

Rig Tuning

It is important to have a correctly tuned rig. Boats which have badly tuned rigs are slower, point lower, heel more, make more leeway and may in addition be more difficult to steer. . . .

These changes can be dramatic on any class of boat. They reduce crew fatigue, widen the skipper's options and improve reputation. Boat value is enhanced and things will be safer in extreme situations.



Rig types

The *Bermudan rig* is the most widely used rig in the world. It may be split into two main groups: The *masthead rig* and the *fractional rig*:

The masthead rig

- Stable, relatively easy to tune.
- Less "tuneable" than a fractional rig.
- Larger and more headsails, relatively small main.

The fractional rig

- More "tuneable" than the masthead rig.
- Large main, smaller and fewer headsails.
- More demanding to tune and maintain the state of tune.

Consider three aspects of rig tuning:

- Trimming the rig sideways
- Trimming the rig fore and aft
- Final tuning under sail

Straighten the mast sideways

- Adjust the cap shrouds until mast is upright.
- Hand tighten cap shrouds equally on both sides.

Ensure the boat is upright and the wind is light. Set up the mast on the boat and lightly tension the cap shrouds, backstay and forestay until the mast is standing fairly upright. NB! If it is a keel stepped mast, the chocks should not be inserted in the mast ring yet. See fig. 10-12 for closer details.

If the boom is mounted, let it rest on deck to release the topping lift. The lower shrouds and inner forestay (baby-stay) should be loose at this moment. Find two fixed points on e.g. the toe rails or gunnels symmetrically located athwartships. Check that these points are equally distant from the mast at deck level. Then start measuring with the halyard. If the distances are unequal, tighten the rigging screw on the side with the largest length. When the lengths on both sides are equal the mast is upright.

Many yachtsmen do this check by eyesight. It may be good enough, but requires an upright boat. The halyard check is better if the boat is symmetrical. Finally hand tighten the cap shrouds with *equal* numbers of turns on each rigging screw and do the halyard measurement again.

The cap shrouds are also called *upper shrouds*. The forestay is also called the *headstay*. A running backstay is also called a *runner*.



Masthead rig
Backstay and forestay are both attached at the masthead.

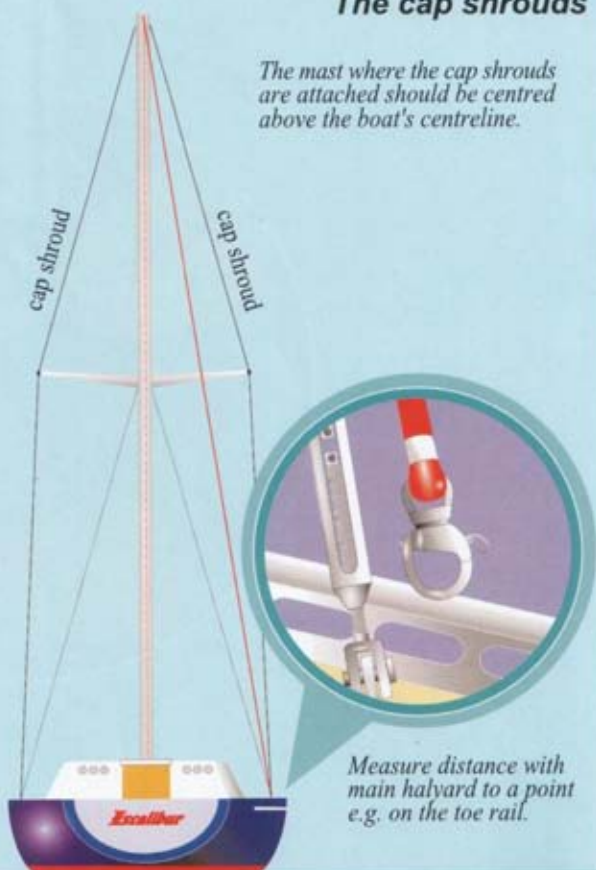
Fractional rig
The forestay is attached some distance below the masthead.



1

The cap shrouds

The mast where the cap shrouds are attached should be centred above the boat's centreline.



Measure distance with main halyard to a point e.g. on the toe rail.

2

Fore and aft tuning

Adjusting the mast rake

The mast is usually set with a slight aft tilt, the so-called **mast rake**, which improves the boat's up-wind performance. Mast rake is usually between 1-3°. Adjust mast rake as follows:

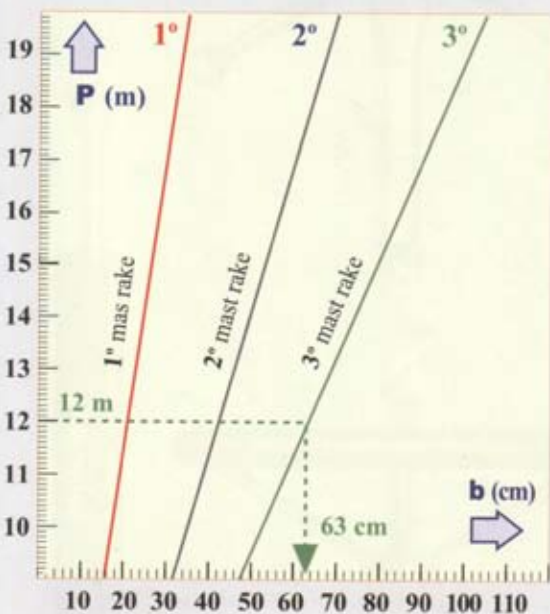
- Trim the boat upright.
- Measure the **b**-value as shown in fig. 3.
- Adjust the fore- and backstay rigging screws for setting the desired rake.

NB! Fractional rig: Better to use a running backstay instead of the backstay when adjusting rake.

Typical settings (higher values for racing yachts):

Masthead rig	0.5-1°	$b = 0.9 - 1.75 \text{ cm/m}$
Fractional rig	2-3°	$b = 3.5 - 5.25 \text{ cm/m}$

Example: Fractional rig where $P=12\text{m}$. We then get: $b=12 \times 5.25 = 63 \text{ cm}$. You may also find $b (=63 \text{ cm})$ from the diagram.

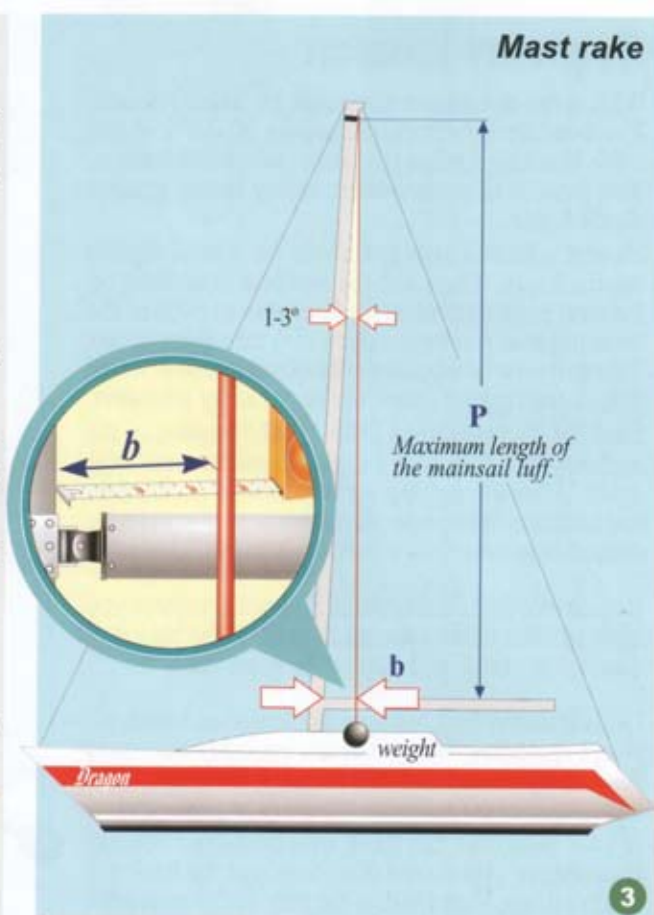


Distance b as a function of P for various rakes:

NB! Forestay length determines the mast rake. Backstay tension has only a small effect on mast rake. On a masthead rig backstay tension mainly controls the forestay sag. On a fractional rig the running backstays (runners) do the same.

On a fractional rig without runners the tension of the cap shrouds mainly determines the sag.

NB! More mast rake leads to more weather helm!



Backstay tension

What is the **maximum allowable backstay tension**? The boat designer often chooses 30-40% of the stay's breaking load as maximum allowable tension. You then have a reasonable safety factor against shock loads.

Having adjusted mast rake, you must hand tighten the backstay. Then use the method described on the next page to tension the backstay to 30% of the breaking load (corresponds to $f=6$ mm elongation). This will now be **maximum backstay tension**. Mark this on the rigging screw or the backstay tensioner. Ease the backstay until $f=4$ mm. The tension of the backstay will then be $2/3$ max. Check the mast rake again. Alter the rigging screw tensions on the fore and backstay in opposite directions until you have the desired mast rake with a backstay tension $2/3$ of max.

Remember that on fractional rigs with runners you have to tension the runners instead of the backstay when you check and adjust the mast rake.

On fractional rigs, using a backstay and with aft swept spreaders, the maximum backstay tension is limited by maximum mastbend. Maximum bend is dependent on mainsail shape (see page 69).

If your boat does not have an adjustable backstay tensioner or you do not wish to adjust the backstay when sailing, then tension the stay to $2/3$ max after completing rig tuning in harbour. You may then leave the backstay permanently tensioned.

It is always best to release rig tension when a boat is moored. Most well built hulls, however, will withstand the loads from a tensioned rig for quite a long time.

If you constantly have to tighten the rig to maintain the desired state of tune, then the hull may be distorting under load. If this is likely, release all rig tension and consult professionals.

Another way to find maximum backstay tension is to sail upwind with your largest genoa in a breeze that heels the boat 20-25°.

Stand on the foredeck facing aft and look up along the forestay. Notice that sag increases as your crew first loosens the backstay to ensure that you start with a loose stay. Then start tightening the backstay until tightening no longer reduces the sag. This will indicate maximum backstay tension. This method is less accurate, but much simpler, than the first one.

Backstay tensioners

max.
 $2/3$ of max.

Mark $2/3$ and maximum backstay tension on rigging screw or backstay tensioner.



Hydraulic tensioners have pressure gauges where tension may be read directly.

Tensioning wire and rod

If you want to trim your rig correctly you should have some idea of the tension in shrouds and stays, either by rules of thumb or a more exact method such as the one described below. Here you measure the elongation of the wire as a percentage and then establish tension as a percentage of the wire's or rod's **breaking load**.

You either measure the elongation of all the wire or a part of it, e.g. 2 m. Accuracy will improve with the sample length. Begin with a minimum tension in the wire. Example (cap shrouds):

- Mark off a 2 metre length of the cap shroud on one side of the boat using the shroud terminal for reference.
- Measure the elastic extension (f) of the measured length as the rigging screws are alternately tightened, little by little. Stop when $f = 3\text{mm}$. (4mm on fractional rigs with aft swept spreaders).

Note that an elongation of $f = 1\text{mm}$ over a sample of 2m of the wire corresponds to 5% of breaking load **independent of the wire diameter**.

NB! For rod, an $f = 1\text{mm}$ elongation over 2m corresponds to 7.5% of breaking load.

Use a similar method to establish backstay tension. Remember that a different sample length will have a different elongation for the same load.

1m wire sample:

- 0.5 mm elongation means 5% of breaking load.
- 1.0 mm elongation means 10% of breaking load.
- 1.5 mm elongation means 15% of breaking load.

2 m wire sample:

- 1.0 mm elongation means 5% of breaking load.
- 2.0 mm elongation means 10% of breaking load.
- 3.0 mm elongation means 15% of breaking load.

Rod-rigging is made of a straight, single strand. Wire rigging is made of many twisted strands. Normally rod rigging is 20% stronger than wire of the same diameter.

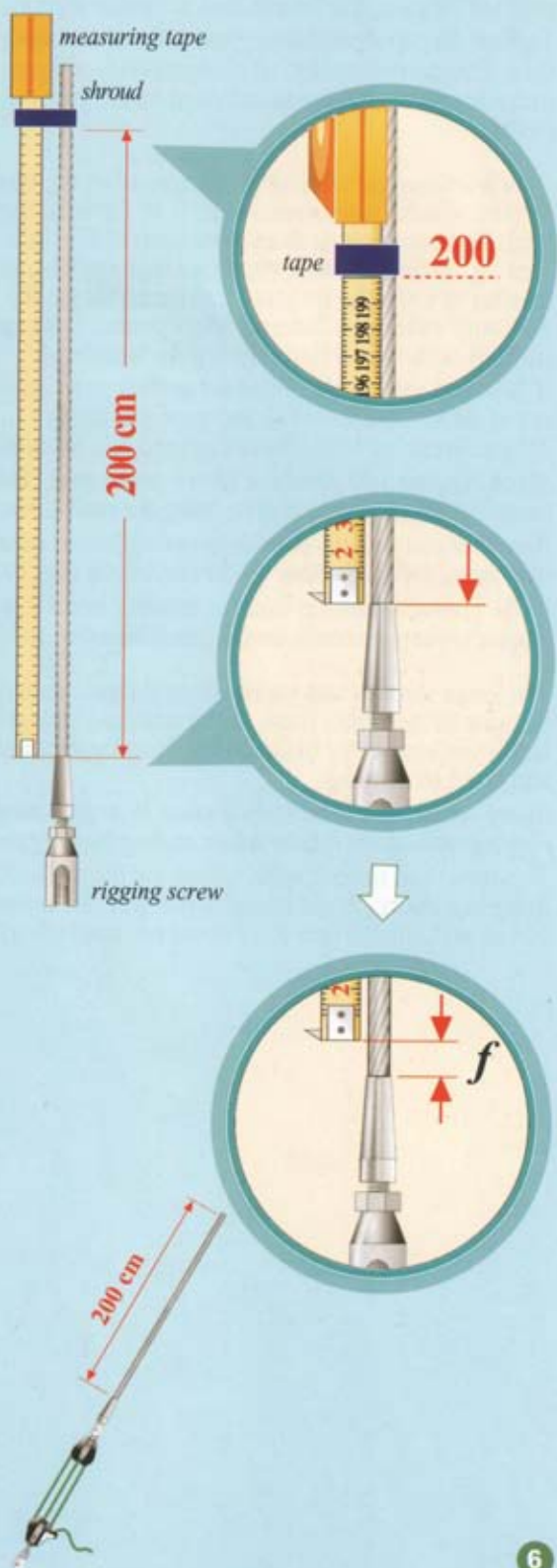
Wire has the advantage of an early warning of fatigue when a strand breaks. Fatigue in rod progresses without any warning at all. It can be sudden and catastrophic.

2m rod sample:

- 1.0 mm elongation means 7.5% of breaking load.
- 2.0 mm elongation means 15% of breaking load.

Remember that the elongation is **always** measured from **hand tight** wire/rod (minimum tension).

Measuring wire tension



Tensioning the cap shrouds

When you have straightened the mast sideways and adjusted the rake, it is time to look at the cap shrouds. Tighten the cap shrouds to approx. 15% of **breaking load**. This corresponds to an elongation (f) of 3 mm over a length of 200 cm as indicated on the previous page.

On a fractional rig with **aft swept spreaders** the cap shrouds should be tensioned to 20% of the breaking load. This corresponds to an elongation of $f=4$ mm. This rig, without runners, requires a high cap shroud tension to keep the forestay tensioned (page 70). To avoid excessive forestay sag upwind, the cap shrouds should be relatively highly tensioned.

If 20% cap shroud tension is not sufficient to keep sag at an acceptable level, increase the tension to 25% of breaking load. Do not exceed this tension.

Slack rigging will produce shock loads that can cause rig failure and may even bring the mast down.

Note that you will not be able to overtighten a wire with hand tools of about 40-50 cm length (fig. 8).

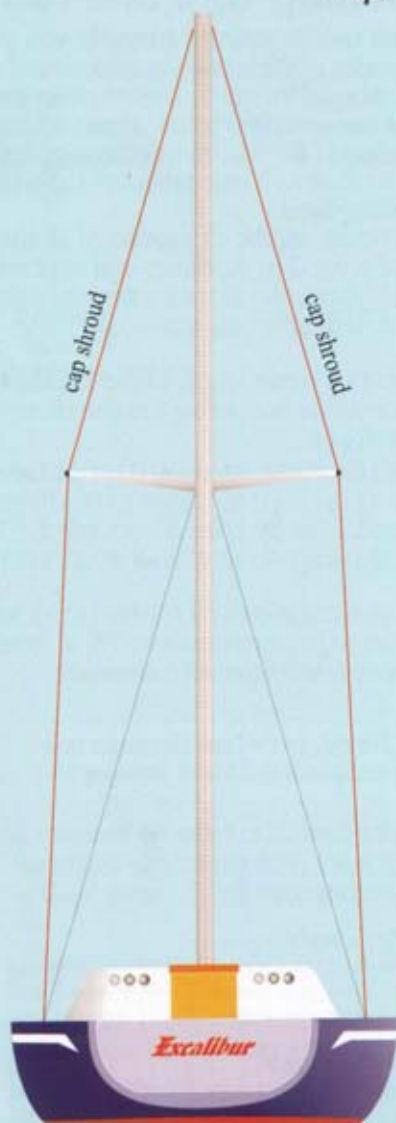
(NB! This may not be true for smaller boats e.g. dinghies where a certain caution must be exercised.)

The lower shrouds and intermediate shrouds should be quite loose at this stage. If the mast has distinct bends you should try to straighten them by sighting and hand tensioning.

Many yachtsmen intuitively tension their standing rigging and adjust it later when sailing has begun.

This may lead to acceptable results but the methods described above, while taking some time, are more certain and reliable (see p. 78 about pre-tensioning).

Cap shrouds



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Approx. break. load
1x19 stainless steel
wire (Kg):

Diameter	BL
3 mm	800
4 mm	1400
5 mm	2200
6 mm	3200
7 mm	4400
8 mm	5700
9 mm	7200
10 mm	9000
11 mm	10900
12 mm	13000

1 Kg = 2.205 Lb (=9.81 N)

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Pre-bending the mast

By adjusting fore and aft mast bend when sailing it is possible to tune the mainsail for various wind strengths and directions. The mast is often **pre-bent** to prevent the mast from bending forwards, make it easier to bend the mast further and make it possible to shift the range of tuneable bending.

Mast bend is used, as mentioned earlier, to flatten the upper half of the main when the wind picks up and must be adjusted so as to match the designed shape of the mainsail.

Masthead rig

Pre-bend of keel stepped masts can be induced by moving the mast heel and/or by use of wedges (fig. 10-12). If you don't want to do this you can, after the wedges have been inserted, tighten the **baby-stay** or **forward lower shrouds** to obtain desired pre-bend. Tighten until mast bend is 15-20 mm. Use the main halyard to estimate the bend. NB! If you tighten the forward lower shrouds, you must check that the mast is still straight sideways. The aft lower shrouds should be loose at this stage.

Fractional rig

There are two main types of this rig: Rigs with **aft swept spreaders** without runners and rigs with **in-line spreaders** which must use **running backstays** (runners) to support the mast.

Fractional rig with aft swept spreaders without runners

When the cap shrouds are tensioned to 20% of breaking load (see page 70), the mast will be forced forward at the spreaders. The lower shrouds should then be adjusted until you have the desired pre-bend.



Fractional rig with in-line spreaders using runners

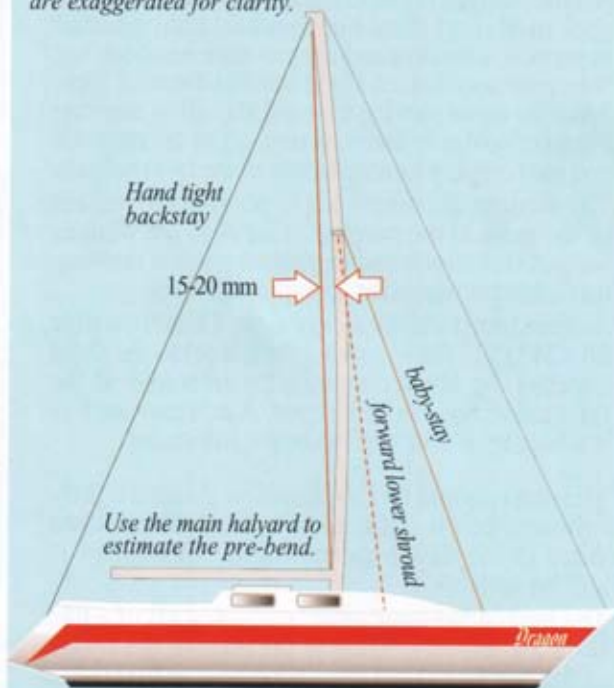
The pre-bend should be adjusted in the same way as for the masthead rig. The runners should be kept hand tight during the pre-bend adjustments.



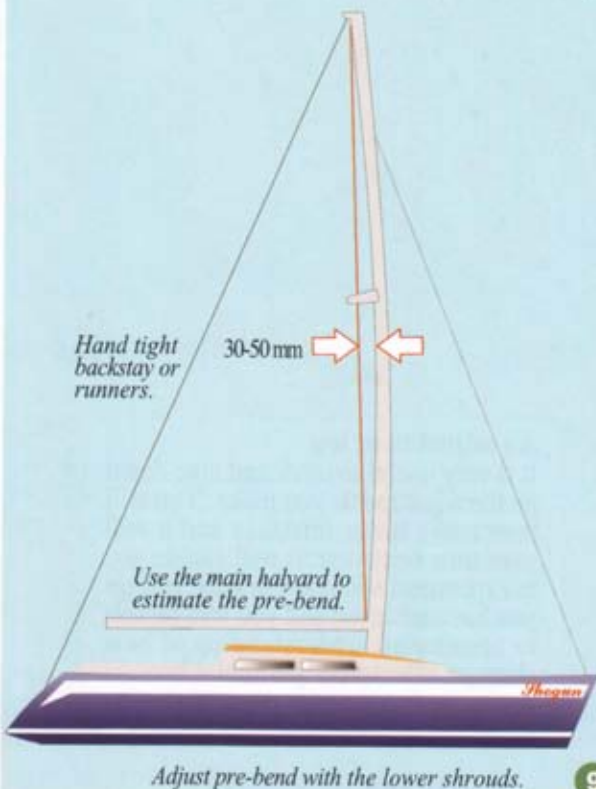
It is difficult to give exact values for the pre-bend because it is totally dependent on the mainsail's shape. Only approximate values are given. Consult your sail maker or boat designer.

Masthead rig

NB! The pre-bend illustrations are exaggerated for clarity.



Fractional rig



Keel stepped masts

All the wedges (chocks) in the *partners* (through deck mast ring) should be removed until the mast is vertical sideways and correct rake has been set. You may now force a slight bend in the mast (*pre-bend*) by either moving the mast step aft or inserting a thicker wedge in the mast ring, aft of the mast. Or you may employ a combination of the two methods. The wedges are necessary to prevent movement of the mast in the partners. Use wooden wedges for wooden masts and to protect against denting, use rubber wedges for aluminium masts.

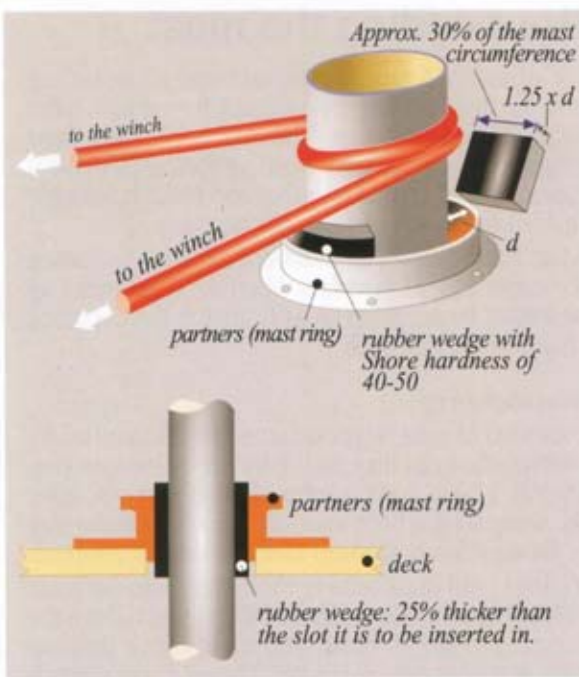
Always insert the *aft wedge* first. Then rig a rope 20 - 24" (50 - 60cm) above deck level to the sheet winches (fig.10) to compress the aft wedge so the forward wedge can be inserted. A lubricant such as washing up liquid will make the job easier.

The mast should be tuned so that it leans lightly forwards below deck in order to obtain an even curve all the way to the masthead. An angle of 1° will be suitable.

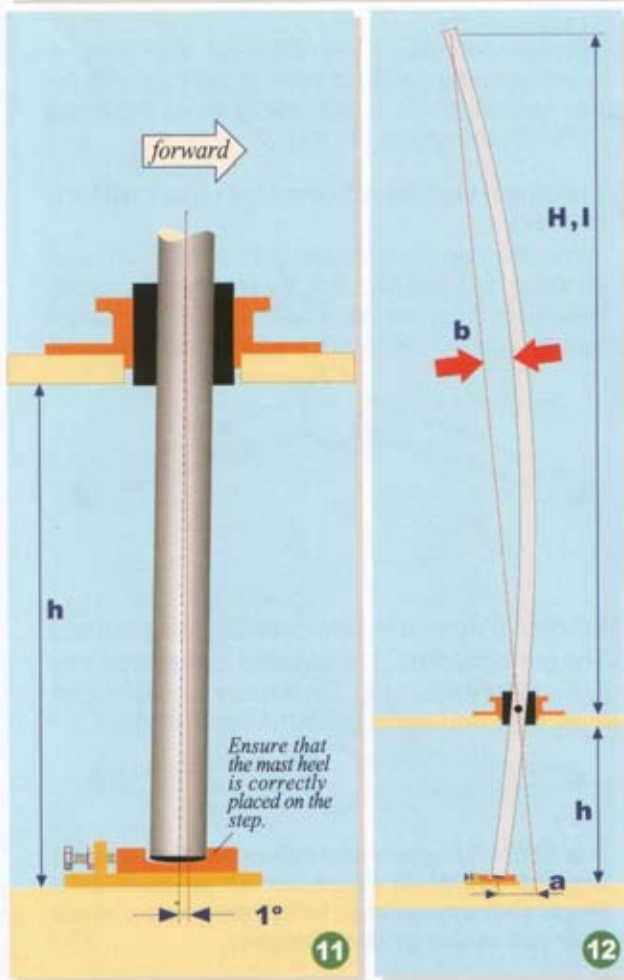
The heel of the mast must be located aft of a line from the forestay fitting in the mast to the centre of the partners when the backstay is at maximum tension. The distance (a) should be approx. 15 mm/m height from mast heel to the partners (h). Maximum mast bend (b) must *never exceed* 2% of H or I.

An adjustment log

It is very useful to mark and note down all the adjustments you make. You will then make fewer mistakes and it will save time next year. It will enable you to experiment without losing the settings you have achieved and you will be able to accumulate understanding of how changes affect your particular boat.



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11

12

Maximum mast bend

Checking mast bend on masthead rigs

- Tension the backstay to the maximum mark. The mast bend can be approx. 50% of the mast's fore and aft diameter (D) but must **never** exceed 2% of H (total mast height above deck).

NB! Many cruising yachtsmen choose to trim their masthead rigs as straight as possible, but some mast bend is often beneficial.

Checking mast bend on fractional rigs with aft swept spreaders without runners.

- Tension backstay until mast bend is approx. 1.5 x D and mark this as max. on the tensioner. NB! Mast bend should never exceed 2% of I (distance from deck to forestay fitting).

Checking mast bend on fractional rigs with in-line spreaders using runners.

- Tension the runner to maximum. A mast bend of approx. 1.5 x D can be suitable, but it must never exceed 2% of I.

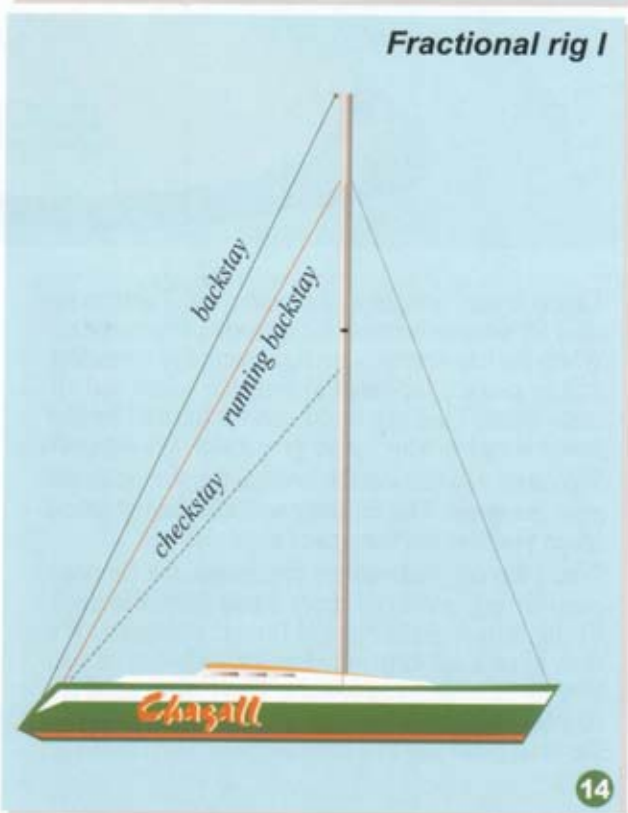
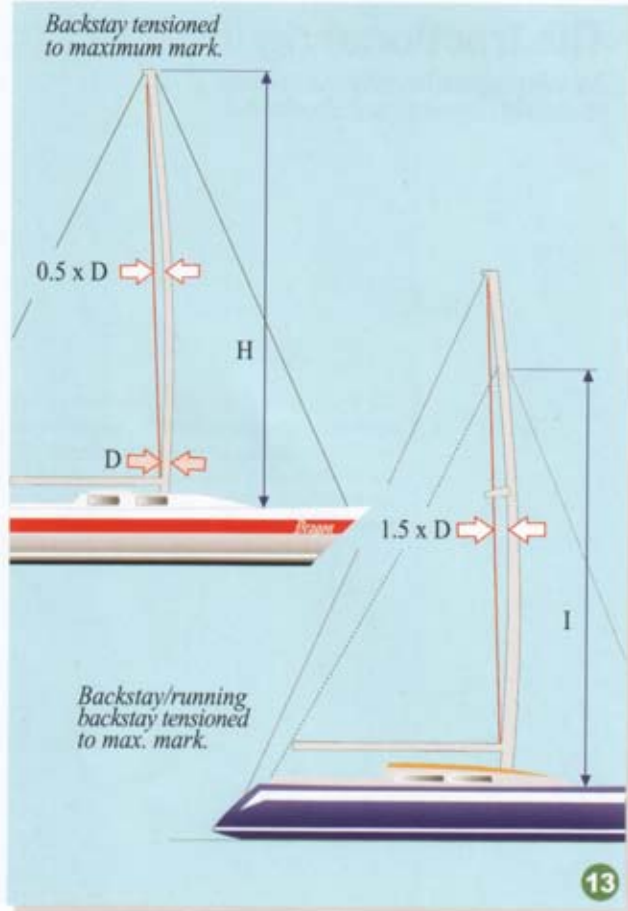
It is difficult to give exact values for maximum mast bend. The design of your main and the characteristics of your rig are overriding. It is best to seek advice from the boat designer, sail maker or a professional rigger.

The class association may also be helpful. Note that the above given values are only typical values that may not be suitable for your boat!

The Fractional rig

The traditional fractional rig, normally with *in-line spreaders* must use running backstays (runners) to stabilize the rig. *Checkstays* are mostly used on racing yachts to control mast bend in the middle and lower parts of the mast.

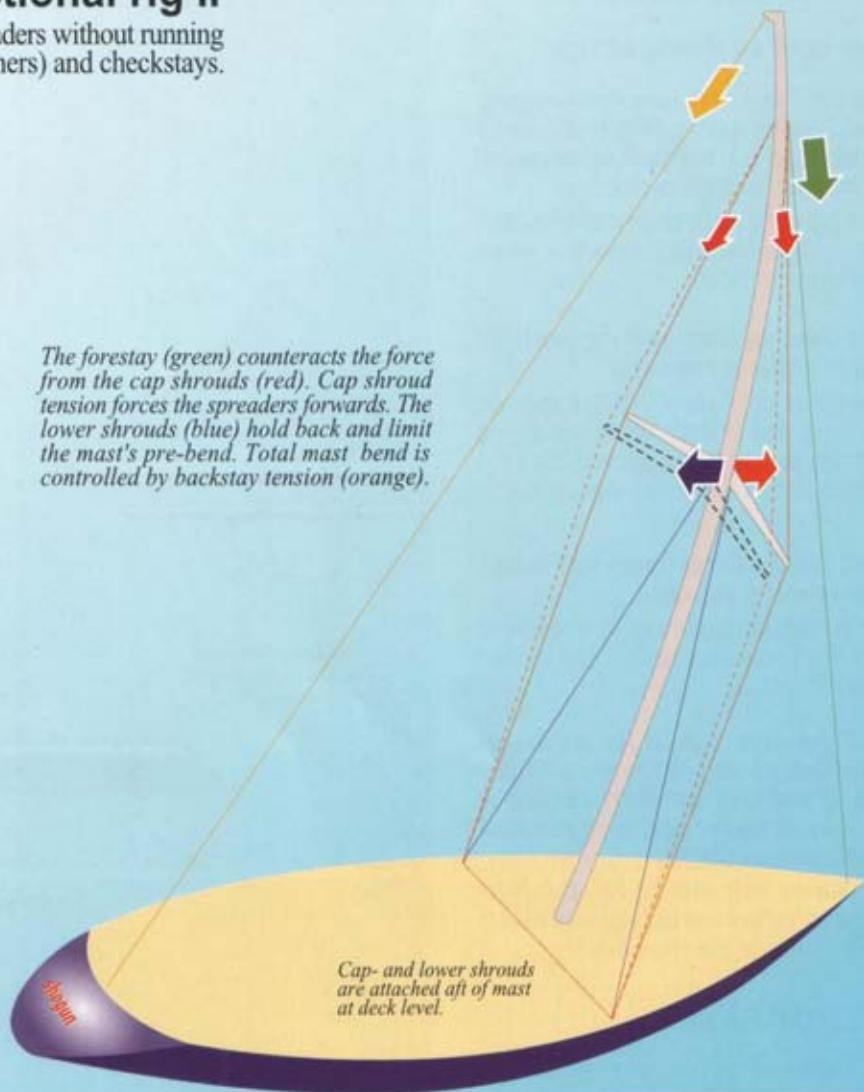
The runners have the same function as the backstay on a masthead rig. Forestay sag will decrease and the mast will bend to flatten the main, when you tighten the runner. The permanent backstay on such a fractional rig is primarily an insurance against rig failure when gybing.



The fractional rig II

Aft swept spreaders without running backstays (runners) and checkstays.

The forestay (green) counteracts the force from the cap shrouds (red). Cap shroud tension forces the spreaders forwards. The lower shrouds (blue) hold back and limit the mast's pre-bend. Total mast bend is controlled by backstay tension (orange).



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This is a very simple and popular rig. There is no need for runners because the spreaders are swept aft. When the cap shrouds are tightened, the spreaders will be pushed forwards to produce a fore and aft mast bend. This pre-bend can be limited by the lower shrouds which also give sideways support. The more you tension the lowers, the straighter the mast becomes. The forestay will also be tightened when you tighten the upper shrouds.

When the cap shrouds are tensioned, the forestay mast fitting is moved more away from the deck fitting thus increasing the forestay tension. We then have a pre-tensioned unit consisting of cap shrouds, forestay and lowers. There is no need for runners and the backstay (if fitted) is used to control the mast bend and as a mast support when running.

The problem with this type of fractional rig is that the forestay tension is difficult to control in varying wind strengths. The forestay tension tends to become relatively low when the wind picks up, which leads to increased sag. Upwind properties will suffer.

In order to compensate for this, the cap shrouds may be tensioned more than on other rig types. It may be advisable to pre-tension the cap shrouds to 20% of breaking load. (The term cap shroud is not quite appropriate for a fractional rig. *Upper shroud* or *top shroud* would be more correct.)

The fractional rig with aft swept spreaders is a rig that, due to the above mentioned reasons, can be difficult to tune perfectly. This simple and popular rig is ideal for small, light boats, but less suitable for boats over 35 feet.

Tuning under sail

Preparations

The mast should be centred sideways, have a correct mast rake and bend with a correct tension in the cap shrouds.

- The **lowers** should only be handtight at this stage. NB! With two sets of lower shrouds their relative tension will affect mast bend. The forward lowers should be tighter than the aft lowers, which should be quite loose before sail setting.
- Handtight any intermediate shrouds to be tighter than the lowers, but less tight than cap shrouds.
- Tighten the backstay to 2/3 of max. tension.
- Lock the rigging screws temporarily with tape before starting to tune under sail.

The following tuning must now be undertaken in wind strengths that will heel the boat 20-25°. This must all be done before the seas build up!

- First check the cap shroud tension by looking at leeward cap shroud. It should be handtight - not slopping around (see fig.16).
- Then adjust the lower shrouds so that the mast is straight sideways from deck to masthead.
- If the rig has double lower shrouds, you must adjust aft and forward lowers in such a way that the pre-bend is not changed, but the mast is kept straight sideways. The forward lower will enforce mast bend and should be tighter than the aft one, which will prevent too much mast bend in heavy airs and should be relatively loose at the dockside.
- Adjustments of any intermediate shrouds should be done subsequent to adjusting the lowers.

Checking cap shroud tension

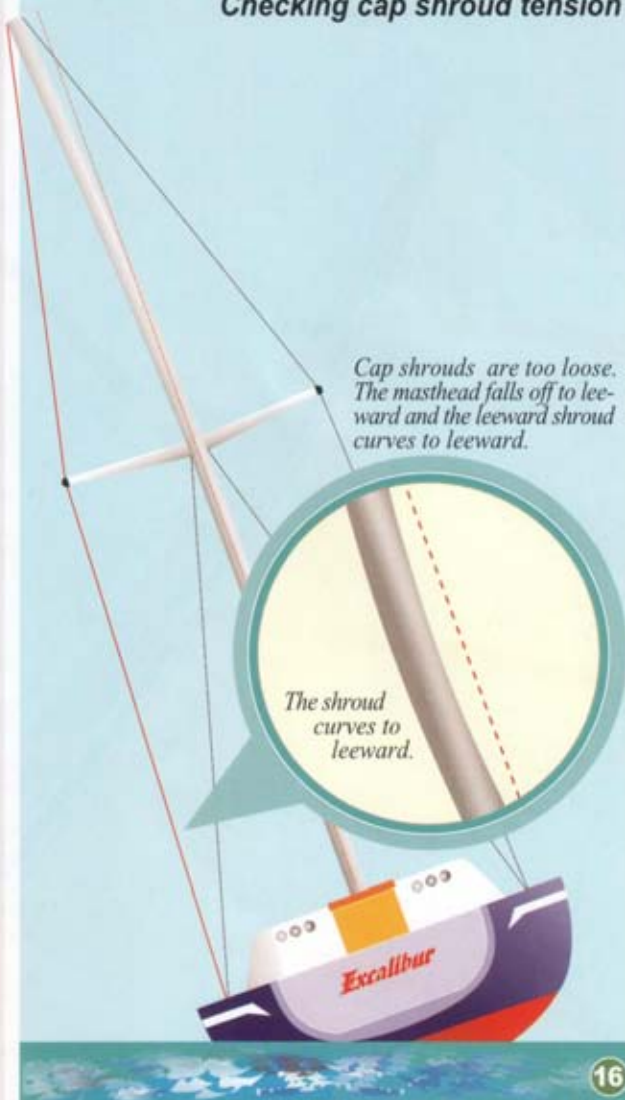
It is assumed that the cap shrouds are tensioned equally on both sides. Check the tension in the leeward cap shroud. It should now be hand tight and not slopping around.

If it is too slack, tighten one or max. two turns on the rigging screw. Then tack and tighten exactly the same amount of turns on the rigging screw on the opposite side (which is now the leeward side). Repeat these adjustments until you are satisfied.

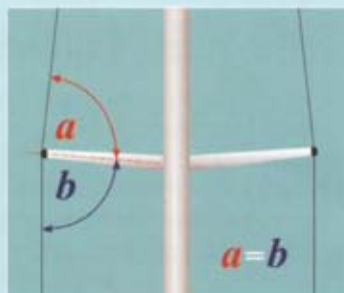
Leeward cap shroud should not be totally loose, but tightened until it no longer curves to leeward.

NB! The cap shrouds are now finally adjusted. Insert the split pins and tape over them.

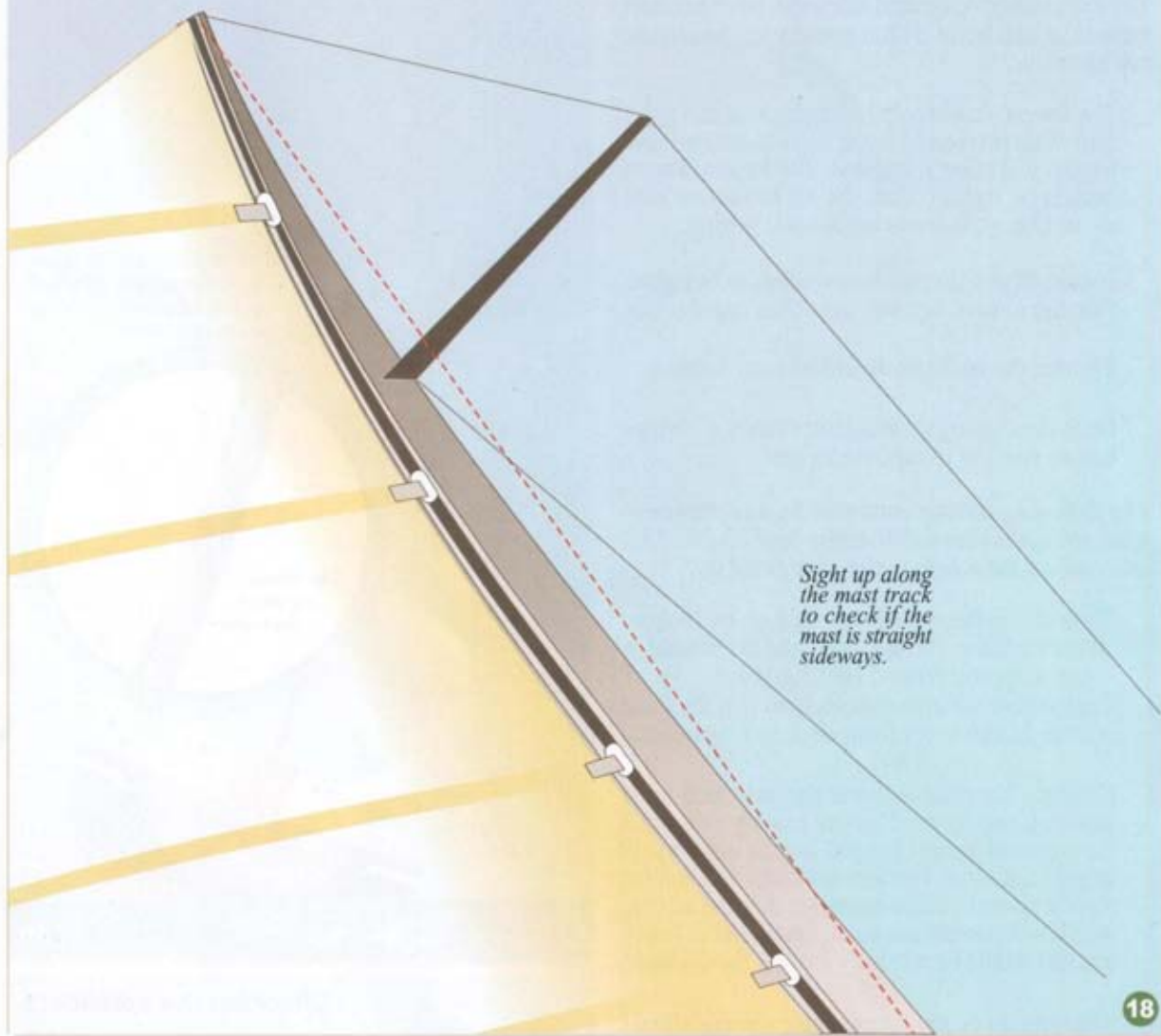
Checking cap shroud tension



Checking the spreaders



NB! It is very important to ensure that the spreaders bisect the angle of the cap shroud. This is very often neglected and has been the cause of a number of mast failures. Correctly positioned spreaders should have their tips very securely locked in place.



Sight up along the mast track to check if the mast is straight sideways.

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Straighten the mast sideways

Place your eye close to the mast track for the main luff on the windward side. Sight up along the track from the boom to the masthead and check if the mast is straight sideways all the way up.

If it is not, the *lowers* and *intermediates* must be adjusted. These adjustments are described on the next pages.

NB! Always adjust the shrouds on the leeward side because they will not be under load. If you want to adjust a windward shroud, then tack and do the adjustment with one or maximum two turns. Then tack again to check your adjustment.

Later adjustments

If the boat has too much weather helm after tuning the rig, you may decrease the mast rake by tightening the forestay. On a masthead rig you must then ease the backstay correspondingly. You also have to change the maximum backstay tension mark.

The rig will stretch as time passes and must therefore be re-checked regularly. A new rig should be re-checked after a few hours of sailing since it will stretch quite a lot in the initial stages.

You may at any time restart the rig tuning from scratch, i.e. from the adjustments at the dockside. If so, then ease off all stays and shrouds, remove the wedges from the mast ring and start the whole process from fig. 2.

Adjusting the lower shrouds

*Windward lower shroud is **too loose**. The midsection of the mast falls off to leeward. Tighten the lower.*



*Windward lower is **too tight**. The midsection of the mast is pulled to windward. Ease the lower.*



When you begin adjusting the lowers, they will be quite loose. While sailing the windward lower(s) will always be under load. If you ease a windward shroud, the middle of the mast will fall off to leeward. If you tighten it, the middle of the mast will be forced to windward. The aim is to maintain the mast straight sideways even when the boat heels 20-25°.

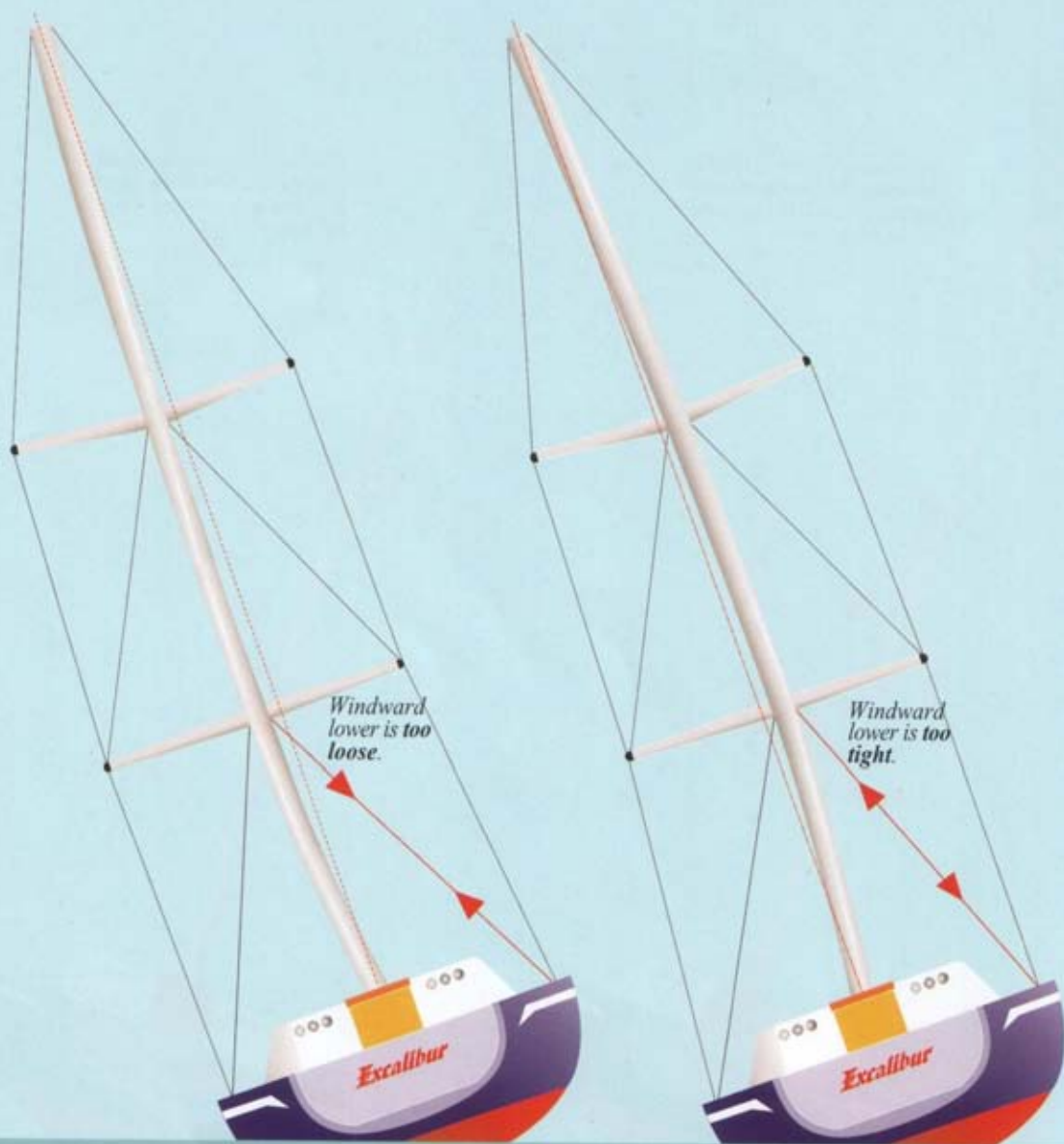
Tighten the rigging screw on the leeward lower one turn and then tack. Sight up the mast and check if it is straight. Repeat the procedure until the mast is straight both on starboard and port tack.

Correctly adjusted lowers will be much looser than the cap shrouds when the boat is at the dockside.

Double lower shrouds

If the rig has got double lowers, you should adjust them relative to each other in such a way that the mast bend is not changed, as mentioned on page 71. The procedure is the same as for rigs with one set of lowers, but tighten (or loosen) on **both** leeward lowers before you tack and check the mast. The forward lowers should be tighter than the aft ones.

Rigs with multiple spreaders



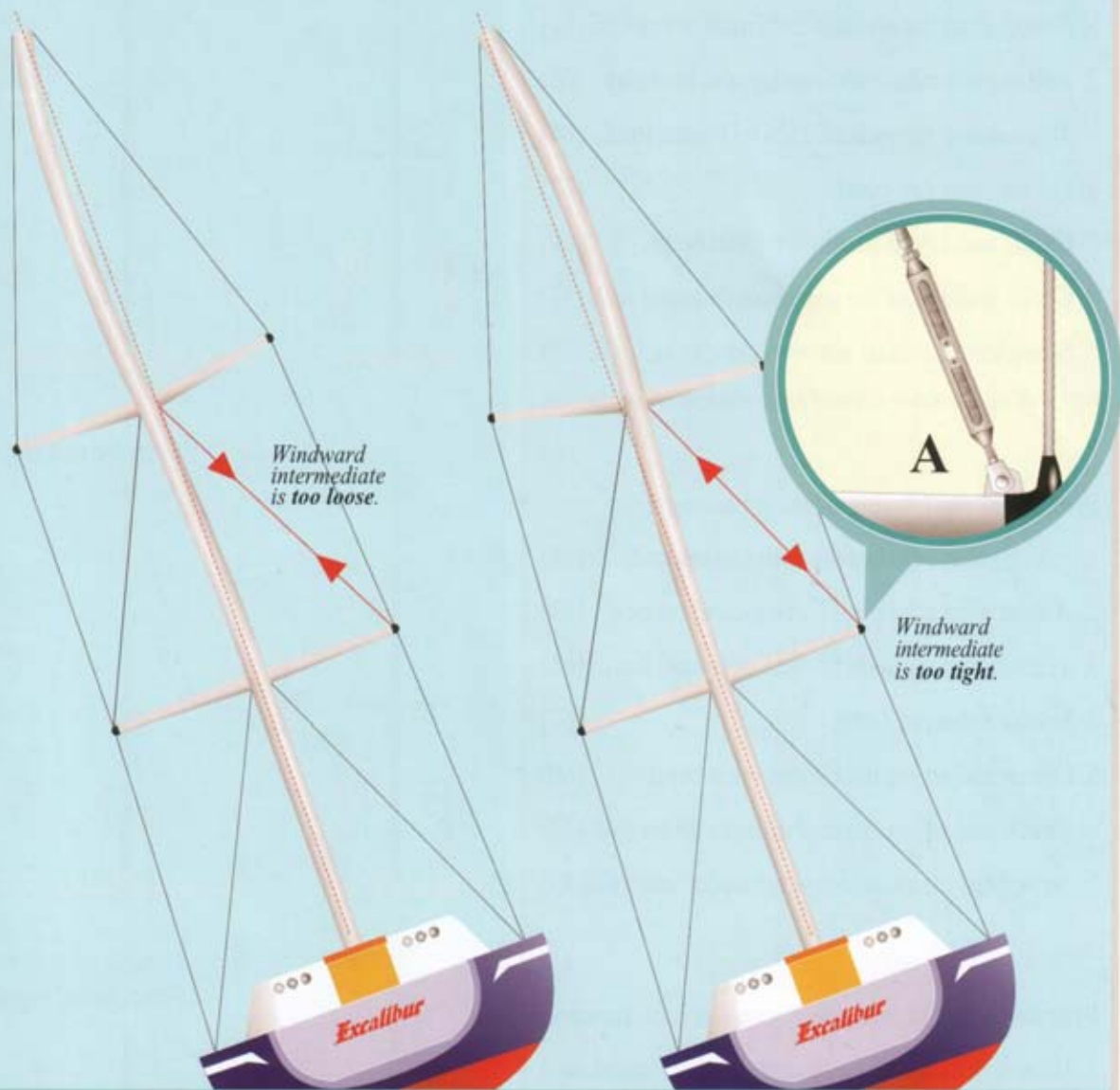
20

Some experts state that after having tensioned the cap shrouds, you should adjust the lowers and then continue upwards with the intermediate shrouds, which is the *most usual way*. Others assert that you should start from the top and continue downwards.

Anyway, using sound reason will help you set up the mast correctly. On the boat in the left half of the figure it is clear that the windward lower is too loose and must be adjusted. On the boat in the right half the windward lower is too tight and has to be eased gradually until the mast becomes straight.

Always adjust the leeward rigging screw one turn (max. two) at a time. Then tack and check the result. Never try to adjust the windward rigging screw which is under load. It is very easy to damage the threads of a loaded rigging screw.

Either you tune the lowers and the intermediates from deck and upwards or from above and downwards, do not adjust the cap shrouds again. Otherwise you will have to do the whole process of tuning the rig once more! This applies however many sets of spreaders the boat has got.



Windward intermediate is too loose.

Windward intermediate is too tight.

A

Here you see clearly that the upper part of the mast is curved while the lower part is quite straight. You therefore have to adjust the intermediates to get the mast straight. On the boat on the left side the upper part of the mast falls off to leeward. The windward intermediate is too loose and has to be tightened gradually to straighten the mast. On the boat on the right side the windward intermediate is too tight because the upper part of the mast is pulled to windward. This may fool you into thinking that the cap shrouds are too loose as it looks

like the top of the mast is falling off to leeward. But at this time you have checked and performed the final adjustments of the cap shrouds, so the problem must be elsewhere. You should therefore ease the windward intermediate gradually until the mast is straight. Some intermediates continue all the way down to the deck where they may be adjusted. These are named *continuous* intermediates. Another type of intermediates are called *discontinuous*. These are rigged diagonally from spreader to spreader and are adjusted at the lowermost spreaders (A).

Tuning diagram

(Page references in parentheses)

Masthead rig

1. Handtighten cap shrouds until mast is vertical. (62)
2. Adjust mast rake with forestay and backstay. (63)
3. Tension cap shrouds to 15% of break. load. (66)
4. Set the mast pre-bend. (67)
5. Check and adjust maximum mast bend. (69)
6. Check and adjust the cap shrouds under sail. (71)
7. Straighten the mast sideways under sail. (72-75)

NB! This rig has either forward lower shrouds or a baby-stay.

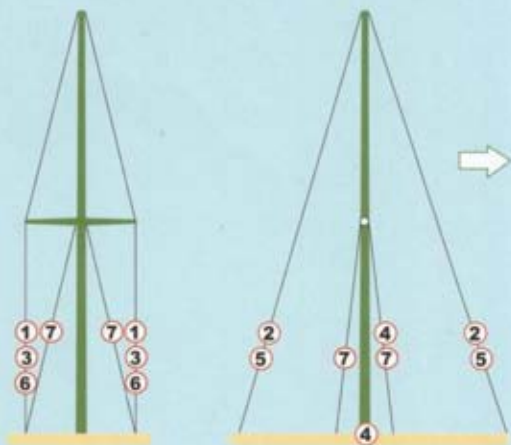
Fractional rig I (using running backstay)

1. Handtighten cap shrouds until mast is vertical. (62)
2. Adjust mast rake with forestay and runner. (63)
3. Tension cap shrouds to 15% of break. load. (66)
4. Set the mast pre-bend. (67)
5. Check and adjust maximum mast bend. (69)
6. Check and adjust the cap shrouds under sail. (71)
7. Straighten the mast sideways under sail. (72-75)

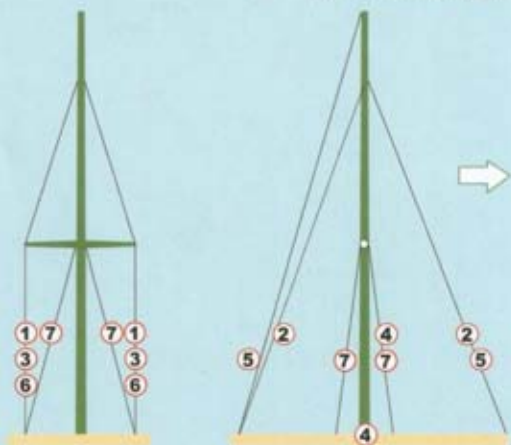
Fractional rig II (aft swept spreaders, no runners)

1. Handtighten cap shrouds until mast is vertical. (62)
2. Adjust mast rake with forestay and backstay. (63)
3. Tension cap shrouds to 20% of break. load. (66)
4. Set the mast pre-bend. (67)
5. Check and adjust maximum mast bend. (69)
6. Check and adjust the cap shrouds under sail. (71)
7. Straighten the mast sideways under sail. (72-75)

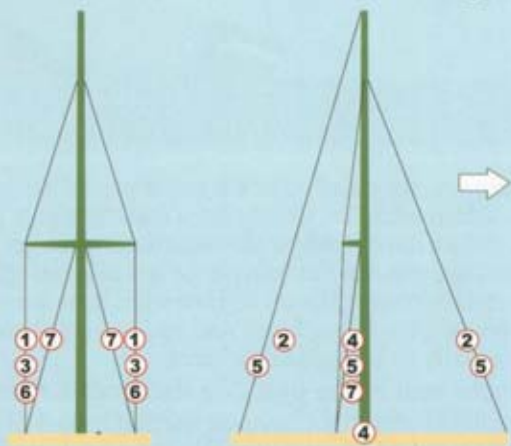
Masthead rig



Fractional rig I



Fractional rig II



Miscellaneous

Always mount the rigging screws with the **right** threaded part down. It will then be easy to remember which way they should be turned to tighten or loosen stays or shrouds. Just imagine that the rigging screw is a normal right threaded bolt that you screw down into the deck (the nut) when you want to tension a stay or shroud.

The rigbolts should be mounted and split pins inserted as shown on figure 23. Split pins or rings are also used to lock the rigging screws after their final adjustment. It is wise to tape over these, or put a protective cover over the whole rigging screw. This will also prevent the headsail and sheets from getting stuck in the split pins. Simple but smart clamps for locking rigging screws are available, these may replace split pins and make it easier to open and lock the rigging screws for adjustments. In addition they are shaped to fit smoothly around the rigging screw so that sails, sheets or clothes are not easily caught by them.



Sideways mast bend (lateral mast bend)

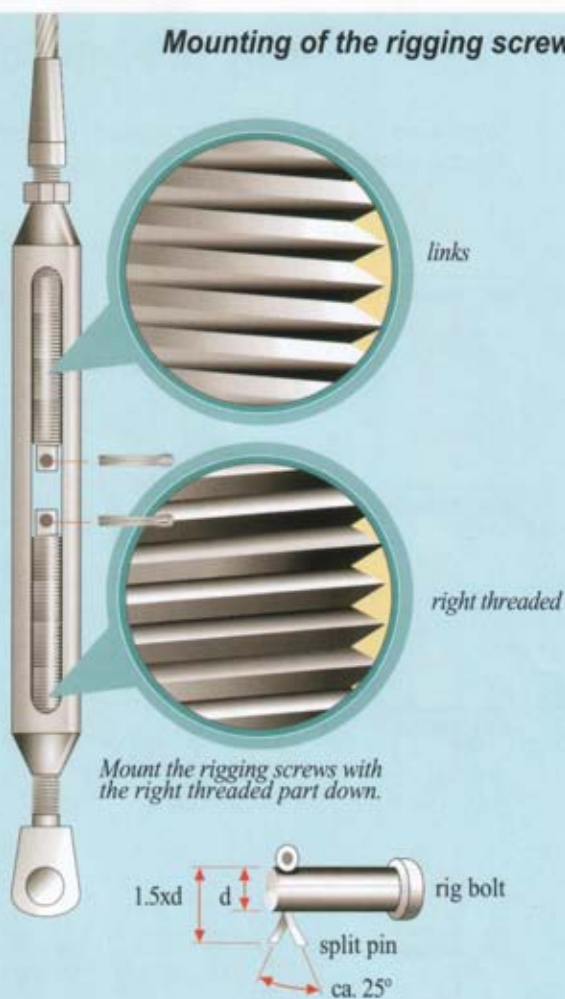
When the masthead on a masthead rig falls off to leeward, the angle between the cap shroud and the mast will decrease. The cap shroud tension will increase as this angle becomes smaller. If the shroud tension becomes high enough, the shroud may be ripped off the mast fitting or the spreader may break. A mast failure will then be the result. This is the main reason for why it is so important to correctly pre-tension cap shrouds.

As mentioned earlier forestay tension will decrease when the masthead falls off to leeward. The pull of the backstay will in addition pull the masthead even more to leeward when the wind picks up.

The sag and the depth of the genoa will increase just when you need flatter sails.

On **fractional rigs** the angle between cap shroud and mast does not change to the same degree when the masthead falls off to leeward. On the contrary the masthead will now act as a shock absorber in the gusts, flattening the main and opening the leech, when the top of the mast falls to leeward and the midsection is forced to windward.

Mounting of the rigging screw



23

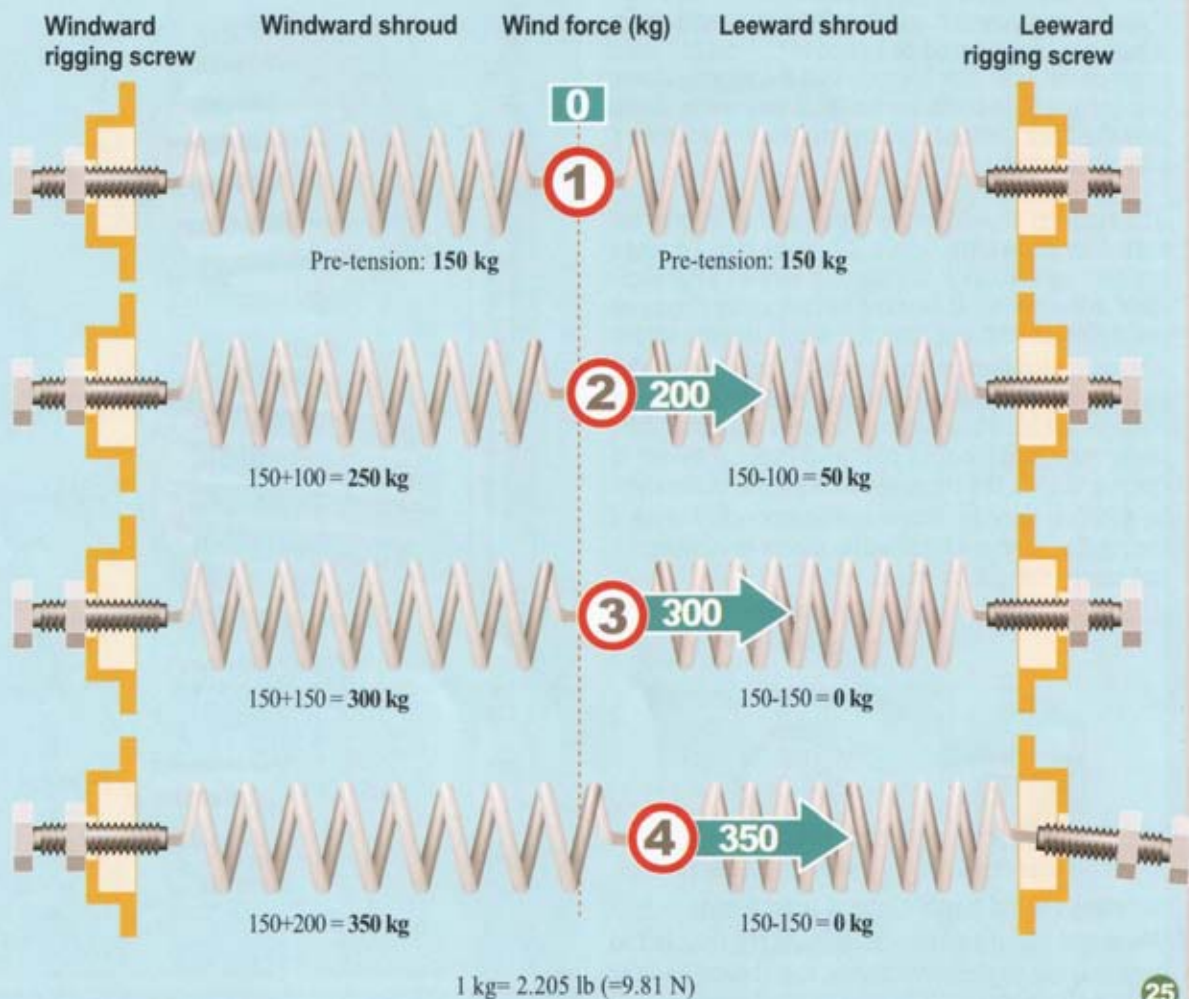
Fractional rig

Masthead rig



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Why pre-tension the cap shrouds?



The simplified illustration shows the interaction between the cap shrouds and the masthead. The cap shrouds are in this example prestressed to 150 kg. The rig is first exposed to a sideways wind force of 200 kg. Without pre-tension the windward shroud would have taken the whole load and the leeward shroud would be totally slack. But as the leeward shroud is prestressed to 150 kg it will be shortened just as much as the windward one will be elongated when the masthead is moved sideways by the wind force. The windward shroud tension will now increase just as much as the leeward shroud tension decreases which is 100 kg. The masthead therefore is only moved half of the distance to leeward that it would have moved *without* pre-stressing. The windward shroud tension will be the pre-tension *plus* half of the wind force, namely $150 \text{ kg} + 100 \text{ kg} = 250 \text{ kg}$. The leeward shroud tension will then be the pre-tension *minus* half of the wind force tension i.e. $150 \text{ kg} - 100 \text{ kg} = 50 \text{ kg}$.

If the wind force increases to 300 kg (3), we'll see that the leeward shroud tension becomes 0 kg. All the pre-tension has been "used", but so far the masthead has only moved half the distance to leeward that it would have done without pre-tension. If the wind force increases even more, e.g. to 350 kg (4), the windward shroud must then take the whole load increase of 50 kg alone. The windward shroud tension now increases from 300 kg to 350 kg, while the leeward shroud has no load and remains slack. This causes a movement of the masthead twice as far to leeward that it would if the shrouds had been pre-tensioned with 175 kg or more: $175 - 350/2 = 0$. *It is therefore most important that the cap shrouds are pre-tensioned so that the leeward cap shroud tension only becomes zero when the highest wind forces are experienced. Pre-tension acts as a shock absorber in variable wind strengths and the masthead is kept under better control.*

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Illustrated

Sail & Rig Tuning

A concentrated and thoroughly illustrated manual which systematically shows you how to trim your sails and rig. The author has been sailing for more than 20 years and has logged close to 40 000 nm including two Atlantic crossings. He has in addition worked for many years as a sailing instructor.



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