# Royal Ocean Racing Club
# Rating Office

**Subject:** Establishing bulb weight
**File Ref:** Measurement Bulb Weight 150805(3)
**Date:** 5th August 2015

For several years now we have required bulb weight to be provided for keel types 10, 11 and 12.

There are several methods which may be used to establish this, with varying levels of accuracy and reliability.

**1. Weigh the bulb.**
This is the ultimate check for us. The bulb needs to be weighed separately from the keel fin, normally at a stage of manufacture and normally this is only possible when a new keel is being assembled. This needs to be done in exactly the same way as boat weight, using a single point lift with an appropriately calibrated and tested load cell. Allowance may need to be made for lifting eyes and corrector weight pockets, along with any additional lead that may be fitted into the fin to bulb recess.

This is generally only an option for top level programs of new builds, and is not something we can rely upon being an option in most cases.

**2. Designer/builder declaration.**
Most boat builders these days will be purchasing the keel from a sub-contractor. In these cases it is common practice for the principle builder to require proof of weight in the purchase agreement so that they can confirm they have got what they have asked for and that it coincides with the designer's specification. Similarly, the designer will have a target weight for the bulb even if they have not required proof of weight.

Again, whilst this information is likely to be somewhere for most boats with these keel types, records of it may be difficult to obtain for older builds and where modifications have been made. We also never really know whether an owner has filled or emptied pockets, or altered the bulb. And often the original designer and builder may not be aware of changes made. It is however a good reference point and in the vast majority of cases will represent the actual bulb weight well.

**3. Volume measurement.**
This can be completed in several ways. I have tried to list these in order of simplicity of measurement. But each situation will present different issues and a combination of methods will hopefully validate each other.

a) Immersed volume
When the boat is being weighed and is over the water, ask the crane driver to hold the boat with the bulb only immersed. Record the boat weight in this position and when completely clear of the water. The difference in weight will give you the immersed volume of the bulb. Provide this information with the measurement data. Quite simply, if the difference in weight is 1000kgs and the weighing is done in saltwater then the water density will be approximately 1025kgs/$m^3$. As such the corrected volume would be 1025 litres. The density of pure lead is 11340kgs/$m^3$. However, including the normal 1.5% antimony and other naturally occurring impurities it is unlikely that the density will be higher than 11000kgs/$m^3$. As such the calculated bulb weight for this volume would be 11000kgs.

b) Measurement of volume

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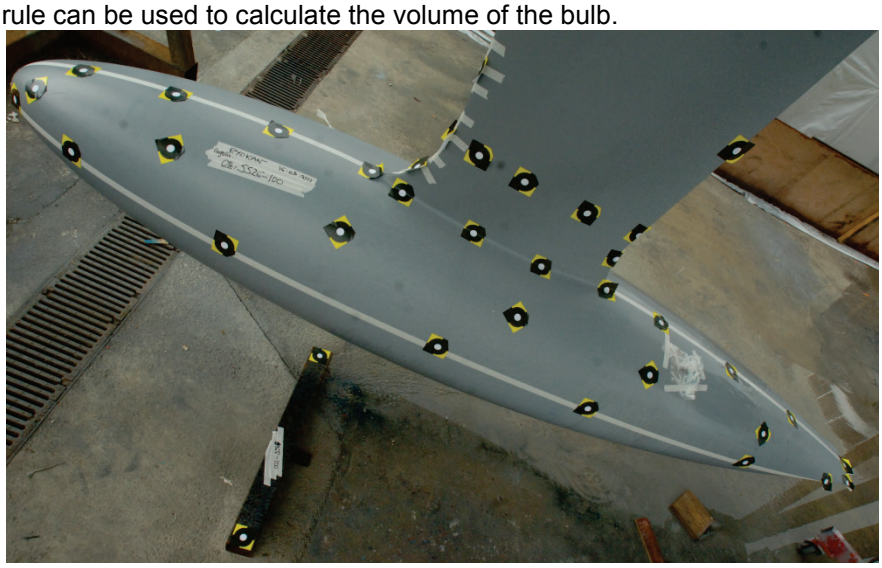
There are several methods that can be used, from the more complex approach of a full laser scan or photogrammetry (photo below) to simply measuring length and circumference at selected points along the length. From this a combination of cross-sectional area and Simpsons rule can be used to calculate the volume of the bulb.



The inaccuracies in these method are:

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|---|---|
| Density of water estimated. | This can be overcome by using a hydrometer and measuring the density. Does not apply to method b). |
| Density of the bulb. | This needs to be estimated. However, deviation is likely to be small. |
| Unaccounted pockets. | There are likely to be voids in the bulb for attachments and possible adjustment pockets. If detail is known of these then they can be accounted for. |
| Internal structure. | Some keels may have internal steel cages. These will reduce the density slightly, but it is best to ignore these unless details are available. But if details are available then we will likely also have full bulb weight details. |
| Defining the top of the bulb. | With a sharp intersection of the bulb to fin joint this is easy to establish. But with a large radius then some assessment is needed. Best to stop the crane at the bottom of the radius, as the joint is likely to be primarily filler and not made of lead. |

For clarity, we consider the definition of the bulb in the following way:

IRC Bulb Weight refers to the **Bulb** as defined by the ISAF Equipment Rules of Sailing. This document is provided as clarification that all under-fin spacers and in-fills shall be included in the total Bulb Weight.

The ERS defines Bulb as

E.1.2(e) A **hull appendage** containing **ballast** at the bottom of another **hull appendage** primarily used to affect stability.

Ballast is defined as

C.6.3(e) Weight installed to influence the stability, flotation or total weight of the boat.

E.1.1 defines Hull Appendage as

**Hull Appendage** Any item of equipment – including the items listed in E.1.2– which is:

• wholly or partly below the **sheerline** or its extension when fixed or when fully exposed if retractable,

• attached to the **hull** shell or another **hull appendage**, and used to affect: stability, leeway, steerage, directional stability, motion damping, trim, displaced volume.

And clarifies that:

Any of the following shall be included in the **hull appendage**:

• **corrector weights,**

• integral **ballast**, and

• associated fittings.

**Therefore, all under-fin spacers and in-fills shall be included in the total Bulb Weight.**