Chapter 2
BOUYANCY, STABILITY AND SUBDIVISION

Part A - General

2.1 General

2.1.1 A craft should be provided with:

.1 stability characteristics and stabilisation systems adequate for safety when the craft is operated in the non-displacement mode and during the transient mode;

.2 buoyancy and stability characteristics adequate for safety where the craft is operated in the displacement mode, both in the intact condition and the damaged condition; and

.3 stability characteristics in the non-displacement and transient modes adequate to transfer the craft safely to displacement mode in case of any system malfunction.

2.1.2 Account should be taken of the effect of icing in the stability calculations. An example for established practice for ice accretion allowances is given in annex 5 for the guidance of Administrations.

2.1.3 For the purpose of this and other chapters, unless expressly defined otherwise, the following definitions apply:

.1 "Down flooding point" means any opening through which flooding of the spaces which comprise the reserve buoyancy could take place while the craft is in the intact or damaged condition, and heels to an angle past the angle of equilibrium.

.2 "Fully submerged foil" means a foil having no lift components piercing the surface of the water in the foil borne mode.

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* *The UK has submitted a number of papers to IMO regarding stability and subdivision on High Speed Craft. Alternative proposals have also been submitted by other administrations with respect to these items. Whatever proposals are finally adopted, significant changes are envisaged to the content of chapter 2.*

Because of the foregoing, submissions should be referred to HQ at the earliest opportunity if problems are encountered in the application of existing code requirements, with special reference being made to cases where stability/subdivision arrangements fail to satisfy the United Kingdoms proposed revisions.

In respect of domestic craft these should also comply wherever possible with the requirements of the existing code. However consideration will be given to equivalent requirements where necessary and referral should be made at the earliest opportunity to HQ where consideration of equivalent arrangements is proposed.

.3 "Multihull craft" means a craft which in any normally achievable operating trim or heel angle, has a rigid hull structure which penetrates the surface of the sea over more than one discrete area.

.4 "Permeability" of a space means the percentage of the volume of that space which can be occupied by water.

.5 "Skirt" means a downwardly-extending, flexible structure used to contain or divide an air cushion.

.6 "Watertight" in relation to a structure means capable of preventing the passage of water through the structure in any direction under the head of water likely to occur in the intact or damaged condition.

.7 "Weathertight" means that water will not penetrate into the craft in any wind and wave conditions up to those specified as critical design conditions.

2.2 Intact buoyancy

2.2.1 All craft should have a sufficient reserve of buoyancy at the design waterline to meet the intact and damage stability requirements of this chapter. The Administration may require a larger reserve of buoyancy to permit the craft to operate in any of its intended modes. This reserve of buoyancy should be calculated by including only those compartments which are:

.1 watertight;

.2 accepted as having scantlings and arrangements adequate to maintain their watertight integrity; and

.3 situated in locations below a datum, which may be a watertight deck or equivalent structure of a non-watertight deck covered by a weathertight structure as defined in 2.2.3.1.

2.2.2 Arrangements should be provided for checking the watertight integrity of those compartments taken into account in 2.2.1.

2.2.3 Where entry of water into structures above the datum as defined in 2.2.1.3 would significantly influence the stability and buoyancy of the craft, such structures should be:

.1 of adequate strength to maintain the weathertight integrity and fitted with weathertight closing appliances; or

.2 provided with adequate drainage arrangements; or

.3 an equivalent combination of both measures.

2.2.4 The means of closing openings in the boundaries of weathertight structures should be such as to maintain weathertight integrity in all operational conditions.

2.3 Intact stability in the displacement mode

2.3.1 Hydrofoil craft fitted with surface-piercing foils and/or fully submerged foils should have sufficient stability under all permitted cases of loading to comply with the relevant provisions of annex 6 and specifically maintain a heel angle of less than 10° when subjected to the greater of the heeling moments in 1.1.2 and 1.1.4 of that annex.

2.3.2 Multihull craft should meet the relevant requirements of annex 7 for all permitted cases of loading.

2.3.3 Subject to 2.3.4, all other craft should meet the following criteria in all permitted conditions of loading:

.1 resolution A.562(14) (weather criterion);

.2 the area under the righting lever curve (GZ curve) should not be less than 0.07 m.rad up to $\theta = 15°$ when the maximum righting lever (GZ) occurs at $\theta = 15°$ and 0.055 m.rad up to $\theta = 30°$ when the maximum righting lever occurs at $\theta = 30°$ or above. Where the maximum righting lever occurs at angles of between $\theta = 15°$ and , $\theta = 30°$ the corresponding area under the righting lever curve should be:

$$A = 0.055 + 0.001\ (30° - \theta_{max})\ \text{(m.rad)}$$

where: θ_{max} is the angle of heel in degrees at which the righting lever curve reaches its maximum;

.3 the area under the righting lever curve between $\theta = 30°$ and $\theta = 40°$ or between $\theta = 30°$ and the angle of flooding θ_f *, if this angle is less than 40°, should not be less than 0.03 m.rad;

.4 the righting lever GZ should be at least 0.20 m at an angle of heel equal to or greater than 30°;

.5 the maximum righting lever should occur at an angle of heel not less than 15°; and

.6 the initial metacentric height GM_o should not be less than 0.15 m.

*In applying this criterion, small openings through which progressive flooding cannot take place need not be considered as open.

2.3.4 Where the characteristics of the craft are unsuitable for application of 2.3.3, the Administration may accept alternative criteria equivalent to those stipulated in 2.3.3, appropriate to the type of craft and area of operation.

2.4 Intact stability in the non-displacement mode

2.4.1 The requirements of this section and section 2.12 should be applied on the assumption that any stabilisation systems fitted are fully operational.

2.4.2 Suitable calculations should be carried out and/or tests conducted to demonstrate that, when operating in the non-displacement and transient modes within approved operational limitations, the craft will, after a disturbance causing roll, pitch, heave or heel due to turning or any combination thereof, return to the original attitude.

2.4.3 The roll and pitch stability on the first and/or any other craft of a series should be qualitatively assessed during operational safety trials as required by chapter 18 and annex 8. The results of such trials may indicate the need to impose operational limitations.

2.4.4 Where craft are fitted with surface piercing structure or appendages, precautions should be taken against dangerous attitudes or inclinations and loss of stability subsequent to a collision with a submerged or floating object.

2.4.5 In designs where periodic use of cushion deformation is employed as a means of assisting craft control, or periodic use of cushion air exhausting to atmosphere for purposes of craft manoeuvring, the effects upon cushion-borne stability should be determined, and the limitations on the use by virtue of craft speed or attitude should be established.

2.4.6 In the case of an air-cushion vehicle fitted with flexible skirts, it should be demonstrated that the skirts remain stable under operational conditions.

2.5 Intact stability in the transient mode

2.5.1 Under weather conditions up to the worst intended conditions, the time to pass from the displacement mode to the non-displacement mode and vice versa should be minimised unless it is demonstrated that no substantial reduction of stability occurs during this transition.

2.5.2 Hydrofoil craft should comply with the relevant provisions of annex 6.

2.6 Buoyancy and stability in the displacement mode following damage

2.6.1 The requirements of this section apply to all permitted conditions of loading.

2.6.2 For the purpose of making damage stability calculations the volume and surface permeabilities should be in general as follows:

Spaces	Permeability
Appropriated to cargo or stores	60
Occupied by accommodation	95
Occupied by machinery	85
Intended for liquids	0 or 95*
Appropriated for cargo vehicles	90
Void spaces	95

* *whichever results in the more severe requirements*

2.6.3 Notwithstanding 2.6.2, permeability determined by direct calculation should be used where a more onerous condition results, and may be used where a less onerous condition results from that provided according to 2.6.2.

2.6.4 Administrations may permit the use of low density foam or other media to provide buoyancy in void spaces, provided that satisfactory evidence is provided that any such proposed medium is the most suitable alternative and is:

.1 of closed cell form if foam, or otherwise impervious to water absorption;

.2 structurally stable under service conditions;

.3 chemically inert in relation to structural materials with which it is in contact or other substances with which the medium is likely to be in contact (reference is made to 7.4.3.7): and

.4 properly secured in place and easily removable for inspection of the void spaces.

2.6.5 Any damage of a lesser extent than that postulated in 2.6.6 to 2.6.8, as applicable, which would result in a more severe condition, should also be investigated. The shape of the damage should be assumed to be a parallelepiped.

2.6.6 The following side damages should be assumed anywhere on the periphery of the craft:

.1 the longitudinal extent of damage should be 0.lL, or 3 m + 0.03L or 11m, whichever is the least;

.2 the transverse extent of penetration into the craft should be 0.2B or 0.05L or 5 m, whichever is the least. However, where the craft is fitted with inflated skirts or with non-buoyant side structures, the transverse extent of penetration should be at least 0.12 of the width of the main buoyancy hull or tank structure; and

.3 the vertical extent of damage should be taken for the full depth of the craft.

2.6.7 Subject to 2.6.8, bottom damages should be assumed anywhere on the bottom of the craft as follows:

.1 the longitudinal extent of damage should be 0.lL or 3 m + 0.03L or 11m, whichever is the least;

.2 the transverse extent of damage should be the full breadth of the bottom of the craft or 7 m, whichever is the less, as shown in figure 2.6.7.2 ; and

.3 the vertical extent of penetration into the craft should be 0.02B or 0.5 m, whichever is the less.

2.6.8 In the case of a category B craft, the length of the assumed damage specified in 2.6.7 should be increased by 50% in the case of damage in the forward 0.5L of the craft.

2.7 Inclining and stability information

2.7.1 Every craft on completion of build should be inclined and the elements of its stability determined. When an accurate inclining is not practical the lightship displacement and centre of gravity should be determined by a lightweight survey and accurate calculation.

2.7.2 The master should be supplied by the owner with reliable information relating to the stability of the craft in accordance with the following provisions of this paragraph. The information relating to stability should, before issue to the master, be submitted to the Administration for approval, together with a copy thereof for their retention and should incorporate such additions and amendments as the Administration may in any particular case require.

2.7.3 Where any alterations are made to a craft so as materially to affect the stability information supplied to the master, amended stability information should be provided. If necessary, the craft should be re-inclined.

2.7.4 A report of each inclining or lightweight survey carried out in accordance with this chapter and of the calculation therefrom of the lightship condition particulars should be submitted to the Administration for approval, together with a copy for their retention. The approved report should be placed on board the craft by the owner in the custody of the master and should incorporate such additions and amendments as the Administration may in any particular case require. The amended lightship condition particulars so obtained from time to time should be used by the master in substitution for such previously approved particulars when calculating the craft's stability.

2.7.5 Following any inclining or lightweight survey the master should be supplied with amended stability information if the Administration so requires. The information so supplied should be submitted to the Administration for

approval, together with a copy thereof for their retention and should incorporate such additions and amendments as the Administration may in any particular case require.

2.7.6 Stability information demonstrating compliance with this chapter should be furnished in the form of a stability information book which should be kept on board the craft at all times in the custody of the master. The information should include particulars appropriate to the craft and should reflect the craft's loading conditions and mode of operation. Any enclosed superstructures or deckhouses included in the cross curves of stability and the critical downflooding points and angles should be identified.

2.7.7 Every craft should have scales of draughts marked clearly at the bow and stern. In the case where the draught marks are not located where they are easily readable, or operational constraints for a particular trade make it difficult to read the draught marks, then the craft should also be fitted with a reliable draught indicating system by which the bow and stern draughts can be determined.

2.7.8 The owner or builder as appropriate should ensure that the positions of the draught marks are accurately determined and that the marks are located on the hull in a permanent manner. Accuracy of the draught marks should be demonstrated to the Administration prior to the inclining experiment.

2.8 Loading and stability assessment

On completion of loading of the craft and prior to its departure on a voyage, the master should determine the craft's trim and stability and also ascertain and record that the craft is in compliance with stability criteria of the relevant requirements. The Administration may accept the use of an electronic loading and stability computer or equivalent means for this purpose.

2.9 Marking and recording of the design waterline

The design waterline should clearly be marked amidships on the craft's outer sides and should be recorded in the high Speed Craft Safety Certificate. This waterline should be distinguished by the notation H.

Part B - Requirements for Passenger Craft

2.10 General

Where compliance with this chapter requires consideration of the effects of passenger weight, the following information should be used:

.1 The distribution of passengers is 4 persons per square metre.

.2 Each passenger has a mass of 75 kg.

.3 Vertical centre of gravity of seated passengers is 0.3 m above seat.

.4 Vertical centre of gravity of standing passengers is 1.0 m above deck.

.5 Passengers and luggage should be considered to be in the space normally at their disposal.

.6 Passengers should be distributed on available deck areas towards one side of the craft on the decks where muster stations are located and in such a way that they produce the
most adverse heeling moment.

2.11 Intact stability in the displacement mode

The craft should have sufficient intact stability that, when in still water conditions, the inclination of the craft from the horizontal would not exceed 10° under all permitted cases of loading and uncontrolled passenger movements as may occur.

2.12 Intact stability in the non-displacement mode

2.12.1 The total heel angle in still water due to the effect of passenger movements and due to beam wind pressure as per 1.1.4 of annex 6 should not exceed 10°.

2.12.2 In all loading conditions, the outward heel due to turning should not exceed 8°, and the total heel due to beam wind pressure as per 1.1.4 of annex 6 and due to turning should not exceed 12° outward.

2.13 Buoyancy and stability in the displacement mode following damage

Following any of the postulated damages detailed in 2.6.5 to 2.6.8, the craft in still water should have sufficient buoyancy and positive stability to simultaneously ensure that:

.1 after flooding has ceased and a state of equilibrium has been reached, the final waterline be 300 mm below the level of any opening through which further flooding could take place;

.2 the angle of inclination of the craft from the horizontal does not normally exceed 10° in any direction. However, where this is clearly impractical, angles of inclination up to 15° immediately after damage but reducing to 10° within 15 min may be permitted provided that efficient non-slip deck surfaces and suitable holding points, e.g., holes, bars, etc., are provided;

.3 there is a positive freeboard from the damage waterline to survival craft embarkation positions;

.4 any flooding of passenger compartments or escape routes which might occur will not significantly impede the evacuation of passengers;

.5 essential emergency equipment, emergency radios, power supplies and public address systems needed for organising the evacuation remain accessible and operational;

.6 the residual stability of multihull craft complies with the appropriate criteria as laid out in annex 7; and

.7 residual stability of any other craft meets the requirements of regulation II-1/8 of the Convention.

2.14 Inclining and stability information

2.14.1 At periodical intervals not exceeding five years, a lightweight survey should be carried out on all passenger craft to verify any changes in lightweight displacement and longitudinal centre of gravity. The passenger craft should be re-inclined whenever, in comparison with the approved stability information, a deviation from the lightweight displacement exceeding 2% or a deviation of the longitudinal centre of gravity exceeding 1% of L is found or anticipated.

2.14.2 A report of each inclining or lightweight survey carried out in accordance with 2.7.1 and of the calculation therefrom of the lightweight condition particulars should be submitted to the Administration for approval, together with a copy for their retention. The approved report should be placed on board the craft by the owner in the custody of the master and should incorporate such additions and amendments as the Administration may in any particular case require. The amended lightweight condition particulars so obtained from time to time should be used by the master in substitution for such previously approved particulars when calculating the craft's stability.

2.14.3 Following any inclining or lightweight survey the master should be supplied with amended stability information if the Administration so requires. The information so supplied should be submitted to the Administration for approval, together with a copy thereof for their retention and should incorporate such additions and amendments as the Administration may in any particular case require.

Part C - Requirements for Cargo Craft

2.15 Buoyancy and stability in the displacement mode following damage

Following any of the postulated damages detailed in 2.6.5 to 2.6.7, the craft in still water should have sufficient buoyancy and positive stability to simultaneously ensure that:

.1 after flooding has ceased and a state of equilibrium has been reached the final waterline is 150 mm below the level of any opening through which further flooding could take place;

.2 the angle of inclination of the craft from the horizontal does not normally exceed 15° in any direction. However, where this is clearly impractical, angles of inclination up to 20° immediately after damage but reducing to 15° within 15 min may be permitted provided that efficient non-slip deck surfaces and suitable holding points, e.g., holes, bars, etc., are provided;

.3 there is a positive freeboard from the damage waterline to survival craft embarkation positions;

.4 essential emergency equipment, emergency radios, power supplies and public address systems needed for organising the evacuation remain accessible and operational;

.5 the residual stability of multihull craft complies with the appropriate criteria as laid out in annex 7; and

.6 the residual stability of any other craft meets the requirements of regulation II-1/8 of the Convention.

2.16 Inclining

Where it is satisfied by lightweight survey, weighing or other demonstration, that the lightweight of a craft is closely similar to that of another craft of the series to which 2.7.1 has been applied, the Administration may waive the requirement of 2.7.1 for craft to be inclined. In this regard, a craft which lies within the parameters of 2.14.1, when compared with a craft of the series which has been inclined, should be regarded as being closely similar to that craft.