



Measurement Handbook

*International Sailing Federation (ISAF) Ltd.,
Ariadne House, Town Quay, Southampton, Hampshire
SO14 2AQ, Great Britain*



Class Rule

This manual contains a collection of recommendations, common practices and procedures, excerpts from the ISAF Equipment Rules of Sailing, and official ISAF interpretations of the International Tornado Class Rules.

The format is designed to supplement the class rules, which are referred to only if they require comment.

The handbook will be updated by the ISAF / ITA from time to time as matters arise.

If the information herein conflicts with the current class rules, the rules shall prevail.

In addition to this handbook, a measurer should have a copy of the current class rules, the current measurement form, the ISAF Equipment Rules of Sailing, and the current ISAF Racing Rules of Sailing.

Questions regarding the interpretation of the class rules should be directed to either an ITA Chief Measurer or to the ISAF through the enquirer's national sailing authority.

TOOLS and EQUIPMENT

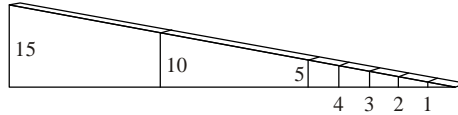
The ISAF EQUIPMENT RULES OF SAILING describes tools required for conducting measurement. Of these, the following are suggested for use when measuring a TORNADO:

1. Steel tape; at least 10 m long. Applicable measurements may be marked on the tape for ease in locating them during measurement.
2. Spirit level; and/or a water tube; to be used for levelling the base line datum.
3. Plum bob; to locate the length (not less than 1m long) stations and measurements on the keel. It is also useful for measuring the angle of the transom.
4. Square; for projecting lines perpendicular to measurement surfaces, 100 mm arms are sufficient.
5. Callipers; vernier for measuring wall thickness and wire diameter. Large inside/outside for measuring beam and mast sections, centreboard thickness, etc.
6. Thread; for forestay strop height, mast tapes and base line measurements.
7. Straight edge; for projecting surfaces. Not more than 200 mm is required.
8. Wedge shims; 24 (and putty) to hold the templates in position on the hulls.
9. Calibrated wedges; for checking tolerance between templates and surfaces.



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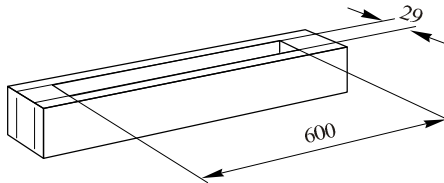


10. Weighing machine; the scale or scales must be accurate from 125 - 150 kg for weighing the boat and 1 - 25 kg for weighing the rigging, rudder, assembly and centreboards. A support must be wide enough to place the assembled hulls on top.
11. Go/no go gauges; for quick checks of some items:

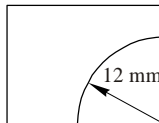
120 mm and 60 mm diameter circles for sail clew boards,

Calibrated battens for sail measurements,

a gauge for checking the centreboard widths may be constructed as follows, and used in place of callipers,



12 mm radius for checking radius at the sheer.



12. Stationery for record keeping; notebooks, ballpoint pens, waterproof marker.
 13. Measurement table; very helpful at major regattas when a large number of boats are to be checked. The table should be of sufficient size (min. 11x3, 2 m) to support a fully laid out gennaker/mainsail, and sufficiently high to promote ease of measurement.
- 5 (a) In a One Design Class unless the rules actually state that something is permitted the Measurer should assume that it is prohibited. "A Measurer should be very cautious in making his own interpretations of the rule if he has a question about a measurement ,,... no deviation or departure from the class rules is permitted."
Measurers should use the procedure outlined in the rules if a question arises that requires a ruling from ISAF.
- ISAF is set up to resolve such enquiries rapidly unless they would require a change in the rules (which usually requires at least a year). Measurers should



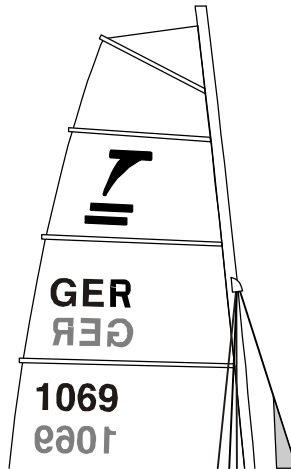
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indicate the relative urgency of the request when submitting the information for resolution.

- 5 (b) Templates cost £345.00 (1999). Allow at least six weeks for delivery. ISAF has a standard measurement procedure for checking templates. The basic dimensions of the templates are shown in the appendix.
- 5 (c) A boat's configuration or equipment may have been changed between measurements and must be re-verified during the re-measurement process to ensure the boat still complies with the rules.
- 6 (b) The following picture is desired as a standard configuration. However all sails which comply with the rule are legal.



- 6 (c) Sailmakers marks:
- Mainsail** - 150 mm x 150 mm maximum dimension and not more than 355 mm from the tack to the furthest point of the mark.
 - Jib** - 150 mm x 150 mm maximum dimension and not more than 300 mm from the tack to the furthest point of the mark.
- 7 Experimental boats shall be identified uniquely by the letter „X“. Numbers shall be issued in sequence by the national authority through the ITA. The „X“ shall either replace or precede the national letters on both the hull and the sail being used. Measurers shall send a copy of the measurement form to ITA so that the performance of these boats may be recorded pending later decisions over whether to make them legal.

The term „open meetings“ refers to events at which more than one nation's participants entered. Events, which are not open meetings, would be governed by that nation's national authority and experimental boats may be allowed to compete.



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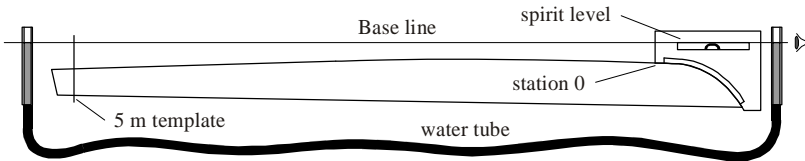


- 8 (a) When applying the templates the hull must be positioned so that the base line is level. Stations are to be located by measurement along the base line and transferring the position to the keel by either a plumb line or spirit level.

For checking measurements at regattas the stations can be located by using a tape along the keel from the „O“ station, which allows location of stations without the extra time required to level the hull. The error is slight. If a tolerance question arises, then the template must be located more accurately and the base line datum levelled.

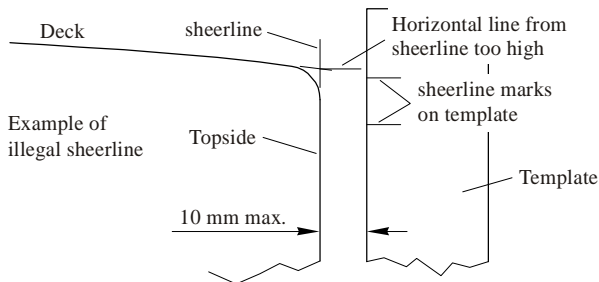
To locate the correct position of the bow template the inscribed base line must be aligned with the 5-metre template base line hole. This requires movement of both templates until the base line is correctly positioned. Only then may the zero station be located, and the sheer at the bow be checked.

Note also that the stem head datum may not necessarily be the forward most portion of the bow.



Either a water tube or a spirit level may be used to level the base line datum.

- 8 (c) If you can sight through all the templates at the same time then the base line is within tolerance.
- 8 (e) The sheerline is located using the standard practice of projecting the line of the deck and outer topside. The deck template is long enough to be used for projecting the deck line and a straight edge may be used on the outer topside. The following diagram illustrates this.

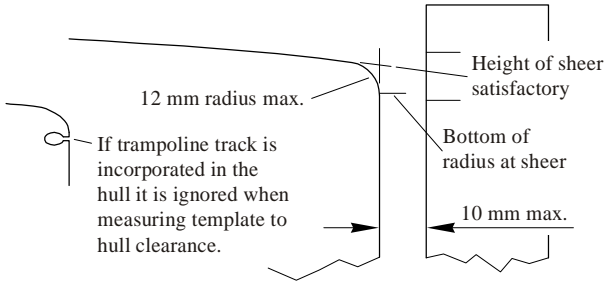


Many boats have a radius on the sheer; 12 mm is the maximum radius allowed. See the following illustration. The 5 mm deck tolerance and the 10 mm hull tolerance do not apply above the bottom of the sheer radius.

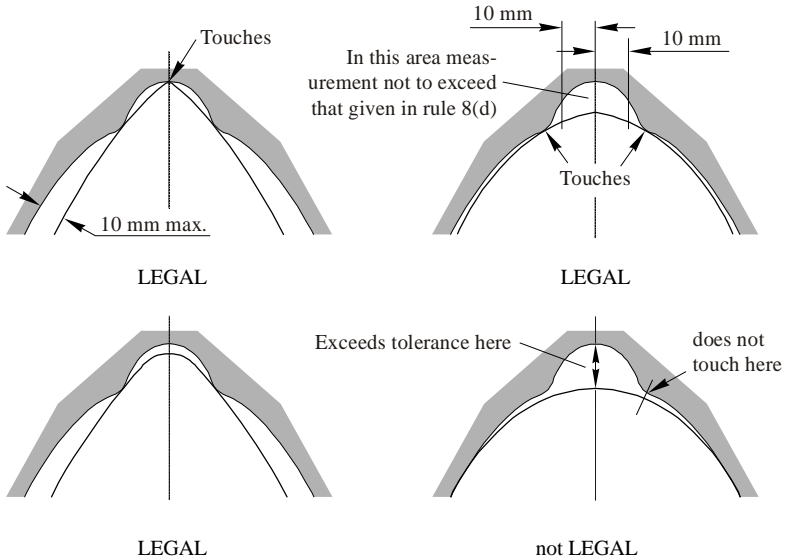


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8 (b & d) The following diagrams depict the limits and measurement points when applying the hull templates.

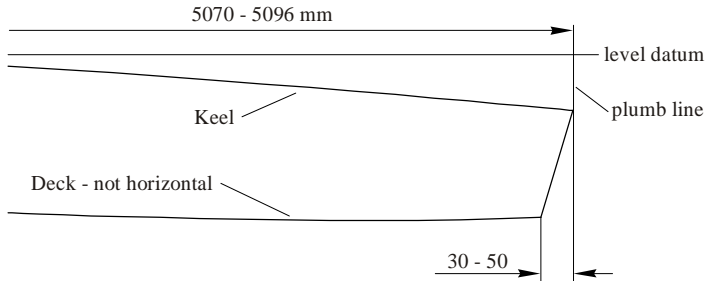


8 (h) The rake of the transom must be measured from a plumb line or vertical spirit level when the hull is set up with the base line datum level. Using a square off the deck or the keel will give an error. See the following illustration (5070-5096, see below).

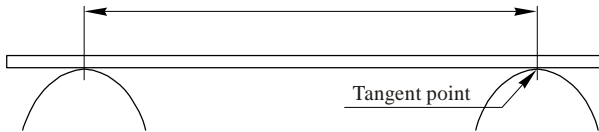


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- 8 (i) Locating the keel centreline is often difficult. Several techniques can be used. Use the one, which gives the most accurate location.
- (a) On glass boats with a mould split line, use the split line if both hulls were made from the same mould.
- (b) Place a straight edge across the hulls and measure to the tangent point.



- 8 (m) The deck contour may be modified only to more easily attach ports and fittings.
- 8 (n) Tests for flotation are in the ISAF Equipment Rules of Sailing, Section VII. This is a builder's requirement but the existence of flotation should be verified by the measurer.
- 8 (o) This applies to items of rigging, including trapeze gear, and to rudder or centreboard controls.
- 9 (a) Tubing in or under trampolines cannot be FIXED to either the beams or the hulls.
- 9 (f) Note that this measurement applies only to the inner sheerline.
- 9 (i) This template has been incorporated in the top edge of the deck template on sets of templates manufactured after January 1979.
- 9 (i) Note that the stem head length datum is not always the forward most portion of the bow, depending on the way the bow template has to be positioned.
- 9 (k) The trailing edge of the tie is not covered by the rule, therefore the trailing edge may not be faired.

Deflection of the main beam, without the mast stepped, has been limited to 15 mm to prevent excessively pre-stressing the beam. Measurement can be taken with the boat assembled as long as the measurer insures that all loads are removed, which would effect the measurement. The boat should not be in trailer cradles or tipped up on one hull, etc. Measurement of the beam prior to installation is the easiest method. In some installations the beam can be

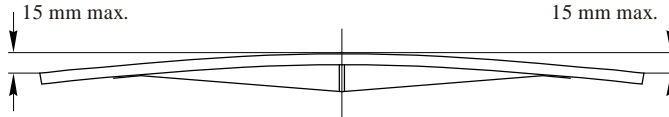


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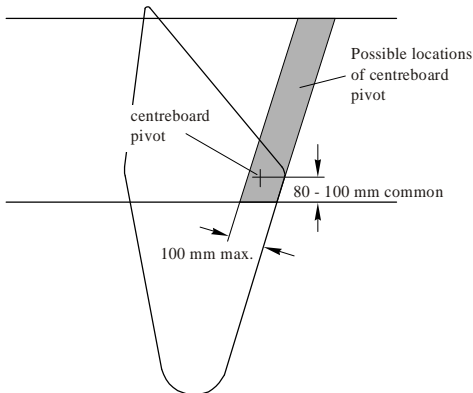


additionally deflected when both beams are tightened into the beam sockets, or the beam itself can be crushed at the attachment point.



Regardless of the method used to take the measurement, 15 mm is the limit. Measurers should ensure that builders use installations, which do not exceed this limit.

- 11 (a) The centreboard pivot point shall be fixed, in such a way that the profile of the board in the fully down position will always be within the template and measurement limits and cannot be moved while racing. It is common practice to have the pivot no higher than 80 - 100 mm above the line of the keel although no specific limit is specified. Note the possible range of pivot locations, all which may not be ruled legal, on the diagram below.



Note: The centreboard pivot is not permitted to move forward and aft. A slot leading down from the deck is permitted to facilitate fitting the centreboard although the pivot must not be lifted while racing.

- 11 (b) Most centreboards are installed from the deck using slots in the trunk. No method to hold boards down in the pivot is required.
- 11 (g) The pivot pin may be free to move along its axis relative to either the hull or the centreboard. It is not considered part of the centreboard for this rule.
- 12 (a) It should be noted that the template forward top edge **MUST** be at the line of the keel.
- 12 (b) Special fittings for holding rudders at an excessive distance off the transom would be illegal.
- 13 (a) The measurer should carefully inspect hulls for hidden weight correctors. The type, weight, and location of correctors should be noted on the certificate. On boats built after 1977 correctors must be removable so that their weight can be verified. Mainsheet blocks are to be removed.



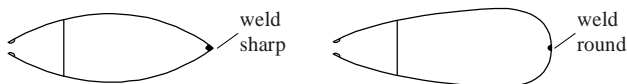
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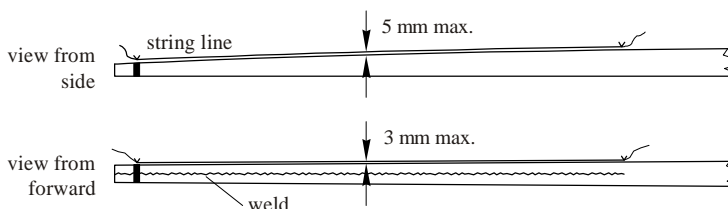


- 14 (a) The measurer shall insure that the mast wall thickness is not less than the minimum and that the dimensions are within the rule. Variations in extrusion runs can often result in sections out of limits especially if they have been designed to the limits permitted by the rules.

- 14 (b) When closing the taper of the mast, the weld may be modified to fair the joint to a smooth curve rather than maintaining a sharp leading edge at the weld.



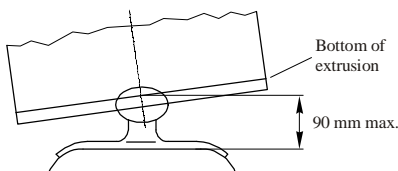
- 14 (c) A hollow shall be measured by stretching a string line along the surface to be checked.



Note: Both sides of the mast have to comply with this rule.

Note that local imperfections due to handling should not necessarily because to rule a mast illegal. The surface at that point may be located by bridging with a flexible rule.

- 14 (g) The painted measurement bands (sail limit marks) should be no less than 15 mm wide so as to be easily visible. Tape is not acceptable.
- 14 (h) Mast rake can often cause the extrusion bottom to not be square with the beam, which can result in a portion of the extrusion bottom above 90 mm limit. Measurement should be taken at the point across from the axis of rotation about the pivot, with the mast centred fore and aft.

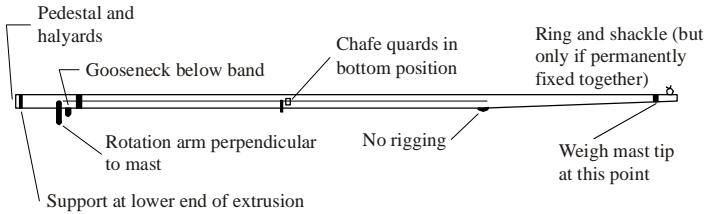


- 14 (i) Excessively large or heavy fittings and large diameter halyards are illegal unless they are used also for racing the boat.

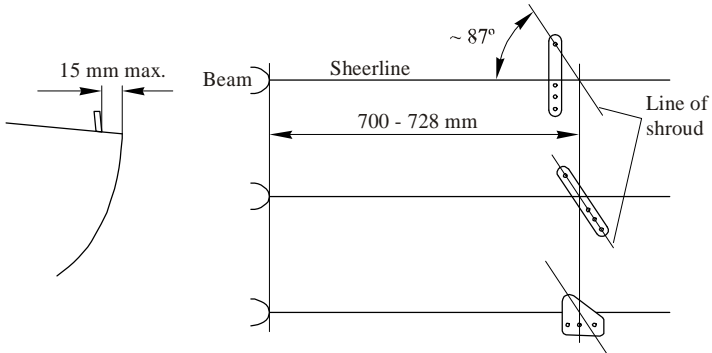


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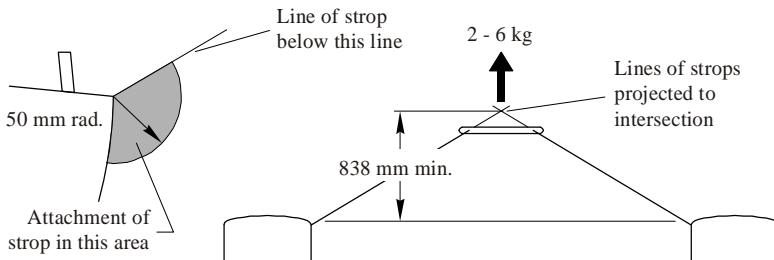
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- 14 (j) Most approved mast sections will meet the total weight minimum without correctors.
- 14 (k) The top must normally have correctors added on newer sections.
- 16 (a) The attachment point and chain plate location shall be measured as follows:



- 16 (c & d) The attachment point for measurement shall be the centreline of the hole in the fittings attached to the hull. If the hole is elongated then the centreline of the pin used to attach the rigging to the fitting shall be used for measurement.



- 16 (g) Fittings shall not be faired to the mast. Fairings shall not be made to cover fittings (except for tape to prevent sail chaffing).
- 17 (a) Sails must be dry. Use a flat surface to lay the sail on. Apply enough tension to remove wrinkles across the line of the measurement being taken.

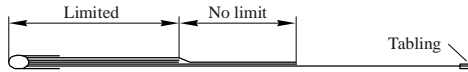


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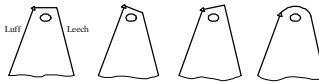


Reinforcement of any fabric having the effect of stiffening the sail is permitted only within a distance from each corner of 595 mm for the mainsail and 440 mm for the headsail. Other reinforcement as a continuation of corner stiffening or elsewhere, comprising not more than two additional layers of material having the same weight as the body of the sail, is permitted provided that the sail can be folded and is not stiffened by the addition of bonding agents, close stitching, or otherwise. Glued seams shall not be considered as stiffening provided that they can be folded as described above. Normal tabling at the edges of the sail is permitted provided that the sail is not stiffened.



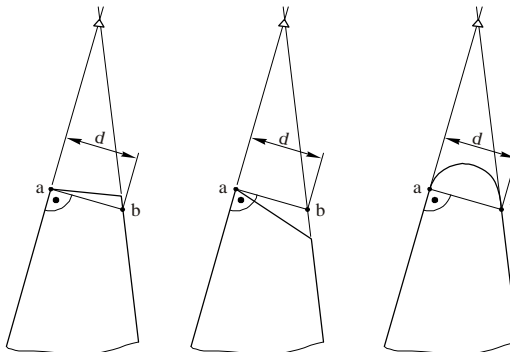
Section through sail reinforcement

- 17 (b) „Openings in the sail, in addition to the normal cringles and reefing eyelets, are permitted provided that the sail is flat in the vicinity of the openings.“
Cunningham holes are permitted.
- 17 (c) Headsail: see also Jib Measurement Form
- 17 (c & i) „The length of the luff shall normally be the distance between the lowest part of the sail on the luff at the tack and the highest point of the sail or luff at the head.“



Examples of measuring point locations when the head is square, slanted or round, and the width of the head does not exceed 50 mm.

- 17 (c & i) Location of measuring point when dimension 'd' is greater than 50mm. Locate points 'a' and 'b' as shown for different shapes of head.
'a' is highest point on luff
'b' is intersection of perpendicular to luff with the leech
'c' is head of sail using 'triangulation method' when 'd' is greater than 50mm
'd' is distance ab.



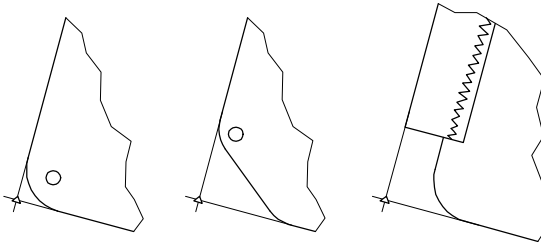


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Examples of tack measuring point locations.



- 17 (c & v) The leech of the headsail shall in no place be convex.
The method of checking this is given in the ISAF Equipment Rules of Sailing and for ease of reference is given below.

Leech Shape

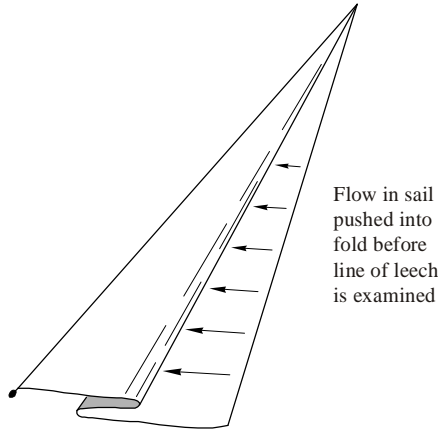
There are many classes, which prohibit convex leeches. In these the Sailmaker will normally cut the leech so that it is straight. However, after the sail has been finished it is usually very difficult to lay the sail out sufficiently flat and free of wrinkles in the area of the leech to check satisfactorily whether the leech is convex or not. The following procedure will help the measurer:

- a) remove the battens;
- b) lay the sail out on a flat surface;
- c) with an assistant holding the head the measurer folds the sail loosely as indicated in the figure;
- d) wrinkles near the leech are worked over into the fold to leave the area of the leech virtually flat;
- e) the line of the leech can then be sighted or a string line used to establish compliance with the rule.

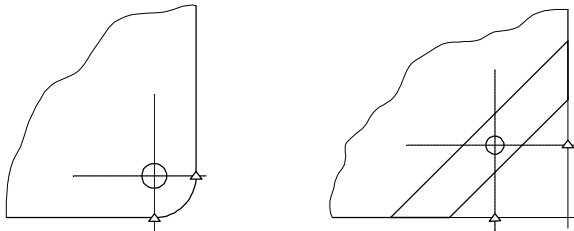


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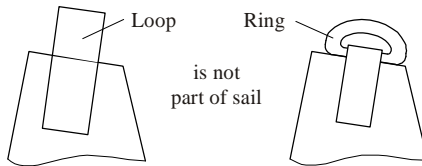
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Headsail Leech Shape



Examples of foot and leech ends locations



'Soft cringles and rings wholly outside of the sail are not to be measured as part of the sail.'

17 (c & vii) Some boats have a jib downhaul system, which leaves the tack free to be pulled below the strop intersection. A device must be fitted to prevent this.

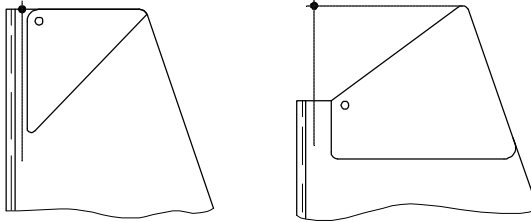
17 (d) Mainsail: the sail shall be dry, see Mainsail Measurement Form

17 (d & i, xi) "The head is located as in the following diagrams."



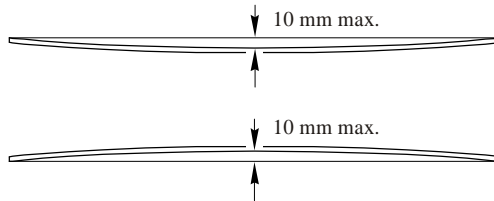
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17 (e) Spinnaker: see Spinnaker Measurement Form

18 The mainsheet track is required to be substantially straight.



19 (g) The forward end of the bowsprit shall be plugged or capped, and blunt to prevent personal injury.

APPENDIX Templates

Dimensions of Tornado Class Templates

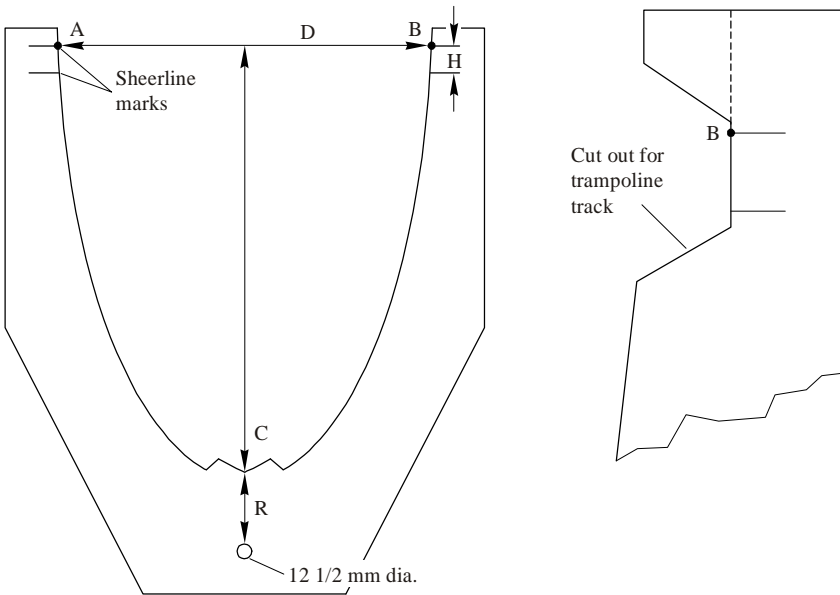
Note: All dimensions are in millimetres

Hull section template



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Template	AB	CD	R	H
0.0	242.5	600	86	15
1	366	615	41.5	15
2	414	594	33.5	15
3.3	446.5	520	65.5	15
4.2	404.5	432	121	15
5	369	324	196	10

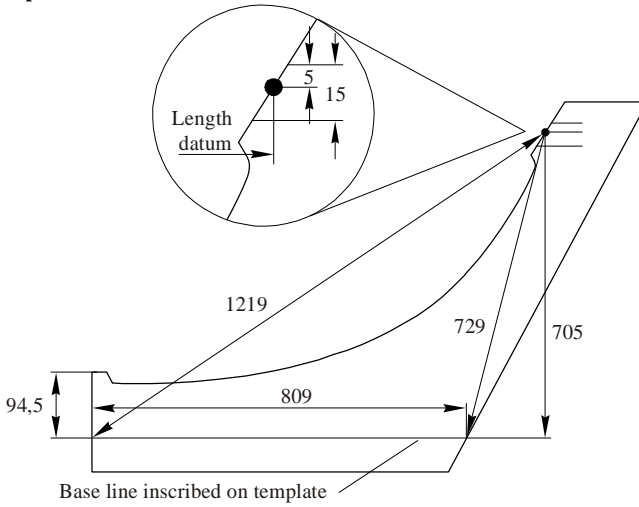


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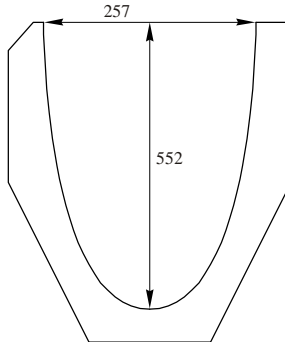
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Stem template



Rudder



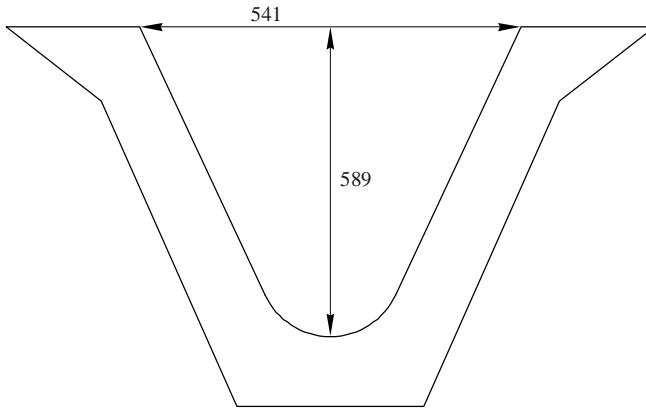


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Centreboard





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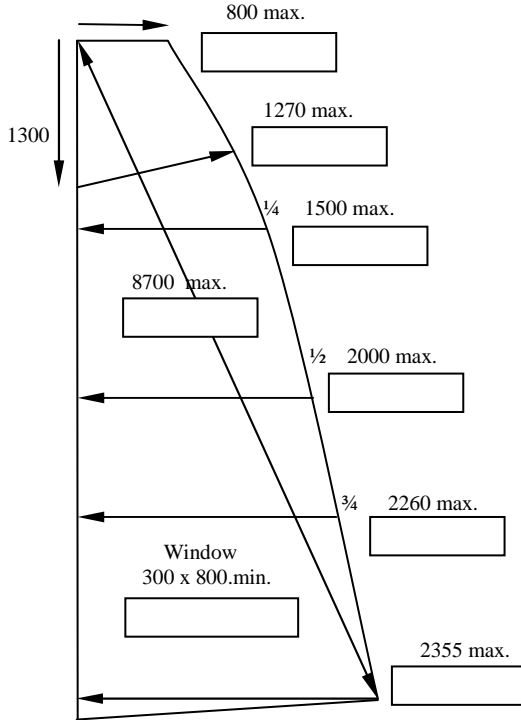
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Mainsail Measurement Form

Sail Number _____

Date _____



Manufacturer

Has Initial Measurement yes/no

Batten protrusion 100 max.

Number of battens 10 max.

Batten width 30 max.

Window from foot 1500 max.

Primary reinforcement 595 max.

Secondary reinforcement 1785 max.

Headboard dia 220 max.

Sailmaker Mark 150 x 150max.



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from tack

355 max.

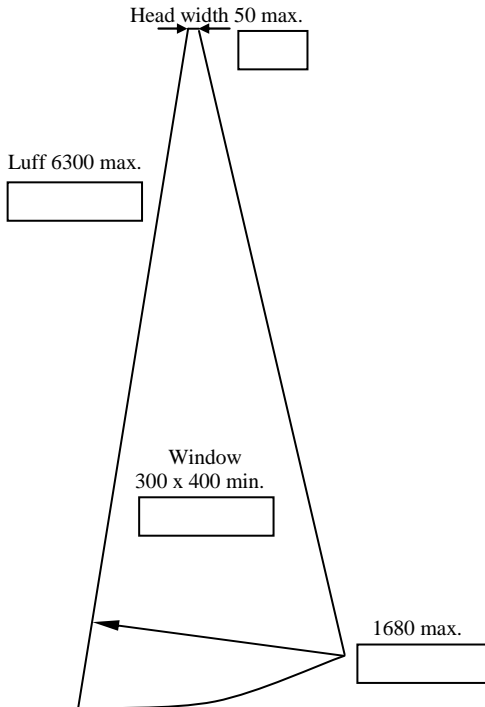
Measured by _____

Comments:

Jib Measurement Form

Sail Number _____

Date _____



Manufacturer

Has Initial Measurement

yes/no

Foot round

80 max.

Number of battens

3 max.

Batten width

20 max.



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Window from foot	1000 max.
Primary reinforcement	440 max.
Secondary reinforcement	1760 max.
Leech	not convex
Sailmaker Mark	150 x 150 max.
from tack	300 max.

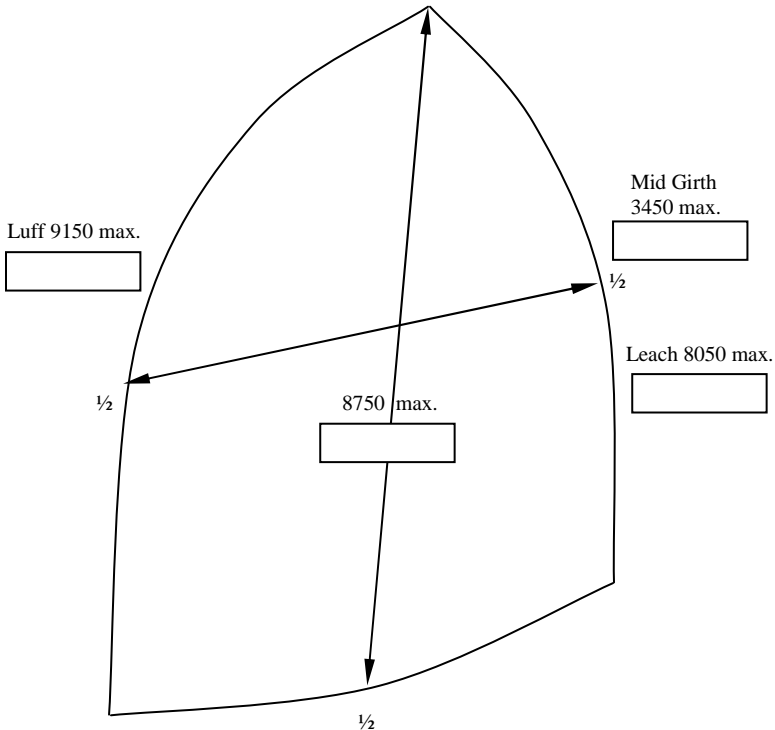
Measured by _____

Comments:

Spinnaker Measurement Form

Sail Number _____

Date _____





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Foot 4250 max.

Manufacturer

Has Initial Measurement

Sailmaker Mark

yes/no

150 x 150 max.

Measured by _____

Comments: