INTERNATIONAL MONOHULL OPEN CLASS ASSOCIATION

WORLD SAILING INTERNATIONAL CLASS

2028 Measurement Protocol

(English version)

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CONTENTS

CONTENTS 2
PREAMBLE 5
SECTION A GENERAL PRINCIPLES 5
A.1 HOW IT WORKS 5
A.2 MEASUREMENT EQUIPMENT, MEASUREMENT DATA, CALCULATION SOFTWARE 5
A.2.1 MEASUREMENT EQUIPMENT 5
A.2.2 MEASUREMENT DATA 6
A.2.3 OFFICIAL CALCULATION SOFTWARE 6
A.3 UNITS OF MEASUREMENT 6
A.4 MEASUREMENT CONDITIONS 6
A.4.1 MEASUREMENT TRIM FOR MEASUREMENT OPERATIONS 6
A.4.2 ASHORE MEASUREMENTS 7
A.4.3 AFLOAT MEASUREMENTS 7
A.5 CHECKLIST-BASED INSPECTIONS 7
A.6 BUOYANCY 7
A.6.1 VOLUMES INCLUDED IN THE BUOYANCY CALCULATIONS 7
A.6.2 BUOYANCY CALCULATIONS 9
A.6.3 LONGITUDINAL LAYOUT OF BUOYANCY VOLUME 9
A.7 ASHORE MEASUREMENTS 10
A.7.1 POSITIONING OF THE FORWARD AND AFT MEASUREMENT MARKS 10
A.7.2 CHECKING THE HULL (OVERALL INSPECTION) IN 3D 10
A.7.3 *HULL LENGHT* AND *LOA* 10
A.7.4 HULL BEAM 10
A.7.5 MAST BASE POSITION 10
A.7.6 POSITION AND LONGITUDINAL ANGLE OF THE ROTATION AXIS OF THE KEEL 11
A.7.7 KEEL-RELATED PARAMETERS 11
A.7.8 DRAUGHT 11
A.7.9 AIR DRAUGHT 11
A.7.10 WEIGHING THE BOAT 12
A.7.11 LOCATING AND DIMENSIONING BALLAST TANKS ON THE BOAT 12
A.7.12 FITTING THE STANDARDISED RIGGING ON THE BOAT 12
A.7.13 DETERMINING THE SHEERLINE 12
A.7.14 DETERMINE WHETHER THE CURVE OF POINTS IN ACCORDANCE WITH CR D.2(e) DOES NOT SHOW ANY REVERSAL OF CURVATURE 12
A.7.15 DETERMINE THE FORWARD AND AFT FREeboards IN ACCORDANCE WITH CR D.2(f) 13
A.8 AFLOAT MEASUREMENTS 13
A.9 HULL APPENDAGES 13

A.10 KEEL NDT 13
A.10.1 NDT FOR ALL KEELS 13
A.10.2 NDT FOR ALL KEEL FINS AND THEIR ASSOCIATED FASTENING SYSTEMS 14
A.11 WEIGHT OF THE STANDARDISED MAST 15
A.12 *IMOCA* STANDARDISED COMPONENT COMPLIANCE SHEETS 15
A.13 AIS INSTALLATION INSPECTION REPORT 15
A.14 SELF-RIGHTING 16
A.15 MINIMUM WEIGHT OF THE RADAR 16
A.16 VALIDATION OF THE FOIL SYSTEM 16
A.17 STATIC MOMENT OF THE FOIL 16
A.18 FOIL DEVELOPED AREA 17
A.19 LENGTH OF THE FOIL IN THE RETRACTED POSITION 17
A.20 LENGTH OF THE FOIL IN THE FULLY EXTENDED POSITION 17
A.21 Y-COORDINATE OF THE CENTROID OF THE SECTIONS 17
A.22 DIMENSIONS OF FOIL FENCES 18
A.23 DEGREES OF FREEDOM OF THE FOIL 18
A.24 VALIDATION OF FOIL TOUCHING 19
A.25 FOIL-RELATED ACTIONS 19
A.26 METHOD OF MANUFACTURING FOIL BEAMS 20
A.27 REDUCED IMPACT SAIL 20
A.28 SAIL IDENTIFICATION 20
A.28.1 PROCEDURE FOR A NEW SAIL 20
A.28.2 DESCRIPTION OF THE INSTALLATION 21
A.28.3 INFORMATION REQUIRED FOR THE IDENTIFICATION OF SAILS 21
A.28.4 PROCEDURE FOR *EXISTING SAILS* 21
A.28.5 PROCEDURE FOR *ACTIVE SAILS* 21
A.29 RACE GRADE COEFFICIENTS 22
A.30 *STANDARDISED LIFE RAFT* 22
A.30.1 OUTDOOR CONTAINER RAFT ISO 9650 1A <24H++ 22
A.30.2 INDOOR BAG RAFT ISO 9650 1A <24H++ 23
A.31 SPECIFICATION OF THE SMOKE MASK 23
A.32 IMOCA ECO-SCORE TOOL 23
A.32.1 PREAMBLE 23
A.32.2 MEASURED DATA 24
A.32.3 DATA COLLECTION METHOD 24
A.33 PENALTY ASSOCIATED WITH FAILURE TO REDUCE THE ENVIRONMENTAL IMPACT OF NEW CONSTRUCTIONS 26
A.34 ANCHORAGES 26
A.35 *MEASUREMENT TRIM* CHANGES 26

A.36 REMOVAL OF SAIL-SPECIFIC COMPONENTS AT RACE VILLAGES 26
A.36.1 DEADLINE FOR REQUESTS TO AMEND THE *MEASUREMENT TRIM* 26
A.37 LIST OF DRAWINGS AND DOCUMENTS RELATED TO THE GENERATION 1 STANDARDISED MAST 27
A.38 LIST OF DRAWINGS AND DOCUMENTS RELATED TO THE GENERATION 2 STANDARDISED MAST 27
SECTION B MEASUREMENT SESSION 28
B.1 MEASUREMENT 28
B.2 ASHORE MEASUREMENTS 28
B.2.1 MEASUREMENT ASHORE REFERENCE (MAR) 28
B.2.2 OVERALL INSPECTION OF THE HULL 28
B.2.3 POSITIONING OF THE KEEL ROTATION AXIS 29
B.2.4 WHEIGT OF THE KEEL FIN AND BULB AND CG OF THE KEEL 29
B.2.5 MAST WEIGHT AND CG 29
B.2.6 WEIGHT AND CG OF THE BOOM 30
B.2.7 WEIGHT, CG AND EXTREME POSITIONS OF THE FOILS 31
B.3 AFLOAT MESUREMENT 32
B.3.1 SPECIFIC GRAVITY OF WATER (SG) 32
B.3.2 WEIGHING OF THE BOAT 32
B.3.3 MEASUREMENT OF FREEBOARDS AT 0 DEGREES TRIM 32
B.3.4 MEASUREMENT OF THE MAXIMUM KEEL ANGLE 32
B.3.5 STABILITY TESTS (90.0 DEGREES) 32
B.3.6 RESERVE 33
B.3.7 BALLAST TANK INSPECTION 33
B.3.8 FUEL TANKS VOLUME CONTROL 33
SECTION C APPENDICES 34
C.1 COMPUTATIONAL CALCULATIONS 34
C.1.1 DETERMINING THE POSITION OF THE BOAT’S CG 34
C.1.2 CORRECTING THE BOAT’S CG POSITION 34
C.1.3 ARAMETERS OBTAINED IN RHINOCEROS AND ORCA 3D 34
C.2 DOCUMENTS TO BE SUBMITTED TO THE CM 35
C.2.1 DOCUMENTS TO BE SUBMITTED FOR THE RENEWAL OF THE MC 35
C.2.2 DOCUMENTS TO BE SUBMITTED TO OBTAIN A FIRST MC OR TO RENEW THE MC IN CASE OF MODIFICATION 35

PREAMBLE

In compliance with the current *IMOCA* Yearbook, this document, known as the "*measurement protocol"*, comes under the authority of the *IMOCA* Technical Committee, which is responsible for defining measurement and inspection procedures.

This document is associated with the 2028 *IMOCA* Class Rule V3.0, 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 ;
- "*italics*" refer to a RRS definition ;
- "*italics and bold*" refer to a definition specified in the CR or in paragraph A.23 of the *measurement protocol*.

Each measurement, unless modified by the CM*,* shall be carried out in compliance with the current ERS requirements and/or ISO standards.

In the event of a conflict between these, the CM shall decide which apply.

The CM applies the measurement, calculation and inspection procedures and methodologies of the *measurement protocol* to draw up the *IMOCA* MC.

The *skipper* is responsible for complying with all applicable class rules, regardless of any inspections and validations carried out.

SECTION A GENERAL PRINCIPLES

A.1 HOW IT WORKS

A.1.1 The rule in CR A.8 how measurements and inspections are conducted for boats afloat.

A.1.2 Paragraphs A.4 and A.5 of the *measurement protocol* shall be applied before starting any measurement operation.

A.1.3 The *skipper* or their official representative must be present during measurement procedures.

If the *skipper* is unable to attend, they must designate their official representative.

A.1.4 All manoeuvres and lifting operations are carried out under the responsibility of the *skipper* or their officially designated 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) electronic spirit level, laser level and self-levelling optical level ;

(d) electronic dynamometer, force sensors, load cells ;

(e) 3D scanning systems (photogrammetry, laser tracker, laser scanner) ;

(f) volumetric meter.

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

The CM may specify the measuring equipment and the accuracy class for each measuring system.

A.2.2 MEASUREMENT DATA

The CM logs all measurement data in a database that is accessible to the *skipper* and their representative upon request.

A.2.3 OFFICIAL CALCULATION SOFTWARE

The software used for the different computer calculations (stability, righting moment, determination of air draught, draught, etc.) is the Orca3D software. If necessary, the CM may specify the use of another calculation software.

A.3 UNITS OF MEASUREMENT

A rule in the *measurement protocol* may change the units of measurement listed below.

Linear measurements : millimetre
Weight measurements : kilogram
Force measurements : decanewton
Angle measurements: degree to one decimal place
Volume measurements : litre

A.4 MEASUREMENT CONDITIONS

A.4.1 MEASUREMENT TRIM FOR MEASUREMENT OPERATIONS

A document listing the *measurement trim* (CR APPENDIX H) specifies the different items of the *measurement trim*.

For measurement operations, the boat shall be in *measurement trim* and comply with the configurations defined in CR APPENDIX H.

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

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

The CM may specify a modification to these configurations, particularly with regard to the *hull appendages*, which, in this case, are subject to a specific measurement procedure and are incorporated into the numerical model provided and used prior to calculation.

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

Similarly, any equipment that is not required in the *measurement trim* and which is present on the boat during measurement operations, and whose mass and CG have been verified beforehand, may, under the authority of the CM, be digitally subtracted from the calculation model used.

The CM reserves the right to make changes to these guidelines with a general aim of improving the data collection process.

Where several measurement methods are proposed or available, the CM shall decide which method to use.

A.4.2 ASHORE MEASUREMENTS

Ashore measurements shall be carried out in a location sheltered from rain and wind. The optimum temperature is 20 degrees Celsius.

If the temperature differs, corrections may be made to the measurements at the CM's discretion.

A.4.3 AFLOAT MEASUREMENTS

Afloat measurements shall be carried out in still water, with less than 15 mm of chop, less than 5 knots of wind, no rain and no current.

Corrections may be made to the measurements at the CM's discretion if conditions differ.

The specific gravity (SG) of water is measured during afloat measurements.

The specific gravity used for all numerical calculations (draught, air draught, stability, RM, etc.) is 1.025.

A.5 CHECKLIST-BASED INSPECTIONS

A checklist of the CR, in the form of two PDF documents, is available from the *IMOCA* measurers (measurers@imoca.org) and in the IMOCA "member" area (https://www.imoca.org/en/technical-committee-documents) :

- Measurement Checklist which covers the CR relating to certain aspects of measurement (deck layout, cockpit, watertight bulkheads, etc.) ;
- Security Checklist which covers the CR relating to safety equipment.

An *IMOCA* Measurer will carry out the checks with the *skipper* or their official representative, completing the various items on the documents, which shall be signed by the *skipper* or their official representative.

A.6 BUOYANCY

See CR D.4.

A.6.1 VOLUMES INCLUDED IN THE BUOYANCY CALCULATIONS

The combined volumes of the solid parts of the non-removable components of the following parts of the boat (including Nomex sandwich and foam) are taken into account :

- the **hull** shell, including the *transom*, the deck including any superstructure (roof + fixed coachroof), the internal structure including the cockpit(s) and ballast tanks, but excluding the fittings associated with these components ;
- *keel* ;
- *rudders* ;
- *foils* ;
- propulsion engine + gearbox : flat rate of 20 L ;
- keel hydraulic equipment : flat rate of 60 L ;

- any volume of closed-cell foam, non-removable, laminated or bonded directly to the hull structure or securely fixed – these foam sections must be protected by a cover or suitable protection that is sufficiently strong to preserve the integrity of the material for the required function.

The spars and the entire rigging are not included in the calculation of the buoyancy volume.

A hollow compartment (such as an old ballast tank or part of a ballast tank) that is not filled with closed-cell foam is not included in the buoyancy volumes.

The sum of the various buoyancy elements listed above is referred to as the buoyancy volume for buoyancy calculations.

A template of the form below is provided.

COMPLIANCE WITH CR D.4

BUOYANCY VOLUME	**Rule D.4(a)**
SANDWICH	
Hull sandwich	
Deck sandwich	
Coachroof sandwich	
Internal structure sandwich	
INTERIOR FITTINGS	
Tunnels	
Winch mounts	
Chart table	
…	
…	
BUOYANCY FOAM ALREADY IN PLACE	
…	
…	
TRACTION ENGINE + GEARBOX	
Flat rate	20 litres (flat rate)
KEEL & SYSTEM	
Keel fin	
Bulb	
Canting system	60 litres (flat rate)
Rudders	
Foils	
…	

TOTAL VOLUME TAKEN INTO ACOUNT [m^3]	

BOAT WEIGHT (*MEASUREMENT TRIM*)	
BOAT DISPLACEMENT (WEIGHT/1.025) [m^3]	
BUOYANCY TO BE ADDED TO ACHIEVE (BUOYANCY/BOAT'S DISPLACEMENT) > 110% [m^3]	
BUOYANCY RATIO REPORT	

Remarks concerning recycled ballast tanks :

- In order not to be counted as ballast tank (volume), old ballast tank (or parts of ballast tank) shall be sufficiently open (significant portion of the walls removed) ;
- A hole in the lower part is not sufficient to ensure that the ballast tank volume is not counted ;
- Any equipment used for filling and emptying this old ballast tank shall be completely removed ;
- Completely filling an old ballast tank with closed-cell foam is strongly recommended and ensures that this volume is no longer counted as ballast tank ;
- The CM may not approve these modifications if they do not comply with the above recommendations ;
- The *skipper* or their official representative shall contact the CM before carrying out any ballast tank modifications.

A.6.2 BUOYANCY CALCULATIONS

The displacement of the boat in m^3 is calculated as follows :

Weight of the boat in *measurement trim* / 1.025

The ratio of the buoyancy volume to the boat's displacement in *measurement trim* condition shall be equal to or greater than that specified in CR D.4(a).

A.6.3 LONGITUDINAL LAYOUT OF BUOYANCY VOLUME

Fixed buoyancy volumes shall be distributed throughout the boat in such a way as to ensure buoyancy in the event of damage, enabling the *skipper* to move around inside the boat and seek shelter in the best possible conditions.

A.7 ASHORE MEASUREMENTS

A.7.1 POSITIONING OF THE FORWARD AND AFT MEASUREMENT MARKS

These marks shall be visible (indicated by a small-diameter hole, a screw or any other permanent feature) and shall allow the freeboard (distance between the mark and the boat's waterplane) to be measured.

These marks are affixed under the authority of the ***skipper*** or their official representative and in accordance with the CM :

(a) RPA, measurement mark at the back of the boat ;

(b) RPF, measurement mark at the front of the boat.

A.7.2 CHECKING THE HULL (OVERALL INSPECTION) IN 3D

The purpose of the measurements below is to verify the digital model used in Rhinoceros and Orca 3D, which is the one provided by the ***skipper*** or their official representative.

The verification is carried out using a 3D scanner or photogrammetry.

This digital file is compared, in the form of a map of differences, with the digital model provided.

If necessary, in the event of differences between this 3D model created from the measurements and the supplied digital model, then the latter is corrected under the authority of the CM.

This method allows the geometry of the **hull**, including its roof and any coachroof, to be validated.

The aim of these operations is to position the real boat within the ***boat reference*** for the various controls required.

A.7.3 ***HULL LENGHT*** AND ***LOA***

See CR D.2(a) & D.2(b).

Required when the overall inspection defined in A.7.2 of ***measurement protocol*** does not allow the measurement to be obtained.

In the case of an overall inspection, the ***hull length*** must be verified, as a minimum, using an alternative measurement method.

A.7.4 HULL BEAM

See CR D.2(c) & D.2(d).

Required when the overall inspection defined in A.7.2 of ***measurement protocol*** does not allow the measurement to be obtained.

A.7.5 MAST BASE POSITION

See CR AC.3.2.

Required when the overall inspection defined in A.7.2 of ***measurement protocol*** does not allow the measurement to be obtained.

A.7.6 POSITION AND LONGITUDINAL ANGLE OF THE ROTATION AXIS OF THE KEEL

See CR E.2(c).

Required when the overall inspection defined in A.7.2 of *measurement protocol* does not allow the measurement to be obtained.

A.7.7 KEEL-RELATED PARAMETERS

These operations are carried out with the *keel* lying flat on the ground.

(a) Check the 3D digital model of the assembled *keel* using a 3D scanner or photogrammetry :

1) Measure the geometry of the underside of the bulb relative to the *keel*'s axis of rotation ;

2) Verify the bulb's shape in order to determine its volume and check its density ;

3) Verify the conformity and non-modification of the keel fin for *standardised keel fins*.

The purpose of this inspection is to verify the real *keel* model against the supplied digital *keel* model.

(b) Record the weight of the *keel fin* and the weight of the bulb prior to assembly.

Note the filling of the bulb cavities, if any.

(c) Determine the weight and CG of the *keel* :

1) Weight of the keel measured at 1 point (load cell at the keel head) ;

2) With the keel fin and bulb suspended horizontally (trailing edge and axis), using two load cells – one at the keel head (keel ram axis) and one at the bulb – measure the horizontal distance between the vertical axes of the load cells ;

3) The *keel* fin and bulb are placed on a suitable weighing platform.

A.7.8 DRAUGHT

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

The draught is determined in the Rhinoceros Orca 3D software using the digital model validated by the CM for the various calculations required to obtain the 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*.

Equipment fitted to the masthead (wind sensors, VHF and AIS antennas, cameras and other systems approved by the CM, and their mountings) is not included in the air draught measurement.

The air draught is the sum of :

- the length of the mast measured from the point of support on the deck, modified by the mast rake (maximum 6.0 degrees) with the fixed forestay in *measurement trim* ;
- the freeboard at the mast base.

A.7.9.1 FREEBOARD AT THE MAST BASE

The freeboard at the mast base is determined.

A.7.9.2 MAST LENGHT

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

A.7.9.3 GEOMETRY OF THE HIGHEST SAILS

Angle of the top section.

Position of the mainsail headboard at the highest possible point on the mast.

A.7.10 WEIGHING THE BOAT

The Measurer shall ensure that the boat is in *measurement trim* (CR APPENDIX H).

It is the responsibility of the *skipper* or their official representative to ensure that the boat is indeed in this condition and, in particular, that all compartments, ballast tanks, etc. are empty.

The weight recorded using one or two load cells shall be expressed in kilograms.

A.7.11 LOCATING AND DIMENSIONING BALLAST TANKS ON THE BOAT

See B.3.7 of the *measurement protocol*.

A.7.12 FITTING THE STANDARDISED RIGGING ON THE BOAT

Measure the position of the mast base (see A.7.2 of the *measurement protocol*).

Measure the position of the rigging attachment points on the *standardised mast*.

A.7.13 DETERMINING THE SHEERLINE

Each transverse half-section of the **hull** contains a point on the **sheerline** which is determined in accordance with the method defined below.

If the method described below does not enable this point to be determined, the CM will decide what this point should be.

Method for determining a point on the **sheerline** :

1) Consider a transverse half-section in the *boat reference* ;

2) From the point at the widest part of the half-section, determine whether it is possible to draw a line inclined at 45 degrees (line represented by an electronic level or equivalent) so that it is tangent to the section, by moving this line to the highest point of the section ;

3) The first point of tangency found corresponds to the point on the **sheerline** to be considered.

The theoretical **sheerline** must be provided in the digital model mentioned in C.2 of the *measurement protocol*.

A.7.14 DETERMINE WHETHER THE CURVE OF POINTS IN ACCORDANCE WITH CR D.2(e) DOES NOT SHOW ANY REVERSAL OF CURVATURE

See CR D.2(e).

The curve of the corresponding points shall be specified in the digital model of the boat mentioned in C.2 of the *measurement protocol*.

A.7.15 DETERMINE THE FORWARD AND AFT FREEBOARDS IN ACCORDANCE WITH CR D.2(f)

The freeboard is measured from the *boat reference* XY plane along the continuous **sheerline** over a length of 1 metre.

The position of the forward freeboard shall be measured on **hull** transverse sections where the X-coordinates are ≥ 17 000 mm.

The position of the aft freeboard shall be measured from a first **hull** transverse section where X ≤ 500 mm.

A.8 AFLOAT MEASUREMENTS

With the boat in *measurement trim*, the measurements and tests to be carried out are :

1) Measurement of the specific gravity (SG) of seawater ;

2) Mast rake ;

3) Angle between the outrigger and its tie-rod (*standardised mast*) ;

4) 90-degree test :

- height of the median plane forward and aft ;
- force at the masthead ;
- angle of heel of the hull ;
- distance between the mainsail sheave and the load cell ;

5) Volume of each ballast tank ;

6) Volume of each fuel tank ;

7) Extension of the spars beyond the aft of the boat ;

8) Engine thrust on the dynamometer (thrust at a fixed point) and the boat's speed under engine power (5 hours at a minimum of 5 knots).

A.9 HULL APPENDAGES

A.9.1 An inspection shall be carried out to identify any *hull appendages* and any movable or fixed components that make up a *keel*, *rudder* or *foil*.

A.9.2 A selection shall be made of each of the components, whether movable or not, that make up a *keel*, *rudder* or *foil*, in order to verify compliance with each relevant CR.

A.10 KEEL NDT

A.10.1 NDT FOR ALL KEELS

The keel NDT shall be carried out by an expert or experts with recognised expertise, using appropriate methods and in good faith.

The aim is to identify surface and volumetric defects, as well as any corrosion that may affect the reliability of the keel fin.

A detailed report of the inspections and examinations carried out shall be provided to the CM.

It shall be approved and signed by the *skipper* and their official representative.

A.10.2 NDT FOR ALL KEEL FINS AND THEIR ASSOCIATED FASTENING SYSTEMS

See CR A.8.3.

The CND shall comply with the specified validity period.

This inspection shall be carried out under the full responsibility of the ***skipper*** and their official representative and shall serve to identify any defects that could compromise the reliability of the keel.

The inspections shall include at least those specified below, depending on the type of keel fin, but they shall be supplemented if deemed necessary by the experts involved in these inspections (designer, manufacturer, inspector, ***skipper*** or their official representative, etc.).

As expertise and NDT methods are constantly evolving, any other technology that enhances the effectiveness of these inspections in relation to the objectives sought may be employed.

In this case, the specifications for preparing the keel fin for inspection may amend paragraphs A.10.2.1 and A.10.2.2 of the ***measurement protocol*** concerning the preparation of the keel fin for inspection.

For all ***keels***, the following items must be provided by the ***skipper*** or their official representative to the NDT operator carrying out the inspections; the inspection report shall include these items :

- ***keel*** manufacturer *;*
- designers ;
- date of manufacture ;
- ***keel*** material *;*
- inspection report for the unmachined block prior to machining ;
- dates and reports of further inspections (all) ;
- manufacturer's/designer's document on the expected lifespan of the ***keel*** *;*
- owner's statement regarding damage to and modifications of the ***keel*** *;*
- ***keel*** drawing.

These documents shall be required prior to any inspection.

A.10.2.1 KILL FIN IN ACCORDANCE WITH CR APPENDIX A-1 OR APPENDIX B-1 AND FULL STEEL KEEL FIN MANUFACTURED BEFORE 2013

For each keel fin, the following shall be carried out as a minimum :

- removal of the keel fairing every 4 years ;
- access to both sides of the keel ;
- removal of the bulb every 4 years.

Exposure of the metal to allow the implementation of various NDT inspection procedures.

Visual inspections, dye penetrant testing, magnetic particle testing, etc., to detect defects such as fatigue cracks and corrosion.

Any other inspection shall be carried out when deemed necessary by the NDT inspector and/or the ***keel*** fin designer.

Dye penetrant testing/magnetic particle testing or replacement of the bulb fixing nuts at each inspection.

A.10.2.2 CARBON KEEL FIN

See CR AA-1.8 with a 2-year validity period for the NDT.

An expert (or recognised competent body) shall carry out the necessary inspections and, upon completion of the inspection, shall certify the integrity of the keel.

The NDT report shall be submitted to the keel fin designer, who shall provide *IMOCA* with the keel fin certification.

A.11 WEIGHT OF THE STANDARDISED MAST

See CR AC.5.

Conditions for measuring the position of the CG and the weight of the « bare mast » :

- The « bare mast » comprises all rigging components that can be affixed to the tube by screwing or gluing, such as reinforcements and all screwed and/or glued plates required for the various equipment as defined in the *standardised mast* specifications, and all fittings directly connected to the tube, such as pins, sheaves and a single traveller, the one to which the mainsail headboard is attached ;
- The « bare mast » does not include components such as navigation lights, wind vane/anemometer, radar (and its mount), other systems such as camera(s) and the various cables (electrical, VHF, fibre optic, etc.) and any equipment mentioned by the CM.

Fit the corrective weights to achieve the total mass of the *standardised mast* as defined in CR AC.5(c).

A.12 *IMOCA* STANDARDISED COMPONENT COMPLIANCE SHEETS

The compliance sheets for standardised components summarise the data provided by the manufacturer of these components.

The purpose of these sheets is to ensure, on behalf of *IMOCA*, that the specifications have been complied with.

There are four types, designated by the following generic names :

- STANDARDISED MAST COMPLIANCE SHEET ;
- STANDARDISED KEEL FIN COMPLIANCE SHEET ;
- STANDARDISED CANTING SYSTEM CONFORMITY SHEET ;
- STANDARDISED BOOM CONFORMITY SHEET.

A.13 AIS INSTALLATION INSPECTION REPORT

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

The purpose of the rule is to verify that the coaxial cable is consistently installed with the antenna :

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

A calculation sheet for verifying the AIS installation is available from *IMOCA* Measurers (measurers@imoca.org) and in the *IMOCA* “member” area (https://www.imoca.org/en/technical-committee-documents).

The installation compliance certificate, which must be less than one year old, shall include :

- the name of the body that verified the installation ;
- the type of VHF antenna and its impedance ;
- the type of coaxial cable (e.g. LMR400), its impedance and its attenuation per metre in dB at a frequency of 156,8 MHz ;
- the length of the coaxial cable ;
- the connectors, if any – apart from the connection to the antenna and the transponder – and their attenuation in dB ;
- the brand and type of the AIS transponder and the VHF ;
- a measurement of the standing wave ratio (SWR) at 160 MHz.

A.14 SELF-RIGHTING

For the 180-degree self-righting test, the **boat**'s CG in *measurement trim* is adjusted to take account of CR D.5.4 specification, therefore the **boat** is considered without the mast, outriggers, rigging or boom.

The weight and CG of the equipment not taken into account in this way are defined.

The boat shall right itself by canting the keel through an angle which must not exceed the maximum permitted angle for the keel and which allows the stability curve area to lie entirely within the positive zone (GZ always positive).

A.15 MINIMUM WEIGHT OF THE RADAR

See CR C.3.14(b).

Provide the radar model to the CM.

A.16 VALIDATION OF THE FOIL SYSTEM

See CR E.4(l).

A folder containing sketches, construction drawings, details of materials used, etc., and a specific folder for the *foil* system shall be submitted to the CM, together with details of how the first *degree of freedom* and, where applicable, the second degree of freedom can be controlled and measured.

These folders shall be validated by the CM in accordance with CR E.4 :

1) on the folder → pre-validation prior to construction and installation on the boat ;
2) on the baot → validation.

A.17 STATIC MOMENT OF THE FOIL

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

The *boat* is placed in the *boat reference*, in accordance with the current CR, at rest, with zero heel and in *measurement trim*.

The *foils* are then positioned to produce the maximum static moment across all degrees of freedom.

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

The calculation takes into account :

- the same section of the *foil* for each 1-degree increment of the boat's rotation between 0 and 25 degrees, with this rotation taking place about the X-axis ;
- the area projected onto the XY plane of the outline 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.

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

area of the projected surface * Y-value of its centroid.

The greatest static moment calculated is the one that characterises the *foil*.

A.18 FOIL DEVELOPED AREA

See CR E.4(c)(ii).

The entire developed area of the *foil* corresponding to its envelope is taken into account along the leading and trailing edges of the *foil*.

The area of the trailing edge is not counted, nor are areas generated by holes or other artifices, unless the CM considers that these areas should be counted.

A.19 LENGTH OF THE FOIL IN THE RETRACTED POSITION

See CR E.4(d).

The *boat* is at rest, with no heel, and in *measurement trim*, with both *foils* retracted as far as possible and symmetrically.

It is checked that both *foils*, with all their control and trim systems in position, are retracted fully to the limit of the boat's median plane simultaneously and symmetrically.

The distance between the XZ plane of the *boat's reference* and the point on each *foil* with the greatest Y-coordinate is measured.

A.20 LENGTH OF THE FOIL IN THE FULLY EXTENDED POSITION

A mark, the nature and position of which on the foil's profile have been approved by the CM, must be affixed to the foil at a distance of 50 mm from the hull below the **sheerline** when the foil is in the "fully extended" position.

This mark will be measured precisely during the 3D scan of the foils and will confirm that the foil is not extended beyond the limits permitted by CR E.4(d).

A.21 Y-COORDINATE OF THE CENTROID OF THE SECTIONS

See CR E.4(e).

The *foil* is positioned in the configuration that provides maximum static moment, and the Y-coordinate of the centroid of all sections is controlled.

A.22 DIMENSIONS OF FOIL FENCES

See CR E.4(f).

Indicative sketch of a 50 mm fence.

A.23 DEGREES OF FREEDOM OF THE FOIL

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

The following definitions, which apply only to this procedure, are used specifically :

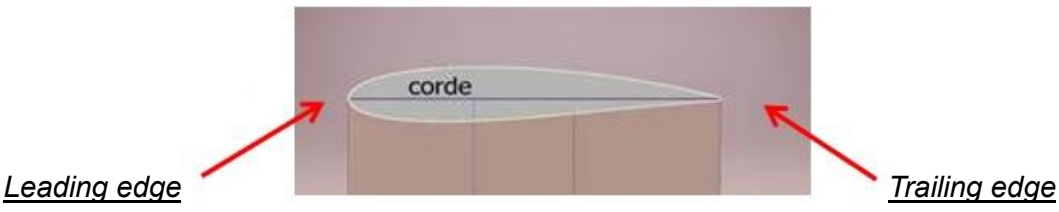
Leading edge : The forwardmost point of the *section* where the radius of curvature of the surface is minimal.

Trailing edge : The aftmost point of the *section*.

Chord : Line segment connecting the leading edge and the trailing edge of a *section*. (See diagram below)

Section : Surface perpendicular to the *foil*. (Grey part of the diagram below)

Foil head : The part of the *foil* that enters and exits the hull below the **sheerline**, where the *sections* are constant and which defines the A1 axis.



We verify that the *foil head* is an extrusion of the *section* following :

- an axis A1 (straight *foil head*) ;
- or a curve of revolution of constant radius around an axis A1 (curved *foil head*).

We check that the first *degree of freedom* is, regardless of the angle of rotation of the second *degree of freedom*, if it exists :

- a translation along this axis A1 (straight *foil head*) ;
- or a rotation about this axis A1 (curved *foil head*).

We check that the second *degree of freedom*, if it exists, is a rotation of the *foil* about an axis called A2 when the *foil* is in its fully extended position.

The A2 axis must intersect one of the foil's *chords*.

We check whether :

- axis A2 is perpendicular to and intersects with axis A1 and the foil's *chord* (straight *foil head*) ;
- or axis A2 is perpendicular to and intersects with axis A1 (curved *foil head*).

We verify that the second *degree of freedom*, if it exists, is a rotation of the foil limited to 5.0 degrees.

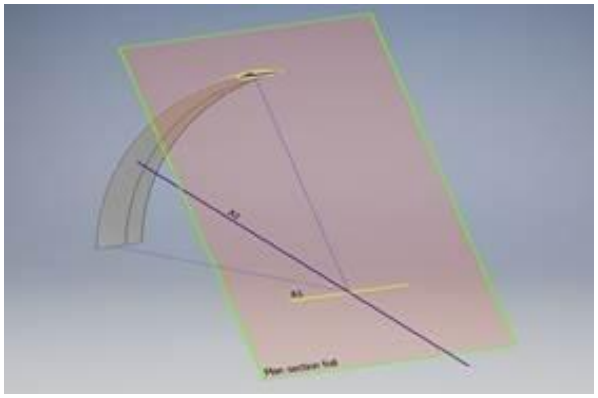
We also verify that there is an intersection (a point « A ») near the hull between the A2 axis and the *foil* for all rotation angles associated with the second *degree of freedom*, if it exists.

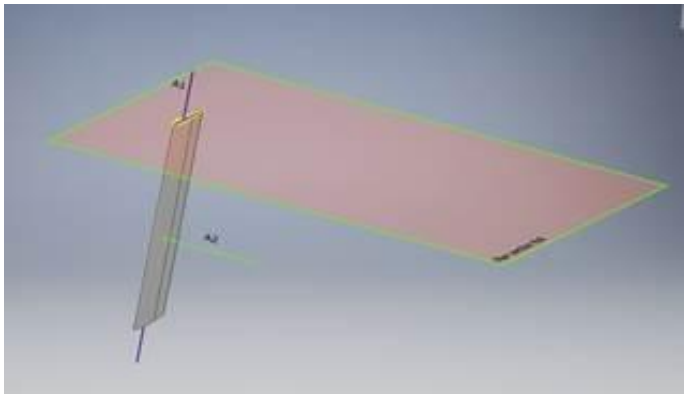
It may be admitted that the A2 axis is not unique in the *boat reference*.

The A2 axes generated by the second *degree of freedom* must intersect at point « A ».

The set of A2 axes shall be contained within a cone of revolution with a half-angle at the apex of 1.0 degrees and with point « A » as its apex.

If the second *degree of freedom* causes one or more unwanted movements, the CM shall determine whether the system offers any advantage in terms of *foil* trim and may decide whether or not to consider the system to be in compliance with the CR.





A.24 VALIDATION OF FOIL TOUCHING

See CR E.4(k).

Provide documentation demonstrating the integrity of the seal even in the event of a significant impact on the foil.

A.25 FOIL-RELATED ACTIONS

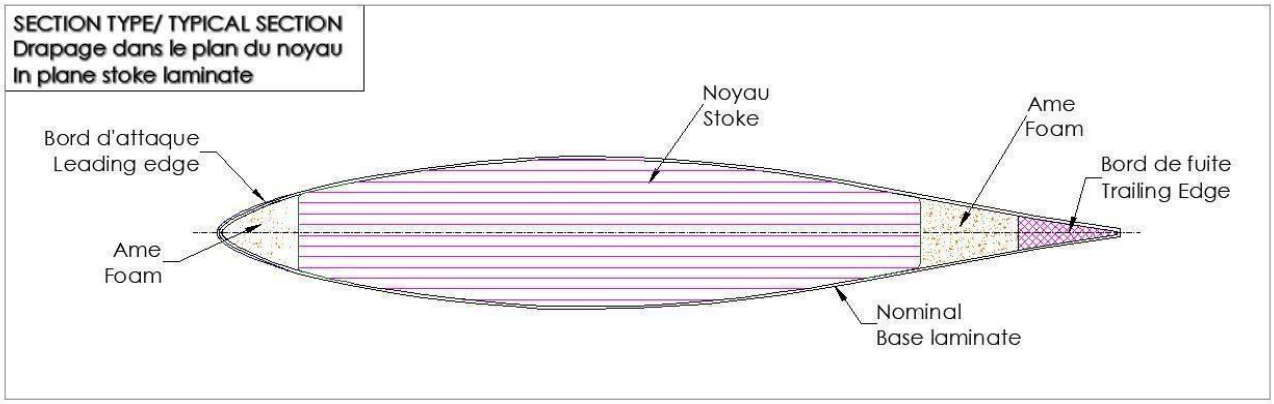
Compare the real *foil* with its 3D digital model (CAD), implemented in Rhinoceros Orca 3D software, by using photogrammetry or 3D scanner.

Determine the weight and CG of the real *foil*.

A.26 METHOD OF MANUFACTURING FOIL BEAMS

See CR AG.2(e).

When the ***foil*** core is manufactured (lay-up) according to the so-called “in-plane” principle, HM fibres are permitted on the sole condition that they are arranged in strict accordance with the diagram below (parallel to the ***foil***'s chord).



When the ***foil*** core is manufactured (layup) according to the so-called “out-of-plane” principle, HM fibres are strictly forbidden.

A.27 REDUCED IMPACT SAIL

See CR AN.3.

Description of the criteria for ***reduced impact sail*** defined in A.2.2 of the CR.

Each candidate sail is submitted for approval by the CM following an analysis carried out using the Reduced Impact Sail Evaluation (***RISE***).

To qualify as a ***reduced impact sail***, the sail’s analysis shall obtain a score between A and C according to the ***RISE*** system.

Air transport is prohibited for ***reduced impact sails***.

The score is given in accordance with the specific ***RISE*** methodology. The methodology is available in the ***IMOCA*** “member” area (https://www.imoca.org/en/technical-committee-documents).

All sails must undergo ***RISE*** to obtain a score, even if this results in a score higher than C.

A.28 SAIL IDENTIFICATION

A.28.1 PROCEDURE FOR A NEW SAIL

See CR AN.1 and AN.2.

A ***button*** is a glued and sewed patch with a serial number referenced by IMOCA. The manufacturer registers the data associated with the team’s available ***buttons*** on the online sail management platform via this link : https://fleet-manager.imoca.org/fr/manufacturer/login.

If the team no longer has any ***buttons*** available, the manufacturer cannot register them.

The data to be entered by the manufacturer when registering a ***button*** is described below.

A.28.2 DESCRIPTION OF THE INSTALLATION

The identification patch is supplied by *IMOCA* to the sailmakers. It shall be glued and sewn within a radius of 500 mm around the tack and less than 150 mm from the foot of the sail. The sailmaker generates the identification number associated with the *sail* in question in accordance with this principle :

First three WS numbers of the boat following the 6	V for sails (« voile » in french)	Three sailmaker identification letters	Three free characters

A.28.3 INFORMATION REQUIRED FOR THE IDENTIFICATION OF SAILS

In order to comply with CR G.1, G.2(a), G.3(a), G.3(d), AN.1, AN.2, suppliers shall provide the information via the online management platform.

Area and dimensions of :

- leech ;
- luff ;
- foot ;
- gaff and gaff angle, in case of mainsail ;
- width at mid-height, in case of headsail.

A.28.4 PROCEDURE FOR *EXISTING SAILS*

In order to comply with CR G.4, *existing sails* shall be identified by the *IMOCA* stamp or identification *button* to verify that the sail has accumulated a total of 10 or more cumulative *coefficients* associated with the races in which it was declared.

A.28.5 PROCEDURE FOR *ACTIVE SAILS*

When an *active sail* is transferred from one **boat** to another **boat**, the **boat** receiving the *active sail* shall assign it to one of its available *buttons*. The *active sail* in question shall also retain its original *button* and the cumulative *coefficients* associated with it to date. If, after twelve months, the *active sail* has not become an *existing sail*, the original owner's *button* may be renewed, if it is renewable.

A.29 RACE GRADE COEFFICIENTS

Grade 1 races correspond to a ***coefficient*** of 10. Grade 1 races are those that allow for the awarding of non-renewable ***buttons***.

Grade 2 races correspond to a ***coefficient*** of 4.

Grade 3 races correspond to a ***coefficient*** of 2.

Grade 4 races correspond to a ***coefficient*** of 1.

For stage races, the ***coefficient*** is awarded to the 7 ***sails*** that have accumulated the most theoretical miles on the stages in which they were declared.

A.30 *STANDARDISED LIFE RAFT*

Description of the contents of ***standardised life rafts*** and their associated grab bags in accordance with CR C.3.4 :

A.30.1 OUTDOOR CONTAINER RAFT ISO 9650 1A <24H++

Equipment for outdoor ***standardised life rafts*** in containers and grab bag :

	Quantity	
Item description	**Raft**	**Additional outdoor raft grab bag**
SURVIVAL FOOD 1 PERS 500GR	1 = 0.5 kg	3 = 1.50 kg
SURVIVAL WATER 1L	2 litres	4 litres
LED SIGNAL TORCH IN CASE + SPARE BULB & BATTERY	1	1
DNS RED HAND-HELD FLARE	3	3
DNS PARACHUTE FLARE	2	
ISO LIFE RAFT FIRST-AID KIT	1	
SEASICKNESS TABLETS (BOX OF 14)	2	
SEASICKNESS SACHET	4	
SOLAS INSULATED THERMAL BAG	2	
PLASTIC SIGNAL MIRROR	1	
ISO ORANGE WHISTLE	1	
SABOT SCOOP	1	
SYNTHET. SPONGE 125X80X40MM	2	
RAINWATER COLLECTION BAG	1	
ISO 900X750 FLOATING ANCHOR	1	
PAIR OF 50CM DETACHABLE PADDLE	1	
FLOATING FOLDING KNIFE	1	
AIS MOB 1 OCEAN SIGNAL BEACON	1	
HX890E PORTABLE VHF	1	
CASE + 5 AAA ALKALINE BATTERIES FOR VHF	1	

The grab bag/external liferaft complement shall be sealed near the emergency exit at the *transom*.

A.30.2 INDOOR BAG RAFT ISO 9650 1A <24H++

Equipment for indoor *standardised life rafts* in bag :

Item description	Raft
SURVIVAL FOOD 1 PERS 500GR	1 = 0.5 kg
SURVIVAL WATER 1L	2 litres
LED SIGNAL TORCH IN CASE + SPARE BULB & BATTERY	1
DNS RED HAND-HELD FLARE	3
DNS PARACHUTE FLARE	2
ISO LIFE RAFT FIRST-AID KIT	1
SEASICKNESS TABLETS (BOX OF 14)	2
SEASICKNESS SACHET	4
SOLAS INSULATED THERMAL BAG	2
PLASTIC SIGNAL MIRROR	1
ISO ORANGE WHISTLE	1
SABOT SCOOP	1
SYNTHET. SPONGE 125X80X40MM	2
RAINWATER COLLECTION BAG	1
ISO 900X750 FLOATING ANCHOR	1
PAIR OF 50CM DETACHABLE PADDLE	1
FLOATING FOLDING KNIFE	1
AIS MOB 1 OCEAN SIGNAL BEACON	1
HX890E PORTABLE VHF	1
CASE + 5 AAA ALKALINE BATTERIES FOR VHF	1

A.31 SPECIFICATION OF THE SMOKE MASK

The smoke mask specified in CR C.3.26 shall be a full-face mask covering the entire head, fitted with an ABEK P3 filter or equivalent.

A.32 IMOCA ECO-SCORE TOOL

A.32.1 PREAMBLE

The *IMOCA Eco Score tool*, available in the *IMOCA* "member" area (https://www.imoca.org/en/technical-committee-documents) compares the construction project against the reference value derived from the results of LCA studies carried out in accordance with CR 2025, using the environmental GPW criterion (kg CO2eq). As the overall impact result of the LCAs is 400 tonnes CO2eq, it sets the reduction target of 15% to 60 tonnes CO2eq.

The *Eco Score tool* only takes into account the environmental impact of the materials used in the tooling, the platform and the foils. This impact is 270 tonnes of CO2eq, which is the baseline figure, corresponding to a score of 5/10.

A 15% reduction corresponds to the score of 5,75/10 that must be achieved for validation by the CM. The scores are derived from calculations involving material scores based on their GWP per kilogram. This score is therefore proportional to the CO2eq savings achieved. Material impact data is sourced from MarineShift 360, which includes the EcoInvent 3.7 database. The material database and associated material scores are fixed for the application of CR 2028. The integration of new materials during this cycle is possible provided it is supported by an LCA compliant with standardisation and environmental assessment methodology

The calculation methods integrated into the Eco Score tool are available in the *IMOCA* "member" area (https://www.imoca.org/en/technical-committee-documents).

The CO2 savings calculated by the *Eco Score tool* are displayed as a percentage. The result shown is rounded to the nearest whole number. To make it easier to understand changes in impact, CO2 savings are displayed to two decimal places.

At the start of the project, the signatory of the declaration of construction shall notify the CM in order to establish the necessary channels of communication with the *IMOCA* class for the purposes of the proper conduct of the project regarding the AG.4 CR verification. The term "construction project" refers to any study or preliminary study carried out with a view to building an *IMOCA*.

The construction project shall be drawn up in consultation with the construction stakeholders (shipyard, architects and structural engineers), who shall certify their ability to comply with the project submitted to the CM and provide all documentation demonstrating that the construction complies with the project.

The aspects relating to *tooling mutualization* may be taken into account where the declaration of construction of the second or third boat is made before the issue of the first measurement certificate for the first boat included in the *tooling mutualization*.

A.32.2 MEASURED DATA

Quantities and types of materials corresponding to the "theoretical quantities ordered" for the project (quantities issued from stock for manufacturing): materials used + offcuts.

Where a component is subcontracted, the team and/or shipyard shall ensure in advance that they are able to collect the data.

Requests for invoices or any other supporting documents may be made by the CM.

A.32.3 DATA COLLECTION METHOD

These are the weights of materials ordered for the complete production of :

- platform preforms ;
- platform moulds ;
- platforms ;
- foils and associated tooling.

Counted	Not counted
Toolings	
• toolings used to construct the boat's watertight shell : deck, hull, transom, cockpit floor and sides, companionway bulkhead ; • components specifically designed to form the framework of the tooling : structure, cradle, frame, etc. ; • any other tools deemed necessary, at the discretion of the CM.	• workbench or other standard shipyard toolings already on site ; • toolings for removable components (companionways door, hatch, emergency escape hatch, etc.) ; • coach roof tooling ; • truncking tooling ; • structural and foil box tooling ; • structural and keel box tooling ; • toolings for other internal structural components ; • shapers designed to support the hull after demoulding.
Platform	
• the boat's watertight shell : deck, deck basins, hull, transom, cockpit floor and sides, companionway bulkhead ; • internal structural elements : bulkheads, stringers, girders, deck beams ; • foil box, keel box ; • trunckings ; • ballast tanks ; • structural grafting and assembly components ; • winch mounts ; • any structure not included in the items listed below.	• hatches, doors ; • removable components ; • fitting components.
Foils	
• beam and sheel ; • tip and shaft ; • tooling.	• foil deployment system ; • equipment needed for adjusting the foils.

The options selected to meet CR AG.4 via the *Eco Score tool* shall be complied during construction. Any changes shall be reported to the CM for approval.

The CM will carry out checks throughout the construction period and after launch to verify compliance with the announced construction proposal.

A detailed description and documentation file shall be submitted to the CM (Excel, invoices, photos, any supporting evidence) at the end of the construction.

A.33 PENALTY ASSOCIATED WITH FAILURE TO REDUCE THE ENVIRONMENTAL IMPACT OF NEW CONSTRUCTIONS

A failure to reduce impact by between 0% and 3% requires the installation of the following corrective weights :

- $0\% < x \leq 1\% = 50$ kg ;
- $1\% < x \leq 2\% = 100$ kg ;
- $2\% < x \leq 3\% = 150$ kg.

The corrective weight(s) may consist of several parts. They must be permanently installed inside the ***hull***, such that the centre of gravity of the entire corrective weights system lies on the ***hull centerplane***, within a maximum of 2000 mm on either side of the X-coordinate of the mast base.

A.34 ANCHORAGES

Among the anchorages defined in CR C.3.21, at least one anchor shall be stored fully assembled.

A.35 *MEASUREMENT TRIM* CHANGES

A.36 REMOVAL OF SAIL-SPECIFIC COMPONENTS AT RACE VILLAGES

Once the **boat** has been made available to the Organising Authority, the unloading of elements associated with sails not carried on board for the race in question is permitted. This authorisation expires at the deadline for submitting the sail declaration for that race.

The following are considered to be elements associated with sails :

- halyard ;
- tacks ;
- hook systems ;
- reefing lines ;
- sheets ;
- sheaves.

Once the **boat** has been made available to the Organising Authority, the following are not permitted :

- the unloading of any other element of the ***measurement trim*** ;
- any modification of the mass and/or CG of any other element of the ***measurement trim*** ;
- the addition of elements not included in the latest measurement.

A.36.1 DEADLINE FOR REQUESTS TO AMEND THE *MEASUREMENT TRIM*

As a general rule, any request to amend the ***measurement trim*** for the purpose of obtaining or renewing the MC for the race in question shall be made no later than the day on which the **boats** are to be made available to the Organising Authority for that race.

In exceptional circumstances, a request for a change to the MC for the race in question may be made between the date on which the **boats** are made available to the Organising Authority and the start time of the race if, cumulatively :

- the request has been sent in writing to the measurement team (measurers@imoca.org) ;
- the request has been approved by the Chief Measurer ;
- the modifications have been made, and verified by a Measurer.

A.37 LIST OF DRAWINGS AND DOCUMENTS RELATED TO THE GENERATION 1 STANDARDISED MAST

The drawings and documents related to CR AC.1 are :

- *Note 2 - Cahier des charges d'implantation et d'utilisation du mât aile standardisé_V7*
- *1050z-01-200 Plan général mat aile - diffusion 2021_revE*
- *1050z-01-300 Plan de moule - diffusion 2019_revA*
- *1050z-01-400 Plan de drapage - diffusion 2019_revA*
- *1050z-02-7XX Plan de renforts - diffusion 2019_revA*
- *1050z-03-200 Plan outrigger - diffusion 2019_revA*
- *1050c-03-310 Outrigger perçage câble_revA*
- *14000 Vue de détail extrémité Outrigger_revB*
- *14000-100 Plan de rail IMOCA 4 ris_revD*
- *Pied de mât + réa de friction_V9*
- *Eclaté HK arbalete_22/02/2019*
- *Note de montage du boîtier de hook d'arbalètes_V1*
- *C12001 Assembly Awentech 27mm Halyard Lock Car_06/02/2014*
- *HGV-H27-Platine_plots_renforcés_revB*
- *Notice HGV IMOCA 2025_V5*
- *Procédure V2 renfort HGV 2020_31/07/2020*
- *IMOCA ONE DESIGN GEN 2 ECSix Handling guide_2024*
- *IMOCA V2-D0-Lower-64T_15/09/2025*
- *IMOCA V2-OUTRIGGER-64T_15/09/2025*
- *MG2_21XXXX IMOCA SIDE STAY approved_3D_17/07/2025*
- *MG2_IMOCA SIDE STAY_29/11/2024*
- *MG2_IMOCA_Spec_CS_LS_17/07/2025*
- *1050c - Lower schroud area process_v4*
- *1050z-02-0711_PLAN TIRANT BAS HAUBAN_v03*
- *1050z G23 MAT STD Renforts préventifs cadènes_V02*
- *1050z G23 MAT STD Renforts préventifs cadènes - sketch detail douille arbalete_V01*

A.38 LIST OF DRAWINGS AND DOCUMENTS RELATED TO THE GENERATION 2 STANDARDISED MAST

The drawings and documents related to CR AC.2 are :

- *Note 5 - Cahier des charges d'implantation et d'utilisation du mât standardisé génération 2 - 1800a 0010 Mast sailing guide_V04*
- *1800a - IMOCA G2 - NDT Tube XX AAAAMMJJ TEMPLATE_V02*
- *1800a_0020_Devis Masse diffusion teams_V05*
- *1800a_1002_Plan général diffusion teams_V05*
- *1800a_1004_3D générale diffusion teams_V03*
- *1800a_4102_3D Pied de Mat diffusion teams_V01*
- *1800a_5001_Outrigger diffusion teams_V02*
- *Notice_HGV_IMOCA_2025_V5*

- *IMOCA ONE DESIGN GEN 2 ECSix Handling guide_2024*
- *IMOCA V2-D0-Lower-64T_15/09/2025*
- *IMOCA V2-OUTRIGGER-64T_15/09/2025*
- *MG2_21XXXX IMOCA SIDE STAY approved_3D_17/07/2025*
- *MG2_IMOCA SIDE STAY_29/11/2024*
- *MG2_IMOCA_Spec_CS_LS_17/07/2025 MG2_Plan_rail_Harken_V01_revB*

SECTION B MEASUREMENT SESSION

B.1 MEASUREMENT

Paragraphs B.2 and B.3 of the *measurement protocol* specify, where necessary, the methodologies and/or measurement procedures set out in the GENERAL PRINCIPLES of the measurement protocol.

These are all procedures that require intervention on the boat and/or on a computer.

B.2 ASHORE MEASUREMENTS

B.2.1 MEASUREMENT ASHORE REFERENCE (MAR)

The vessel shall be in a ashore measurement trim such that the DWL declared in the digital model provided is horizontal, in particular for the operations defined 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 carried out as part of the overall inspection specified in A.7.2 of the *measurement protocol*.

The Measurer may request an amendment to the MAR plan if he considers that it is too “far removed” from the real afloat trim.

B.2.2 OVERALL INSPECTION OF THE HULL

See A.7.2 of the *measurement protocol*.

For this operation, the *skipper* or their official representative shall ensure that the boat’s hull is made fully available for a full day.

No other operations or access to the boat are possible.

The mast base shall be in place on the deck.

The keel bearings shall be in place on the hull.

To ensure that the entire hull shell can be captured under the conditions required by photogrammetry or 3D scanning technologies, please ensure that the following points are strictly complied with :

- no protection on the boat (deck completely clear with deck fittings in place) ;
- boat completely clear of any construction-related elements (scaffolding, etc.) ;
- minimum clearance of 4 metres around the boat ;
- ability to lift the hull to inspect the underside of the hull and the keel axis.

The *skipper* or their official representative shall provide a stable and safe mobile scaffold that allows for photogrammetry shots or for positioning the 3D scanner.

The height shall be sufficient to provide an unobstructed, downward view of the deck (at least 3 metres above deck level), and the same applies to the underside of the hull.

B.2.3 POSITIONING OF THE KEEL ROTATION AXIS

See the principle diagram in A.7 of the *measurement protocol*.

In the case of a non-global measurement in accordance with A.7.6 of the *measurement protocol*, the longitudinal positions of the following two points shall 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 WHEIGT OF THE KEEL FIN AND BULB AND CG OF THE KEEL

B.2.4.1 The keel fin and bulb shall be weighed separately at a single point.

The configuration, including the filling of the bulb cavities (if any), shall be recorded.

B.2.4.2 WEIGHING OF THE COMPLETE KEEL IN ONE POINT

The *skipper* or their official representative shall provide the necessary means to lift the complete keel (fin with its fairings and assembled bulb) in one point in order to weigh it.

B.2.4.3 WEIGHING THE KEEL IN 2 POINTS

To determine the position of the CG of the keel (fin with its fairings and bulb assembled), the *skipper* or their official representative must provide two means of determining, with the keel in a horizontal position, the weight at the bulb and at the keel ram axis.

For the bulb, the *skipper* or their official representative must provide slings to hold the bulb.

The two lifting lines shall be vertical, and the distance between the two lifting lines shall be measured.

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

B.2.5 MAST WEIGHT AND CG

B.2.5.1 *STANDARDISED MAST*

See A.11 of the *measurement protocol*.

Weigh the unequipped mast at a single point using the mast rail’s top car positioned at the mast’s CG when horizontal.

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

B.2.5.2 WEIGHT AND CG OF THE MAST AND OUTRIGGERS WITH STANDING AND RUNNING RIGGING

See A.11 of the *measurement protocol*.

The *standardised mast* shall be equipped with the following components :

- movable swivels and their protective covers fitted at the base of the mast ;
- fairings and mast cover in position ;
- mast protective covers in position ;
- complete electrical harness in position, excluding any equipment required by a Notice of Race ;
- radar mount and radar in position ;

- masthead mounts – without sensors, antennas or cameras – in position ;
- all halyards in position ;
- forestays with their upper loops in position ;
- lower stays with their upper loops in position ;
- J2 stay with its loops and swivel – without the lower furler – in position ;
- lower and upper backstays, and backstay deflectors set to maximum tension, along with their control lines – without the lower block – in position ;
- all mainsail cars - in position ;
- all deck lighting equipment, etc.

The halyards for the headsails are led down to the base of the mast, with the halyard ends laying on the ground. These are weighed separately and added to the rig at X = -3000 mm and Z = -500 mm relative to the reference of the *standardised mast* as defined in Notes 2 and 5.

The mainsail cars are stacked above the gooseneck, with the mainsail halyard secured to the top car.

The masthead antennas and cameras shall be removed.

The other parts of the standing and running rigging are brought down the mast and secured with light ropes so that they do not drag on the ground.

The Measurer checks that each item described above is present and correctly positioned.

A detailed inventory of the equipment is noted and photographs are taken.

The measurement is carried out indoors. The mast is suspended at two points and the measurement is taken using two dynamometers : the first on the gooseneck axis, the second at the J0 chain plate or the emergency axis.

Both outriggers shall be equipped with the following components :

- polymer housings and end fittings in position ;
- fittings in position ;
- lower shroud lashings in position ;
- sensors and cables in position ;
- protective covers and fairings in position ;
- outrigger tie-downs (D0, fore, aft).

The two outriggers and the D0 tie-downs are brought together and secured with light ropes so that they do not drag on the ground.

The cameras shall be removed.

The Measurer checks that each item described above is present and correctly positioned.

A detailed inventory of the equipment is noted and photographs are taken.

The measurement is carried out indoors. The outriggers are suspended from a single point and the measurement is taken using a dynamometer mounted on a briddle.

B.2.6 WEIGHT AND CG OF THE BOOM

The *standardised boom* shall be equipped with the following components :

- reef lines and foot rope in position, hauled taut ;
- reefing hooks in position, if used ;
- straps and their fastenings in position ;

- sheet sheaves in position ;
- downhaul sheaves in position, if used ;
- constrictors and their control lines in position ;
- fairings, deck sweepers and protection in position.

The reef lines and foot rope are brought to the gooseneck, and the ends of the reef lines and foot rope are laid on the ground. These are weighed separately and added to the rigging at X = -3000 mm and Z = -500 mm relative to the reference of the *standardised mast* as defined in Notes 2 and 5.

The Measurer checks that each item described above is present and correctly positioned.

A detailed inventory of the equipment is noted and photographs are taken.

The measurement is carried out indoors. The boom is suspended from a single point and the measurement is taken using a dynamometer mounted on a briddle.

B.2.7 WEIGHT, CG AND EXTREME POSITIONS OF THE FOILS

B.2.7.1 WEIGHT AND CG OF THE FOILS

Each *foil* is weighed at a single point to obtain its weight.

The CG of each *foil* must be determined using a 3-point weighing method; the use of weighing blocks is recommended.

A flat, stable surface is required for the use of weighing blocks.

These support points (in the case of weighing blocks) are measured relative to a reference of the *foil*.

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

B.2.7.2 MOVEMENT OF THE FOIL

See CR E.4(h).

The aim is to establish visual reference points :

1) the position of the *foil* relative to the hull in position 0 (the *foil* is fully retracted) ;

2) the position of the *foil* relative to the hull in position 1 (the *foil* is fully extended).

The movement of the *foil* involves a rotation or translation between position 0 and position 1.

The *skipper* or their official representative shall ensure that two reference marks are positioned on the *foil* to indicate these two positions on the outside of the hull.

B.2.7.3 FOIL ROTATION (MAXIMUM 5.0 DEGREES)

See CR E.4(i).

The aim is to validate the installation of the *foil* bearings and associated systems as defined in the numerical model provided and in the documentation referred to in paragraph A.16 of the *measurement protocol*.

In the event that the angle of rotation of the *foil* exceeds 5.0 degrees, mechanical limitations shall be installed and sealed.

B.3 AFLOAT MESUREMENT

B.3.1 SPECIFIC GRAVITY OF WATER (SG)

A sample shall be taken approximately 300 mm below the surface.

B.3.2 WEIGHING OF THE BOAT

The ***skipper*** or their official representative shall provide all lifting equipment suitable for their boat. All operations involved in organising the lifting shall be the responsibility of the ***skipper*** or their official representative.

The boat is lifted at a single point.

The lower attachment point of the dynamometer shall be fixed to this point. The upper attachment point of the dynamometer shall be fixed to the crane hook.

To prevent any negative impact on the proper functioning of the dynamometer, two shackles shall be installed above and below the dynamometer.

B.3.3 MEASUREMENT OF FREEBOARDS AT 0 DEGREES TRIM

The freeboards at the reference points RPF and RPA are measured.

B.3.4 MEASUREMENT OF THE MAXIMUM KEEL ANGLE

The maximum angle of keel rotation shall be measured.

The stroke of the keel cylinder from one side to the other shall be checked with the boat on a 0-degree heel, keel in the boat's median plane.

Measure the lengths of the cylinder rod(s), then cant the keel to the mechanical stop on each side (do not take into account the electrical or electronic stroke limiters).

The mechanical stop may be provided by external rings limiting the cylinder's stroke. These rings shall be sealed.

B.3.5 STABILITY TESTS (90.0 DEGREES)

The ***skipper*** or their official representative shall provide and set up the necessary means to heel the boat to 90.0 degrees.

The ***keel*** is in the boat's centerplane, in the 0-degree position, with the emergency keel lock engaged. The ***keel*** is in the boat's centerplane, in the 0-degree position, with the emergency keel lock engaged. The dagger-boards are in the raised position and the ***foils*** – if any – are positioned symmetrically and retracted as far as possible (to the level of the ***hull's centerplane***), with the ***rudders*** in the "maximum down" position.

It is recommended to perform the test at 90.0 degrees without the ***foils*** in order to determine the boat's CG in the ***measurement trim*** without the ***foils***.

The ***foils***, in this case, are added numerically to the numerical calculation model.

The boat is heeled over to an angle which is measured.

This angle shall be as close as possible to 90.0 degrees, and the boat shall be held in this position by a sling around the mast (as close as possible to the masthead).

All other lines attached to the boat (hawser, mooring line, etc.) shall be completely slack for a sufficiently long period to allow the load to be measured on the masthead dynamometer (until the

load reading stabilises). If it is not possible to meet this requirement, the conditions (wind, current, etc.) necessary to carry out the test are not met.

The force exerted at the sling is measured using a dynamometer and its position relative to the mainsail sheave is measured.

The spreaders, of mast or deck (outriggers), shall not be sealed for the test.

The CM may request that this test be carried out on both sides.

B.3.6 RESERVE

B.3.7 BALLAST TANK INSPECTION

B.3.7.1 VOLUME

The Measurer shall ensure that the ballast tanks are empty.

Each ballast tank shall have access via an opening hatch allowing access to the lowest point of the tank.

The measurement shall be carried out by successively filling each of the ballast tanks and measuring the volume of the fill using a precision flow meter validated by the CM.

B.3.7.2 GEOMETRY

The Measurer shall measure the geometry and position of the ballast tanks in order to verify the digital model provided and, in particular, to determine the CG.

The CM shall specify the measurements required by the Measurer in accordance with the desired ballast tank configurations.

B.3.8 FUEL TANKS VOLUME CONTROL

The Measurer shall ensure that all fuel tanks are empty.

It is the responsibility of the ***skipper*** to provide a suitable quantity of fuel for the measurement, as well as an empty collecting container, and a 220 V socket.

The measurement is carried out using a volumetric pump approved by the Chief Measurer. The Measurer fills the tanks in turn until they are completely full and measures their volumes.

The diameters and lengths of the fuel hoses shall be reasonable and will not be included in the volume of the tanks. These elements will be assessed by the Chief Measurer.

In the event that the capacity of the measured tank is less than the required capacity, if such a requirement exists, the missing volume shall be stored in a dedicated additional container, sealed in filling and use.

SECTION C APPENDICES

C.1 COMPUTATIONAL CALCULATIONS

For information, the calculations are performed using Rhinoceros and Orca 3D software.

C.1.1 DETERMINING THE POSITION OF THE BOAT'S CG

C.1.1.1 TRIM AND HEEL, MEASUREMENT TRIM (LONGITUDINAL DETERMINATION OF THE SHIP'S X-CG)

The trim in the Rhinoceros and Orca 3D software is obtained by the PDYNA weighting and the measurement of the aft freeboard from the aft measurement mark RPA (boat's draught).

C.1.1.2 90.0-DEGREE TEST (DETERMINATION OF THE BOAT'S Z-CG HEIGHT)

The digital model, in the Rhinoceros and Orca 3D software, is set to the 90.0-degree test configuration.

C.1.2 CORRECTING THE BOAT'S CG POSITION

For a *measurement trim* determined by the CM, equipments may be added and/or removed to meet the defined *measurement trim*. These elements are added and/or removed from the digital model of the boat as decided by the CM.

These elements shall be known numerically (mass, centre of gravity (CG), volume if submerged).

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

Only the CM may decide to use this correction method.

C.1.2.1 CREDIT GRANTED FOR THE REINFORCEMENT OF THE GENERATION 1 *STANDARDISED MAST*

The weight of the preventive chainplate reinforcements for the Generation 1 *standardised mast* – corresponding to drawing *1050z_g23-mat-std-renforts-preventifs-cadenes_v02* – is deducted from the *measurement trim* for stability calculations of **boats** equipped with the Generation 1 *standardised mast*, i.e. 9.6 kg at a height of 21 660 mm in the mast reference.

C.1.3 ARAMETERS OBTAINED IN RHINOCEROS AND ORCA 3D

The parameters obtained in Rhinoceros and Orca 3D are :

(a) draught ;
(b) freeboard at the mast base for the air draught ;
(c) AVS
(d) area ratio of the stability curve (keel in neutral position, ballast tanks empty) ;
(e) AVSwc ;
(f) RM ;
(g) heeling angle (10.0 degrés) ;
(h) self-righting test ;
(i) bow and stern freeboards.

C.2 DOCUMENTS TO BE SUBMITTED TO THE CM

See CR APPENDIX K-4.

C.2.1 DOCUMENTS TO BE SUBMITTED FOR THE RENEWAL OF THE MC

The documents to be submitted by the ***skipper*** or their official representative to renew the MC for the boat in question, regardless of when the boat's first MC was issued, are :

- the form set out in RDC ANNEX K-4 ;
- in accordance with CR A.8.3, the keel NDT report ;
- in accordance with CR A.8.4, the mast NDT report ;
- in accordance with CR A.8.5, the hull NDT report ;
- in accordance with CR AA.3.1, the boat's NDT report ;
- in accordance with CR C.7.2, the certificate of conformity for the AIS installation, specifying Class A or B+, and the calculation sheet referred to in A.13 of the ***measurement protocol*** ;
- in accordance with CR D.4(a), the volumetric layout diagram of buoyancy materials with a summary table of components, including the characteristics of the closed-cell foams taken into account for the buoyancy volume calculation.

The associated checklist is available in the IMOCA "membre" area at : https://www.imoca.org/en/technical-committee-documents.

C.2.2 DOCUMENTS TO BE SUBMITTED TO OBTAIN A FIRST MC OR TO RENEW THE MC IN CASE OF MODIFICATION

The documents to be submitted by the ***skipper*** or their official representative to obtain a first MC or to renew the MC when the relevant document in the list below has been modified are :

- the complete digital model of the boat (known as « MNCB », in Rhino format) with the full rigging (all cables in position), working deck, **sheerline**, ballast tanks and their filling/draining systems, the keel in the 0° position with its axis of rotation, etc. in the ***boat reference*** ;
- installation diagram of the ***standardised mast*** with the various chain plates (digital document specifying the relevant dimensions and the angles defined in CR APPENDIX C) based on a dimensioned 2D digital plan (may be « MNCB » if a specific layer) ;
- the « MNCB » digital model shall be structured into different layers, including one specific to the stability calculation ;
- the 2D/3D diagram showing the various watertight bulkheads with hatches and specifying the maximum distances between each bulkhead (may be « MNCB » if a specific layer) ;
- the boat's waterline plans in measurement trim, with the companionway door (CR D.9.2) closed, at 0 degrees, 90 degrees and 180 degrees of heel angle, with the emergency exit located within 500 mm of the rearmost point of the boat; where applicable, the boat's waterline may be required at any other angle of heel ;
- the boat's waterline plans in measurement trim, with the companionway door (CR D.9.2) open and all watertight bulkhead doors closed, with, for the 0° case, the compartment corresponding to this (these) companionway door(s) filled to the cockpit coaming level, 90 degrees and 180 degrees of heel angle with the position of the emergency exit in accordance with CR D.9.1(c) ;
- a diagram of the ship's bilge pumping system (CR C.3.2) specifying the types of pumps used and their flow rates ;

- calculation notes certifying compliance with CR D.8.2(c) regarding watertight bulkhead doors ;
- certification of compliance with CR D.9 regarding the strength of hatches and emergency exits ;
- volumetric layout diagram of buoyancy materials with a summary table of components, including the characteristics of the closed-cell foams taken into account for the buoyancy calculation (CR D.4(a)) ;
- the document certifying the density of the bulb ;
- the technical drawing (2D longitudinal section) of the bulb showing any empty cavities where they exist; this document specifies the weight of the bulb alone, and the weight and material characteristics of the various parts and fittings used to connect the bulb to the keel, in compliance with CR E.3 ;
- certificate of installation of the bulb with an Inconel 718 H, 17.4 PH or equivalent shaft ;
- document confirming compliance with CR C.6.1, specifying :
    - the brand and type of engine ;
    - the installation of a separate starter battery, with its capacity, or another source for starting the engine ;
    - that RDC C.6.1(d) is fully complied with and that the system can be sealed during the race to prevent the boat from being propelled, together with the technical description enabling the system to be sealed ;
- purchase invoice for the propeller, confirming the brand, type and specifications of the propeller used ;
- certificate from the battery supplier confirming *commercial production* ;
- in accordance with CR C.7.2, the certificate of conformity for the installation of the AIS, specifying class A or B+ ;
- general electrical diagram of the boat with a table specifying the various batteries on board and their positions in the *boat reference* ;
- dimensioned working deck diagram (CR C.9.1) showing the height of the cockpit floor (lowest point)/DWL, including the toe rail, stanchions and pulpits ;
- in the case of self-draining cockpits, a calculation note shall be provided regarding the requirements for cockpit drainage (ISO 11812) as well as the certificate as specified in CR D.7.(c);
- document certifying compliance with hull materials (CR D.3), including a list of the various materials used and the certificates of conformity for each batch of fibres used ;
- signed certificate of conformity for the *standardised mast* ;
- signed certificate of conformity for the *standardised keel fin* ;
- signed certificate of conformity for the *standardised canting system* ;
- signed certificate of conformity for the *standardised boom* ;
- certificate of compliance with CR D.1(d) issued by the boat's designer ;
- a signed and dated declaration by the builder confirming that the boat has been built in accordance with the plans checked by the boat's designer ;
- any additional documents upon request by the CM.

The associated checklist is available in the IMOCA "membre" area at : https://www.imoca.org/en/technical-committee-documents.