



INTERNATIONAL MONOHULL OPEN CLASS ASSOCIATION

WORLD SAILING INTERNATIONAL CLASS

MEASUREMENT PROTOCOL 2025

[English version]

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| A vertical line to the left of the text indicates changes to 'Measurement protocol 2021 V1.2'.

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CONTENTS:

PREAMBLE	3
GENERAL PRINCIPLES	3
A.1 PROCEDURE	3
A.2 MEASUREMENT EQUIPMENT, MEASUREMENT DATA, CALCULATION SOFTWARE	3
A.3 UNITS OF MEASURE	4
A.4 MEASUREMENT CONDITIONS	4
A.5 CHECKLIST INSPECTIONS	5
A.6 BUOYANCY	5
A.7 MEASUREMENTS ASHORE	6
A.8 MEASUREMENT AFLOAT.....	9
A.9 HULL APPENDAGES	10
A.10 KEEL NDT.....	10
A.11 BEND TEST FOR STANDARDISED ELEMENTS OF AN <i>IMOCA</i>	11
A.12 WEIGHT OF THE STANDARDISED MAST	12
A.13 COMPLIANCE DOCUMENTS OF <i>IMOCA</i> STANDARDISED ITEMS.....	12
A.14 INSPECTION REPORT FOR THE AIS INSTALLATION.....	12
A.15 SELF-RIGHTING TEST	13
A.16 MINIMUM WEIGHT OF THE RADAR	13
A.17 SYSTEM FOR DETECTING THE USE OF THE PROPELLER SHAFT	13
A.18 VALIDATION OF THE FOIL SYSTEM.....	13
A.19 STATIC MOMENT OF THE FOIL.....	13
A.20 DEVELOPED SURFACE AREA OF THE FOIL.....	14
A.21 LENGTH OF THE FOIL IN THE RETRACTED POSITION	14
A.22 Y VALUE OF THE CENTROID OF SECTIONS	14
A.23 DIMENSIONS OF THE FOIL FENCES	14
A.24 DEGREES OF FREEDOM OF THE FOIL	14
A.25 VALIDATION OF IMPACT ON THE FOIL.....	16
A.26 OPERATIONS RELATING TO THE FOIL	16
A.27 METHOD OF MANUFACTURE OF THE FOIL BEAMS	16
A.28 COMMERCIALY PRODUCED SENSORS.....	17
A.29 VOILE VERTE.....	17
A.30 SAIL IDENTIFICATION	17
A.30.1 Operation for a new sail.....	17
A.30.2 Description of the installation	18
A.30.3 Information needed to identify sails	18
A.30.4 Operation for <i>existing sails</i>	18
A.31 STANDARDISED LIFERAFT.....	18
A.32 SPECIFICATION OF THE SMOKE MASK.....	20
A.33 SPECIFICATION OF THE SMOKE MASK.....	20
MEASUREMENT SESSION	20
B.1 MEASUREMENT	20
B.2 MEASUREMENTS ASHORE	20
B.3 MEASUREMENTS AFLOAT.....	22
C.1 COMPUTER CALCULATIONS.....	24
C.2 DOCUMENTS TO BE SUBMITTED TO THE CM.....	24

PREAMBLE

In compliance with the current *IMOCA* Yearbook, this “*measurement protocol*” document comes under the jurisdiction of the *IMOCA* Technical Committee which is responsible for defining the measurement procedures and inspections.

This document is associated with the 2025 *IMOCA* Class Rules V3.1, save for some exceptions. The same abbreviations are used, and with the exception of the titles of appendices and paragraphs, the terms printed in:

- ‘**bold**’ refer to an ERS definition, save for some exceptions,
- ‘*italics*’ refer to a RRS definition,
- ‘*italics*’ and ‘underlined’ refer to a definition specified in the CR and in paragraph A.24 of the *measurement protocol*.

Each measurement, unless modified by the CM, shall be done in compliance with the current ERS prescriptions and/or ISO norms.

Where there is a conflict in the above, the CM will decide which ones apply.

The CM applies the procedures and measurement methods, calculations and inspections of the *measurement protocol* to draw up an *IMOCA* MC.

The skipper is responsible for complying with all the current class rules, no matter which inspections and verifications are conducted.

GENERAL PRINCIPLES

A.1 PROCEDURE

- | A.1.1 The rules in CR A.8 define how measurements and inspections are conducted for boats afloat.
- A.1.2 Paragraphs A.4 and A.5 of the *measurement protocol* apply before starting any measurement operations.
- A.1.3 The presence of the *skipper* or his official representative is compulsory during measurement operations.
If he is unable to attend, the *skipper* must designate his official representative.
- A.1.4 All manœuvres and lifting operations are under the responsibility of the *skipper* or his designated official representative as above.

A.2 MEASUREMENT EQUIPMENT, MEASUREMENT DATA, CALCULATION SOFTWARE

A.2.1 Measurement equipment

The following systems are used:

- [a] Lead line, tape measures, rulers.
- [b] Laser telemeter.
- [c] Digital spirit level, laser level, self-levelling optical level.
- [d] Digital load cells.
- [e] 3D scanning system [photogrammetry, laser tracker, laser scanner].
- [f] Flow meter.

The CM will ask the *IMOCA* Measurer to supply certification for each item of equipment used.

The CM can impose the use of certain measurement equipment, as well as the level of accuracy for each measurement system.

A.2.2 Measurement data

The CM logs all the measurement data in a document called “Fiche d’entrée...” (Data Form).

A.2.3 Official calculation software

The software used for the different computed calculations (stability, righting moment, determining air draught, draught, ...) is the Orca3D software. If necessary the CM can specify the use of an other calculation software.

A.3 UNITS OF MEASURE

A rule in the measurement protocol can change the units of measure listed below.

Linear:	Metres with 3 numbers after the decimal point.
Weight:	Kilogrammes.
Force:	Decanewtons.
Angle:	Degrees with one number after the decimal point.
Volume:	Litres.

A.4 MEASUREMENT CONDITIONS

A.4.1 Measurement trim for measurement operations

The document measurement trim [CR Appendix H] describes the various requirements for measurement trim.

It is available on and can be downloaded from the www.IMOCA.org website.

For measurement operations, the boat shall be in measurement trim and comply with the configuration described in CR Appendix H.

The measurement trim applied during measurement operations is calculated with the hull appendages which must be in place in their “fully down” position, except where their respective positions are:

- specified in a rule
- or specified by the CM.

The CM can specify a modification to these configurations, particularly with regard to the hull appendages which, in this case, will undergo a separate measurement and will be integrated into the digital model provided and used prior to calculation.

Any other equipment missing which is listed in CR Appendix H, and which must be on board in measurement trim, is digitally added to the calculation model.

The same goes for any item of equipment which is not required in measurement trim and which is on board the boat during measurement operations, and whose weight and CG have been recorded beforehand, and which can be digitally subtracted from the calculation model under the authority of the CM.

The CM reserves the right to make changes in line with the overall aim of improving the processes for acquiring data.

Where several proposed or possible measurement methods exist, the CM decides which method to use.

A.4.2 Measurements ashore

Measurements ashore shall be conducted out of the rain and wind. The ideal air temperature is 20 degrees Celsius.

If the air temperature is different, corrections to the values measured may be applied at the CM’s discretion.

A.4.3 Measurements afloat

Measurements taken afloat shall be on still water, with less than 15 mm chop, less than 5 knots of wind, no rain and no current.

If the conditions are different, corrections to the values measured may be applied at the CM’s discretion..

The level of water salinity [SG] is measured during measurement sessions afloat.
The level of salinity used for all digital calculations [draught, air draught, stability, RM, etc ...] is 1.025.

A.5 CHECKLIST INSPECTIONS

A checklist of the CR, in the form of 2 PDF documents is available from the IMOCA secretariat [contact@imoca.org]:

- Measurement Checklist which lists the CR which relate to certain aspects of measurement [deck layout, cockpit, watertight bulkheads, etc ...]
- Safety Checklist which lists the CR which relate to safety equipment.

An IMOCA Measurer will conduct the inspection with the skipper or his official representative and fill in the different parts of the documents, which shall be signed by the skipper or his official representative.

A.6 BUOYANCY

[See CR D.4]

A.6.1 Volume included in the buoyancy calculations

- Fixed elements are included in the combined buoyancy volume, excluding hollow compartments of the following elements of the boat for which the solid parts are counted (including Nomex sandwich and foam):
 - The hull shell, including the transom, the deck including any superstructure (coachroof + fixed protection), the internal structure including cockpit(s) and ballast tanks but without their associated equipment
 - keel
 - rudders
 - foils
 - traction engine + gearbox / 20 L required
 - keel hydraulic equipment / 60 L required
 - the volume of all closed-cell foam which is non-removable, laminated or glued directly to the hull structure or solidly affixed.
These blocks of foam must be protected by casing or appropriate protection that is sufficiently robust to preserve the integrity of the material for its purpose.
- The spars and rigging are not included in the buoyancy volume calculation.
- A hollow compartment (such as an old ballast tank or part of a ballast tank) which is not filled with closed-cell foam does not count towards the buoyancy volume.

Remark concerning recycled ballast tanks:

- For an old ballast tank (or part of a ballast tank) to not count as ballast (volume), it must be sufficiently open [panels clearly removed].
- A hole in the lower section is not a sufficient reason to not count it as a ballast tank.
- Any filling and emptying equipment of an old ballast tank must be entirely removed.
- It is highly recommended that a ballast tank which is no longer in use be entirely filled with closed-cell foam, thereby excluding it from being counted as a ballast tank.
- The CM will not be able to validate these modifications if the above recommendations are not complied with.
- The skipper or his official representative shall contact the CM before undertaking any modification to ballast tanks.

The sum of the various buoyancy elements retained below is called buoyancy volume for the buoyancy calculations.

A form as per the example below is available.

Compliance with CR D.4

Buoyancy Volume	Rule D.4(a)
SANDWICH	
Hull sandwich	
Deck sandwich	
Cockpit protection sandwich	
Internal structure sandwich	
INTERIOR FITTINGS	
Tunnels	
Winch mounts	
Chart table	
...	
...	
Buoyancy foam already in place	
...	
...	
Traction engine + gearbox	
Quantity required	20 litres (required)
KEEL & SYSTEM	
Keel fin	
Bulb	
Canting system	60 litres (required)
<u>Rudders</u>	
<u>Foils</u>	
...	
Total volume to count in m3	

Boat weight (<i>measurement trim</i>)	
Boat displacement (weight / 1.025) in m3	
Buoyancy volume in m3 to be added to obtain (buoyancy/Displacement of boat) > 110 %	
Buoyancy volume total	

A.6.2 Buoyancy calculations

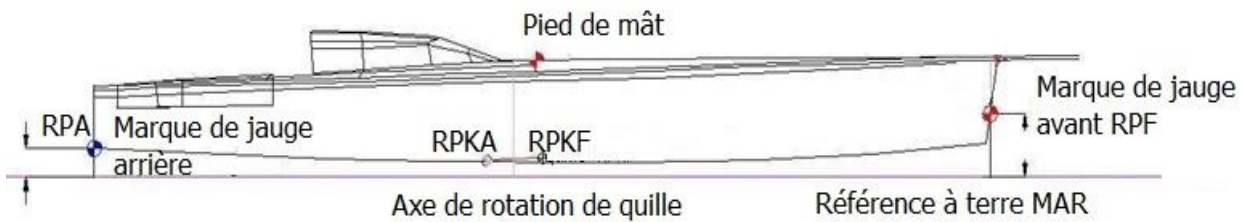
- The boat's displacement in m3 is obtained as follows:
Weight of boat in measurement trim / 1.025
- The ratio of the buoyancy volume to the boat's displacement in *measurement trim* must be equal to or greater than that defined in CR D.4(a).

A.6.3 Longitudinal layout of buoyancy volume

The fixed blocks of buoyancy shall be located around the boat in such a way as to favour buoyancy in the case of damage, enabling the *skipper* to move around inside the boat and to isolate himself in the best possible conditions.

A.7 MEASUREMENTS ASHORE

Drawing showing the marks or points for measurement:
(the dimensions shown are for illustration purposes only)



A.7.1 Forward and aft measurement marks

These marks must be visible (a small hole, a screw or any other permanent means) and allow the freeboard to be measured (distance between the mark and the boat's waterplane).

These marks are made under the authority of the skipper or his official representative and with the CM's agreement:

- [a] RPA, measurement mark at the back of the boat
- [b] RPF, measurement mark at the front of the boat

A.7.2 Hull inspection [overall inspection] in 3D

Preamble: The measurements below are to check the accuracy of the digital model used in Rhinoceros and Orca3D which is the one provided by the skipper or his official representative.

The inspection involves creating a point cloud.

This is done by photogrammetry or laser tracker or laser scanner,

The method used is capable of producing a digital file of points in 3 dimensions [x, y, z] on a scale of one.

This digital file of points is compared to the digital model supplied by mapping the differences.

If necessary, where there are differences between the 3D model using the measurements taken and the digital model supplied, then the latter will be corrected under the authority of the CM.

This method enables:

- validation of the geometry of the hull with its coachroof and cockpit protection if any.

The aim of these operations is to situate the real boat in the boat reference for the various measurements/ inspections required.

A.7.3 Hull length and LOA

[See CR D.2[a]&[b]]

Required when the measurement cannot be obtained from the overall inspection described in A.7.2 of the measurement protocol.

In the case of an overall inspection, the hull length at the very least shall be measured using another method.

A.7.4 Hull beam

[See CR D.2[c]&[d]]

Required when the measurement cannot be obtained from the overall inspection described in A.7.2 of the measurement protocol.

A.7.5 Position of the mast base

[See CR AC.2.2]

Required when the measurement cannot be obtained from the overall inspection described in A.7.2 of the measurement protocol.

A.7.6 Position and longitudinal angle of the keel rotation axis

[See CR E.2(c)]

Required when the measurement cannot be obtained from the overall inspection described in A.7.2 of the measurement protocol.

A.7.7 Parameters relating to the keel

These operations are done with the keel off and laid flat on the ground.

[a] Verify the complete digital 3D model of the assembled keel, using photogrammetry or laser system.

The aim of this inspection is to compare the real keel model to the digital keel model supplied.

- Measure the geometry of the underside of the bulb in relation to the axis of rotation of the bulb.
- Check the bulb shape to determine its volume and check its density.
- In the case of a standardised keel fin, check that the keel fin complies and that there have been no modifications.

[b] Record the weight of the keel fin and the weight of the bulb prior to assembly.

Note the filling of cavities in the bulb, if any.

[c] Determine the weight and CG of the keel:

c.1. Weight of the keel measured from a single point (load cell at the keel head).

c.2. The keel fin and bulb suspended horizontally (trailing edge and pin), with two load cells, one load cell at the keel head (keel ram pin) and one load cell at the bulb.

The horizontal distance between the vertical axes of the load cells is measured.

The centre of gravity of the keel is calculated from these measurements.

A.7.8 Draught

Vertical distance between the waterplane of the boat and the lowest point of the boat in measurement trim.

The draught is determined using the Rhinocéros and Orca 3D software programme based on the digital model validated by the CM for the various calculations required to obtain a measurement certificate.

A.7.9 Air draught

Measure the vertical distance between the boat's waterplane and the highest point of the boat in measurement trim.

Items of equipment at the masthead (wind sensors, VHF and AIS antennas, cameras and other systems validated by the CM, and their mounts) are not included in the air draught measurement.

Air draught is the sum of:

- The length of the mast from the point of contact on the deck, modified by the mast rake (maximum 4.0 degrees), with the fixed forestay in measurement trim,
- the freeboard at the mast base,
- sails and related equipment which protrude above, if relevant (these protrusions are measured on the relevant sails, see paragraph A.7.9(c)).

[a] Freeboard at the mast base

The freeboard at the mast base is ascertained.

[b] Mast length

The mast is issued with a certificate of compliance which states its length.

[c] Geometry of the highest sails.

- Angle of the top section.
- Position of the mainsail headboard at the highest possible point on the mast.
- Measurement of the protrusion in relation to the highest point of the mast (excluding items of equipment at the mast head).

A.7.10 Boat weighing

The Measurer checks that the boat is in measurement trim.

It is the responsibility of the skipper or his official representative to ensure that the boat is in the correct configuration and in particular that all compartments, ballast tanks... etc, are empty.

The only exceptions are the hydraulic system reservoirs and the engine fuel tanks [see CR C.6.1] which shall be in working order and contain the correct quantity of liquid [oil, at least 5 litres of fuel, ...] to function normally.

The weight recorded using one or two load cells is expressed in kgs.

In the case of a boat which is not weighed using a single point, the procedure for weighing using 2 points must be validated by the CM beforehand.

A.7.11 Locating and measuring ballast tanks in the boat

[See B.3.7 of the measurement protocol]

A.7.12 Installing the standardised rig on the boat

- Measure the position of the mast base [see A.7.2 of the measurement protocol].
- Measure the position of the attachment points for the rigging of the standardised mast.

A.7.13 Determining the sheer line

Each transverse half-section of the hull contains a point of the sheer line which is determined using the method described below.

Where it is not possible to determine this point using the method below, the CM will decide which where this point should be.

Method for determining a point on the sheer line:

- Take a transverse half-section from the boat reference.
- From the point situated at the widest part of the half-section, see whether it is possible to draw a tangent at 45 degrees (line denoted using a digital spirit level or equivalent) by moving this line to the highest point of the section.
- The 1st point of tangency found corresponds to the sheer line point to be taken.

The theoretical sheer line must be drawn in the digital model supplied as per Appendix C.2 of the measurement protocol.

A.7.14 Establishing that the curve of the points as per CR D.2 [e] does not show any inversion of the curve.

[See CR D.2[e]]

The curve of the corresponding points must be shown on the digital model of the boat as per Appendix C.2 of the measurement protocol.

A.7.15 Determining fore and aft freeboard as per CR D.2[f]

The freeboard is measured between the boat reference XY plane and the continuous sheer line over a 1 metre section.

The position of the forward freeboard must be measured on transverse sections of the hull, the X values of which are ≥ 17000 mm

The position of the aft freeboard must be measured starting from an initial section of the hull situated at $X \leq 500$ mm.

A.8 MEASUREMENT AFLOAT

With the boat in measurement trim, the measurements and tests to be conducted are:

A.8.1. Measurement of the freeboard at points RPF and RPA, boat at 0 degrees of heel.

A.8.2 Measurement of the density of the sea water [SG].

A.8.3 Mast rake.

A.8.4 Angle between the outrigger and its tie-rod [standardised mast].

A.8.5 90 degrees test:

- freeboard at point RPF,
- load at masthead FDYNA,
- angle of the hull,

- distance deck/load cell LDYNA.

A.8.6 Volume of each ballast tank.

A.8.7 Overhang of spars at the back of the boat.

A.8.8 Engine traction on the load cell (traction from a fixed point) and the boat's speed under engine [5 hours at a minimum of 5 knots].

A.9 HULL APPENDAGES

A.9.1. An inspection must be done to determine the *hull appendages* and all items of equipment, removeable or not, which make up a *keel*, a *rudder*, a *foil*.

A.9.2 Any part of any item of equipment, removeable or not, which makes up a *keel*, a *rudder*, a *foil* must be checked for compliance with each of the associated CR.

A.10 KEEL NDT

A.10.1 NDT for all keels

Preamble:

The keel NDT must be conducted by an expert/ by experts whose expertise is recognised, and the test shall be done using the correct methods and in good faith.

The aim is to highlight surface and density defects as well as any corrosion which could have an impact on the reliability of the keel fin.

A detailed report of the inspections and tests shall be submitted to the CM.

It must be approved and signed by the *skipper* and his official representative.

A.10.1.2 NDT for all keel fins and associated attachment systems

[See CR A.8.3]

The NDT must comply with the defined period of validity.

This inspection/test must be conducted under the sole responsibility of the *skipper* and his official representative and must be able to highlight any defects which could affect the reliability of the keel.

The inspection/tests shall include at least those described below, depending on the type of keel fin, with additional tests/inspections if deemed necessary by the experts concerned [designer/manufacturer/surveyor/*skipper* or his official representative...].

The survey and the methods used for NDTs are evolving, and therefore may employ any other technology which improves on these inspections/tests.

In this case, the specifications for preparing the keel fin for inspection/testing may modify points (a) and (b) of paragraph A.10.1.2 of the *measurement protocol* relating to the preparation of the keel fin for its inspection.

For all keels, the *skipper* or his official representative shall provide the following to the NDT surveyor who will conduct the inspection/ tests; these must be listed in the inspection/ test report:

- Keel manufacturer
- Designers
- Date of manufacture
- Keel material
- Inspection document of the block of steel prior to machining
- Date and report of further tests/ inspections [all]
- Document from the manufacturer/designer on the expected lifespan of the keel
- Declaration from the owner relating to any damage and modifications to the keel
- Drawing of the keel

These documents must be submitted prior to any inspection.

[a] Keel fin as per CR Appendix A-1 or Appendix B-1 and keel fin machined from a block of steel manufactured prior to 2013

For each keel fin, the following must be done as a minimum:

- Removal of the olive fairing
- Both sides of the keel to be accessible

Removal of bulb at each inspection.

Exposing the metal to enable the various NDT tests to be conducted.

Visual inspection, dye penetration, magnetic particle testing, etc... to seek defects such as fatigue cracks and corrosion.

Any other inspections/ tests shall be conducted if deemed necessary by the NDT surveyor and/ or the designer of the keel fin.

Dye penetration inspection/ magnetic particle testing or replacement of the bulb attachment bolts.

[b] Carbon keel fin

[See CR AA.1.8 NDT validity of 2 years]

An expert (or recognised body) must conduct the necessary inspections/ tests and must validate the integrity of the keel after the inspection.

The NDT report must be submitted to the designer of the keel fin, who will submit the validation of the keel fin to IMOCA.

A.11 BEND TEST FOR STANDARDISED ELEMENTS OF AN IMOCA

The bend values measured below are those stated on the relevant certificates of conformity.

A.11.1 Principle of the bend test of standardised keel fins

The test is performed on a bench specifically designed for this test.

The keel fin must be positioned horizontally.

For this, the keel fin sits on its 2 pivots of its axis of rotation and is held in place by the pin at the keel head (keel ram connection).

This configuration is called "fin at rest".

[a] A vertical load of 3000 kg is applied to the end of the keel fin upwards and then the load is removed and the keel fin returns to its at rest position.

[b] A vertical load of 3000 kg is applied to the end of the keel fin downwards.

The amount of bend measured is the amount of bend recorded on the keel fin's certificate of conformity.

The amount of bend of the keel fin must be measured vertically from the zero position which is defined as the "fin at rest" configuration.

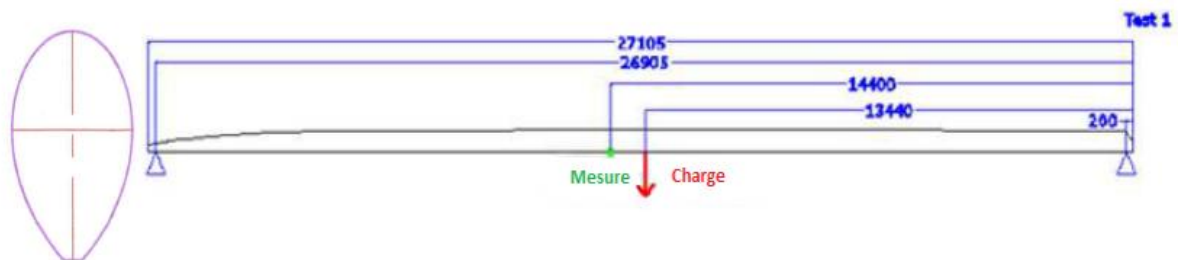
A.11.2 Principle of the bend test for standardised masts (bare tube after removal from the mould)

The bend test on the tube must be done upon removal from the mould.

The mast rests on 2 parts as defined in the drawings below.

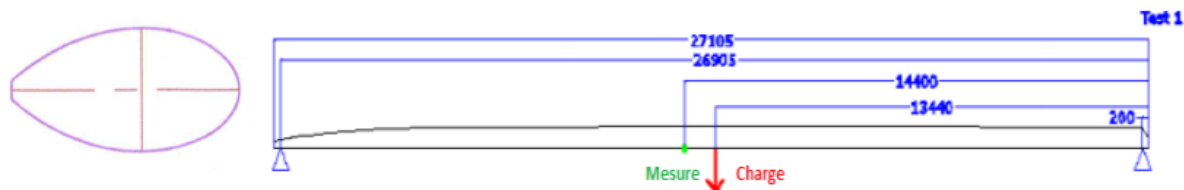
[a] Longitudinal bend test (aft face of the mast under load as per the drawing)

Application of a 500 kg load at 13440 mm from the extremity of the mast base and measurement of the amount of bend at 14400 mm from the extremity of the mast base.



[b] Lateral bend test

Application of a 250 kg load at 13440 mm from the extremity of the mast base and measurement of the amount of bend at 14400 mm from the extremity of the mast base.



A.12 WEIGHT OF THE STANDARDISED MAST

[See CR AC.4]

Conditions for measuring the CG and the weight of the “bare mast”:

The “bare mast” includes all fittings of the rig which can be affixed to the mast tube with screws or glue, such as the reinforcements and all plates screwed on/glued as defined in the specifications for the *standardised mast*, and all the fittings directly relating to the mast tube, such as the pins, sheaves, and just one mast car – the one on which the mainsail headboard is attached.

The “bare mast” does not include items such as navigation lights, wind sensors/ windex, radar [and its mount], any other systems such as camera(s) and the various cables [electrical, vhf, fibre optic...] and any equipment dictated by the CM.

Corrector weights are added to obtain the total weight of the *standardised mast* defined in CR AC.4(c)]

A.13 COMPLIANCE DOCUMENTS OF *IMOCA* STANDARDISED ITEMS

The compliance documents of standardised items summarise the data supplied by the manufacturers of these items.

The aim of these documents is to demonstrate to *IMOCA* that the production specifications have been met.

There are 4 types with the generic names as follows:

- 1 – COMPLIANCE DOCUMENT OF THE STANDARDISED MAST
- 2 – COMPLIANCE DOCUMENT OF THE STANDARDISED KEEL
- 3 – COMPLIANCE DOCUMENT OF THE STANDARDISED CANTING SYSTEM
- 4 – COMPLIANCE DOCUMENT OF THE *STANDARDISED BOOM*

A.14 INSPECTION REPORT FOR THE AIS INSTALLATION

CR C.7.2 specifies that a certificate of conformity of the AIS installation must be submitted to the CM in order to obtain a MC.

The aim of the rule is to check the consistency of the installation of the coaxial cable with the antenna.

- The cable and the antenna must have the same impedance.
- The cable must not have more than 40% power loss.

A calculation sheet to check the AIS installation is available from the *IMOCA* secretariat [contact@imoca.org].

The certificate of conformity dated within less than 1 year, shall contain:

- The name of the entity which checked the installation;
- The type of VHF antenna and its impedance;
- The type of coaxial cable [example LMR400], its impedance and attenuation per metre in dB for a frequency of 156.8 MHz;
- The length of the coaxial cable;
- The connections, if any, [other than the connection to the antenna and to the transponder] and their attenuation in dB;

- The brand and type of AIS transponder and VHF;
- The value of the standing wave ratio (SWR) at 160 Mhz.

A.15 SELF-RIGHTING TEST

For the self-righting test from inversion at 180 degrees, the CG of the boat in *measurement trim* is modified to take into account the requirement of CR D.5.5, therefore without the mast, the outriggers, the rigging and the boom.

The weight and CG of the items of equipment which are not therefore taken into account are then defined.

The boat must come upright by canting the keel to an angle which must be no greater than the maximum angle permitted for the keel, and which enables the stability curve area to be entirely in the positive area [GZ always positive].

A.16 MINIMUM WEIGHT OF THE RADAR

[See CR C.3.14(b)]

A list of radar[s] has been drawn up by the CM and is available from the *IMOCA* secretariat [contact@IMOCA.org].

A.17 SYSTEM FOR DETECTING THE USE OF THE PROPELLER SHAFT

[See CR C.6.1(g)]

A procedure has been drawn up by the CM and is available from the *IMOCA* secretariat [contact@IMOCA.org].

Available in 2023.

A.18 VALIDATION OF THE FOIL SYSTEM

[See CR E.4(l)]

A file containing the drawings, build plans, materials used, etc... and a file relating specifically to the *foil* system shall be presented to the CM, including details on how the first *degree of freedom* can be controlled and measured, as well as the second *degree of freedom* if any.

These files must be validated by the CM as per CR E.4:

- 1) files => pre-validation before starting the build and installation on the boat.
- 2) on the boat => validation.

A.19 STATIC MOMENT OF THE FOIL

[See CR E.4(c)(i)]

The *boat* is positioned in the *boat reference*, in compliance with the current CR, at rest, at zero heel and in *measurement trim* with both *foils* symmetrically retracted as far as possible.

The *foils* are then put in their extended position which provides the maximum static moment, and without changing the position of the boat in the *boat reference*.

The second *degree of freedom* of the *foils*, if any, is taken into account.

For this, the *foils* are then positioned at their minimum and their maximum angle of rotation.

The position which provides the greatest static moment is ascertained.

Only the sections of the *foil* whose Y coordinates are equal to or greater than 2925 mm are taken into account for the rest of the calculation procedure.

The calculation takes into account:

- the same part of the *foil* for each 1 degree step of rotation of the boat between 0 degrees and 25 degrees.

This rotation is around the X axis from one side to the other.

- The projected surface area on the XY plane of the contour of the part of the *foil* whose points have Z values less than or equal to 0.

- the Y value of the centroid of this projected surface area.

The static moment in m³ of each projected surface area is equal to:

- Projected surface area * Y value of its centroid.

The greatest static moment calculated is the one which applies to the *foil*.

A.20 DEVELOPED SURFACE AREA OF THE FOIL

[See CR E.4(c)(iii)]

The whole developed surface area of the concave and convex curves of the *foil's* external skin is counted.

The trailing edge surface area is not included, nor are the surface areas generated by holes or any other artifice, unless the CM considers that these surface areas should be included.

A.21 LENGTH OF THE FOIL IN THE RETRACTED POSITION

[See CR E.4(d)]

The *boat* at rest, with zero heel and in *measurement trim* with both *foils* fully symmetrically retracted.

Both *foils* are inspected, with all their control and trim systems in place, to ensure that they are fully simultaneously and symmetrically retracted to the limit of the boat's median plane.

The distance which separates the *boat reference* XZ plane from the tip of each *foil* which has the greatest Y is measured.

A.22 Y VALUE OF THE CENTROID OF SECTIONS

[See CR E.4(e)]

The *foil* is positioned in the position of maximum static moment and the Y value of the centroid of each section is measured.

A.23 DIMENSIONS OF THE FOIL FENCES

[See CR E.4(f)]

Sample drawing of a 50 mm fence.



A.24 DEGREES OF FREEDOM OF THE FOIL

[See CR E.4(h)&(i)]

Solely the following definitions apply for this procedure:

Leading edge: The forwardmost point of the *section* where the radius of curvature of the surface is the least.

Trailing edge: Aftmost point of the *section*.

Chord: Straight section which joins the leading edge and the trailing edge of a section {See drawing below}.

Section: Surface normal of a foil {Grey part in the drawing below}.



Leading edge

Trailing edge

Foil head: The part of the foil which goes in and out of the hull shell whose sections are constant and which enables axis A1 to be defined.

The foil head is inspected to ensure that it is an extrusion of the following section:

- axis A1 [straight foil head]
or
- a constant radius of curvature about axis A1 [curved foil head].

The first degree of freedom is checked to ensure that it is:

- a translatory motion along axis A1 [straight foil head]
or
- a rotation about axis A1 [curved foil head].

And that this is the case, no matter what the angle of rotation of the second degree of freedom, if it exists.

The second degree of freedom, if it exists, is checked to ensure that it is a rotation of the foil about an axis A2 when the foil is in its fully extended position.

Axis A2 must be a secant with a chord of the foil.

Are checked that:

- axis A2 is perpendicular and is a secant to axis A1 and the foil chord [straight foil head]
or
- axis A2 is perpendicular and is a secant to axis A1 [curved foil head].

The second degree of freedom, if it exists, is checked to ensure that the rotation of the foil is limited to 5.0 degrees.

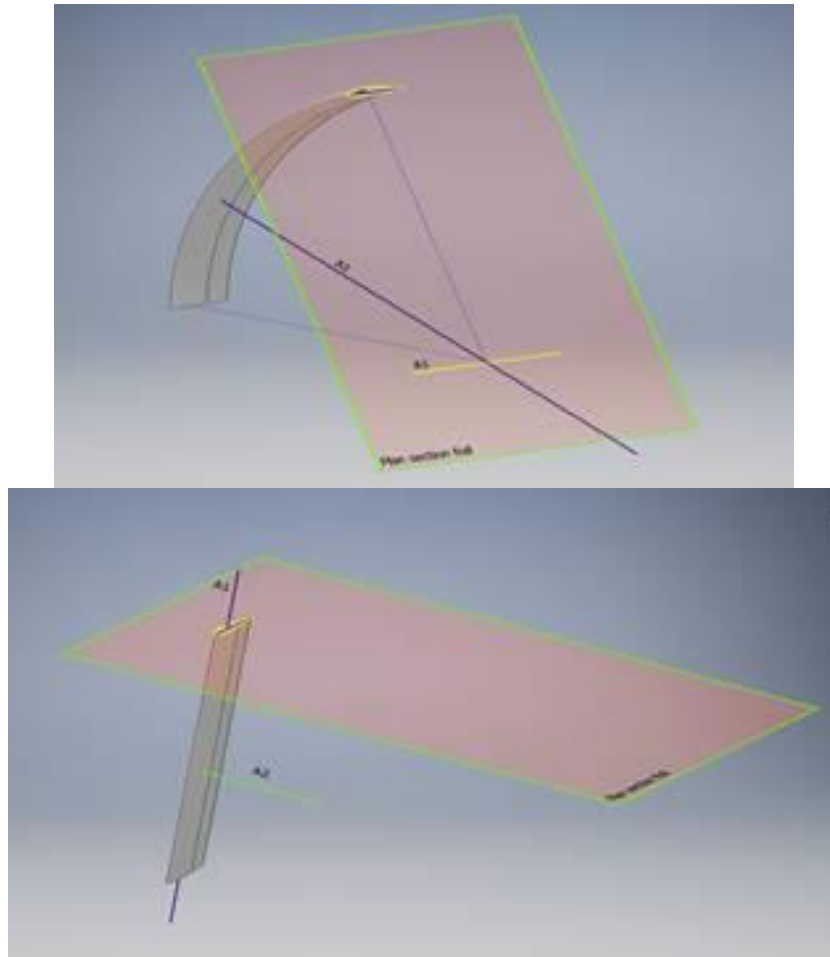
Is also checked that there is an intersection [a point "A"] close to the hull between axis A2 and the foil for all the angles of rotation relating to the second degree of freedom if it exists.

There may more than one Axis A2 in the boat reference.

Axes A2 produced by the second degree of freedom must be secants to point "A".

All of axes A2 must fall within a cone half angle of revolution at the apex of 1.0 degree and where point "A" is the apex

In the case where the second degree of freedom leads to a or some unwanted movements, the CM will decide whether the system provides an advantage to the foil trim and establishes whether or not it complies with the CR.



A.25 VALIDATION OF IMPACT ON THE FOIL

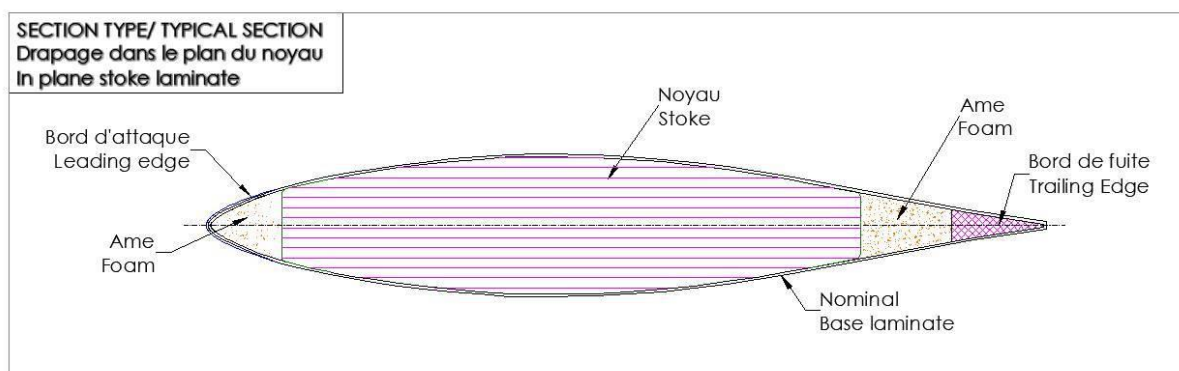
[See CR E.4(k)]

A.26 OPERATIONS RELATING TO THE FOIL

- Comparison of the real *foil* with the 3D digital model [CAD], used in the MAAT Hydro+ software, either by photogrammetry or laser.
- Verification of the weight and the CG of the real *foil*.

A.27 METHOD OF MANUFACTURE OF THE FOIL BEAMS

[See CR AG.2(c)]



The structural core of the *foil* is manufactured [lay-up] as per the principle “parallel to the chord axis”; HM fibres are therefore permitted on the sole condition that these are laid up in strict compliance with the above drawing (parallel to the *foil* chord).

When the structural core of the *foil* is manufactured [lay-up] as per the principle “Perpendicular to the chord axis”, HM fibres are strictly forbidden.

A.28 COMMERCIALY PRODUCED SENSORS

[See CR Section H]

The CM will draw up a list of sensors which comply with the requirements in CR Section H.

A.29 VOILE VERTE

[See RDC AN.3]

Description of the green sail criteria (defined in Appendix N of the RDC). Each candidate sail is submitted to the CM for approval on the basis of an audit carried out via the criteria system.

To become a Green Sail, the sail must obtain a minimum of 3 points from at least 2 different criteria described in the table below.

Only one point line per category will be taken into account, with no bonus awarded for transport by air.

Each sailmaker wishing to have a green sail assessed must have signed the commitment agreement available on request.

Criteria	Point available
Energie	
0% renewable energy	<u>0</u>
25 – 50%	<u>0.5</u>
51 – 75%	<u>1</u>
>75%	<u>2</u>
TRANSPORT from the <u>sourcing</u> until the end of <u>fabrication</u>	
Air	<u>-1</u>
Cargo ship, Train, truck	<u>2</u>
Alternativ transport : soft mobility [by foot, bike] [minimum 1% of the total transport distance]	<u>2 [bonus]</u>
Alternativ transport: sailing cargo ship, sailing ship, electric or hydrogen transport [minimum 10% of the total transport distance]	<u>2 [bonus]</u>
Waste : reduction in the ratio of waste per kilo of sail manufactured (base: 6kg of waste for 1kg of sail)	
<u>4.10 kg</u> of waste for <u>1 kg</u> of sail	<u>1</u>
<u>3.6 kg</u> of waste for <u>1 kg</u> of sail	<u>1.5</u>
<u>3.00 kg</u> of waste for <u>1 kg</u> of sail	<u>2</u>
<u>2.42 kg</u> of waste for <u>1 kg</u> of sail	<u>3</u>
<u>1.85 kg</u> of waste for <u>1 kg</u> of sail	<u>4</u>
<u>1.55 kg</u> of waste for <u>1 kg</u> of sail	<u>5</u>
<u>2.42 kg</u> of waste for <u>1 kg</u> of sail	<u>6</u>

A.30 SAIL IDENTIFICATION

A.30.1 Operation for a new sail

[see RDC AN.1 and AN.2]

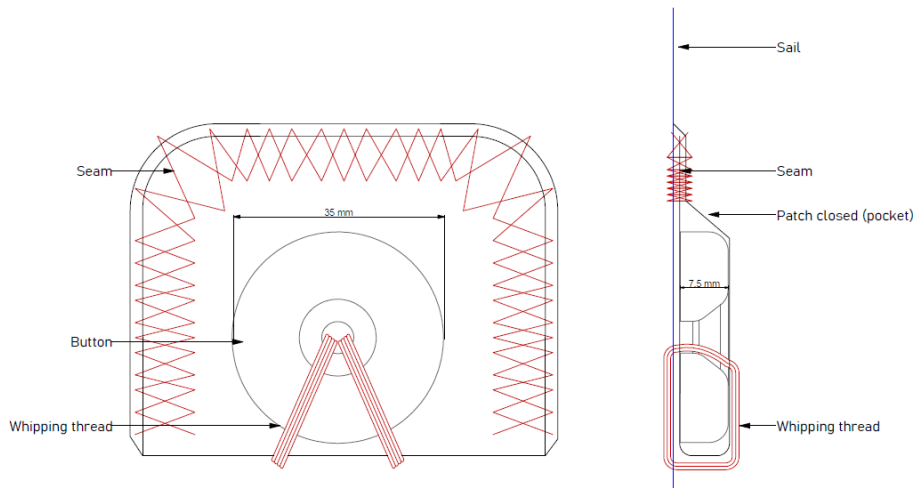
A *button* is a RFID chip provided and encoded by IMOCA. To obtain the *button* for a *new sail*, the team must make a request to the IMOCA Class via the sail button request form available on imoca.org by email at measurers@imoca.org. This request must include a description of the sail

concerned and the manufacturer's contact details. After validation of the allocation of a button for a new sail, the IMOCA will send the matched button(s) to the manufacturer who will fit them.

A.30.2 Description of the installation

The RFID chip is inserted in a closed patch: patch folded in half and sewn on the three open edges. The closed patch is sewn to the sail within 500 mm of the tack and within 150 mm of the foot. The RFID chips will be named and supplied by IMOCA to the sailmakers. The sailmakers must send the serial number of the new sails manufactured to the IMOCA at the following address: measurers@imoca.org.

Diagrams of how to fit the chip and the protective patch:



A.30.3 Information needed to identify sails

In order to check RDC G.1 ; G.2 (a) ; G3 (a) (c) ; AN.1; AN.2, the description sent via the button request form by the team must contain the following information:

Dimensions of: leech; leader; edge; horn and horn angle in case of GV; as well as width at half height in case of headsail.

A.30.4 Operation for existing sails

In order to verify RDC G.4, in order to race, all existing sails must have an IMOCA stamp.

A.31 STANDARDISED LIFERAFT

Description of the contents of standardised liferafts and their associated grabbags in accordance with RDC C.3.4 :

Outside container raft ISO 9650 1 A<24h++

ITEM	Quantity	
	Raft	complémentary Grab bag for the outside liferaft
SURVIVAL RATION 1 PERS 500GR	1 = 0.5 kg	3 = 1.50 kg

SURVIVAL WATER 1L	2 litres	4 litres
LED SIGNAL TORCH IN CASE + BULB & SPARE BATTERY	1	1
HAND FIRE RED DNS	3	3
DNS PARACHUTE ROCKET	2	
ISO LIFERAFT FIRST AID KIT	1	
ANTI-SEASICKNESS GELULES (BOX OF 14)	2	
SEA SICKNESS BAG	4	
SOLAS INSULATING THERMAL BAG	2	
PLASTIC SIGNAL MIRROR	1	
ISO ORANGE WHISTLE	1	
SABOT ECOP	1	
SYNTHET SPONGE. 125X80X40MM	2	
RAINWATER COLLECTOR BAG	1	
FLOATING ANCHOR ISO 900X750	1	
REMOVABLE PADDLES 50CM	1	
FLOATING FOLDING KNIFE	1	
AIS MOB 1 OCEAN SIGNAL	1	
VHF PORTABLE HX890E	1	
CASE + 5 ALKALINE AAA BATTERIES FOR VHF	1	

The grabbag/complement for the external liferaft must be sealed near the emergency exit in the transom.

Inside raft in bag ISO 9650 1 A <24h++

ITEM	raft
SURVIVAL RATION 1 PERS 500GR	1 = 0.5 kg
SURVIVAL WATER 1L	2 litres
LED SIGNAL TORCH IN CASE + BULB & SPARE BATTERY	1
HAND FIRE RED DNS	3
DNS PARACHUTE ROCKET	2
ISO LIFERAFT FIRST AID KIT	1
ANTI-SEASICKNESS GELULES (BOX OF 14)	2
SEA SICKNESS BAG	4
SOLAS INSULATING THERMAL BAG	2
PLASTIC SIGNAL MIRROR	1
ISO ORANGE WHISTLE	1
SABOT ECOP	1
SYNTHET SPONGE. 125X80X40MM	2
RAINWATER COLLECTOR BAG	1
FLOATING ANCHOR ISO 900X750	1
REMOVABLE PADDLES 50CM	1
FLOATING FOLDING KNIFE	1
AIS MOB 1 OCEAN SIGNAL	1
VHF PORTABLE HX890E	1
CASE + 5 ALKALINE AAA BATTERIES FOR VHF	1

A.32 SPECIFICATION OF THE SMOKE MASK

The smoke mask specified in C.3.26 of the RDC must be a full face mask covering the entire head and fitted with an ABEK P3 reference filter or equivalent.

A.33 SPECIFICATION OF THE SMOKE MASK

The means of support and extraction specified in C.3.27 of the RDC must be a vacuum mattress and its pump.

MEASUREMENT SESSION

B.1 MEASUREMENT

Paragraphs B.2 and B.3 of the *measurement protocol* specify, where necessary, the methods and/or measurement operations outlined in the GENERAL PRINCIPLES section of the *measurement protocol*.

These are all the operations which require procedures on the boat and/or on a computer.

B.2 MEASUREMENTS ASHORE

B.2.1 MAR : Measurement ashore reference

The boat must be positioned for measurement ashore in such a way that the DWL drawn in the digital model supplied is horizontal and especially for the procedures described in paragraphs A.7.3, A.7.4, A.7.5, A.7.6, A.7.13, A.7.14 of the *measurement protocol*.

Some of these measurement procedures are not necessary if they are conducted during the overall inspection described in A.7.2 of the *measurement protocol*.

The Measurer can require a modification of the MAR plan if he deems the true trim of the boat afloat to be too different.

B.2.2 Overall inspection of the hull

[See A.7.2 of the *measurement protocol*]

For this operation, the *skipper* or his official representative must schedule an entire day of access to the boat hull.

No other operation or access to the boat will be possible.

The mast base must be in place on the deck.

The keel bearings must be in place in the hull.

In order for the entire hull to be accessible to be able to carry out photogrammetry and laser operations, you are requested to scrupulously comply with the points below:

- No protection on the boat (deck totally clear with deck fittings in place).
- Boat totally clear of any items relating to the build (scaffolding, etc...).
- A minimum of 4 metres clear space around the boat.
- Possibility to lift the hull to be able to measure the underside of the hull and the keel axis.

The *skipper* or his official representative must provide a safe, stable mobile scaffold platform to be able to undertake photogrammetry or to position the laser scanner.

The height must be sufficient to have a clear view of the deck from [3 metres minimum above the deck], the same for beneath the hull.

B.2.3 Position of the keel rotation axis

See drawing A.7 of the *measurement protocol*.

In the case where an overall measurement cannot be done as per A.7.6 of the *measurement protocol*, the longitudinal positions of the 2 following points must be measured:

- RPKF: centre of the forward keel rotation bearing on the keel side.
- RPKA: centre of the aft keel rotation bearing on the keel side.

B.2.4 Weight of the keel fin and bulb and the CG of the keel

B.2.4.1 The keel fin and the bulb must weighed independently from a single point. The configuration with the bulb cavities filled, if any, must be noted.

B.2.4.2 Weighing of the entire keel from a single point.

The skipper or his official representative must provide the appropriate means for lifting the entire keel (faired fin with bulb attached) from a single point in order to weigh it.

B.2.4.3 Weighing of the keel from 2 points.

In order to determine the CG of the keel (faired fin with bulb attached), the skipper or his official representative must provide 2 means to be able to determine the weight at the bulb as well as at the keel ram pin, with the keel horizontal.

For the bulb, the skipper or his official representative must provide lifting slings to hold the bulb. The 2 lifting lines must be vertical, and the distance between the 2 lifting lines must be measured.

The CG of the keel can also be determined using a system of appropriate weighing pads or scales.

B.2.5 Weight and CG of the mast

B.2.5.1 Standardised mast

[See A.12 of the measurement protocol]

Weighing of the bare mast from a single point using the headboard car positioned at the centre of gravity (CG) of the mast in horizontal position.

The static moment of the mast is calculated from the above-measured elements.

B.2.5.2 Weight and CG of the mast and outriggers with the standing and running rigging

[See A.12 of the measurement protocol]

The various parts of the standing rigging are stowed alongside the mast, and the running rigging is positioned where the CM specifies.

The Measurer will check that each item of rigging is present and correctly positioned.

It is recommended that the individual weight and CG of the various items of standing and running rigging be determined.

A precise list of items of equipment is noted and photos taken.

There are 2 measurement methods:

- From a single point with a load cell positioned at the centre of gravity of the mast.
- From 2 points with two load cells, mast suspended horizontally, one load cell at the mast base area and one load cell at the masthead area.

The horizontal distance between the axes of the 2 load cells is measured, as is the distance between the load cell positioned in the mast base area and the mast base.

B.2.6 Weight and CG of the boom

The boom must be entirely equipped (reefs, mainsail sheet, ...).

The weight and CG are measured using either 1 or 2 load cells.

B.2.7 Weight, CG and fully extended position of foils

B.2.7.1 Weight and CG of the foils

Each foil is weighed from a single point to obtain the weight of the foil.

The CG of each foil must be determined using a 3 point weighing method, for which weighing pads are recommended.

A flat and stable area is required to use weighing pads.

The points of contact [in the case of weighing pads] are measured in relation to a reference of the foil.

The method for determining the CG of the foil must be approved by the CM.

B.2.7.2 Displacement of the foil

[See CR E.4(h)]

The aim is to put in place visual reference points.

(a) Positioning of the foil in position 0 with regards to the hull [the foil is fully retracted]

(b) Positioning of the foil in position 1 with regards to the hull [the foil is fully extended]

The displacement of the foil corresponds to a rotation or translatory motion between position 0 and position 1.

The skipper or his official representative must have marked two reference points on the foil in order to visualise these two positions outside the hull.

B.2.7.3 Rotation of the foil [5.0 degrees maximum]

[See CR E.4(i)]

The aim is to validate the installation of the foil bearings and associated systems as defined in the digital model provided and the files described in paragraph A.18 of the measurement protocol.

In the case where the angle of rotation of the foil is greater than 5.0 degrees, mechanical stops must be installed and sealed in place.

B.3 MEASUREMENTS AFLOAT

B.3.1 Water density [SG]

A sample must be taken at approximately 300 mm below the surface.

B.3.2 Weighing of the boat

The skipper or his official representative must supply all the appropriate equipment for lifting the boat. The organisation of all operations relating to lifting the boat are the sole responsibility of the skipper or his official representative.

The boat is lifted from a single point.

The lower attachment of the load cell must be attached to this point. The upper attachment of the load cell must be attached to the crane hook.

In order to avoid any detrimental effects on the proper functioning of the load cell, there must be 2 shackles, one at the upper and one at the lower end of the load cell.

B.3.3 Measurement of freeboard and trim at 0 degrees

The freeboard at the measurement marks RPF and RPA is measured.

B.3.4 Measurement of the maximum angle of the keel

The maximum angle of rotation of the keel must be measured.

The inspection of the travel of the keel ram from one side to the other must be done with the boat trimmed at 0 degrees of heel as the starting point, [keel on the centreplane of the boat].

The length of the ram piston(s) is/ are measured, and the keel is then canted all the way to the mechanical end stop on each side [electrical or electronic end stops should not be taken into account].

The mechanical end stop can be external rings which limit the travel of the ram. These rings must be sealed in place.

B.3.5 Stability tests [90.0 degrees]

The skipper or his official representative must provide and set up the means required to incline the boat to 90.0 degrees.

The keel is on the centreplane of the boat [in the 0 degrees position, the back-up keel ram locked in place], the position of the appendages [daggerboards, foils] must be recorded. Daggerboards are in their up position and foils (if any) in their retracted position, rudders in their “fully down” position.

Foils are positioned symmetrically retracted as far as possible [on the hull centreplane].

It is recommended that the 90.0 degree test be done without the foils in order to determine the CG of the boat in measurement trim without the foils.

In this case, the foils, are added digitally to the digital calculation model.

The boat is inclined to a an angle of heel which is measured.

This angle must be as close as possible to 90.0 degrees, and held in this position by a strop around the mast [as close as possible to the masthead].

All other lines holding the boat [mooring lines, ...] must be totally slack for a long enough period of time to measure the load on the load cell at the masthead [steady reading of the load]. In the case where this is not possible, the required conditions [wind, current, ...] for this test have not been met.

The load at the strop is measured using the load cell and its position in relation to the masthead is measured.

The spreaders, be they mast or deck [outriggers], must not be rendered watertight for the test.

The CM may require the test to be performed for both sides.

B.3.6 Spare

B.3.7 BALLAST TANK INSPECTION

B.3.7.1 Volume

The Measurer checks that the ballast tanks are empty.

Each ballast tank must have an access hatch through which the lowest point of each tank can be reached.

Measurement is done by filling each ballast tank successively, using an accurate flow meter validated by the CM to measure the volume of water put in.

B.3.7.2 Geometry

The Measurer will measure the geometry and position of the ballast tanks with the aim of verifying the digital model provided and especially to determine the CG.

The CM will tell the Measurer which measurements are required depending on the desired ballast tank configurations.

APPENDICES

C.1 COMPUTER CALCULATIONS

For information, the calculations are done using the Rhinoceros and Orca3D software.

C.1.1 Determining the position of the CG of the boat

Boat trim and free heel, measurement trim [to determine the longitudinal CG of the boat [X]]

The trim in the Rhinoceros and Orca3D software is obtained with the PDYNA weight and the aft freeboard measurement from the aft measurement reference point RPA (immersion of the boat).

90.0 degree test [to determine the height of the boat's CG [Z]]

The digital model in the Rhinoceros and Orca3D software is positioned in the 90 degree test configuration.

C.1.2 Correcting the position of the CG of the boat found in paragraph C.1.1 above

For a measurement trim configuration determined by the CM, items of equipment can be added and/or removed to meet the specified measurement trim; these items are added to and/ or removed from the digital model of the boat as decided by the CM.

The characteristics of these items must be known (weight, centre of gravity [CG], volume if under water).

In this case, the boat's CG found in paragraph C.1.1 above is corrected.

Solely the CM can decide to apply this method of correction.

C.1.3 Parameters obtained through Rhinoceros and Orca3D

- [a] draught;
- [b] freeboard at the mast base for the air draught;
- [c] AVS
- [d] Stability curve area ratio (keel centred, ballast tanks empty)
- [e] AVSwc
- [f] RM
- [g] angle of heel (10.0 degrees)
- [h] self-righting test
- [i] Forward and aft freeboard

C.2 DOCUMENTS TO BE SUBMITTED TO THE CM

[See CR Appendix K-4]

Documents to be submitted by the skipper or his official representative for the renewal of a boat's MC (no matter what the date of the boat's first MC):

- The form as per CR Appendix K-4.
- As per CR A.8.3, the keel NDT report.
- As per CR A.8.4, the mast NDT report.
- As per CR A.8.5, the hull NDT report.
- As per CR AA.3.1, the boat NDT report.
- As per CR C.7.2, the certificate of conformity for the AIS installation, stating whether class A or B+ and the calculation sheet described in A.14 of the measurement protocol.
- A drawing showing the volumes of the buoyancy foam installation, along with a table summarising the elements with the characteristics of the closed-cell foam taken into account for the buoyancy volume calculation. [See CR D.4(a)] .

Documents to be submitted by the skipper or his official representative to obtain a first MC or to renew a MC when a document in the list below is modified:

- The complete digital model of the boat [called “MNCB” – ‘modèle numérique complet du bateau’ in Rhino format] with the full rig [all cables in place], working deck, sheer, the ballast tanks and their filling/emptying systems, the keel in the 0° position with its axis of rotation, etc in the boat reference.
- Drawing of the installation of the standardised mast with all the chainplates [digital document specifying the various dimensions of the installation as well as the angles defined in CR Appendix C] as per a 2D digital drawing [can be “MNCB” if it exists as a specific layer].
- The MNCB digital model must be structured into different layers, including one specific to stability calculations.
- 2D/3D drawing of the different watertight bulkheads with their hatches, and which specifies the greatest distance between each bulkhead [can be “MNCB” if it exists as a specific layer].
- The boat’s waterplanes in measurement trim, companionway hatch closed [CR D.9.2], and all the hatch of watertight bulkhead closed at 0 degrees, 90 degrees and 180 degrees of heel, with the position of the escape may be required.
- The boat’s waterplanes in measurement trim, companionway hatch open [CR D.9.2], at 0° with the compartment adjacent to this/these hatch(es) filled to the level of the cockpit coaming, 90 degrees and 180 degrees of heel, with the position of the escape hatch within 500 mm of the back of the boat.
- Drawing showing the bilge pump layout [See CR C.3.2] specifying the types of pumps and their rated capacity.
- Calculation notes demonstrating compliance with CR D.8.2 [c] [Watertight bulkhead hatches].
- Declaration of compliance with CR D.9 [robustness of hatches and emergency exits].
- Drawing of the layout of buoyancy foam volumes, along with a table summarising the elements with the characteristics of the closed-cell foam taken into account for the buoyancy volume calculation [See CR D.4[a)] .
- The document certifying the density of the bulb.
- The technical drawing [2D longitudinal cut] of the bulb with its empty cavities if any. This document contains the weight of the bulb alone, the weight and the different material characteristics of the different parts and attachments required to attach the bulb to the keel fin in accordance with RDC E.3
- Declaration that the bulb has been attached with Inconel bolts 718 H, 17.4 PH or equivalent.
- Document relating to compliance with CR C.6.1:
The brand and type of engine.
The declaration must specify:
 - The installation of a separate start battery plus its capacity, or of an alternative source for starting the engine.

- that CR C.6.1[d] is fully complied with and that the system can be sealed when racing to prevent propulsion of the boat, along with the technical description of the sealing system.
- Purchase invoice for the propeller, showing the brand, type and characteristics of the propeller used.
- Declaration from the supplier of the commercially produced batteries.
- As per CR C.7.2, the certificate of conformity of the AIS installation, and whether it is class A or B+.
- Drawing of the general electrical layout of the boat with a table detailing the different batteries on board and their positions in the boat reference.
- Drawing of the working deck (See CR C.9.1) with the height of cockpit floor (lowest point)/DWL, including the toe rail, stanchions and pulpits.
- In the case of quick-draining cockpits, a calculation note regarding the requirements for cockpit drainage (ISO 11812) must be supplied, as well as the declaration specified in CR D.7.(c).
- Document attesting compliance of the hull materials (See CR D.3). This document includes the list of different materials used with the certificate of compliance for each batch of fibres used.
- Signed certificate of compliance for the standardised mast.
- Signed certificate of compliance for the standardised keel.
- Signed certificate of compliance for the standardised canting system.
- Signed certificate of compliance for the standardised boom.
- The declaration of conformity with CR D.1[d]) issued by the designer of the IMOCA.
- The signed and dated declaration from the builder confirming that the boat has been built in compliance with the drawings checked by the designer of the IMOCA.
- Any additional document if required by the CM.

End of document