Monohull sailing vessels operating in categories 2 to 6 with external ballast keels carrying not more than 15 persons are not required to have full stability books and consequently no computed information is held by the Certifying Authority.

The Master should complete all sections relevant to the vessel and make it available to watchkeepers.
This booklet was prepared by a working group comprising representatives from:
The Royal Institution of Naval Architects
The Royal Yachting Association
The Royal National Lifeboat Institution
The Jubilee Sailing Trust
The Multihull Offshore Cruising and Racing Association
The Wolfson Unit for Marine Technology and Industrial Aerodynamics
in consultation with a wide range of experienced seafarers.

Illustrations by Sarah Selman

It should be noted that, while every care has been taken in the preparation of this booklet, the advice and information given cannot take account of every exceptional circumstance. Final responsibility for the safety of the vessel rests with the Master.

Owners may find it helpful to display pages 1 to 5 in a prominent place for the information of the crew.
Master's standing orders

Recommended sequence for reducing sail area

<table>
<thead>
<tr>
<th>Sail combination</th>
<th>Maximum apparent wind speed (kts)</th>
<th>Computed</th>
<th>Master's instruction</th>
</tr>
</thead>
<tbody>
<tr>
<td>(eg: mainsail, mizzen, working genoa)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(eg: mainsail, mizzen, 70% of working genoa)</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>(eg: 1st reef in mainsail, 40% of working genoa)</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>(eg: 2nd reef in mainsail, heavy weather jib)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(eg: 3rd reef in mainsail, heavy weather jib)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(eg: trysail, storm jib)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(eg: storm jib)</td>
<td></td>
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</tr>
</tbody>
</table>

What to do if hit by a sudden gust

What to do after a knockdown

Certifying Authority approving the data (computed and below)

Stability assessed assuming

- Maximum permitted number of persons
- Maximum permissible weight to be carried (kg)
- Minimum operating displacement (tonnes)
- Maximum loaded displacement (tonnes)

Outfit items included in the assessment

- Life raft(s) (eg: 2 by 8 person life rafts in containers on coach roof)
- Mast(s) (eg: alloy extrusions, main = 7.4kg/m, mizzen = 2.9kg/m)
- Dinghy (eg: rigid dinghy in stem davits)
- Radar (eg: radar antenna weighing 4kg on wheelhouse roof)
- Furling (eg: in-mast furling mainsail, roller furling genoa)

Other topweight

8 List to be tailored to individual vessel.
9 Caution – refer to explanatory note 18.
10 Calculations are required by MCA Code for all multi-sail and form-stable vessels. Data to be supplied or verified by the Certifying Authority.
12 Data to be provided by the Master, especially when computed data is not available. These figures are not required to be checked by the Certifying Authority. Where both are provided, the Master’s instruction should not exceed the computed value.
13 To be completed by the Master. Not required to be checked by the Certifying Authority.
14 Where this is available.
15 All items likely to significantly affect the vertical centre-of-gravity should be included. This list may not be necessary in very large vessels.
Explanatory notes

General cautions

1 Weight added above the centre-of-gravity of the vessel, or taken off below the centre-of-gravity reduces the stability. What may seem to be a small effect near the upright is greatly increased at 90° of heel.

The ability to recover from a knockdown or inversion may be drastically reduced by a seemingly small increase in centre-of-gravity height.

The effect of a suspended weight is as if it were located at the point of suspension. A vessel can be capsized even in perfectly calm water by lifting an excessive weight, or by raising the point of suspension too high. A very slow rolling motion is a sign that this condition may be being reached.

2 A list or permanent heel in one direction reduces the stability in that direction. A trim down by the bow may reduce the directional stability, increasing the tendency to turn and increasing the possibility of broaching in following seas, or of shipping water over the bow.

A trim down by the stern may increase the directional stability, thus reducing the ability to manoeuvre, and increasing the possibility of shipping seas over the stern.

3 All monohull vessels under about 24m length are capable of being inverted by a breaking wave of sufficient size. To be dangerous in this respect, a breaking wave must have a height exceeding the beam of the vessel.

Carefully designed fore-and-aft rig monohull sailing vessels with a sufficiently high Angle of Vanishing Stability (eg: as required by the Code of Practice) can be expected to recover after a complete inversion within a short period of time.

4 Multihulls and form-stable monohulls reach maximum stability at a relatively small angle of heel (typically 10° to 15°) and very seldom have sufficient righting moment at 90° heel to overcome the wind forces on the bridge-deck structure. Virtually all multihulls and form-stable monohulls are therefore capable of being capsized by wind action alone if too much sail is carried.

As soon as the wind moment exceeds the maximum righting moment, a complete inversion is inevitable. Code vessels are designed to continue to float if this occurs, but clearly this is not a situation from which the crew can recover without outside assistance.

It is therefore vital that the amount of sail carried is not sufficient to cause capsise, even in a gust, which may cause a doubling of wind heeling moment.

Before putting to sea

5 Bilge water if present in any quantity reduces the effective stability of the vessel. As the vessel heels, loose water moves to the lower side, thus increasing the initial heel angle (‘free-surface effect’). Many vessels make some bilge water in rough conditions, so regular bilge checks at sea are advisable.

Pump suction is often prone to clogging with debris that has found its way to the bilges, so suction points should be checked and cleared before sailing.

6 Cockpits, or decks with bulwarks rely on drains and free-line ports to enable any water shipped to drain away quickly. It is important that such fittings are working properly, because trapped water reduces the stability in two ways:

Firstly water trapped on deck has the same ‘free-surface effect’ as loose bilge.
water (see note 5 above). Secondly water trapped high in the vessel raises the
centre-of-gravity (see note 1), and its weight also reduces freeboard so that
more water is likely to be shipped.

Deck drains and freeing ports (especially those fitted with non-return flaps)
must therefore be in proper working order.

7 Most vessels are fitted with various types of opening that may admit water if
left open when at sea, namely: portlights, skylights, engine or deck hatches.
The stability is assessed assuming that all openings marked ‘to be kept shut at
sea’ have been closed.

If such openings are not closed before putting to sea, a progressive
accumulation of bilge water is likely with consequent adverse effect on the
stability – see note 5 above.

8 Some seacock must be left open for the proper working of the vessel’s
systems, eg: engine cooling, drains and scuppers, fire pump suction. Some
may cause inadvertent flooding if left open. Typically these include those
relating to toilets and sinks fitted relatively low in the vessel and which may
become submerged when the vessel is heeled to large angles.

9 Loose gear, if not properly secured, will fall to the low side of the vessel
when it heels. Apart from the risk of injury or damage, this has a similar
effect on stability as loose water – see note 5.

It is especially important that heavy items such as batteries or spare anchors
are very well secured against movement, even at very large angles of heel,
for example after being heeled to 90° or more.

10 If the vessel is fitted with air tanks or flotation spaces, survival after swamping or
damage may be severely impaired if such spaces are not well maintained and
regularly checked for water. Drain plugs on all such spaces should therefore be
opened at regular intervals to ensure that leakage has not occurred.

At sea in normal conditions

11 The bigger the wave relative to your vessel, the greater the risk of being
rolled by a beam sea. This risk can be significantly reduced by not taking
such waves beam-on. See also note 24.

12 A recommended sequence for shortening sail is given in the front of this
booklet. It is important to be familiar with this, especially on sailing
multihulls and form-stable monohulls, which can be capsized if too much
sail is carried.

13 Monohull sailing vessels, if sailed at less than the recommended maximum
steady heel angle (see front of booklet) are unlikely to experience
significant downflooding even in a strong gust (ie: 40% higher than the
average wind speed).

Rather than continuously referring to an inclinometer, check how this angle
for your vessel compares to the angle at which the lowest point of the deck-
edge or bulwark becomes submerged – see the information in the front of
this booklet. Keeping the side-deck dry is often a good indicator.

A full explanation of recommended maximum steady heel angle is given in
the full MCA Master’s Stability Information Booklet in the section called
Maximum Steady Heel Angle to Prevent Downflooding in Gusty.

14 Resonant rolling occurs when an initial disturbance causes a rolling motion
that progressively grows due to the action of the wind or waves.

Vessels may experience resonant rolling if encountering a series of fairly
regular beam waves. The waves do not have to be especially large, but may
just have a period similar to the natural rolling period of the boat. Due to the
damping effect of wind in the sails, this is generally of less concern to vessels
under full sail.

A change of heading and/or
speed reduces resonant rolling
motions.

Fore-and-aft rigged monohull
sailing boats running dead before
the wind, even in smooth water,
can develop a rolling action that
can magnify so much that control
is lost and the boat broaches
violently.

Sheeting in the mainsail, or fitting a gybe preventer and running by the lee
may solve the problem.

15 Tight turns at speed generate substantial centrifugal forces that can increase
the risk of capsizing.

16 A fast ferry develops a different kind of wash from a conventional ship, a
wash that may only reach your vessel some 15 to 20 minutes after it has
passed. Such wash comprises a few very short and steep waves that are
normally not dangerous.

However, when such waves encounter relatively shallow water they can
become dangerously high and steep, sufficient to swamp smaller boats. It is
therefore wise to avoid shallow water in the vicinity of routes where such
ferries operate at high speed.
17 The apparent wind speed is dependent on the vessel’s speed and the apparent wind direction. Altering course closer to the wind will increase the apparent wind speed, particularly in faster vessels. Therefore be aware that conditions can seem to get significantly rougher after altering course closer to or into sea and wind, and consider reducing sail before such an alteration of course.

18 To be prepared for the eventuality, make sure that you know the best technique for heaving-to or laying-a-hull for your specific vessel. This may require some experiment in suitably fresh conditions, especially for square-rigged sailing vessels.

The Master’s instructions are given at the front of this booklet.

19 Squalls (localised dramatic increases in wind strength) can often be anticipated by carefully observing the behaviour of other sailing vessels to windward, and are often detectable on radar. Squalls are also often accompanied by marked changes in cloud type and wind direction. If possible, reduce sail before encountering a squall. A good lookout is therefore necessary.

An explanation of how to restrict the steady heel angle to minimise problems in squalls is given in the full MCA Master’s Stability Information Booklet in the section called Maximum Steady Heel Angle to Prevent Downflooding in Squalls.

In unsettled weather, especially with rain squalls about, be aware that white squalls (or ‘microbursts’) can occur with no visible warning.

20 If a sudden gust of wind is unusually strong, threatening to heel a sailing vessel beyond 60°, rapid action should be taken to reduce the effect on the boat. Action with the helm is quickest to perform, but any navigational hazards in the area should be considered. Freeing all sheets is an alternative course of action if a change of course is not possible.

Because vessels differ in their behaviour, it is not possible to give generalised advice. The Master’s specific instructions should therefore be followed if such gusts are encountered — see the front of this booklet.

21 All vessels, if driven too hard in following or quartering seas, can bury their bows into the sea, resulting in a sudden increase in apparent wind speed. This behaviour may lead to ‘pitchpoling’ due to the bows digging into the trough of the wave while the stern is being lifted by wind and sea. The stern is then lifted OVER the bows!

Sailing multihulls, if pressed too hard in beam or quartering winds may ‘cartwheel’, i.e. when the lee-bow becomes submerged, causing tremendous drag, so that the boat pivots about this point in both pitch and yaw.

The solution is to reduce speed, and perhaps deploy a drogue.

At sea in rough conditions

22 In rough weather, small amounts of water regularly finding their way into the vessel over a lengthy period can accumulate alarmingly. One litre every ten seconds becomes 1080 litres or over a tonne every three hours! Before the going gets rough, all potential downflooding openings should be closed unless they really need to be open. On smaller vessels the only ventilators that should be left open are those fitted with water traps.

Special care should be taken with any hatches or ventilators fitted well off the centreline of the vessel, as these will be the first to become immersed when the vessel heels.

23 The main hatchway opening should be kept as small as practicably possible by keeping the sliding top closed, and one or more washboards in position. If hatches or doors need to be opened in a rough sea, close and secure them as soon as possible afterwards.

24 The broken crest of a breaking wave contains a massive amount of energy that can exert a powerful heeling effect on any vessel, especially those under about 24m length. Such waves are one of the most likely causes of capsize, so it is prudent to avoid areas where they are likely to occur.

Breaking waves are especially likely when wind is against tide, when the wind is rapidly increasing in strength, or after a sudden wind shift when waves are coming from different directions.
The most dangerous breaking waves are likely to occur where:
- there are tide races or overfalls marked on the chart
- the wind is contrary to the current direction
- the sea bed shoals rapidly, even if the least depth seems to be very generous
- near lee shores, especially those that shoal steeply
- in areas such as headlands where the current is strongest.

It is often possible, by alert helmsmanship, to steer the vessel away from threatening waves, but this is a tiring task and requires frequent changes of helmsman. However, avoiding such waves is much more important than keeping a steady course.

Broaching in following seas occurs when a wave crest picks up the stern, causing the bow to dig in and the boat to slew rapidly through 90°. In large waves, the violence of this uncontrolled manoeuvre can result in the boat being thrown onto its side, sometimes being completely inverted.

If the tendency to broach is persistent, consult the Master and slow the vessel down, in extreme cases by towing long hights of heavy warps or a strong drogue.

Emergency conditions

If any compartment is being flooded, whether through hoiling, failure of a fitting or downflooding, any watertight doors should be closed immediately, only being opened temporarily for access.

Similar action should be taken as a precaution when navigating in reduced visibility, or crossing shipping lanes, as the risk of collision damage is greatest. Some vessels do not slow down sufficiently when visibility is poor, so that a collision may occur within seconds of the other vessel being sighted.

**Some definitions**

<table>
<thead>
<tr>
<th>Angle of Vanishing</th>
<th>The angle of heel at which, in calm water, a vessel continues to an inversion rather than returning to the upright.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stability (AVS)</td>
<td>One of seven categories assigned under the MCA Small Commercial Vessel and Pilot Boat Code, based on distance from refuge.</td>
</tr>
<tr>
<td>Broaching</td>
<td>A violent turning and heeling effect created in following or quartering seas.</td>
</tr>
<tr>
<td>Buoyancy</td>
<td>The upward force produced when a vessel is immersed in water.</td>
</tr>
<tr>
<td>Capsize</td>
<td>When a vessel is heeled to any angle from which it cannot recover without assistance.</td>
</tr>
<tr>
<td>Design Category</td>
<td>One of four categories defined in the EU Recreational Craft Directive based on sea and wind conditions.</td>
</tr>
<tr>
<td>Downflooding</td>
<td>Flooding through openings that are normally above the calm water level.</td>
</tr>
<tr>
<td>Flooding</td>
<td>When a vessel fills with water relatively slowly, eg: through submerged downflooding openings, or through leaks of fittings below the waterline.</td>
</tr>
<tr>
<td>Flotation</td>
<td>Means of providing buoyancy in a vessel after swamping or flooding, eg: air tanks, air bags or foam material.</td>
</tr>
<tr>
<td>Form-Stable</td>
<td>Stability derived from the shape of the hull rather than ballast. Applies to vessels such as barges or multihulls.</td>
</tr>
<tr>
<td>Inversion</td>
<td>When a vessel turns completely upside down in the water.</td>
</tr>
<tr>
<td>Knockdown</td>
<td>When a sailing vessel is heeled to about 90°.</td>
</tr>
<tr>
<td>Pitchpole</td>
<td>When the vessel inverts end-for-end, eg: stern over bow.</td>
</tr>
<tr>
<td>Righting Moment</td>
<td>The moment tending to return a vessel to the upright, being the product of vessel weight and righting lever.</td>
</tr>
<tr>
<td>Swamping</td>
<td>When a vessel is suddenly filled with water from above, eg: by waves.</td>
</tr>
</tbody>
</table>
Explanatory notes

A vessel assigned to Area 0 is not restricted and therefore may be assumed to at times experience storms (force 10) with accompanying very high sea states, significant wave heights exceeding five metres.

A vessel assigned to Area 1 may experience severe gale (force 9) winds and associated sea states, significant wave heights exceeding four metres.

A vessel assigned to Area 2 may experience gale (force 8) winds and associated sea states, but is expected to seek sheltered waters before severe gale force conditions are met. Significant wave heights up to four metres may be encountered.

A vessel assigned to Area 3 may experience near-gale (force 7) winds and associated sea states, but is expected to seek sheltered waters before gale conditions are met. Significant wave heights up to three metres may be encountered.

Vessels assigned to Areas 4 to 6 may experience force 6 winds and associated sea states, but are expected to seek sheltered waters before force 6 conditions are exceeded. Significant wave heights up to two metres may be encountered.

29 Sailing vessels can reduce the heeling effect of breaking waves by raising the centreboard or daggerboard, because this reduces the tendency of the underwater hull to resist the waves. Boats fitted with twin daggerboards should only raise the leeward one.

Because righting moments would be reduced if a ballasted ‘drop keel’ were to be raised, this is not recommended. Indeed it is preferable for them to be locked down, so as to avoid movement in the event of an inversion.

Emergency conditions

30 In the event of a collision, if locked together the two vessels should not be separated immediately. This is for two reasons:

Firstly, the withdrawal of one vessel will increase the flow of water into the other, potentially resulting in rapid sinking.

A properly designed vessel will usually survive bow damage without immediate difficulty.

Secondly, evacuation of the more badly damaged vessel is much easier if the two remain in contact with one another.

Therefore carefully assess the condition of both vessels before attempting to separate them.