

LASEROLOGY

Tuning Mast Rake

So you thought there was nothing new on a **Laser**? Here is a discussion for Masters about mast rake, from a South African sailor. It is premised on comparing Bye-law 1.23 of 1974 concerning mast rake with the present rules. It deals not only with the technique of rake, but with the ethics involved.

Fast sailing needs neutral helm. In stronger winds, on the beat, the Laser continually pulls to windward, due to excessive weather helm. Of course, compensating with the rudder destroys boatspeed. So we are told to straight-leg-hike the boat flat. However, older, lighter and less fit sailors are at a huge disadvantage, because this approach needs fitness, force and bulk.

A better approach is to tune the helm neutral. To do this, we need to move the centre of lateral resistance (CLR) back. We can't, as the Laser has a daggerboard. Or we need to move the centre of effort (CE) of the sail plan forward. But we can't, as mast rake is not controllable, although we do "torture" the CE forward by tensioning the downhaul and opening the leech.

However, the mast step on a Laser is unique. Most dinghies have wedges, chocks, or struts at deck level and an adjustable step. Thus Optimists clamp the mast at deck level, but move the mast heel. The Laser does the opposite. It clamps the heel, but the mast flops back and forth at deck level. This is because the tube is oval at the top, but round at the bottom. No book of tuning techniques I've seen analyses this unique Laser anomaly. I became aware of the subtle shape of the tube when mine rotted and broke, and the mast bored a hole in the bottom. This shows that the power of the bendy rig is transmitted to the hull via the step and tube. It's the hull/rig interface.

So, here's my request:

Let's rake the mast more upright by tying a figure-of-eight in the bottom loose end of the downhaul rope, after it has been attached, via a clove hitch, to the kicker tang at the foot of the mast. Then stuff the knotted rope down the back of the mast tube, which is oval at the top. It goes in about four centimetres before jamming as the tube becomes round. A small adjustment to mast rake in the tube leads to considerable forward movement higher up.

This has four positive results

1. It moves the CE forward, reducing weather helm, and releases the brake of a stalled rudder. Feel improves, and the boat becomes lively and responsive to windward.
2. The mast bends more, because for the boom to "hit the deck" (actually the mainsheet goes block-to-block) the leech has to pull the topmast further back. So, the less aft rake, the more bend is induced.
3. With more mast bend, the sail gets flatter, earlier than your competition.
4. The flat sail helps to keep the boat flat.

To put it differently, Masers and lighter sailors will benefit from a more upright mast, as well as any sailor wishing to flatten and depower the sail more or earlier than conventional sailors.

Paul Elvström discovered this many years ago. He found that Finns benefited, in heavy winds, from an upright mast rake:

“We knew way back in about ’57 or ’58 that, to go to windward, we had to have the boom right on the deck, even in light winds. Therefore, we raked the mast back in light winds so that when we had the boom on the deck, the mast didn’t bend so much and then we raked it more upright in strong winds, so that, with the boom on the deck, it bent more.” (Elvstöm Speaks, 1969, p.158)

This technique could be especially fast when planing on a close reach, because weather helm is most unwelcome. However, once the wind goes on the beam, your mast rake will be no different from the “loose” masts, which have all raked forward, anyway.

As Elvström said, raking aft is not needed in light winds, as the block-to-block restriction stops the mast flattening the sail too much, and weather helm is not a problem – in fact it’s needed for pointing.

The Finn now has a more elegant solution. Finns can move the whole mast forward by controlling the heel and with chocks at deck level. This moves the CE forward, reduces weather helm and flattens the sail. With carbon masts, the top bends and opens the leech in gusts. ILCA members have correctly voted against a carbon top-section, which would contradict the One-design Laser principle, as some couldn’t afford it. My knot is affordable.

Now, is this legal?

1. The one design character of the boat is not altered, because the position and rake of the mast tube is not altered. Bye-law 1.13 of Appendix 4, 1974, stated “no fittings, wedges or other attachments may be affixed to the hull or deck.” Therefore, a loose wedge may be used, but I feel that it would be an “extra” fitting, against the spirit of the rule. A wedge could also be thrown away after the race, and no-one would be any the wiser.
2. The downhaul is a maximum of three lines. My technique needs one line only.
3. The mast tube
The measurement diagram illustrates the position of the tube. The rake of the mast tube is left unspecified.
4. Mast rake
However, there was a specific rule against controlling mast rake. Bye-law 1.23 of 1974 stated, “No attachments, fittings or devices may be used which affect or may affect the position or rake of the mast and nothing may be placed or wedged in the mast cavity other than the mast.” This rule is now omitted from the rule-book, because ILCA Bye-Law 1: Rules, valid from 1 December 2006, cancels all previous rules and interpretations. So my simple and inexpensive tuning technique can be used.

The present rules about mast rake

Let me summarise the present rules as pertaining to my technique. The principle of the Laser Class Rules is that no changes or additions to the boat are allowed unless they are specifically permitted by the class rules. My technique does not change or add to the boat. The mast travels backwards or forwards in the tube as far as is legal.

This principle would also ban many progressive changes or additions, not specifically permitted in the rules, like adding an expensive windvane. The thimbles to protect ropes were first tried, found to be cost-effective, then legitimised.

I would gladly throw away the expensive new block and tackle systems, which just do more of the same, in order to control mast rake cheaply. This is a good idea, and good ideas are what changed the Laser from a cartopper to an affordable Olympic class.

In fact, the new controls are not a good idea. Besides being expensive, they are unseamanlike, as the powerful vang can break the boom, and the powerful downhaul can tear the tack, distort the sail, and shorten its life. This means more expense in buying a new sail earlier.

- The Fundamental Rule is that a Laser must be built by a licensed builder, to design specifications known as the Construction Manual. No additions or alterations are allowed, and fittings as supplied by the builder must be used. My technique does not contradict the Construction Manual.
- The mast cavity location is governed by the measurement diagrams. These do not specify mast rake, but place the mast cavity at 2947 from the transom. My technique doesn't alter the placing of the cavity.
- An anti-abrasion protection may be wrapped around the entire circumference of the lower mast or the mast step cavity: The protection is attached and becomes part of the boat, so the boat is different from the rest. My rope is loose, so the boat is the same. There is no rule about where the end of the downhaul is placed i.e. in the cavity. It could be in the skipper's mouth, like the mainsheet sometimes. A knot is allowed in the loose end of the downhaul, since, for example, the vang rope end can be knotted.
- A rule prevents any changes to the standard boat which will make old boats redundant: A knot does not make old boats redundant.
- Use skill not money: A knot is cheap.
- Nothing may be complicated. The seven bend vang and five bend downhaul are complicated. One knot is easy.
- No cheating to change the Laser and its equipment: One knot in the tube doesn't change the Laser or its equipment.
- Anything that makes the boat go faster is "probably" illegal: In that case, we are all disqualified. Of course we all want to go faster. However, my idea is targeted at lighter, older, or unfit Master sailors, to make the boat easier to sail and a joy to handle.
- Controlling mast rake is not specifically allowed or disallowed. It used to be. Unless Bye-law 1.23 is re-instated, it should be allowed. Here's the Laser wording for a legal way to endorse a change (See the Laser website). Many sailors looped the CB shock-cord around the bow with clips. The existing rule at the time did not "specifically allow or disallow" (ILCA) this. So it was used. Now it is specifically allowed (Rule 14f).

One knot does the same as the new recut Radial sail, which as ILCA says: It depowers more easily, and suits smaller sailors. I'd add unfit Masters – my goal exactly. Most young and fit sailors would not depower so early. However, I'd urge everyone to try it, and see if the feel of the boat is better in 15 kts and more. A figure-of-eight over 15 gives 1½, or the 1.5 theory.

I submit that my method breaks no rules. We all want the same boats to get strict one-design racing, but the ingenuity of the skipper should be encouraged. This principle is shown by the many and varied changes to the Laser over the years.

The only drawback to my technique is the danger of breaking the bottom section where it jams against the knotted rope just below deck level. This is a stress point. I have specifically tested for breakages here over the years. The boom and top section, when over-stressed, have broken, but never the lower section. It is thicker than the top section, which also has a stress point at the join. This means the top section of the mast will break before the bottom section. In fact, in 15 years, I have never heard of a bottom section breaking; only going through the step. The knot does not damage the cavity in any way nor does the heel of the mast break the very strong tube.

If the skipper wants to over-bend his mast, as all Lasers do with the new vang system, let them be governed by the danger of breaking their mast and losing races, and the expense will soon regulate the 'market'. The new vang easily adjusts mast bend. One knot cheaply adjusts mast rake. Let's join all other classes which tune mast rake – even Optimists do.

I repeat, upright rake in a breeze reduces weather helm, flattens the sail earlier, and makes the Laser more responsive and a joy to sail for older, lighter and less fit sailors. This happens when the CE of the sail is moved forward by a knot. One knot faster with one knot in the downhaul end! Don't use it in less than 12 kts windspeed, as power is definitely needed. I've sometimes done so – the Laser feels dead as a duck.

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Now as to the desirability of adjusting equipment settings like mast rake. That's how we sail Lasers. We raise and lower the board and restrict it with shockcord. We adjust the rudder, vang, downhaul, outhaul, mainsheet, traveller, tie-down and toestrap, all with rope. My method controls the forward and aft movement of the mast in the tube also with an existing rope, just like the rudder, which moves up and down with a rope between set points. Think of my mast as a rudder blade in the air. So this means that the last non-adjusted setting on a Laser is the degree of mast rake and I have proposed a legal, cheap and easy method of controlling it with an existing rope. A Finn sailor would never put up with the lack of tuning mast rake.

The technique is the eighth way of bending the mast, along with supervanging, a boom sleeve, a tight traveller, a flat tiller, tight tie-down, tight mainsheet and a very short webbing strap over the head of the sail. The shorter the webbing, the higher the sail, so the mast bends more when the sail is sheeted block to block. My knot therefore continues a Laser trend.

In conclusion, the areas I have covered in the discussion on mast rake are:

1. Theory – CE / CLR theory.
2. Practice – Try it yourself. One knot in the 'loose' end of the downhaul, stuffed down the aft end of the mast cavity makes a difference.
3. Legality – The position and rake of the mast tube is not altered.
4. Desirability – The sail depowers earlier, helping the older, unfit sailor. The boat points better and stays flatter. Without weather helm, the feel is lively, so sailing is more enjoyable.

Mast rakes differ

Glenn Bourke wrote in an article (reprinted in SA Yachting, March 1990) that lighter sailors could benefit from more rake. He favours a rake of between 3 815 and 3 825, as measured from the top rear edge of the mast bottom section, to the tangent of the transom. This is an admission that mast rake does vary from boat to boat!

Ben Ainslie says: too much rake – you lose leech tension and get more weather helm, both bad. Too little rake – you get too much bend, creases in the sail, and less weather helm, which makes steering less tiring for older sailors. If in doubt, he says, forward rake is better, because its quick downwind and you get good leech tension upwind. My knot encourages forward rake.

The point underlying this is quite serious. There is no measurement for mast rake specified in public. So its entirely up to the builders to build in the mast tube at some ‘correct’ angle.

I measured some boats at my club, from builders in Canada, Ireland, UK and South Africa, using Glenn’s technique.

Boat	Rake	Tube
Simon	3 835	2 955
Bob	3 835	2 955
Ant	3 830	2 955
Terry	3 815	2 955
Willy	3 810	2 955
Brian	3 800	2 955

All the boats were equal as to the tube position as measured from the transom, but the correct measurement is 2 947. A sample of boats at my club has them at 2 955. The rakes differ. Simon, Ant and Bob had less rake than me. Hiking becomes easier, and steering less tiring, for them. Brian has the most rake, so he cannot flatten his sail properly.

I also read in sailingsource.com that the best mast rake is 12’6½” implying the rake is variable, but “the technical specs are not published” anywhere. Ben Ainslie gives his rake as 12ft 6 inches or 3 810 and says 3 759 is the limit of aft rake – this is far more than even Brian’s 3 800! And Annapolis Performance System sells shims for the mast heel that “improve mast rake” and says these are class legal! I don’t believe so.

These differences are strange, since, according to Tillman (1975, p7), “even the mast rake is checked by putting a lower section in the mast step and fitting a template to it to determine whether it is within class limits.” What are those limits? Where are they published? In the measurement diagrams of the Rules, no template for mast rake is provided, whereas a template for rudder blade rake is. It is correct at 78°.

At the Laser Worlds in Cadiz, a competitor measured a sample after the regatta, but found no difference in rake. The rakes were equal, but perhaps not correct – i.e. according to specs. Put in the context of measurement theory, the measurements may have been reliable, but not valid. Take, for example, a rifle shooting at a target. A good rifle will shoot a good grouping, but if the grouping is off the bull, the rifle is not accurate. A good grouping on the bull means that the rifle shoots reliable and valid scores. What was needed for that Laser fleet was the operational measurement for perfect mast rake from the manufacturer i.e. how to (tape from top of lower mast section to transom?) measure it in practice. The fleet measurer should use this transparent method on a sample before a regatta.

The problem may be that the tube is glassed in place using a jig, then the hull is sealed, so no-one can 'get at' the tube; a good 'open' way is the external tape routine. If this is so, why not give this measurement to everyone, with tolerances? Laser International does use a Technical Manager to go around sampling rake; the position was recently advertised. South African-built yachts, not built under licence, were never inspected.

My local Laser agent simply dismissed the problem by saying that all Lasers are built the same. Not so. And he confused mast rake with mast bend. Of course mast bend rakes the mast aft, but mast rake is determined by the angle of the tube.

Since Lasers will differ as to the amount of weather helm they carry, and how much the sail can be flattened, to buy a fast Laser to suit your age, weight and fitness, measure mast rake! And watch out if the tube has been replaced. It may not be cut into the deck at the right angle.

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I wonder if designer Bruce Kirby got it right in the design stage. The last thing he finalised was the mast rake and step position, but the testing process was quite rushed.

1. **October 1969:**

Basic design of yacht. First sailplan. The boom end is above the transom. The sailplan is far back. There was too much weather helm.

The design shows a pivoting centreboard, but this was changed to a daggerboard as it intruded into the cockpit, which is very small anyway. A centreboard would have helped reduce weather helm.

2. **The prototype October 1970:**

The first boat, the "Weekender" (TGIF = Thank Goodness it's Friday) was raced by Hans Fogh, at the America's Teacup Regatta, who recut the sail during the regatta. In a photo, the mast hardly bends, the boom is cocked high off the deck, and there is no vang. The boom is sheeted at the transom, thus the CE was still too far back, causing too much weather helm.

3. **November 1970:**

Montreal. A second boat was tested against the prototype. It had the deck cut open and a movable mast step. The sailplan had the mast three inches forward. Obviously weather helm was a problem.

According to Kirby:

"Finally the three of us – Ian Bruce, Hans Fogh and I – met at Royal St Lawrence YC near Montreal on a cold and blustery weekend in late November 1970, to sail the two boats and make the final choice of mast position and rake, the pipes that made up the mast and the sail itself. It was a cold, numbing, but very satisfying task, and when the job was finished, we stood in the yacht club showers for an hour toasting the new little craft with one hot buttered rum after another. At a more populous, but no more festive party later that night, the name Laser was chosen and the following week Performance Sailcraft began tooling up for production. (Handbook No 3, 1991)."

Do photos of these historic events exist in the Laser archives? I'd like to see the different degrees of mast bend, rake and sail shape.

4. **December 1970:**

A third boat incorporated all the changes and was the first production model. The boom was now too far forward to sheet on the transom, so the traveller was moved forward to its present position. So,

from the above, testing apparently took just over a year, during which the CE moved steadily forward. I wonder if more testing would have seen the sailplan moving even further forward, or was the need to exhibit at the New York Boat Show in January 1971 a factor? From there, 144 orders were taken and the boat's success was assured.

5. 1971:

Baltimore. First North American Championship, won by Dick Tillman. Could anyone who sailed then confirm my analysis of events?

In fairness, it is very difficult to establish an optimum CE with such a bendy mast. Pete Commette mentions that they sailed, in the early days, with a loose traveller rope and without a clew tie-down, thus keeping the mast relatively straight. Geoff Myburgh, who imported the first Laser into South Africa in 1973, says they kept the vang quite loose; later, when over-vanging to bend the mast, a boom sleeve was used to stop breakages. This was a seamanlike change to minimize damage to equipment which could cause tragic consequences at sea. With so much bend induced, the CE has definitely moved further back than was intended, hence the pronounced weather helm and the difficulty of ducking under the boom when tacking. This is why its imperative to move the mast upright by the knot.

However, looking at their sailing records, the designers didn't need much time! These were hard-core sailors:

Bruce Kirby: Twice Canadian Olympic Finn rep.

Ian Bruce: Twice Int. 14 POW Winner.

Such is the pedigree of our little "cartopper"! But, had they known it would become an Olympic class, wouldn't they have spent more time on testing?

Optional equipment

If you don't believe in my 1.5 theory, flatten the sail and reduce weather helm by using the downhaul and vang. Glenn Bourke, three times World Champion, braces a leg on the forward cockpit and heaves, "to torture the sail over the side of the boom." This is really stupid, as it reduces the life of the sail.

The problem has now been over-addressed by using the optional, expensive, huge downhaul and vang systems, far from what Bruce Kirby intended. One can't call a Laser One-design if it has 'optional' equipment. This contradicts the Laser philosophy that no changes to the standard boat may be made which may make old boats redundant. There is now no such thing as a 'standard boat', so the Rules on page 30 of the Handbook are now wishful thinking, dishonest and untenable and should be rewritten to encompass the concept of options. A good option is the knot. Expense should also have ruled out the carbon-fibre tiller. "The Laser is a strict One-design dinghy where the true test, when raced, is between helmspersons and not boats and equipment". Will ILCA members please leave our little lamb ALONE.

The multi-blocked downhaul strains the tack patch, and pulls the cringle out. It's too much gear added to a sail not designed for the load. The original Laser sails were never stressed like this, but the full rig sail has not been redesigned to cope. I expect to read reports of the downhaul tearing the tack right off the sail. This is why the Radial sail has been redesigned, recut and strengthened at the corners. I'm also not in favour of this, as it makes the old sail redundant. Radials still have terrible weather helm, despite the new, flatter design. Although the luff of the sail is shorter, the foot is the same as the full rig. This keeps the CE aft, so the 1.5 theory still holds.

Lasers seem to ‘feel’ better when beating block-to-block, but with the mast more upright with the knot, one shouldn’t go block-to-block, as the sail will flatten too much. So I tie a stopper knot 7cms from the aft end of the mainsheet, so it jams against the foot block, and the sail goes knot-to-block. One can still let the sail right out. The boom stays slightly out, so one is prevented from overshooting. The helm goes neutral, the feel of the boat improves, and one can be more playful when beating.

I will, as a matter of principle and in keeping with the Laser philosophy, only use the sleeve to protect the boom and thimbles to protect the control lines, not blocks to let them run. Win by the skill of the skipper, not by expensive equipment. When racing, I have heard, “Terry Gilman” doesn’t even have the new stuff”. For ‘stuff’ read status symbols. This is sailing snobbery and shows how ‘optional’ equipment discriminates against the dignity of poorer sailors. The strict One-design concept, now devastated, was my friend. Because I can’t afford the new tackle, a free knot might level the playing field. I am so glad that the carbon-fibre top section has been thrown out, but feel the addition of a compass, carbon-fibre tiller and clew quick-release system are unconstitutional. It’s come to the stage that the standard boat, called a Laser, is the proper class, and the rest should be raced separately, as an extra-ordinary, Formula X, Olympic class.

To put it another way, there are handicap classes and One-design classes. With its lack of go-fast equipment, my Laser should receive an appropriate rating. The elite Lasers should be adversely handicapped. Since anyone can use the 1.5 theory, my knot is democratic.

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Reduce weather helm by a knot

Heeling to windward also neutralises the helm, but don’t just do it downwind; do it on the beat. One can see Glenn Bourke’s Laser in perfect balance in a photo in his book, heeling to windward.

Glenn says: “In light air there’s a great technique where you heel the hull to weather, creating a peculiar “upwash” of the centreboard – its superfast.” I believe it’s partly due to the wonderful “feel” that neutral helm gives. Putting it technically, the CE is over the CLR, the helm is perfectly balanced and steering is an absolute pleasure, because the messages of wind and water are transmitted direct to you without fighting the tiller. In addition, if a puff hits, it will only cause the boat to come level, not heel over, so maximum power is gained. A knot gives this feeling.

I bought the video of South African Olympian Dave Hibberd in the Seiko “Reach for a Dream” series, as well as in the 1996 BP World Championships and studied Dave’s technique in slow motion. He sometimes sailed with terrible weather helm, because he vanged excessively and his leech was too tight. Instead of fighting the helm, he could have used the knot.

Downwind, all the masts go forward anyway, so where’s the edge? Be aware of rake. Although, on a broad reach, the mast will go forward immediately, on a beam reach there is a point at which it falls forward (or not). Be aware of this point, and get the mast forward by the knot to reduce weather helm.

Conclusion

So my message to ILCA in a nutshell: let’s re-introduce Bye-law 1.23 of 1974 to read “**No attachments, fittings or devices may be used which affect or may affect the position or rake of the mast, and nothing may be placed or wedged in the mast cavity other than the mast and an existing rope which may be knotted.**” This would kill the Laser’s weather helm upwind, flatten the sail earlier, and make it easier for Masters to keep the boat flat. A neutral helm makes the Laser a

delight to sail, and a flatter sail upwind extends the range of wind speeds in which lighter or older sailors could stay competitive. This would be good for the class.

And here's my request to ILCA, the builders and measurers, which I've e-mailed to them. Please make available the operational measurement for mast rake. This will put to bed suspicions and rumours about it.

This article has been 15 years in the making and is the fullest analysis of Laser mast rake ever written and one of the few to combine a technique with a democratic philosophy. Please e-mail me with your comments. You could also distribute it at your club or to your local Masters for discussion. We all want the best for our little boat. Let ingenuity, skill and a good 'feel' for the boat take precedence over expensive equipment.

Regards in sailing

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