and those which are pertinent to the machinery installation are as follows:—

(*i*) The ship is to operate world-wide with a minimum of dockyard support between refits. It is the aim to increase the time between refits to four years.

(*ii*) The main machinery arrangement is to consist of a twin shaft, all gas turbine installation.

(*iii*) Sufficient main engine lubricating oil is to be provided for the ship to be self-sufficient between Assisted Maintenance Periods or able to effect a complete change of main engine lubricating oil in an emergency. A single lubricating oil for ship use is most desirable.

(*iv*) The main and auxiliary machinery and electrical installation is to be such to facilitate as far as is practicable the removal and replacement of whole equipments and/or sub-assemblies in a reasonable time. The installation is to be arranged to ensure proper accessibility for routine maintenance.

A four-year refit cycle calls for a very high standard of reliability and with this in mind the aim was to design the installation within the following guide lines:—

(*a*) *Redundancy of Vital Equipments*—This has been achieved.

(*b*) *Simplicity of Control Systems*—This has been largely achieved.

(*c*) *Simplicity of Pipe Systems*—This is one of our problem areas.

(*d*) *Minimum of Valves and Pipework*—One achievement in this area has been in the minimizing of underwater fittings in the machinery spaces. There are only seven sea tubes below the bilge keels in the Type 42 compared with 28 in a *Leander*. However, it must be remembered that the fewer sea tubes there are, the more pipework is required in leading systems to them.

Although we have few cross-connections compared with a steam turbine installation, we still have plenty of valves. One reason for this has been the replacement of the screw-down non-return valve by a ball valve and a swing check valve. Whereas in many instances we now have two valves instead of one—but not necessarily for the price or the size of one—the gain is expected to come in increased reliability and a lesser maintenance requirement.

For a number of reasons, which will be described later, we have not been successful in minimizing pipework.

The second Staff Requirement (*ii*) referred to an all gas turbine installation. Such an installation can almost be described as all-electric. Diesel generators and the auxiliary compressor excepted, all machines have motors and therefore starters, junction boxes, etc. There has been a great problem in siting all the necessary electrical units.

The third Staff Requirement (*iii*) called for the desirability of a single lubricating oil. This has not been possible. Three main lubricating oils are carried onboard, one for the Olympus power turbine and main gearbox, another for the C-P propeller system and a third for the Diesel generators.

The requirement for refit-by-replacement routes for whole equipments, with the exception of the Olympus power turbine and the main gearbox for which it was never intended, has been met although some of the routes are very tight. The penalty incurred is the taking up of valuable space which cannot be used for anything else. The further requirement for proper accessibility for routine maintenance has not been met in certain areas, but this requirement is difficult to accurately define and therefore becomes a matter of opinion or degree.

To sum up what has so far been said, the installation has been fully developed in the 1/6th scale model in machinery spaces, the size of which were determined before the final details and complexity of a number of equipments and systems were known. Nevertheless, a number of aims have been met, such as the provision of refit-by-replacement routes, redundancy of vital equipments, simplicity of control systems and the minimizing of underwater fittings. All this has given us an installation which, we believe, is better than any other in the Fleet today. But, we have problem areas and some of these problems must be remembered for future designs. They have come about by a mixture of insufficient guidance information, tardy development of systems with consequent poor assessment of space needed, and all this has led to congestion in certain areas, lack of proper accessibility to certain equipments and systems, and some complex and unnecessarily long pipework. Some of the details of these problems are described below.

PROBLEMS IN THE INSTALLATION DESIGN

General

General Marine Engineering Specification

It has not always been possible to conform to the specification, e.g., in meeting the correct size of fuel service tanks, in limiting pipe-bend radii, in keeping pipes 6 inches clear of the bilge and in keeping bulkhead valves adjacent to bulkheads.

Siting of Electrical Equipments (Starters, Changeovers, Switches, Junction Boxes, etc.

The full extent and size of all electrical equipments was not fully appreciated in the early days, as a result of which electrical 'boxes' have been sited wherever a space is available and in many cases to the detriment of proper accessibility.

Double-Bottom Tanks

The fitting of double-bottom fuel and lubricating oil tanks has resulted in a clean bilge line but produced the penalty of numerous manholes, vent pipes, sounding tubes, filling and suction connections, stripping connections, etc. All this has contributed to congestion in the bilges, particularly in the after engine room.

Water-Displaced Fuel System

The requirement for approximately half the fuel system to be water-displaced has aggravated the problems of congestion in the bilges by the addition of more tanks than would otherwise be necessary, together with their sampling cocks, vent cocks, stripping connections, etc. There are five chains/groups of displaced tanks with three or four tanks in each group. The total number of tanks involved is 18, compared with the 7 or 8 which would be needed if the fuel was in undisplaced tanks. Another complication in having half the fuel system water-displaced and the other half in deep tanks is that additional equipment has to be carried on board which might otherwise have been avoided; in this case both centrifuges and transfer pumps are fitted.

Pipe Runs

Due to the congestion in the machinery spaces, particularly in the after engine room, it has not always been possible to use the most direct pipe runs.

Lack of Systems Lead

In the 1960's, maintenance of salt-water systems was a big consumer of maintenance effort and resources. To reduce this work a sea-water cooled fresh-water cooling system for auxiliaries has been fitted. The fresh-water system contains a heat exchanger and a chemical dosing tank in addition to normal requirements and twice the amount of pipework that would otherwise be necessary. From this experience it seems likely that the increase in cost and complexity was underestimated. For other new construction we shall revert to direct salt-water cooling, using improved materials and closer tolerancing of design, e.g., joints, radii of bends, water speeds, etc., to achieve the necessary reliability.

We have had to build up a code of practice and the working details for the water-displaced fuel system. Fortunately, we have had to face a similar problem in the Ikara *Leanders*. It is expected that the design principles evolved will form a departmental Code of Practice to be applied and developed as a standard policy for all such systems in the future.

Fuel Control Position

Lack of space between the two pairs of service tanks has limited the size of the fuel control position and necessitated the fuel supply pipe to the forward displaced tanks passing through a service tank, thus losing more capacity.

Withdrawal Trunk

In this space the withdrawal trunk is adjacent to the bulkhead, as a result of which nothing can be sited on the bulkhead concerned nor can pipes be run across it.

After Engine Room

Congestion

As previously mentioned, the bilges in this space are very congested and proper accessibility to some equipments and systems does not exist. The area forward of the main gearboxes, which is the removal route for the oil transfer box, is very tight.

Double Bottom

In the double bottom beneath this space there are:

(*i*) One water displacement group, consisting of four fuel tanks
(*ii*) One cofferdam
(*iii*) One contaminated lubricating oil tank
(*iv*) Eleven lubricating oil storage and drain tanks.

The manholes, vent pipes, sounding tubes, etc., for these tanks have added to the congestion in this already crowded space.

Controllable-Pitch Propeller System

The complexity of this system and the difficulties of installing it within the space available were not apparent until it was almost fully developed in the model. It is now being redeveloped on a separate model.

Electrical Equipments

In this space the problem of siting electrical equipments is at its greatest and has been overcome, to the detriment of much accessibility, by the fitting of two mini and two maxi additional bulkheads.

Conclusion

In conclusion, all the shortcomings described above have arisen from compromises on or between cost, size, simplicity, accessibility, refit-by-replacement philosophy and last, but by no means least, meeting the ship programme.