Then AD = KA-KD

The heeling moment = Bollard Pull x ED

When the vessel is inclined to angle $\Theta°$ to the upright

$$ED = AD \cos (30° + \theta°) - AC \sin (30° + \Theta°)$$

and Heeling Moment at angle $\Theta°$

$$= P [AD \cos (30° + \Theta°) - AC \sin (30° + \Theta°)]$$

$$\text{Now Heeling lever} = \frac{\text{Heeling Moment}}{\text{Displacement}}$$

$\therefore$ Heeling Lever at $\Theta°$

$$= P \quad \frac{AD \cos (30° + \Theta°) - AC \sin (30° + \Theta°)}{\text{Displacement}}$$

Note: that the reduction in displacement due to the vertical component of P is neglected.

(c) The righting lever (GZ) should be at least 0.20 metres at an angle of heel equal to or greater than 30°.

(d) The maximum righting lever (GZ) should occur at an angle of heel not less than 15°.

(e) The initial transverse metacentric height (GM_o) should not be less than 0.15 metres.

C.9.3 The criteria mentioned in C.9.1 and C.9.2 above fix minimum values, but no maximum values are recommended. It is advisable to avoid excessive values, since these might lead to acceleration forces which could be prejudicial to the vessel, its complement, its equipment and to the safe carriage of the cargo.

C.9.4 Where anti-rolling devices are installed in a vessel the Authority should be satisfied that the above criteria can be maintained when the devices are in operation.

C.9.5 A number of influences such as beam wind on vessels with large windage area, characteristics of motion, following seas, adversely affect stability and the Authority may require these to be taken into account so far as it deems necessary.

C.10 Tugs

C.10.1 Tugs should meet the criteria laid down in clause C.2.

C.10.2 In many cases tugs will be unable to attain their maximum summer draught by filling all tanks and store spaces. It may be necessary therefore to assume the addition of deck cargo to give the required summer draught. If the resulting curve of righting levers does not meet the criteria of clause C.2 a further loading condition should be arranged which will meet the minimal criteria of clause C.2. The summer freeboard will then be increased by the Authority to correspond with this modified loading condition.

C.10.3 In all conditions where towing can be undertaken, the tow rope heeling lever curve is to be plotted on the curve of righting levers. The tow rope heeling lever curve is to be based on the application athwartships of the bollard pull assumed operating at 30° to the horizontal or such other angle as is acceptable to the Authority. The vertical component should be ignored. (See Figure 4).

C.10.4 The area of the curve of righting levers above the heeling lever curve up to 40° angle of heel (or up to the angle of flooding $\Theta_f°$ if this angle is less than 40°) is to be calculated and presented. The proportion of this area to the total area of the curve of righting levers from 0° to 40° (or from 0° to $\Theta_f°$ where $\Theta_f°$ is less than 40°) is to be calculated and if this result is less than 40 per cent special consideration of the stability will be required.

C.10.5 The towing gear should be designed to minimise any overturning moment which may occur as a result of the lead of the towline.

C.10.6 The towing hook when fitted should have positive means of quick release which will function correctly under all operating conditions. It should not be fitted forward of the longitudinal centre of gravity but be fitted at least 2 per cent of the length of the vessel abaft midships and as low as practicable. The release mechanism should be controlled from the wheelhouse or the after control position and preferably from both of these positions.

C.11 Class 2B and 2C Vessels Carrying Persons in Addition to the Master and Crew

C.11.1 The stability will be considered satisfactory if it can be shown that the vessel has a net metacentric height GM, not less than the greater of the values determined in (a) and (b) below:

(a) $GM = \frac{0.046\ Ah}{\Delta \tan \theta} + 0.15$ metres

where A = projected lateral area of the vessel above the waterline in metres^2

h = vertical distance in metres from the centre of area A to the centre of the underwater lateral area

Δ = displacement in tonnes

θ = angle of heel to one half of freeboard to the deck edge or 14° whichever is less.

(b) $GM = \frac{0.0053\ V^2 d}{L \sin \theta} + 0.15$ metres

where V= service speed in knots

L= waterline length of vessel

d= vertical distance in metres between the vertical centre of gravity of the vessel and the centre of the underwater lateral area.

θ= angle of heel to one half the freeboard to the deck edge or 14° whichever is less.

This formula applies only to vessels where $\frac{V}{\sqrt{L}}$ is less than 4.

C.12 Sailing Vessels

C.12.1 General

Passenger carrying sailing vessels should have stability characteristics which take account of the considerations outlined below.

C.12.2 Handiness

Sailing vessels vary widely in hull and rig characteristics and are not always suitable for the passenger service desired.

A sailing vessel for commercial passenger service must be arranged to provide maximum safety for the passengers, and to allow easy handling with a relatively small crew with minimum interference by untrained passengers.

The rig fitted to the vessel must be simple and capable of being worked without assistance from the passengers. Light sails will only be accepted by the Authority where interference by passengers on deck or where the number of crew assigned will enable rapid handling of the sails. Square sails will only be accepted by the Authority where arranged for maximum ease of handling. The Authority may restrict operating weather conditions where light sails or square sails are carried.

C.12.3 Stability

Sailing vessels normally operate heeled and are more likely to be forced to large heel angles than are powered vessels. Such vessels' response throughout their range of stability is thus especially important. Requirements for initial metacentric height and freeboard cannot by themselves assure adequate stability. For example, a vessel with high initial stability, but with a relatively low range of positive stability, may seem to have adequate stability and yet be potentially dangerous in certain circumstances.

Because of the inherently large windage area, direct application of the weather criteria applicable to Class I vessels (vide clause C.1) and listed below would be unrealistic:

Category P and Category Q	Wind moment derived from a wind pressure of 600 Pa
Category R	Wind moment derived from a wind pressure of 300 Pa

Category S	Wind moment derived from a wind pressure of 450 Pa
Category T	Wind moment derived from a wind pressure of 300 Pa

A large portion of this 'windage area' is controllable and can be reduced by easing or shortening sail in heavy weather. The ease with which this can be accomplished is extremely important. Stability analysis must consider the 'handiness' and size of the rig as well as the hydrodynamic characteristics of the hull.

C.12.4 Deck Openings

The arrangement of deck openings must minimize the chance of flooding the hull at large angles of heel. Deck openings should be of moderate size and located on or near the centreline. They should be fitted with adequate coamings. Companionways shall open fore and aft. Athwartships companionways are not normally acceptable to the Authority.

C.12.5 Auxiliary Power

Installed auxiliary propulsion power, adequate to manoeuvre the vessel under emergency conditions is required. Care should be taken to ensure that the storm sails and ground tackle are suitable for the safety of the vessel and that the rig is arranged so that it can be reduced very quickly in squall conditions.

C.12.6 Existing Vessels

If the owner desires a change in the limits of operation to those of no more severe service conditions no further stability analysis may be necessary. However, an increase in passenger allowance or in severity of service may be made only after a stability analysis supporting such a change.

C.12.7 Criteria for stability to be applied for Monohull sailing vessels of class 1 and 2 less than 15 m measured length

C.12.7.1 ***This alternative assessment may be used only for off-the-beach type vessels engaged in smooth or partially smooth operations.***

All of the following criteria shall be met:

(a) The vessel shall have sufficient buoyancy to remain afloat when capsized.
(b) The vessel should be fitted with suitable hand holds or other means to allow a person to cling to the boat in the event of capsize. This requirement would not be necessary on boats proven to be self righting after severe knockdown or having a ballast keel which is locked in place and representing between 25 and 40 percent of the full load displacement.
(c) Any cockpit shall be self draining and watertight.
(d) Operation tests shall be performed to demonstrate that the rig is in fact handy, and that the vessel shows satisfactory handling characteristics under sail.
(e) The vessel shall be tested by being pulled down to 90 degrees from the upright and released. The vessel shall be under bare poles with openings through which flooding may occur closed, all gear normally carried secured in place and no persons on board. If the vessel returns to the upright without shipping water then its stability will be regarded as satisfactory.

OR

Compliance with the stability criteria contained in Australian Standard 1799-2 SECTION 4 *Requirements for other monohull yachts*.

OR

Compliance with the Hire and Drive sailing vessel criteria given in Section 18C.5.4.1 or 18C.5.4.2 as revised.

C.12.7.2 Class 2 monohull sailing vessels less than 15m measured length operating in smooth or partially smooth waters.

C.12.7.2.1 The centre of gravity (KG) of the vessel shall be established by an inclining experiment and curves of statical stability (GZ curves) are to be calculated for the following conditions:

(a) loaded departure with 95% consumables

(b) loaded arrival with 10% consumables

C.12.7.2.2 The derived wind heeling moment is to be calculated and plotted on each of the GZ curves to define the maximum recommended steady heel angle.

Note: The method of calculating the maximum steady heel angle is set out in Appendix C.

C.12.7.2.3 The GZ curves for each condition of loading shall show the vessel to have a minimum positive range of at least 110 degrees.

C.12.7.2.4 The angle of heel obtained from the intersection of the derived heeling lever curve with either of the GZ curves shall be greater than 15 degrees.

C.12.7.2.5 The following guidance notes and data, in a format which can be readily used by the operator shall be provided:

(a) plan of tanks and ballast
(b) sail plan with a polar diagram or similar data recommending maximum wind strength for the combination of sails set.
(c) angles of deck immersion and downflooding with an explanation of which openings were used for the calculation.
(d) guidance notes for the master which include an explanation of the recommended steady heel angle.
(e) guidance notes for the master setting out his responsibility for reducing sail.

C.12.7.2.6 A suitable inclinometer and anemometer are considered to be essential items of equipment.

C.12.7.3 Class 2 monohull sailing vessels less than 15m measured length operating in offshore and restricted offshore areas.

C.12.7.3.1 The calculations and data set out in C.12.7.2.1 and C.12.7.2.2 are required.

C.12.7.3.2 The stability criteria detailed in C.12.7.2.3 and C.12.7.2.4 shall be met.

C.12.7.3.3 Information to be provided for all vessels meeting C.12.7.3 shall be set out in three sections as follows:-

(1) OPERATIONAL INFORMATION

(a) plan of tanks and ballast
(b) sail plan which includes a table of areas and the centre of area of each sail above a specified base
(c) angles of deck immersion and downflooding with an explanation of which openings were used for the calculation
(d) notes on the stability characteristics of the vessel for the guidance of the master
(e) guidance notes for the master setting out his responsibility for reducing sail.

(2) TECHNICAL DATA

(a) tables of tank capacities with KG and free surface values
(b) conditions of loading with stability curves and wind heeling moments.

(3) REFERENCE INFORMATION

(a) hydrostatic data
(b) KN curves with an explanation of their use

(c) sample calculation from measured freeboards to entry into hydrostatic tables

(d) the inclining report and lightship data.

C.12.7.3.4 A suitable inclinometer and anemometer are considered to be essential items of equipment.

C.12.7.3.5 Watertight subdivision shall be in accordance with the relevant section of the USL Code.

C.12.7.4 Class 1 monohull sailing vessels less than 15 m measured length operating in smooth or partially smooth waters.

C.12.7.4.1 The calculations and data set out in C.12.7.2.1 and C.12.7.2.2 are required.

C.12.7.4.2 Using passenger crowding data as set out in C.1.1, the passenger moment is to be calculated and plotted on the GZ curves.

C.12.7.4.3 The stability criteria detailed in C.12.7.2.3 and C.12.7.2.4 shall be met.

C.12.7.4.4 The stability criteria detailed in C.1.3.4 shall be met with the vessel under bare poles.

C.12.7.4.5 The specific information for the guidance of the master set out in C.12.7.2.5 shall be provided.

C.12.7.4.6 A suitable inclinometer and anemometer are considered to be essential items of equipment.

C.12.7.5 Class 1 monohull sailing vessels less than 15m measured length operating in offshore & restricted offshore areas.

Note: Vessels over 15m, those carrying more than 50 persons, and those of unusual design or construction, shall be specially considered by the Authority.

C.12.7.5.1 The calculations and data set out in C.12.7.2.1 and C.12.7.2.2 are required.

C.12.7.5.2 Using passenger crowding data as set out in C.1.1, the passenger moment is to be calculated and plotted on the GZ curves.

C.12.7.5.3 The GZ curves for each condition of loading shall show the vessel to have a minimum positive range of at least 90 degrees. The angle of heel obtained from the intersection of the derived heeling lever curve with either of the GZ curves shall be greater than 15 degrees.

C.12.7.5.4 The stability criteria detailed in C.1.3.1.1 shall be met with the vessel under bare poles.

C.12.7.5.5 Damaged stability under bare poles is to be assessed for the conditions set out in Appendix 3 Section 5 Sub-Section C.

C.12.7.5.6 The specific information for the guidance of the master set out in C.12.7.3.3 shall be provided.

C.12.7.5.7 Watertight subdivision and loadline provisions shall be in accordance with the relevant sections of the USL Code.

C.12.7.5.8 A suitable inclinometer and anemometer are considered to be essential items of equipment.