

# THE MACHINERY TRIALS UNIT

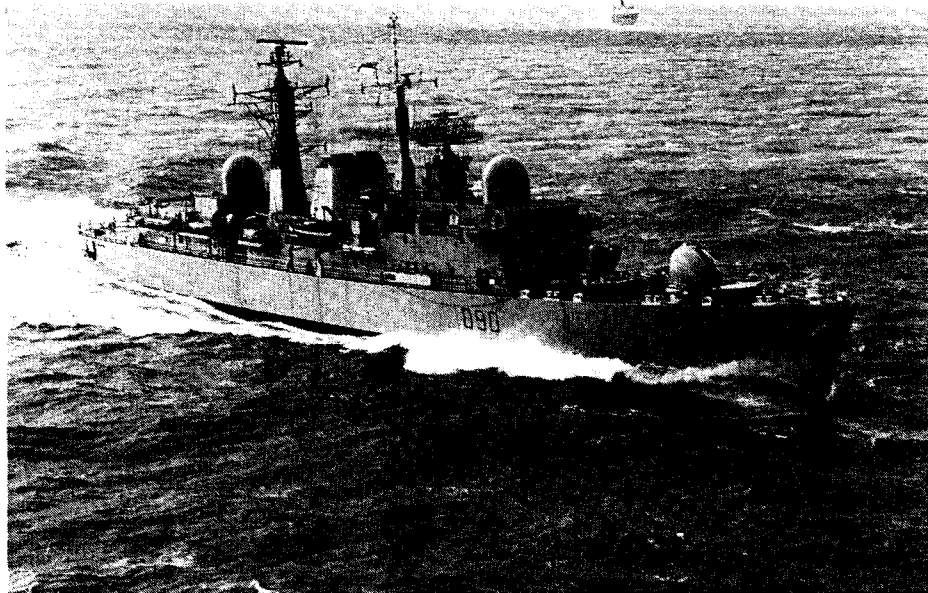
BY

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'Never accept without proof'  
M.T.U. motto

## Introduction

The acceptance of main machinery in new-construction ships has, since 1964, been the responsibility of the Machinery Trials Unit. Trials have been conducted by the MTU on practically every surface ship in R.N. service today: for the ship's acceptance, on completion of a major refit, when new design machinery has been installed, and when new performance figures have been required. In addition, the MTU has conducted acceptance machinery trials in surface ships on behalf of the Royal Fleet Auxiliary Service, the Army, the Royal Air Force, and of a number of foreign navies where the ships have been built by shipyards in the United Kingdom.

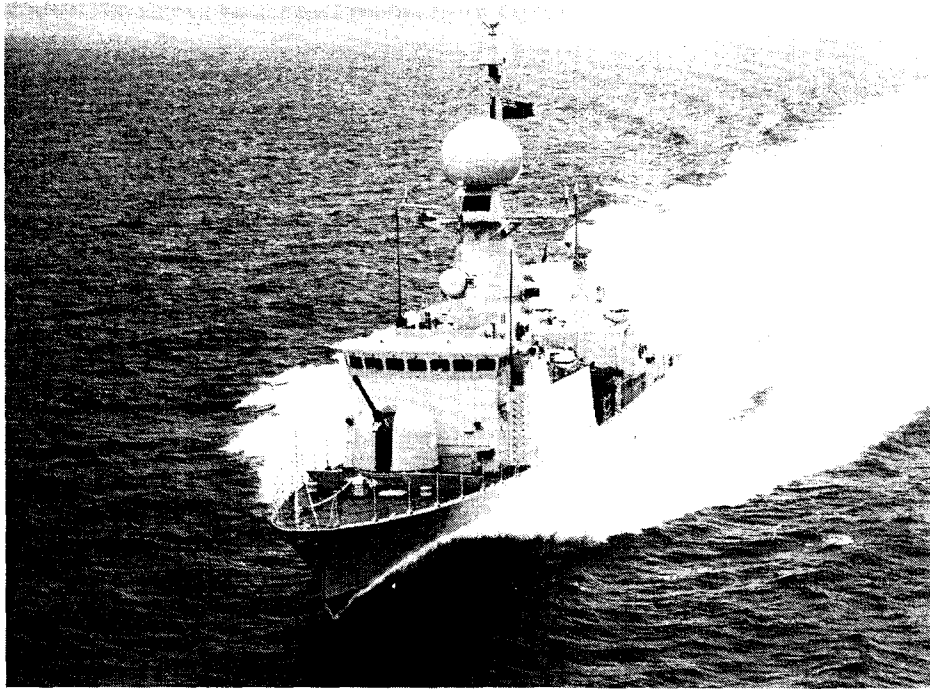


H.M.S. 'SOUTHAMPTON'

## The Past

Throughout the 1939–45 War and for several years afterwards, the acceptance trials of the main machinery in H.M. ships were conducted by trials commanders and their assistants on the staffs of the Commanders-in-Chief of the three Home Ports. Much of the detailed testing of the main and auxiliary machinery during a ship's build was conducted by the shipbuilder or his sub-contractors under the supervision of the Admiralty Engineer Overseer.

In 1960 a Board of Inquiry, appointed to investigate the failure of main turbine bearings in H.M.S. *Lion*, recorded the view that machinery trials of new surface ships should become the responsibility of the Director of Marine



RAMADAN CLASS EGYPTIAN FAST MISSILE STRIKE CRAFT

Engineering. In 1961, following recommendations made at a meeting chaired by the then Director of Marine Engineering, REAR-ADMIRAL R. S. HAWKINS, formal concurrence of the C.-in-C. Portsmouth, C.-in-C. Plymouth, and the Commodore Superintendent Contract Built Ships was given to the proposal that:

'The Director of Marine Engineering, the only Authority with full knowledge of the design, should be the Accepting Authority for the machinery of new construction ships'.

A Working Party, under the chairmanship of the late CAPTAIN P. L. CLOETE, O.B.E., R.N., was appointed by the Board of Admiralty:

'To formulate detailed proposals for an appropriate re-allocation of responsibilities and duties for the conduct of machinery trials in new construction ships (excluding submarines)'

and in 1962 the report of the Working Party proposed the setting up of a Machinery Trials Unit working under the direction of the Director of Marine Engineering on behalf of the Director General Ships. The Cloete Report recommended a number of tasks for the Machinery Trials Unit and, in some detail, defined the requirements for, and means of, accepting machinery in surface ships.

The Unit was inaugurated in May 1964, located first in H.M. Dockyard Portsmouth and then, from 1966, in its present offices at what is now called the Naval Auxiliary Machinery Division of the Admiralty Marine Technology Establishment, Haslar, Gosport.

Between 1965 and 1975, considerable discussion took place on the subject of the general requirements for assurance of quality in new construction warships (GRAQs). The aim of GRAQs was to place back onto the shipbuilders responsibility for providing a satisfactory product. Shipbuilders were required to form Dockside Test Organizations (DTOs) which would be responsible for programming and carrying out dockside trials; responsibility for conducting dockside trials of machinery, systems, and auxiliaries was, therefore, transferred from the MTU to the DTO. Test groups, consisting of the shipbuilders, PNOs, and ships' staffs were required to be set up with the tasks of ensuring

that the trials proposed, the documentation for them, and the results of the trials were in all respects satisfactory.

The official basin trial and subsequent sea trials remained the responsibility of the MTU as the conducting, recording, and accepting authority, the shipbuilder at all times being responsible for the operation of machinery and systems.

## THE PRESENT

### Definition of Terms

The Machinery Trials Unit is an outstation of the Ship Department of the Ministry of Defence and, as Section PD213, the Unit forms part of the Directorate of Post Design (Ships).

The current DGS Specification 205A entitled 'Tests and Trials Organization' states the requirements for the organization that the shipbuilder is required to set up for all tests and trials carried out during the building of naval vessels (excluding nuclear submarines).

A number of terms are defined in DGS 205A; these are referred to during the trials and a correct understanding of their meaning is necessary to understand the roles of the various authorities tasked with the presentation of trials and acceptance of ships' machinery and systems. A summary of these terms is as follows:

#### *The Contractor's Senior Representative*

The Shipbuilder's appointee on board who is nominated as being responsible for conducting the trials programme.

#### *The Master*

A suitably qualified officer who is appointed by the Shipbuilder with Ministry agreement. He is responsible for the safe navigation of the vessel and for the safety of the ship during sea trials.

#### *In Charge of Machinery*

The Authority who has the direct responsibility for the safe operation of machinery; the starting, running, and stopping of machinery; and for operating valves. In normal circumstances he is a Shipbuilder's nominee.

#### *Inspection Authority*

The Principal Naval Overseer (PNO) or his nominated representative. He will act as the Ministry's senior representative on board during sea trials.

#### *Trials Authority*

The PNO, the Head of a Ministry or other Trials Team (or Unit), or a Specialist Trials Officer authorized to accept/reject a test or trial on behalf of the Ministry. He will invariably be a Ministry appointee. Responsibility for certification on behalf of the Ministry that trial results are satisfactory is vested in the appropriate Trials Authority.

#### *Conducting Authority (in charge of Trials)*

This Authority is responsible, in consultation with the Trials Authority, for ensuring that the sequence of trials events follows the agreed trial procedure, that all the prerequisites of the trial have been achieved, that the necessary instrumentation is in place, and that the trials party is available and knows its duties. Once an acceptable set of results has been obtained within the objectives of the trial, the Conducting Authority formally presents the trial to the Trials Authority for acceptance. When a 'Sea Propulsion Test Group' is formed, that group will act as Conducting Authority for the machinery trials concerned.

*Recording Authority*

This is the Authority that ensures that appropriate records are taken and is responsible for the raising of any necessary forms and reports on completion of the trials.

*Category 1 Trials*

Tests and trials supervised by a Ministry Test Team/Unit.

*Category 2 Trials*

Tests and trials conducted by the Shipbuilder assisted by sub-contractors.

*Category 3 Trials*

Tests and trials conducted by the Shipbuilder.

*The Quality Assurance Authority (QAA)*

A Ship Department Director who is responsible, on behalf of the Ministry, for approving any Quality Plan produced and for accepting and rejecting those tests and trials which are the responsibility of the Director General Ships.

*The Quality Assurance Representative (QAR)*

The QAR is normally the PNO. The QAR accepts or rejects the results of each test on behalf of the QAA.

*Sea Propulsion Test Group*

From the Official Basin Trials, trials of main machinery may be conducted by the MTU or by a Sea Propulsion Group which will comprise:

- (a) A Shipbuilder's representative;
- (b) The MTU representing the QAR.

**M.T.U. Methods and Practices**

From the above it will be seen that the role of the MTU in the acceptance of machinery starts with the Official Basin Trial, continues through the Contractor's Sea Trials, and the Final Machinery Trials to the Acceptance Final Machinery Demonstration.

The MTU represents the QAR as the Trials Authority for these trials and is therefore authorized to accept or reject a test or trial on behalf of the Ministry. If a Sea Propulsion Test Group is formed, the MTU shares with the Shipbuilder the roles of Conducting Authority and Recording Authority; if it is not formed, then the MTU acts as both these Authorities.

**Test Groups**

The shipbuilder is required to set up a DTO (headed by a Chief of Dockside Tests and Trials) that is required to work on a Test Group System. The test group organization for dockside machinery trials consists of a Joint Test Group comprising a representative each from:

- (a) The shipbuilder
- (b) The appropriate naval overseer.
- (c) The Senior Officer/Commanding Officer of the ship.

The function of the test group includes approving test documents prepared by the shipbuilder, attending and evaluating any test or trial, and certifying on the completed test form that the trial requirements have been met.

**M.T.U. Complement**

The MTU consists of three teams:

- (a) Team 1, headed by a commander (TC1) who is also the Officer-in-Charge of the MTU, comprising a lieutenant-commander or lieutenant

(TO1), a PTO III(M) (the Trials Records Officer—TRO), a PTO III(M), and a FCMEMN(P).

- (b) Teams 2 and 3, headed by a commander (TC2), each comprising a lieutenant-commander or lieutenant as Trials Officer, a PTO III(M) as TRO, and a CMEMN(P)/MEA(P). Team 2 has an additional PTO III(M).

Office support is provided by a Trials Staff Officer (TSO), a clerical officer, and a typist.

#### **Auxiliary Machinery Demonstration (AMD)**

Experience over the years has shown that, because the official basin trial and subsequent sea trials must primarily be concerned with the trials of main machinery, there is every advantage, before the official basin trial, in the MTU witnessing the operation of important auxiliaries such as diesel generators, air compressors, distilling plants, and auxiliary boilers. The test forms for these auxiliaries may have been completed many months before the official basin trial and it is recognized that time spent repeating some trials on auxiliaries is an addition to what is usually a tight programme; the guarantee that an AMD provides, however, regarding the reliability and operation of these auxiliaries justifies the time and effort involved. On first attending a ship therefore, the MTU team may witness the performance of auxiliaries which for a frigate will take three to four days.

#### **First Machinery Inspection and Official Basin Trial**

The first contractual task of the MTU on arrival at the ship is to conduct the First Machinery Inspection (IMI); the team visits all machinery spaces and notes defects and deficiencies with the machinery stopped, the aim being to ensure that the machinery is in a fit state to start the official basin trial (OBT). As a general guide, 'good engineering practice' may be used as an acceptable standard which can, for the most part, be recognized by the shipbuilder. The more usual items arising from the IMI include pipe fouls, distorted flexibles, lagging deficiencies, inadequate bracketing and clipping, debris in uptake spaces, poor preservation, etc. Occasionally, a more startling deficiency may be observed such as 'hole in ship's side, port side aft of AER to be closed before sea trials'! The machinery space firefighting, access, ventilation, and bilge clearing arrangements are all carefully examined and any defects noted.

While the remainder of the team are conducting the IMI, the Trials Commander will carry out a Test Form Audit. A statement is prepared by the shipbuilder's Head of DTO giving details of those test form activities that are required to be completed before the OBT can be started. Test Forms Series 300 mostly apply to the main machinery and auxiliaries and the Test Form Phase 2 (system preparation, flushing, and pressure testing) and Phase 6 (functional tests or trials) will be required to be completed for all relevant machinery before the OBT. The aim of the audit is to provide the Trials Commander with a datum regarding the state of the machinery and systems; the shipbuilder may also declare any outstanding work or important deficiencies at this time.

On completion of the test form audit and of the IMI, which takes about three days for a frigate, the Trials Commander will chair a wash-up meeting with the shipbuilder and his subcontractors, PNO's staff, and ship's staff. At this meeting, defects arising from the inspection will be discussed, important defects will be noted, and the shipbuilder's intentions regarding the rectification of defects and the programming of the basin trial serials, hopefully, will be agreed.

Following the IMI, the OBT may be started provided any important defects affecting the trials or safety have been rectified. The trials requirements for the

OBT will have been agreed well before the start. The aim of a particular trial, the trials prerequisites, procedures and conduct, limitations, and records required are documented in a Trials Requirement Form which will have been written either by the shipbuilder or by the MTU. If written by the shipbuilder, the trials requirements forms will have been agreed by the MTU. The quality of this documentation is of fundamental importance when it comes to conducting the trial and deciding whether it is successful. If written by the MTU, documentation for any trial will be forwarded to the PNO and ship's staff six months before the trial is programmed to take place—it is for the PNO to pass the requirements to the shipbuilder.

It is, of course, the task of the MTU to accept the machinery presented for the OBTs and it is the practice, therefore, for all of the trial's serials to have been conducted by the shipbuilder and for the Naval Engineer Overseer to witness a basin trial before the MTU arrive for the OBT. For a frigate, the OBT takes about five days; the time spent with shafts turning may be affected by the tides but the aim is to conduct all those trials on main machinery, steering gear, stabilizers, etc. to an agreed limit in the harbour condition to ensure that the machinery is in a fit state to proceed on contractor's sea trials (CSTs) and that there is no reason to doubt that the CSTs will be successful. The MTU team will usually man all the main machinery compartments for the main machinery trials, and the Trials Commander will be in the control room with the shipbuilder's representative presenting the trials. The machinery controls trials team (MCTT) support the MTU and will, in fact, have attended the Phase 6 Test Form Trials of the control system, panels, etc.

The trials instrumentation is checked and records are taken to ensure that sensible readings are being taken. Ultimately for the OBTs, there will be a requirement to turn the shafts ahead and astern at a maximum agreed speed for approximately half an hour in each direction, to witness important overspeed trips, and to demonstrate machinery operations, engine changeovers, and emergency procedures from all possible control positions. At the end of each day of the OBTs, a wash-up will be held whereat the Trials Commander will express his opinion regarding the acceptability of the trials that have been presented and the defects arising will be discussed. On completion of the OBTs, a final wash-up meeting is held when any actions necessary before CTSs will be agreed. Subsequently the Trials Commander will write a detailed report of the trials and inspection and this is circulated to all responsible authorities. Items requiring Ship Department action or approval are reported to the Post Design Directorate; and items requiring action by the shipbuilder are communicated to him through the overseeing staffs.

### **Contractor's Sea Trials**

The contractor's sea trials (CSTs) usually take place within a month of the completion of successful OBTs. The MTU team returns to the ship to conduct a second machinery inspection (2MI); this is similar to the IMI but has the primary aim of ensuring that the safety of machinery and personnel during CSTs is adequate and that important deficiencies arising from OBTs, etc. have been rectified.

CSTs, defined as Part 2 of the Build Programme, consist of a series of manoeuvring trials, engine changeovers, steering gear and stabilizer trials, emergency operations, etc. culminating in full-power trials of four hours duration (for COGOG ships, these would be on Tyne and then on Olympus engines). Distilling machinery trials are recorded and the MTU, as Recording Authority, subsequently completes Forms D560—Report on Distilling Machinery Trials. For the full-power trials, Forms D408/S346 are raised by the MTU from the readings taken during CSTs. CSTs are usually a very

intensive period, the shipbuilder is anxious to achieve the minimum disruption to his build programme and the MTU need to see that the specified standards are met. CSTs are also very expensive: for a modern frigate, a cost of £30 000 a day excluding fuel costs has been quoted.

As for OBTs, the trials requirement will have been agreed with the Ship Department and the MTU beforehand, and comprehensive trials requirements forms are written by the MTU or the shipbuilder to cover all aspects of the trials. Again, the trials documentation is of fundamental importance for it is essential that the specified performance parameters are stated, required records are listed, and the procedure for the conduct of the trials is fully detailed.

Accurate instrumentation for the trials records and measurement of plant performance is absolutely necessary and measurements of torque, shaft speeds, temperatures, etc. require to be known for any trial to be valid.

During and on completion of CSTs, wash-up meetings will be held at the final of which the Trials Commander will pronounce on the acceptability of each of the trials that have been conducted. The Trials Commander will also agree with the NEO a list of machinery to be examined during the post-CST docking period. In addition to routine inspections such as of heat exchangers, underwater valves, and gearing, this list will include items arising as a result of the trials.

A full report of the CSTs as for the OBTs is circulated to the responsible authorities about three weeks after completion of the trials.

### **Final Machinery Trials**

Part 3 of the build programme is the period between CSTs and ship acceptance. On completion of the examinations and docking in this period, the MTU will return to the ship for a third machinery inspection immediately before the ship sails for final machinery trials (FMTs). FMTs are conducted to prove that machinery has been correctly assembled after examination; the FMT period also provides an opportunity to repeat any trials or to conduct any that are outstanding from CSTs.

The various inspections and trials conducted by the MTU are now detailed in NES 351–354 for which the MTU is the sponsor section.

### **Acceptance**

At this stage of the ship's build, the MTU involvement is almost completed. The Trials Commander will attend the Terminal Date Inspection (TDI)—the Terminal Date being defined as 'all work complete except for final clean and paint'—and will advise the Commodore Naval Ship Acceptance, who conducts the inspection, on all aspects of the main machinery performance, appearance, and acceptability. A preliminary reading of the D448 is held at the time of the TDI when a list of outstanding work and defects is presented by the PNO at a meeting chaired by CNSA when the shipbuilder's intentions regarding the work to be done are stated.

The Final Inspection (FI), conducted by CNSA, will also be attended by the Trials Commander and the first reading of the D448 usually takes place on the day following the FI.

By this time the ship will be complete, sparkling, and ready for acceptance into R.N. service. A team from the MTU headed by the Trials Commander conduct, with the shipbuilder, a Final Machinery Demonstration which is a short formal presentation of the ship at full power; manoeuvring and steering gear trials are briefly demonstrated and the Trials Commander should be able on completion to advise CNSA formally, by letter, that acceptance of the main machinery is recommended. It is usually the practice for the shipbuilder to

deliver the ship to her base port when CNSA accepts the ship and, at last, the ship's staff can operate the machinery themselves and, in due course, after the Part 4 programme, demonstrate their ability to do so to the Flag Officer Sea Training.

### **Post-refit Trials**

In addition to new construction ships, the MTU is tasked with conducting acceptance trials of main machinery and of major alterations and additions after a ship's major refit or refit by contract. The methods employed are very similar to new construction: an inspection, a trial, a wash up, and a report. The MTU will almost invariably provide the trials documentation although for As. and As. the specialist section of the Ship Department may do so. The MTU will act as the recording authority raising the required D and S forms for full-power trials, etc.

### **Portscript**

As an appointment, working for the MTU is interesting, exciting, exhausting, and sometimes a little disconcerting; the variety of machinery fits in various ships—ranging from four-shafted fast missile craft built by Vosper to bow thrusters and Voith Schneider propulsors in H.M.S. *Challenger* being built by Scotts—demands a certain flexibility of outlook. However, a sense of fulfilment and achievement is felt when a ship is accepted to the required standards, sometimes after considerable effort.

The MTU is not a setting-to-work organization but an instrument whereby the Royal Navy accepts ships into service. There are many advantages in having a separate authority, with knowledge of the shipyards and often of ships of the same class, to accept the main machinery in surface ships of the Royal Navy; the MTU has the experience and ability to do the job and to ensure that the best possible performance standards are achieved and maintained.

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