STANDARDIZATION IN 1906

The following is an extract from an article entitled 'Warship Engineering,' by C. De Grave Sells, M.Inst.C.E., published in the 1906 Edition of Jane's 'Fighting Ships.' It is now reproduced by permission of the Publishers.

At the commencement of this article reference was made to the enlightened policy of the Engineering branch of the British Admiralty, as evidenced by their decided step of progress in the adoption of turbine engines on such a large scale. The fact of such a decision is generally known and is certainly approved by most practical and unprejudiced engineers.

But there is a step that this authority has taken with regard to reciprocating engines, which although less generally known, is nevertheless every whit as much a mark of progress and deserves as much to be chronicled, and which, although its results may not be immediately apparent may possibly have a tremendous influence on the eventual result towards the end of a conflict, should the British Empire be engaged in a desperate and prolonged struggle.

From time to time the general idea of standardization had been given close and serious attention, as from a military point of view it held out promises of many advantages.

It is certain that outside the Admiralty itself, all professional opinion was against standardizing propelling machinery, but it must be borne in mind that not only was there no experience of its feasibility, but also that owing to the lack of any regular system of shop gauges, and absolute definite accuracy in working to dimensions with this class of work, there was in many cases an antagonistic feeling against such a practice, due to trouble already experienced in meeting the requirements of the Admiralty as to the interchangeability of the pieces of spare gear. And directly the subject was brought forward many were the objections urged against it. It must be remembered that the underlying principle of the contracts for propelling machinery has ever been that the builders of the machinery are entirely responsible for its fulfilling all the conditions of the specification, and also for the efficient working, durability, safety and efficiency of the various parts. The specification gives the outline of the project and also the minimum dimensions and strength which are considered necessary, but in every case the contractor is held liable not only for any variation, but also that the conditions of the contract are sufficient.

It will therefore be seen what a serious question was involved in any general standardization of the machinery for any given class of vessel, for it would almost seem that a wholesale reversal of the old conditions would be necessary, and if the several makers were to adhere to a certain dimension for any given

part, it would appear as if it would fall to the naval authorities to decide what that said dimension should be, and thereby relieve the contracting firms of all responsibility in the matter so far as design and strength were concerned, leaving them only the matters of quality of material and workmanship to be responsible for.

In addition to this there was involved the no less serious question of the various practices of the different firms, each one based on its own experience, in some cases extending over a long period of time, and which of course each one considered to be better than that of other firms, and in consonance with which their shops were laid out and their business carried on.

These are but the outlines of some of the objections to such a change as was contemplated, the magnitude of which can only be properly realised by those who have had experience of the direction of large engineering or other industrial establishments.

However, the advantages of such a scheme were so very great from a military point of view, that it was eventually decided to make the experiment and to standardize the propelling machinery for the vessels of the ' Duke of Edinburgh ' Class, which are developments of the six vessels of the ' Devonshire ' Class.

The engines are similar to those of the cruisers of the ' County ' Class, being four-cylinder triple expansion of 3 ft 6 in stroke, running at 135 to 140 revolutions per minute when developing 23,500 h.p., their full power. Their machinery was unfortunately decided on in accordance with the recommendation of the Boiler Committee, that a combination of one-fifth cylindrical boilers should be fitted with four-fifths of water-tube boilers, these latter to be one of the four specified types that they favoured. Consequently the steam pressure was limited to 210 lb per sq in, and they carry 140 tons more weight in machinery than they need, and with this develop some 1,500 less h.p. than they would have done had a more rational policy been adopted.

When the decision to standardize the machinery had been come to, that for the *Duke of Edinburgh* had been ordered from Messrs. Hawthorn, Leslie of Newcastle, and that for the sister vessel, the *Black Prince* from the Thames Engineering Co. of Greenwich. As soon as it was decided to make these sets of machinery identical and interchangeable, a conference took place between Admiralty officers and representatives of the two firms, which was presided over by the Controller of the Navy, and at which the Engineer-in-Chief of the Navy was present.

It was eventually decided that the respective firms should retain the full responsibility they assumed under their contract, and they agreed to make the following parts interchangeable in their two ships.

(*a*) Main bearing frames and the back and front columns.

(*b*) Cylinders, cylinder covers and pistons.

(*c*) Piston rods, connecting rods, etc., glands and metallic packing.

(*d*) Slide valves, slide rods and slide valve gear, including eccentrics, eccentric rods, weigh shafts and reversing gear.

(*e*) The shafting, thrust blocks and tunnel bearings.

(*f*) Propeller bosses, and flanges and bolts of the propeller blades.

(*g*) Boiler fittings and steam pipes as far as possible.

Thus it will be seen that broadly speaking, the whole of the parts of the machinery which it would be at all advantageous to make interchangeable were included in the arrangement.

As the manufacture of the machinery progressed, frequent conferences were held between an engineer officer specially appointed by the Admiralty, and the managers of the engineering works, and the various incidental questions were discussed and disposed of as they arose. Amongst other interesting decisions come to were the following :—

(*a*) In all cases of driving fits, the part that is to be a driving fit on another part should accompany that part, and as far as interchangeability is concerned, the two parts are to be regarded as one piece.

(*b*) In cases where a definite clearance or allowance for working has to be made for parts which move on one another, the work is to be carried out to interchangeable gauges for certain specified parts, leaving the constructors free to adopt their ordinary shop practice for the corresponding parts.

(*c*) All minor fittings, such as cocks, small valves, unions, etc. are to be regarded as a whole, and the constructors may adopt their usual design for such fittings.

But it is hard to fully realise the infinitude and large scope of the discussions that were necessary and the matters that came up for decision. Take for example the case of the connecting rod. Was it to be regarded as a whole, and in case of need was it considered that the entire rod should be changed and another substituted, or was each of its component parts to be so duplicated that any one part could be substituted for its corresponding part of any rod, and on either ship ?

In the first case one large and costly gauge would be necessary, whilst a large number of smaller ones would be sufficient in the other case. And again in the case of the brasses, would it be considered sufficient to have the diameter and length of the bearings of the brasses and their width, length, and thickness to gauge, or must they be of identical form and dimentions in every respect ? Or take the bolts, was it sufficient that they should be of the correct diameter to go into place, or was it desirable that they should exactly correspond all over, and even the heads also be made to gauge ? And the external dimensions of the caps, was there any reason for making these identical ? And the diameter of the stump ; should this also be made exactly to gauge ? This will give but a faint idea of the many questions that came up for settlement some of which could be decided by a definite line of action laid down at the commencement and a common sense reasoning, but there were others for which there was as much to be said on one side as on the other, and which required very considerable discussion before a decision was come to.

To put into effect the arrangements come to, over 1,800 templates and jigs of various forms and description were devised and constructed by the two firms concerned, the drawings for them being sent to the Admiralty for examination and approval. But this by no means represents the extra work involved by the adoption of the new system for the drawings of the machinery itself now had to be consulted on by the two firms, and a definite arrangement come to about them before they could be sent to the Admiralty ; and as they were now based on a combination of ideas and not on the regular practice of one firm, they in many cases embodied features new to one firm or the other, so that the preparation and examination of the working drawings entailed a large amount of extra work for all concerned, and as it was imperative not to delay the actual manufacture of the machinery, it was mostly done at very high pressure. As regards the auxiliary machinery, not only were the parts of the different engines to be made interchangeable, but it was also required that it should be possible to take an engine from one ship and put it in another, and

that it should go directly into place, and be capable of being fixed and all the flanges of steam, exhaust, suction, and delivery pipes, be able to be coupled up without trouble or loss of time. It will be seen at once that this required not only a very accurate template, but also one of considerable size. This part of the work was somewhat simplified by it being decided that the practice of 'handing' was to be done away with, and all auxiliary machinery made to one hand only, the arrangement of pipes on the second side of the ship being modified to suit.

The special appliances made for standardizing the machinery, ranged from templates large enough to cover a section of the main bedplate, to gauges for such small articles as condenser tube ferrules, and the actual manufacture of them was divided between the two firms. It was arranged that whatever gauge or template one firm elected to construct, the same firm should also make the duplicate for use in the works of the other firm, and every one of the gauges and templates was verified, both as to its accuracy and agreement with the drawings by the engineer overseer before it was put into use.

The various arrangements described had all been settled and got into working order, and the actual work of construction was in full swing, when tenders were issued by the Admiralty for the machinery of four other vessels of the same class. The conditions stated that they were to be in all respects identical and interchangeable with those under construction for the *Duke of Edinburgh* and *Black Prince*, and that they were to be made to sets of gauges and templates, similar to those already in use by the constructors of these two sets of machinery, and which would be furnished by them. For the purpose of tendering, the competing firms were furnished with copies of the plans which were already being worked to, and they were asked to guarantee the machinery results to be obtained, in a precisely similar manner to that which had obtained before.

The orders were placed as follows :—

For the machinery of the *Cochrane*, Fairfield ; for the *Natal*, Vickers ; and for the *Warrior*, Wallsend ; whilst for the *Achilles*, a repeat order was given to Hawthorn, Leslie ; and it is well worth placing on record, that within 15 months of the putting into practical shape the decision to standardize the machinery of British warships, there were six sets of engines of 23,500 h.p. being made in five different parts of Great Britain, which were all precisely similar, and identical in all their parts. Note should also be taken of the remarkable goodwill shown by the firms concerned and their officials, and the results fully prove the honest desire manifested by all concerned to make the scheme a thorough and practical success.

In constructing such large sets of engines, in which every endeavour was being made to economize space and weight, from the joint design of two firms 300 miles apart, it would not have been surprising if some fouling of parts had been found when it came to the fitting together and erecting, but thanks to the extensive and thorough examination made of the designs, both by the firms themselves and the Admiralty officials, no trouble of this kind manifested itself.

The placing of the repeat order with Messrs. Hawthorn, Leslie was of considerable advantage in affording a very good test of the immediate benefits of the system of standardizing, and the actual value of the templates and gauges adopted to carry it into effect. So well was the purpose fulfilled, that parts were machined and finished without any reference at all as to which place or which ship they were intended for, and thus a considerable saving of time was effected, and the construction of the second set of engines was rapidly carried out.

During the progress of the work there were of course many cases in which material that could perfectly well have been utilized under the old conditions, by a slight modification of the corresponding part, had to be put on one side as it would not hold up to the required size, and therefore could not be made to fulfil the requirements of interchangeability.

It is worthy of note that the use of the gauges was found to cause a very material improvement in the standard of workmanship, and not only that, but a very considerable saving of time was effected by the less work required in fitting the various parts together ; this was very noticeable indeed when it came to erecting the engines.

When the manufacture of the gauges was completed, and the construction of the six sets of engines well advanced, a special report was made to the Engineer-in-Chief and the results of the experiment were summed up. It was stated that all the jigs and most of the templates had been found to be necessary for the special object in view, but that most of the gauges and a few of the templates were only such as should form part of the regular equipment of a modern establishment for the construction of warship engines, and therefore should not be regarded as especially necessary for standardizing.

The extra cost of the machinery due to the new system was about £10,000 per ship which is about 4 per cent on the total cost of the engines and boilers, but this amount has already been reduced to less then 3 per cent in the case of more recent engines of somewhat greater power which are to be built under similar conditions, and this will certainly be still further reduced in future. It is probable that the addition of such a sum to the cost of the machinery, will lead the authorities of many navies to decide against its adoption, but given the fact that the one aim of a war vessel is that it should be an effective fighting machine, and that the object of a navy should be to prepare for the day of battle, and not for one combat only but for many, there can be no doubt that the immense advantages obtained from a military point of view are worth considerably more than the extra outlay involved. Not only will there be very material advantages in wartime, in the case of several vessels on a station having identical machinery, but even in the case of one vessel only of its kind the advantage of the new system is very great in the facility and saving of time, in which parts could be replaced from home in time of need, and be fitted in place on arrival without trouble or loss of time.

Note.—In evaluating the degree of standardization and interchangeability achieved at that time, it should be noted that the Engineering Standards Committee (which was then in existence and has since become the British Standards Institution) had only been set up five years earlier, in 1901, and had to date published only 24 specifications.

It was only in 1906 that Report No. 27 on a British Standard system for limit gauges was issued and it is therefore understandable that the decisions recorded on page 233 (a) and (b) were taken.