HALL SPARS & RIGGING

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Essential Rig Tuning Manual

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Tuning Your Rig

The goal of rig tuning is to have a mast that's straight athwartships. This will help you gain control of sail shape and achieve proper helm balance in a variety of conditions. Most importantly, the resulting mast tune will not impart any excessive strain or loads on the spars, rigging, or the structure of the boat. The basic adjustments for tuning a rig are actually straightforward and not the mystery that some people might make them out to be.

To begin, we should define the difference between fore-and-aft tune and transverse tune. Fore-and-aft tune basically refers to rake and mast bend. Transverse or lateral tune refers to setting the mast up straight sideways and setting up the uppers to minimize lean.

Fore-and-Aft Tune

Let's begin with rake, which is determined by headstay length. Rake affects helm by moving the center of effort of the sails relative to the center of lateral resistance. A longer headstay gives more rake which gives you more weather helm.

A starting point for arriving at the correct rake is to measure the designed rake of the sailplan. A typical 40' boat would have about 15"-18" of rake. To calculate rake, hang a plumb bob from the main halyard and measure from the aft side of the mast along the cabin top to the plumb bob. This should be done with the backstay tensioned at about 60%. The actual amount of rake you end up with may vary depending on the normal conditions you sail in and may be a compromise between what's optimum in light air vs. heavy air.

The second aspect of fore-and-aft tune is mast bend. A certain amount of mast bend is desirable. Mast bend is determined by the relationship between the positions of the masthead, deck partners, and mast step. If we've decided on the proper rake, then the masthead position is fixed and we have the deck partners and mast butt positions to adjust to induce mast bend. By either moving the mast forward in the deck collar or moving the mast butt aft in the step, we can induce some bend into the rig.

Another factor that can affect mast bend is the angle at which the butt of the mast is cut off. If the mast is resting on its forward or aft face, the resulting moment will have a major effect on bend. We normally radius the butt of the mast so that the spar will bear near the center axis of the section, thereby minimizing the bending moment regardless of the angle of the spar to the step.

Other factors that control mast bend are double lower shrouds, babystays, and inner forestays. Double lower shrouds can be tuned to increase or limit mast bend. Babystays are typically used on boats with single, in-line lowers and pull the rig forward down low in the same way as forward lowers. Inner forestays with a staysail can put a large bending moment in the spar and are usually opposed with running backstays or aft intermediates.

Spreader sweep is also a big factor in mast bend. This factor, however, is a design feature of the spar system, and not a variable as most spreaders are fixed rigidly to the spar. Aft-swept spreaders will facilitate some mast bend and in-line spreaders will restrict mast bend.

So what does all this talk of mast bend mean? Why is it important? A certain amount of bend is necessary as it makes the spar more stable and less likely to pump in a breeze. Most mainsails require a certain amount of mast bend to set properly, and, as the breeze increases, the combination of more backstay tension and more bend will flatten the main. This will keep the boat standing more upright and ease the helm.

Another consideration is headstay sag. Controlling the amount of headstay sag with an adjustable backstay will allow you to optimize the shape of the genoa through a range of wind strengths. With an adjustable backstay, particularly an hydraulic backstay, it's extremely important to establish a maximum backstay load as well as some lower reference points. A good upper limit is 30-40% of the breaking strength of the backstay wire or rod. This allows some margin of error in the system in case of shock loading.

Lateral Tune

Lateral tuning is probably the most important tuning process and is often the most confusing, particularly with multiple-spreader rigs. Keeping the mast straight athwartships over a range of wind strengths and sea conditions is essential to keeping the rig in the boat.

In addition to keeping the spar straight or in column, we're interested in having the upper shrouds tight enough to minimize how far the mast leans over the side when sailing upwind. This will help reduce weather helm. Although the effect is small, most boats have too much weather helm in fresh air and it's important to minimize it any way we can.

The first step in lateral tuning is to center the mast in the boat. The backstay and upper shrouds should be relatively loose at this point to minimize bending the rig. Pull a steel tape up on the main halyard and measure to the chainplate or to a point on the gunwale on each side. Adjust the upper shrouds until you get the same readings port and starboard.

At this point, check to see that the spar is firmly secured in the partners with wood wedges or preferably hard rubber wedges. They should be very tight so the mast cannot work or move at the deck. Spartite is the most efficient and effective means of securing the mast in the partners, and is required for carbon spars.

The next step is to tension the upper shrouds at the dock. Make sure the turnbuckle threads are lubricated to prevent damage from galling. A dry lubricant is preferred, such as Rig Lube or Bike Aid. The upper shrouds should be as tight as you can get them with a 10" crescent wrench. Don't use a larger wrench or an extender as you can damage the

threads. Additional tensioning must be done under sail. The lowers and intermediates should be fairly loose, or just tight enough to keep the mast straight.

If the boat has discontinuous rigging, it's important that the diagonals be very loose before tensioning the verticals. They will tension as the verticals are tensioned.

Now we're ready to further tension the upper shrouds under sail. In about 15 knots of breeze, put up the main and begin by tightening the leeward upper shroud. Keep track of the number of turns. While tacking back and forth, continue to tighten the turnbuckles on each leeward side until the uppers are snug with the boat heeled at 20 degrees. Don't worry about the lowers or intermediates at this stage; the object is to fully tension the uppers.

Another method for tensioning the uppers without sailing is to heel the boat over at the dock using a halyard. The halyard must lead through a fair lead lock at the masthead and have a clear lead directly abeam. This method saves time and also allows adjustment of the lowers and intermediates—but exercise caution tuning this way.

Now that we have the target tension on the upper shrouds, we're ready to straighten the mast with the lowers and intermediates. With a single-spreader rig, simply tension the lowers until the mast appears straight when sighting up the sail track or groove. This should be done under full sail in 15 knots of breeze. If the boat has double lowers, generally the forward lower will be tighter than the aft lower. The forward lower does most of the work supporting the mast laterally. The aft lower acts primarily to limit mast bend as the backstay is tightened in heavy air. At the dock, the lowers will be a good deal looser than the uppers. Under sail, the lowers on the leeward side will flop around a lot, and it's a good idea to use a shock cord lashing to take out the slack and prevent fatigue.

Multiple spreader rigs are more complex, but the tuning process is essentially the same. After the uppers are secured, start with the D1 shrouds (lowers). These should be tight enough to prevent sagging to leeward at the first spreader in 18 knots of breeze.

The next shroud up in a double-spreader rig would be the D2 or the intermediate. The adjustment of the D2 is very important as it has a large effect on the transverse bend in the upper part of the spar. It should be set up fairly loose in the beginning of the tuning process and gradually tightened to eliminate sag at the second spreader.

If the D2 is too tight, the upper spreader is pulled to windward and the masthead is relatively to leeward. This situation is undesirable as the angle between the upper shroud and the spar at the upper tang is reduced. Many people view that as the tip falling off, with the solution to tighten the uppers, when the correct adjustment is to ease the D2. The final fine-tuning adjustments of the diagonal shrouds should be done at 20-30 degrees of heel, as the adjustment is relatively insensitive at low loads.

Prebend for Stability and Speed

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Prebend is the amount of bend induced into the mast after the backstay (or runner) is tensioned just enough to straighten the headstay. The amount of prebend depends on several adjustments that will be examined in detail.

There are several reasons to use prebend. The main benefit of prebend is to “match” the mast to the luff curve of your mainsail. If the prebend and luff curve are in sync, then the mast/sail combination will have a wider wind range potential. Net net is more speed. Another benefit of prebend is a more stable mast. In the early ’80s when the babystay was eliminated from most racing rigs, prebend became a necessity to keep the mast in the boat. The combination of low bend (prebend) and compression bend generated by backstay loads produced a stable rig. Basically, bent masts are more stable (pump less) than straight masts.

Keel-Stepped Masts with Straight Spreaders

Three adjustments affect the prebend with this type of rig.

Headstay Length — This is the easiest way to change the prebend in your mast. Most headstays have a turnbuckle adjustment. To increase prebend, simply lengthen the headstay by opening the turnbuckle. Conversely, if your mast is overbending because you have too much prebend, tighten the turnbuckle to reduce prebend.

Keep in mind that adjusting the headstay will change your mast rake as well. If exact mast rake is critical to the balance of your boat, you should fix the length of the headstay and use a combination of the following adjustments to change prebend.

Butt Position — No, this is not where your crew sits on the rail. Butt position relates to the location of the mast step. Most mast steps have fore-and-aft slots to facilitate adjustment. With the mast fixed at the deck with wedging, a slight movement of the butt can change your prebend. While headstay adjustments are usually in increments of inches, mast butt adjustments are done in millimeters (or fractions of inches).

To put things in perspective, imagine your mast bury is 6' (this is about average), your mast extends 45' above the cabin top, and your foretriangle base is 14'. The effect of moving the mast butt back 1/2" is equivalent to lengthening the headstay 1-1/4".

Moving the mast butt is not as easy as turning a turnbuckle. You should slacken your rigging (easy if you have a hydraulic step, but a pain if you do not), loosen the bolts in the step, and push or pull the butt to the desired location. This is easier said than done, especially if the mast is enclosed by a small head compartment. You may have to resort to a 4 x 4 and a big hammer to “finesse” the mast step forward or aft. If you are sailing in a one-design class, check with the fastest boats in the fleet on their butt position and headstay length. At least you will start off in the ball park and can tweak from there.

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Deck Position — This is the third method to adjust prebend. Generally, the mast is chocked with wedges to position the mast to the designed (or rated) J. You can rearrange this wedging to change prebend. Moving the mast forward at the deck increases prebend just as lengthening the headstay or moving the butt aft. If you have an oval mast collar, moving the mast will necessitate “fashioning” your mast wedges to fit the new position. If you have a rectangular collar (more prevalent on custom race boats) the process is much easier. Thin wedges (3/16" to 1/4") can be moved from the front of the mast to the back. The main hassle with changing the position at the deck is dealing with the mast boot, silicon seal, and cranky mast wedges.

Masts with Swept Spreaders

Following the basic steps of headstay length, deck and butt position, you can adjust the prebend on a mast with swept spreaders. Prebend can also be induced by increasing the tension on the upper shrouds. Tensioning the lower shrouds will reduce prebend. If your mast is deck-stepped, the only method of inducing prebend is by having swept spreaders or using the techniques described below.

Deck-Stepped Masts with In-Line Spreaders

Inducing prebend into a deck-stepped mast is a bit more subtle. The mast must be securely fastened to the mast step so that it cannot rock on the step. Once secure, the mast will act in a similar fashion to a keel-stepped mast. Changing the headstay length or the angle cut of the butt of the mast will alter prebend. Again, lengthening the headstay will add or induce prebend.

If you trim the bottom of the mast shorter on the front edge, the relaxed mast will be leaning forward slightly. When you tension the backstay so the headstay becomes straight, the mast will then have prebend in it.

This is not recommended unless you are fairly sure of the results. Once you have cut the mast, you cannot go back without shortening the overall length of your mast.

Prebend and Boatspeed

Mast Stability — It’s desirable to have some prebend simply for mast stability. Rigs with in-line spreaders, in-line lower shrouds, and no babystay rely on prebend for fore-and-aft stability. Pumping is reduced with proper prebend and total mastbend. The size, shape, and wall thickness of your mast section also are key factors in rig stability, but are something you cannot change unless you replace your mast.

Sail Shape & Boatspeed — The most important use of prebend is to match your mast to your mainsail. If you sail in a class that has an optimum rake and prebend, your sailmaker will construct a mainsail with a luff curve and an overall design to match this mast curve. If a main is built with too much luff curve, the sail will be too full in medium- to heavy-air conditions and cannot be depowered. A main with too little luff curve will "blade out" too early when backstay pressure is applied. Ideally, a main will be deep and powerful with light backstay tension and will flatten as more backstay pressure is applied. At full backstay, the sail will be bladed out and depowered.

Assuming your mainsail is built with the proper luff curve to optimize the speed and versatility of the sail, your prebend should be adjusted to best match the sail. For instance, if the lower portion of the main is too flat in medium air, try reducing prebend by any of the methods discussed earlier. Working closely with your sailmaker to "match" the sail and mast bend will mean more speed on the racecourse.

To have consistently good boatspeed through a wide wind range, you must shift gears to change sail shapes to suit the wind and wave conditions. If your sail and mast are in sync, the sail shape transition is almost automatic simply with backstay tension. If your sail and mast are not in concert, you will grind your way through the wind range with less boatspeed. Bottom line: spend time getting your prebend right. The results are dramatic on the racecourse.

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Rig Inspection Guide

Deck-Level Inspection

1. Check the general tuning and rake of your mast. Check for proper positive bend with minimum and maximum backstay tension.

2. Check mast collar for secure blocking and install a proper mast boot.

3. Check that mast sits flush on mast step.

4. Check that chainplates are water tight and inspect attachment points belowdecks for wear or movement. Check for water stains around chainplates attached to wooden bulkheads that might indicate dry rot.

5. Check turnbuckles for signs of galled threads, bent body or studs, cracks, secure locking nuts or cotter pins, signs of elongated holes or bent clevis pins. Make sure that all shrouds and the headstay have proper toggles for articulation.

6. Check all rod or wire terminals for signs of fatigue, cracks, or bends.

7. Inspect furler hardware for loose or missing fasteners. Make sure the system rotates freely and the bearing on both the drum and the halyard swivel are cleaned and lubricated. Check for proper lead on the furling line.

8. Check boom and vang goosenecks for worn pins, elongated holes, cracks in toggles or welds. Check for loose fasteners.

9. Inspect boom for cracks or dents. Check all attachment bails or pad eyes for signs of wear. Is outhaul and reefing equipment in good order? Are mainsheet blocks and shackles working properly?

10. Check mast at deck level: Look for cracks or excessive wear at halyard exit slots. Check sailgate and mast track. Check mast-mounted hardware for problems.

11. Check for proper operation of winches. Winches should be serviced several times a year for best operation.

12. Lifelines: Inspect all swage terminals for cracks. Check turnbuckles, eyes, and pelican hooks for bends or cracks. Check the lifeline cable where it goes through the stanchion for excessive wear. Check bow and stern pulpits and stanchions for secure attachment.

13. Inspect jacklines and their attachments.

14. Inspect halyards: Attach spare line or halyard tail to halyard shackle and pull up to inspect full length of halyard and wire to rope splice. Check wire for broken strands and shackle for proper operation.

15. Running rigging should be gone over for signs of wear and fatigue. Inspect all shackles and deck hardware.

Inspection Up the Mast

1. Mast head: Check the attachments for the headstay, backstay, and upper shrouds for cracks, elongated clevis pin holes, secure cotter pins, and proper alignment. Headstay should be toggled. Check sheaves and pins for wear and ensure that sheaves turn freely. Check for sharp edges where halyards exit. Check spinnaker halyard blocks and shackles and their attachment to masthead for wear. Check masthead wind indicators and electronic instruments for secure attachment. Inspect top of mainsail track for wear in headboard area. Check that all fasteners, rivets, and screws are tight. All Dee shackles should be seized to prevent screw pin from backing out.

2. Headstay and furler: The top of the headstay foil should be inspected for damage caused by halyard wrapping. Check for proper angle of halyard-to-halyard swivel to prevent halyard wrap. Check for proper height of the halyard swivel. Make sure that smaller, short-hoist jibs have wire pennants. Check upper terminal on wire or rod for fatigue or cracked swage.

3. Upper, intermediate, and lower shrouds: Check all terminals for signs of fatigue and cracks. Check tangs and surrounding areas for signs of stress or cracks. Make sure all tang fasteners are secured. Inspect clevis and cotter pins for wear. Check shrouds or terminals at the ends of the spreaders.

4. Backstay: Check terminals for fatigue and cracks. Check backstay insulators. Check backstay turnbuckle or hydraulic cylinder for proper function.

5. Spreaders: Check spreader for bends, dents, or cracks. Check any area that's welded for stress cracks. Check leading and trailing edges of spreader for wear caused by runners and/or inner forestays. Add chafe protection locally to runners. Check that the spreader bases are secure. On wooden spreaders, check for signs of dry rot around fittings. Check spreader tips for excessive corrosion (remove chafe gear or tape if possible to inspect). Make sure shrouds are securely attached to spreader tips with tip plate, seizing wire, or clamps.

6. Check sailtrack fasteners if the mainsail track is mechanically fastened to the spar. Loose rivets or screws could prevent the sail from dropping.

7. Running backstays, inner forestay, and babystay: Inspect terminals for fatigue, cracks, and proper alignment. Check toggles and clevis/cotter pins. Check tangs for signs of wear. T-terminals should have rubber retaining plugs.

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Care of Carbon-Fiber Spars

Each carbon-fiber piece built by Hall Spars & Rigging has been manufactured using heat and pressure autoclave curing, the best process available.

Carbon fiber has properties differing from aluminum. Though carbon composite is stronger than aluminum, it is less resistant to impact loads. Where aluminum will dent on severe impact, carbon composite could shatter or suffer serious delamination. Clearly, subjecting your carbon spars to severe impact is to be avoided.

Since carbon fiber composite is different than aluminum to drill, file, or otherwise process, always contact Hall Spars & Rigging for advice before making any modifications to the mast.

Handling & Storage

When you receive your carbon fiber mast, remove the plastic packaging bag immediately. If the mast is left in the plastic bag, the Awlgrip coating can be damaged. Do not store your mast with any type of cover.

The mast can be lifted by conventional methods, again, making sure fork lifts, cranes or hoists are adequately padded to protect the mast from sharp impact.

Commissioning

Rigging of a carbon mast is the same as of an aluminum mast with the following exceptions:

Spreader Bar Installation — Spreader bar installation should be done with care. Do not force the bar into the mast. If the bar does not go in with the light tap of a rubber mallet, check spreader bar hole for excess paint/primer build-up. Lightly sand off excess build-up and reinsert bar. After installing bar, attach spreader and insert clevis pins. Fit the other spreader and insert pins. If second spreader's pins do not appear to line up, gently squeeze the mast with a carpenter's clamp (with clean rags to pad the mast) to facilitate insertion of pins.

NOTE: Use Spartite to ensure the carbon mast is supported evenly in the mast collar area.

Spreader Tips — Upper and lower spreaders may require the use of stainless steel seizing wire to secure rod rigging to the spreader tip. The two holes provided in the tip are used to secure the seizing wire. After seizing, tape the spreader tips to prevent sail chafe. The upper spreader may also require the above seizing wire treatment.

Installation of Electronics

Wind instruments — Install in conventional manner, securing by drilling and tapping through the masthead cap into the masthead crane. Coat screws with Red Loctite before final installation.

Windex — Install at outboard end of crane only. Install by drilling and tapping crane. Coat Windex threads with Red Loctite.

VHF antenna — Install on side of mast with standard "L" stainless steel bracket. Drill and tap. Coat screws with Red Loctite.

If you add more wires than above, you may require an additional conduit.

Modifications

Any modifications or addition of hardware must be approved by Hall Spars & Rigging in advance. Please call us if you have any questions. CALL BEFORE YOU DRILL!

Here are a few examples of typical questions:

1. Can a radar unit be installed on the mast?
Yes, but we do not recommend it. First, the weight aloft is excessive and the radar interferes with the jib while tacking. If a radar unit is required, a custom backing plate must be installed to accept the bracket fasteners.

2. Can a flag halyard block be fastened to the lower spreader?
Yes, but a fitted backing plate must be installed to accept the fasteners of the padeye.

3. Can I fasten instrument brackets under the boom?
Yes. Drill and tap as in aluminum, but coat screws with Red Locite. Call Hall Spars & Rigging for best location of wire entry hole.

Maintenance & Cleaning

Your spars are faired with Awlgrip epoxy primers and coated with Awlgrip, a paint originally developed for aircraft. It is a tough paint with excellent gloss retention, but it can be damaged. Here are some hints to preserve the finish:

1. Use care when servicing mast. Cover areas adjacent to work area with rags.

2. Cleaning the mast: Use light detergent (SoftScrub or similar NON abrasive cleansers). For especially tough grease smudges, Acetone or Toluol may be used if coating has cured at least one month (Awlgrip is fully cured after one month). Remember both Acetone and Toluol are hazardous materials — use gloves and use only in well-ventilated areas.

3. Small scratches: Using an Awlgrip touch-up kit available from an Awlgrip distributor, mix parts 1 to 1 and carefully fill the scratch using a modeler's brush.

Large scrapes: Repair should be done by professional painters using Awlgrip products. (A paint scratch is a cosmetic problem with no danger of structural damage. If the spar is gouged, it may be damaged. Call Hall Spars & Rigging for advice.)

4. Hairline cracks: Report all hairline cracks to Hall Spars & Rigging regardless of harmless appearance. These cracks may be structural in nature. Generally though, hairline cracks represent filler material brittleness. To remedy, fill crack with body filler, lightly sand, then touch up as directed in Item 3 above.

Tuning

See the tuning section of this guide. Please contact Hall Spars & Rigging with any specific tuning questions or problems.

Who to Call at Hall Spars & Rigging

Our sales and customer service people are available to answer your questions about spar products or rigging. If you get our voice mail system, simply dial the extension of the person you're trying to reach and you'll be sent directly to their desk/voice mail.

Nan Hall, ext. 103
nan@hallspars.com
Nan can answer all your questions about spar products, from warranty to ordering. She's also an expert on QuikVang and QuikTrip parts. Nan has a wealth of experience racing and sailing on everything from one-designs to big boats.

Corey Butlin, ext. 131
corey@hallspars.com
Corey is a rigging specialist, and can answer all your questions about set-up for running rigging or lengths and specs for standing rigging. Corey owns and races a J/30.

Cara Read, ext. 116
cara@hallspars.com
Cara is also a rigging expert, with hands-on cruising experience and an extensive racing resume. She's a whiz at recommending hardware for any application.

John McCabe, ext. 125
jmccabe@hallspars.com
John is a top J/24 sailor—he finished fourth at the 2000 J/24 Worlds and second at the 2001 Midwinters. John has also worked as a boat captain, and he's ready to field your questions on any area of rigging, as well as Hall carbon poles and QuikVangs.

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