

Mast Rake

Checking and Setting Mast Rake

The balance of a boat is usually adjusted by moving the mast forward or aft. This adjusts the 'lead', the distance that the hydrodynamic lateral centre of effort is ahead of the sail plan lateral centre of effort.

For many hulls, the mast heel is held in a fixed position by the fin box assembly, and balance is therefore adjusted by raking the mast.

As well as knowing the rake angle of the mast under 'normal' sailing conditions, it is also useful to know maximum and minimum values of rake. There may be an unanticipated limit on aft rake due to interference of the main boom with the deck, and similarly on forward rake due to interference of the jib boom with the mast. It is good to know about these before the event where the wind picks up or dies unexpectedly.

An oft-quoted rule of thumb is to set up a boat so that the 'normal' rake for the largest rig is between 0° and 2° degrees aft, with a minimum available of -1° or -2°, and a maximum of 4° or 5° which may be used in different conditions and with lower rigs.

Set up

Rig the boat

Rig the boat with each suit of sails in turn, locating the mast in its 'normal' position and tensioning the rigging to give 'normal' mast bend.

Hang a plumb line

Construct a plumb line from an adjustable length of light line, and attach it to the forward face of the mast at, or close to, the forestay attachment point (see discussion in the 'Points to note' section below). If this is inconvenient, the mast head is suggested. If neither of these, mark the attachment point with a dot on the mast or similar to ensure consistency and aid later measurement.

Support the boat securely in a stand and secure the main boom a few degrees off to one side. Ensure the plumb bob is free to hang. It should not foul the aft or fore deck as the mast rake is adjusted between maximum and minimum. Depending on the space available around the gooseneck region, it may be necessary to use a slender plumb bob rather than one with much girth. A trussing, sailmakers, upholstery, weaving, loom, tent, canvas, or leather-work needle may be preferable rather than a typical jib counterbalance weight or fishing line weight. A simple 'lollipop' bob can be made by bending an eye onto a 150 mm length of 1.8 mm wire.

Ensure that the plumb line does not foul any sail or fitting attachments on the mast. In particular, attention may need to be paid to relocating the line forward of a spreader when measuring minimum or negative (forward) rake.

Level the hull



Ten Rater illustrating the hull set-up in a boat stand

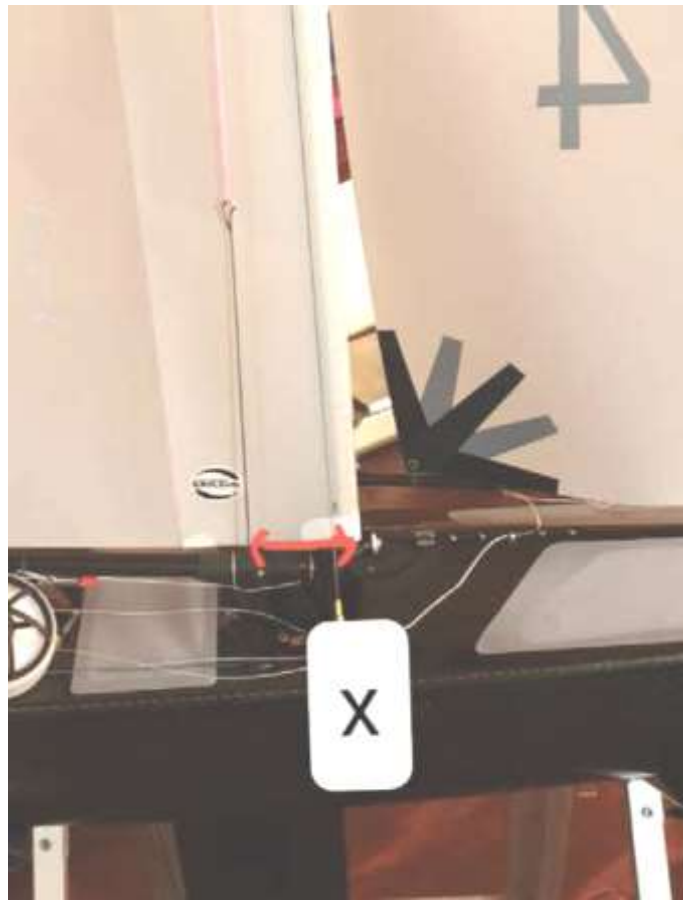
Set the hull so that its waterline is parallel to the floor. For boats that have waterline marks, this is most easily done by ensuring the same distance between the floor and the waterline limit marks. For boats that do not have waterline marks*, the fully-rigged hull should ideally be floated first and a note made of its waterline. Note that the floor should be level for this technique to give accurate results. If a level floor is not available, then the procedure will need to be carried out on a floating boat.

* For an IOM or Marblehead there will be little error involved if the waterline endings are taken to be at the bottom of the transom and the bottom of the bow.

Measurement

With the plumb line hanging freely and steadily, identify a convenient point on the plumb line and measure the gap between the line and the forward face of the mast, holding the ruler or measuring tape horizontal. Call this distance 'X'.

Mark the position on the plumb line where measurement is taken from, and then measure the working length of the line as the vertical distance between this point and its attachment point on the mast. Call this distance 'Y'. This is most easily done by taking and holding the line forward and under light tension. For 'normal' and aft rake, the line curls around the mast as it hangs, but there is no need to attempt to measure or account for the amount of this curl, the slight inaccuracy it introduces in the calculations may safely be ignored.



*Illustrating 'X', the distance between the plumb line and the forward face of the mast.
(Note light line in pink and slender 'lollipop' wire bob.)*

Calculation of rake

Some sailors have little interest in calculating mast rake in degrees, and instead simply keep a record of the value 'X'. This is usual in free-sailing, where a boat is often floated just prior to the start of the day's racing and a plumb line is hung to check lateral symmetry as well as rake.

In radio sailing, it is more common to record mast rake in degrees.

$$\text{Rake in degrees} \approx 57.3 \times X / Y$$

For example, $X = 70$ mm, $Y = 2000$ mm, and so rake = 2° (to 1 decimal place).

Mathematically inclined sailors may recognise the number 57.3 as $180/\pi$, where π (pi) ≈ 3.14 . They may also recognise the formula as an approximation. The expression " X/Y " is the equivalent of 'opposite over adjacent' and defines the tangent of the angle, not the angle itself. It turns out that, for small angles, the tangent and sine of an angle is numerically almost the same value as the angle itself when measured in radians. Since there are 2π radians in 360° , an angle in radians is converted into an angle in degrees by multiplying by 57.3.

Points to note

A difficulty with recording and adjusting mast rake to suit particular sailing conditions is deciding what is being measured. The reason for this is that the mast will rarely be straight (Walicki type masts may be the only exception) so it is necessary to decide where on the mast the rake is measured to.

The rake of the mast tube where it emerges from the deck is determined by the mast ram adjustment. The rake of the mast taken at the mast head depends on the backstay tension. Changes to sailing conditions require more or less backstay tension, and more or less mast ram pressure. Both of these adjustments, but especially backstay tension, cause significant changes to the value of 'X' if it were to be measured, yet the actual amount of mast rake essentially remains constant since all that happens is that the mast takes up more or less bend.

Adjusting mast rake

Mast rake is generally adjusted by forestay length/tension. Hence it is preferable to measure the rake of the mast taken at the forestay attachment point, as recommended earlier.

Alternative ways of checking mast rake

It has become commonplace for designers/builders to give guidance to a new owner of a boat regarding the distance from a point on the bows to the forestay attachment point. This guidance is essentially expressing the amount of mast rake considered desirable and is clearly wise to follow.

What this form of measurement does not tell you is the actual make rake relative to the waterline and how that may change for different rigs and different conditions. When you change to another design or class you will not be able to transfer the knowledge you have gained. Putting a number to the mast rake itself will help you understand more about rig trim and may give you a head start when changing to another boat.

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