

NEW UNIVERSAL RULE OF MEASUREMENT

A PROPOSED REVISION TO THE MEASUREMENT RULE



CLASS M

Version 12.1.0

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INTRODUCTION TO VERSION 12

This proposed new version of the Universal Rule of Measurement takes into account development work done over a number of years, incorporating what has been learned about this kind of boat from that work, and also from considerations of desired sailing characteristics. This proposed version of the measurement rule is far more restrictive than the original, and is intended to produce modernized hulls of the same general type and character as the original class, though keels and rigs are allowed to depart from traditional forms by a greater amount.

It should be noted that this version envisions only boats built to Class M. Hence certain equations and especially constants therein will be found totally inapplicable to other sizes of boats.

While the intent of the original rule appears to have been to rate any – or at least a wide range of – boats in a workable manner, experience over the years has shown that to be a most difficult task to accomplish, even more so now in the 21st Century where sailboats are so different as to hardly be recognizable as different forms of the same thing.

At the same time, the gradual rise of preferences for “one design” racing shows the fear that many people have, often well-founded, of design developments leaving their boat behind and hence useless for racing.

In this rule, the objective is to retain the design competition, based both on the fact of that being traditional, and on the concept that the winning team should be the team with the best design, best construction, best sails, and best rigging and equipment, as well as the best sail handling, steering, and tactics. In other words, the entire spectrum of sailing is tested, but – except for the actual sailing – each portion is tested in a very limited way. The intent is to preserve the competitive life of the boats, and to ensure the likelihood that any progress in design or equipment can be retrofitted into the existing boats at a reasonable cost.

This rule is, therefore, open to a great variety of development, but only on a very restricted and regulated basis.

MAJOR CHANGES IN Version 12.1.0

- ◆ Maximum beam changed to 13.73 ft (4.185 m), correcting error in previous versions.
- ◆ New drawings are provided reflecting the change in draft initiated in version 11.7.0. There is no change in the rule itself due to this change in drawings, it is simply an update to the drawings.
- ◆ The Introduction has been changed to reflect the intent of the rule as a very strict development rule.
- ◆ A new term, P_{depth} , has been added to penalize hulls of insufficient depth. See Section 1.1.2.8. Some drawings have been renumbered, and some equations renumbered, due to the insertion of the new depth requirement.
- ◆ The maximum QBL without penalty has been increased, by changing the constant in the equation to 4.00. The corresponding change has also been made to the penalty.
- ◆ The maximum forward position of QBL has been reduced from $0.12 * LWL$ to $0.117 * LWL$ aft of the forward end of LWL.
- ◆ Maximum and minimum beam have been changed from a function of LWL to a fixed maximum and minimum value. See Section 1.1.2.5.1 and 1.1.2.5.3. The corresponding changes have been made to the penalty calculations.
- ◆ A new section 2.0.14 has been added calling out a short-footed mainsail for strong-wind use, in order to avoid the dangers to human safety of attempting to reef in heavy going, and the danger to sails and equipment.
- ◆ Figure 6 has been moved to a location closer to the text to which it refers, and has been modified to include indication of how stem and counter angles are to be measured in practice, as this drawing is shared with Instructions to Measurers.
- ◆ Figure 5 and Figure 6 have been altered to improve clarity, and in the case of Figure 6, to indicate how the stem and counter angles will be measured. This last change to Figure 6 is not meant to provide a complete explanation to measurers, which will be in the Instructions to Measurers, but rather to guide designers in determining how to decide what stem angle they want and how it will be treated under the measurement rule.
- ◆ Section 1.1.2.3.3 and 1.1.2.3.4 are added to define an additional measurement point on the counter, and a penalty for exceeding the maximum. Equations 10.1 and 10.2 are added defining these additions in quantitative terms.
- ◆ Figure 2 is replaced with a new Figure 2 which includes the requirement that the forward end of QBL not be taken for measurement purposes as further aft than $0.12 * LWL$ aft of the forward end of LWL. This requirement has been in the text of the Rule for a long time, but the drawing didn't indicate the requirement until now.
- ◆ Figure 3 is replaced with a new Figure 3 which illustrates the new counter measurement point, and also clarifies the measurement point locations for FWD and AFT without changing FWD or AFT.
- ◆ Section 5.1.6 and 12.1.6 (Metric version) are altered to permit gradual reduction in floor scantlings forward of Frame 12.
- ◆ Section 5.1.7 and 12.1.7 (Metric version) are altered to permit gradual reduction in frame web heights forward of Frame 12.
- ◆ Section 5.1.14 and 12.1.14 (Metric version) are altered to reduce the scantling of the heavy longitudinal deck beams.
- ◆ Miscellaneous minor clarifications and changes are included in other sections of the construction scantlings.
- ◆ The Example Construction Plan is replaced with a new drawing illustrating one possible construction using the new scantlings, and based on one of the present demonstration boats, 66F15.
- ◆ The Example Lines Plan is replaced with a new lines plan consistent with the new AFT₂ measurement, Hull 66F22a.
- ◆ Section 1.3.6.1: The minimum length overall is increased to 85.25 ft (25.95 m).
- ◆ Section 1.3.9.1: The minimum angle of the stem to the LWL without penalty is reduced to 12.80 degrees.

- ◆ Section 3.1.4.2: The depth below which hollows in keel profile and transverse section are prohibited is changed to -6.500 ft (-1.981 m) WL to permit more options in joining keel to hull, and to bring the section into sync with the provisions of Supplement 13 which clarifies keel cross-sectional shape.
- ◆ Section 2.0.4.1: The maximum girth of mainsail at height of 65% of P above base of P is changed to $0.52 * E$ to resolve a potential problem with clearing the standing backstay.
- ◆ Section 1.1.2.2.2 and Section 11.1.3: The penalty for excessive breadth forward (P_{fwd}) is reduced from 2 times the excess to 1.5 times the excess.
- ◆ Section 3.2.1 and related sections referring to skegs have been changed to eliminate the requirement that a rudder be connected to the skeg in order for the skeg to be legal.
- ◆ Section 5.1.28 and Section 12.1.28: The minimum requirements for bulkhead closure have been changed.
- ◆ Section 1.3.9.1 has been changed to clarify measurement of irregular shapes of counters.

GENERAL PROVISIONS APPLICABLE THROUGHOUT THE RULE

INQUIRIES ABOUT THE RULE

Inquiries about this rule should be addressed to info@universalrule.com.

TERMINOLOGY INDICATING MANDATORY OR ALLOWABLE

Throughout this measurement rule, the term “shall” is taken to mean mandatory, while the term “may” is taken to mean allowable but not mandatory. The term “or” shall be taken as inclusive (that is, and/or) unless otherwise indicated.

MULTIPLE MEASUREMENT CERTIFICATES

A boat measured under this measurement rule shall have only one valid measurement certificate at a given time. That is, if any change in ballast, flotation, sail plan, hull form, keel form, rudder configuration or any other factor requiring re-measurement is made to the boat, then the re-measurement must be physically performed and a new measurement certificate covering the new configuration must be issued. Issuing of that new certificate automatically voids the old certificate, such that the boat, if returned at some point to the earlier configuration, must then be re-measured and yet another new certificate must be issued for the configuration to which the boat was returned.

It is never legal to change back and forth between configurations requiring re-measurement without actually performing the re-measurement.

EXOTIC MATERIALS LIMITATIONS

Exotic materials are taken to be materials having a tensile strength greater than that of the highest tensile strength stainless steel in common use, which is taken to be a yield strength of 30,000 psi. If a material is considered to be totally incapable of plastic deformation, then its rupture strength would be used.

At the time of implementation of this version of the rule, only the following items are permitted to be of exotic materials:

- ◆ masts;
- ◆ spreaders, cranes, and other rigging elements generally attached to the mast;
- ◆ booms, and rigging elements generally attached to the boom;
- ◆ spinnaker booms and reaching struts;
- ◆ transverse rigging and fore/aft rigging (headstays, backstays, running backstays);
- ◆ running rigging (“rope” materials such as dyneema, etc.);
- ◆ blocks and internal mechanisms of winches provided the winch or block is an off-the-shelf item.

SUPPLEMENTS TO THE RULE

In this or any measurement rule, there are a vast number of questions which can arise, which cannot all be covered in the Measurement Rule. For this reason, the Rule includes Supplements to the Measurement Rule, which contain clarifications, explanations and interpretations. These clarifications do not necessarily work the same way as the Rule itself. Some may not set absolute limits, but rather set limits or provide interpretations which are not to be exceeded with a penalty as a part of the Rule itself might be, but rather are to ensure good appearance of the boat or prevent extreme shapes.

In these situations, the Supplement itself will provide the proper information as to whether a limitation is a rigid limit, not to be exceeded at all, or a guideline, not to be exceeded deliberately, but where an insignificant excess or deficiency would be permissible when it is reasonable to assume that the excess or deficiency resulted from error or building tolerance in a boat which was intended to be built right to the particular limit in question, but not intended to exceed it.

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GUIDING PRINCIPLE IN DETERMINATION OF LEGALITY OF DESIGNS

The guiding principle in making a determination about the legality of some particular hull design or proposed hull design under this rule, is whether or not the concept in question will continue the kind of boat, appearance of the boat, and performance of the boat in the tradition of the class. Changes which simply carry forward the kind of design progress which has been seen in previous boats is encouraged, while totally new and different shapes are discouraged unless allowed by some provision of this rule or its appendixes.

This rule contains the lines of “demonstration” M boats, identified as “Hull 66F15c” and “66F22a”. These boats illustrate in a general way what we expect a modern M boat to be like. Any feature incorporated in the demonstration boat, or any feature which is simply an extension of any such included feature, is deemed to be legal and suitable, regardless of historical foundation. However, in case of apparent conflict, the wording of the “Limitations” sections of this rule take priority over the demonstration hulls and over historical consideration.

A similar situation exists with appendages, except that the date range for appendages is any date prior to September 1983.

See APPENDIX 1 for a more thorough discussion. APPENDIX 1 governs in all cases.

CLASS RATING FOR UNIVERSAL RULE CLASS M

The class rating for Universal Rule Class M shall be 46.00 feet.

1.0 BASIC RATING FORMULA

The basic rating formula for the Universal Rule of Measurement is:

$$R = 0.18 \frac{L\sqrt{S}}{\sqrt[3]{D}}$$

Where:

- R = Class Rating in Feet;
- L = Rated Length in Feet;
- S = Rated Sail Area in Square Feet;
- D = Rated Displacement in Cubic Feet.

1.1 LENGTH FORMULAS

The formulas for determining Rated Length are:

$$L = LWL + P_{qbl} + P_{fwd} + P_{aft} + P_{disp} + P_{beam} + P_{draft} + P_{fbd} + P_{depth} \quad (2)$$

Where:

- L = Rated Length In Feet;
- LWL = Water Line Length in Feet, in Measurement Trim;
- P_{qbl} = Quarter Beam Penalty in Feet;
- P_{fwd} = Excessive Breadth of Section Penalty at forward end of LWL in Feet;
- P_{aft} = Excessive Breadth of Section Penalty at aft end of LWL in Feet;
- P_{disp} = Insufficient Actual Displacement Penalty in Feet;
- P_{beam} = Excessive or Insufficient Breadth Penalty at Maximum Beam Station in Feet;
- P_{draft} = Excessive Draft Penalty at the Maximum Draft Station in Feet;
- P_{fbd} = Insufficient Freeboard Penalty in Feet;
- P_{depth} = Insufficient Hull Depth Penalty in Feet.

1.1.1 **MAXIMUM & MINIMUM LWL AND MEASUREMENT OF B**

The LWL shall be the length, at the line of flotation with the boat in measurement trim, from the forward most point of immersion to the after most point of immersion. The Beam B shall be the greatest width of the line of flotation, measured in the transverse plane. See FIGURE 1.

The Maximum LWL in Measurement Trim shall be:

$$LWL_{max} = (1.08 * \text{Class Rating}) + 5.0 \text{ ft} \tag{3}$$

The Minimum LWL in Measurement Trim shall be:

$$LWL_{min} = (1.08 * \text{Class Rating}) + 3.0 \text{ ft} \tag{4}$$

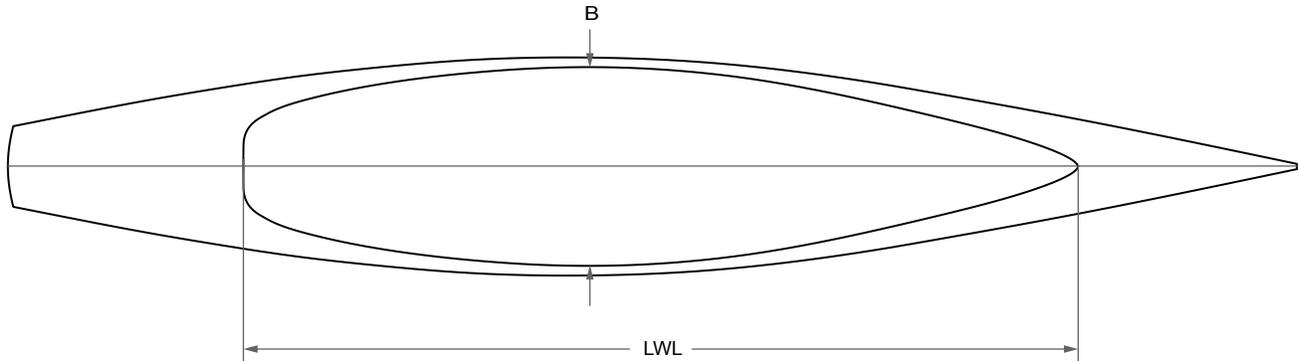


FIGURE 1. MEASUREMENT OF B AND LWL

If any point on the hull, below the LWL, lies further forward than the forward end of the LWL, then a vertical projection of that point up to the surface of the water shall be taken as the forward end of LWL for all purposes under this rule. Nothing in this section shall be taken to imply any exception to the limitations on hull profile in the Limitation on Hull Forms section below.

If any point on the hull, below the LWL, lies further aft than the aft end of the LWL, then a vertical projection of that point up to the surface of the water shall be taken as the aft end of LWL for all purposes under this rule. Note that the rudder is not considered to be a point on the hull.

1.1.2 **PENALTIES ADDED TO LENGTH L**

1.1.2.1 **Quarter Beam Length**

1.1.2.1.1 The quarter beam length, QBL, shall be the length of the boat measured in the water plane parallel to the LWL in measurement trim, and measured parallel to the centerline of the boat, at a height B/10 above the LWL, and at a breadth B/4 from fore/aft the centerline of the boat. See FIGURE 2.

The maximum quarter beam length without penalty shall be:

$$QBL_{max} = \frac{100 - \sqrt{LWL}}{100} * LWL + 4.00 \text{ ft} \tag{5}$$

1.1.2.1.2 If the quarter beam length is greater than the maximum permitted without penalty in (5), the quarter beam penalty shall be given by:

$$P_{qbl} = 0.5 [QBL - \left(\frac{100 - \sqrt{LWL}}{100}\right) * LWL] - 2.00 \text{ ft} \tag{6}$$

1.1.2.1.3 The forward end of QBL shall not be taken as further aft than 0.117 * LWL aft of the forward end of LWL.

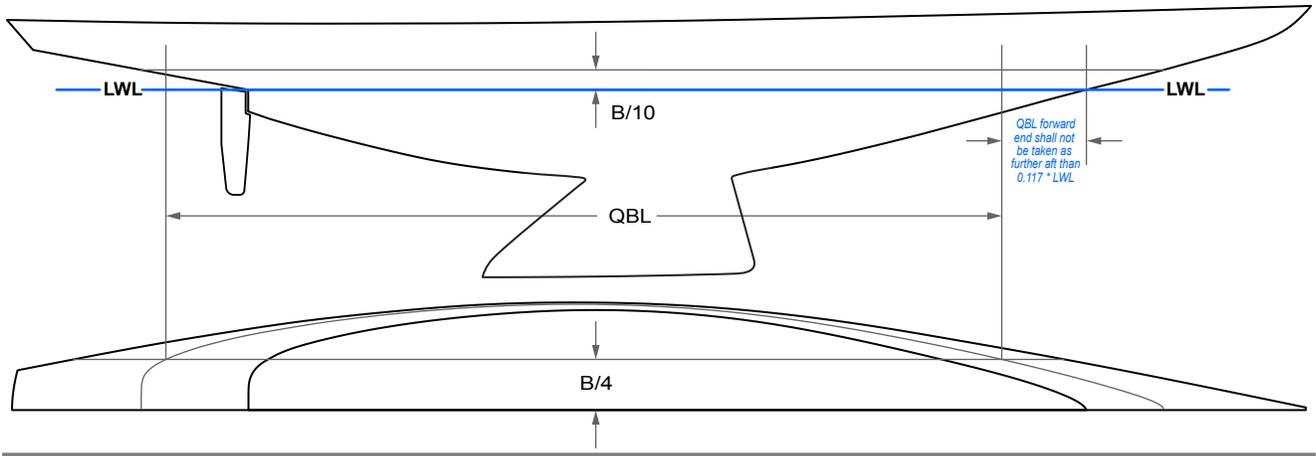


FIGURE 2. QUARTER BEAM LENGTH

1.1.2.2 **Forward Breadth**

1.1.2.2.1 The forward breadth, FWD, shall be the breadth of the boat measured in the transverse plane at the forward ending of LWL, taken at a height of 0.400 ft (122 mm) above LWL. See FIGURE 3.

The maximum forward breadth without penalty shall be:

$$FWD_{max} = 0.04 * LWL \tag{7}$$

1.1.2.2.2 If the forward breadth as defined above is greater than the maximum allowed without penalty in (7), the penalty shall be given by:

$$P_{fwd} = 1.5 * (\text{actual forward breadth} - (0.04 * LWL)) \tag{8}$$

P_{fwd} shall not be taken as less than zero.

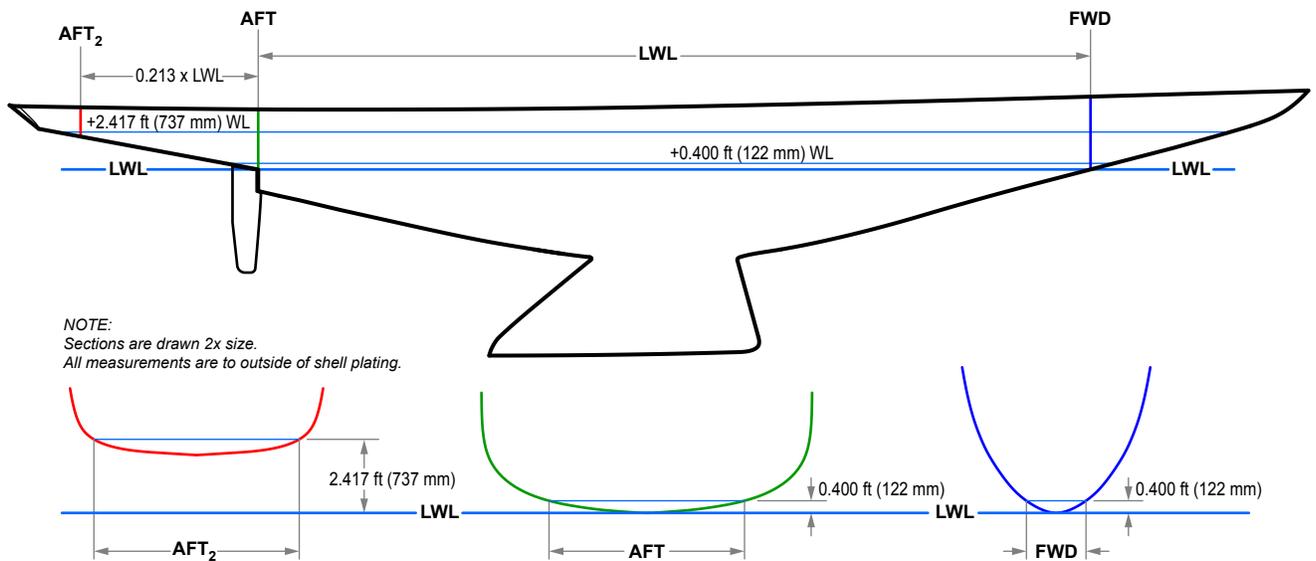


FIGURE 3. FORWARD & AFT BREADTHS

1.1.2.3 Aft Breadth

1.1.2.3.1 The aft breadth, AFT, shall be the breadth of the boat measured in the transverse plane at the aft ending of LWL, taken at a height of 0.400 ft (122 mm) above LWL. See FIGURE 3.

The maximum aft breadth without penalty shall be:

$$AFT_{\max} = 0.125 * LWL \quad (9)$$

1.1.2.3.2 If the aft breadth as defined above is greater than the maximum allowed without penalty in (9), the penalty shall be given by:

$$P_{\text{aft}} = \text{actual aft breadth} - (0.125 * LWL) \quad (10)$$

P_{aft} shall not be taken as less than zero.

1.1.2.3.3 A second aft breadth, AFT_2 , shall be the breadth of the boat measured in the transverse plane at a horizontal distance of $0.213 * LWL$ aft of the aft end of LWL, at a vertical height of 2.417 ft (737 mm) above the line of flotation in measurement trim. See FIGURE 3.

The maximum AFT_2 without penalty shall be:

$$AFT_2 \max = AFT_{\max} \quad (10.1)$$

1.1.2.3.4 If the AFT_2 breadth as defined above is greater than the maximum allowed without penalty, then one-half the excess shall be added to P_{aft} , so that::

$$P_{\text{aft}} = \text{actual AFT} - (0.125 * LWL) + 0.5 [\text{actual } AFT_2 - AFT_{\max}] \quad (10.2)$$

The term (actual AFT – (0.125 * LWL)) shall not be taken as less than zero.

The term (actual $AFT_2 - AFT_{\max}$) shall not be taken as less than zero.

1.1.2.4 Displacement

1.1.2.4.1 The minimum displacement (in cubic feet) without penalty shall be

$$\text{Disp}_{\min} = (0.2 * LWL + 0.5)^3 \quad (11)$$

1.1.2.4.2 If the actual displacement (in cubic feet) is less than the minimum given by (11), then the displacement penalty shall be

$$P_{\text{disp}} = LWL - \frac{\sqrt[3]{(\text{actual displacement})} - 0.5 \text{ ft}}{0.2} \quad (12)$$

1.1.2.4.3 Rated displacement, D in the rating formula, shall be the actual displacement of the boat as determined by weighing. D shall not be taken as greater than the rule minimum displacement as defined in (11) above. Therefore

$$\sqrt[3]{D} \leq (0.2 LWL + 0.5 \text{ ft}) \quad (13)$$

1.1.2.5 Beam

1.1.2.5.1 The Beam, B, as defined in Section 1.1.1, shall be not less than

$$B_{\min} = 13.25 \text{ ft} \quad (14)$$

1.1.2.5.2 If B is less than the minimum defined in (14), the penalty shall be

$$P_{\text{beam}} = 13.25 - \text{actual LWL beam} \quad (15)$$

1.1.2.5.3 The Beam, B, as defined in Section 1.1.1, shall be not greater than

$$B_{\max} = 13.73 \text{ ft} \quad (16)$$

1.1.2.5.4 If B is greater than the maximum defined in (16), the penalty shall be

$$P_{\text{beam}} = \text{actual LWL beam} - 13.73 \quad (17)$$

1.1.2.6 Draft

1.1.2.6.1 Draft, H, shall be the maximum vertical depth that can be found, perpendicular to the water line plane with the boat upright in measurement trim, from the water line plane to the lowest point on the boat or any extension thereof or on any appendage attached thereto, with any centerboard or daggerboard fully retracted. Note that the maximum depth might not lie on the transverse centerline of the boat.

The maximum draft as defined just above shall be

$$H_{\max} = 0.16 * LWL + 3.50 \text{ ft} \quad (18)$$

1.1.2.6.2 If the draft exceeds the maximum defined just above, the penalty shall be

$$P_{\text{draft}} = 3 * (\text{actual draft} - (0.16 * LWL + 3.50)) \quad (19)$$

1.1.2.7 Freeboard

1.1.2.7.1 The sheer line shall be a fair, continuous concave curve, from stem head to transom. The Freeboard, F, shall be the vertical height from the line of flotation to the top of the deck at the side of the boat at the appropriate fore/aft location.

The freeboard taken in measurement trim at the midship (50% LWL) station shall be not less than

$$F_{\min} = 0.062 * LWL + 0.6 \text{ ft} \quad (20)$$

The freeboard at the forward end of LWL, in measurement trim, shall be not less than

$$F_{\min \text{ fwd}} = F_{\min} * 1.165 \quad (21)$$

and the freeboard at the aft end of LWL, in measurement trim, shall be not less than

$$F_{\min \text{ aft}} = F_{\min} * 0.979 \quad (22)$$

1.1.2.7.2 If any of the above 3 freeboard measurements is less than the minimum required, the penalty shall be

$$P_{\text{fbd}} = 2 * (F_{\text{rqd}} - F_{\text{act}}) \quad (23)$$

Where:

F_{rqd} = Freeboard required at that station from (20), (21), or (22) above;

F_{act} = Actual freeboard at that station.

1.1.2.7.3 If more than one of the measured freeboards is less than the required minimum, the penalty shall be based on the largest deficiency, not the sum of the deficiencies.

1.1.2.7.4 Decks shall not have “negative camber”, that is the deck shall not get lower when one moves from the edge of the deck toward the centerline. The maximum deck camber shall be 7.5 in (190 mm).

1.1.2.7.5 There shall be no winches below deck, nor shall anyone stand in a hatch to operate a winch or tail a line from the winch.

1.1.2.8 Hull Depth

1.1.2.8.1 The Hull Depth Offset, HDO, shall be the distance perpendicular to a tangent on a transverse section of the hull at the fore/aft location with the greatest depth, to a point 5.500 ft (1.676 m) below the LWL. The lower end of the tangent shall be taken to the hull, keel or fillet, whichever lies at the 5.500 ft (1.676 m) depth, and at the point along that tangent which gives the greatest dimension. This measurement is to be taken to each side of the boat, and the greater Hull Depth Offset found is to be taken as the Hull Depth Offset. See FIGURE 4a and FIGURE 4b.

1.1.2.8.2 The maximum Hull Depth Offset without penalty shall be 0.125 ft (38 mm).

1.1.2.8.3 If the Hull Depth Offset is greater than 0.125 ft (38 mm), then the penalty shall be

$$P_{\text{depth}} = 2 * HDO \quad (24)$$

The term P_{depth} shall not be taken as less than zero.

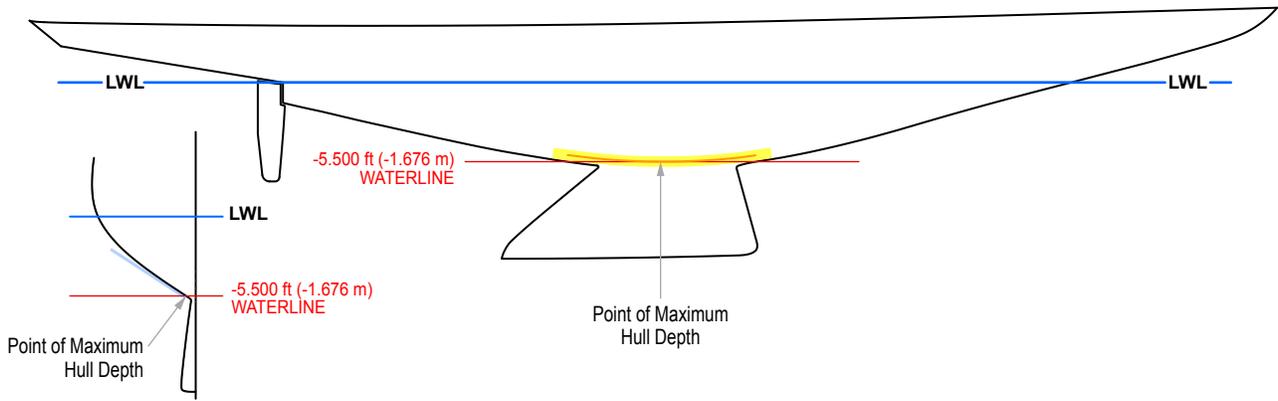


FIGURE 4a. DETERMINING FORE / AFT LOCATION OF POINT OF MAXIMUM HULL DEPTH FOR HDO

1.1.2.8.4 FIGURE 4a illustrates the longitudinal location of the point of maximum depth for purposes of determining HDO. Several sections along the fore/aft length of the hull should be tried in order to determine the actual location of the section containing the point of maximum depth as defined in this section. At each section, the maximum HDO should be determined by testing several transverse locations along that section, as the point of maximum offset for a given section may not be in the same transverse location on one section as on another. See FIGURE 4b below.

HDO is to be taken at the transverse section giving the least HDO measurement, and at the point on that transverse section which gives the maximum HDO for that transverse section.

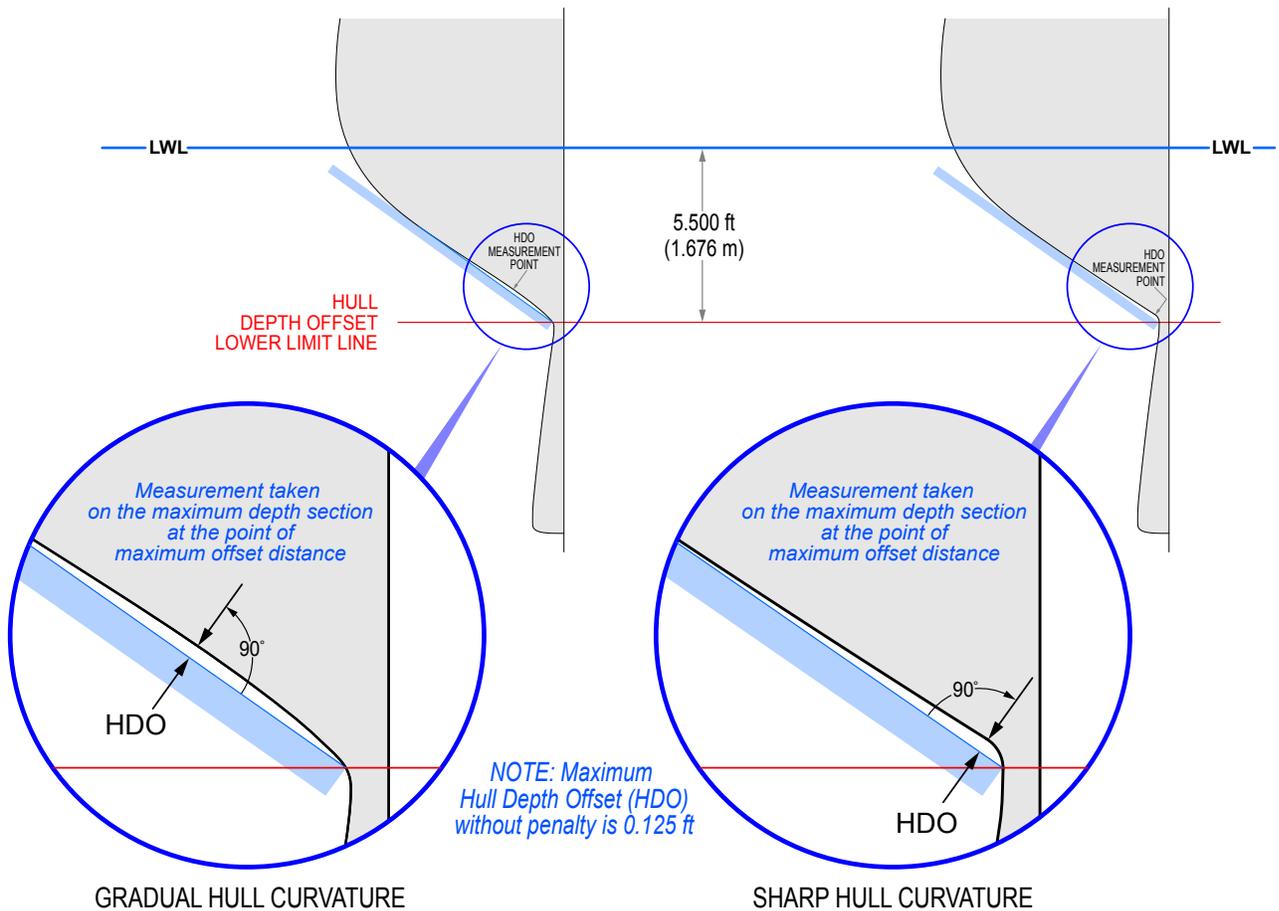


FIGURE 4b. DETERMINATION OF HULL DEPTH OFFSET

1.2 SAIL AREA

1.2.1 *Sail Area Formula*

Rated sail area, S, in the rating formula shall be the triangular area of the mainsail plus 85% of the area of the fore triangle, that is

$$S = \frac{P * E}{2} + 0.85 \frac{I * J}{2} \quad (25)$$

Where:

P = Mainsail luff length in feet;

E = Mainsail foot length in feet;

I = Fore triangle height in feet, taken from the sheer line abreast the mast;

J = Base of fore triangle in feet.

1.3 LIMITATIONS ON HULL FORM

1.3.1 **General Description**

Boats designed to this measurement rule shall be of a narrow, deep, form with long, relatively low, overhanging ends. For purposes of section 1.3, the hull is the entire surface of the boat from the sheerline to the -5.50 ft (-1.676 m) waterline, excluding the rudder. The following stipulations are specifically included:

1.3.2 **Multiple Hulls & Outriggers**

1.3.2.1 Configurations with multiple hulls of any kind are prohibited. The basic test of this shall be that the longest length measurement, on the centerline plane, shall be on the transverse centerline itself, and shall be taken to points on the actual hull, not on extensions or interpolations of same. In similar manner, the maximum depth of the hull at any transverse section shall be on the transverse centerline, and shall also be to a point on the physical hull, not to extensions or interpolations thereof. Thus, catamarans are illegal. Where a cross section is flat or nearly flat, near the centerline of the boat, a tolerance of $\frac{1}{8}$ in (3 mm) is permitted such that an unintended depth of hull off the centerline not more than $\frac{1}{8}$ in (3 mm) in depth is not considered to contravene this rule.

1.3.2.2 There shall be no outriggers of any kind attached to the hull, or suspended above or alongside or below it. For this purpose an outrigger is a device which supports a pontoon or other object(s) which may, at some angle of heel or other orientation of the boat, touch or become immersed in the water. Thus, trimarans are illegal.

1.3.2.3 There shall be no device for positioning the crew outboard of the edge of the deck of the boat, or outboard of a vertical extension of the deck of the boat, with the boat upright. A small cap strip on top of a bulwark is not an outrigger for purpose of this paragraph, provided that it extends no further than $1\frac{1}{2}$ in. (38 mm) outboard of the outer surface of the bulwark. Likewise, a tapered chafing sleeve for mooring lines may extend outside the hull through a drain hole in the rail, but it also shall not extend further than $1\frac{1}{2}$ in (38 mm) beyond the edge of the hull.

1.3.2.4 Bowsprits, and similar devices at the stern of the boat, are prohibited.

1.3.3 **External “Hulls”**

1.3.3.1 There shall be only one hull. No appendage shall be configured such that it simulates a hull, and – except for one rudder which is mounted at the aft end of LWL – no appendage shall increase the waterline length or the sailing length of the boat. There is no legal configuration in which there is a hull, or part of a hull, inside of another hull or part of a hull.

1.3.4 **Flexible Hulls**

1.3.4.1 The hull of the boat shall be essentially rigid, and fixed in shape. No flexible skin, fluid-filled skin, or other methodology shall be used to make it possible to alter the shape of the hull, other than by standard rebuilding methods during a major alteration of the boat.

1.3.5 **Surface Roughness**

1.3.5.1 No material shall be added to the hull for the purpose, or with the effect, of adding roughness to the surface of the hull or keel, except that a strip 1.00 ft (305 mm) long, measured parallel to the line of flotation, and beginning at the leading edge of the stem of the boat and/or the leading edge of the keel, may be made rough by means of adding ground shells or other material to the bottom paint.

This section shall not be construed so as to prevent flat plates or pegs or similar devices from being used as turbulence generators along portions of the keel or other appendages.

1.3.5.2 Turbulence generators, other than the additions to paint described in the previous paragraphs, shall not be used on the hull.

1.3.5.3 For purposes of surface roughness as addressed in this section, the deck is not part of the hull.

1.3.6 **Overhang & Length Requirements**

1.3.6.1 The minimum forward overhang of the boat, when in measurement trim, shall be 14.25 ft (4.343 m), measured in the horizontal plane, from the forward most ending of LWL, in measurement trim, to the stem head, neglecting any fitting or attachment on or over the stem head. The minimum overall length of the boat, measured in the horizontal plane from the stem head as defined herein, to the farthest aft point on the transom or stern overhang, shall be 85.25 ft (25.98 m).

1.3.6.2 Unless it is double-ended, the boat shall have a transom. The transom, if it slopes aft as freeboard increases, when measured at the transverse centerline, shall make an angle with the vertical not less than 40 degrees. A transom which slopes forward as freeboard increases (reverse transom), shall make an angle to vertical not greater than 40 degrees. Where a reverse transom is used, special transom construction regulations apply so that no significant advantage in weight or weight distribution is achieved. See Supplements for provisional reverse transom rules. A transom is always part of the hull, not part of the deck.

1.3.7 **Hull/Deck Radius**

1.3.7.1 The maximum radius of the side of the boat to the deck shall be $\frac{3}{16}$ in (4 mm)

1.3.8 **Hollows in Hull Profile**

1.3.8.1 There shall be no hollows in the deck planform (ie. top view profile).

1.3.8.2 There shall be no hollows in the profile of the stem between the sheer line and the LWL, forward of the forward end of LWL, in measurement trim. Below the LWL, and forward of a transverse station 10% of LWL abaft the forward end of LWL, the stem profile between the forward end of LWL and the 10% LWL station aft of the forward end of LWL, may be straight, concave or convex, but shall not be a combination of convex and concave.

Drawing A at right shows a straight stem below LWL.

Drawing B at right shows a boat with a stem which is hollow (concave) below the LWL.

Drawing C at right shows a stem which is convex below the LWL.

All of the above are legal configurations.

Drawing D at right shows a stem with a bulge in it, that is, it is hollow (concave), then reverses the curvature to be convex, both below LWL but forward of a Station 10% of LWL aft of the forward ending of LWL. The form in Drawing D is illegal.

To allow for transitions from convex above the LWL to concave below the LWL, a tolerance of $\frac{1}{4}$ in (6 mm) is permitted on the double-inflection portion of this rule. That is, if a double-inflection has no convex portion or concave portion greater than $\frac{1}{4}$ in (6 mm) in the area in question, then it is allowed. See FIGURE 5. See also the section which follows.

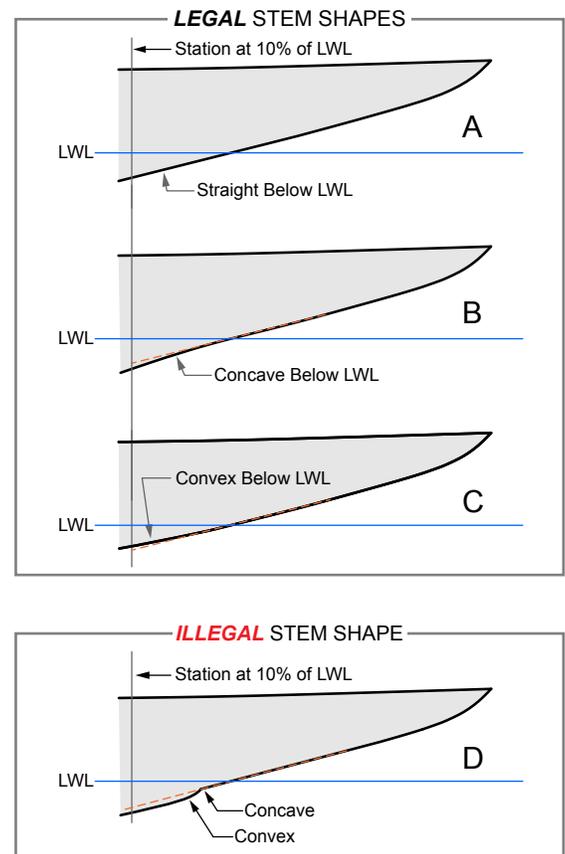


FIGURE 5. LEGAL & ILLEGAL STEM SHAPES

- 1.3.8.3 A straight-edge shall be placed on the stem from a point located on the stem at a horizontal distance of 3.5% of LWL forward of the forward end of LWL, and extending along the stem to a point on the stem a horizontal distance of 3.5% of LWL aft of the forward end of LWL. Any hollow lying within that portion of the stem shall be bridged as described, and a new value of LWL established from the aft end of the original LWL to the point where the water plane established by the original LWL intersects the bridge. The bridged value of LWL shall be used for calculating the measured Length and for calculating the minimum displacement. All other functions of LWL shall be calculated using the non-bridged value of LWL. The non-bridged value of LWL is to be utilized in determining whether the boat complies with the maximum waterline requirement in Section 1.1.1.

Except at the aft end of the LWL, if any hollow in the surface of the hull occurs at or near a measurement point [i.e. within 1.00 ft (305 mm) above and 1.00 ft (305 mm) below the measurement point, and/or one-third of B forward and/or one-third of B aft of the measurement point], that hollow shall be bridged with a straight edge whose length is one-third of B, and whose center is at the measurement point within the hollow area. Hollows shall be bridged in both the buttock and the waterline plane of the measurement point, and whichever measurement gives the greater result shall be used in the determination of QBL.

The same methodology applies at the aft end of the LWL, except that the bridging forward of the aft end of the LWL is not to be done below the + 1.333 ft (+ 406 mm) waterline.

1.3.9 ***Angles of Stem and Counter***

- 1.3.9.1 The minimum angle between the stem and the LWL, taken at the intersection of the stem and the LWL when the boat is in measurement trim, shall be 12.80 degrees. The minimum angle between the counter and the LWL, taken as defined in this section, with the boat in measurement trim, shall be 8.10 degrees. See FIGURE 6.

Any deficiency in stem angle or counter angle is to be added to the rating **R**, 0.1 ft for each 0.1 degree etc., interpolated linearly to find the penalty for deficiencies which are not exactly tenths of a degree.

If the counter profile is concave, the counter angle shall be taken as the angle to the horizontal formed by a straight line connecting the aft end of the waterline with the point on the centerline of the counter which gives the lowest measurement of counter angle (normally the bottom of the transom). The same procedure shall be followed for a counter which is convex, taking the counter angle at whatever point along the centerline of the counter gives the least counter angle.

Where the counter intersects a skeg or “kicker” above the LWL, the forward end of the counter angle shall be taken to the point at which the counter intersects the skeg or “kicker”, so that the lower leg of the counter angle is taken parallel to the LWL at the height above the LWL where the counter intersects the skeg or “kicker”.

1.3.10 ***Free Flooding Tanks, Water Ballast, etc.***

- 1.3.10.1 There shall be no free flooding tanks. Water or other fluids shall not be carried on board for the purpose of acting as ballast, and if carried, shall not be shifted by any manner other than by the natural force of gravity while the boat is underway, except that the fluid in such a tank may be used for its intended purpose(s), for instance water in a water tank may be consumed or used for cooking, washing, etc.

1.3.11 ***Tumble Home***

- 1.3.11.1 The maximum tumble home, if any, on each side of the boat, shall be not greater than 0.32 ft (98 mm). Any excess shall be added to the rating **R**. Tumble Home shall be taken as the difference, in the vertical plane of any transverse section, between the maximum beam at any vertical height of that section above LWL, and the beam on deck at that same transverse section.

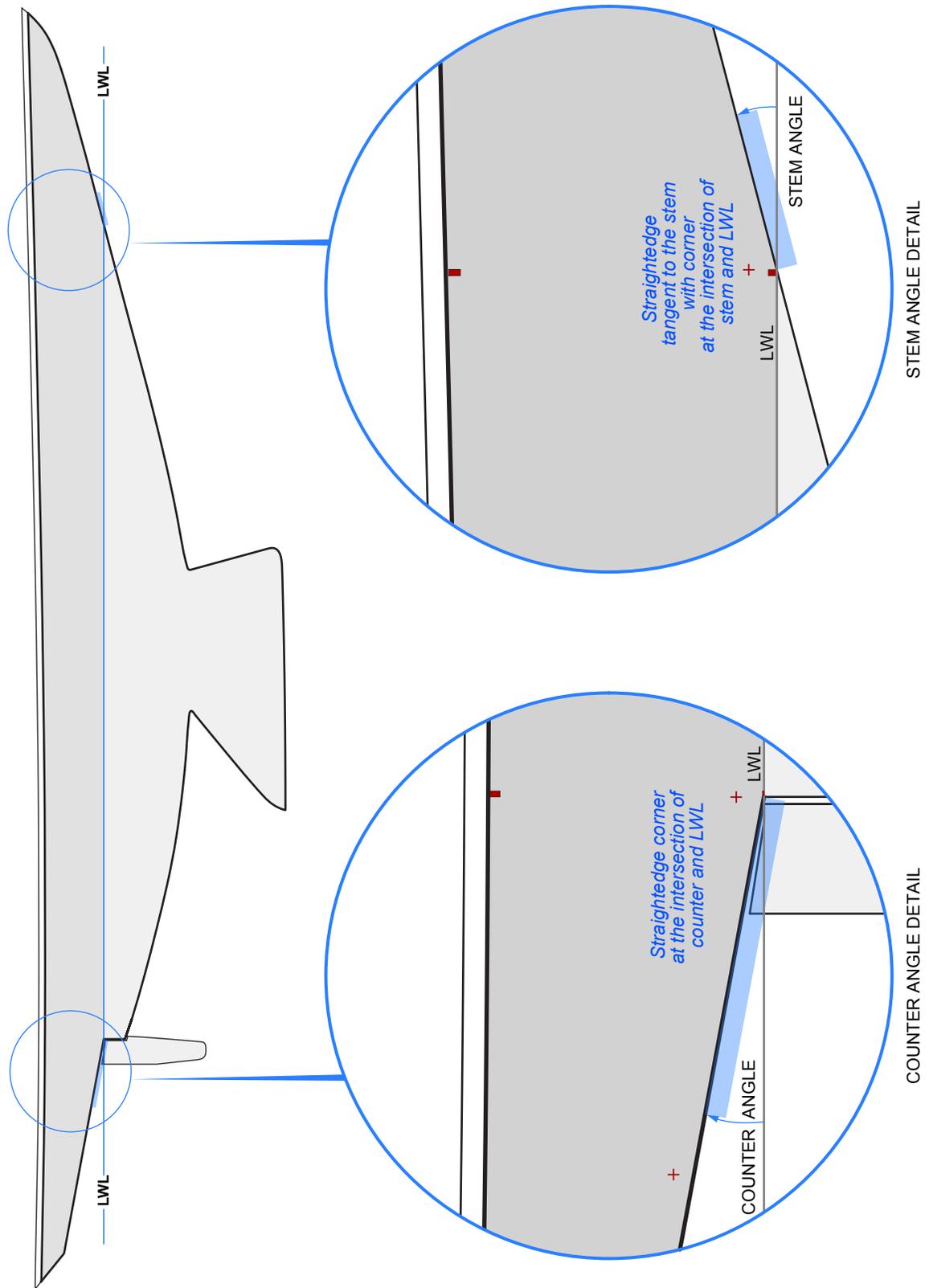


FIGURE 6. STEM AND COUNTER ANGLE MEASUREMENT

1.3.12 Bulwark

- 1.3.12.1 There shall be a bulwark around the entire edge of the deck of the boat, the outer edge of which shall be within 1.00 in (25 mm) of the edge of the side of the boat, taken where the edge of the hull meets the edge of the deck. Where there is a radius at the intersection of the deck and hull, the distance shall be taken to a projection of the side and deck. The bulwark shall be not less than 3 ³/₄ in (95 mm) high, the height taken as the distance from the intersection of the outside edge of the bulwark at the deck to the top of the bulwark, measured perpendicular to the sheerline in the longitudinal plane (which will often not be a vertical measurement). Where there is a cap or rail of any kind at the top of the bulwark, that cap or rail shall be included in the measured height.
- 1.3.12.2 The bulwark may be constructed of any material, except that no exotic material may be used. [See definition of exotic materials under General Provisions of this rule.] However, the minimum weight of the bulwark, excluding glue, welding bead, filler and fasteners, shall be at least 1.33 lbs/foot run (1.98 kg/metre run).
- 1.3.12.3 There shall be no holes specifically for lightening the bulwark. However, drainage holes (which may be lined for use for mooring lines) may be used, providing that the opening in each drainage hole is not greater than 0.085 ft² (0.008 m²) in face area. Additional drainage slots in the bulwark along the deck may be used, but shall not exceed 1/2 in (13 mm) in height and 4 in (100 mm) in length.
- Large drainage holes shall not exceed 10 per side of the boat, and small drainage slots shall not exceed 1 slot per 2 ft (610 mm) of bulwark length. While large drainage slots may be concentrated near the low point of the sheerline, the small drainage slots shall be more or less evenly distributed along the length of the bulwark.
- 1.3.12.4 A handrail is not a bulwark, and may not be substituted for a bulwark nor for any portion of a bulwark.

2.0 LIMITATIONS ON SAIL CONSTRUCTION & SAIL PLAN

2.0.1 ***Sail Construction***

2.0.1.1 Sails shall be made of a form of “cloth”, that is, they shall not be rigid wings or foils. Sails shall be constructed of a material such that the sail may be folded loosely into segments not greater than 3 ft (0.914 m) in width. Provided that the sail can be folded in this manner, it may be constructed of any material, including kevlar, mylar, carbon fiber, Dacron, or any combination of these. The purpose of the term “loosely” in this section is to require that the sail be of a cloth-like material rather than a rigid wing configuration, not to require that the sail be creased which would potentially damage the threads or other flexible materials from which it is constructed.

Double-luffed sails or sails which in any way wrap around any spar(s) are prohibited.

2.0.2 ***Maximum Height of Sail Plan***

2.0.2.2 The maximum height of the sail plan above the sheer line, measured along the aft edge of the mast (not necessarily vertical), shall be given by

$$\text{Rig Height}_{\max} = 1.90 \sqrt{S} + 5.0 \text{ ft} \quad (26)$$

2.0.3 ***Minimum Height of Boom Above Sheer***

2.0.3.1 The minimum vertical height of the lower measurement point of mainsail luff P above the sheer line of the boat, abreast the aft edge of the mast, shall be 6.00 ft (1.828 m).

2.0.4 ***Maximum Girth of Mainsail***

2.0.4.1 The maximum dimension of the mainsail, measured perpendicular to the luff at a height 65% of P above the base of P, shall be

$$\text{Girth}_{\max} = 0.52 * E \quad (27)$$

2.0.4.2 The leech of the mainsail shall lie on a fair continuous convex curve drawn through the headboard, the boom black band, and the outboard end of each batten. Small flat spots or hollows between battens, used solely to make the leech of sail stand properly, do not violate this rule, but the girth maximum shall be taken to a fair curve through the battens, even if that curve lies off of the sail.

2.0.5 ***Maximum Size of Mainsail Headboard***

2.0.5.1 The maximum horizontal length of the top of the mainsail headboard abaft the aft end of the mast shall be 1.40 ft (427 mm). No part of the headboard shall be longer than a fair interpolation of the top length and the girth and foot of the mainsail.

2.0.6 ***Maximum Height of Fore Triangle***

2.0.6.1 The maximum height of the fore triangle above the sheer line, measured along the leading edge of the mast (not necessarily vertical) shall be 85.25 ft (25.984 m).

2.0.6.2 A jib is taken to be any sail which is set within the fore triangle of the boat, except that a jib may extend aft of the mast. Jibs may be of any planform shape, but may not have battens and may not have headboards. Exception: jibs which do not at any point overlap or extend aft of the mast may use up to 5 battens in the leech, provided the battens are not longer than 5 ft (1.524 m) in length, and are not more than 3 in (76 mm) in width.

2.0.7 *Maximum Height and Shape of Spinnaker*

- 2.0.7.1 The maximum height of the spinnaker halyard above the upper measurement point of I shall be not greater than 0.50 ft (152 mm). Spinnakers may be of asymmetrical or symmetrical shape.

2.0.8 *Length and Construction of Spinnaker Pole*

- 2.0.8.1 The spinnaker pole length shall be not greater than $1.10 * J$. Spinnaker pole(s) may be constructed of aluminum, steel, wood, fiberglass, titanium, carbon fiber, kevlar, or any combination thereof.

2.0.9 *Minimum Weight and Construction of Mast*

- 2.0.9.1 The mast shall have a minimum weight of 1100 lbs (499 kg), including all spreaders, standing rigging and fittings, but excluding running rigging. The vertical center of gravity of the mast, when in measurement condition, shall be not lower than 37.5% of the maximum height of sail plan above the sheer line. The minimum weight is to ensure good racing, and does not guarantee the safety of the mast or rigging. It remains the responsibility of the designer, builder, and spar maker to ensure that the mast and rig are adequate for the purpose.

The mast may be made of aluminum, steel, wood, fiberglass, kevlar, carbon fiber, titanium, or any combination thereof. All other materials are prohibited.

- 2.0.9.2 The mast shall be stepped either on or just above the keel/stem centerline structure of the boat, and shall be fixed athwartship such that the base of the mast may not move from side to side. The deck partners shall have only the opening width required to properly pass the mast through, in no case more than 0.75 in (19 mm) on each side of the mast, such that the mast is effectively prevented from moving from side to side at the deck. The mast may be free to move forward/aft at the deck, but the base of the mast shall be fixed in the forward/aft direction. The maximum motion of the mast forward/aft at the deck shall be 0.333 ft (102 mm). Hydraulic rams and other mechanical devices may be used to move the mast forward/aft at the deck, or to constrain the mast from moving forward/aft at the deck. Where the mast is permitted/caused to move at the deck, the “J” dimension shall be taken with the mast in its aft-most deck position.

- 2.0.9.3 Masts which tilt from side to side, other than that which occurs naturally due to stretch in rigging, etc., and masts which consist of a structure other than a single spar supported by rigging with spreaders, are prohibited. Rotating and permanently bent masts are prohibited. A small permanent bend of less than 0.667 ft (203 mm), which is incidental and not deliberately built into the mast, is acceptable.

- 2.0.9.4 Spreaders may be made of aluminum, steel, wood, fiberglass, titanium, carbon fiber, kevlar or any combination thereof.

2.0.10 *Transverse Rigging & Head Stay*

- 2.0.10.1 Transverse rigging, that is shrouds, and the head stay, shall not be adjusted during a race, except if an emergency situation arises which requires making such an adjustment. If that occurs, the boat shall report the situation and the action taken to the Race Committee and/or Rules Committee for their decision whether the action taken was in fact warranted. Transverse rigging, headstays, and running or standing backstays may be of steel, titanium, kevlar or carbon fiber.

2.0.11 *Dimensions and Construction of Boom*

- 2.0.11.1 The boom shall have a maximum width of 2.50 ft (762 mm), measured in the transverse plane and horizontal. The maximum vertical depth of the boom shall be not greater than 1.375 ft (419 mm).
- 2.0.11.2 The boom may be constructed of aluminum, steel, wood, fiberglass, titanium, carbon fiber, kevlar, or any combination thereof. All other materials are prohibited.

2.0.12 Luff Groove Devices

- 2.0.12.1 Luff groove devices for jibs are prohibited. All jibs must be attached to the head stay or a fore stay by means of pull-pin hanks, twist hanks, Velcro wrap-around straps, or other similar methods. All mainsails must be attached to the mast by means of slides running along a track, or by means of slugs running inside a tunnel. The mast cross-sectional shape may be such that the track is essentially internal.

2.0.13 Loose-Footed Mainsails

- 2.0.13.1 Loose-footed mainsails are prohibited.
- 2.0.13.2 Booms with transverse sail slides for shaping the sail, and mechanically bent booms, are permitted.

2.0.14 Strong-Wind Mainsails

- 2.0.14.1 Each boat shall have available for its use a short-footed mainsail, having a maximum foot length not greater than:

$$E - 3.0 \text{ ft, or } (E - 0.914 \text{ m})$$

This mainsail must be used in any race in which it is determined at the skipper's/tactician's meeting prior to the race that expected weather conditions warrant the use of a reduced-area mainsail. Substituting a conventional reefed mainsail is not permitted.

- 2.0.14.2 A measurement band shall be applied to the boom at a distance 3.0 ft (0.914 m) forward of the band indicating measurement point of E to reflect this sail's length.

3.0 LIMITATIONS ON APPENDAGES

3.1 *Characterization of Appendages*

Appendages are items which protrude from the hull or from another appendage, and which carry out at least one of their functions by means of aerodynamic lift, drag, etc.

Appendages may be broken down into different groups, whose limitations will be set as a function of which group they fall into:

3.1.1 **RUDDERS:** the main function of a rudder is to steer the boat. Typically a rudder rotates about some post which is vertical in the transverse plane, thus creating a difference in lift on each side of the rudder which has the effect of turning the boat. A rudder may also generate lift which resists the side force generated by the sail plan of the boat; this is not the main function of the rudder, but does not disqualify the rudder from being deemed a rudder.

3.1.1.1 A rudder may be attached to a skeg or keel. A rudder must be mounted on the transverse centerline of the boat. A rudder may be mounted above the LWL if and only if the rudder post is entirely aft of the aft end of the LWL, and only if it is on the transverse centerline and is vertical in the transverse plane. A rudder mounted in this manner may not have its leading edge, or the leading edge of the post about which it rotates – whichever is further aft – further aft than 0.125 ft (38 mm) aft of the after end of LWL. Where any portion of the rudder blade is above the LWL with the boat upright in measurement trim, the longest horizontal length of the rudder above the LWL shall be 1.64 ft (500 mm), and the trailing edge of the rudder must not slope aft so as to increase the length of the rudder below the LWL.

3.1.1.2 A rudder shall not be deeper (below the LWL) than 0.6 times the rule maximum draft of the boat, that is the rudder shall have a maximum depth below the LWL of

$$\text{Rudder Depth}_{\max} = 0.6 * H_{\max} \quad (27)$$

Where:

H_{\max} = maximum draft without penalty per (18) above.

Exception: if a rudder is the only movable appendage except for a centerboard or daggerboard, and if the rudder is attached to the trailing edge of the keel, then the rudder may be any depth provided that the rule draft (equation 18 above) is not exceeded.

3.1.1.3 Rudders may be made of aluminum, steel, wood, or fiberglass, or any combination thereof. If made of fiberglass, the mechanical characteristics of the laminate may not exceed that of S-Glass.

3.1.2 **SKEGS:** the main function of a skeg is to direct fluid flow along the after underbody of the boat toward the rudder.

3.1.3 **CENTERBOARDS AND DAGGERBOARDS:** a centerboard is a device which protrudes from the bottom of a keel, and which is raised and lowered by means of rotation about some point, usually at or near the leading edge of the centerboard. A daggerboard is a device which protrudes from the bottom of a keel, and which is raised and lowered by means of lifting up on it causing it to slide up and down. A centerboard rotates about some point, while a daggerboard translates vertically. Centerboards and daggerboards must operate through a slot in the keel, and must not protrude from the hull instead of a keel. The keel slot through which the centerboard or daggerboard works may not extend beyond the limits of the keel in any longitudinal or transverse direction.

3.1.3.1 It must always be possible to raise a centerboard or daggerboard high enough that the draft with the centerboard or daggerboard fully retracted does not exceed the Maximum draft as defined in (18) above.

3.1.3.2 The maximum total exposed lateral area in feet² of centerboard(s) and/or daggerboard(s), if any, shall be not greater than

$$\text{Area}_{\max} = 0.42 * \text{LWL (in feet)} \quad (28)$$

- 3.1.3.3 The maximum draft in feet of the boat with the centerboard(s) and/or daggerboard(s) fully extended shall not exceed

$$\text{Total Draft}_{\text{max}} = H_{\text{max}} * 1.40 \quad (29)$$

Where:

H_{max} = Maximum Draft without Penalty from (18) above.

- 3.1.3.4 Centerboards and daggerboards may not be heavier than manganese bronze (518.2 lbs/ft³, or 8301 kg/m³).
- 3.1.4 **KEELS:** a keel is an airfoil which is attached to the centerline structure of a hull, and serves at least the two primary purposes of:
- Holding ballast which keeps the boat upright or more nearly upright than it would be without the ballast; and
- Providing lateral resistance, usually developed by means of aerodynamic lift, which acts to counteract the side forces generated by the rig and sail plan.
- 3.1.4.1 A Keel must be vertical in the transverse plane when the boat is upright in measurement trim. A keel may have one or more of the following attached to it:
- ◆ One rudder;
 - ◆ One set of winglets (one winglet per side);
 - ◆ One trim tab (if there is no rudder attached to the keel);
 - ◆ One centerboard, or one daggerboard, but not one of each.
- 3.1.4.2 Below the – 6.500 ft (– 1.981 m) waterline, the perimeter profile of the keel may not have hollows. Where necessary, compliance with this provision shall be confirmed by testing with a straight edge. This restriction does not apply to intersection of the hull profile to the keel profile, even if that intersection lies below the plane just specified, provided the intersection is clearly a genuine intersection of hull and keel. Hollows immediately and clearly created by fairing of the hull profile into the keel profile are permitted even if below that plane.
- 3.1.4.3 Keels may be thicker, even dramatically thicker, at the tip than at the root, but bulbous projections in profile or in transverse plane are prohibited. For this purpose, a bulbous projection is taken to be a sharp or sudden, as opposed to gradual, increase in length or breadth.
- 3.1.4.4 In keels where the tip chord is longer than the root chord, the tip chord must be not greater than two times the length of the root chord. Canting and rotating keels are prohibited.
- 3.1.4.5 Keels may not be heavier than lead (708 lbs/ft³, or 11,341 kg/m³).
- 3.1.5 **TRIM TABS:** trim tabs are secondary rudders, mounted on the trailing edge of a keel, which have as a primary purpose to influence the lift generated by the keel by aerodynamic means, and have as a secondary purpose to aid in steering the boat. The difference between a trim tab and a rudder is that a trim can exist only if there is another rudder, and then it has steering as its secondary, not primary, purpose. A rudder always has steering as its primary purpose. Trim tabs may not comprise more than 20% of the total keel chord dimension along any given keel chord.
- 3.1.5.1 Trim tabs may be attached to the keel at the bottom extremity of their position, but the mounting must be in the form of support for the trim tab, and must not have a second purpose of altering the shape of the tab or the keel to effectively create a bulb at the tip of the keel or trim tab. The mounting may not increase the depth of the keel or of the trim tab, and the trim tab is at all points restricted to a chord length no greater than 20% of the corresponding keel chord (including the tab).
- 3.1.5.2 Trim tabs may not be heavier than lead (708 lbs/ft³, or 11,341 kg/m³).

- 3.1.6 **WINGLETS:** winglets are airfoil surfaces mounted to the keel near the bottom of the keel, and projecting outward very approximately perpendicular to the surface of the keel. Winglets must be fixed in orientation; that is they may not rotate, translate, pivot (as to alter sweep angle), etc., in any plane or in any axis.
- 3.1.6.1 The maximum span, from winglet tip on one side of the boat, to winglet tip on the other side of the boat, must be not greater than B as defined above in FIGURE 1. Winglets may have dihedral angles which place the winglet tip lower than the winglet root, but the static draft given by equation 18 above must not be exceeded when the boat is upright in measurement trim. Winglets may not have a t/c greater than 15%, that is the thickness as a percentage of the chord length must be less than or equal to 0.15.
- 3.1.6.2 [Deleted; no longer part of the measurement rule]
- 3.1.6.3 Winglets may not be heavier than manganese bronze (518.2 lbs/ft³, or 8301 kg/m³).

3.2 **Legal Appendage Configurations**

- 3.2.1 An M-boat shall have one keel and one rudder (which may or may not be connected to each other). Optional appendages are limited to:
 - ◆ One Trim Tab;
 - ◆ One Centerboard or one Daggerboard, but not both;
 - ◆ One set of two keel-mounted Winglets (one winglet per side of the keel);
 - ◆ One skeg.

Excluding a centerboard or a daggerboard, a maximum of two movable appendages are allowed (one of which is the rudder).

- 3.2.2 There is no legal configuration in which a series of high aspect ratio foils are used along the fore/aft axis of the boat rather than using one larger keel. There is no legal configuration which uses a bulb at the bottom of a foil or a keel. Canards are illegal. A Canard is a wing-like projection from the hull located forward of the keel. See FIGURE 7.

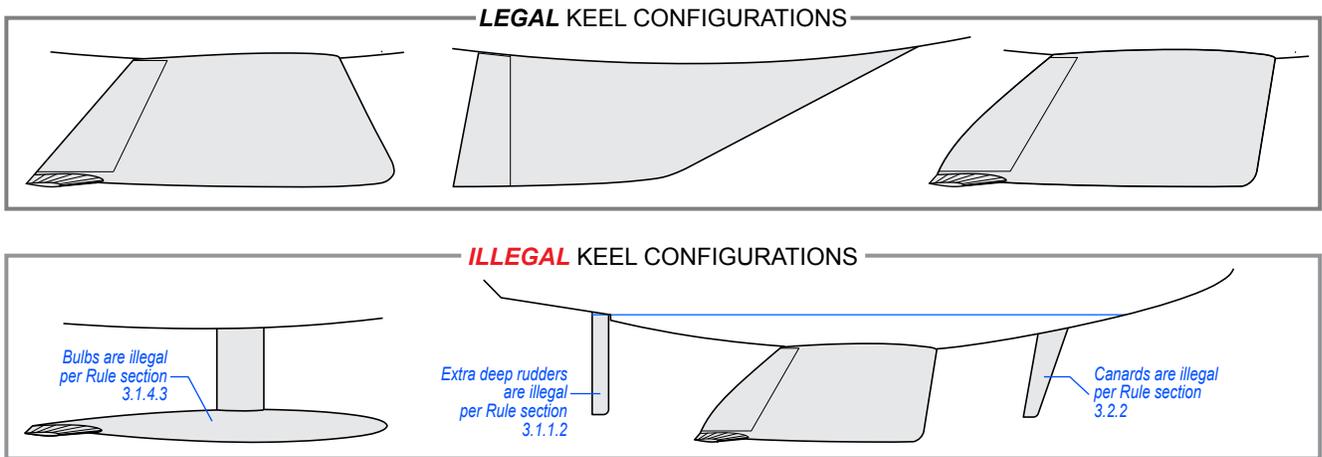


FIGURE 7. LEGAL AND ILLEGAL KEEL CONFIGURATIONS

3.3 **Appendage Construction Requirements**

3.3.1 **Basic Keel Construction**

- 3.3.1.1 Except where the upper portion of a keel must be made of multiple materials, the keel shall be all of one material, normally lead. There shall be no voids in the keel casting, and only those holes or other openings shall be permitted which are there for attachment of winglets or a trim tab, or for attachment of the rudder in a configuration where the rudder is hung from the keel.

Exception: a slot may be cast or cut into the keel to permit use of a centerboard or daggerboard. This slot may be lined with a different material, (e.g. Bronze) if desired. Where a centerboard is used, there is also an exception allowed for the “pin” about which the centerboard rotates in order to be lifted or lowered into position below the keel. Finally, there is an exception for a shallow relief for fairing strips used when the rudder or trim tab is attached to the trailing edge of the keel or is in the wake of a skeg (also see “Fairing Rudder Connections to Keel or Skeg” section 3.3.3 below).

3.3.2 **Hybrid Keel Construction**

- 3.3.2.1 It may happen that the upper portion of the keel must be made of a different material than lead, if for instance, the amount of lead available for the keel is less than is required to make up the size of the keel. In this case the keel shall be built in two stages, where the lower portion is the lead casting complying with all of the above provisions, and the upper portion is another casting, say of aluminum, which also complies with all the previously-stated requirements, the only difference being the material from which this upper casting is made.

- 3.3.2.2 Where the hybrid keel construction is utilized, a weldment may be used instead of a separate casting. That is, where the upper portion would be an aluminum casting, it would be acceptable to use an aluminum weldment instead of a casting, provided that full allowance is made for the actual welded strength of aluminum which is considerably less than that of a solid (unwelded) aluminum.

In the case of a hybrid keel, the keel portions must each comply with all the requirements for attaching the keel to the hull, that is:

Each portion of the hybrid keel is connected to the portion physically above it (keel or hull) by means of keel bolts meeting all the requirements for size, number, and strength of keel bolts. Hence, there are two sets of keel bolts, one holding the lead casting to the aluminum casting (or weldment), and the second holding the now bolted-together lead/aluminum keel to the hull;

It is not acceptable to use one long set of bolts to connect the lead to the hull, with the aluminum being sandwiched in between, as there is too much possibility of the pieces moving on each other and working the structure loose.

Exception: where, for purposes of making a hard surface for the keel to bear against when the boat is heeled over, a spacer of a harder material than lead is used between the top of the lead keel and the bottom of the aluminum hull, then one set of bolts may pass through that spacer and into the hull without requirement for a second set of bolts. In this case, the spacer must be solid, not a casting or a weldment, and must be not greater than 2 in (51 mm) thick.

Note that, where the nature of the structure is such that the width is very different for one attachment, say hull to aluminum, from the other attachment, aluminum keel to lead keel, the requirements for the keel bolts may also differ greatly, and each connection is to be made with bolts appropriate for that connection.

3.3.3 *Fairing Rudder Connections to Keel or Skeg*

3.3.3.1 Where the rudder is attached to the trailing edge of the keel, or is in the wake of a skeg, it will be necessary to fair the rudder to the keel or skeg (this also applies to the trim tab hung from the trailing edge of the keel). In this case a shallow relief is allowed to be cut into the keel or skeg so that a flexible plastic strip can be set flush into the keel or skeg, then overlapping the rudder or trim tab post to provide a fair transition. Note though that there is a limit to how far aft of the skeg that the rudder post can be located.

3.3.4 *Keel Attachment to Hull to Comply with International or Other Standard*

3.3.4.1 Because each case may be different, no single norm for size or strength of keel attachment bolts, etc., is given here. The method chosen, and the dimensions, etc., utilized, shall comply with one of the International standards such as ISO, RINA, Lloyds, or American Bureau of Shipping, or with the new scantlings published by Dave Gerr, *The Elements of Boat Strength*. As they cover both English and Metric units, the standards published by American Bureau of Shipping and in *The Elements of Boat Strength* are particularly convenient to use.

4.0 **PATENTED, COPYRIGHTED, & OTHER PROTECTED DESIGNS & DESIGN CONCEPTS**

No patented, copyrighted or otherwise legally protected design or design concept may be used in the design of a boat built to this measurement rule unless that design or design concept is available to all boats built to this measurement rule without charge.

5.0 MINIMUM CONSTRUCTION REQUIREMENTS

5.0.1 *Scope & Proper Interpretation of these Scantlings*

The construction minimum scantlings which follow are not intended to be a complete listing of all the components of construction of the boat, nor does compliance with them ensure a strong or well-built boat. Many critical items, such as rudder post, chain plates, and keel bolts, are not covered at all. These scantlings are meant to be a listing of a sufficient number of large or heavy structural items so that boats which comply with these scantlings will have, relative to their exact size and shape, weights, centers of gravity, and gyradii which are consistent from boat to boat. In other words, the goal of these scantlings is not to state all the requirements for a properly built M-Boat, but rather to define minimums for a sufficient number of structural components that it can be reasonably assumed that construction weights and weight locations will not substantially favor one boat over another with regard to racing performance.

In all cases, it remains the responsibility of the Designer and the Builder to ensure that the boat is a properly built and seaworthy boat.

Any item not specified in the following construction scantlings should be built in accord to best practices, as defined (for instance) in RINA, *Lloyd's Rules for Aluminium Yachts*, in American Bureau of Shipping's *Rules for Offshore Yachts* (ABS Rules), or with the methods and scantlings laid down in *The Elements of Boat Strength* by Dave Gerr.

5.0.2 *Types of Materials and Methods of Construction*

These minimum scantlings presume an aluminum boat, of welded construction, except that some deck and cabin areas may be riveted if specifically permitted in the scantlings. Where no construction method is specifically indicated, the construction is to be MIG or TIG welded, whichever is industry standard for that particular location and application.

While no one alloy of aluminum is specified for these scantlings, since they are minimums allowed for race performance purposes rather than for structural strength purposes, the following scantlings presume that the alloys used are 5383, 5456, or Hoogoven's Alustar.

The construction system envisions frames, floors and beams that are made together of one piece, or — where too large to be cut from one piece — of sections welded together, rather than from separate floor, frame and beam shapes. Throughout this section, it is assumed that doubling plates are used to ensure sufficient strength of any structural member which must be welded up from multiple pieces. Doubling plates are not to be counted as part of the compliance with the scantling; rather their weight is extra, in addition to what the part would weigh if it were made all of one piece.

Note: If in any place there is minor discrepancy between dimensions listed on the drawing, versus maximums or minimums in the scantling text, the value in the text shall govern. The construction drawings are to be considered advisory illustrations, not necessarily exact rule values.

5.0.3 *Scantling Review*

These scantlings have been reviewed by an Independent Consultant who is very familiar with the ISO Standard, and have been found to comply with the ISO Standard for Category 5 yachts in every parameter evaluated.

5.1 **Minimum Construction Requirements for the English System**

STRUCTURAL ITEM		MINIMUM SCANTLING
5.1.1	Frame Spacing	Frame spacing shall be not greater than 1' 5 1/2", except that one frame space may be one standard frame thickness greater for the purpose of making proper frame bevels. While it is not a requirement that a frame be located at the forward ending of the LWL, that assumption is made for defining frame scantlings. Normally this will be Frame 10. Frame 10 shall be not more than a horizontal distance of 14.583 ft aft of the stem head. If some feature of construction makes this requirement impracticable, then special consideration will be given by the Rules Committee.
5.1.2	Vertical Plate Keel	8" high x 1" thick. There shall be no lightening holes in the vertical plate keel, except in the two full frame spaces forward of the rudder post. See Example Construction Plan.
5.1.3	Vertical Plate Keel in Way of Mast	Not less than 1' 3 3/4" x 1" for at least 2 frames forward and 2 frames aft of center of mast step. The mast step is thus to be bounded on the fore and aft ends by a heavy frame at each end, with two standard and one heavy frame between these heavy end frames.
5.1.4	Stem	Height not less than 6 3/4" at connection to keel, tapering uniformly to 4 3/4" high over length of stem. 1" thick at keel to Frame 9; 7/8" thick forward of Frame 9. There shall be no lightening holes in the stem, except forward of Frame 1. A flange 3" wide x 1 1/2" thick shall be fitted from Frame 15 to at least one frame space aft of the aft end of the mast step. This flange may be expanded in width in the mast step area to form the mast step.
5.1.5	Counter	Height not less than 6 3/4" at aft end of LWL, tapering uniformly to 5" at aft-most frame; 7/8" thickness throughout. There shall be no lightening holes in the counter.
5.1.6	Floors	Thickness same as frames; depth 1.6 x Rule (not actual) keel vertical height at that fore/aft location. Where the counter sections are flat or have little deadrise, floors on the counter may be the same height as the vertical counter. Extra floors, at one-half the regular frame spacing, are to be fitted throughout the length of the mast step, and under any heavy machinery such as engines or generators. Along the length of the mast step, floors are to be at least the height of the vertical plate keel at that location. Flanges for floors are to be not less than 1/2" thick x 2 5/8" wide. Where the floor is associated with a heavy frame, the flange width shall be at least equal to the width of the heavy frame flange. Forward of Frame 12, floors depth may be reduced gradually to a depth of 70% that of the midship specified depth (1.6 x Rule vertical plate keel height). See scantlings in TABLE 1.
5.1.7	Standard Frames	Not less than 3/8" thick throughout. Height at floor not less than 3 9/16", tapered approximately uniformly to 3 1/16" at the midpoint, and to 2 1/2" at the sheer line. All frames shall comply with (or exceed) the standard frame scantlings except for the heavy frames specified just below, and the frames in the area of the mast step and chain plates. Standard frames may have lightening holes as indicated on the accompanying drawing, one in each frame segment between longitudinal stiffeners, but all such lightening holes shall be essentially round, and shall occupy not more than 45% of the frame height at that point, exclusive of shell plating and frame flange. Minimum frame/floor radius for standard frames is 0' 8 7/8". Where the standard frame is above the ballast keel or a vertical projection thereof, the minimum frame/floor radius shall be the heavy frame/floor radius 1' 11", though the frame thickness may remain the 3/8". Standard frames are to have flanges not less than 1/2" x 2 5/8". Forward of Frame 12, frame webs may be reduced gradually to a web 70% that of the standard midship frame at any given height. See forward frame scantlings in TABLE 1 following this listing of scantlings.

- 5.1.8 Heavy Frames Frames 12, 17, 22, 33, and 42 shall be heavy frames. Heavy frames and their associated floors and beams are to be of $\frac{1}{2}$ " aluminum plate throughout, and are to have a height not less than $5\frac{3}{4}$ ", with no taper. Heavy frames may have lightening holes as indicated on the accompanying drawing, but such holes shall be not more than one per longitudinal space, and shall not take up more than 45% of the frame height at that location, not counting shell plate and frame flange. Lightening holes shall be essentially round. Minimum frame/floor radius for heavy frames is 1' 11". Heavy frames are to have flanges not less than $\frac{1}{2}$ " x $2\frac{3}{4}$ ". Where a bulkhead is to be fitted at Frame 12, the plate thickness may be reduced to $\frac{3}{8}$ ". Where this alternate arrangement is used, the bulkhead may have a removable portion for service access to the forward part of the boat. However, the removable portion of the bulkhead must be bolted, screwed or other-wise securely fastened in place whenever measuring the boat and whenever racing.
- 5.1.9 Frames at Chain Plates Frames 24, 25 and 26 shall be $\frac{1}{2}$ " aluminum. Frames 24 and 26 shall have the same web and flange scantlings for floor, frame, and deck beam as heavy frames. Scantlings for frames 24, 25, and 26 shall be adjusted as indicated on the attached scantling drawing, as needed for adequate chain plate strength and support. Frames at chain plates shall not be tapered.
- 5.1.10 Longitudinal Hull Stiffeners Longitudinal hull stiffeners shall be employed as indicated in the accompanying scantling drawing. There shall be a minimum of 8 stiffeners along the bottom and middle shell plating areas, and a minimum of 2 additional stiffeners along the top side portion of the shell plating. Bottom and middle plating stiffeners shall be not less than $\frac{3}{8}$ " thick x $1\frac{1}{4}$ " high. Top side plating stiffeners shall be not less than $\frac{5}{16}$ " thick x $1\frac{1}{8}$ " high. The lowest stiffener shall begin at a height approximately 0.4 ft. above the LWL; each succeeding stiffener shall begin an additional 0.4 ft. above the LWL, as indicated in the accompanying drawing. Each stiffener shall continue the full length of the hull, taken at the height above the LWL at which it begins and ends, except that a stiffener may be cut short if it interferes with the rudder post or some other structure at or near the aft end of the LWL. Stiffeners shall be angled such that they have no sharp twists in them, and positioned such that they divide the midship section into roughly equal parts, except that the upper-most top side stiffener may be positioned such that there is a larger than average space between it and the deck than between the other stiffeners. No lightening holes are permitted in longitudinal stiffeners.
- 5.1.11 Standard Beams $2\frac{3}{8}$ " x $\frac{3}{8}$ " thick throughout, except on heavy frames. Beams are not to be tapered. Lightening holes are permitted, one per longitudinal space. Lightening holes must not take up more than 45% of the beam height at that location, not counting shell plate and frame flange, and shall be essentially round. For standard beams, the minimum beam/frame radius is 0' 6", except as indicated on the scantling drawing. Flanges are to be the same dimensions as flanges for the corresponding frame.
- 5.1.12 Heavy Beams $5\frac{3}{4}$ " x $\frac{1}{2}$ ". Minimum frame/beam radius is $1' 3\frac{5}{8}$ ". Beams are not to be tapered. Lightening holes are permitted one per longitudinal space. Lightening holes must not take up more than 45% of the beam height at that location, not counting shell plate and frame flange, and shall be essentially round. Flanges are to be the same dimensions as flanges for the corresponding frame.
- 5.1.13 Longitudinal Deck Stiffeners Longitudinal deck stiffeners shall begin 0' 10" to either side of the centerline of the deck, and spaced 0' 10" apart thereafter. Deck longitudinal stiffeners run parallel to the centerline of the boat. Deck longitudinal stiffeners are $1\frac{1}{8}$ " by $\frac{1}{4}$ ". Generally, longitudinal deck stiffeners are continuous, except that:
- 1) they do not span hatches or small deck houses with planform area less than 30 ft²;
 - 2) they do not pass through the partners at the mast;
 - 3) they need not extend further forward than frame 4;
 - 4) they are not required to extend all the way to the edge of the boat, but instead may stop at the nearest deck beam.
- Where longitudinal deck stiffeners intersect heavy deck longitudinals, the longitudinal deck stiffeners may be interrupted for one frame space.
No lightening holes are permitted in longitudinal deck stiffeners.

5.1.14	Heavy Deck Longitudinals	Heavy longitudinals are to be fitted such that the foredeck centerline is reinforced against bending. This longitudinal reinforcement is to be carried aft as far as the point of attachment of the aft-most running backstay, and should be split into two pieces, one on each side of the boat, beginning at a point somewhere forward of the mast. Aft of the point of division into two pieces, each piece shall have at least these scantlings: 4" x 3/8" with flange 3" by 3/8". Forward of Frame 4, the longitudinal heavy deck beam shall have the same scantlings as the stem forward of Frame 3, so that the stem is in effect carried around the forward part of the boat and back down the deck to form one rigid vertical construction element. From Frame 4 aft to the point of division into two pieces, the minimum scantling shall also be 4" x 3/8" with 3" x 3/8" flange.
5.1.15	Horizontal Plate Keel	There shall be a horizontal plate keel which constitutes the lower limit of the hull, at a height which provides a good foundation for mounting the ballast keel. The horizontal plate keel shall be not less than 1 1/2" thick.
5.1.16	Main Hull Plating	The main hull plating shall continue from an upper limit to a lower limit defined as follows: <i>upper limit</i> – 1' 1" above the LWL, from stern to midship, and gradually increasing in height forward of midship to a maximum height of 2' 8 1/2" at the stem; <i>lower limit</i> – 4' 4 1/2" below, and parallel to, the LWL. The main hull plating shall be 3/8" thick.
5.1.17	Bottom Hull Plating	The bottom hull plating shall extend from the lower limit of the main hull plating to the horizontal plate keel, and shall be 1/2" thick.
5.1.18	Topsides Hull Plating	The topsides hull plating shall extend from the upper limit of the main hull plating to the sheerline. If the topside hull plating is extended upward above the deck to form a bulwark-like rail, then the extension shall be of the same scantling as the topside hull plating. The topside hull plating shall be 5/16" thick.
5.1.19	Deck Plating	The basic deck plating shall be 1/4" thick. The 1/4" plating is to be used for the entire deck of the boat.
5.1.20	Deck House Beams	Deck House Beams shall be the same scantlings as Standard Beams.
5.1.21	Deck House Longitudinals	Deck House Longitudinals shall be the same scantlings as Standard Longitudinal Deck Stiffeners.
5.1.22	Cockpit Frames & Beams	Cockpit Frames and Beams shall be the same scantlings as Standard (deck) Beams.
5.1.23	Cockpit Longitudinals	Cockpit Longitudinals shall be the same scantlings as Standard Longitudinal Deck Stiffeners.
5.1.24	Deck House Plating	Deck House side, forward, aft and top plating shall be not less than 3/16". Deck Houses may be of welded or riveted construction.
5.1.25	Cockpit Sides & Sole Plating	Cockpit sides and sole plating shall be not less than 1/4".
5.1.26	Transom	The transom shall be not less than 3/8" thick plating.
5.1.27	Transom Frames & Longitudinals	Transom Frames shall have Standard Frame scantlings. Transom Longitudinals shall have the same scantlings as topside hull longitudinals.
5.1.28	Bulkhead at or Forward of a point 6% of LWL Aft of Forward End of LWL	Any method of construction is acceptable provided that the frame weight is maintained. The bulkhead may be fitted with an opening for access forward, in which case a closure must be fitted. The minimum weight of the closure, including stiffeners, must be not less than 3.5 lbs/ft ² . The closure must be in place and closed when the boat is racing. See the Example Construction Plan.
5.1.29	Note that heavy frames	may be moved forward or aft one frame space if indicated by the structural requirements of rig or keel, or if indicated by the requirements of the interior arrangement plan.

TABLE 1. CALCULATION OF SCANTLINGS FOR FRAMES 1-11			
FRAME #	MULTIPLY FRAME & FLOOR WEB BY	MULTIPLY FRAME to FLOOR RADIUS BY	MULTIPLY FRAME to BEAM RADIUS BY
STANDARD FRAMES	1.00	1.00	1.00
FRAME 11	0.97	0.97	0.97
FRAME 10	0.94	0.94	0.94
FRAME 9	0.91	0.91	0.91
FRAME 8	0.88	0.88	0.88
FRAME 7	0.85	0.85	0.85
FRAME 6	0.82	0.82	0.82
FRAME 5	0.79	0.79 or max fit [Note 1]	0.66
FRAME 4	0.76	0.76 or max fit [Note 1]	0.49
FRAME 3	0.73	0.73 or max fit [Note 1]	0.35
FRAME 2	0.70	0.70 or max fit [Note 1]	0.20
FRAME 1	Note 2	Note 3	Note 4

Notes:

1. These frame/floor radii to be at least the lesser of that given by a) the web multiplier for that frame, or b) the largest radius that will fit at the required floor height and web height
2. Web height and beam height to be 1 in (25 mm), no taper. Floor height to be 2 in (51 mm) (see Example Construction Plan)
3. Web/floor radius to be maximum which will fit floor and web heights
4. Web/beam radius to be not less than 1 in (25 mm)

5.2 ***Minimum Weight of Rudder Stock***

The rudder stock, excluding any attachments, for a rudder mounted at the aft end of LWL, shall weigh not less than 100 lbs (45.4 kg).

A trim tab or rudder mounted on the trailing edge of the main ballast keel does not count as a rudder for purposes of this section of the rule.

5.3 ***Deck Sheathing***

5.3.1 The deck, as specified in the scantlings, shall be sheathed with a layer of teak, with a nominal density of 44 lbs/ft³ (704.8 kg/m³). The teak sheathing shall be a minimum of 0.5 in (13 mm) thick. The sheathing may be scored to simulate planking which may be “laid” as either straight planks or curved planks corresponding to the curvature in the planform of the shear line.

5.3.1.1 The wood sheathing shall cover the entire deck except as specified as follows:

5.3.1.2 There may be a perimeter of deck not covered by wood sheathing along the sides of the boat, the width of which shall not exceed 5.5 in (140 mm).

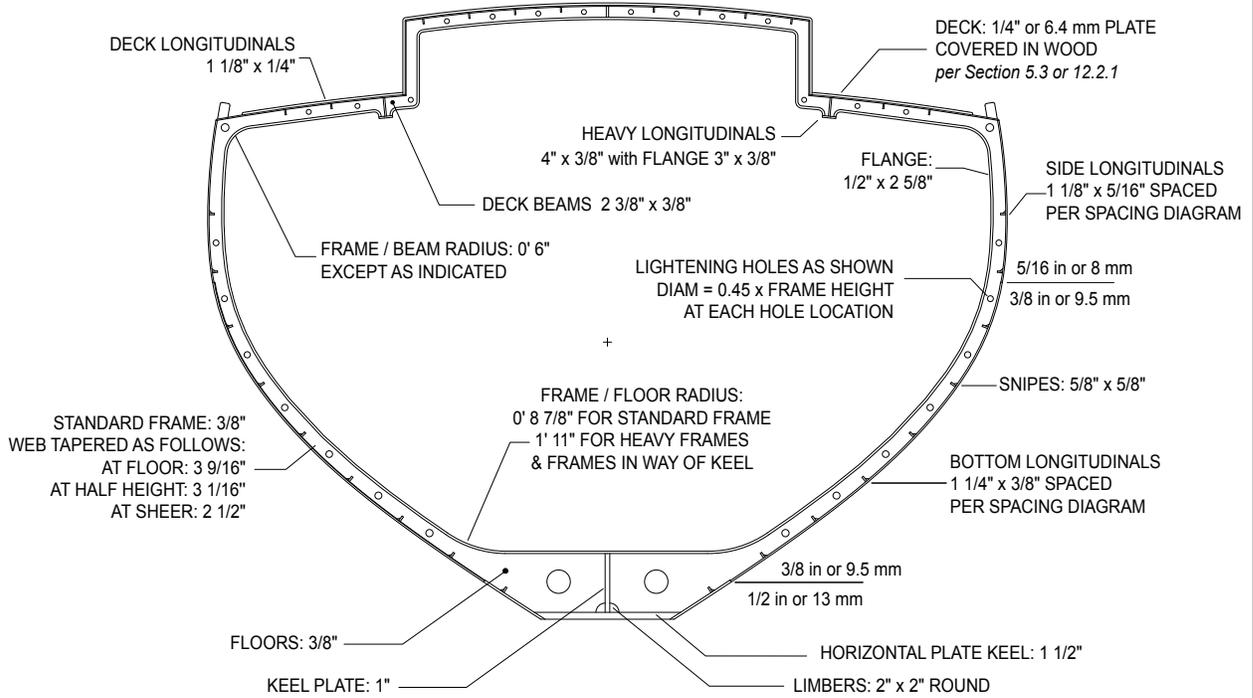
5.3.1.3 The wood sheathing may be terminated at right angles to the centerline of the boat at a horizontal distance of 5.25 ft (1.600 m) aft of the stem head.

5.3.1.4 The wood sheathing may be terminated in an arc roughly matching the arc of the transom or its bulwark at a horizontal distance of 10 in (254 mm) forward of the aft edge of the bulwark. Where this distance is not taken at the centerline of the boat, it shall be taken perpendicular to the inner edge of the bulwark at that point.

5.3.2.1 Where teak can not be obtained in a legal and sustainable manner, or where the owner desires some other wood, that wood may be substituted in a thickness proportional to the difference of the nominal density of that wood to that of teak, such that the total material weight is maintained.

EXAMPLE MIDSHIP CONSTRUCTION SECTION

MIDSHIP CONSTRUCTION SECTION



DO NOT SCALE

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 <p>FLADLIEN & ASSOCIATES, LLC</p>	CONSTRUCTION SCANTLINGS	CLASS M SLOOP FOR MEASUREMENT RULE
		HULL 66F15 - DJF
		DWG No. 1064 - DJF
		SCALE: FULL
		NOVEMBER 7, 2018

6.0 INTERIOR ARRANGEMENT AND RELATED REQUIREMENTS

6.1 *Deck Houses*

6.1.1 At least one deck house shall be fitted, the dimensions of which shall be not less than:

- ◆ Height of side above sheer line at mid-length of deck house: 1' 7" (482 mm)
- ◆ Height of center above sheer line at mid-length of deck house: 1' 8" (508 mm)
- ◆ Horizontal fore/aft length of deck house: 9' 3" (2.819 m)
- ◆ Horizontal athwartship width of deck house: 7' 4" (2.235 m)

6.1.2 The planform of the deck house shall be a rectangle with vertical or essentially vertical sides and forward and aft endings, or shall be a shape and size capable of containing an unaltered rectangle of the same or larger dimensions. Cut-outs in the deck house sides or front/back are permitted provided that the total frontal or side 2-dimensional areas are maintained.

6.2 *Interior Arrangements*

6.2.1 Interior arrangement shall include at least the following items:

6.2.1.1 at least 8 built-in berths (not pipe berths); Note: swing-up (hinged) beds are built-in berths, provided that they include a frame of wood or metal, and utilize some sort of mattress, not a suspended cloth.

6.2.1.2 at least 3 fully-enclosed heads, including w.c. and sink; at least one of such enclosed system must be entirely forward of the mast.

6.2.1.3 cooking and eating facilities including at least the following:

6.2.1.3.1 cooking appliance or appliances, which taken together provide both oven and burner capability, whether or not those are in the same appliance or in the same location;

6.2.1.3.2 refrigerator(s) and freezer(s) adequate for a 4-day trip with 8 people;

6.2.1.3.3 canned goods storage sufficient for a 4-day trip for 8 people;

6.2.1.3.4 galley sink, not less than 165 in² area in planview;

6.2.1.3.5 microwave oven;

6.2.1.3.6 seating for at least 4 persons at one time;

6.2.1.4 private owner's cabin, including berths and seating arrangements suitable for relaxed short cruises;

6.2.1.5 navigation station including chart table, fixed chair and appropriate chart storage; or folding or fixed table(s) suitable for use of a laptop computer for reading charts, and provision for sitting while using that laptop computer.

6.2.1.6 hanging lockers sufficient for 8 persons for a 4-day trip.

6.2.2 All of the preceding equipment is to be "off the shelf" equipment, unless there is a compelling reason for a custom-made piece of equipment. In that case, the owner or builder or manufacturer must show that there is no advantage in weight saving to using the custom-made piece of equipment.

Exception: small pieces of interior equipment, such as door handles, hinges, latches, etc. may be custom-made if their maximum dimension in any direction is less than 6 in (152 mm), and provided that no exotic materials, as defined in this Rule, are used.

7.0 DECK LAYOUT AND RELATED REQUIREMENTS

7.1 *Cockpits & Cockpit Areas*

The boat shall have at least two cockpits, which shall be fully self-draining, and separate from each other. One shall be the main working cockpit; the other, aft of the main working cockpit, shall be a cockpit dedicated to on-board, non-sailing guests.

7.1.1 The planform areas of these cockpits shall be not greater than:

7.1.1.1 Main Working Cockpit(s) total: 57.0 ft² (5.30 m²)

7.1.1.2 Guest Cockpit: 15 ft² (1.394 m²)

7.1.2 The main working cockpit may be comprised of two or more physical cockpits, each of which is used for steering the boat and/or trimming sails and other similar activities. Where there is more than one working cockpit, their total planform area shall be not greater than that allowed in this section.

7.1.3 Additional arrangements may be provided for on-deck sail storage, etc, but where these are actual openings in the deck, they must be self-draining or fully enclosed and provided with a pump system, and must be closed by a cover of equal weight and vertical strength (for standing on) as the deck area that they replace. The cover shall be closed when these areas are not in use, and no person shall stand, sit or kneel in these areas for any purpose except storage/retrieval of sails into or from the storage area.

7.1.4 To avoid the use of excessive numbers or sizes of hatches to save weight, hinged hatch covers shall maintain the same structural scantlings as, or greater than, the piece of deck or deckhouse which they replace.

8.0 PROVISIONAL ENGINE AND PROPELLER REQUIREMENTS

8.1 *Engine Requirements*

8.1.1 The boat shall be equipped with a diesel engine which, in combination with the propeller and propeller mounting utilized, shall be demonstrably capable of driving the boat in the forward direction at a speed of at least 9.0 knots, sustainable for at least one nautical mile, in smooth water with no wind. The transmission used shall be capable of powering the boat in reverse.

8.1.2 The engine shall not be mounted in, or immediately adjacent to, the owner's cabin.

8.2 *Propeller and Propeller Mounting Requirements*

8.2.1 While the value of PIPA, as standardly defined (see APPENDIX 2), is not a direct component of the rating, each boat shall have a propeller and mounting which has a PIPA value of not less than 0.0117, and which meets the following additional requirements:

8.2.1.1 the propeller used shall be a 3- or 4-blade feathering propeller;

8.2.1.2 the propeller mounting shall meet all the requirements in Appendix 2 for an "out of aperture" propeller mount;

8.2.1.3 ESL shall not exceed 5.25 ft (1.6 m).

9.0 CREW LIMIT

9.1 *Crew & Observer Limits*

9.1.1 The maximum number of crew on board during a race, not counting guest observers, shall be 19.

The maximum number of guest observers on board during a race shall be 2. While observers may make occasional suggestions or comments, they are not to be regular tacticians, navigators, or strategists during a race, and – except in a clear emergency (where immediate action is needed to avoid injury to a person or to avoid severe damage to the boat or its equipment) – they shall play no physical role in sailing the boat during a race.

9.1.2 Local authorities may make their own crew and observer limit rules for racing amongst themselves.

10.0 PROVISIONAL FORMULAS FOR BOATS MEASURED UNDER THE METRIC SYSTEM

10.1 *Metric Measurement Certificates Validity and Resolution in Case of Conflict*

The following Metric formulas and scantlings are provided for the use of those wishing to work under the Metric system of measurement. Rating Certificates developed under the Metric system are valid for all purposes. However, in case of question or conflict, the English units and their calculated results shall govern.

10.2 *Class Rating*

The Class Rating shall be 14.021 metres.

11.0 BASIC RATING FORMULA

The basic rating formula for the Universal Rule of Measurement is:

$$R = 0.18 \frac{L\sqrt{S}}{\sqrt[3]{D}}$$

Where:

- R = Class Rating in metres;
- L = Rated Length in metres;
- S = Rated Sail Area in Square metres;
- D = Rated Displacement in Cubic metres.

11.1 *Equations and Constraints for Rating Calculation Using the Metric System*

Note: English and metric equation numbers are identical.

The formulas for determining Rated Length are:

$$L = LWL + P_{qbl} + P_{fwd} + P_{aft} + P_{disp} + P_{beam} + P_{draft} + P_{fbd} + P_{depth} \quad (2)$$

Where:

- L = Rated Length In Metres;
- LWL = Water Line Length in Metres, in Measurement Trim;
- P_{qbl} = Quarter Beam Penalty in Metres;
- P_{fwd} = Excessive Breadth of Section Penalty at forward end of LWL in Metres;
- P_{aft} = Excessive Breadth of Section Penalty at aft end of LWL in Metres;
- P_{disp} = Insufficient Actual Displacement Penalty in Metres;
- P_{beam} = Excessive or Insufficient Breadth Penalty at Maximum Beam Station in Metres;
- P_{draft} = Excessive Draft Penalty at the Maximum Draft Station in Metres;
- P_{fbd} = Insufficient Freeboard Penalty in Metres;
- P_{depth} = Insufficient Hull Depth Penalty in Metres.

11.1.1 **Maximum and Minimum LWL**

The Maximum LWL in Measurement Trim shall be:

$$LWL_{max} = (1.08 * \text{Class Rating}) + 1.524 \text{ m} \quad (3)$$

The Minimum LWL in Measurement Trim shall be:

$$LWL_{min} = (1.08 * \text{Class Rating}) + 0.914 \text{ m} \quad (4)$$

11.1.2 Quarter Beam Length

The maximum quarter beam length, in metres, without penalty shall be:

$$QBL_{\max} = \frac{100 - \sqrt{\frac{LWL}{0.3048}}}{100} * LWL + 1.219 \text{ m} \quad (5)$$

If the quarter beam length is greater than the maximum permitted without penalty in (5), the quarter beam penalty shall be given by:

$$P_{qbl} = 0.5 \left[QBL - \frac{100 - \sqrt{\frac{LWL}{0.3048}}}{100} * LWL \right] - 0.6095 \text{ m} \quad (6)$$

11.1.2.1 The forward end of QBL shall not be taken as further aft than $0.12 * LWL$ aft of the forward end of LWL.

11.1.3 Forward Breadth

The maximum forward breadth, taken at a height of 122 mm above LWL, without penalty shall be:

$$FWD_{\max} = 0.04 * LWL \quad (7)$$

If the forward breadth as defined above is greater than the maximum allowed without penalty in (7), the penalty shall be given by:

$$P_{fwd} = 1.5 * (\text{actual forward breadth} - (0.04 * LWL)) \quad (8)$$

11.1.4 Aft Breadth

The maximum aft breadth, taken at a height of 122 mm above LWL, without penalty shall be:

$$AFT_{\max} = 0.125 * LWL \quad (9)$$

If the aft breadth as defined above is greater than the maximum allowed without penalty in (9), the penalty shall be given by:

$$P_{aft} = \text{actual aft breadth} - (0.125 * LWL) \quad (10)$$

11.1.5 Displacement

The minimum displacement (in cubic metres) without penalty shall be

$$Disp_{\min} = (0.2 * LWL + 0.1524)^3 \quad (11)$$

If the actual displacement (in cubic metres) is less than the minimum given by (11), then the displacement penalty shall be

$$P_{\text{disp}} = LWL - \frac{\sqrt[3]{(\text{actual displacement})} - 0.1524 \text{ m}}{0.2} \quad (12)$$

Rated displacement, D, in the rating formula shall be the actual displacement of the boat as determined by weighing. D shall not be taken as greater than the rule minimum displacement as defined in (11) above. Therefore

$$\sqrt[3]{D} \leq (0.2 * LWL + 0.1524 \text{ m}) \quad (13)$$

11.1.6 Beam

The Beam, B, as defined above under Quarter Beam Length, shall be not less than

$$B_{\min} = 4.038 \text{ m} \quad (14)$$

If B is less than the minimum defined in (14), the penalty shall be

$$P_{\text{beam}} = 4.038 - \text{actual LWL beam} \quad (15)$$

The Beam, B, as defined above under Quarter Beam Length, shall be not greater than

$$B_{\max} = 4.185 \text{ m} \quad (16)$$

If B is greater than the maximum defined in (16), the penalty shall be

$$P_{\text{beam}} = \text{actual LWL beam} - 4.185 \text{ m} \quad (17)$$

11.1.7 **Draft**

The maximum draft shall be

$$H_{\max} = 0.16 * \text{LWL} + 1.067 \text{ m} \quad (18)$$

If the draft exceeds the maximum defined just above, the penalty shall be

$$P_{\text{draft}} = 3 * (\text{actual draft} - (0.16 * \text{LWL} + 1.067)) \quad (19)$$

11.1.8 **Freeboard**

The freeboard taken in measurement trim at the midship (50% LWL) station shall be not less than

$$F_{\min} = 0.062 * \text{LWL} + 0.183 \text{ m} \quad (20)$$

The freeboard at the forward end of LWL, in measurement trim, shall be not less than

$$F_{\min \text{ fwd}} = F_{\min} * 1.165 \quad (21)$$

and the freeboard at the aft end of LWL, in measurement trim, shall be not less than

$$F_{\min \text{ aft}} = F_{\min} * 0.979 \quad (22)$$

If any of the above 3 freeboard measurements is less than the minimum required, the penalty shall be

$$P_{\text{fbd}} = 2 * (F_{\text{rqd}} - F_{\text{act}}) \quad (23)$$

Where:

F_{rqd} = Freeboard required at that station from (20), (21), or (22) above;

F_{act} = Actual freeboard at that station.

If more than one of the measured freeboards is less than the required minimum, the penalty shall be based on the largest deficiency, not the sum of the deficiencies.

11.1.9 **Sail Area Formula**

Rated sail area, S, in the rating formula shall be the triangular area of the mainsail plus 85% of the area of the fore triangle, that is

$$S = \frac{P * E}{2} + 0.85 \frac{I * J}{2} \quad (24)$$

Where:

P = Mainsail luff length in metres;

E = Mainsail foot length in metres;

I = Fore triangle height in metres, taken from the sheer line abreast the mast;

J = Base of fore triangle in metres.

11.1.10 **Maximum Height of Sail Plan**

The maximum height of the sail plan above the sheer line, measured along the aft edge of the mast (not necessarily vertical), shall be given by

$$\text{Rig Height}_{\max} = 1.90 \sqrt{S} + 1.524 \text{ m} \quad (25)$$

11.1.11 **Maximum Girth of Mainsail**

The maximum dimension of the mainsail, measured perpendicular to the luff at a height 65% of P above the base of P, shall be

$$\text{Girth}_{\max} = 0.52 * E \quad (26)$$

11.1.12 **Maximum Depth of Rudder Below LWL**

The maximum depth of the tip of the rudder below the LWL shall be not greater than

$$\text{Rudder Depth}_{\max} = 0.6 * H_{\max} \quad (27)$$

Where

$$H_{\max} = \text{maximum draft without penalty per (18)}$$

11.1.13 **Centerboards & Daggerboards**

The maximum total exposed lateral area of centerboard(s) and/or daggerboard(s), if any, in metres², shall be not greater than

$$\text{Area}_{\max} = 0.128 * \text{LWL (in metres)} \quad (28)$$

The maximum draft of the boat with the centerboard(s) and/or daggerboard(s) fully extended shall not exceed

$$\text{Total Draft}_{\max} = H_{\max} * 1.43 \quad (29)$$

Where:

$$H_{\max} = \text{Maximum Draft without Penalty from (18) above.}$$

11.1.14 **Minimum Weight of Rudder Stock**

The rudder stock, excluding any attachments, for a single rudder mounted at the aft end of LWL, shall weigh not less than 45.3 kg.

A trim tab or rudder mounted on the trailing edge of the main ballast keel does not count as a rudder for purposes of this section of the rule.

12.0 MINIMUM CONSTRUCTION REQUIREMENTS

12.1 *Minimum Construction Requirements for the Metric System*

STRUCTURAL ITEM		MINIMUM SCANTLING
12.1.1	Frame Spacing	Frame spacing shall be not greater than 444.5 mm, except that one frame space may be one standard frame thickness greater for the purpose of making proper frame bevels. While it is not a requirement that a frame be located at the forward ending of the LWL, that assumption is made for defining frame scantlings. Normally this will be Frame 10. Frame 10 shall be not more than a horizontal distance of 4.45 m aft of the stem head. If some feature of construction makes this requirement impracticable, then special consideration will be given by the Rules Committee.
12.1.2	Vertical Plate Keel	203 mm high x 25.4 mm thick. There shall be no lightening holes in the vertical plate keel, except in the two full frame spaces forward of the rudder post. See Example Construction Plan.
12.1.3	Vertical Plate Keel in Way of Mast	Not less than 400 mm x 25.4 mm for at least 2 frames forward and 2 frames aft of center of mast step. The mast step is thus to be bounded on the fore and aft ends by a heavy frame at each end, with two standard and one heavy frame between these heavy end frames.
12.1.4	Stem	Height not less than 172 mm at connection to keel, tapering uniformly to 121 mm high over length of stem. 25.4 mm thick at keel to Frame 9; 22.23 mm thick forward of Frame 9. There shall be no lightening holes in the stem, except forward of Frame 1. A flange 76 mm wide x 38.1 mm thick shall be fitted from Frame 15 to at least one frame space aft of the aft end of the mast step. This flange may be expanded in width in the mast step area to form the mast step.
12.1.5	Counter	Height not less than 172 mm at aft end of LWL, tapering uniformly to 127 mm at aft-most frame; 22.23 mm thickness throughout. There shall be no lightening holes in the counter.
12.1.6	Floors	Thickness same as frames; depth 1.6 x Rule (not actual) keel vertical height at that fore/aft location. Where the counter sections are flat or have little deadrise, floors on the counter may be the same height as the vertical counter. Extra floors, at one-half the regular frame spacing, are to be fitted throughout the length of the mast step, and under any heavy machinery such as engines or generators. Along the length of the mast step, floors are to be at least the height of the vertical plate keel at that location. Flanges for floors are to be not less than 12.7 mm thick x 67 mm wide. Where the floor is associated with a heavy frame, the flange width shall be at least equal to the width of the heavy frame flange. Forward of Frame 12, floor depth may be reduced gradually to a depth of 70% that of the midship specified depth (1.6 x Rule vertical plate keel height). See scantlings in TABLE 1.
12.1.7	Standard Frames	Not less than 9.5 mm thick throughout. Height at floor not less than 91 mm, tapered approximately uniformly to 78 mm at the midpoint, and to 64 mm at the sheer line. All frames shall comply with (or exceed) the standard frame scantlings except for the heavy frames specified just below, and the frames in the area of the mast step and chain plates. Standard frames may have lightening holes as indicated on the accompanying drawing, one in each frame segment between longitudinal stiffeners, but all such lightening holes shall be essentially round, and shall occupy not more than 45% of the frame height at that point, exclusive of shell plating and frame flange. Minimum frame/floor radius for standard frames is 225 mm. Where the standard frame is above the ballast keel or a vertical projection thereof, the minimum frame/floor radius shall be the heavy frame/floor radius 584 mm, though the frame thickness may remain the 9.5 mm. Standard frames are to have flanges not less than 12.7 mm x 67 mm. Forward of Frame 12, frame webs may be reduced gradually to a web 70% that of the standard midship frame at any given height. See forward frame scantlings in TABLE 1 following this listing of scantlings.

- 12.1.8 Heavy Frames Frames 12, 17, 22, 33, and 42 shall be heavy frames. Heavy frames and their associated floors and beams are to be of 12.7 mm aluminum plate throughout, and are to have a height not less than 146 mm, with no taper. Heavy frames may have lightening holes as indicated on the accompanying drawing, but such holes shall be not more than one per longitudinal space, and shall not take up more than 45% of the frame height at that location, not counting shell plate and frame flange. Lightening holes shall be essentially round. Minimum frame/floor radius for heavy frames is 584 mm. Heavy frames are to have flanges not less than 12.7 mm x 70 mm. Where a bulkhead is to be fitted at Frame 12, the plate thickness may be reduced to 9.5 mm. Where this alternate arrangement is used, the bulkhead may have a removable portion for service access to the forward part of the boat. However, the removable portion of the bulkhead must be bolted, screwed or otherwise securely fastened in place whenever measuring the boat and whenever racing.
- 12.1.9 Frames at Chain Frames 24, 25 and 26 shall be 12.7 mm aluminum. Frames 24 and 26 shall have the same web and flange scantlings for floor, frame, and deck beam as heavy frames. Scantlings for frames 24, 25, and 26 shall be adjusted as indicated on the attached scantling drawing, as needed for adequate chain plate strength and support. Frames at chain plates shall not be tapered.
- 12.1.10 Longitudinal Hull Longitudinal hull stiffeners shall be employed as indicated in the accompanying Scantling drawing. There shall be a minimum of 8 stiffeners along the bottom and middle shell plating areas, and a minimum of 2 additional stiffeners along the top side portion of the shell plating. Bottom and middle plating stiffeners shall be not less than 9.5 mm thick x 32 mm high. Top side plating stiffeners shall be not less than 7.9 mm thick x 29 mm high. The lowest stiffener shall begin at a height approximately 122 mm above the LWL; each succeeding stiffener shall begin an additional 122 mm above the LWL, as indicated in the accompanying drawing. Each stiffener shall continue the full length of the hull, taken at the height above the LWL at which it begins and ends, except that a stiffener may be cut short if it interferes with the rudder post or some other structure at or near the aft end of the LWL. Stiffeners shall be angled such that they have no sharp twists in them, and positioned such that they divide the midship section into roughly equal parts, except that the upper-most top side stiffener may be positioned such that there is a larger than average space between it and the deck than between the other stiffeners. No lightening holes are permitted in longitudinal stiffeners.
- 12.1.11 Standard Beams 60 mm x 9.5 mm thick throughout, except on heavy frames. Beams are not to be tapered. Lightening holes are permitted, one per longitudinal space. Lightening holes must not take up more than 45% of the beam height at that location, not counting shell plate and frame flange, and shall be essentially round. For standard beams, the minimum beam/frame radius is 152 mm, except as indicated on the scantling drawing. Flanges are to be the same dimensions as flanges for the corresponding frame.
- 12.1.12 Heavy Beams 146 mm x 12.7 mm. Minimum frame/beam radius is 397 mm. Beams are not to be tapered. Lightening holes are permitted one per longitudinal space. Lightening holes must not take up more than 45% of the beam height at that location, not counting shell plate and frame flange, and shall be essentially round. Flanges are to be the same dimensions as flanges for the corresponding frame.
- 12.1.13 Longitudinal Deck Longitudinal deck stiffeners shall begin 254 mm to either side of the centerline of the Stiffeners deck, and spaced 254 mm apart thereafter. Deck longitudinal stiffeners run parallel to the centerline of the boat. Deck longitudinal stiffeners are 29 mm by 6.4 mm. Generally, longitudinal deck stiffeners are continuous, except that:
- 1) they do not span hatches or small deck houses with planform area less than 2.79 m²;
 - 2) they do not pass through the partners at the mast;
 - 3) they need not extend further forward than frame 4;
 - 4) they are not required to extend all the way to the edge of the boat, but instead may stop at the nearest deck beam.
- Where longitudinal deck stiffeners intersect heavy deck longitudinals, the longitudinal deck stiffeners may be interrupted for one frame space. No lightening holes are permitted in longitudinal deck stiffeners.

12.1.14	Heavy Deck Longitudinals	Heavy longitudinals are to be fitted such that the foredeck centerline is reinforced against bending. This longitudinal reinforcement is to be carried aft as far as the point of attachment of the aft-most running backstay, and should be split into two pieces, one on each side of the boat, beginning at a point somewhere forward of the mast. Aft of the point of division into two pieces, each piece shall have at least these scantlings: 102 mm x 9.5 mm with flange 76 mm by 9.5 mm. Forward of Frame 4, the longitudinal heavy deck beam shall have the same scantlings as the stem forward of Frame 3, so that the stem is in effect carried around the forward part of the boat and back down the deck to form one rigid vertical construction element. From Frame 4 aft to the point of division into two pieces, the minimum scantling shall also be 102 mm x 9.5 mm with 76 mm x 9.5 mm flange.
12.1.15	Horizontal Plate Keel	There shall be a horizontal plate keel which constitutes the lower limit of the hull, at a height which provides a good foundation for mounting the ballast keel. The horizontal plate keel shall be not less than 38 mm thick.
12.1.16	Main Hull Plating	The main hull plating shall continue from an upper limit to a lower limit defined as follows: <i>upper limit</i> – 330 mm above the LWL, from stern to midship, and gradually increasing in height forward of midship to a maximum height of 826 mm at the stem; <i>lower limit</i> – 1.334 m below, and parallel to, the LWL. The main hull plating shall be 9.5 mm.
12.1.17	Bottom Hull Plating	The bottom hull plating shall extend from the lower limit of the main hull plating to the horizontal plate keel, and shall be 12.7 mm thick.
12.1.18	Topsides Hull Plating	The topsides hull plating shall extend from the upper limit of the main hull plating to the sheerline. If the topside hull plating is extended upward above the deck to form a bulwark-like rail, then the extension shall be of the same scantling as the topside hull plating. The topside hull plating shall be 7.9 mm thick.
12.1.19	Deck Plating	The basic deck plating shall be 6.4 mm thick. The 6.4 mm plating is to be used for the entire deck of the boat.
12.1.20	Deck House Beams	Deck House Beams shall be the same scantlings as Standard Beams.
12.1.21	Deck House Longitudinals	Deck House Longitudinals shall be the same scantlings as Standard Longitudinal Deck Stiffeners.
12.1.22	Cockpit Frames & Beams	Cockpit Frames and Beams shall be the same scantlings as Standard (deck) Beams.
12.1.23	Cockpit Longitudinals	Cockpit Longitudinals shall be the same scantlings as Standard Longitudinal Deck Stiffeners.
12.1.24	Deck House Plating	Deck House side, forward, aft and top plating shall be not less than 4.8 mm. Deck Houses may be of welded or riveted construction.
12.1.25	Cockpit Sides & Sole Plating	Cockpit sides and sole plating shall be not less than 6.4 mm.
12.1.26	Transom	The transom shall be not less than 9.5 mm thick plating.
12.1.27	Transom Frames & Longitudinals	Transom Frames shall have Standard Frame scantlings. Transom Longitudinals shall have the same scantlings as topside hull longitudinals.
12.1.28	Bulkhead at or Forward of a point 6% of LWL Aft of Forward End of LWL	Any method of construction is acceptable provided that the frame weight is maintained. The bulkhead may be fitted with an opening for access forward, in which case a closure must be fitted. The minimum weight of the closure, including stiffeners, must be not less than 17.088 kg/m ² . The closure must be in place and closed when the boat is racing. See the Example Construction Plan.
12.1.29	Note that heavy frames may be moved forward or aft one frame space if indicated by the structural requirements of rig or keel, or if indicated by the requirements of the interior arrangement plan.	

TABLE 1. CALCULATION OF SCANTLINGS FOR FRAMES 1–11			
FRAME #	MULTIPLY FRAME & FLOOR WEB BY	MULTIPLY FRAME to FLOOR RADIUS BY	MULTIPLY FRAME to BEAM RADIUS BY
STANDARD FRAMES	1.00	1.00	1.00
FRAME 11	0.97	0.97	0.97
FRAME 10	0.94	0.94	0.94
FRAME 9	0.91	0.91	0.91
FRAME 8	0.88	0.88	0.88
FRAME 7	0.85	0.85	0.85
FRAME 6	0.82	0.82	0.82
FRAME 5	0.79	0.79 or max fit [Note 1]	0.66
FRAME 4	0.76	0.76 or max fit [Note 1]	0.49
FRAME 3	0.73	0.73 or max fit [Note 1]	0.35
FRAME 2	0.70	0.70 or max fit [Note 1]	0.20
FRAME 1	Note 2	Note 3	Note 4

Notes:

1. These frame/floor radii to be at least the lesser of that given by a) the web multiplier for that frame, or b) the largest radius that will fit at the required floor height and web height
2. Web height and beam height to be 25 mm (1 in), no taper. Floor height to be 51 mm (2 in) (see Example Construction Plan)
3. Web/floor radius to be maximum which will fit floor and web heights
4. Web/beam radius to be not less than 25 mm (1 in)

12.2 Deck Sheathing

- 12.2.1 The deck, as specified in the scantlings, shall be sheathed with a layer of teak, with a nominal density of 704.8 kg/m³ (44 lbs/ft³). The teak sheathing shall be a minimum of 13 mm (0.5 in) thick. The sheathing may be scored to simulate planking which may be “laid” as either straight planks or curved planks corresponding to the curvature in the planform of the shear line.
- 12.2.1.1 The wood sheathing shall cover the entire deck except as specified as follows:
- 12.2.1.2 There may be a perimeter of deck not covered by wood sheathing along the sides of the boat, the width of which shall not exceed 140 mm (5.5 in).
- 12.2.1.3 The wood sheathing may be terminated at right angles to the centerline of the boat at a horizontal distance of 1.600 m (5.25 ft) aft of the stem head.
- 12.2.1.4 The wood sheathing may be terminated in an arc roughly matching the arc of the transom or its bulwark at a horizontal distance of 254 mm (10 in) forward of the aft edge of the bulwark. Where this distance is not taken at the centerline of the boat, it shall be taken perpendicular to the inner edge of the bulwark at that point.
- 12.2.2 Where teak can not be obtained in a legal and sustainable manner, or where the owner desires some other wood, that wood may be substituted in a thickness proportional to the difference of the nominal density of that wood to that of teak, such that the total material weight is maintained.

APPENDIX 1

General Discussion of Permissible Hull Shapes Under This Measurement Rule

The objective of this measurement rule is to produce a modernized version of the traditional M-Class, and is therefore a tightly-regulated development class. In doing so, the principle is that the boat which results should in a generalized way look, above the water in profile, like the last of the Universal Rule boats of the 1930s. This is not necessarily true of transverse sections, however, or even of the plan view, as those don't influence too greatly the impression left by the boat on the typical viewer. Hence, while the stem angle and counter angle are limited by the rule, the transverse sections may be "V" shaped, "U" shaped, or even round, flat, or square with a chine. This is true anywhere along the length of the boat. Similarly, the ends of the boat in plan view may be greatly "straightened" to make the corresponding sides more vertical.

However, the boat may not have protrusions from the hull. Those were never seen in the original M-Class, and so "humps" under the bow of the boat are not permitted, and neither are bulbs protruding forward of the waterline under water, even though in theory neither of these would affect the above-water appearance of the boat. However, it was common to have a hollow in the stem of the boat beginning slightly aft of the forward end of the waterline. This was most often in the R-Class, but was also seen in the J-Class Rainbow and (to some appearances) in Endeavour and Endeavour II. These hollows are legal in Class M, but see the Supplement for limits on the radius of such hollows.

It is desired to have a more modern boat, so that a separate rudder hung behind a skeg at the aft end of the waterline is permitted, as is a greater-than-unity taper keel ("upside-down" keel) with or without winglets.

Clearly not all of the above-mentioned characteristics can be represented in one drawing, but this rule does contain a lines plan which gives a general idea of what we expect a modern M-Boat to look like. This is the Hull 66F22a whose lines plan is attached, and which should therefore serve as a good guide for characteristics which are permitted, but not for characteristics which are prohibited. In other words, if Hull 66F22a contains a particular trait, then that the trait is permitted; however, the fact that Hull 66F22a does not embody some other characteristic should not be taken as a statement that the trait in question is prohibited.

For the guidance of anyone designing a boat to this measurement rule, if a trait or feature is contained in Hull 66F22a, or is a direct extension of such a trait, or if the proposed trait is mentioned in this Appendix as being permitted, then that trait is permitted. If the trait is prohibited in this Appendix, or in the body of the rule itself (such as "humps" under the bow of the boat), then that trait is prohibited.

If a proposed trait is neither specifically permitted nor specifically prohibited, then the legality of the trait must be determined. The best keys to resolving that question are:

First: does the proposed trait continue the kind of appearance, performance and handling characteristics of the class as described above? If so, this is an argument for the trait's acceptability.

Second: does the proposed trait exist in any Universal Rule or International Rule boat in the 1920s, 1930s, 1940s, or 1950s? If it does exist, then this is a very strong case for the trait's acceptability.

Any designer should keep in mind, however, that anyone who contemplates building a boat to this measurement rule almost certainly wants a modernized, but still traditional, kind of boat. It is therefore assumed that the owners of these boats will have the authority to rule out any design concept which they collectively feel is contrary to the modernized traditional concept for this class as outlined above, and as defined to some (definitely not all-inclusive) extent in the text of the rule. The designer should be prepared for the potential that a boat which clearly and significantly falls outside of these guidelines will not be permitted to race with the class, regardless of its compliance with the letter of the rule.

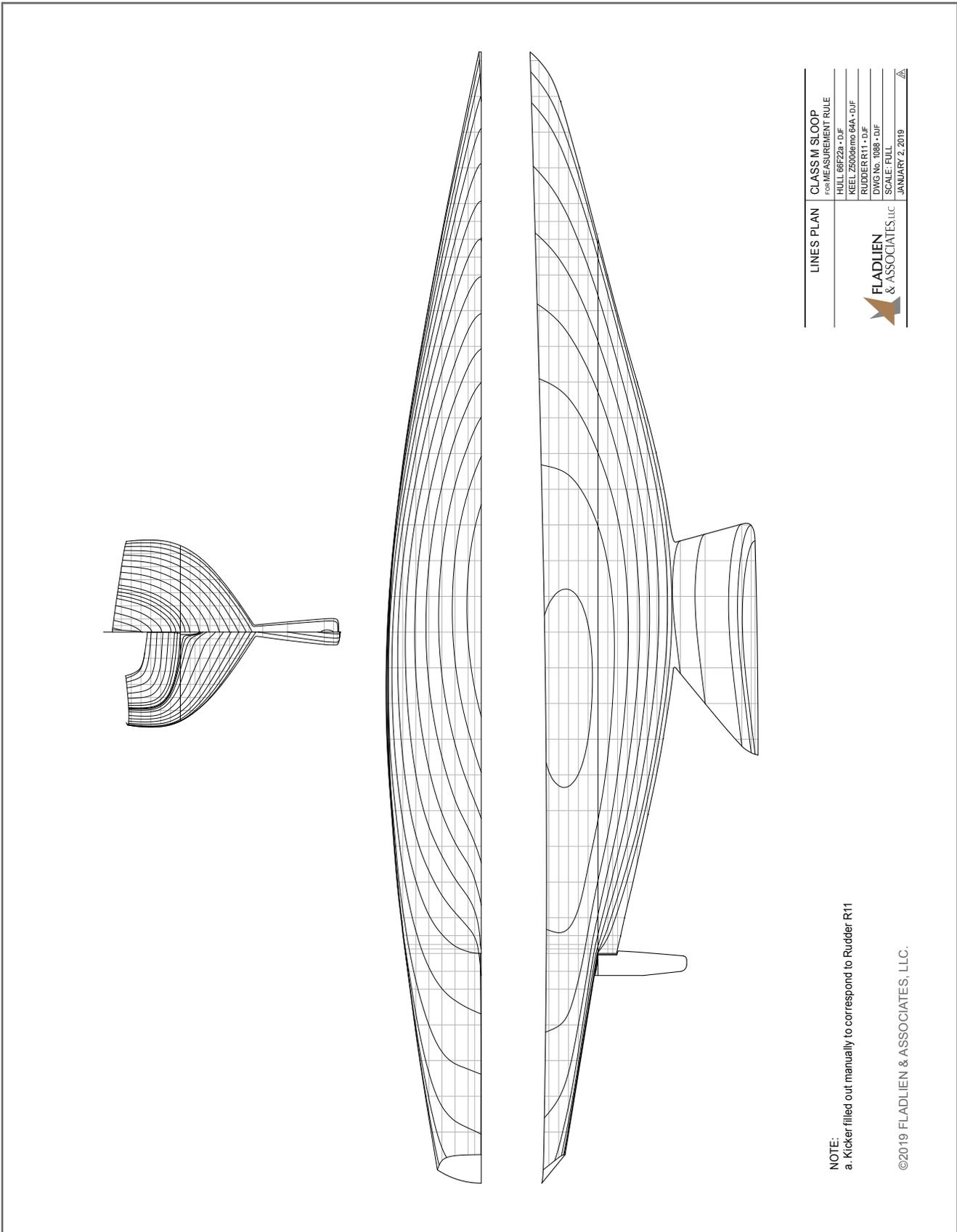
The order of precedence for evaluating legality of concepts is:

First: The text of this rule, including this Appendix, and the text of the Rule Supplement;

Second: Lines Plan of Hull 66F22a, included in this rule, as discussed in this appendix;

Third: Historical precedent as discussed in this appendix.

EXAMPLE LINES PLAN



LINES PLAN	CLASS M SLOOP
	FOR MEASUREMENT RULE
	HULL: 68F228 - DJF
	KEEL: Z5000mmg 64A - DJF
	RUDDER R11 - DJF
	DWG No: 1088 - DJF
	SCALE: FULL
	JANUARY 2, 2019

FLADLIEN & ASSOCIATES, LLC

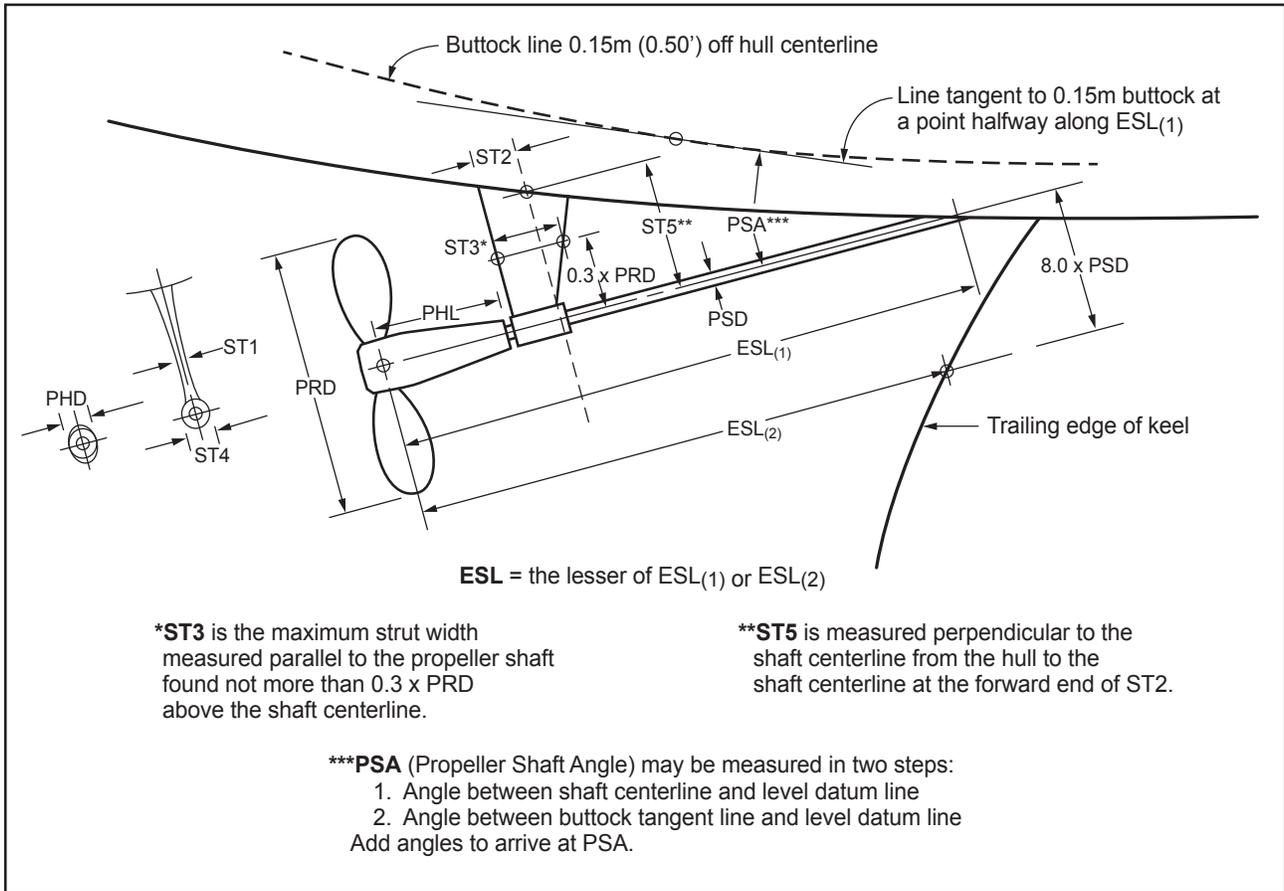
NOTE:
a. Kicker filled out manually to correspond to Rudder R11

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APPENDIX 2

Out of Aperture Propeller Mounts

Calculation of PIPA – Parameters



Calculation of PIPA – Formulas

$$IPA = (0.04 + \sin(\text{PSA}))3 \times (\text{PSD} (\text{ESL} - \text{ST} 2 - \text{PHL}) + \text{ST} 4 (\text{ST} 2 + \text{PHL})) + 0.03 \times \text{ST} 1(\text{ST} 5 - \text{ST} 4/2)$$

$$\text{PIPA} = \text{IPA} + 0.70 \times (0.9 \text{PHD})^2$$

APPENDIX 3

Special Rules for Exterior Decorum

Advertising

Except for a decal or similar emblem which may be placed on the boat during a specific regatta for a sponsor of that regatta, no advertising symbols may be displayed on the sides or transom of the boat, nor on the underbody, appendages or sails. Where a sponsor's mark of the kind permitted herein is displayed, it will have only one such mark on each side of the boat. Sponsors advertising in this manner must be sponsors of the entire event, or of the entire M-Class in that event, and not just of a particular boat or boats or team.

Advertising which complies with the requirements of the previous paragraph must further contain only words and/or logo clearly identifying the sponsor and/or his/her product. In no case shall there be any advertising containing any image which a reasonable person would deem lewd or marginal or debatable in that regard.

Sails may contain the standard maker's mark, of standard size, in the vicinity of the tack of the sail, or the clew if the sail is a symmetrical spinnaker.

Winches, spars, and fittings may contain standard manufacturer's marks of the standard size.

The designer(s) of the boat, and the builder(s) of the boat may place or cause to be placed an identifying plaque or engraving in a prominent place on a bulkhead below deck. As above, these marks or plaques are to be artful, or simple text, and serve only the purpose of identifying the designer(s) or builder(s), and shall not be done in a manner which a reasonable person would deem to be advertising.

Symbols on Hull or Transom

In principle, there should not be symbols or markings on the hull or the transom other than wording stating the name and (if desired) the home port of the boat. A single small symbol (not larger in any dimension than the boat name) and which has special significance to the owner would be acceptable.

By tradition, a stripe or arrow has long been permitted on the topside a short distance below the sheer line. An additional strip of a color which contrasts with both the side and bottom paint (that is, "boot top") has also been allowed at the connection of the bottom paint to the topside paint. This is particularly helpful when the construction or construction material of the boat dictates a bottom paint color which does not butt well with the desired topside color. These stripes, arrows, and boot tops are permitted providing that they are only large enough to be clearly visible and to accomplish their intended artistic purpose.

Placing of the boat's name on the side of the boat, on the bulwark or just below the deck line, is permitted, providing the name is in lettering not more than 7 in (178 mm) in height.

There are to be no pictures, artist's rendering of people or animals, or any other such displays on the topsides, underbody, appendages or transom of the boat, except that the home port of the boat may be displayed on the transom if the name of the boat is also displayed either on the transom or the side of the boat. In general, the paint on the topsides of the boat should be of one color only. Speckles or light marbling of the color might be permissible if approved by the governing body, but multi-color topsides are not permitted. Subtle color gradients are permitted.

APPENDIX 4

Major Design Parameter Limits List for English Units

MEASUREMENT PARAMETER	DESCRIPTION	LIMIT
LWL	Length of Line of Flotation in Measurement Trim	$(1.08 * R + 3 \text{ ft}) \leq \text{LWL} \leq (1.08 * R + 5 \text{ ft})$
QBL	Quarter Beam Length	Penalty if $> \frac{100 - \sqrt{\text{LWL}}}{100} * \text{LWL} + 4.00 \text{ ft}$
Forward end QBL	Forward end of QBL	Not to be taken as further aft than $0.117 * \text{LWL}$
BWL	Maximum Beam along LWL	See limit on B just below
B	Equal to BWL as defined just above	$13.25 \text{ ft} \leq B \leq 13.73 \text{ ft}$
FWD	Breadth at +0.400 ft WL at fwd end LWL	Penalty if $> (0.04 * \text{LWL})$
AFT	Breadth at +0.400 ft WL at aft end LWL	Penalty if $> (0.125 * \text{LWL})$
AFT ₂	Breadth at +2.417 ft WL at AFT ₂ station	Penalty if $> \text{AFT}_{\text{max}}$
DISP	Displacement in measurement trim	Penalty if $< (0.2 * \text{LWL} + 0.5 \text{ ft})^3$
Draft	Maximum draft of boat including keel	Penalty if $> 0.16 * \text{LWL} + 3.50 \text{ ft}$
F _{min}	Minimum Freeboard	Penalty if $<$ limits in (20), (21), or (22)
HDO	Hull Depth Offset	Penalty if $> 0.125 \text{ ft}$
Stem angle	Angle of stem to LWL at line of flotation	Penalty if < 12.80 degrees
Counter angle	Angle of counter to LWL at line of flotation	Penalty if < 8.10 degrees
Tumble home	Amount per side by which deck is narrower than maximum beam at that fore/aft location	Penalty if $> 0.32 \text{ ft}$
Rig height	Height of upper P band above deck at side of boat opposite mast	Maximum allowed = $1.90 \sqrt{S} + 5.0 \text{ ft}$
Mainsail max girth	Maximum dimension perpendicular to luff of sail at height = $0.65 * P$	Maximum allowed = $0.52 * E$
Headboard length	Length of headboard at longest point	Maximum allowed = 1.40 ft
Max height of fore triangle	Maximum height of halyard sheave intersection above sheer line	Maximum allowed = 85.25 ft
Max height of spinnaker halyard	Maximum height of spinnaker halyard above top of I dimension	Maximum allowed = 0.5 ft
Max length of spinnaker pole	Maximum length of spinnaker pole from inboard end to bearing point of afterguy	Maximum allowed = $1.10 * J$
Min weight of mast	Minimum weight of mast in specified condition	Minimum = 1100 lbs
Max mast motion	Maximum fore/aft motion of mast at deck	Maximum allowed = 0.333 ft
Max boom width	Maximum width of boom at any location	Maximum allowed = 2.50 ft

Max boom depth	Maximum depth of boom at any location	Maximum allowed = 1.375 ft
Rudder aft of LWL	Maximum distance leading edge of rudder or post can be aft of aft end of LWL	Maximum allowed = 0.125 ft
Rudder depth	Maximum depth of rudder below LWL	Maximum allowed = $0.6 * H_{max}$
Maximum keel taper ratio	Maximum ratio of keel tip chord/keel root chord	Maximum allowed = 2.0
Centerboard / Daggerboard Maximum depth	Maximum draft of a boat below LWL with a centerboard or daggerboard fully extended	Maximum allowed = $1.40 * H_{max}$ with centerboard or daggerboard not extended
Centerboard / Daggerboard maximum area	Maximum exposed area of a centerboard or daggerboard with that board fully extended	Maximum allowed = $0.42 * LWL$ (area in ft ²)
Maximum weight of keel material	Heaviest material from which a keel may be made	Maximum allowed = 708 lbs/ft ³
Maximum chord length of trim tabs	Longest horizontal dimension of a trim tab as a function of the length of the keel itself at that vertical height	Maximum allowed = 20% of corresponding keel chord length at that vertical height below LWL
Maximum weight of trim tab material	Heaviest material from which a trim tab may be made	Maximum allowed = 708 lbs/ft ³
Maximum weight of winglets	Heaviest material from which a winglet may be made	Maximum allowed = 518.2 lbs/ft ³
Maximum thickness coefficient of winglets	Maximum ratio of winglet thickness to winglet chord length at the corresponding distance from the keel centerline	Maximum allowed = 15% of chord length
Minimum weight of rudder post	Minimum weight of rudder post for rudder mounted near aft end of LWL	Minimum allowed = 100 lbs
PIPA	Minimum value per Appendix 2	Minimum allowed = 0.0117

APPENDIX 5

Major Design Parameter Limits List for Metric Units

MEASUREMENT PARAMETER	DESCRIPTION	LIMIT
LWL	Length of Line of Flotation in Measurement Trim	$(1.08 * R + 0.914 \text{ m}) \leq \text{LWL} \leq (1.08 * R + 1.524 \text{ m})$
QBL	Quarter Beam Length	Penalty if $> \frac{100 - \sqrt{\frac{\text{LWL}}{0.3048}}}{100} * \text{LWL} + 1.219 \text{ m}$
Forward end QBL	Forward end of QBL	Not to be taken as further aft than $0.117 * \text{LWL}$
BWL	Maximum beam along LWL	See limit on B just below
B	Equal to BWL as defined just above	$4.038 \text{ m} \leq B \leq 4.185 \text{ m}$
FWD	Breadth at +122 mm WL at fwd end LWL	Penalty if $> (0.04 * \text{LWL})$
AFT	Breadth at +122 mm WL at aft end LWL	Penalty if $> (0.125 * \text{LWL})$
AFT ₂	Breadth at +737 mm WL at AFT ₂ station	Penalty if $> \text{AFT}_{\text{max}}$
DISP	Displacement in measurement trim	Penalty if $< (0.2 * \text{LWL} + 0.1524 \text{ m})^3$
Draft	Maximum draft of boat including keel	Penalty if $> 0.16 * \text{LWL} + 1.067 \text{ m}$
F _{min}	Minimum Freeboard	Penalty if $<$ limits in (20), (21), or (22)
HDO	Hull Depth Offset	Penalty if $> 38 \text{ mm}$
Stem angle	Angle of stem to LWL at line of flotation	Penalty if < 12.80 degrees
Counter angle	Angle of counter to LWL at line of flotation	Penalty if < 8.10 degrees
Tumble home	Amount per side by which deck is narrower than maximum beam at that fore/aft location	Penalty if $> 98 \text{ mm}$
Rig height	Height of upper P band above deck at side of boat opposite mast	Maximum allowed = $1.90 \sqrt{S} + 1.524 \text{ m}$
Mainsail max girth	Maximum dimension perpendicular to luff of sail at height = $0.65 * P$	Maximum allowed = $0.52 * E$
Headboard length	Length of headboard at longest point	Maximum allowed = 427 mm
Maximum height of fore triangle	Maximum height of halyard sheave intersection above sheer line	Maximum allowed = 25.984 m
Max height of spinnaker halyard	Max height of spinnaker halyard above top of I dimension	Maximum allowed = 152 mm
Max length of spinnaker pole	Maximum length of spinnaker pole from inboard end to bearing point of afterguy	Maximum allowed = $1.10 * J$
Min weight of mast	Minimum weight of mast in specified condition	Minimum = 499 kg
Max mast motion	Maximum fore/aft motion of mast at deck	Maximum allowed = 102 mm
Max boom width	Maximum width of boom at any location	Maximum allowed = 762 mm

Max boom depth	Maximum depth of boom at any location	Maximum allowed = 419 mm
Rudder aft of LWL	Maximum distance leading edge of rudder or post can be aft of aft end of LWL	Maximum allowed = 38 mm
Rudder depth	Maximum depth of rudder below LWL	Maximum allowed = $0.6 * H_{max}$
Maximum keel taper ratio	Maximum ratio of keel tip chord/keel root chord	Maximum allowed = 2.0
Centerboard / Daggerboard maximum depth	Maximum draft of a boat below LWL with a centerboard or daggerboard fully extended	Maximum allowed = $1.40 * H_{max}$ with centerboard or daggerboard not extended
Centerboard / Daggerboard maximum area	Maximum exposed area of a centerboard or daggerboard with that board fully extended	Maximum allowed = $0.128 * LWL$ (area in m ²)
Maximum weight of keel material	Heaviest material from which a keel may be made	Maximum allowed = 11,341 kg/m ³
Maximum chord length of trim tabs	Longest horizontal dimension of a trim tab as a function of the length of the keel itself at that vertical height	Maximum allowed = 20% of corresponding keel chord length at that vertical height below LWL
Maximum weight of trim tab material	Heaviest material from which a trim tab may be made	Maximum allowed = 11,341 kg/m ³
Maximum weight of winglets	Heaviest material from which a winglet may be made	Maximum allowed = 8301 kg/m ³
Maximum thickness coefficient of winglets	Maximum ratio of winglet thickness to winglet chord length at the corresponding distance from the keel centerline	Maximum allowed = 15% of chord length
Minimum weight of rudder post	Minimum weight of rudder post for rudder mounted near aft end of LWL	Minimum allowed = 45.4 kg
PIPA	Minimum value per Appendix 2	Minimum allowed = 0.0117

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