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MEMORANDUM regarding OSR 3.02.2 (OFFSHORE SPECIAL REGULATIONS).

Reminder of this requirement

§ 3.02.2 / Structural Inspection –
Consult the owner's manual for any instructions for keel bolt checking and re-tightening. The following inspection to be conducted by a qualified person externally with the boat out of the water. Check that there are no visible stress cracks particularly around the keel, hull/keel attachment, hull appendages and other stress points, inside the hull, backing plates, bolting arrangements and keel floors. (See Appendix L - Model Keel and Rudder Inspection Procedure)

Preamble

This paper does not question the will expressed for several decades by the "Special Regulations" Committee, initiated by the ORC, then by World Sailing, to improve and universalize the safety regulations for sailing boats participating in regattas.

The objective of this paper is to identify:

- The introduction in the OSR, of a requirement initiating non-destructive inspection operations.
- The problems resulting from the application of this requirement 3.02.2
- The reliability of the possible controls carried out
- The possible conclusions and their applications, following this series of controls or inspections.

First, the technical environment imposed by the applicable certifications before the boats are new and the technical follow-up of these boats during their maritime life will be discussed.

Then, the paper will treat the interaction between the technicality of these biannual controls in regard to the mechanical solicitations generated by the sea and the wind met by the boats during this period.

The objective of the "Special Regulations" is to prevent events that could endanger the sailors. To do this, the SRs impose both requirements that protect the crew individually and requirements that concern the vessel. For this second part, the "SRs" are based on ISO standards or the use of "good practices (rules of the art)".

This new requirement 3.02.2 is essentially a preventive rule whose objective is to anticipate, as much as possible, a risk of ruin of the keel assembly or steering gear.

The question is therefore: ***Does rule 3.02.2 achieve this objective?*** This paper attempts to answer this question.

1/ Scope of application of this prescription

The scope of this prescription concerns the attachment of keels (in the general sense) and extends to hull appendages including steering gear (rudders).

It should be noted that the consequences of the failure of a rudder stock (even a single one) are not the same as those resulting from the loss of the keel, which directly affects the boat's stability and therefore its possible capsizing.

It should also be noted that the loss of a boat's keel often has tragic consequences, although some boats have managed to reach a shelter or wait for help after the loss of their keel (the Avs of a boat having lost its keel is of the order of 45° to 60°).

Finally, this prescription only concerns the mechanical ruins relative to the entities "**keels or appen**dages", to their assemblies on the boat and excludes the consequences of shocks during navigation with shoals, marine mammals or floating objects.

The part relating to rudders will be dealt with at the end of this file.

2/ Construction norms and introduction to the market of (racing) yachts

Some details:

- The " EC 94/25 " Directive was implemented in Europe in June 1996. From this date, all boats from 2.5 to 24m, to be sold on the European market, must comply with the prescriptions contained in this Directive.

- The Notified Bodies are organizations recognized by the EC. They are charged with the application of this certification.
  Their mission is limited to guaranteeing that a pleasure boat from 2.5 to 24 m can be sold on the European market.

- The " 94/25 " Directive only imposes 3 " ISO Standards ".
  - ISO 8666 (Main dimensions)
  - ISO 10087 (CIN / HIN code).
  - ISO 12217-2 (Stability / Buoyancy)

I specify that the use of the ISO 12215-9 norm, which deals with sampling calculations (implemented in 2012) is not mandatory.

The **shipyard (builder)** can use its own methods (or internal "Norms"), or other references (e.g., classification societies, other norms such as ABS) as long as their requirements are at least equal to those of the above-mentioned ISO.

- The CE certification only concerns the construction of the boat.
  Under no circumstances are the notified bodies responsible for issuing an opinion on repairs following accidents or on routine maintenance operations.

  On possible modifications of the boat (keel, structure, etc.). This operation must be requested in advance by the shipyard builder and be the subject of a new buoyancy/stability certificate and a new sampling study (12215-9).
  A local repair yard cannot make this request since it does not have the CE certification file of the boat, which is the property of the shipbuilder.
  In other words, only the Shipyard can modify the boat, such as replacing a bulb keel with a straight keel.
  Normally, any modification of the keel must be declared (and possibly retested for stability) as an introduction to the market of a new model with its buoyancy certificate.

- The OSRs classify races in "Categories 0, 1, 2, 3..." and refer to the requirements contained in the norms "ISO 12215 or ISO 12217-2 Category A, B, C".
  In fact, and this is not obvious to owners and/or skippers, this double use of the word "category" often makes the SROs complex to interpret.
  CE Certification uses the term Design Category A, B, C, D.
  Design Category A refers to "offshore" sailing, which encompasses "categories 0, 1, 2" of the OSRs.

- For boats over 24 m, it is simpler since they are not CE certified but must be certified by a classification and control society (Veritas, Lloyd's, Rina, etc.) when they are first launched, but also in case of damage or modifications.

- For boats less than 24 m, not CE certified, because identified as "sailing boats for competition only" (e.g. IMOCA), their class rules often require that their structures be validated by a recognized organization or by the architect and that they must comply with the regulations of their flag.

- The ISO 12215 norm includes 6 modules (modules 1, 2, 3 have been deleted).
  Modules 4, 5, 6 are limited to construction codes or definitions of structural elements. Module 8 deals with rudder calculations and does not take into account the risks of fatigue cracking. In fact, the evolution of the calculation of samples has progressively moved from the know-how accumulated by the Builders to a scientific approach with module 12215-9.

  Module 9 takes into account the resistance of the hull to certain heeling conditions and presents in an annex (Informative) a "Simplified evaluation of the fatigue strength".
  Module 10 covers mast and rigging calculations.

- The "Plan Review" initiated by World Sailing.

Extract from the description of the "Plan Review« Calculations
The plan review shall include independent calculations by the notified body of the areas listed above. These calculations may be by hand, spreadsheet or by an ISO 12215 program. The designers/builders submitted calculations shall not be taken as the only proof of compliance. »

In itself, this idea of "Plan Review" is not aberrant, because it amounts to instituting a redundant control system. In order to carry out this control, World Sailing approves a number of Notified Bodies.

In reality, World Sailing only manages the administrative side of this "Plan Review".
Indeed, the methodology of the "Plan Review" is not redundant, since it is (for cost reasons) the same Notified Body that proceeds to the initial CE certification, which is totally independent of World Sailing's prescriptions, and then carries out the "Plan Review". There is little chance that the organization that validated the CE certification will derail its own work in the "Plan Review".

Remarks on this § 2:

For sailboats under 24 m, the OSRs establishes a borderline before and after 2009, (i.e. 1987 to 2009 and after 2010), this borderline seems incomprehensible since 1996 all sailboats introduced to the market in Europe must be "CE". In reality, all non-European manufacturers wishing to export to Europe comply with the CE regulations.

Normally the reference should be 1996 (or at least 1998 in order to absorb the time of implementation of the Directive in the legislations of each European country) and not 2009.

On the other hand, it is surprising that the earliest date is 1987, especially since boats prior to 1987 still participate in offshore regattas (Fastnet, Bermuda race, Sydney Hobart ...).

There are even plans for a remake of the Whitbread: ***"2023 Ocean Globe Race: The Whitbread Race is back!":***
« ***Entries are limited to 'approved' fiberglass production yachts designed prior to 1988, from 47ft (14.32m) to 66ft (20.11m) LOA segregated into two groups:***
ADVENTURE 47 to 56ft (14.32-17.06m) and SAYULA 56-66ft (17.07-20.11m) classes. In addition, original entries from the first three Whitbread Races (1973/4, 1977/8 and 1981/2) together with 'Class surveyed' production sail training yachts up to 68ft (20.73m) make up a third FLYER Class. Nautor Swan production yachts that fall within the age/length parameters are currently approved, and similar well-proven production yachts will be considered on application. The fleet is limited to a maximum of 30 yachts and the Race will be sailed under the International Collision Regulations. »

The first Whitbread was 50 years ago!!! and yet a SWAN 65 is not yet classified as a "classic sailboat", moreover a dozen SWAN 65 are still measured in 2021 in ORC or IRC.

This paragraph on the evolution of the implementation of the OSR rules allows us to situate the field of application of this OSR 3.02.2 prescription in relation to the regulations that were in force when the boats were built.

It is also important to take into account that the EC Certification only concerns the construction of boats and their introduction to the European market and is in no way applicable to repairs, maintenance, or possible "refits".

Only boats over 24 m are subject to periodic inspections during their life or after a disaster.

3/ Causes of failure of keel assemblies

The records that have been compiled by the Special Regulations Committee list approximately 90 keel failures (usually the loss of the keel) affecting boats participating in offshore regattas or delivery.

Of these 90 known cases between 1983 and 2018 (35 years) we identify:

- **Approximately 20 keels have been lost due to groundings, violent contact with marine mammals, containers, wrecks.**
- 22 IMOCA Class boats that lost their keel or bulb or suffered damage to the keel head or control systems.
- 11 Mini 6.50 boats that lost their keel.

Of the 90 known cases, recurring disorders were identified on more than 60 boats with the following technical causalities:

"**Fatigue, Design, Welds, Fabrication, Assembly Technology, Delamination, Under sizing**".

We note that only a few boats over 24 m have been victims of this type of accident. This is normal, because firstly these boats are less numerous, and secondly because they are subject to more stringent regulations which apply during their maritime lives (regulations of their "flag"), whereas pleasure sailing boats (up to 24 m) are not subject to any post-construction technical inspection, even after a loss.

In case of a damage, the insurer will send a surveyor to inventory the damage and to determine with the repairing shipyard the methodology for the repair. In no case is the insurer obliged by the insurance contract to commission the follow-up of the works and the receipt of these works.

It is also impossible for a marine surveyor to obtain information from the insurers regarding any previous damage to a vessel.

Although keeping a ship's logbook is normally mandatory in offshore navigation, this is not the reality. It is therefore impossible to know the history of the navigations, the possible events, the maintenance operations, etc...

Out of these 90 keel losses, we can exclude the 20 losses due to grounding or contact with an obstacle. These events are the responsibility of the skipper or the lack of chance to hit a floating obstacle.

The last module of the ISO 12215-9 norm includes a paragraph "Vertical heeling of a keelboat". This paragraph was added to encourage Builders to provide a structure that takes into account the dry-docking for inspections or careening.

Thus the prescriptions of the norm 12215-9 require that the structure must resist a vertical force equal to :

F (newtons) = 9.81 * (Maximum load displacement - keel mass).

For a 12 m boat (5500 kg) this force is about $40*10^3$ Newtons.

We understand that it is impossible to impose that the structure of this pleasure boat resists to a frontal shock on a rock, at the level of the low point of the keel during a navigation at 8 or 10 knots (5,2 m/s).

At the moment of this type of impact, the sudden deceleration is of the order of 16 m/s2.

The laws of dynamics evaluate the force at contact at 5500 * 16 = $88*10^3$Newtons.

We must remain realistic, a boat must remain Archimedean, i.e. be calculated to resist the forces in normal navigation relative to this mode.

33 boats of the IMOCA or Mini 6.50 type have effectively lost their keel. This important number of damaged boats is quite simple to explain. To do so, we must put these losses in the context of the time.

During the 80's and 90's, there was a spirit of adventure and freedom, which expressed itself by the will to get out of the conventional regatta schemes which were based on very restrictive rules (the main one being then the IOR rule).

This was the case for the Mini-Transat, the BOC Challenge and the Vendée Globe.

We then found ourselves in the pattern and deviations known in all motor sports. This can be summarized as follows: "Engineers, architects and skippers are obsessed with gaining speed. They look for this speed where it is technically feasible and easy".

The invention of the pendulum keel (first in Mini 6.50), which can be compared to the turbo compressor on internal combustion engines, will be the starting point of the obsession to build the lightest possible FIN KEEL in order to recover this delta of weight to increase the weight of the bulb, without increasing the displacement of the boat.

With the diffusion of Carbon, which appeared at that time, as "the miracle material" that can be worked in any workshop, we have all the ingredients to make the failures happen.

Having been very close to the Teams, as co-director of the race (Vendée Globe 89/92/96/2000), I can say that the technological imagination was rife from 1992 to 2000 and that all technological solutions were tried, but not always to good effect.

Thus, about fifteen carbon Fin Keels had very serious problems (partial or total rupture)

The use of Carbon having shown its limit, the IMOCA community then turned to a new technology using mechanically welded construction from HLE type steels (example STRENX 700/960/1300 or WELDOX 700/900/1200).

The result will be technically less disastrous, but the publicity on this type of manufacture and especially on the HLE material will prove to be the cause of failure of keel sails of standard boats and also of boats over 24m. These failures are not related to the quality of the material but to the post-weld stress relieving treatments which are very often neglected or badly conducted.

A forgotten or badly performed stress relieving treatment leaves residual stresses in some welds. These stresses are added to the fatigue stresses and can quickly lead to cracking.

The failure to respect the "good practices" of the mechanical welding design appears to be a serious cause of keel failure.

It was not until the 2010s that the IMOCA Class imposed the solution of mutualizing keel sails by adopting a manufacturing process based on the same model in monobloc forged steel (without welding). Only one grade of steel will be authorized, ("APX4" for Aubert & Duval or "VG900i" for Thyssen). Since that date, there have been no incidents.
I would add that a very precise and documented design document relating to the technological equipment of keel sails has been introduced in the Class Rules.

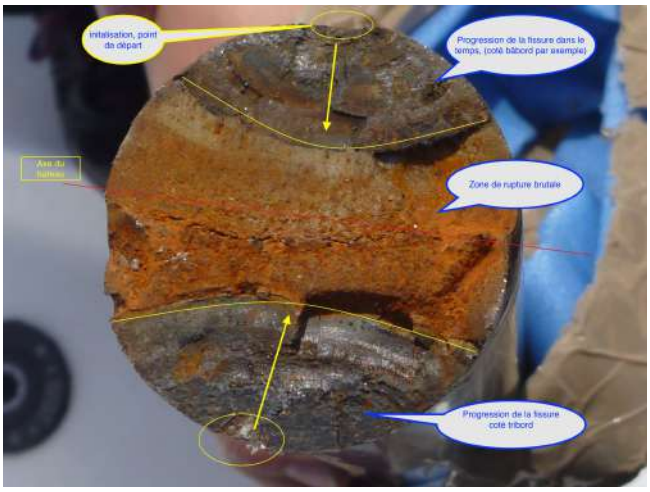
On the Mini 6.50s, an identical scheme has been developed, but the scale factor compared to the IMOCA boats will limit the consequences of failures.

Causes cited in loss reports:

Fatigue, Design, Welds, Fabrication, Joining Technology, Delamination, Undersizing

These technical causes of ruin, listed above, are in fact intimately linked.
In reality, there is **never an initial sudden plastic failure** resulting from an obvious under-dimensioning of the keel fin or its assembly.

The failure of the assembly takes place by fatigue of a mechanical element, <u>under the effect of strengths much weaker</u> than those taken into account in the assumptions of calculations (static or dynamic) usual of RDM (Resistance of Materials) relating to the various cases of loading.

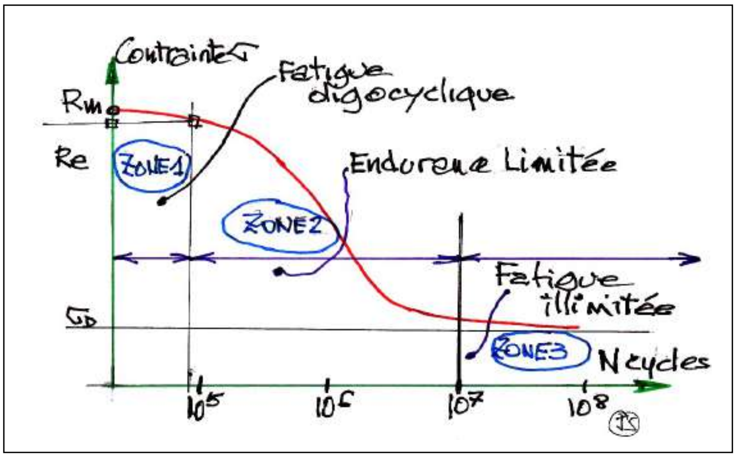


The term "*loading cases or conditions*" refers to the influence of the ship's displacement and sailing conditions (speed, acceleration, sea state, etc.), which generate dynamic mechanical solicitations, vibratory regimes that act on the ship and in particular on the ship's beam and are at the origin of the creation of cyclic solicitations.

The consideration of cyclic stresses then becomes essential.

The ISO 12215-9 standard provides an overview of these cycle numbers:

- Tacking and gybing - typically on the order of 10^4 alternating stress cycles over the life of the vessel
- Rigid body motions - typically on the order of 10^5 alternating stress cycles over the life of the vessel
- Flutter or vibration related phenomena - typically on the order of 10^5 alternating stress cycles over the life of the vessel.



Fatigue strength is well represented by the Wöhler curve.

The Wöhler curve of a material represents the experimental relationship between the amplitude of the applied stresses S (ordinate) and a number of cycles N (abscissa).

At the beginning "Cycle 1" the maximum admissible stress is the mechanical resistance Rm of the material. As the number of cycles increases, the fatigue stress decreases.

The horizontal line at the bottom of the curve is called "endurance limit".

Below this stress, the service life is infinite (provided that no other damage occurs, such as corrosion).

The Wöhler curve divides the "Ncycles" space into 3 zones:

o The low cycle fatigue zone (between "0" and 10^5cycles)

Low cycle fatigue corresponds to the area (Zone 1 of the Wöhler curve) with a very short life span. It includes "plastic fatigue", however there are for example high strength alloys for which low cycle fatigue does not necessarily involve plastic deformation.

o Limited endurance zone (between 10^5 and 10^7 cycles)

This is zone 2. The life without failure must not exceed the number of cycles determined by the tests.

o Unlimited Fatigue Zone (beyond 10^7 cycles)

This is Zone 3. If no cracks appear during the 10^7-cycle tests, the part or assembly is considered "sound". That is, there is little chance of a fatigue failure occurring.

The problem is that everything is based on the number of fatigue cycles and that this total number of cycles is closely related to the time factor, i.e. the life of the vessel and the severity of the cyclic stresses it encounters.

The life of a boat is theoretically based on 8 million cycles (assumption of the ISO 12215-9 standard).
These 8 million cycles are (10^7 cycles) - (2 million cycles).
We are therefore quite close to the hinge between the zone (2) of endurance and the zone (3) of unlimited fatigue.

These 8 million cycles refer to different periods, speeds and sailing conditions (maneuvers, sea conditions, regularity of wind, etc.). It is obvious that this number in the global state is an approximation.
Not all mechanical components undergo the same number of cycles over the same period. For example, the rudder stock is subject to much more alternating bending than the keel blade, because each force on the tiller generates a cycle, and therefore a bending moment in the stock, the intensity of which depends on the force exerted on the tiller.

As it is impossible to carry out full-scale tests over an unlimited period of time (at least up to 107 cycles), we work on a hypothesis that we think is realistic. For the keel sail, the cycles are generated by the tacking, the instability of the heel and the movements resulting from the waves encountered.

Thus, for Standard 12215-9, the assumptions correspond to about 25 to 30 years of moderate to heavy use in normal recreational sailing (including basic racing) or about 5 years of intensive offshore racing (about 30,000 miles of racing per year plus associated training and preparation).

These assumptions are close to reality, with a very large safety margin, for cruising yachts (even some one-offs).
On the other hand, for boats used by "professional" crews, the assessment is much more complex and depends on the type of boat and the race course. For example, a Vendée-Globe is 28,000 miles in Category 0.
In addition, these hypotheses implicitly consider that the boats remain permanently Archimedean during their operating time.

Indeed, these assumptions become false in the case of racing yachts which use, occasionally during navigation, means of lift (foils and pendulum keels) which amplify the cyclic movements and generate variations in loads which are very difficult to evaluate and which are higher than those of the same boat sailing permanently in Archimedian regime.

As for the effects of shocks, buckling, punching by the sea of the planks or associated structures, slamming, they are also much less well evaluated (remember the punching of the planking of American Magic during AC36).

4/ How can we control this problem?

The number of accidents concerning keel losses in relation to the number of pleasure boats in circulation in the world is infinitesimally low, which does not exempt us from being interested in this phenomenon of ruin.

Secondly, the ISO 12215-9 standard seems, to date, sufficiently complete and explicit to govern the assembly of keels to the hull of boats during design and manufacture.

Indeed, the tools contained in ISO 12215-9 allow design offices to dimension, but especially to design systems that limit stress concentrations. It is obvious that the know-how of the design office is the best defense against these types of fatigue failure.

This does not mean, however, that in the field of ocean racing, it is not necessary to alert builders, owners and skippers of certain risks of technological ruin caused by cyclic fatigue stresses.

The CE certification appears as the exhaustive reference for the manufacturing of a pleasure boat.
Moreover, the OSRs refer both to this certification (especially for Sampling and Stability) and to the texts of the ISO standards.

There is no classification in the EC Directive for sailing boats that can be used in regattas, whether coastal, offshore or "transatlantic", even though these boats are used in offshore races in more difficult sailing conditions than those normally encountered by a cruising boat.

However, the European legislator has issued this warning about loading conditions.

"During the final stages of development of ISO 12215-9, and after some of its essential parts were published, several authorities adopted this International Standard for the assessment of high-performance racing yachts. While it is true that a Class A cruising yacht intended for trans-oceanic sailing can theoretically undergo the same loads as a competitive racing yacht, these have not been the primary focus of ISO 12215-9. Designers are therefore strongly cautioned not to design a competition sailboat with virtually all structural elements just right."

This precision is important and in fact defines the limits of application of ISO 12215-9 or any standards that rely on the same limits.

Indeed, the interpretation of structural strength calculations (hull bottom, keel assembly, etc.) is based on the calculation methods used, but above all, in the end, on the comparison of the results with the limits that must not be exceeded.

And these limits depend on the conditions of use of the boat, i.e :

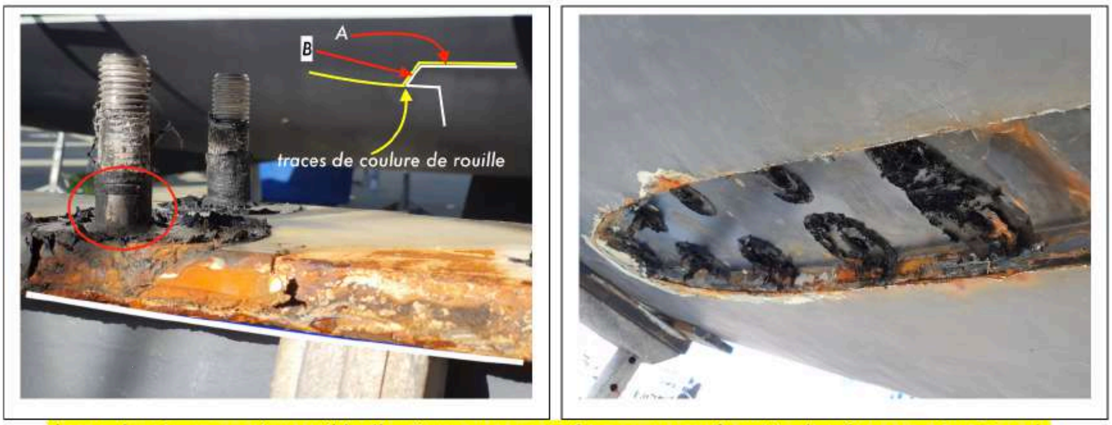
- **Its type and characteristics**
- **Its navigation area (sea and weather)**
- **The duration of navigation**

5/ The reliability and fragility of the recommended diagnostics

It should be noted that in the case of keel losses, **the ruptures affect totally inaccessible areas,** such as the interface between the sole and the hull, or the embedding of the nose of the keel fin in a well-integrated into the hull, or the bearings of a canting keel, etc... Three of the most common examples.

Local cracks in the gel-coat at the interface, or even traces of rust are not usable to deduce a diagnosis. At most, they point to remove the keel and a very local investigation of the bolts (the structural steel elements overmolded in the lead keel cannot be inspected), or of the composite (ultrasound).

As shown in the removal operation (keel) below, the entire periphery of the sole of the keel design showed rust runs at the hull bottom. The removal operation (keel) showed that the assembly was very sound, that even the stud threads were limited in such a way as to have a smooth cylinder at the exit of the cast iron ballast (sensitive zone in fatigue). The rust runs were in fact coming from the lower edge of the cast iron sole which is impossible to protect from corrosion, even with a paint.



Il est mécaniquement impossible d'avoir un contact surface contre surface simultanément en A et B car la géométrie est surabondante. On privilégie l'appui sur A car c'est la surface fonctionnelle, la surface B est liée à la hauteur d'implantation du goujon ou de la tête de la vis, suivant le type d'assemblage. Son encastrement dans l'épaisseur de la coque est optionnel, la semelle pourrait très bien être entièrement en surépaisseur sur la coque du bateau.

This removal of the keel prescribed by the OSRs appears to be a precautionary principle. The decision to remove at the time of the inspection (rust on the periphery of the keel sole) will remain a very subjective decision.

Prescription 3.02.2 also refers to the tightening of bolts, screws, studs used for the assembly of the keel to the hull and asks for reference to the owner's manual.

Let's be realistic, this operation is not trivial, and especially should not be carried out without having the keel/hull assembly plan. Indeed, everything depends on the type of assembly:

- o Has a rigid gasket such as casting resin or a Sykaflex type gasket or a non-polymerizing gasket, etc., been used in the keel/hull interface?
- o Is it a conical embedding?
- o What is the tightening torque?

These are all questions that are not answered in the owner's manual. Even if you go to a local boatyard, unless it is a dealer of the manufacturer (and even then), there is little chance that it can answer these questions. Also, on many boats, the hex nut heads are covered with lamination, when they are not completely inaccessible, especially for a torque wrench.

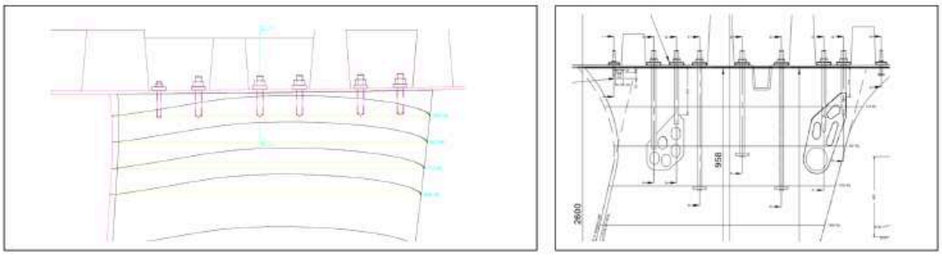
In fact, it is not recommended at all (it is not even recommended) to attempt to tighten the keel bolts. In fact, over time, both threads (threaded rod and internal nut threads) will wear away, making it impossible to check the torque on each bolt.

If you really want to carry out this type of control (existing torque), you must first completely unscrew all the nuts, clean the threads, then grease them, renew the waterproof mastics ... etc. It is also necessary, in the case of lead pins, to know if the threaded rods are integral with an internal structure overmolded in lead or are studs screwed into overmolded nuts, because loosening can extract the studs and not unscrew the nuts ... which will cause serious difficulties.

It is obvious that without the technical documents (mechanical drawings, technical bills of materials, etc...) it is impossible to generate a technically reliable investigation process.

If the objective of OSR 3.02.2 is to perform a real check of the assembly elements and the hull bottom connection structure, it is essential to proceed to a real removal of the keel of the boat, following a procedure established by the manufacturer. This is not clearly requested in the form and in Annex L, which only mentions "tightening the bolts".

This type of operation, if not carried out properly, can lead to a more degraded situation afterwards than before, and even dangerous.



Deux types d'implantations (quille en plomb) très différentes.
D'où l'obligation d'avoir le plan complet de conception avant de se lancer dans des opérations de resserrages.

It must be taken into account that some operations totally unsuitable but carried out within the framework of this research imposed by the prescription 3.02.2 can create an environment that is potentially triggering ruin processes that did not exist before the prescribed interventions.

6/ The relationship between space-time and the use of the boat

As explained in the previous paragraph, this prescription (3.02.2) suffers from a method of expertise that is based exclusively on the external vision of the assembly.

From this vision, the operator draws a diagnosis which is not very reliable because of the nature of the type of potential ruin which is sought.

Finally, both the expertise and the diagnosis are carried out without the operator knowing the nature of the technical design of the assembly and the assembled elements.

Then this prescription, by listing the actions to be carried out, appears to be very generalist, almost universal and totally independent of factors of scale and temporality.

- This requirement should apply to a 9m boat (3.2 T displacement) equipped with a basic cast iron keel of 1 T and a draft of 1.70 m as well as to a 20 m boat (10 T) and 4.50 draft, 4 T bulb and a canting keel.
  While everything, by the effect of scale, differentiates these two boats.
  Just the visual access to the interface (exterior) to be inspected is very different. In the first case, this is normally done on the boat park, in the second case, a scaffold or a self-contained gondola is required.

- This requirement must be applied on a fixed periodicity of 24 months, without taking into account the navigation (number of cycles and possible incidents) that will have been actually carried out. This distorts the validity of the inspection since the potential causalities that could lead to the ruin of the assembly depend on the actual navigation time and the incidents. After a 26,000 mile round the world race, the risk of fatigue is greater than after a season of racing in Europe, even if it is intensive (4,000 miles with transport over a year, that is 20 to 25 days at sea).

- One element is missing in this prescription, it is the log book which represents the "space-time / sailing conditions" element of the boat. Imposing a periodicity of 24 months between two inspections only makes sense if a record of the findings exists and remains accessible and also if the inspectors have the same level of training.

- This prescription, by its current decision-making organization, does not bring any certainty as to the seaworthiness of the boat, which is however the objective, since it is initiated in order to see if the boat is in a condition to participate in the race for which it is registered. I remind you that this inspection is not a mandatory technical control for all boats but an inspection before participating in one or more offshore regattas, since this document is valid for 24 months.

  In fact, the prescription lists a large number of actions to be carried out, the vast majority of which are technically impossible to carry out without complex operations and significant means, and also asks that a simple "technical" note be written (see Annex 1) on what has been observed. It is surprising that this note specifies in conclusion:

« *This visual inspection was conducted to observe and report on any notable visible indications that may compromise the structural integrity of the boat's keel and rudder. It does not guarantee that the boat is seaworthy or that the Owner has repaired any problems noted.»*

This note is, a priori, presented by the owner in his registration file as he does for his certificate of measurement or conformity to a Class.

The question that then emerges is the following:
What to do with this inspection form (which is not a control), which, according to the text of the OSR 3.02.2 seems very precise technically, and above all, what decision will eventually be taken by the organizer, the race director...?

It should be noted that Annex L of this requirement 3.02.2, imperatively details the actions that the authorized person must carry out. It is a "check list". But above all, the operator must note his conclusions opposite each action.

The following checks may be completed with boat in the water:		
Item:	Action:	Inspector's Notes:
Keel Bolts	Check for excessive corrosion. Torque to manufacturer's specs.	
Internal Hull Structure	Check for signs of structural failure and/or laminate separation especially in area around keel structure, keel floor and other stress points.	

What does "excessive corrosion" mean, where is the line between acceptable and excessive corrosion? We are entering a fuzzy area.

When we see (opposite) a canting keel sail during machining operations, we can reasonably question the validity of the findings of a visual inspection when the keel is assembled on the boat.

6/ Inspection of the rudder and control systems

For the purposes of rule 3.02.2, this is in principle the most easily achievable inspection (without taking into account the cost and resources required to carry out the operation, which obviously depends on the size of the boat).

The mechanical stresses acting on the rudder (or rudders) are almost exclusively those affecting the rudder stock in alternating bending, stresses which are closely related to the risk of ruin by cyclic fatigue. In fact, for more than 40 years, rudders have been of the suspended type (quite rarely installed on the transom), which exposes them to this type of stress.

Thus the inspection will focus on the search for fatigue cracks in the area of the rudder stock exit at the bearing. This inspection requires that the rudder stock be "lowered" (after disconnecting the control systems) when the boat is dry, without removing the entire rudder from the boat. The upper bearing area may be excluded from this inspection.

The most effective basic technique is local dye penetrant testing of the rudder shaft in the area near the hull bearing.

But here again the knowledge:
o Of the number of cycles related to mechanical stresses,
o The design of the rudder,
o the material of the rudder stock,

These are the essential parameters that the inspector must know in order to draw up his conclusions.

Thus, in this OSR 3.02.2 prescription, we always come back to :

- Ignoring what I will call "the time horizon" which is the basis of all operations of monitoring and aging of a mechanical assembly solicited in a cyclic way.
- Do not correlate the type of boat and its use with the idea of inspection of this type.
- Impose a bi-annual inspection, which will result in a "certificate" without technical value.

7/ Conclusion

The boats put on the market since more than forty years are more and more reliable and safe. This is true for cruising boats and for those used in offshore regattas.

That leaves the boats, let's say for "regatta" use in "professional" circuits.

This is where the hinge between the "basic" use of the standard owner (CE boat) and that of boats where optimization, innovation in terms of design can result in technological risks amplified by sailing in complicated areas.

Very often these types of boats belong to well-structured classes (IMOCA, CLASS 40, FAST 40, MAXI, Mini-Maxi, Mini 6.50 etc.).

If we want to manage these risks, we must work with the classes. Indeed, their loading cases are clearly superior to those of "basic" boats, even if they are used in offshore races, even transatlantic ones.

We think that this 3.02.2 prescription will quickly become a biannual "paying formality", which will not bring any additional safety to the "basic" boats and also to those that can be classified as "high performance".

But we must not forget that the application of this rule OBVIOUSLY imposes that someone or some entity (Organizer, Race Committee, Jury, ... etc...) decides on the participation OR the non-participation of the boat in a regatta...

The responsibility of the decision maker will be engaged, whatever is written in the race documents to avoid a possible responsibility (Special Reg, Notice of Race... etc...), especially if by misfortune the debate moves to the Penal one since this rule 3.02.2 seems to supplant the rule 1.02 (Responsibility of the owner on the state of his boat described in the OSR rule 1.02 Responsibility of the Person in charge of the boat).

Jean SANS / Hubert SCHAFF (09/04/2022)

ANNEXE 1 Commentaires possible sur les actions décrites dans l'ANNEXE L de la 3.02.2

ACTIONS	**VISIBILITY Or Comments**	**DIAGNOSIS POSSIBLE? Y/N**
The inspection of the structure of a boat must be done by a qualified person,		
Inside and outside	Possible	
Owner's Manual for the specific boat	Very succinct document technically	Very limited or impossible
The type of keel		
▪ Inspect in detail any high load areas	Impossible without blueprint	None
○ Keel attachment	Very limited to poor	Extremely limited
○ Keel sole	NO	NO
Pay particular attention to prior repairs, especially after a grounding.	No knowledge of the life history of the boat	None
Internal inspection: Check the bearing plates, bolting devices, sump area and keel sole for signs of cracking, weakening or delamination.	Very limited visibility, possibly none.	No serious diagnosis possible
Lead or lead alloy keels may require tightening of bolts to ISO	Tightening not recommended. Tightening can generate causes of ruin	No diagnosis possible
Check that the bolt holes are not "ovalized	No visibility	Aberrant action
Visually inspect the supporting structure for disbondment.	Aberrant action	No diagnosis
External inspection: Check for signs of stress cracks (not gelcoat cracks) around the keel to hull attachments	Gelcoat cracks do not mean "cracks" in the hull	No reliable diagnosis possible
Movement or opening around the keel/hull interface that could allow water ingress	Not both actions at the same time	What diagnosis to make?

Consequential corrosion of the keel bolt	Visible, but what does "consequential" mean?	What diagnosis can be deduced from this? Is it absolutely prohibitive?
If in doubt, sand the bottom paint/gelcoat to identify the depth of the crack	Action that can be taken	Who is repairing after the inspection?
Check the deflection of the keel tip to ensure immediate return and no concomitant internal movement in the keel bottom	On COMANCHE (6.80m draft), WILD OATS XI, Etc... ?	Visual diagnosis impossible...
Visually check the zones of strong constraint, in particular around the zones of front and back fixing of the keel	Where are these areas located?	Aberrant instruction.
Lift and rotate the keels		
Check that there are no significant stress cracks in the structure around the pins supporting the keel	No visibility (ashore: fairing. afloat: underwater)	No diagnosis possible
Check for heavy corrosion on the shafts, bearings and supporting metal structure.	What is a lot of corrosion? Shafts, bearings?	Access impossible without removing the canting keel.
Steering systems		
Rudder(s).		
Check for damage or stress cracks in the bearing area	Remove rudder(s)	Carry out tests to find cracks
Vérifier l'intégrité de l'arbre et des pales du gouvernail	Visually?	Subjective diagnosis
Effectuer un essai de flexion de l'extrémité pour déceler tout mouvement excessif	Test possible, BUT which range of deflection do they accept?	Very subjective diagnosis.

ANNEXE 2 Modèle de formulaire annexé à la règle 3.02.2

APPENDIX L
Model Keel and Rudder Inspection Procedure

The model form is not the only means of meeting the needs of OSR 3.02.3 Evidence of Periodic Structural Inspection, Organizing Authorities may develop on-line forms.

Structural Inspection of a boat shall be completed by a qualified person both internally (may be in the water) and externally (out of the water). The purpose of this inspection is to identify and report to the Owner the condition of the keel and keel structure observed during this inspection. It is the responsibility of the Owner to undertake any repairs.

Consult the Owners' Manual for the specific boat, steering system and type of keel (e.g. fin, lifting, swinging, full length). Inspect in detail any high-load areas: keel attachment, keel floor, steering systems, rudder(s). Pay special attention to prior repairs, especially following groundings.

Internal Inspection: Check backing plates, bolting arrangements, sump area and keel floors for any signs of cracking, weakening, or de-laminated tabbing. Lead or lead alloy keels may require tightening of bolts to ISO standards due to lead creeping. Inspect keel bolt nuts for corrosion. Check bolt holes for "ovaling." Visually inspect for possible de-bonding of the supporting structure.

External Inspection: Check there are no signs of stress cracks (not gelcoat cracks) around the keel attachments to hull, or movement or opening around the keel/hull interface which may allow water ingress and consequent keel bolt crevice corrosion. If in doubt, sand back bottom paint/gel coat to identify depth of crack. Check keel tip deflection to insure immediate return and no internal concomitant movement in the keel floor. Visually check high stress regions, particularly around the forward and aft hull attachment areas of the keel, for signs of paint or gelcoat cracking or large, deep blisters, which can indicate separation and structural weakness.

Rudder/Steering system: Check bearing area for any damage/stress cracks; check rudder shaft and blade integrity, especially at any shaft joins and at upper connections to hull/deck. Undertake a tip deflection test to identify any excessive movement. If applicable, check rudder straps and gudgeons for corrosion or cracking.

Lifting and swing keels: In addition to above, check there are no significant stress cracks in structure around pins supporting the keel. Check for extensive corrosion on pins, cylinders and supporting metal structure.

Model Keel and Rudder Inspection Form

Boat Name:		Sail Number:
Owner Name:		Designer:
Address:		
Owner email:		Builder:
Primary Launch Date:		Hull Identification Number:
World Sailing Plan Review Certificate Number:		
The following checks may be completed with boat in the water:		
Item:	Action:	Inspector's Notes:
Keel Bolts	Check for excessive corrosion. Torque to manufacturer's specs.	
Internal Hull Structure	Check for signs of structural failure and/or laminate separation especially in area around keel structure, keel floor and other stress points.	
The following checks to be conducted externally with boat out of the water:		
External Hull Condition	Check for hull stress cracks around leading and trailing edge attachment point to structure, hull appendages and keel sumps. Inspect keel/hull interface for signs of damage by tip deflection test.	
Rudder	Check for cracking of the rudder bearing/hull assembly. Inspect rudder for integrity by tip deflection test.	
Declaration of Completed Inspection:		
Location:	Date:	
This visual inspection has been conducted to observe and report on visually noticeable indications that may compromise the structural integrality of the vessel's keel and rudder. It does not ensure that the vessel is seaworthy or that the Owner has repaired the identified problems.		
Print name:	Signature:	
Address:		