Slim & Trim

For a yard an obese yacht is bad news indeed as speed targets fall by the sea trials' wake-side and boot tops slide beneath the briny, while lawyers start re-reading penalty clauses. Almost seen as a black art, Peter Mitchell, Principal Consultant Naval Architect at Burness Corlett Three Quays (BCTQ), details here the how and why of weight control management and the actual technique – not art – of slimming the superyacht.

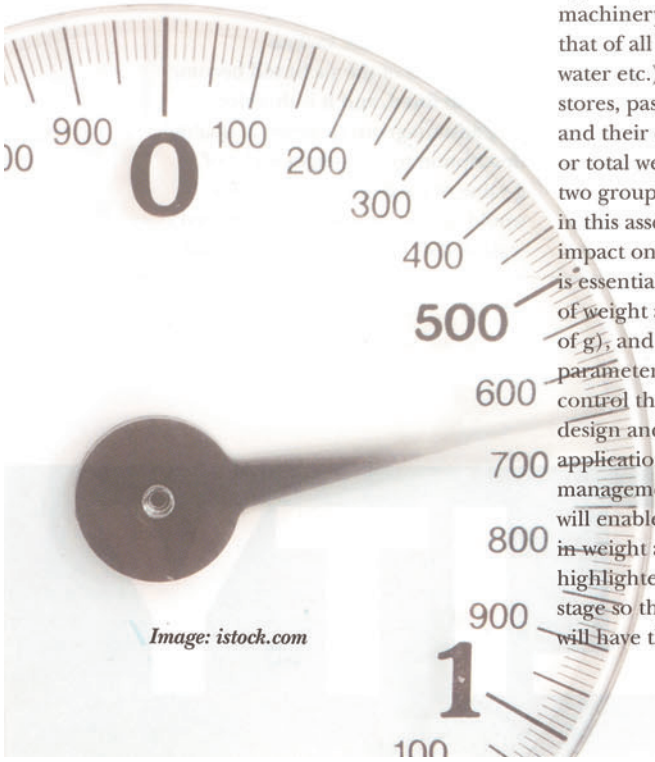


Image: istock.com

A key part of the design development process of a new one-off custom-built yacht is an early assessment of the lightship weight and centre of gravity (with suitable margins), combined with generating satisfactory loading conditions. The lightship comprises the hull and machinery, whereas deadweight is that of all liquids on board (fuel, water etc.), tenders and water toys, stores, passengers/guests and crew and their effects. The displacement or total weight is the sum of these two groups. The assumptions made in this assessment will have a lasting impact on the final outcome, so it is essential to make a good estimate of weight and centre of gravity (c of g), and then to ensure that these parameters are kept under firm control throughout the remaining design and build process, through the application of an effective weight-management system. Such a system will enable any undesirable trends in weight and centre of gravity to be highlighted at the earliest possible stage so that any corrective actions will have the best chance of success.

Burness Corlett Three Quays (BCTQ) stresses the potential consequences of poor weight management, particularly in the case of a single one-off design. The owner will want to be assured that his yacht will be able to achieve the speed and range he asked for; that he will be able to enter certain harbours or restricted waters with minimal trim and have the capacity for a degree of future growth in weight. If the lightship weight exceeds the initial estimates, then the deadweight will need to be reduced if the draft is to be maintained, with a consequent reduction in range – since by far the largest component of deadweight is fuel.

If the longitudinal c of g of the lightship is much different from that estimated, some form of ballast, whether permanent or not, will be needed to correct the trim. This will in turn increase the displacement. If the ballast causes the maximum draft to be exceeded, the deadweight will again need to be reduced. It is quite possible to design a yacht that needs no ballast for stability reasons. Instead one transfers fuel as it is consumed

INSIDE ANGLE

Lead shot ballast in stern

Our role is to satisfy ourselves that a yacht as shown by the designer's arrangement drawings will meet all the technical requirements of the owner and regulatory authorities.

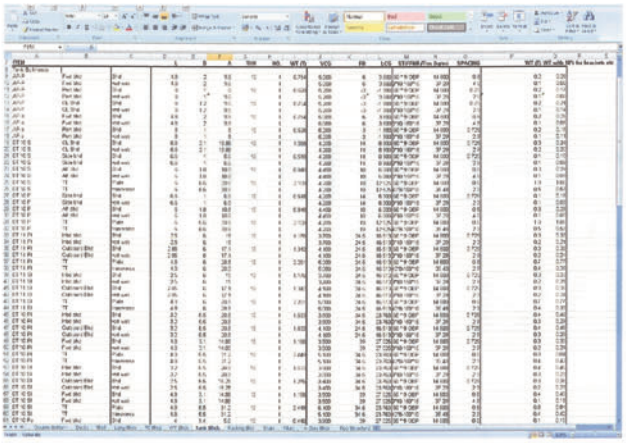
to maintain trim. So any inclusion of ballast will imply a poor design. Corrective measures to lightship weight and c of g, if determined at a very early stage, can include increasing buoyancy forward or aft. Later on in the project, when it is too late to change the hull form, it can be possible to substitute some parts of the yacht by lightweight components. Any of these options will, of course, carry a price tag.

A common process in arriving at a contract with a shipbuilder will involve the above close liaison between designer and naval architect consultant, and we have frequently taken the latter role combined with input from our marine engineers. Our role is to satisfy ourselves that a yacht as shown by the designer's arrangement drawings will meet all the technical requirements of the owner and regulatory authorities. Included in this assessment would be verifying the lightship weight and c of g locations against the large number of yachts in our database. This provides a high level of confidence in the project's viability. We would then prepare a technical specification and assist the owner in the process of selecting a suitable shipyard to build the yacht.

At this point – the awarding of the shipbuilding contract – the responsibilities for design must be fully understood by all concerned. The responsibility of ensuring that the yacht will meet all the technical requirements will be taken over from us (as the consultant naval architect) by the shipyard, so the shipyard must satisfy themselves, before signing the contract, that they can indeed design and build a yacht meeting all the requirements. We would then take up the role of providing technical assistance to the owner through plan approval, witnessing model testing, on-site supervision and attending tests and trials. The designer will continue to develop the interior design after contract award until an interior design and build sub-contract can be awarded by the shipyard, so he and the shipyard will need to agree on space and weight limitations to enable the design of the remainder of the yacht to be progressed.

Once the shipbuilding contract has been awarded the shipyard should (among of course many other key tasks) set up a weight-management system. This should enable active control of all weight aspects of the design and build. It is sound shipyard practice to have a project work breakdown structure for the whole vessel on which all activities from design through procurement to construction is based. By basing the weight-management system on this structure a reliable and complete weight database can be maintained which will ensure its ability to provide a credible prediction of the final lightship weight and centre of gravity.

As the design is developed, information on the various components of the yacht will become better defined, and it is therefore very advantageous to assign a 'quality' description to the weight and c of g value of each component. This would, as a minimum, be 'estimated', 'calculated' or 'weighed', and detail



Weight management spreadsheet

whether the data were provided by the shipyard, sub-contractor or supplier. These qualifications will then allow the trend in weight quality to be tracked on a continuous basis, and to highlight any areas which have not improved in line with expected design development. Control of weight data can be more difficult when provided by sub-contractors, so it is beneficial for the shipyard to agree weight limits within their spec and contract with the sub-contractor.

Suitable margins are always included for both weight and c of g at the design stage, and these can reduce in magnitude as the design progresses and levels of confidence in the weights increase. The process of assigning weight qualities can assist greatly in assessing the overall levels of confidence. This process should continue right up to delivery of the yacht, but the first inclination test once it is afloat will of course prove if the weight management system has functioned well (or not!).

The BCTQ project manager at the shipyard will of course want to know if there is a worrying trend in the weight, but in any event a weight report should be prepared internally on a regular basis up until delivery. Many shipbuilding contracts also require the shipyard to provide the owner with a weight report usually on a quarterly basis. This may occur more frequently if weight is a particularly critical feature of the design such as on a high-speed yacht.

These reports should be accompanied by the corresponding key loading conditions demonstrating compliance with trim and stability requirements. Weight reporting should process upwards from the originator to section leaders through to a weight coordinator, who in turn should report directly to the project manager. The weight coordinator has the responsibility of combining all the data from the various input sources into a manageable document, from which the regular reports can be prepared

Contract variations (VTC) are an inevitable part of shipbuilding, and the way in which they are to be handled should be described in detail in the contract. This should include a statement of the effect of any proposed changes on the vessel performance including weight before agreement is reached on the variation. An efficient and functioning weight-management system will be able to provide important data for such VTCs.

The weight management system should form an integral part of the shipyard's quality management system (whether formal or not), and should therefore be subjected to regular auditing to ensure all concerned in the process are carrying out their required responsibilities. We have carried out several external audits of different shipyard weight-management processes, and from that experience have been able to assist in improving the systems as well as helping the shipyard and 0wner find solutions to weight problems in the design.

In conclusion, therefore, it is of paramount importance that weight management in a yacht's design and construction is undertaken by experienced and qualified personnel.

Peter Mitchell
Burness Corlett Three Quays

Images: Burness Corlett Three Quays

To comment on this article, email issue114@synfo.com with subject: Slim & Trim