

Name of Authorised Person:	Glen Stanaway
Position:	Australian Sailing
Title of Proposal:	Keel Inspections
Subtitle:	Non-destructive testing of welded metal keels and full re-write of related Offshore Special Regulations.
Related proposals:	

Proposal:

Amend Offshore Special Regulation 3.02 and Appendix L by:	
- Introducing non-destructive testing requirements for welded metal keels. - Introducing references to ISO12215-9 Clause B.5 for keel bolt tightening. - Making many other administrative edits to terminology, grammar and punctuation.	
Mo0,1,2	3.02 Watertight and Structural Integrity of a Boat 3.02.2 a) <u>Structural Inspection – An inspection shall be conducted by an independent qualified person with the boat out of the water. Consult the owner’s manual for any instructions for keel bolt checking and re-tightening. See also ISO12215-9 clause B.5. In addition, 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).</u> b) <u>Non-Destructive Testing - Welded metal keels shall be examined by an independent qualified person using non-destructive testing techniques (such as dye penetrant, ultra-sonic, X-ray and other methods) to reveal any cracks or other defects in welds.</u>
	Mo0,1,2 3.02.3 a) <u>Evidence of a structural inspection in accordance with 3.02.2(a) within 24 months before the start of the race or after a grounding whichever is later.</u> b) <u>From 2030, evidence of non-destructive testing in accordance with 3.02.2(b) within 10 years before the start of the race or after a grounding whichever is later.</u>
Mo3	3.02.4 At a haul-out within 2 years prior to the event, the owner or his/her representative shall inspect the integrity of the keel and rudder following the requirements of Appendix L.

Mo0,1,2,3	3.02.5	Inspection after Grounding – an appropriately qualified person shall conduct an internal and external inspection after each unintentional grounding.
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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(a). As evidence of Periodic Structural Inspection, Organising Authorities may develop on-line forms.

Evidence of non-destructive testing and its findings meeting the needs of OSR 3.02.3(b) shall be provided in a document signed by the person representing the organisation that performed the tests.

Category 0,1,2 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 regular inspection is to identify and report to the Owner the condition of the rudder, keel and keel structure observed during this inspection. For Category 3 inspection, the Owner/representative shall inspect the integrity of the keel and rudder. It is the responsibility of the Owner to undertake any repairs.

Category 0,1,2 from 1 January 2030, welded metal keels shall undergo non-destructive testing to examine welds for cracks or other defects. Techniques such as dye penetrant, ultrasonics, X-rays and other methods may be used. These tests shall be conducted by an independent, qualified person.

Consult the Owners' Manual for the specific boat, steering system and type of keel. 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: Inspect backing plates, bolting arrangements, sump area and keel floors for any signs of weakening, such as cracking or de-laminated tabbing etc. Keels may require tightening of bolts in accordance with the torque specified in the Owner's Manual. In the absence of an Owner's Manual, refer to ISO12215-9 clause B.5. Inspect keel fasteners for corrosion. Inspect bolt holes for deformation. Conduct a visual inspection to identify potential de-bonding of the supporting structure.

External Inspection: Inspect for any signs of stress cracks (not paint or gelcoat cracks) around the keel attachments to hull, or movement or opening around the keel/hull interface which allows water ingress and consequent keel bolt crevice corrosion. If in doubt, remove bottom paint/gelcoat to identify depth of crack. Undertake a keel tip deflection test to identify any excessive movement. Visually inspect 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, swing and canting 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

<u>Boat Name:</u>	<u>Sail Number:</u>
<u>Owner Name:</u>	<u>Designer:</u>
<u>Address:</u>	
<u>Owner email:</u>	<u>Builder:</u>
<u>Series Date:</u>	<u>Hull Identification Number:</u>
<u>World Sailing Plan Review Certificate Number:</u>	

The following checks may be completed with boat in the water:

<u>Item:</u>	<u>Action:</u>	<u>Inspector's Notes:</u>
<u>Keel Bolts</u>	<u>Inspect for excessive corrosion. Torque to manufacturer's specs (In the absence of manufacturer's specs, refer to ISO 12215-9 clause B.5).</u>	
<u>Internal Hull Structure</u>	<u>Inspect for signs of structural failure and/or laminate separation especially in area around keel structure, keel floor and other stress points.</u>	

The following checks to be conducted externally with boat out of the water:

<u>External Hull Condition</u>	<u>Inspect for hull stress cracks around forward and aft edge attachment point to structure, hull appendages and keel sumps.</u> <u>Inspect keel/hull interface for signs of damage by tip deflection test.</u>	
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<u>Rudder</u>	<u>Inspect for cracking of the rudder bearing/hull assembly.</u>	
	<u>Inspect rudder for integrity by tip deflection test.</u>	
<u>Declaration of Completed Inspection:</u>		
<u>Location:</u>	<u>Date:</u>	
<u>This visual inspection has been conducted to observe and report on visually noticeable indications that may compromise the structural integrity 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.</u>		
<u>Print name:</u>	<u>Signature:</u>	
<u>Address:</u>		

Category	Rule number	Rule wording
0, 1, 2	3.02.2	Introducing references to ISO12215-9 Clause B.5 for keel bolt tightening.
0, 1, 2	3.02.3	Introducing non-destructive testing requirements for welded metal keels.
0, 1, 2, 3	Appendix L	Adding references to ISO12215-9 Clause B5 for keel bolt tightening Adding references to non-destructive testing of welded metal keels. Making many other administrative edits to nomenclature, grammar and punctuation

Current position:

The Offshore Special Regulations are silent on:		
1. Non-destructive testing of keels; there is no current position. 2. Alternate sources of advice on keel bolt checking and retightening for cases when the owner's manual is not available. 3. There are many errors in nomenclature or expressions.		
Mo0,1,2	3.02	Watertight and Structural Integrity of a Boat
	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).

Mo0,1,2	3.02.3	Evidence of a structural inspection in accordance with 3.02.2 within 24 months before the start of the race or after a grounding whichever is the later.
Mo3	3.02.4	At a haul-out within 2 years prior to the event, the owner or his/her representative shall inspect the integrity of the keel and rudder following the recommendations in Appendix L.
Mo0,1,2,3	3.02.5	Inspection after Grounding – an appropriately qualified person shall conduct an internal and external inspection after each unintentional grounding.

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, Organising Authorities may develop on-line forms.

Category 0,1,2 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. Category 3 inspection: from 1 January 2023 the Owner/representative shall inspect the integrity of the keel and rudder. 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.

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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:	
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This visual inspection has been conducted to observe and report on visually noticeable indications that may compromise the structural integrity 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.

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Print name:	Signature:
Address:	

Reasons:

Non-destructive tests:

1. Fatigue in metallic fabricated welded keels is a significant mode of keel failure globally. In recent decades there have been multiple keel failures resulting in loss of life, of which the majority was due to this mode.
2. ISO12215-9:2025 seeks to address this by improving fatigue-life assessment procedures and increasing the life of metal fatigue from 8 million cycles to 16 million cycles and requiring that recommended inspection methods be clearly stated in the Owner's Manual. This will apply to new boats with fabricated metal keels; however, this does not lower risks of fatigue in existing keels designed and built under earlier versions of ISO12215-9 or the ABS Guide for Building and Classing Offshore Yachts.
3. Fatigue in metals is the mechanism of progressive failure that occurs due to the repeated cyclical application of loads of magnitude less than the yield stress and the ultimate strength of the metal. Failure initiates and progresses due to cracking of the metal. Cracking can usually be identified before ultimate failure.
4. If not identified, fatigue crack initiation and growth results in instantaneous catastrophic separation of the keel from the vessel's hull, resulting in its capsize and inversion due to grossly inadequate remaining stability, which is what ultimately leads to loss of life.
5. Fatigue cracks in metal are not always visible to the human eye. These cracks that the non-destructive tests should identify may be as small as 5 microns (five-thousandths of a millimetre).
6. Performing periodic non-destructive testing on metallic fabricated welded keels will reduce the likelihood of loss of life due to keel failure.
7. Welding is a process where it's easy to include flaws and the easiest time to conduct a non-destructive test is before the fairing has been applied. An Xray test will pick up these welding flaws, therefore they can be corrected before the fabrication is shipped to the boat shop.

Keel bolt tightening:

8. When boats change owners, manuals are sometimes lost or over time designers are unavailable. Alternate sources of advice on bolt tightening are required for these cases.
9. The *ISO12215-9 Small craft - Hull construction and scantlings - Part 9: Sailing craft appendages* provides advice on bolt tightening and pre-stressing. This standard is relied on by relevant subject matter experts globally.
10. Bolt tightening in accordance with the manual or ISO12215-9 Clause B.5 should identify degradation to keel bolts and avoid the risk of this mode of keel failure.

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Changes to terminology:

11. Terminology used in the OSR must be correct. A working party of engineers/naval architects read the OSR and Appendix and recommended the changes.