INTERNATIONAL 420
CLASS ASSOCIATION

HULL MEASUREMENT GUIDE

Version 1.0
DECEMBER 2005

This guide is not part of the class rules and it is not meant to replace them in any way. Its sole purpose is the explanation of the new hull measurement system, first introduced in the 2003 edition of the class rules. The various tools described below are not the only ones that may be used. Measurers are encouraged to find other easier ways to measure hulls with the same or better accuracy, and this guide will be updated to include novel ideas when they become available.
Certain diagrams are taken from the 1986 IYRU Measurement Manual, and the upcoming ISAF Guide to Measurement.

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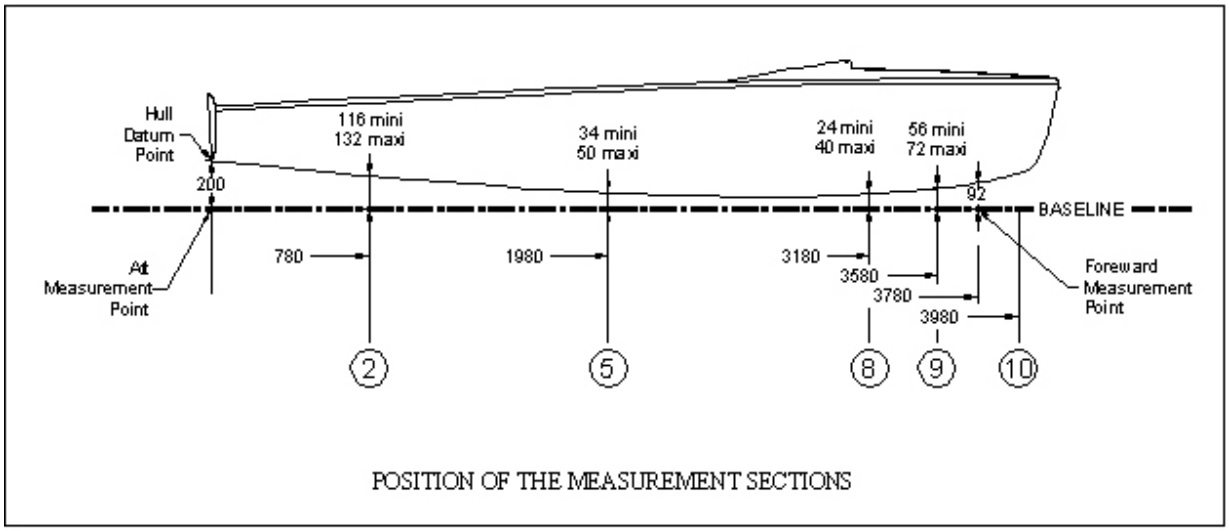
Acting Chairman,
Int. 420 Class Technical Committee

1. BASELINE DEFINITION

The main difference between the new and the old hull measurement system is the definition of the hull baseline:

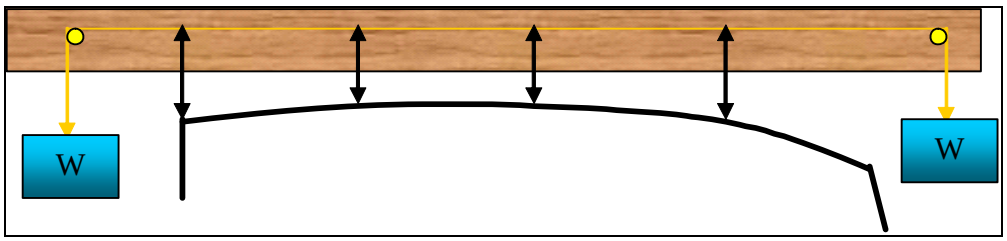


POSITION OF THE MEASUREMENT SECTIONS

The baseline is now defined as a line passing through a point 200mm under the HDP, and another at 92mm under the hull surface but at a set distance of 3780mm from HDP. Therefore, the baseline for every hull can be found easily and with great accuracy, and most importantly, the repeatability of the setup is guaranteed.

There are various tools and methods that may be used to set up the baseline:

- A lightweight and thin thread, tensioned at both edges by suspended weights. It may be combined with a beam, as shown in the next diagram:



The sag in the middle of the span is small if the line is light and the weights heavy enough. This system is not very easy and fast to setup correctly, but it is very easy to transport from place to place.

- A laser-drawn line using a surveyor's level or a simple laser level. This system is not recommended as it is time-consuming to set up and not easy to work with.

- Specially-built jigs may also be used, especially for normal production measurement and if there is enough free space at the boat builder's premises.

- A straight beam of wood or aluminum. The section should be rectangular and as light and stiff as possible. Wood is not recommended because it may warp. Aluminum sections should be high and thin-skinned, to increase the stiffness and decrease the weight of the section, and stored carefully to avoid permanent deformations. Sag in the middle is always present due to self-weight of the beam, but with the correct selection of section it can be minimized. For example, a 60mmX25mmX2mm aluminum section (height X width X skin thickness) sags about 0,75mm in the middle of the span in the case of a 420 hull (3780mm/2=1890mm from HDP). This is the

maximum found, and in other stations towards the ends of the hull it will be much less. Therefore, the measurer can take these figures into account when measuring a hull. All measurement stations can be clearly marked on the beam along with notes such as the minimum and maximum limits, and a steel tape can also be fixed on the upper surface for quick reference. Obviously this cannot be done in the case of the thread baseline. The aluminum baseline may be made in two or more pieces with proper joining systems, so its transportability is acceptable (for the 420, three pieces of less than 1,50m each are enough, and they fit easily in a car or ever for airplane transport. This is the recommended way of setting up a baseline and the rest of the guide is written for this system.

Of great importance is the way of making the 200mm and 92mm “legs” of the baseline, and there are various ways to do that:

- Using pieces –preferably of the same aluminum section as the baseline- cut in the correct length and fastened with bolts or clamps on the baseline beam. Great care must be taken to ensure that they are fixed at right angles to the baseline and the bearing points are exactly 200 and 92 mm from it. Another thing to consider is the designation of the baseline “edge” on the baseline beam, because the legs must be attached so they follow that edge: the recommendation is to assign the lower left edge of the beam as the baseline, and while the aft (transom) leg may be flush with the baseline beam’s left side, the front leg is better made in a configuration similar to that shown in the picture. In this way, it will be easier for the baseline system to stay put on the hull keel while in use. Otherwise, the baseline will be prone to slipping aside at the front end. Teflon pieces may be attached at the edges of the legs, because aluminum tends to leave marks on the hull gelcoat –as long as their length is included in the total length of the legs.

- Using the stem and transom templates themselves, fastened with clamps (or even bolts) on the baseline beam. Great care must be taken to ensure that their scribe lines are perfectly aligned to the baseline. When using the templates as “legs”, it is impossible to have an arrangement on the front one to facilitate the safe positioning of the baseline. Therefore, great care must be exercised to keep the baseline in place during measurement, and external supports may be used as well in the form of beams where the baseline may be clamped for extra security.



- It is also possible to use external supports for the baseline beam and fix it at the correct height from HDP and at 3780mm from HDP, but this is not recommended because it is time consuming and impossible to check easily during measurement.

Using removable legs makes for a truly “universal” system, which may be used for other classes similar in length simply by substituting the legs for the class specific ones.

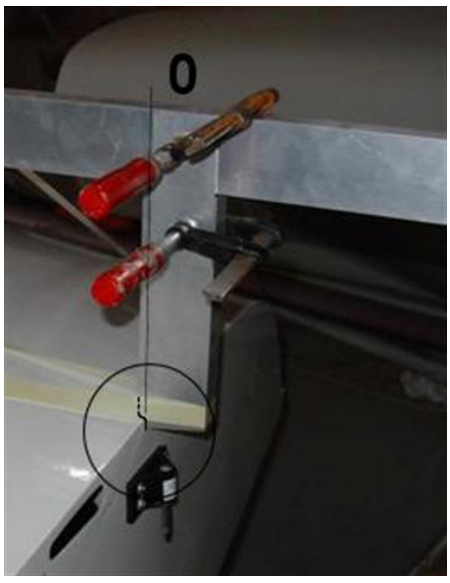
2. HULL SETUP

The setup of the hull is fairly straight-forward: Above all, the hull has to be supported in such a way that it is not twisted and does not sag or hog. 420 hulls are relatively stiff because they are short and deep, so sagging is not a big problem. However, it is recommended that all hulls are set up in the following way:
The stern of the boat must be set on a simple but stable base, preferably at the aft end of the gunwale. The transom edge is not a good choice because the hull will sit on the highest point which is on the center plane, and therefore it will be unstable and prone to rotate.
In this way, using small wedges or even cardboard pieces as shims on one side, the hull shall be leveled athwartships with the help of a simple water-tube or bubble level. Reference points for the leveling shall be the sheerline points at the transom corners. Alternatively, more sophisticated systems using car jacks and attached levels may be used as well.


For the bow, a car jack with some foam pads attached is needed and positioned near the stem, and it must not obstruct the positioning of the stem template.

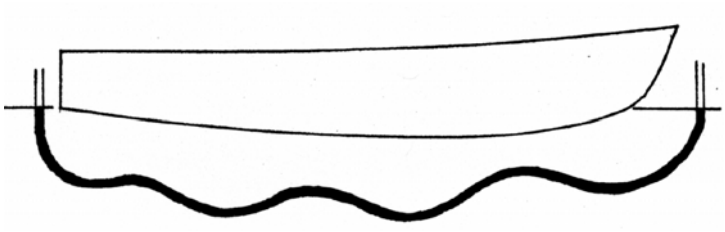
The HDP of the hull shall be defined next: This is the intersection on the hull centre plane of the transom external surface with the underside of the hull surface, both extended as necessary. For hull measurement purposes, and lacking another way of finding the symmetry plane of the transom, this shall be the point at the above said intersection at equal distances from the two sheerline points at port and starboard transom corners. It can be found using a measurement tape and it shall be clearly marked on the hull with a pencil or pen and a piece of masking tape for protection.

The baseline is then ready to be set on the hull and fixed with masking tape. Note that if legs are used, the aft leg must be made in such a way that the longitudinal “zero point” is actually a few millimeters inside the leg front edge, unlike the front leg, where the Station 9½ point is the aft edge of the leg. This is done because we need a small “dent” to help the baseline “sit” on the hull. It is of great importance that this dent is made so that the baseline sits at a distance of 200mm. The transom template may be used for tracing the correct shape of this dent (if using the template as leg, the dent is already built-in).



The front leg shall be positioned so that the baseline is above the highest point of the keel at station 9½ (3780mm from HDP). The baseline beam system is leveled vertically using a

plumb bob or a bubble level. The vertical plane passing through the baseline, set as described above, is the hull centreplane for measurement purposes.
Using a water tube (principle shown on picture below) or a spirit level, the hull can then be leveled fore and aft with a few turns of the front support jack screw (“C” on figure 3.1 below). The whole procedure takes very little time to complete. The fore and aft leveling of the hull is not really necessary but will help on the template positioning later.



3. KEEL PROFILE MEASUREMENT

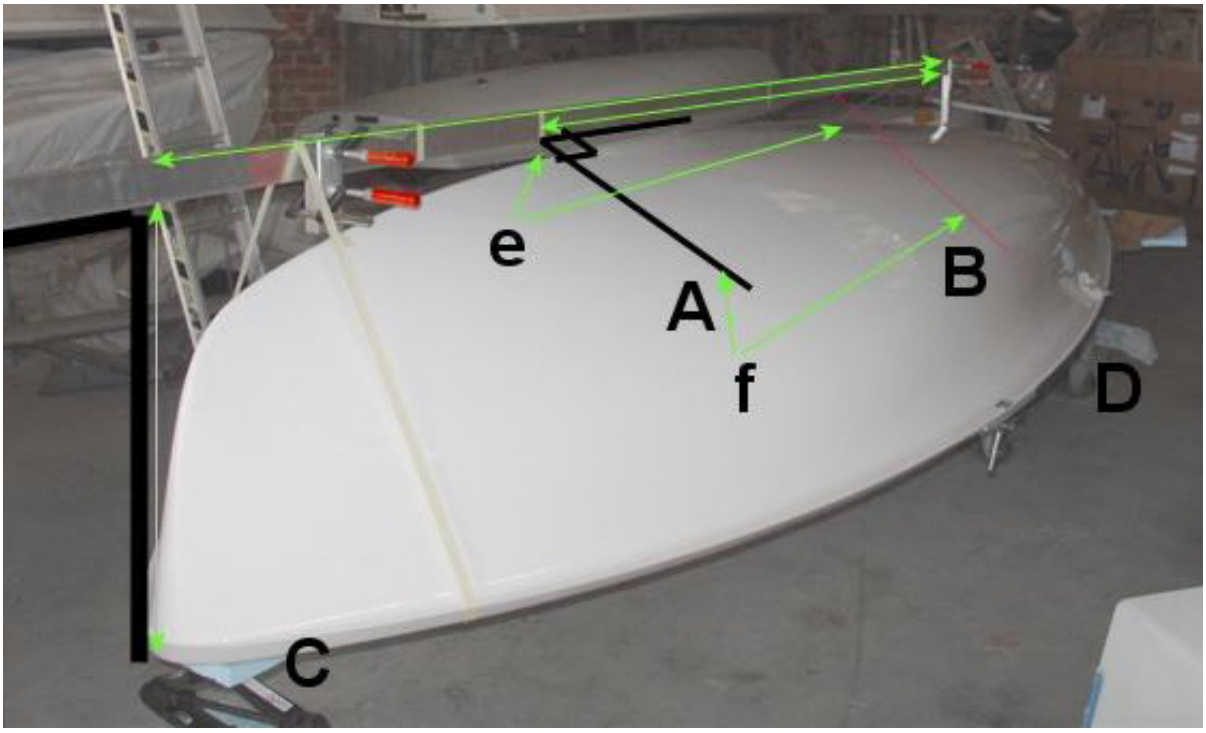
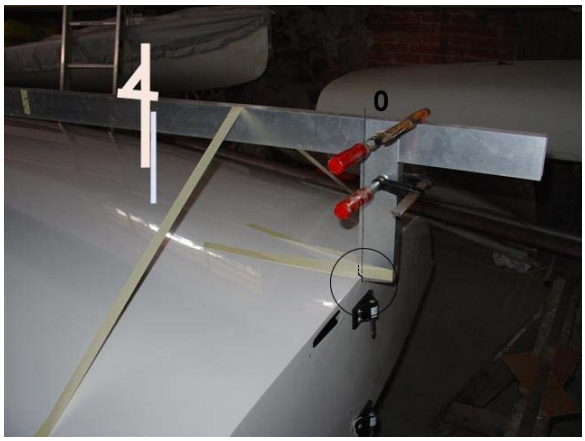
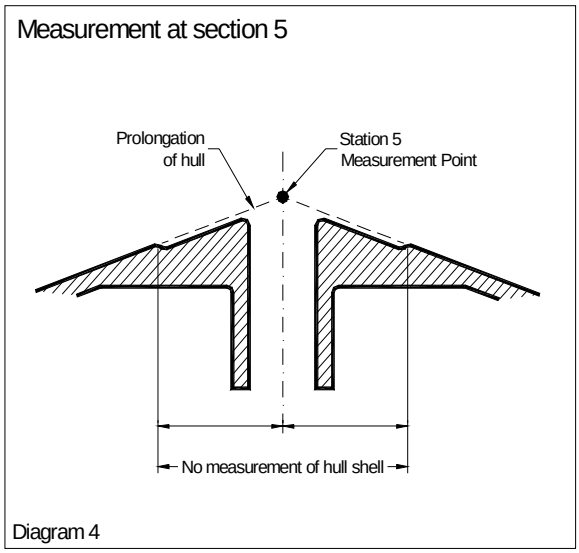


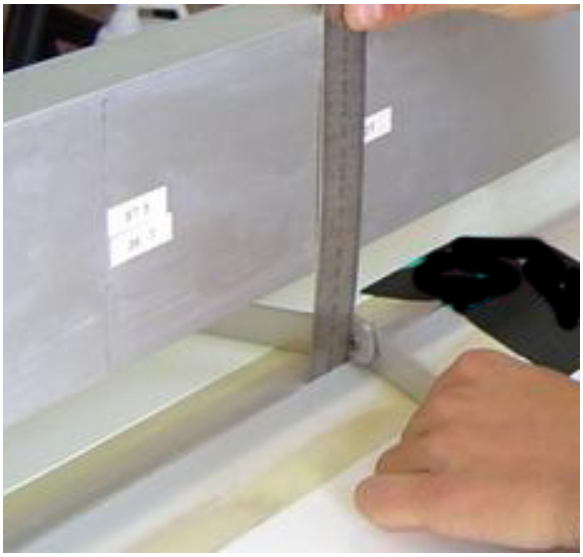
Fig. 3.1 Baseline setup on Hull

With the baseline set and fixed on the (leveled) hull, the next step is to check the keel profile at the various stations, and then the marking on the hull of the stations for template positioning. The first can be done with an adjustable square and a steel ruler, but for the second a carpenter’s square (figure 3.1 “A”) or a laser square (figure 3.1 “B”) are needed to extend each station on the hull sides (figure 3.1 “f”). Centreline station points shall be those found exactly under the baseline, even if the hull is not perfectly symmetric in construction: If the highest point on the keel seems to be offset to the side, it will be still marked as the “centre” of that station, but the keel height shall be the one found by measuring from the baseline to the highest keel point. The last step for this part

of the job is to measure the sheerline heights at the stem and the top of the transom, as well as the transom top deviation from the vertical (horizontal distance from HDP); these measurements will be needed later, to set the deck baseline. For those stations that are in the centerboard case area such as station 5, a special tool is needed to bridge the gap: it may be made from two aluminum strips bolted together. Pencil or pen marks covered with masking tape shall be done at all measurement points.





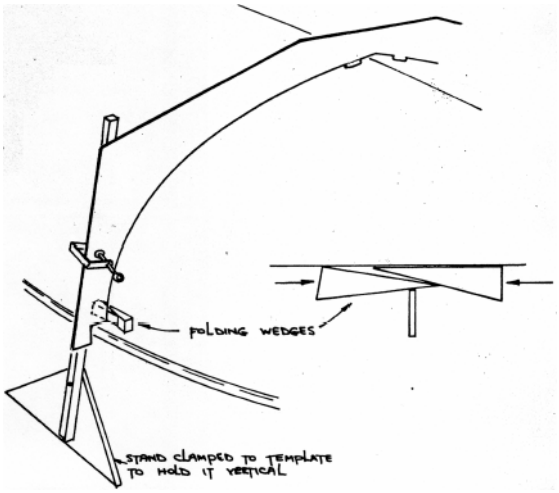


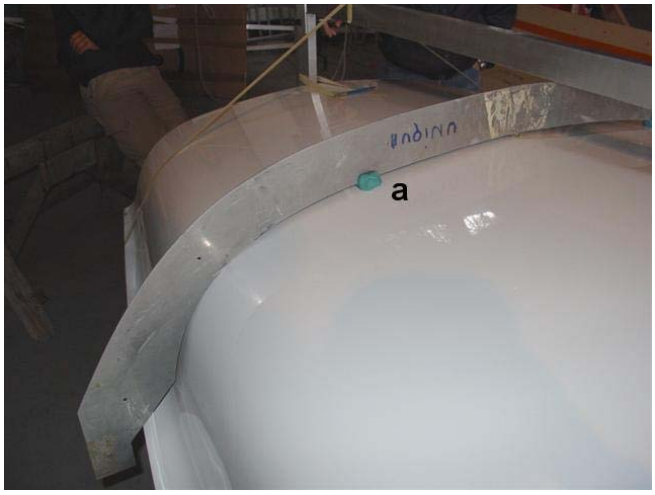
At this stage, the centerboard case position can be also checked, and if the stem/transom templates have been used as baseline legs, the profiles of the stem and transom should be checked as well. The transom radius shall be checked at this point too. The point at 400mm below the baseline shall be marked on the transom centerline, and then the measurement taken using an aluminum bar/straight edge at least 1040mm long, a spirit level, a square and a ruler.

4. TEMPLATE MEASUREMENT

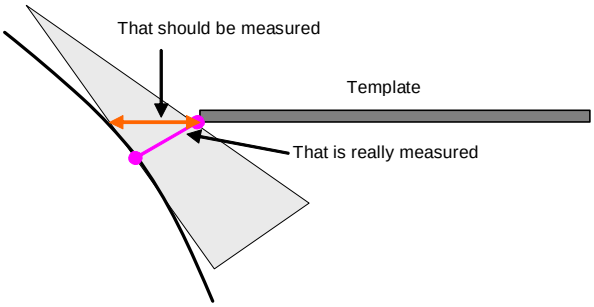
When the keel profile measurements and the station marking has been done, the baseline must be removed (without disturbing the leveling of the hull), to make way for the templates. With three points marked on the hull for each station (centre and two sides, see figure 3.1 “e” and then “f”, done for both sides), each template can be positioned easily and fixed on the hull with small pieces of plasticine on each side. The centre of the template shall be coincident with the mark on the hull centreplane and one face of the template coincident with the station marks. It is recommended that for the aft part of the hull, the measurement face of the templates shall be the one facing aft, and for the front part of the hull it shall be the opposite. Initially, the templates shall be leveled so that the

sheerline marks on both port and starboard sides are on the same horizontal level. If the hull is leveled correctly, the self weight of each template will help it stand vertically, without any other outside assistance, but for extra security, a support system may be used as well. It is essential that the templates are accurately located, particularly towards the bow of the boat, since the shape of the boat changes rapidly towards the bow and a small error in positioning can make a significant difference to the clearance recorded.





Hull minimum and maximum clearance from templates is to be measured and recorded for both sides. The sheerline height is also to be recorded both for port and starboard sides. If the hull is not perfectly symmetric, and the template clearance is outside the limits at some point, the template may be rotated at the centerline if that solves the problem, but the sheerline points shall be at all times inside their respective limits and the exact positions of both sheerlines recorded to facilitate the repeatability of the measurement. A metal ruler held parallel to the face of the template shall be used for measurement of the template clearance. Use of a calibrated wedge is not recommended because it may lead to incorrect measurements as shown below:



5. DECK MEASUREMENT

The last step is the upturning of the hull and the measurement of the deck, using the same bar baseline but with different height legs, according to the following system: by measuring the difference of the sheerline height between the stem and the top of the transom, two legs with lengths differing by that amount can be made. Enough length must be added to both legs for the baseline to clear the breakwater. It is recommended that one of the legs shall be adjustable in length, to compensate for differences in sheerline heights between boats. Alternatively, the aft leg may be fixed at a set height and the baseline positioned -with the help of a vertical bar- at the appropriate height at the stem. There is no need to level the boat fore and aft for deck measurement, since there are no templates to hang, unless the measurer is using plumb bobs to transfer measurement points vertically. It is recommended to use squares instead since they are easier to use,

especially laser ones. If leveling is needed, the hull shall be leveled athwartships using the sheerline points at the transom corners, and the baseline for fore-aft leveling, as done previously for the hull.
Taking into account the horizontal distance of the transom top from the HDP, the HDP can be “transferred” on the transom top and the baseline AMP set fore and aft without errors.