By the decision of the General Committee to the Croatian Register of Shipping,

RULES FOR THE CLASSIFICATION OF SHIPS
Part 4 – STABILITY
edition January 2020

have been adopted on 20th December 2019 and shall enter into force on 1st January 2020
REVIEW OF AMENDMENTS IN RELATION TO PREVIOUS EDITION OF THE RULES

RULES FOR THE CLASSIFICATION OF SHIPS

Part 4 – STABILITY

All major changes in respect to the Rules for the classification of ships, Part 4 – Stability, edition 2013, as last amended by Amendments No. 3, edition July 2018 throughout the text are shaded (if any).

Items not being indicated as corrected have not been changed.

The grammar and print errors, have been corrected throughout the Rules and are not subject to above indication of changes.
This part of the Rules includes the requirements of the following international organisations:

**International Maritime Organization (IMO)**

**Conventions:**
- International Convention for the Prevention of Pollution from Ships 1973, as modified by the Protocol of 1978 thereto (MARPOL 73/78) and all subsequent amendments up to and including the 2015 amendments (MEPC. 248(66)).

**Resolutions:**
- MEPC.117(52); MEPC.248(66); MSC.235(82); MSC.398(95); A.715(17); MSC.413(97); MSC.415(97); MSC.421(98); MSC.436(99); MSC.443(99); MSC.444(99)

**Codes:**
- International Code on Intact Stability, 2008 (MSC.267(85)), as amended with the 2016 amendments (MSC.444(99))

**International Association of Classification Societies (IACS)**

**Unified Requirements (UR):**
- L2 (Rev.2, 2013); L5 (Rev.3, 2017)

**Unified Interpretations:**
- LL80, MPC11 (Rev. 2, 2016), SC161 (Rev. 1, 2008), SC280
RULES FOR CLASSIFICATION OF SHIPS

PART 4

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1 GENERAL

1.1 APPLICATION

This part of the Rules for the classification of sea going ships (hereafter referred to as: the Rules) applies to all newbuildings of the decked ships navigating in displacement mode.

This part of the Rules also provides intact stability criteria applicable to the same ships and marine vehicles when engaged in certain operations.

1.1.2 This part of the Rules applies to existing ships in service as far as it is reasonable and practicable, but it is, however, compulsory for ships which undergo conversions, major repairs, alterations or modifications, replacement of engines, installations and equipment, if their stability is impaired as a result.

Stability of ships under 24 m in length after conversion, major repair, alteration or modification, replacement of engines, installations and equipment, is to comply either with the requirements of this part of the Rules or with the requirements applied to such ships before conversion, major repair, alteration or modification.

1.1.3 The requirements set forth in this part of the Rules do not extend to the light-ship condition.

1.2 DEFINITIONS AND EXPLANATIONS

1.2.1 Definitions and explanations concerning the general terminology of the Rules are given in the Rules, Part 1 - General requirements, Chapter 1 – General information.

For the purpose of this part of the Rules, the following definitions have been applied:

1.2.2 Length of the ship (L) - The length should be taken as 96% of the total length on a waterline at 85% of the least moulded depth measured from the top of the keel, or the length from the fore-side of the stem to the axis of the rudder stock on that waterline, if that be greater. In ships designed with a rake of keel the waterline on which this is measured shall be parallel to the designed waterline.

1.2.3 Breadth of the ship (B) - is the maximum breadth of the ship measured amidships to the moulded line of the frame in a ship with a metal shell and to the outer surface of the hull in a ship with a shell of any other material.

1.2.4 Moulded depth (D)

.1 The moulded depth is the vertical distance measured midlength of the ship from the top of the keel to the top of the freeboard deck beam at side. In wood and composite ships the distance is measured from the lower edge of the keel rabbet. Where the form at the lower part of the midship section is of a hollow character, or where thick garboards are fitted, the distance is measured from the point where the line of the flat of the bottom continued inwards cuts the side of the keel.

.2 In ships having rounded gunwales, the moulded depth shall be measured to the point of intersection of the moulded lines of the deck and side shell plating, the lines extending as though the gunwale were of angular design.

.3 Where the freeboard deck is stepped and the raised part of the deck extends over the point at which the moulded depth is to be determined, the moulded depth shall be measured to a line of reference extending from the lower part of the deck along a line parallel with the raised part.

1.2.5 Draught – is the vertical distance from the moulded baseline to the waterline.

1.2.6 Liquid cargo - are all liquids on board, including tanker cargo, the ship's liquid stores, ballast water, water in the antirolling tanks and in the swimming pool, etc.

1.2.7 Homogenous cargo - is cargo having constant stowage rate.

1.2.8 Bulk cargo - is grain and non-grain cargo constituted by separate particles and loaded without packaging.

The term "grain" includes wheat, maize (corn), oats, rye, barley, rice pulses, seeds and processed forms thereof whose behaviour is similar to that of grain in its natural state.

1.2.9 Stores - are fuel, lubricants, fresh water, rations, expendable supplies, etc.

1.2.10 Superstructure - is a decked structure on the upper continuous deck extending from side to side of the ship or with the side plating not being inboard of the shell plating more than 4% of the breadth of the ship (B). A raised quarter deck is regarded as a superstructure. (Windows are not allowed to be fitted in superstructures. Only side scuttles with inside hinged deadlights are allowed).

1.2.11 Openings considered to be open - are openings in the upper deck or hull sides as well as in decks, sides and bulkheads of superstructures and deckhouses whose closures do not comply with the requirements of the Rules Part 3 - Hull Equipment, Section 7, as to their strength, watertightness and safety.

Small openings, such as discharges of ship's systems and pipes which actually have no effect on stability in dynamical heeling of a ship are not considered to be open.

1.2.12 Angle of flooding - is the angle of heel at which openings in the hull, superstructures or deck-houses which cannot be closed weathertight immerse. Small openings through which progressive flooding cannot take place need not be considered as open.

1.2.13 Weather criterion - is a ratio of the capsizing moment to the combined heeling moment due to beam wind and rolling.

1.2.14 Arm of windage area - is the vertical distance measured from the centre of windage area above waterline to the centre of projected lateral area below waterline.
1.2.15 Windage area - is projected lateral area of the portion of the ship (except for floating crane) and deck cargo above the waterline with the ship in the upright position.

1.2.16 Lightship - is the displacement of a ship in tonnes without cargo, fuel, lubricating oil, ballast water, fresh water and feedwater in tanks, consumable stores, and passengers and crew and their effects. See also definition in 1.7.1.3.

1.2.17 Special personnel - are all the persons found on board for performing the special purpose of a ship, but who are not passengers, and children under one year old or crew members.

1.2.18 Amplitude of roll - assumed calculated amplitude of roll.

1.2.19 Hydrostatic curves - are curves of hydrostatic properties of the vessel's form at a series of drafts.

1.2.20 Wind pressure - an assumed calculated pressure of wind depending on the area of navigation and height above sea surface.

1.2.21 Diagram of limiting moments - is a diagram of limiting statical moments, on the abscissa of which ship's displacement, deadweight or draught is plotted and on the ordinate, limiting values of the vertical statical moments of masses meeting the complex of various requirements of this part of the Rules for ship's stability.

1.2.22 Universal diagram - is a diagram of ship's stability with a non-uniform scale of abscissa proportional to the heeling angle sines, a set of curves for arms of the form stability for various displacements and a scale of metacentric heights (or of heights of the ship's centre of gravity) along the axis of ordinates for constructing straight half-lines determining the weight stability.

1.2.23 Stability book - is the ship's book which contains sufficient information to enable the master to operate the ship in compliance with the applicable requirements for ship's stability contained in this part of the Rules. On High Speed Crafts (HSC), the stability book is referred to as an "Operating manual".

1.2.24 Wind heeling moment - is an assumed moment of heeling caused by wind pressure.

1.2.25 Correction for free surfaces - is a correction allowing for decrease in the ship's stability due to the effect of free surfaces of liquid cargoes.

1.2.26 Anti-rolling device (stabilising unit) - are special devices fitted on board, active or passive type, for reducing amplitude of rolling.

1.2.27 Special facility - is a system of approved type permanently installed in a ship for estimation of her initial stability during service, as well as for measurement of angles of inclination during the inclining test.

1.2.28 Special purpose ship - means a mechanically self-propelled ship which, by reason of its function, carries on board more than 12 special personnel as defined in item

1.2.17, including passenger (ships engaged in research, expeditions and survey; ships for training of marine personnel; whale and fish factory ships not engaged in catching; ships processing other living resources of the sea, not engaged in catching or other ships with design features and modes of operation similar to ships mentioned above which, in the opinion of the Register, may be referred to this group).

1.2.47 Offshore supply vessel - means a vessel which is engaged primarily in the transport of stores, materials and equipment to offshore installations and designed with accommodation and bridge erections in the forward part of the vessel and an exposed cargo deck in the after part for the handling of cargo at sea.

1.2.48 High-speed craft (HSC) - is a craft capable of a maximum speed, in metres per second (m/s), equal to or exceeding:

\[ 3.7 \sqrt{V^0.1667} \text{ [m/s]} \]

where:

\[ V = \text{displacement corresponding to the design waterline (m}^3\text{)} \]

1.2.49 Dynamically supported craft (DSC) - is a craft constructed before 1 January 1996 that is operable on or above water and that has characteristics so different from those of conventional displacement ships, to which the existing international conventions, particularly SOLAS and Load Line, apply, that alternative measures should be used in order to achieve an equivalent level of safety. Within the aforementioned generality, a craft which complies with either of the following characteristics would be considered a DSC:

- if the weight or a significant part thereof, is balanced in one mode of operation by other than hydrostatic forces;
- if a craft is capable of maximum speed equal to or exceeding:

\[ 3.7 \sqrt{V^0.1667} \text{ [m/s]} \]

where \( V \) is defined as in 1.2.48.

Craft constructed on or after 1 January 1996 that has characteristics as stated in .2 of this item is to be regarded as HSC craft, as defined in 1.2.48.

1.2.50 Containership - means a ship that is used primarily for the transport of marine containers.

1.2.51 Freeboard - is the distance between the assigned load line and freeboard deck**.

1.2.52 Combination carrier - means a ship designed to carry either oil or solid cargoes in bulk.

* The Code of Safety for High-Speed Craft, 2000 (2000 HSC Code) has been developed following a thorough revision of the Code of Safety for High-Speed Craft, 1994 (1994 HSC Code) which was derived from the previous Code of Safety for Dynamically Supported Craft (DSC Code) adopted by IMO in 1977, recognizing that safety levels can be significantly enhanced by the infrastructure associated with regular service on a particular route, whereas the conventional ship safety philosophy relies on the ship being self-sustaining with all necessary emergency equipment being carried on board.

** Various symbols used in this Part of the Rules are given in the Table in Appendix 6.

1.2.53 Ship engaged in anchor handling operations - means a ship engaged in operations with deployment, recovery and repositioning of anchors and the associated mooring lines of rigs or other vessels. Forces associated with anchor handling are generally associated with the winch line pull and may include vertical, transverse, and longitudinal forces applied at the towing point and over the stern roller.

1.2.54 Ship engaged in harbour towing - means a ship engaged in an operation intended for assisting ships or other floating structures within sheltered waters, normally while entering or leaving port and during berthing or unberthing operations.

1.2.55 Ship engaged in coastal or ocean-going towing - means a ship engaged in an operation intended for assisting ships or other floating structures outside sheltered waters in which the forces associated with towing are often a function of the ship's bollard pull.

1.2.56 Ship engaged in lifting operation - means a ship engaged in an operation involving the raising or lowering of objects using vertical force by means of winches, cranes, a-frames or other lifting devices.

1.2.57 Ship engaged in escort operation - means a ship specifically engaged in steering, braking and otherwise controlling of the assisted ship during ordinary or emergency manoeuvring, whereby the steering and braking forces are generated by the hydrodynamic forces acting on the hull and appendages and the thrust forces exerted by the propulsion units (see also figure 3.7.3.1).

1.3 SCOPE OF SUPERVISION

1.3.1 General provision applying to the procedure of classification, construction supervision and classification surveys, of sea-going ships as well as the requirements for the technical documentation submitted to the Register for consideration and approval are set forth in the Rule, Part I - General, Chapter 1 – General information.

1.3.2 For every ship meeting the requirements of this part of the Rules, the Register shall carry out the following:

1 Prior to the commencement of ship's construction:
- consideration and approval of technical documentation relating to ship's stability;

2 During ship's construction and trials:
- supervision of the inclining test;
- consideration and approval of the Stability Book and inclining test calculations.

3 In the case of modification, repairs or class renewal survey:
- check for changes in light ship condition in order to conclude whether the Stability Book is still applicable;

* Refer to the Guidelines for safe ocean towing (MSC/Circ.884).

* Fishing vessels should not be included in the definition of lifting operations. Reference is made to items 3.5.15.2 and 3.5.16 of Head 3.15. For anchor handling operations reference is made to Head 3.15 of this Part of the Rules.
1.3.3 After intact stability checking, letter "S" shall be added in class notation, as stated in the Rules, Part 1 - General Requirements, Chapter 1 - General Information, 4.

1.4 TECHNICAL REQUIREMENTS IN PREPARING STABILITY INFORMATION

1.4.1 All calculations shall be made by the methods generally accepted in naval architecture. When using a computer, the methods of computation and programme shall be deemed suitable by opinion of the Register.

1.4.2 Calculation of cross curves of stability

1.4.2.1 General

1.1 Hydrostatic and stability curves should be prepared for the trim range of operating loading conditions taking into account the change in trim due to heel (free trim hydrostatic calculation).

1.2 The calculations shall take into account the volume to the upper surface of the deck sheathing. In the case of wood ships, the dimensions shall be taken to the outside of the hull planking.

1.3 Appendages and sea chests need to be considered when calculating hydrostatics and cross curves of stability. In the presence of port-starboard asymmetry, the most unfavourable righting lever curve should be used.

1.4.2.2 Superstructures, deckhouses, etc. which may be taken into account

2.1 Enclosed superstructures complying with regulation 3(10)(b) of the 1966 Load Line Convention and 1988 Protocol as amended may be taken into account.

2.2 Additional tiers of similarly enclosed superstructures may also be taken into account. As guidance windows (pane and frame) that are considered without deadlights in additional tiers above the second tier if considered buoyant should be designed with strength to sustain a safety margin of 30% with regard to the required strength of the surrounding structure.

2.3 Deckhouses on the freeboard deck may be taken into account, provided that they comply with the conditions for enclosed superstructures laid down in regulation 3(10)(b) of the 1966 Load Line Convention and 1988 Protocol relating thereto, as amended.

2.4 Where deckhouses comply with the above conditions, except that no additional exit is provided to a deck above, such deckhouses shall not be taken into account; however, any deck openings inside such deck-houses shall be considered as closed even where no means of closure are provided.

2.5 Deckhouses, the doors of which do not comply with the requirements of regulation 12 of the 1966 Load Line Convention and 1988 Protocol as amended should not be taken into account; however, any deck openings inside the deckhouse are regarded as closed where their means of closure comply with the requirements of regulations 15, 17 or 18 of the 1966 Load Line Convention and 1988 Protocol as amended.

2.6 Deckhouse on decks above the freeboard deck shall not be taken into account, but openings within them may be regarded as closed.

2.7 Superstructures and deckhouses not regarded as enclosed can, however, be taken into account in stability calculations up to the angle at which their openings are flooded (at this angle, the static stability curve shall show one or more steps, and in subsequent computations the flooded space shall be considered non-existent).

2.8 In cases where the ship will sink due to flooding through any openings, the stability curve shall be cut short at the corresponding angle of flooding and the ship shall be considered to have entirely lost its stability.

2.9 Small openings such as those for passing wires or chains, tackle and anchors, and also holes of scuppers, discharge and sanitary pipes should not be considered as open if they submerge at an angle of inclination more than 30°. If they submerge at an angle of 30° or less, these openings should be assumed open if the Register considers this to be a source of significant flooding.

2.10 Trunks may be taken into account. Hatchways may also be taken into account, having regard to the effectiveness of their closures.

2.11 The interpolation curves of the arms of form stability shall have a small-scaled scheme of superstructures and deckhouses taken into account, specifying the openings considered to be open and portions of the upper deck where the deck planking is taken into consideration. In addition the limiting points for cross curves of stability calculation shall be traced on a drawing.

2.12 A curve of angles of flooding for the lowest opening in the ship's side, deck or superstructure assumed to be open shall be appended to the calculation of cross curves of stability for each ship.
2.13 In ships under 20 m in length, only first tier of deckhouses may be taken into account provided that they meet the requirements set forth in 1.4.2.2.1 and 1.4.2.2.3 and that they have an additional exit to the deck above or exit to both sides.

1.4.3 Arrangement of compartments

A drawing of watertight compartments of the ship design documentation shall contain data necessary to calculate the positions of the centres of gravity for individual tanks filled with liquid cargoes and values of corrections for the effect of free surfaces of liquid cargoes on stability.

1.4.4 Deck plan

1.4.4.1 Deck plans of the ship design documentation shall include all data necessary to determine the centres of gravity of deck cargoes.

1.4.4.2 The deck plans for passenger ships shall indicate the deck area on which passengers can walk freely and maximum permissible crowding of passengers on free areas of the deck, with passengers moving to one side of the ship (see 3.1.9 to 3.1.11).

1.4.5 Arrangement of doors, companionways and side scuttles

1.4.5.1 The arrangement plan of doors and companionways shall include all doors and companionways to an exposed deck, as well as all openings ports and hatches in the shell plating with appropriate references to their design.

1.4.5.2 The arrangement plan of side scuttles shall incorporate all side scuttles located below the uppermost continuous deck, as well as the side scuttles in the superstructures and deckhouses taken into account when calculating the cross curves of stability.

1.4.6 Calculation of windage area of a ship

1.4.6.1 The windage area shall include the projections of all continuous surfaces of the ship's hull, superstructures and deckhouses on the centre line plane, as well as projections of masts, ventilators, boats, deck machinery, all tents that might be stretched in stormy weather as also the projections of side surfaces of deck cargoes, including timber cargo, if the carriage of the latter is provided by the ship's design.

For ships having auxiliary sails, the projected lateral areas of rolled up sails are to be taken into account in the total windage area.

It is recommended that projected lateral areas of discontinued surfaces of rails, spars (except for masts) and rigging of ships having no sails and those of various small objects are to be taken into account by increasing the total projected lateral area of continuous surfaces calculated for draught $d_{\text{min}}$ by 5% and the statical moment of this area by 10%, where $d_{\text{min}}$ is draught for the minimum sea-going loading condition of the ship.

The projected lateral areas of discontinued surfaces of ships subjected to icing is to be taken into account by increasing the projected lateral area and its statical moment of continuous surfaces calculated for draught $d_{\text{min}}$ under icing conditions by 7.5 and 10 % or 15 and 20 %, respectively, depending upon the rates of icing stated in 2.2. In this case, the value of the projected lateral area of discontinued surfaces and the position of its centre of gravity with respect to the base plane are assumed to be constant for all loading conditions.

For containers ships the projected lateral area shall be taken into account as a continuous surface having no regard to the clearances between containers.

1.4.6.2 The application of the said approximated methods for taking into account the projected lateral areas of discontinued surfaces and small objects is not obligatory. These components of windage area can be determined in a more precise way, if deemed necessary by the designer.

For this purpose when calculating the projected lateral area of discontinued surfaces, such as spars and rigging of ships having no sails, rails, crane trusses of lattice type, etc., the overall areas taken into consideration, shall be multiplied by filling factors whose values are taken as follows:

No icing  | Icing
---|---
for rails covered with meshed wire | 0.6  | 1.2 |
for rails without meshed wire | 0.2  | 0.8 |
for crane trusses of lattice type | 0.5  | 1.0 |

For spars, tackle and shrouds of ships with no sails, values of the filling factors shall be adopted in compliance with the Table 1.4.6.2 depending upon the ratio $z_o/b_o$, where $z_o$ is the height of the bulwark to the point of shrouds fastening to the mast, $b_o$ is the distance between the shrouds at bulwark.

<table>
<thead>
<tr>
<th>Ratio $z_o/b_o$</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
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<tbody>
<tr>
<td>No icing</td>
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<td>0.84</td>
<td>0.91</td>
<td>1.00</td>
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</tr>
</tbody>
</table>
The projections of the hull above the waterline, deckhouses and superstructures shall be taken into account with a flow coefficient 1.0. The projections of circular section structures located separately on the deck (funnels, ventilators, masts) shall be assumed to have a flow coefficient of 0.6.

When calculating in detail, the projected lateral areas of small objects, discontinued surfaces, spars, rigging, rails, shrouds, tackle, etc., shall be taken to have a flow coefficient of 1.0. If the projections of individual components of the windage area overlap one another fully or in part, the areas of only one of the overlapping projections shall be included in the computation.

If the overlapping projections have different flow coefficients, those with higher coefficients shall be taken for the computation.

1.4.6.3 The arm of windage area $z$ for determining the heeling moment due to wind pressure in accordance with 2.1.5.2 shall be defined as a distance, in metres, between the centre of the windage area and the centre of the underwater lateral area or approximately to a point of one half of the draught, for an upright ship in smooth water.

The position of the centre of windage area is determined by a method generally applied for determining the co-ordinates of the centre of gravity for a plane figure.

1.4.6.4 The windage area and its statical moment shall be calculated for the ship's draught $d_{min}$. These components for other draughts are determined by the same manner. The use of linear interpolation is permissible if the second point is calculated at the draught corresponding to the summer load line.

1.4.6.5 Method of calculation of wind force on high structures of various shapes (including floating crane)

1.4.6.5.1 When calculating heeling moment generated by the wind acting on complicated shapes, especially on high structures of lattice type (cranes, large truss masts, etc.), more detailed calculation of wind forces may be required. The curves of wind heeling moment should be drawn for wind forces calculated by the following formula:

$$ F = 0.5 \cdot C_S \cdot C_H \cdot \rho \cdot v^2 \cdot A $$

Where:

- $F$ is the wind force (N),
- $C_S$ is the shape coefficient depending on the shape of the structural member exposed to the wind (see table 1.4.6.5-1),
- $C_H$ is the height coefficient depending on the height above sea level of the structural member exposed to wind (see table 1.4.6.5-2),
- $\rho$ is the air mass density (1.222 kg/m$^3$),
- $v$ is the wind velocity (m/s),
- $A$ is the projected area of all exposed surfaces in either the upright or the heeled condition (m$^2$).

### Table 1.4.6.5-1
Values of the coefficient $C_S$

<table>
<thead>
<tr>
<th>Shape</th>
<th>$C_S$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spherical</td>
<td>0.40</td>
</tr>
<tr>
<td>Cylindrical</td>
<td>0.50</td>
</tr>
<tr>
<td>Large flat surface (hull, deck-house, smooth under-deck areas)</td>
<td>1.00</td>
</tr>
<tr>
<td>Drilling derrick</td>
<td>1.25</td>
</tr>
<tr>
<td>Wires</td>
<td>1.20</td>
</tr>
<tr>
<td>Exposed beams and girders under deck</td>
<td>1.30</td>
</tr>
<tr>
<td>Small parts</td>
<td>1.40</td>
</tr>
<tr>
<td>Isolated shapes (crane, beam, etc.)</td>
<td>1.50</td>
</tr>
<tr>
<td>Clustered deck-houses or similar structures</td>
<td>1.10</td>
</tr>
</tbody>
</table>
### Table 1.4.6.5-2
Values of the coefficient $C_H$

<table>
<thead>
<tr>
<th>Height above sea level (m)</th>
<th>$C_H$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 15.3</td>
<td>1.00</td>
</tr>
<tr>
<td>15.3 - 30.5</td>
<td>1.10</td>
</tr>
<tr>
<td>30.5 - 61.0</td>
<td>1.20</td>
</tr>
<tr>
<td>46.0 - 76.0</td>
<td>1.30</td>
</tr>
<tr>
<td>61.0 - 91.5</td>
<td>1.37</td>
</tr>
<tr>
<td>76.0 - 106.5</td>
<td>1.43</td>
</tr>
<tr>
<td>91.5 - 122.0</td>
<td>1.48</td>
</tr>
<tr>
<td>106.5 - 137.0</td>
<td>1.52</td>
</tr>
<tr>
<td>122.0 - 152.5</td>
<td>1.56</td>
</tr>
<tr>
<td>137.0 - 167.5</td>
<td>1.60</td>
</tr>
<tr>
<td>152.5 - 183.0</td>
<td>1.63</td>
</tr>
<tr>
<td>167.5 - 198.0</td>
<td>1.67</td>
</tr>
<tr>
<td>183.0 - 213.5</td>
<td>1.70</td>
</tr>
<tr>
<td>198.0 - 228.5</td>
<td>1.72</td>
</tr>
<tr>
<td>213.5 - 244.0</td>
<td>1.75</td>
</tr>
<tr>
<td>228.5 - 256.0</td>
<td>1.77</td>
</tr>
<tr>
<td>244.0 - 256.0</td>
<td>1.79</td>
</tr>
<tr>
<td>Above 256</td>
<td>1.80</td>
</tr>
</tbody>
</table>

1.4.6.5.2 Wind forces should be considered from any direction relative to the unit and the value of the wind velocity should be as follows:
- in general, a minimum wind velocity of 36 m/s (70 knots) for offshore service should be used for normal operating conditions and a minimum wind velocity of 51.5 m/s (100 knots) should be used for the severe storm conditions; and
- where a unit is to be limited in operation to sheltered locations (protected waters such as lakes, bays, harbours, rivers, etc.), consideration should be given to a reduced wind velocity of not less than 25.8 m/s (50 knots) for normal operating conditions.

1.4.6.5.3 In calculating the projected areas to the vertical plane, the area of surfaces exposed to wind due to heel or trim, such as under decks, etc., should be included, using the appropriate shape factor. Open truss work may be approximated by taking 30% of the projected block area of both the front and back section, i.e. 60% of the projected area of one side.

1.4.6.5.4 In calculating the wind heeling moments, the lever of the wind overturning force shall be taken vertically from the centre of pressure of all surfaces exposed to the wind to the centre of lateral resistance of the underwater body of the unit. The ship or pontoon is to be assumed floating free of mooring restraint.

1.4.6.5.5 The wind heeling moment curve should be calculated for a sufficient number of heel angles to define the
curve. For ship-shaped hulls the curve may be assumed to vary as the cosine function of ship heel.

1.4.6.5.6 Wind heeling moments derived from wind-tunnel tests on a representative model of the unit may be considered as alternatives to the method given in this item. Such heeling moment determination should include lift and drag effects at various applicable heel angles.

1.4.7 Effect of free surfaces of liquids in tanks

1.4.7.1 For all loading conditions, the initial metacentric height and the righting lever curve shall be corrected for the effect of free surfaces of liquids in tanks.

1.4.7.2 Free surface effects shall be considered whenever the filling level in a tank is less than 98% of full condition. Free surface effects need not be considered where a tank is nominally full, i.e. filling level is 98% or above. Free surface effects for small tanks may be ignored under condition specified in 1.4.7.9.*

1.4.7.3 But nominally full cargo tanks should be corrected for free surface effects at 98% filling level. In doing so, the correction to initial metacentric height should be based on the inertia moment of liquid surface at 5° of heeling angle divided by displacement, and the correction to righting lever is suggested to be on the basis of real shifting moment of cargo liquids.

1.4.7.4 Tanks which are taken into consideration when determining the free surface correction may be in one of two categories:

.1 Tanks with filling levels fixed (e.g. liquid cargo, water ballast). The free surface correction shall be defined for the actual filling level to be used in each tank.

.2 Tanks with filling levels variable (e.g. consumable liquids such as fuel oil, diesel oil and fresh water, and also liquid cargo and water ballast during liquid transfer operations). Except as permitted in 1.4.7.5 and 1.4.7.6, the free surface correction shall be the maximum value attainable between the filling limits envisaged for each tank, consistent with any operating instructions.

1.4.7.5 In calculating the free surface effects in tanks containing consumable liquid, it shall be assumed that for each type of liquid at least one transverse pair or a single centreline tank has a free surface and the tank or combination of tanks taken into account should be those where the effect of free surfaces is the greatest.

1.4.7.6 Where water ballast tanks, including anti-floating tanks and anti-heeling tanks, are to be filled or discharged during the course of a voyage, the free surface effects shall be calculated to take account of the most onerous transitory stage relating to such operations.

* Refer to the intact stability design criteria, contained in MARPOL regulation I/27, together with the associated Unified Interpretation 45.

1.4.7.7 For ships engaged in liquid transfer operations, the free surface corrections at any stage of the liquid transfer operations shall be determined in accordance with the filling level in each tank at that stage of the transfer operation.

1.4.7.8 The corrections to the initial metacentric height and to the righting lever curve shall be addressed separately as follows:

   1.4.7.8.1 In determining the correction to initial metacentric height, the transverse moments of inertia of the tanks shall be calculated at 0° angle of heel according to the categories indicated in 1.4.7.4.

   1.4.7.8.2 The righting lever curve may be corrected by any of the following methods subject to the agreement of the Register:

   1.1 correction based on the actual moment of fluid transfer for each angle of heel calculated;

   1.2 correction based on the moment of inertia, calculated at 0° angle of heel, modified at each angle of heel calculated.

   Corrections may be calculated according to the categories indicated in 1.4.7.4.

   Whichever method is selected for correcting the righting lever curve, only that method should be presented in the ship's stability booklet. However, where an alternative method is described for use in manually calculated loading conditions, an explanation of the differences which may be found in the results, as well as an example correction for each alternative, should be included.

1.4.7.9 Small tanks which satisfy the following condition corresponding to an angle of inclination of 30°, need not be included in the correction:

\[ \frac{M_{fs}}{\Delta_{min}} < 0.01 \text{ m} \]

where:

- \( M_{fs} \) - is free surface moment, in (tm)
- \( \Delta_{min} \) - is the minimum ship displacement calculated at \( d_{min} \), in (t)
- \( d_{min} \) - is the minimum mean service draught of the ship without cargo, with 10% stores and minimum water ballast, if required, in (m).

1.4.7.10 The usual remainder of liquids in empty tanks need not be taken into account in calculating the corrections, provided that the total of such residual liquids does not constitute a significant free surface effect.

1.4.8 Loading conditions

1.4.8.1 Stability shall be checked in all loading conditions specified in Sections 3 and 4 for various types of ships.

* A sufficient number of loading conditions representing the initial, intermediate and final stages of the filling or discharge operation using the free surface correction at the filling level in each tank at the considered stage may be evaluated to fulfill this recommendation.
1.4.8.2 For the types of ships which are not covered by special provisions of Sections 3 and 4, the loading conditions to be examined shall be as follows:

1. ship in fully loaded condition with full stores and fuel;
2. ship in fully loaded condition with 10% of stores and fuel;
3. ship without cargo, with full stores and fuel;
4. ship without cargo, with 10% of stores and fuel.

1.4.8.3 If the loading conditions anticipated in normal service of a ship as regarding stability are less favourable than those listed in 1.4.8.2 or specified in Sections 3 and 4, stability shall also be checked for these conditions.

1.4.8.4 If there is solid ballast on board, its mass shall be included in the light-ship condition. See also item 1.5.4.

1.4.8.5 In all cases of loading which might occur in the ship's service, except those that expressly prohibited it in Sections 3 and 4, the weight of ballast water may be included in the deadweight of the ship, where necessary. Additional diagrams shall be calculated taking into account the water ballast. Its quantity and disposition shall be stated.

1.4.8.6 In all cases, the cargo in holds is assumed to be fully homogeneous unless this condition is inconsistent with the practical service of the ship.

1.4.8.7 In all cases, when deck cargo is carried, a realistic stowage mass shall be assumed and stated, including the height of the cargo.

1.4.8.8 If a ship operates in zones where ice accretion is likely to occur, allowance for icing should be made in accordance with the provisions of Head 2.2 (Allowance for icing).

1.4.8.9 Except as otherwise required by this part of the Rules, for the purpose of assessing in general whether the stability criteria are met, stability curves using the assumptions given in this part of the Rules should be drawn for the loading conditions intended by the owner in respect of the ship’s operations.

1.4.8.10 If the owner of the ship does not supply sufficiently detailed information regarding such loading conditions, calculations should be made for the standard loading conditions.

1.4.9 Design data relating to stability checking and summary tables

1.4.9.1 For ships subject to survey, all design data relating to stability checking (calculations of loading, initial stability, curves of stability, windage area, amplitudes of roll, heeling due to crowding of passengers on one side, when turning and also that due to cargo shifting, icing etc.) shall be submitted to the Register for consideration.

1.4.9.2 For all design loading conditions summary tables indicating the results of displacement, position of the centre of gravity, initial stability and trim as well as summary tables of results of stability checking for the compliance with the requirements of the present part of the Rules, shall be represented.

1.4.10 Universal diagram of stability and diagram of limiting statical moments of a ship

1.4.10.1 For ships at the design stage, a universal diagram enabling to determine characteristics of curves of statical stability for any values of displacement and metacentric height (or height of the ship's centre of gravity) shall be submitted.

1.4.10.2 A diagram of limiting moments (or metacentric heights, or heights of centres of gravity) enabling to estimate the extent of compliance with the requirements of the present part of the Rules shall be submitted.

1.5 STABILITY INFORMATION FOR THE MASTER

1.5.1 Stability booklet

1.5.1.1 Stability data and associated plans should be drawn up in the working language of the ship and any other language the Register may require (reference is also made to the International Safety Management (ISM) code, adopted by the Organisation by resolution A.741(18)). All translation of the stability booklet should be approved.

1.5.1.2 Each ship should be provided with a stability booklet, approved by the Register, which contains sufficient information as is necessary to enable the Master by rapid and simple processes to obtain accurate guidance as to the stability of the ship under varying conditions of service and to operate the ship in compliance with the applicable requirements contained in this part of the Rules. The Register may have additional requirements. The stability booklet may include information on longitudinal strength. This part of the Rules addresses only the stability-related contents of the booklet.

1.5.1.3 The format of the stability booklet and the information included will vary dependent on the ship type and operation. The stability booklet, shall include the following information:

1. a general description of the ship;
2. instructions on the use of the booklet;
3. general arrangement plans showing watertight compartments, communications, downflooding angles, permanent ballast, allowable deck loading and freeboard diagrams;
4. hydrostatic curves, or tables and cross curves of stability calculated on a free-trimming basis, for the ranges of displacement and trim anticipated in normal operating conditions;
.5 capacity plan or tables showing capacities and centres of gravity for each cargo stowage space;
.6 tank soundings tables showing capacities, centres of gravity and free surface data for each tank (as an Appendix to Stability Booklet);
.7 information on any loading and operative restrictions;
.8 curves or tables of minimum operational metacentric height (\(GM\)) and maximum permissible trim versus draught which assures compliance with the intact and damage stability requirements where applicable, alternatively corresponding curves or tables of the maximum allowable vertical centre of gravity (\(KG\)) and maximum permissible trim versus draught, or with the equivalents of either of these curves or tables;
.9 general precautions for preventing unintentional flooding;
.10 information concerning the operation of any special cross-flooding arrangements, with descriptions of damage conditions which may require cross-flooding;
.11 any other necessary data and aids for the safe operation of the ship under normal and emergency conditions and to maintain the required intact stability and, if applicable, stability after damage;
.12 standard operating conditions and examples for developing other acceptable loading conditions using the information contained in the stability booklet;
.13 a brief description of the stability calculations done, including assumptions;
.14 a table of contents and index for each booklet;
.15 inclining test report for the ship, or:
.15.1 where the stability data are based on a sister ship, the inclining test report of that sister ship along with the light-ship measurement report for the ship in question; or
.15.2 where light-ship particulars are determined by other methods than from inclining of the ship or its sister ship, a summary of the method used to determine those particulars;
.16 recommendation for determination of ship's stability by means of an in-service inclining test.

1.5.1.4 When curves or tables of minimum operational metacentric height (\(GM\)) or maximum allowable \(KG\) versus draught are not provided, the Master shall ensure that the operating condition does not deviate from approved loading conditions, or verify by calculation that the stability requirements are satisfied for this loading condition.

1.5.1.5 As an alternative to the stability booklet specified in this Head, a simplified booklet in an approved form containing sufficient information to enable the Master to operate the ship in compliance with the applicable provisions of this part of Rules may be provided at the discretion of the Register.

1.5.1.6 The intact and damage stability information required by sub-items 1.5.1.3.8 to .11 shall be presented as consolidated data and encompass the full operating range of draught and trim. Applied trim values shall coincide in all stability information intended for use on board. Information not required for determination of stability and trim limits should be excluded from this information.

1.5.1.7 For ships which have to fulfil the damage stability requirements of Heads 2.4 to 2.8, and, if applicable, of Heads 2.9 and 2.11, of the Rules, Part 5 – Subdivision, a stability limit curve is be determined using linear interpolation between the minimum required \(GM\) assumed for each of the three draughts \(d_s\), \(d_p\) and \(d_e\). When additional subdivision indices are calculated for different trim values, a single envelope curve based on the minimum values from these calculations shall be presented. When it is intended to develop curves of maximum permissible \(KG\) it shall be ensured that the resulting maximum \(KG\) curves correspond with a linear variation of \(GM\).

1.5.1.8 As an alternative to a single envelope curve, the calculations for additional trim values may be carried out with one common \(GM\) for all of the trims assumed at each subdivision draught. The lowest values of each partial index \(A_s\), \(A_p\) and \(A_e\) across these trims shall then be used in the summation of the attained subdivision index \(A\) according to item 2.5.1 of the Rules, Part 5 – Subdivision. This will result in one \(GM\) limit curve based on the \(GM\) used at each draught. A trim limit diagram showing the assumed trim range shall be developed.

1.5.1.9 For the series-built ships, the Stability Booklet shall be prepared on the basis of the inclining test data on a leading ship or the first ship of each group consisting of five ships.

The Stability Booklet compiled for the leading ship or the first ship of any group may be extended to the ships of another group provided the inclining test results for ships under comparison comply with the following requirements:

1. That the difference in mass characteristics of the light ship does not exceed any of the limits stated in 1.7.2.2.2,
2. That the worst loading conditions as to stability calculated on the basis of the inclining test data for the ship concerned comply with the requirements set forth in this part of the Rules.

Notes on exemption of inclining tests as well as on extension of Stability Booklet on other ships shall be indicated in Stability book of the ship concerned.

1.5.1.10 The Stability booklet for ships under 20 m in length shall include data on permissible speed and angles of rudder shifting in turning.

Permissible speed and angle of rudder shifting on steady turning are determined by tests during test trial of the leading ship of the series, provided that the list of the ship on steady turning does not exceed:
1.5.1.11 The Stability booklet of ships under 20 m in length, irrespective of their purpose, shall specify that the speed $v_s$ of the ship under way in following waves with the length equal to or exceeding the ship's length, shall be not greater than that obtained from the formula:

$$v_s = 1.4 \cdot \sqrt{L}, \quad [\text{kn}] \quad (1.5.1.9)$$

where:

$L = \text{the ship's length, in [m]}.$

1.5.1.12 The Stability booklet of container ships shall contain an example of calculation for one of the unfavourable permissible loading condition taking into account containers of different weight.

1.5.1.13 Stability booklet of ships provided with stabilizers is to contain instruction to the effect that the requirements of the stabilizer operation manual should be complied with as well as the list of loading conditions for the ship during which stabilizers are not to be used and of cases when stabilizers are to be quickly activated.

1.5.2 General requirements for stability instruments*

Detailed set of requirements and recommendations are specified in Appendix 5.

1.5.2.1 The scope of stability calculation software should be in accordance with the approved stability booklet and should at least include all information and perform all calculations or checks as necessary to ensure compliance with the applicable stability requirements.

1.5.2.2 An approved stability instrument is not a substitute for the approved stability booklet, and is used as a supplement to the approved stability booklet to facilitate stability calculations.

1.5.2.3 The input/output information should be easily comparable with the approved stability booklet so as to avoid confusion and possible misinterpretation by the operator.

1.5.2.4 An operation manual is to be provided for the stability instrument.

1.5.2.5 The language in which the stability calculation results are displayed and printed out as well as the operation manual is written should be the same as used in the ship’s approved stability booklet. A translation into a language considered appropriate may be required.

* Refer to the Guidelines for the approval of stability instruments (MSC.1/Circ.1229).

1.5.2.6 In order to validate the proper functioning of the computer hardware and software, pre-defined standard loading conditions shall be run in the computer periodically, at intervals recommended by the suppliers but at least at every annual load line inspection, and the printout shall be maintained on board as check conditions for future reference.

1.5.2.7 The stability instrument is ship specific equipment and the results of the calculations are only applicable to the ship for which it has been approved.

1.5.2.8 In case of modifications of the ship which cause alterations in the stability booklet, the specific approval of any original stability calculation software is no longer valid. The software is to be modified accordingly and re-approved.

1.5.2.9 Any change in software version related to the stability calculation should be reported to and be approved by the Register.

1.5.3 Operating booklets for certain ships

1.5.3.1 Special purpose ships and novel craft shall be provided with additional information in the stability booklet such as design limitations, maximum speed, worst intended weather conditions or other information regarding the handling of the craft that the master needs to operate the ship safely.

1.5.3.2 For double hull oil tankers of single cargo tank across design, an operation manual for loading and unloading cargo oil shall be provided, including operational procedures of loading and unloading cargo oil and detailed data of the initial metacentric height of the oil tanker and that of free surface correction of liquids in cargo oil tanks and ballast tanks during loading and unloading cargo oil (including ballasting and discharging) and cargo oil washing of tanks. **

1.5.3.3 The stability booklet of ro-ro passenger ships shall contain information concerning the importance of securing and maintaining all closures watertight due to the rapid loss of stability which may result when water enters the vehicle deck and the fact that capsize can rapidly follow.

1.5.4 Permanent ballast

If used, permanent ballast should be located in accordance with a plan approved by the Register and in a manner that prevents shifting of position. Permanent ballast shall not be removed from the ship or relocated within the ship without the approval of the Register. Permanent ballast particulars shall be noted in the ship's stability booklet.

1.5.5 Draught marks

Every ship shall 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 ship shall also be fit-
ated with a reliable draught indicating system by which the bow and stern draughts can be determined.

1.6 OPERATIONAL PROVISIONS AGAINST CAPSIZING

1.6.1 General precautions against capsizing

1.6.1.1 Compliance with the stability criteria does not ensure immunity against capsizing, regardless of the circumstances, or absolve the master from his responsibilities. Masters should therefore exercise prudence and good seamanship, having regard to the season of the year, weather forecasts and the navigational zone, and should take the appropriate action as to speed and course warranted by the prevailing circumstances.

1.6.1.2 Care shall be taken that the cargo allocated to the ship is capable of being stowed so that compliance with the criteria can be achieved. If necessary, the amount shall be limited to the extent that ballast weight may be required.

1.6.1.3 Before a voyage commences, care shall be taken to ensure that the cargo and sizeable pieces of equipment have been properly stowed or lashed so as to minimize the possibility of both longitudinal and later shifting, while at sea, under the effect of acceleration caused by rolling and pitching.

1.6.1.4 A ship, when engaged in towing operations, shall possess an adequate reserve of stability to withstand the anticipated heeling moment arising from the tow line without endangering the towing ship. Deck cargo on board the towing ship shall be so positioned as not to endanger the safe working of the crew on deck or impede the proper functioning of the towing equipment and be properly secured. Tow line arrangements should include towing springs and a method of quick release of the tow.

1.6.1.5 The number of partially filled or slack tanks should be kept to a minimum because of their adverse effect on stability. The negative effect on stability of filled pool tanks should be taken into consideration.

1.6.1.6 The stability criteria contained in Section 2 set minimum values, but no maximum values are recommended. It is advisable to avoid excessive values of metacentric height, since these might lead to acceleration forces that could be prejudicial to the ship, its complement, its equipment and to safe carriage of the cargo.

Slack tanks may, in exceptional cases, be used as a means of reducing excessive values of metacentric height. In such cases, due consideration should be given to sloshing effects.

1.6.1.7 Regard should be paid to the possible adverse effects on stability where certain bulk cargoes are carried. In this connection, attention should be paid to the IMO Code of Safe Practice for Solid Bulk Cargoes.

1.6.2 Operational precautions in heavy weather

1.6.2.1 All doorways and other openings, through which water can enter into the hull or deckhouses, forecastle, etc., should be suitably closed in adverse weather conditions and accordingly all appliances for this purpose should be maintained on board and in good condition.

1.6.2.2 Weathertight and watertight hatches, doors, etc., should be kept closed during navigation, except when necessarily opened for the working of the ship and should always be ready for immediate closure and be clearly marked to indicate that these fittings are to be kept closed except for access. Hatch covers and flush deck scuttles in fishing vessels should be kept properly secured when not in use during fishing operations. All portable deadlights should be maintained in good condition and securely closed in bad weather.

1.6.2.3 Any closing devices provided for vent pipes to fuel tanks should be secured in bad weather.

1.6.2.4 Fish should never be carried in bulk without first being sure that the portable divisions in the holds are properly installed.

1.6.3 Ship handling in heavy weather

1.6.3.1 In all conditions of loading necessary care should be taken to maintain a seaworthy freeboard.

1.6.3.2 In severe weather, the speed of the ship should be reduced if propeller emergence, shipping of water on deck or heavy slamming occurs.

1.6.3.3 Special attention should be paid when a ship is sailing in following, quartering or head seas because dangerous phenomena such as parametric resonance, broaching to, reduction of stability on the wave crest, and excessive rolling may occur singularly, in sequence or simultaneously in a multiple combination, creating a threat of capsizing. A ship’s speed and/or course should be altered appropriately to avoid the above-mentioned phenomena.

1.6.3.4 Reliance on automatic steering may be dangerous as this prevents ready changes to course which may be needed in bad weather.

1.6.3.5 Water trapping in deck wells should be avoided. If freeing ports are not sufficient for the drainage of the well, the speed of the ship should be reduced or the course changed, or both. Freeing ports provided with closing appliances should always be capable of functioning and are not to be locked.

1.6.3.6 Masters should be aware that steep or breaking waves may occur in certain areas, or in certain wind and current combinations (river estuaries, shallow water areas, fun-

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* Refer to the Revised Guidance to the master for avoiding dangerous situations in adverse weather and sea conditions (MSC.1/Circ.1228).

** Refer to the Guidelines for the preparation of the Cargo Securing Manual (MSC/Circ.745).

*** Refer to the Revised Guidance to the master for avoiding dangerous situations in adverse weather and sea conditions (MSC.1/Circ.1228).
nel shaped bays, etc.). These waves are particularly dangerous, especially for small ships.

1.6.3.7 In severe weather, the lateral wind pressure may cause a considerable angle of heel. If anti-heeling measures (e.g., ballasting, use of anti-heeling devices, etc.) are used to compensate for heeling due to wind, changes of the ship's course relative to the wind direction may lead to dangerous angles of heel or capsizing. Therefore, heeling caused by the wind should not be compensated with anti-heeling measures, unless, subject to the approval by the Register, the vessel has been proven by calculation to have sufficient stability in worst case conditions (i.e. improper or incorrect use, mechanism failure, unintended course change, etc.). Guidance on the use of anti-heeling measures should be provided in the stability booklet.

1.6.3.8 Use of operational guidelines for avoiding dangerous situations in severe weather conditions or an on-board computer based system is recommended. The method should be simple to use.

1.6.3.9 High-speed craft should not be intentionally operated outside the worst intended conditions and limitations specified in the relevant certificates or in documents referred to therein.

1.7 DETERMINATION OF LIGHTSHIP DISPLACEMENT AND CENTRES OF GRAVITY

1.7.1 Definitions

For the purpose of this head, unless expressly provided otherwise:

.1 Certification of the test weights is the verification of the weight marked on a test weight. Test weights shall be certified using a certificated scale. The weight measurement shall be performed close enough in time to the inclining test to ensure that the measured value is accurate. Process of certification shall be conducted in front of the Register's representative.

.2 The inclining test involves moving a series of known weights, normally in the transverse direction, and then measuring the resulting change in the equilibrium heel angle of the ship. By using this information and applying basic naval architecture principles, the ship's vertical centre of gravity (VCG) is determined.

.3 Light-ship condition is a ship complete in all respects, but without consumables, stores, cargo, crew and effects, and without any liquids on board except that machinery and piping fluids, such as lubricants and hydraulics, are at operating levels.

.4 A light-weight survey involves taking an audit of all items which shall be added, deducted or relocated on the ship at the time of the inclining test so that the observed condition of the ship can be adjusted to the light-ship condition. The weight, longitudinal, transverse and vertical location of each item shall be accurately determined and recorded. Using this information, the static waterline of the ship at the time of the inclining test as determined from measuring the freeboard or verified draught marks of the ship, the ship's hydrostatic data, and the seawater density, the light-ship displacement and longitudinal centre of gravity (LCG) can be obtained. The transverse centre of gravity (TCG) may also be determined for ships which are asymmetrical about the centreline or whose internal arrangement or outfitting is such that an inherent list may develop from off-centre weight.

1.7.2 Application

1.7.2.1 The following ships shall be subjected to inclining test:

.1 series-built ships as per 1.7.2.2, except passenger ships;

.2 every newly built ship of non-series construction and every new passenger ship;

.3 ships after alternations or modifications, major repairs or replacement of machinery installations and equipment as per 1.7.2.3;

.4 ship after installation of permanent solid ballast, as per 1.7.2.4;

.5 ships whose stability is unknown or gives rise to doubts;

.6 passenger ships in service at periodic intervals not exceeding five years, if it is necessary as per 1.7.2.5.

1.7.2.2 Series-built ships at the same shipyard apply to inclining test as follows:

.1 the first (leading), then each fifth ship of the series (i.e. first, sixth, eleventh etc.), if it is shown to the satisfaction of the Register that reliable stability information for the exempted ships can be obtained from provided stability data available from the inclining test of a sister ship, according to 1.7.2.2.2.

Except for the first ship, if during the inclining test the weather conditions are unfavourable, the Register may permit that

* The weight of mediums on board for the fixed fire-fighting systems (e.g., freshwater, CO2, dry chemical powder, foam concentrate, etc.) should be included in the lightweight and lightship condition.
For intermediate \( L \):
- by linear interpolation;
- the deviation of the lightship’s longitudinal centre of gravity (LCG) referred to \( L \) by more than 0.5 % regardless of the ship’s length;
- the increase of the calculated lightship’s vertical centre of gravity (VCG) by more than 4 cm and the lesser value determined by the formula:

\[
\Delta KG = 0.10 \cdot \frac{\Delta \lambda_1}{\Delta \lambda_0} \cdot GZ_{\text{max}}
\]  

\[
\Delta KG = 0.05 \cdot \frac{\Delta \lambda_1}{\Delta \lambda_0} \cdot GM
\]  

where:
- \( \Delta \lambda_0 \) = lightship displacement in [t],
- \( \Delta \lambda_1 \) = ship’s displacement under the most unfavourable loading condition with respect to the GM or GZ max values in [t],
- \( GZ_{\text{max}} \) = the maximum righting arm of statical stability curve corrected due to the free surfaces at the design ship’s loading condition which is most unfavourable with respect to this arm in [m];
- \( \lambda_1 \) if the particular designed loading conditions do not satisfy the requirements stated in this part of the Rules caused by change of displacement or increased ordinate of the lightship’s vertical centre of gravity.

Such ship shall be considered as the first ship of a new series as regards stability and the inclining test procedure of the subsequent ships from this series shall comply with the requirements of 1.7.2.2.1.

1.7.2.3 The ships shall be subjected to the inclining test after major repairs, alterations and modifications of their machinery, installation and equipment if the calculations indicate that the later results in at least one of the following cases:

1. the change of the load, i.e. total mass of loads removed and added by more than 6% of the lightship displacement, or
2. the change in the lightship displacement by more than 2 %, or
3. the change of the lightship’s longitudinal centre of gravity (LCG) referred to \( L \) by more than 1 %, or
4. the increase of the calculated lightship’s vertical centre of gravity height by more than the value obtained as per 1.7.2.2.2-3, or
5. unfulfillment of the requirements for single designed loading conditions referred to in the present part of the Rules.

Irrespective of the calculations, Register may require the inclining test to be performed for the ships stated in 1.7.2.1.5.

1.7.2.4 After installation of the permanent solid ballast each ship is to be inclined.

The inclining test of the ship may be dispensed with if the Register is satisfied that when installing the ballast, efficient control is effected to ensure the design values of mass and centre of gravity position, or these values of mass and centre of gravity position, or these values can be properly confirmed by calculation.

1.7.2.5 At periodic intervals not exceeding five years, a lightweight survey should be carried out on all passenger ships to verify any changes in lightship displacement and longitudinal centre of gravity. The ship should be re-inclined whenever, in comparison with the approved stability information, a deviation from the lightship displacement exceeding 2% or a deviation of the longitudinal centre of gravity exceeding 1% of \( L \) is found, or anticipated. The results of survey with check for compliance with here stated criteria shall be submitted for approval to Register in documented form.

1.7.2.6 Where the inclining test results show that the height of the centre of gravity exceeds the designed height by the value which results in the unfulfillment of the requirement of the present part of the Rules, calculations with explanation of the reasons of such differences are to be attached to the Inclining Test Record.

Based on the check of the technical documentation submitted, or in case such documentation is not available, Register may require the repeated inclining test to be performed. In this case both Inclining Test Records are to be submitted to the Register for consideration.
1.7.3 Preparations for the inclining test

1.7.3.1 Notification of the Register

Written notification with the proposal of the inclining test should be submitted for approval to the Register as it requires and in due time before the test. The Register representative shall be present to witness the inclining test and the test results be submitted for approval.

The responsibility for making preparations, conducting the inclining test and light-weight survey, recording the data, and calculating the results rests with the shipyard, owner or naval architect. While compliance with the procedures outlined herein will facilitate an expeditious and accurate inclining test, it is recognized that alternative procedures or arrangements may be equally efficient. However, to minimize risk of delay, that all such variances shall be submitted to the Register for approval prior to the inclining test.

1.7.3.2 Details of notification

Written notification shall provide the following information as the Register may require:

1. identification of the ship by name and shipyard hull number, if applicable;
2. date, time, and location of the test;
3. inclining weight data:
   a. type;
   b. amount (number of units and weight of each);
   c. certification;
   d. method of handling (i.e. sliding rail or crane);
   e. anticipated maximum angle of heel to each side;
4. Measuring devices:
   a. pendulums - approximate location and length;
   b. U-tubes - approximate location and distance between legs;
   c. inclinometers - location and details of approvals and calibrations;
5. approximate trim;
6. condition of tanks;
7. estimated weights to deduct, to complete, and to relocate in order to place the ship in its true lightship condition;
8. detailed description of any computer software to be used to aid in calculations during the inclining test;
9. name and phone number of the person responsible for conducting the inclining test.

1.7.3.3 General condition of the ship

1. A ship should be as complete as possible at the time of the inclining test and its weight shall be as far as practicable close to the lightship displacement. The test should be scheduled to minimize the disruption in the ship’s delivery date or its operational commitments.

2. The mass of missing loads shall not exceed 2 % of the lightship displacement, and the mass of surplus loads (less inclining weight and ballast according to 1.7.3.3) not to exceed 4 % of the lightship displacement.

3. The metacenter height of the ship in the process of the inclining test shall be at least 0.20 m. For this purpose necessary ballast may be taken. When water ballast is taken, the tanks shall be filled up and carefully sealed.

1.7.3.4 The amount and type of work left to be completed (mass to be added) affect the accuracy of the lightship characteristics, so good judgement shall be used. If the mass or centre of gravity of an item to be added cannot be determined with confidence, it is best to conduct the inclining test after the item is added.

1.7.3.5 Temporary material, toolboxes, staging, sand, debris, etc., on board shall be reduced to absolute minimum before the inclining test. Excess crew or personnel not directly involved in the inclining test should be removed from on board the ship before the test.

1.7.3.6 Decks shall be free of water. Water trapped on deck may shift and pocket in a fashion similar to liquids in a tank. Any rain, snow or ice accumulated on the ship shall be removed prior to the test.

1.7.3.7 The anticipated liquid loading for the test shall be included in the planning for the test. Preferably, all tanks shall be empty and clean, or completely full. The number of slack tanks shall be kept to an absolute minimum. The viscosity of the fluid, the depth of the fluid and the shape of the tank shall be such that the free surface effect can be accurately determined.

1.7.3.8 The ship shall be moored in a quiet, sheltered area free from extraneous forces such as propeller wash from passing vessels or sudden discharges from shore-side pumps. The tide conditions and the trim of the ship during the test shall be considered. Prior to the test, the depth of water shall be measured and recorded in as many locations as are necessary to ensure that the ship will not contact the bottom. The specific gravity of water shall be accurately recorded. The ship shall be moored in a manner to allow unrestricted heeling. The access ramps shall be removed. Power lines, hoses, etc., connected to shore shall be at a minimum, and kept slack at all times.

1.7.3.9 The ship should be as upright as possible; with inclining weights in the initial position, up to 0.5° of list is acceptable. The actual trim and deflection of keel, if practical, should be considered in the hydrostatic data. In order to avoid excessive errors caused by significant changes in the water plane area during heeling, hydrostatic data for the actual trim and the maximum anticipated heeling angles should be checked beforehand.

1.7.3.10 The total weight used shall be sufficient to provide a minimum inclination of one degree and a maximum of four degrees of heel to each side. The Register may, however, accept a smaller inclination angle for large ships provided that the requirements on pendulum deflection or U-tube...
ference in height in 1.7.3.11 are complied with. Test weights shall be compact and of such a configuration that the vertical
centre of gravity of the weights can be accurately deter-
mined. Each weight shall be marked with an identification
number and its weight. Re-certification of the test weights
shall be carried out prior to the inclining. A crane of suffi-
cient capacity and reach, or some other means, shall be avail-
able during the inclining test to shift weights on the deck in
an expeditious and safe manner. Water ballast transfer may
be carried out, when it is impractical, to incline using solid
weights, if acceptable to the Register.

1.7.3.11 The use of three pendulums is recommended but a minimum of two shall be used to allow identification of
bad readings at any one pendulum station. They shall each be
located in an area protected from the wind.

1.7.3.12 Efficient two-way communications shall be
provided between central control and the weight handlers and
between central control and each pendulum station. One per-
son at a central control station shall have complete control
over all personnel involved in the test.

1.7.4 Plans required
The person in charge of the inclining test shall have available a copy of the following plans at the time of the inclining test:

1. lines plan;
2. hydrostatic curves or hydrostatic data;
3. general arrangement plan of decks, holds, inner bottoms, etc.;
4. capacity plan showing capacities and ver-
tical and longitudinal centres of gravity
of cargo spaces, tanks, etc. When ballast
water is used as inclining weight, the
transverse and vertical centres of gravity
for the applicable tanks for each angle of
inclination, must be available;
5. tank sounding tables;
6. draught mark locations; and
7. docking drawing with keel profile and
draught mark corrections (if available).

1.7.5 Test procedure

1.7.5.1 Procedures followed in conducting the inclining
test and lightweight survey shall be in accordance with the
recommendations laid out in Appendix 3 to this part
Rules.

1.7.5.1.1 Freeboard/draught readings shall be taken to
establish the position of the waterline in order to determine
the displacement of the ship at the time of the inclining test.
It is recommended that at least five freeboard readings, ap-
proximately equally spaced, be taken on each side of the ship
or that all draught marks (forward, midship and aft) be read
on each side of the ship. Draught/freeboard readings shall be
read immediately before or immediately after the inclining
test.

1.7.5.1.2 The standard test employs eight distinct weight
movements. Movement No. 8, a recheck of the zero point,
may be omitted if a straight line plot is achieved after move-
ment No. 7. If a straight line plot is achieved after the initial
zero and six weight movements, the inclining test is complete
and the second check at zero may be omitted. If a straight
line plot is not achieved, those weight movements that did
not yield acceptable plotted points shall be repeated or ex-
plained.

1.7.5.2 A copy of the inclining data shall be forwarded
to the Register along with the calculated results of the inclin-
ing test in a form of a document for approval. Data shall cor-
respond to those in the official form “Record of inclining
test”, filled in on the site by the Register’s representative.

1.7.5.3 All calculations performed during the inclining
test and in preparation of an inclining test report may be car-
ried out by a suitable computer program. Output generated
by such a program may be used for presentation of all or par-
tial data and calculations included in the test report if it is
clear, concise, well documented, and generally consistent in
form and content with Register requirements.

1.7.6 Acceptance of the inclining test results

1.7.6.1 In well performed inclining test the value of the
metacentric height obtained may be used in calculations with
no deduction for probable error of the test.

The inclining test is considered to be satisfac-
tory performed, provided:

\[ |h_i - h_k| \leq 2 \sqrt{\frac{\sum (h_i - h_k)^2}{n-1}} \]

where

- \( h_i \) = metacentric height obtained by individual
  measurement;
- \( h_k \) = \( \frac{\sum (h_i)}{n} \) is metacentric height obtained
  in inclining the ship;
- \( n \) = number of measurements.

Measurements not meeting the above condition
are excluded when treating the results with appropriate
change of the total number $n$ and repeated calculation of the metacentric height $h_k$:

\[ t_{am} \sum \frac{(h_i - h_k)^2}{n (n-1)} \]

\[ \leq 0.02 (1 + h_k) \text{ if } h_k \leq 2 \text{ m} \]

fulfils the condition

\[ t_{am} \sum \frac{(h_i - h_k)^2}{n (n-1)} \leq 0.04 h_k \text{ if } h_k > 2 \text{ m} \]

and

The following condition is fulfilled:

\[ t_{am} \sum \frac{(h_i - h_k)^2}{n (n-1)} \leq 0.05 h \text{ or } l_{max} \]

whichever is less, but not less than 4 cm, where $h$ and $l_{max}$ are calculated for the most unfavourable design loading conditions as regards their values;

No more than one measurement is excluded from the calculation (greater number of measurements may be excluded only in well-grounded cases on agreement with the Register).

1.7.6.2 Where the requirements of 1.7.6.1 are not fulfilled the value of the metacentric height less the probable error of the test obtained as per 1.7.6.1.1 may be taken for calculations upon agreement with the Register.

1.7.6.3 The inclining test of the ship shall be performed in compliance with the Register's detailed guidance for the conduct of an inclining test set in Appendix 3.

### Table 1.7.6.1.2

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1.8 DEPARTURES FROM THE RULES

1.8.1 If doubts arise regarding stability of any ship in complying with the requirements of this part of the Rules, or the requirements set forth in this part of the Rules are considered to be too severe, Register may permit, on its own initiative or on well-grounded statements of designers and shipowner, appropriate aberrations from the requirements of this part of the Rules for the ship concerned.

1.8.2 When a ship navigating in a particular area does not comply with the requirements of this part of the Rules, the Register may, in each particular case either restrict the ship's area of navigation or place other limitations depending upon the ship's stability characteristics, service conditions and purpose the ship is intended for.

1.8.3 For small ships of up to 45 m in length in restricted areas of navigation 3 to 8 (definitions of areas are set in item 4.2.3 of the Rules, Part 1 - General Requirements, Chapter 1 - General information), the Register may allow use of alternative calculations for wind heeling moments, set in Appendix 4.

1.9 CONDITIONS OF SUFFICIENT STABILITY

1.9.1 Under the most unfavourable loading conditions with regard to stability, the ship's stability, except for floating cranes, pontoons, floating docks and berth-connected ships, shall comply with the following requirements:

\[ \text{.1 the ship shall withstand, without capsizing, simultaneously the effect of dynamically applied wind pressure and rolling the parameters of which are determined in compliance with the directions given in Section 2;} \]

\[ \text{.2 numerical values of the parameters of the statical stability curve for the ship on still water and the values of the corrected initial metacentric height shall not be below those specified in Section 2.} \]

\[ \text{.3 the effect of consequences of probable icing upon stability shall be taken into account when checking compliance with Section 2 for ship that is intended to navigating in waters where icing is possible;} \]

\[ \text{.4 stability of a ship shall comply with additional requirements of Section 3.} \]

1.9.2 The stability of floating cranes, pontoons, floating docks and berth-connected ships shall comply with the requirements of Section 4.

1.9.3 For ships to which the requirements of the Rules, Part 5 - Subdivision are applicable, the intact stability shall be sufficient to meet these requirements in damaged condition.
1.10 PASSAGE OF SHIPS FROM ONE PORT TO ANOTHER

1.10.1 When passing from one port to another, the ship's stability shall meet the requirements imposed upon ships navigating in a region through which the passage is expected to be undertaken.

1.10.2 For ships whose stability cannot be raised up to that required by 1.10.1, the Register may permit the passage of the ship provided that weather restrictions are imposed on it and that the ship's stability complies with those restrictions.
2 GENERAL REQUIREMENTS ON STABILITY

2.1 GENERAL INTACT STABILITY CRITERIA

2.1.1 Scope of application

2.1.1.1 Requirements of this Section of the Rules apply to all ships. However, some relaxation may be granted to ships less than 24 m in length, after the consideration of the Register on case by case basis.

2.1.1.2 The criteria stated in this Section of the Rules present a set of minimum requirements that shall apply to cargo and passenger ships. The criteria stated under Section 3 are special criteria for certain types of ships and shall be used as mandatory requirements for them. Those specific considerations may also apply to other ships subject to similar external forces, when determining the adequacy of stability.

2.1.1.3 Multihull ships may, as alternative to the criteria set in this Section, use the intact stability criteria from the Annex 7 of the Rules, Part 28 - High-speed craft instead, even if they are not classified as high-speed crafts.

2.1.2 General

2.1.2.1 All criteria shall be applied for all conditions of loading appropriate for certain type of ship, as set out in 1.4.8, in Section 3 and in Section 4.

2.1.2.2 Free surface effect (1.4.7) shall be accounted for in all conditions of loading as set out in 1.4.8, in Section 3 and in Section 4.

2.1.2.3 Where anti-rolling devices are installed in a ship, the Register shall be satisfied that the criteria can be maintained when the devices are not in operation.

2.1.2.4 A number of influences, such as beam wind on ships with large windage area, icing of topsides, water trapped on deck, rolling characteristics, following seas, etc., adversely affect stability is to be take into account, so far as Register deems it necessary.

2.1.2.5 Provisions shall be made for a safe margin of stability at all stages of the voyage, regard being given to additions of weight, such as those due to absorption of water and icing (details regarding ice accretion are given in 2.2), and to losses of weight, such as those due to consumption of fuel and stores.

2.1.2.6 Each ship shall be provided with a stability booklet, approved by the Register, which contains sufficient information (see 1.5.1) to enable the master to operate the ship in compliance with the applicable requirements contained in this part of the Rules. If a stability instrument is used as a supplement to the stability booklet for the purpose of determining compliance with the relevant stability criteria such instrument shall be subject to the approval by the Register (see Appendix 5 - Stability calculations performed by stability instruments).

2.1.2.7 If curves or tables of minimum operational metacentric height (GM) or maximum vertical centre of gravity (VCG) are used to ensure compliance with the relevant intact stability criteria those limiting curves shall extend over the full range of operational trims, unless the Register agrees that trim effects are not significant. When curves or tables of minimum operational metacentric height (GM) or maximum centre of gravity (VCG) versus draught covering the operational trims are not available, the master must verify that the operating condition does not deviate from a studied loading condition, or verify by calculation that the stability criteria are satisfied for this loading condition taking into account trim effects.

2.1.2.8 For ships carrying oil-based pollutants in bulk, the Register shall be satisfied that the criteria given in 3.4 can be maintained during all loading and ballasting operations.

2.1.2.9 For ships which do not comply with the requirement of this Section with respect to the angle of vanishing stability because the curve cut short at the angle of flooding \( \theta_f \), navigation may be permitted in that restricted area of navigation which results from the calculation for the weather criterion, i.e. the ship's stability to endure lateral wind pressure. It is necessary, however, that the conventional angle of vanishing stability determined on the assumption of weather-tight closures of the openings through which flooding occurs shall be not less than that required by this Section.

2.1.2.10 For ships less than 20 m in length, the curve of statical stability is not allowed to cut short at angles of heel less than 40°.

2.1.2.11 See also general recommendations of an operational nature given in item 1.6.1.

2.1.3 Criteria regarding righting lever curve properties

2.1.3.1 The area under the righting lever curve (GZ curve) shall not be less than 0.055 metre-radians up to \( \theta = 30^\circ \) angle of heel and not less than 0.09 metre-radians up to \( \theta = 40^\circ \) or the angle of down flooding \( \theta_f \) if this angle is less than 40°.

Additionally, the area under the righting lever curve (GZ curve) between the angles of heel of 30° and 40° or between 30° and \( \theta_f \), if this angle is less than 40°, should not be less than 0.03 metre-radiants.

2.1.3.2 The righting lever GZ shall be at least 0.2 m at an angle of heel equal to or greater than 30°.

\* \( \theta_f \) is angle of heel at which openings in the hull, superstructures or deck-houses which cannot be closed weathertight immure. In applying this criterion, small opening through with progressive flooding cannot take place need not be considered as open. Openings which cannot be closed weathertight include ventilators (complying with ILLC 19(4)) that for operational reasons have to remain open to supply air to the engine room, emergency generator room or closed ro-ro and vehicle spaces (if the same is considered buoyant in the stability calculation or protecting openings leading below) for the effective operation of the ship. Where it is not technically feasible to treat some closed ro-ro and vehicle space ventilators as unprotected openings, Register may allow an alternative arrangement that provides an equivalent level of safety.
2.1.3.3 The maximum righting arm shall occur at an angle of heel not less than 25°. If this is not practicable, alternative criteria presented in 2.1.3.4 may be applied.

2.1.3.4 For certain ships the requirement contained in 2.1.3.3 may not be practicable. Such ships are typically of wide beam and small depth, indicatively B/D ≥2.5. For such ships the following equivalent criteria are required as an alternative:

.1 the maximum righting lever (GZ) shall occur at an angle of heel not less than 15°; and

.2 the area under the curve of righting levers (GZ curve) shall not be less than 0.070 metre-radians up to an angle of 15° when the maximum righting lever (GZ) occurs at 15° and 0.055 metre-radians up to an angle of 30° when the maximum righting lever (GZ) occurs at 30° or above. Where the maximum righting lever (GZ) occurs at angles of between 15° and 30°, the corresponding area under the righting lever curve shall be:

\[ 0.055 + 0.001(30° - \theta_{max}) \text{[m rad]} \]

2.1.4 Metacentric height

2.1.4.1 The corrected initial metacentric height for all ships in all loading conditions, except for the lightship conditions shall be:

.1 For ships less than 20 m in length, except those referred in .3, at least 0.5 m.

.2 For timber carriers, not less than indicated under 3.3.5.

.3 For single-deck fishing vessels not less than 0.35 m.

.4 For all other decked ships, including fishing vessels with complete superstructure or of 70 m in length and over, not less than 0.15 m.

2.1.4.2 The corrected initial metacentric height of well-deck ships shall be checked for the case of water penetration into the well.

Amount of water in the well and its free surface shall correspond to the water level up to the lower edge of the freeing ports for a ship in upright position allowing for the deck camber.

If a ship has two or more wells, stability shall be checked for the case of flooding of the largest one.

2.1.4.3 For all ships in "lightship" loading condition, initial metacentric height may be determined taking into account trim of the ship and so determined metacentric height is subject to special consideration of the Register in each case.

\* \( \theta_{max} \) is the angle of heel in degrees at which the righting lever curve reaches its maximum.

2.1.5 Severe wind and rolling criterion (weather criterion)

2.1.5.1 The ability of a ship to withstand the combined effects of beam wind and rolling shall be demonstrated for each standard condition of loading, with reference to figure 2.1.5.1 as follows:

.1 the ship is subjected to a steady wind pressure acting perpendicular to the ship’s centreline which results in a steady wind heeling lever \( L_{w1} \);

.2 from the resultant angle of equilibrium \( \theta_0 \), the ship is assumed to roll owing to wave action to an angle of roll \( \theta_1 \) to windward. The angle of heel under action of steady wind \( \theta_0 \) shall not exceed 16° or 80% of the angle of deck edge immersion, whichever is less;

.3 the ship is then subjected to a gust wind pressure which results in a gust wind heeling lever \( L_{w2} \);

.4 under these circumstances, area b shall be equal to or greater than area a, as indicated in figure 2.1.5.1;

.5 free surface effects (according 1.4.7) shall be accounted for in all conditions of loading.

The angles in figure 2.1.5.1 are defined as follows:

* The angle of roll of ships with anti-rolling devices shall be determined without taking into account the operation of these devices.
\( \theta_c \) = angle of heel at which openings in the hull, superstructures or deckhouses which cannot be closed weathertight immerse. In applying this criterion, small openings through which progressive flooding cannot take place need not be considered as open.

\( \theta_c \) = angle of second intercept between wind heeling lever \( l_{w1} \) and GZ curves.

### 2.1.5.2

The wind heeling levers \( l_{w1} \) and \( l_{w2} \) referred to in 2.1.5.1.1 and 2.1.5.1.3 are constant values at all angles of inclination and shall be calculated as follows:

\[
l_{w1} = \frac{P \cdot A \cdot Z}{1000 \cdot g \cdot \Delta} \quad \text{[m]} \quad \text{and}
\]

\[
l_{w2} = 1.5 \cdot l_{w1} \quad \text{[m]}
\]

where:

- \( P \) = wind pressure of 504 Pa. The value of \( P \) used for ships in restricted service may be reduced subject to the approval of the Register;
- \( A \) = projected lateral area of the portion of the ship and deck cargo above the waterline \([\text{m}^2]\);
- \( Z \) = vertical distance from the centre of \( A \) to the centre of the underwater lateral area or approximately to a point at one half the mean draught \([\text{m}]\);
- \( \Delta \) = displacement \([\text{t}]\)

### Table 2.1.5.3-1

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<tr>
<th>( c )</th>
<th>( X_2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \leq 0.45 )</td>
<td>0.75</td>
</tr>
<tr>
<td>0.50</td>
<td>0.82</td>
</tr>
<tr>
<td>0.55</td>
<td>0.89</td>
</tr>
<tr>
<td>0.60</td>
<td>0.95</td>
</tr>
<tr>
<td>0.65</td>
<td>0.97</td>
</tr>
<tr>
<td>( \geq 0.70 )</td>
<td>1.0</td>
</tr>
</tbody>
</table>

The symbols in the above tables and formula for the rolling period are defined as follows:

- \( L_{WL} \) = length of the ship at waterline \([\text{m}]\)
- \( B \) = moulded breadth of the ship \([\text{m}]\)
- \( d \) = mean moulded draught of the ship \([\text{m}]\)
- \( C_B \) = block coefficient
- \( A_K \) = total overall area of bilge keels, or area of the lateral projection of the bar keel, or sum of these areas \([\text{m}^2]\)
- \( g \) = gravitational acceleration of 9.81 \([\text{m/s}^2]\)

### Table 2.1.5.3-3

<table>
<thead>
<tr>
<th>( \frac{A_K \cdot 100}{L_{WL} \cdot B} )</th>
<th>( k )</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1.0</td>
</tr>
<tr>
<td>1.0</td>
<td>0.98</td>
</tr>
<tr>
<td>1.5</td>
<td>0.95</td>
</tr>
<tr>
<td>2.0</td>
<td>0.88</td>
</tr>
<tr>
<td>2.5</td>
<td>0.79</td>
</tr>
<tr>
<td>3.0</td>
<td>0.74</td>
</tr>
<tr>
<td>( \geq 4.0 )</td>
<td>0.70</td>
</tr>
</tbody>
</table>

### Table 2.1.5.3-4

<table>
<thead>
<tr>
<th>( T )</th>
<th>( s )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \leq 6 )</td>
<td>0.100</td>
</tr>
<tr>
<td>7</td>
<td>0.098</td>
</tr>
<tr>
<td>8</td>
<td>0.093</td>
</tr>
<tr>
<td>12</td>
<td>0.065</td>
</tr>
<tr>
<td>14</td>
<td>0.053</td>
</tr>
<tr>
<td>16</td>
<td>0.044</td>
</tr>
<tr>
<td>18</td>
<td>0.038</td>
</tr>
<tr>
<td>( \geq 20 )</td>
<td>0.035</td>
</tr>
</tbody>
</table>

**Table 2.1.5.3**

- Values of factor \( X_1 \)
- Values of factor \( X_2 \)
- Value of factor \( k \)
- Value of factor \( s \)

**The angle of roll** \( \theta \) referred to in 2.1.5.1.2 shall be calculated as follows:

\[
\theta = 109 k X_1 X_2 \sqrt{\frac{r}{s}} \quad \text{[degrees]}
\]

where:

- \( X_1 \) = factor as shown in Table 2.1.5.3-1
- \( X_2 \) = factor as shown in Table 2.1.5.3-2
- \( k \) = factor as follows:
- \( k = 1.0 \) for a round-bilged ship having no bilge or bar keels
- \( k = 0.7 \) for a ship having sharp bilges
- \( k \) = as shown in Table 2.1.5.3-3 for a ship having bilge keels, a bar keel or both

\[ r = 0.73 + 0.6 \frac{OG}{d} \]

with:

- \( OG = KG - d \)
- \( d \) = mean moulded draught of the ship \([\text{m}]\)

**Rolling period** \( T = \frac{2 \cdot C \cdot B}{\sqrt{GM}} \) \([\text{s}]\)

where:

- \( C = 0.373 + 0.023 (B/d) - 0.043 (L_{WL}/100) \)

The symbols in the above tables and formula for the rolling period are defined as follows:

### 2.1.5.4

The tables and formulae described in 2.1.5.3 are based on data from ships having:

- \( B/d \) smaller than 3.5;
- \( (KG/d-1) \) between -0.3 and 0.5; and
- \( T \) smaller than 20 s.
For ships with parameters outside of the above limits the angle of roll (θ) may be determined with model experiments of a subject ship with the procedure described in MSC.1/Circ.1200 as the alternative. In addition, the Register may accept such alternative determinations for any ship, if deemed appropriate.

2.2 ALLOWANCE FOR ICING

2.2.1 For any ship operating in areas where ice accretion is likely to occur, adversely affecting a ship’s stability, icing allowances shall be included in the analysis of conditions of loading, in addition to the main loading conditions. In the calculation for icing, account should be taken of increase in displacement, height of the centre of gravity and windage area due to icing.

The stability under icing should be calculated for the worst loading condition as to stability. The mass of ice when calculating stability under icing, is considered as an overload and is not included in the ship's deadweight.

2.2.2 In the application of the standards stated in 2.2.3 and 2.2.4 the following icing areas shall apply:

1. the area north of latitude 65° 30´ N, between longitude 28° W and the west coast of Iceland; north of the north coast of Iceland; north of the rhumb line running from latitude 66° N, longitude 15° W to latitude 73° 30´ N, longitude 15° E, north of latitude 73° 30´ N between longitude 15° E and 35° E, and east of longitude 35° E, as well as north of latitude 56° N in the Baltic Sea;
2. the area north of latitude 43° N bounded in the west by the North American coast and the east by the rhumb line running from latitude 43° N, longitude 48° W to latitude 63° N, longitude 28° W and thence along longitude 28° W;
3. all sea areas north of the North American Continent, west of the areas defined in .1 and .2 of this item;
4. the Bering and Okhotsk Seas and the Tatarsky Strait during the icing season; and
5. south of latitude 60° S.

A chart to illustrate the areas is attached at the end of this Head.

For vessels operating in areas where ice accretion may be expected:

6. within the areas defined in .1, .3, .4 and .5 of this item known to having icing conditions significantly different from those described in 2.2.3, ice accretion requirements of one half to twice the required allowance may be applied; and
7. within the area defined in .2 of this item, where ice accretion in excess of twice the allowance required by 2.2.3 may be expected, more severe requirements than those given in 2.2.3 may be applied.

2.2.3 For vessels operating in areas where ice accretion is likely to occur, the following icing allowance shall be made in the stability calculations:

1. 30 kg per square metre on exposed weather decks and gangways. The total horizontal projection of decks shall include horizontal projections of all exposed decks and gangways, irrespective of the availability of awnings. The vertical moment due to this loading is determined for heights of the centre of gravity of the corresponding areas of decks and gangways. The deck machinery, arrangements, hatch covers, etc. are included in the projection of decks and are not taken into account separately.
2. 7.5 kg per square metre for projected lateral area of each side of the vessel above the water plane. That area and its height of the centre of gravity shall be determined for a draught dmin as specified in 1.4.6, calculated without considering the effect of ice accretion.
3. the projected lateral area of discontinuous surfaces of rail, sundry booms, spars (except masts) and rigging of vessels having no sails and the projected lateral area of other small objects shall be computed by increasing the total projected area of continuous surfaces by 5% and the static moments of this area by 10%.

Vessels intended for operation in areas where ice is known to occur shall be:

4. designed to minimise the accretion of ice; and
5. equipped with such means for removing ice as the Register may require; for example, electrical and pneumatic devices, and/or special tools such as axes or wooden clubs for removing ice from bulwarks, rails and erections.

2.2.4 Allowance for ice accretion on cargo ships carrying timber deck cargoes

.1 The ice accretion weight, w (kg/m2), may be taken as follows:

\[ w = 30 \cdot \frac{2.3 (15.2L - 351.8)}{l_{FB}} \cdot f_a \cdot \frac{l_{bow}}{0.16L} \]

where:

- \( f_a \) = timber and lashing factor = 1.2
- \( L \) = length of ship in m
- \( l_{FB} \) = freeboard height in mm
- \( l_{bow} \) = length of bow flare region in m, to be taken as the distance from the longitudinal position at which the maximum breadth occurs on a water line located 0.5 metres
below the freeboard deck at side to the foremost point of the bow at that water-line.

.2 The ice accretion weight, w (kg/m2), over the timber deck region should be applied to each of the load cases as illustrated in figure 2.2.4.2:

2.2.5 Register shell take into account and permit to apply national standards where environmental conditions are considered to warrant a higher standard than those in this part of the Rules.

![Figure 2.2.4.2](chart.png)

**Figure 2.2.4.2**

Chart of areas of icing conditions

Legend:
- Full ice accretion allowance should be applied
- Vessels operating in these areas have been subjected to conditions in which vessels have been observed with the indicated ice accretion allowances
3 ADDITIONAL REQUIREMENTS FOR STABILITY

3.1 PASSENGER SHIPS

3.1.1 Stability of passenger ships shall be checked for the following loading conditions:

1. ship in the fully loaded departure condition, having a draught to the summer load line, with cargo, full stores and fuel and with the full number of passengers with their luggage;
2. ship in the fully loaded arrival condition, with cargo, the full number of passengers and their luggage but with only 10% stores and fuel remaining;
3. ship without cargo, but with full stores and fuel and the full number of passengers with luggage;
4. ship in the same condition as in .3 above with only 10% stores and fuel remaining;
5. ship without cargo and passengers, but with full stores and fuel;
6. ship in the same loading conditions as in .5, but with 10% of stores and fuel;
7. ship in the same loading conditions as in .2, but with 50% of stores and fuel.

When calculating these loading conditions ballast tanks shall be assumed to be empty. A possibility of liquid ballasting shall be agreed with the Register.

3.1.2 A minimum weight of 75 kg shall be assumed for each passenger except that this value may be increased subject to the approval of the Register. In addition, the mass and distribution of the luggage shall be approved by the Register.

Passengers and luggage shall be considered to be in the spaces normally at their disposal, with cabin passengers assumed to be in their accommodations and deck passengers on appropriate decks.

The height of the centre of gravity for passengers shall be assumed equal to:

1. 1 m above deck level for passengers standing upright. Account may be taken, if necessary, of camber and sheer of deck; and
2. 0.3 m above the seat in respect of seated passengers.

3.1.3 The stowage of cargo in holds, tweendecks and on decks is assumed as for normal service conditions.

3.1.4 Stability with an allowance for icing shall be checked with no passengers on exposed decks.

3.1.5 Initial stability of passenger ships shall be such that in the eventual case of crowding of passengers to one side on the uppermost decks accessible for passengers, as near to the bulwark as possible, the angle of statical heel is not more than the angle at which the freeboard deck immerses or the angle at which the bilge comes out of water, or one half of the angle of flooding, whichever is less; in any case, the angle of heel shall not exceed 10°.

For ships under 20 m in length, the angle of statical heel shall be greater than the angle corresponding to the 0.1 m freeboard before the deck immerses or 12°, whichever is the lesser.

Where necessary, the Register may apply this requirement to stability of non-passenger ship under 20 m in length (e.g. in case of carriage of persons who do not belong to the regular crew of the ship). In this case, the heel is determined taking into account the crowding to one side of all persons on board who are not engaged in handling the ship.

3.1.6 The heeling moment due to turning should not exceed 10° when calculated using the following formula:

\[ M_{h2} = 0.2 \frac{v_0^2}{L_{WL}} \Delta \left( \bar{K}G - \frac{d}{2} \right) \]  

(3.1.6)

where:

- \( M_{h2} \) - heeling moment due to the ship's turning, [KNm]
- \( v_0 \) - service speed, [m/s]
- \( L_{WL} \) - length of ship at waterline, [m]
- \( \Delta \) - displacement [t]
- \( d \) - mean draught [m]
- \( \bar{K}G \) - height of the ship's centre of gravity above baseline [m]

Where anti-rolling devices are installed in a ship, the Register should be satisfied that the above criteria can be maintained when the devices are in operation.

3.1.7 The angle of heel due to the combined effect of heeling moments \( M_{h1} \) (as a result of crowding of passengers to one side on the promenade decks) and \( M_{h2} \) (on steady turning) shall not exceed the angle at which the freeboard deck immerses or the angle at which the bilge comes out of water, whichever is the less, but in any case the angle of heel shall not exceed 12°.

3.1.8 When checking the ship's stability on turning, with additional heeling caused by crowding of passengers to one side, no account shall be taken of wind and rolling effects.

3.1.9 When determining admissible distribution of passengers crowding to one side on their promenade decks, it is to be assumed that the ship's normal operating conditions are duly observed with an allowance for the position of the equipment and arrangements and the regulations concerning the access of passengers to a particular deck area.

3.1.10 When determining the area where crowding of passengers may be permitted, the passages between benches shall be included in the computation with factors 0.5.

The area of narrow external passages between the deckhouse and the bulwark or railing up to 0.7 m wide shall be included with factor 0.5.

3.1.11 Passengers without luggage shall be considered as distributed to produce the most unfavourable combination
of passenger heeling moment and/or initial metacentric height which may be obtained in practice when assessing compliance with the criteria given in 3.1.5, 3.1.6 and 3.1.7 respectively.

The assumed density of distribution of passengers is 4 persons per square metre of the free area of the deck.

3.1.12 All computations of the statical angle of heel caused by passengers crowding to one side and by turning shall be carried out taking no account of icing, but with a correction for free surfaces of liquid cargoes as specified in 1.4.7.

3.1.13 The requirements referred to in 3.1.6 and 3.1.7 do not apply to ships under 20 m in length.

3.1.14 Each ship shall 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 ship shall also be fitted with a reliable draught indicating system by which the bow and stern draughts can be determined.

3.1.15 On completion of loading of the ship and prior to its departure, the master shall determine the ship's trim and stability and also ascertain and record that the ship is in compliance with stability criteria and the relevant regulations. The determination of the ship's stability shall always be made by calculation or by ensuring that the ship is loaded according to one of the precalculated loading conditions within the approved stability information. The Register may accept the use of an electronic loading and stability computer or equivalent means for this purpose.

3.1.16 Water ballast should not in general be carried in tanks intended for oil fuel. In ships in which it is not practicable to avoid putting water in oil fuel tanks, oily-water separating equipment to the satisfaction of the Register shall be fitted, or other alternative means, such as discharge to shore facilities, acceptable to the Register shall be provided for disposing of the oily-water ballast. The provisions of this item are without prejudice to the provisions of the International Convention for the Prevention of Pollution from Ships in force.

3.1.17 The stability booklet of ro-ro passenger ships shall additionally fulfill the requirements stated in 1.5.3.3.

### 3.2 DRY CARGO SHIPS

3.2.1 Stability of dry cargo ships shall be checked for the following loading conditions:

1. ship having a draught to the summer load line, in the fully loaded departure condition, with cargo homogeneously distributed throughout all cargo spaces and with full stores and fuel.

Where, owing to the peculiarities of the ship's service, the full-load draught is less than that to the prescribed load line, the stability calculations shall be carried out for this smaller draught;

2. ship in the same conditions as in .1, but with 10 % of stores and fuel remaining;

3. ship in ballast condition without cargo but with full stores and fuel;

.4 ship in the same condition as in .3, but with 10 % of stores and fuel.

3.2.2 In all cases, the cargo in holds is assumed to be fully homogeneous unless this condition is inconsistent with the practical service of the ship, as is stated in 1.4.8.6.

3.2.3 If in any of loading conditions in .3.2.1 water ballast is necessary, additional diagrams shall be calculated taking into account the water ballast. Its quantity and disposition shall be stated.

3.2.4 Where cargo holds of a ship in the loading conditions as under .3 and .4 of 3.2.1 are used to additionally take liquid ballast, ship's stability with liquid ballast in these holds shall be checked. The effect of free surfaces in holds with liquid ballast shall be taken into account in compliance with the provisions of 1.4.7 in accordance with their actual filling.

3.2.5 In all cases, when deck cargo is carried, a realistic stowage mass should be assumed and stated, including the height of the cargo, as is stated in 1.4.8.7.

3.2.6 Where ships are normally engaged in carrying deck cargoes, their stability shall be checked for the following additional conditions:

1. ship in the fully loaded departure, having a draught to the summer load line or, if intended to carry timber deck cargo to the summer timber load line (with regard to 3.3.1.1). Cargo shall be assumed as homogeneously distributed in the holds and with cargo specified in extension and mass on deck, with full stores and fuel;

2. ship in the same loading condition as in .1, but with 10 % of stores and fuel.

3.2.7 The loading conditions which should be considered for ships carrying timber deck cargoes are specified in 3.2.6. The stowage of timber deck cargoes shall comply with the provisions set in next Head (3.3 Timber carriers) or with Chapter 3 of the Code of Safe Practice for Ships Carrying Timber Deck Cargoes, 1991 (resolution A.715(17)).

3.2.8 For the fully loaded conditions mentioned in 3.2.1.1, 3.2.1.2, 3.2.6.1 and 3.2.6.2, if a dry cargo ship has tanks for liquid cargo, the effective deadweight in the loading conditions therein described should be distributed according to two assumptions, i.e. with cargo tanks full and with cargo tanks empty.

3.2.9 The corrected initial metacentric height of ro-ro ships in the loaded condition, with icing disregarded, shall not be less than 0.2 m.

3.2.10 Bulk carriers of less than 150 m in length constructed on or after 1 July 2006 shall be fitted with a loading instrument capable of providing information on the ship's stability in the intact condition. The computer software shall be approved for stability calculations by the Register and
shall be provided with standard conditions for testing purposes relating to the approved stability information.

3.3 TIMBER CARRIERS

3.3.1 The following definitions apply for the purposes of the present Head:

.1 timber means sawn wood or lumber, cants, logs, poles, pulpwood and all other types of timber in loose or packaged forms. The term does not include wood pulp or similar cargo;

.2 timber deck cargo means a cargo of timber carried on an uncovered part of a freeboard or superstructure deck. The term does not include wood pulp or similar cargo;***

.3 timber load line means a special load line assigned to ships complying with certain conditions related to their construction set out in the 1966 LL Convention with 1988 Protocol, as amended, and used when the cargo complies with the stowage and securing conditions of the Code of Safe Practice for Ships Carrying Timber Deck Cargoes, 1991 (resolution A.715(17));

.4 deepest timber subdivision draught is the waterline which corresponds to the timber summer draught to be assigned to the ship;

.5 partial timber subdivision draught is the light service draught as defined in Head 2.2 of the Rules, Part 5 – Subdivision plus 60% of the difference between the light service draught and the deepest timber subdivision draught.

3.3.2 Stability of timber carriers shall be checked for the following loading conditions:

.1 ship carrying timber cargo with the project prescribed stowage rate (if stowage rate of timber cargo is not specified, the calculation of stability shall be made assuming \( \mu = 2.32 \, \text{m}^2/\text{t} \)) in holds and on deck and having a draught to the timber summer load line, with full stores;

.2 ship in the same loading condition as in .1, but with 10 % of stores and fuel;

.3 ship with timber cargo, having the greatest stowage rate specified, in holds and on deck, with full stores and fuel;

.4 ship in the same loading condition as in .3, but with 10 % of stores and fuel;

.5 ship without cargo, but with full stores and fuel;

.6 ship in the same loading condition as in .5, but with 10 % of stores and fuel.

* Refer to the relevant parts of the Appendix 5 – Stability calculations performed by the stability instruments.

** Refer to regulation 42(1) of the 1966 LL Convention and 1988 Protocol.

3.3.3 The stowage of timber cargo in timber carriers shall comply with the requirements of 1966 LL Convention with 1988 Protocol, as amended, as well as the provision of Chapter 3 of the Code of Safe Practice for Ships Carrying Timber Deck Cargoes, 1991 (IMO Resolution A.715(17)).

3.3.4 When calculating the arms of form stability in addition to the provisions given in 1.4.2 the Register may allow account to be taken of the buoyancy of the deck cargo, assuming that such cargo has a permeability of 25% of the volume occupied by the cargo. Additional curves of stability may be required if the Register considers it necessary to investigate the influence of different permeabilities and/or assumed effective height of the deck cargo.

3.3.5 For ships loaded with timber deck cargoes and provided that the cargo extends longitudinally between superstructures (where there is no limiting superstructure at the after end, the timber deck cargo shall extend at least to the after end of the aftermost hatchway)*** transversely for the full beam of ship after due allowance for a rounded gunwale not exceeding 4% of the breadth of the ship and/or securing the supporting uprights and which remains securely fixed at large angles of heel, the following criteria shall be satisfied:

.1 The area under the righting lever curve (GZ curve) shall not be less than 0.08 metre-radian up to \( \theta = 40^o \) or the angle of flooding if this angle is less than \( 40^o \).

.2 The maximum value of the righting lever (GZ) shall be at least 0.25 m.

.3 At all times during a voyage, the metacentric height \( GM_k \) shall not be less than 0.10 m after correction for the free surface effects of liquid in tanks and for the absorption of water by the deck cargo and/or ice accretion on the exposed surfaces (details regarding ice accretion are given in 2.2). For loading conditions stated in 3.3.2.5 and 3.3.2.6 the corrected initial metacentric height shall not be less than 0.15 m.

.4 When determining the ability of the ship to withstand the combined effects of beam wind and rolling according to 2.1.5, the 16° limiting angle of heel under action of steady wind shall be complied with, but the additional criterion of 80% of the angle of deck edge immersion may be ignored.

3.3.6 When the effect of icing is calculated, the upper surface of deck timber cargo shall be considered as if it were the deck, and its side surface above the bulwark - as if they were part of the designed windage area. The icing rate for these surfaces should be three times that specified in 2.2.

3.3.7 For timber carriers intended to operate in areas in which the icing is not required to be taken into account as well as for those navigating in summer within winter seasonal zones, the stability calculation shall be made for the most unfavourable loading conditions out of those indicated in

*** Refer to regulation 44(2) of the 1966 LL Convention and 1988 Protocol.
3.3.2.1 to 3.3.2.4 with regard to possible addition in mass of the deck cargo due to absorption of water.

Where no appropriate data on the extent of water absorption by different kinds of wood are available, the addition in mass of the deck cargo shall be assumed equal to 10%. This addition is considered as an overload and is not included in the ship's deadweight.

3.3.8 Stability booklet shall include data to enable the master to estimate the ship's stability when carrying a timber cargo on deck the permeability of which differs substantially from 0.25. Where the approximate permeability is not known, at least three values shall be adopted, namely, 0.25, 0.4 and 0.6.

3.3.9 The ship should be supplied with comprehensive stability information which takes into account timber deck cargo. Such information should enable the master, rapidly and simply, to obtain accurate guidance as to the stability of the ship under varying conditions of service. Comprehensive rolling period tables or diagrams have proved to be very useful aids in verifying the actual stability conditions.

3.3.9.1 For ships carrying timber deck cargoes it is necessary that the master be given information setting out the changes in deck cargo from that shown in the loading conditions when the permeability of the deck cargo is significantly different from 25% (see 3.3.4 above).

3.3.9.2 For ships carrying timber deck cargoes, stability calculation for loading condition shall be done indicating the maximum permissible amount of deck cargo, having regard to the lightest stowage rate likely to be met in service.

3.3.10 The stability booklet of timber carriers should include the following information to assist the master to:

.1 check stability of the ship at all times, including during the process of loading and unloading timber deck cargo, shall be as in 3.3.5 and to a standard acceptable to the Register. It should be calculated having regard to:
  .1.1 the increased weight of the timber deck cargo due to:
    - absorption of water in dried or seasoned timber, and
    - ice accretion, if applicable (chapter 2.2)
  .1.2 variations in consumables;
  .1.3 the free surface effect of liquid in tanks; and
  .1.4 weight of water trapped in broken spaces within the timber deck cargo and especially logs.

.2 cease all loading operations if a list develops for which there is no satisfactory explanation and it would be imprudent to continue loading;

.3 ensure, before proceeding to sea, that;
  .3.1 the ship is upright;
  .3.2 the ship has an adequate metacentric height; and

.4 also for ships having less than 100 m in length:

.4.1 to exercise good judgement to ensure that a ship which carries stowed logs on deck has sufficient additional buoyancy so as to avoid overloading and loss of stability at sea;

.4.2 be aware that the calculated GM₀ in the departure condition may decrease continuously owing to water absorption by the deck cargo of logs and consumption of fuel, water and stores and ensure that the ship has adequate GM₀ throughout the voyage;

.4.3 be aware that ballasting after departure may cause the ship's operating draught to exceed the timber load line. Ballasting and deballasting should be carried out in accordance with the guidance provided in the Code of Safe Practice for Ships Carrying Timber Deck Cargoes, 1991 (resolution A.715(17)).

.5 Ships carrying timber deck cargoes shall operate, as far as possible, with a safe margin of stability and with a metacentric height which is consistent with safety requirements but such metacentric height shall not be allowed to fall below the recommended minimum, as specified in 3.3.5.3.

.6 However, excessive initial stability shall be avoided as it will result in rapid and violent motion in heavy seas which will impose large sliding and racking forces on the cargo, causing high stresses on the lashings. Operational experience indicates that metacentric height shall preferably not exceed 3% of the breadth in order to prevent excessive accelerations in rolling provided that the relevant stability criteria given in 3.3.5 are satisfied. This recommendation may not apply to all ships and the master should take into consideration the stability information obtained from the ship's stability booklet.

3.3.11 For ships carrying timber deck cargoes which have to fulfil the damage stability requirements of the Rules, Part 5 – Subdivision, stability information shall include, as stated in 1.5.1.3.8, among other damage stability related issues, a curve of minimum operating metacentric height (GM) versus draught or maximum allowable vertical centre of gravity (KG) versus draught, determined from the following considerations:

.1 To ensure the buoyancy of timber deck cargo can be justifiably credited in damage stability calculations, the integrity of the lashed timber deck cargo shall comply with the provisions of Chapters 3 and 4 of the CODE OF SAFE PRACTICE FOR SHIPS CARRYING TIMBER DECK CARGOES, 1991 (Resolution A.715(17)).
.2 The height and extent of the timber deck cargo shall be in accordance with Chapter 3.2 of the CODE OF SAFE PRACTICE FOR SHIPS CARRYING TIMBER DECK CARGOES, 1991, and shall be at least stowed to the standard height of one superstructure.

.3 The permeability of the timber deck cargo is not to be less than 25% of the volume occupied by the cargo up to one standard superstructure.

.4 Unless instructed otherwise by the Register, the stability information for ships with timber deck cargoes shall be supplemented by additional curve(s) of limiting GM (or KG) covering the timber draught range.

.5 The above described curve(s) applicable for conditions with timber deck cargo is/are to be developed as described in 1.5.1.6, and considering timber deck cargo at the deepest timber subdivision draught and at the partial timber subdivision draught only.

.6 The limiting GM shall be varied linearly between the deepest timber subdivision draught, and between the partial timber subdivision draught and the light service draught respectively. Where timber free-boards are not assigned the deepest and partial draughts shall relate to the summer load line.

.7 When considering the vertical extent of damage, the instruction from 2.21.8 of the Rules, Part 5 – Subdivision.

3.3.12 If timber carriers are used for the carriage of other kinds of cargo, their stability shall be checked according to the provisions of 3.2. In such a case, computation of the arms of form stability and the windage area shall be carried out taking no account of deck timber cargo.

3.3.13 Double bottom tanks where fitted within the midship half-length of the ship shall have adequate water-tight longitudinal subdivision.

3.3.14 The requirements of this Head apply to other types of ships when they are used for the carriage of deck timber cargo.

### 3.4 TANKERS

3.4.1 Stability of tankers carrying liquid cargoes shall be checked for the following loading conditions:

.1 ship having draught up to summer load line (with regard to 3.2.1.1), fully loaded and with full stores and fuel;

.2 ship fully loaded, but with 10% of stores and fuel;

.3 ship without cargo, but with full stores and fuel;

.4 ship in the same loading condition as in .3, but with 10% of stores and fuel.

3.4.2 For refuelling tankers, stability shall be checked for additional loading condition: a ship with 75% of cargoes and free surfaces in tanks for each kind of cargo, and 50% of stores and fuel without liquid ballast. Account of the free surface effect in ship's stores tanks shall be taken as specified in 1.4.7 and in cargo tanks according to the extent of their actual filling.

The requirements of this item apply to oil recovery ships as well.

3.4.3 For tankers assigned with a tropical load line, the ship should be assumed to be loaded in accordance with the following:

.1 a fully loaded departure condition at the tropical load line and the corresponding arrival loading condition are considered;

.2 the cargo is homogeneously distributed throughout all cargo tanks; and

.3 sea water density is 1.025 t/m3.

3.4.4 Stability of tankers, including stages of liquid transfer operations

3.4.4.1 Liquid transfer operations include cargo loading and unloading, lightening, ballastling and deballasting, ballast water exchange, and tank cleaning operations.

3.4.4.2 Every tanker is to comply with the following intact stability criteria for any operating draught reflecting actual, partial or full load conditions, including the intermediate stages of liquid transfer operations:

.1 In port, the initial metacentric height MG is not to be less than 0.15 m. Positive intact stability is to extend from the initial equilibrium position at which GM is calculated over a range of at least 20° to port and to starboard.

.2 All sea-going conditions shall fulfill the intact stability criteria set in Head 2.1 of this part of the Rules.

3.4.4.3 For all loading conditions in port and at sea, including intermediate stages of liquid transfer operations, the initial metacentric height and the righting lever curve are to be corrected for the effect of free surfaces of liquids in tanks according to 1.4.7. Under all conditions the ballast tanks shall be assumed slack.

3.4.4.4 For a new tanker of 5000 DWT and above, delivered on or after 1 February 2002, the intact stability criteria specified in 3.4.4.2 is to be met by design of the ship, i.e.: the design shall allow for maximum free surface effects in all cargo, ballast and consumables tanks during liquid transfer operations. For proving compliance with this requirement, either 3.4.4.5 or 3.4.4.6 shall be applied.

3.4.4.5 The vessel shall be loaded with all cargo tanks filled to a level corresponding to the maximum combined total of vertical moment of volume plus free surface inertia moment at 0° heel, for each individual tank. Cargo density shall correspond to the available cargo deadweight at the displacement at which transverse KM reaches a minimum value, assuming full departure consumables and 1% of the total water ballast capacity. The maximum free surface moment shall
be assumed in all ballast conditions. For the purpose of calculating $G_{M_{0}}$, liquid free surface corrections shall be based on the appropriate upright free surface inertia moment. The righting lever curve may be corrected on the basis of liquid transfer moments.

3.4.4.6 As an alternative to the loading case described in previous item, an extensive analysis covering all possible combinations of cargo and ballast tank loading is to be carried out. For such extensive analysis conditions it is considered that:

1. Weight, centre of gravity co-ordinates and free surface moment for all tanks are to be according to the actual content considered in the calculations.
2. The extensive calculations are to be carried out in accordance with the following:
   2.1 The draughts are to be varied between light ballast and scantling draught.
   2.2 Consumables including but not restricted to fuel oil, diesel oil and fresh water corresponding to 97%, 50% and 10% content are to be considered.
   2.3 For each draught and variation of consumables, the available deadweight is to comprise ballast water and cargo, such that combinations between maximum ballast and minimum cargo and vice-versa, are covered. In all cases the number of ballast and cargo tanks loaded is to be chosen to reflect the worst combination of VCG and free surface effects. Operational limits on the number of tanks considered to be simultaneously slack and exclusion of specific tanks are not permitted. All ballast tanks are to have at least 1% content.
   2.4 Cargo densities between the lowest and highest intended to be carried are to be considered.
   2.5 Sufficient steps between all limits are to be examined to ensure that the worst conditions are identified. A minimum of 20 steps for the range of cargo and ballast content, between 1% and 99% of total capacity, are to be examined. More closely spaced steps near critical parts of the range may be necessary.

At every stage the criteria specified in 3.4.4.2.1 and 3.4.4.2.2 are to be met.

3.4.4.7 If for the existing ship in service and combination carriers the intact stability criteria specified in 3.4.4.2 are not met through its design alone, the master is to be provided with clear written instructions, approved by the Register, covering the operational restrictions and methods necessary to ensure compliance with these criteria during liquid transfer operations. These instructions should be simple and concise and:

1. require no more than minimal mathematical calculations by the officer-in-charge;
2. indicate the maximum number of cargo and ballast tanks that may be slack under any possible condition of liquid transfer;
3. provide pre-planned sequences of cargo/ballast transfer operations. These sequences specifically indicate the cargo and ballast tanks that may be slack to satisfy the stability criteria under any specific condition of liquid transfer and possible range of cargo densities. The slack tanks may vary during stages of the liquid transfer operations and be of any combination provided they satisfy the stability criteria;
4. provide instructions for pre-planning other sequences of cargo/ballast transfer operations, including use of stability performance criteria in graphical or tabular form which enable comparisons of required and attained stability. These instructions for pre-planning other sequences, in relation to individual vessels, should take account of:
   4.1 the degree or criticality with respect to the number of tanks which can simultaneously have maximum free surface effects at any stage of liquid transfer operations;
   4.2 the means provided to the officer-in-charge to monitor and assess the effects on stability and hull strength throughout the transfer operations;
   4.3 the need to give sufficient warning of an impending critical condition by reference to suitable margins (and the rate and direction of change) of the appropriate stability and hull strength parameters. If appropriate, the instructions should include safe procedures for suspending transfer operations until a suitable plan of remedial action has been evaluated.
5. the use of on-line shipboard computer systems during all liquid transfer operations, processing cargo and ballast tank ullage data and cargo densities to continuously monitor the vessel's stability and hull strength and, when necessary, to provide effective warning of an impending critical situation, possibly automatic shut-down, and evaluation of possible remedial actions. The use of such systems is to be encouraged.
6. be prominently displayed:
   6.1 in the approval trim and stability booklet;
   6.2 at the cargo/ballast transfer control station;
   6.3 in any computer software by which intact stability is monitored or calculations performed;
.6.4 in any computer software by which hull strength is monitored or calculations performed.

3.4.4.7 For double hull oil tankers of single cargo tank across design, see also the requirements for operating manual, set in sub-item 1.5.3.2.

3.4.5 Stability instrument on tankers

3.4.5.1 All oil tankers shall be fitted with a stability instrument, capable of verifying compliance with intact and damage stability requirements approved by the Register having regard to the performance standards presented in Appendix 5 of this part of the Rules and considerations given in the item 9.7.7 of the Rules, Part 5 – Subdivision:

.1 oil tankers constructed before 1 January 2016 shall comply with this regulation at the first scheduled renewal survey of the ship after 1 January 2016 but not later than 1 January 2021;

.2 notwithstanding the requirements of sub-item .1 a stability instrument fitted on an oil tanker constructed before 1 January 2016 need not be replaced provided it is capable of verifying compliance with intact and damage stability, to the satisfaction of the Register; and

.3 Register shall issue a document of approval for the stability instrument.

3.4.5.2 The Register may waive the requirements of sub-item 3.4.5.1 for the following oil tankers if loaded in accordance with the conditions approved by the Register taking into account the considerations given in the Head 9.7 of the Rules, Part 5 – Subdivision:

.1 oil tankers which are on a dedicated service, with a limited number of permutations of loading such that all anticipated conditions have been approved in the stability information provided to the master in accordance with item 9.5.1 of the Rules, Part 5 – Subdivision;

.2 oil tankers where stability verification is made remotely by a means approved by the Register;

.3 oil tankers which are loaded within an approved range of loading conditions (see item 9.7.4 of the Rules, Part 5 – Subdivision); or

.4 oil tankers constructed before 1 January 2016 provided with approved limiting KG/GM curves covering all applicable intact and damage stability requirements (see item 9.7.5 of the Rules, Part 5 – Subdivision).

3.5.4.3 Equivalent requirements for chemical tankers are provided in items 2.2.6 and 2.2.7 of the Rules, Part 27 – Chemical tankers.

3.5 FISHING VESSELS

3.5.1 Stability of fishing vessels shall be checked in service for the following loading conditions:

.1 departure for the fishing grounds with full fuel, stores, ice, fishing gear, etc.;

.2 arrival at home port from fishing grounds with full catch in holds and on deck (if provision is made for the deck cargo in the design) and with 10% of stores and fuel;

.3 arrival at home port from fishing grounds with 20% of catch in holds or on deck, (if provisions is made in the design for stowage of cargo on deck) with 10% of stores and fuel;

.4 departure from fishing grounds with full catch and the amount of fuel and stores to ensure the ship’s draught up to the assigned load line, i.e. to full loading condition;

.5 while being in fishing grounds, without catch in holds and the hatches of holds open; with wet nets and catch (the maximum amount that is allowed to be carried on that way) stowed on deck; 25% of stores and fuel and full amount of ice and salt.

3.5.2 Stability of a fishing vessel shall be checked for compliance with the criteria set in Head 2 of this part of the Rules for all of the above stated loading conditions. Special attention is drawn on requirements on the initial metacentric height GM₀ (2.1.4) that for fishing vessels shall not be less than 0.35 m for single-deck vessels. In vessels with complete superstructure or vessels of 70 m in length and over the initial metacentric height may be reduced, but to no less than 0.15 m.

3.5.3 Weather criterion shall be checked also for all conditions but at least the compliance of the most severe case with regard to that criterion shall be included in stability booklet.

Specific wind pressure on vessels of unrestricted service area should be assumed as is stated in 2.1.5. For fishing vessels up to 45 m in length, the alternative values of wind pressure may be taken from the table 3.5.3, where \( h \) is the vertical distance from the centre of the projected vertical area of the vessel above the waterline related to checked loading condition, to the waterline.

### Table 3.5.3

<table>
<thead>
<tr>
<th>( h ) (m)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6 and over</th>
</tr>
</thead>
<tbody>
<tr>
<td>( P ) (Pa)</td>
<td>316</td>
<td>386</td>
<td>429</td>
<td>460</td>
<td>485</td>
<td>504</td>
</tr>
</tbody>
</table>

2020
3.5.4 For vessels where nets and catch are hauled in by means of cargo booms, account shall also be taken on negative influence of hoisted cargo, with the cargo weight equal to the boom safe working load. Loading condition presented for checking the compliance of the criterion set in 3.5.5 shall be the one that generates the greatest heel angle.

3.5.5 For vessels in loading condition as in 3.5.4, initial stability shall be such that the angle of static heel during working with nets and with maximum possible outreach of cargo boom is not more than 10°, or the angle at which the deck immerses, whichever is the lesser.

3.5.6 The amount of catch allowed to be stowed on deck shall be specified both in the vessel's design and the Stability booklet, and is determined depending on the ship's type, capacity of cargo space, stability characteristics and shall correspond to the load line assigned by the Register.

3.5.7 For net fishing vessels in loading conditions referred to in 3.5.1, from .2 to .5, allowance shall be made for weight of wet fishing nets and tackle on deck. When this allowance is not specifically known, it should be assumed as 20% in stability calculations.

3.5.8 In the loading condition referred to in 3.5.1.5 the angle of heel at which the coaming of a cargo hatch immerses shall be regarded as one of the angles of flooding of the ship.

3.5.9 Wherever the ship used for processing fish and other living resources of the sea has a crew on board of more than 12 persons engaged in catching and processing only, the ship's stability is to conform to the requirements of the Head 3.1, under all loading conditions. From the point of the above requirements the crew members in question are regarded as passengers.

3.5.10 When loading conditions are conditioned by water ballast, then such conditions shall be specified in the Stability booklet with the appropriate instructions.

3.5.11 Water ballast should normally be included in the above loading conditions only if carried in tanks that are specially provided for this purpose.

3.5.12 For ships intended to operate in areas in which the icing is possible; stability shall be checked taking into account allowance for icing in compliance with requirements set forth in 2.2.3.

3.5.13 Fishing vessels engaged in towing of tuna cages shall additionally fulfil the criterion for towing operations, set in 3.7.2. At least two loading conditions, for the percentage of stores and fuel set to 100% and 10%, shall be checked for ship in towing condition, additional to conditions stated in 3.5.1.

3.5.14 For fishing vessels in restricted service (navigation areas 3 to 8) and of less than 45 m in length, the Register may allow the alternative method for calculating the wind heeling moments, set in Appendix 4, to be used instead of that in 2.1.5.

3.5.15 Apart from general precautions referred to in Head 1.6, the following measures shall be considered as preliminary guidance on matters influencing safety as related to stability:

1. all fishing gear and other large weights shall be properly stowed and placed as low as possible;
2. particular care shall be taken when pull from fishing gear might have a negative effect on stability, e.g., when nets are hauled by power-block or the trawl catches obstructions on the sea-bed. The pull of the fishing gear shall be from as low a point on the vessel, above the waterline, as possible;
3. gear for releasing deck load in fishing vessels carrying catch on deck, e.g. sardines, shall be kept in good working condition for use when necessary;
4. when the main deck is prepared for carrying deck load by dividing it with pound boards, there shall be slots between them of suitable size to allow easy flow of water to freeing ports, thus preventing trapping of water;
5. fish shall never be carried in bulk without first being sure that the portable divisions in the holds are properly installed;
6. reliance on automatic steering may be dangerous as this prevents changes to course that may be needed in bad weather;
7. in all conditions of loading, necessary care shall be taken to maintain a seaworthy freeboard.

3.5.16 Particular care should be taken to the dangerous heeling of the ship due to excessive force in the hauling rope of the fishing gear. This may occur when fishing gear rope fastens onto an underwater obstacle or when handling fishing gear, particularly on purse seiners, or when one of the trawl wires tears off.

The heeling angles caused by the fishing gear in these situations may be eliminated by employing devices that can relieve or remove excessive forces applied through the fishing gear. Such devices should not impose a danger to the vessel through operating in circumstances other than those for which they were intended.

3.6 SPECIAL PURPOSE SHIPS

3.6.1 The provision given here under applies to special purpose ships, as defined in 1.2.46.

3.6.2 The stability of whale factory ships, fish factory ships and other ships used for processing the living resources of the sea and not engaged in catching the same is to be checked for the following loading conditions:

1. ship with special personnel, full stores and fuel, and full cargo of tare and salt on board;
2. ship with special personnel, 10% of stores and fuel, and full cargo of its production on board;
.3 ship in the same loading condition as in .2, but with 20% of production and 80% of tare and salt on board;
.4 ship in the same loading condition as in .2, but with 25% of stores, fuel and the cargo being processed on board.

3.6.3 Stability of the scientifically - research ships, expedition ships, hydrographical ships, training ships etc. shall be checked for the following loading conditions:
.1 ship with special personnel and full stores and fuel;
.2 ship as stated in .1 but with 50% of stores and fuel;
.3 ship as stated in .1 but with 10% of stores and fuel;
.4 ship as stated in .1, .2 and .3 with full cargo if it is designed for cargo loading.

3.6.4 The stability of special purpose ships is to be in accordance with 3.1.2 to 3.1.10. From the point of view of the above requirements special personnel is to be regarded as passengers.

3.6.5 The intact stability of special purpose ships of similar design and characteristics as offshore supply vessels, on agreement with the Register, shall comply with provisions given in Head 3.12.

3.6.6 For whale factory ships, fish factory ships and other ships used for processing the living resources of the sea, the requirements of 3.5.12 for the static stability curve in the case of icing apply.

3.6.7 Operating booklet for special purpose ships shall be provided with additional information, according to 1.5.3.1.

3.7 SHIPS ENGAGED IN TOWING AND ESCORT OPERATIONS

3.7.1 General

3.7.1.1 For a ship engaged in a harbour, coastal or ocean going towing operation and/or escort operation, the following loading conditions should be included in addition to the standard loading conditions for a cargo ship in item 3.2.1:
.1 maximum operational draught at which towing or escorting operations are carried out, considering full stores and fuel;
.2 minimum operational draught at which towing or escorting operations are carried out, considering 10% stores and fuel; and
.3 intermediate condition with 50% stores and fuel.

3.7.1.2 In addition to compliance with the requirements of Section 2, the ships engaged in towing and/or escort operations shall have sufficient dynamic stability to withstand the heeling effect of the towing force in the beam direction. Thus, compliance with a criterion set in this Head shall be fulfilled.

3.7.1.3 The provisions given in items 3.7.2, 3.7.3 and 3.7.4 apply to ships the keel of which is laid or which is at a similar stage of construction on or after 1 January 2020, engaged in harbour towing, coastal or ocean-going towing and escort operations and to ships converted to carry out towing operations after this date.

3.7.1.4 The requirements for stability while towing of ships of less than 24 m in length and of those permitted to operate only in restricted navigation areas 6 to 8 shall be specially considered by the Register in any particular case. For vessels up to 20 m in length applied for towing operations in navigation areas 6 to 8 exclusively, the Register may allow the use of alternative criterion for stability while towing, set in 3.7.5.

3.7.1.5 A drawing “Towing arrangement plan”, with clear presentation of the direction and intensity of design forces acting on towline attachment points, shall be submitted to the Register, additionally to the standard documentation needed for stability approval. The requirements of 1.6.1.4 shall be fulfilled also.

3.7.1.6 When checking stability of ships while towing, the angle of flooding shall be determined assuming that all accesses fitted with non-watertight type of closure and leading form cargo deck to the spaces below, are open. Openings arranged according to 3.7.6.1 may be exempted from this requirement.

3.7.1.7 For all ships engaged in towing, allowance should be made for the anticipated weight of cargo on and below deck, chain in lockers, anticipated type of wire or rope on storage reels and wire on the winches when calculating loading conditions.

3.7.1.8 For tugs in areas where ice accretion is likely to occur, when checking stability for compliance with the requirements of Section 2 and this Head, the icing rates are assumed to be:
.1 for tugs specially designed for salvage operations, twice as much of the values given in 2.2;
.2 for all other tugs, in accordance with 2.2.

3.7.2 Heeling lever for towing operations

3.7.2.1 The self-tripping heeling lever is calculated as provided below:
.1 A transverse heeling moment is generated by the maximum transverse thrust exerted by the ship's propulsion and steering systems and the corresponding opposing towline pull;
.2 The heeling lever \( HL \phi \), in (m), as a function of the heeling angle \( \phi \), should be

A similar stage of construction means the stage at which:
- construction identifiable with a specific ship begins; and
- assembly of that ship has commenced, comprising at least 50 tonnes or 1% of the estimated mass of all structural material, whichever is less.
**3.7.2.2** The tow-tripping heeling lever $HL\phi$, in (m), is calculated according to the following formula:

$$HL\phi = \frac{BP \cdot C_1 \cdot (h \cdot \cos \phi - r \cdot \sin \phi)}{(g \cdot \Delta)}$$

where:
- $BP$ - bollard pull, in (kN), which is the documented maximum continuous pull obtained from a static bollard pull test performed in accordance with relevant IMO guidelines$^*$ or a standard acceptable to the Administration;
- $C_T$ - 0.5 - for ships with conventional, non-azimuth propulsion units; or
- $0.90/(1 + L_{L4L})$ - for ships with azimuth propulsion units installed at a single point along the length. However, $C_T$ should not be less than 0.7 for ships with azimuth stern drive towing over the stern or tractor tugs towing over the bow, and not less than 0.5 for ships with azimuth stern drive towing over the bow or tractor tugs towing over the stern.
- For tugs with other propulsion and/or towing arrangements, the value of $C_T$ is to be established on a case by case basis to the satisfaction of the Register;
- $\Delta$ - displacement, in (t);
- $L$ - longitudinal distance, in (m), between the towing point and the vertical centreline of the propulsion unit(s) relevant to the towing situation considered;
- $h$ - vertical distance, in (m), between the towing point and the horizontal centreline of the propulsion unit(s) as relevant for the towing situation considered;
- $g$ - gravitational acceleration, in (m/s$^2$), to be taken as 9.81;
- $r$ - the transverse distance, in (m), between the centre line and the towing point, to be taken as zero when the towing point is at the centre line;
- $L_{L4L}$ - length (L) as defined in the International Convention on Load Lines in force.

The towing point is the location where the towline force is applied to the ship. The towing point may be a towing hook, staple, fairlead or equivalent fitting serving that purpose.

**3.7.3 Heeling lever for escort operations**

**3.7.3.1** For the evaluation of the stability particulars during escort operations the ship is considered to be in an equilibrium position determined by the combined action of the hydrodynamic forces acting on hull and appendages, the thrust force and the towline force as shown in figure 3.7.3.1.

**3.7.3.2** For each equilibrium position the corresponding steering force, braking force, heel angle and heeling lever are to be obtained from the results of full scale trials, model tests, or numerical simulations in accordance with a methodology acceptable to the Register.

**3.7.3.3** For each relevant loading condition the evaluation of the equilibrium positions is to be performed over the applicable escort speed range, whereby the speed of the assisted ship through the water is to be considered.$^{**}$

**3.7.3.4** For each relevant combination of loading condition and escort speed, the maximum heeling lever is to be used for the evaluation of the stability particulars.

**3.7.3.5** For the purpose of stability calculations the heeling lever is to be taken as constant.

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$^*$ Refer to annex A to the Guidelines for safe ocean towing (MSC/Circ.884).

$^{**}$ The typical escort speed range is 6 to 10 knots.
3.7.4 **Stability criteria**

3.7.4.1 For ships engaged in harbour, coastal or ocean-going towing operations the area A contained between the righting lever curve and the heeling lever curve calculated in accordance with paragraph 3.7.2.1 (self-tripping), measured from the heel angle (φ₀) to the angle of the second intersection (φ_c) or the angle of down-flooding (φ_f), whichever is less, shall be greater than the area B contained between the heeling lever curve and the righting lever curve, measured from the heel angle φ = 0 to the heel angle (φ₀), where:

- φ₀ - Angle of first intersection between the heeling lever and righting lever curves;
- φ_f - Angle of down-flooding as defined in sub-item 2.1.5.1.5 of this part of the Rules, using the symbol (θ_f). Openings required to be fitted with weathertight closing devices under the ICLL but, for operational reasons, are required to be kept open shall be considered as down-flooding points in stability calculation;
- φ_c - Angle of second intersection between the heeling lever and righting lever curves;

Area A and area B are as defined in sub-item 3.7.4.3 (see also figure 3.7.4.3).

3.7.4.2 For ships engaged in harbour, coastal or ocean-going towing operations the first intersection between the righting lever curve and the heeling lever curve calculated in accordance with sub-item 3.7.2.2 (tow-tripping) shall occur at an angle of heel less than the angle of down-flooding (φ_f).

3.7.4.3 For ships engaged in escort operations the maximum heeling lever determined in accordance with item 3.7.3 should comply with the following criteria:

1. Area A ≥ 1.25 × Area B;
2. Area C ≥ 1.40 × Area D; and
3. φ₀ ≤ 15 degrees,

where:

- **Area A** = Righting lever curve area measured from the heel angle φ₀ to a heel angle of 20 degrees (see figure 3.7.4.3);
- **Area B** = Heeling lever curve area measured from the heel angle φ₀ to a heel angle of 20 degrees (see figure 3.7.4.3);
- **Area C** = Righting lever curve area measured from the zero heel (φ = 0) to φ_d (see figure 3.7.4.3).
**Area D** - Heeling lever curve area measured from zero heel ($\phi = 0$) to the heeling angle $\phi_D$ (see figure 3.7.4.3);

$\phi_D$ - Equilibrium heel angle corresponding to the first intersection between heeling lever curve and the righting lever curve;

$\phi_D$ - the heel angle corresponding to the second intersection between heeling lever curve and the righting lever curve or the angle of down-flooding or 40 degrees, whichever is less.

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### 3.7.5 Alternative criterion for small tugs in restricted service

Tugs of less than 20 m in length and applied for restricted service, as per 3.7.1.4, may be exempted from complying with the requirements specified in 3.7.2 to 3.7.4 provided that the initial metacentric height $GM_0$ [m], corrected according to 1.4.7, in the most severe loading condition is not less than the value obtained from the following formula:

$$ GM_0 \geq 66 \cdot T \cdot H \cdot B / (f \cdot \Delta) $$

where:

- $B$ - ship's maximum breadth [m];
- $f$ - ship's freeboard [mm], to be assumed not greater than 650 mm;
- $T$ - maximum towing pull [kN]. Where this force is unknown, it can be assumed equal to:
  - $T = 0.179 \cdot P$ for propellers not fitted with nozzles,
  - $T = 0.228 \cdot P$ for propellers fitted with nozzles;
- $P$ - maximum continuous power [kW] of the propulsion engine;
- $H$ - vertical distance [m] between the towing hook, or equivalent fitting, and half draught corresponding to $\Delta$;
- $\Delta$ - loading condition displacement [t].

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### 3.7.6 Constructional precautions against capsizing

#### 3.7.6.1 Access to the machinery space, excluding emergency access and removal hatches, should, if possible, be arranged within the forecastle. Any access to the machinery space from the exposed cargo deck should be provided with two weathertight closures, if practicable. Access to spaces below the exposed cargo deck should preferably be from a position within or above the superstructure deck.

#### 3.7.6.2 The area of freeing ports in the side bulwarks of the cargo deck shall at least meet the requirements of regulation 24 of the International Convention on Load Lines, 1966 or the Protocol of 1988 relating thereto, as amended, as applicable. The disposition of the freeing ports shall be carefully considered to ensure the most effective drainage of water trapped on the working deck and in recesses at the after end of the forecastle. In ships operating in areas where icing is likely to occur, no shutters shall be fitted in the freeing ports.
3.7.6.3 A ship engaged in towing operations shall be provided with means for quick release of the towline.

3.7.7 Operational procedures against capsizing

3.7.7.1 The arrangement of cargo stowed on deck should be such as to avoid any obstruction of the freeing ports or sudden shift of cargo on deck. Cargo on deck, if any, should not interfere with the movement of the towline. For small vessels on which alternative criterion of item 3.7.5 may be applied, no cargo is allowed on any part of the weather deck during towing operations.

3.7.7.2 A minimum freeboard at stern of at least 0.005\(L_{1/2}\) shall be maintained in all operating conditions.

3.7.8 Stability booklet

3.7.8.1 Besides the general information required for all ships, set in sub-item 1.5.1.3, the stability booklet for ships engaged in harbour, coastal or ocean going towing operations and/or escort operations shall contain additional information on:

1. maximum bollard pull;
2. details on the towing arrangement, including location and type of the towing point(s), such as towing hook, staple, fairlead or any other point serving that purpose;
3. identification of critical down-flooding openings;
4. recommendations on the use of roll reduction systems;
5. if any wire, etc. is included as part of the lightship weight, clear guidance on the quantity and size should be given;
6. maximum and minimum draught for towing and escort operations;
7. instructions on the use of the quick-release device; and
8. for ships engaged in escort operations, the following additional operating information should be included:
   - a table with permissible limits of the heel angle in accordance with the criteria included in paragraph 2.7.3.4 as function of loading condition and escort speed; and
   - instructions on the available means to limit the heel angle within the permissible limits.

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3.8 VESSELS OF DREDGING FLEET

3.8.1 Working conditions

"Working conditions" means operation of a vessel according to its purpose within the prescribed operation zones:

1. coastal zone up to 20 miles from the coast;
2. zone including the prescribed area of navigation of a vessel.

3.8.2 Loading conditions

Depending on the type of a vessel of dredging fleet and its dredging gear the following conditions of loading are to be considered.

3.8.2.1 For vessels of dredging fleet of all types during voyages:

1. vessel with full stores, without spoil, dredging gear being secured for sea;
2. vessel in the same loading condition as in .1, but with 10% of stores.

3.8.2.2 In operating conditions for hopper dredgers and hopper barges:

1. vessel with full stores, with spoil in the hopper, dredging gear being secured for sea;
2. vessel in the same loading condition as in .1, but with 10% cent of stores.

For hopper dredgers equipped with grab cranes additional loading conditions are to be considered, such as:

1. with grab cranes operating from one side and crane boom being in the athwartship plane; with spoil in the grab; with maximum loading moment and also with the highest position of the boom with regard to initial heel, as per 4.2.4. These conditions are to be considered for a vessel with 10% of stores and full stores, both with spoil and without it.

Notes:

1. The mass of spoil in the grab is taken to be 1.6 \(V\) [t], where \(V\) is the volume of the grab, in [\(\text{m}^3\)].
2. The quantity of spoil in the hopper and the position of the centre of gravity is to be determined assuming that the hopper is filled with homogeneous spoil up to the level of the upper discharge holes or the upper coaming edge; if the discharge holes are not provided, with the vessel having a draught up to the load line permitted when dredging.

3.8.2.3 In operating conditions for dredgers equipped with bucket ladder:

1. vessel with full stores, with spoil in buckets, ladder is secured for sea;
2. vessel in the same loading condition as in .1, but with 10% of stores.
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Note:

Spoil is taken into the buckets of the upper part of the ladder (from upper to lower drum).

The mass of spoil in each bucket is taken to be $2V \text{ [t]}$, where $V$ is the full volume of the bucket [m$^3$].

3.8.2.4 In operating conditions for dredgers, other than those equipped with bucket ladder:

1. vessel with full stores, with dredging gear in the highest position possible in normal operation,
2. vessel in the same loading condition as in .1, but with 10% of stores.

For dredgers equipped with grab cranes the additional loading conditions are to be considered in compliance with 3.8.2.2.

Notes:

1. Spoil pipeline within vessel is assumed to be filled with spoil having density equal to 1.3 [t/m$^3$],
2. The mass of spoil in the grab (bucket) is assumed to be 1.6 $V$ [t], where $V$ is the volume of the grab (bucket), in [m$^3$].

3.8.3 Form stability calculation and inclining test

3.8.3.1 When determining the arms of form stability for vessels of dredging fleet, the manholes of air spaces may be considered closed irrespective of the coaming height if they are fitted with covers conforming to 7.9 of the Rules, Part 3 – Hull Equipment.

3.8.3.2 Hopper barges, dredgers and other vessels in which the watertight integrity of their hoppers cannot be achieved due to the structural peculiarities may be inclined with water in the hoppers which communicates easily with sea water.

3.8.4 Checking of stability in working conditions and during voyages

3.8.4.1 Stability of vessels of dredging fleet during voyages is to be calculated having regard to the area of navigation prescribed to the vessel concerned.

Restrictions on navigation, if any (ballast water available, extent to which the dredging gear is dismantled, the position of the bucket, the possibility of spoil transportation in the hopper beyond the limits of 20 mile coastal zone, etc.), are to be stated both in the specification and in the Stability booklet. The dredgers equipped with a bucket may undertake voyages in the unrestricted area of navigation only with the buckets dismantled.

3.8.4.2 When calculating stability of vessels of dredging fleet under working conditions, the following is assumed:

1. in zone referred to in 3.8.1.1, wind pressure is to be taken as for the vessels of unrestricted service but reduced by 25%; less values may be allowed only in previous agreement with the Register. The amplitude of roll is to be taken as for the restricted area at navigation;
2. in zone referred to in 3.8.1.2 wind pressure and amplitude of roll are to be taken in accordance with area of navigation prescribed for the vessel concerned.

3.8.4.3 The amplitude of roll of vessel of dredging fleet having no cut-out in the hull, bilge keels or bar keel is determined by formula:

$$\theta_{1r} = X_1 \cdot X_2 \cdot Y$$

and Tables 3.8.4.3-1, 3.8.4.3-2 and 2.3.2.3-2.

Table 3.8.4.3-1
Values of factor "$Y$"

<table>
<thead>
<tr>
<th>$\frac{\sqrt{GM_0}}{B}$</th>
<th>0.04</th>
<th>0.05</th>
<th>0.06</th>
<th>0.07</th>
<th>0.08</th>
<th>0.09</th>
<th>0.10</th>
<th>0.11</th>
<th>0.12</th>
<th>0.13</th>
</tr>
</thead>
<tbody>
<tr>
<td>unrestricted navigation area</td>
<td>24</td>
<td>25</td>
<td>27</td>
<td>29</td>
<td>30.7</td>
<td>32</td>
<td>32</td>
<td>33</td>
<td>35.3</td>
<td>36</td>
</tr>
<tr>
<td>restricted navigation area</td>
<td>16</td>
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<td>19.7</td>
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<td>27.6</td>
<td>29.2</td>
<td>30.5</td>
<td>31.4</td>
<td>32.0</td>
</tr>
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</table>

Table 3.8.4.3-2
Values of factor $X_1$

<table>
<thead>
<tr>
<th>Type of vessel</th>
<th>Ratio $\frac{B}{d}$</th>
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<th>2.75</th>
<th>3.00</th>
<th>3.25</th>
<th>3.50</th>
<th>3.75</th>
<th>4.00</th>
<th>4.25</th>
<th>4.50</th>
<th>4.75</th>
<th>5.00</th>
<th>5.25</th>
<th>5.50</th>
</tr>
</thead>
<tbody>
<tr>
<td>dredgers</td>
<td>1.08</td>
<td>1.06</td>
<td>1.04</td>
<td>1.02</td>
<td>1.00</td>
<td>0.99</td>
<td>0.98</td>
<td>0.96</td>
<td>0.94</td>
<td>0.92</td>
<td>0.90</td>
<td>0.90</td>
<td>0.90</td>
<td>0.90</td>
</tr>
<tr>
<td>hopper dredgers and hopper barges</td>
<td>1.12</td>
<td>1.09</td>
<td>1.06</td>
<td>1.03</td>
<td>1.01</td>
<td>0.98</td>
<td>0.96</td>
<td>0.94</td>
<td>0.92</td>
<td>0.90</td>
<td>0.88</td>
<td>0.85</td>
<td>0.83</td>
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Table 3.8.4.3-3
Values of factor $X_3$

<table>
<thead>
<tr>
<th>$\sqrt{\frac{GM_0}{B}}$</th>
<th>0.04</th>
<th>0.05</th>
<th>0.06</th>
<th>0.07</th>
<th>0.08</th>
<th>0.09</th>
<th>0.10</th>
<th>0.11</th>
<th>0.12</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\frac{1}{X_3}$</td>
<td>1.27</td>
<td>1.23</td>
<td>1.16</td>
<td>1.08</td>
<td>1.05</td>
<td>1.04</td>
<td>1.03</td>
<td>1.02</td>
<td>1.01</td>
</tr>
<tr>
<td>$\sqrt{\frac{GM_0}{B}}$</td>
<td>0.13</td>
<td>0.14</td>
<td>0.15</td>
<td>0.16</td>
<td>0.17</td>
<td>0.18</td>
<td>0.19</td>
<td>0.20 and over</td>
<td></td>
</tr>
<tr>
<td>$\frac{1}{X_3}$</td>
<td>1.00</td>
<td>1.00</td>
<td>1.01</td>
<td>1.03</td>
<td>1.05</td>
<td>1.07</td>
<td>1.10</td>
<td>1.13</td>
<td></td>
</tr>
</tbody>
</table>

For restricted area of navigation, the amplitude of roll obtained by formula (3.8.4.3) is to be multiplied by the factor $X_3$ determined to the table 3.8.4.3-3.

The bilge keels and/or bar keel are to be taken into account in compliance with 2.3.2.3-3.

For vessels with sharp bilges the provisions of 2.3.2.3 shall be taken into consideration.

For hopper dredgers and hopper barges having bottom recesses for flaps, factor $X_3$ is determined from the ratio $B/d$ multiplied by coefficient $V$, where:

$V = \frac{V + V_B}{V}$

where:

$V$ is the volume displacement of the vessel with no regard to recess, in $m^3$; $V_B$ is the volume of bottom recess $m^3$.

3.8.4.4 Stability of dredgers and hopper dredgers equipped with grab cranes when additional loading conditions (see 3.8.2.2) are considered is to meet the requirements of 4.2.4.

3.8.4.5 Stability of hopper dredgers and hopper barges whose construction of bottom flaps and their drive does not prevent the possibility of spoil discharge from one side shall be checked with due regard to such discharge only for compliance with weather criterion as specified in 3.8.4.6 and 3.8.4.7 for the most unfavourable loading condition out of .1 and .2 (see 3.8.2.2):

.1 where spoil in the hopper, having density less than 1.3 t/m$^3$ with static heeling angle $\theta_{BC1}$ and amplitude of roll 10°;

.2 where spoil in the hopper, having density equal to or more than 1.3 t/m$^3$ and, with regard to dynamic character of discharge, with amplitude of roll equal to the sum of 10° and the maximum amplitude of vessel's rolling $\theta_{3r}$ with respect to statical inclination just after the spoil discharge.

The value of $\theta_{3r}$ in degrees, is computed from the formula

$$\theta_{3r} = \frac{0.2 \cdot \theta_{BC1}}{3.8.4.5.2}$$

The recommended pattern for determination of capsizing moment is given in Appendix 2 to the present part of the Rules.

3.8.4.6 The value of horizontal shifting of the vessel's centre of gravity $Y_G$, in $m$, when discharging half the spoil from one side out of fully loaded hopper, is computed from the formula

$$\Delta = \frac{P \cdot Y}{2 \cdot \Delta_{max}} \quad (3.8.4.6-1)$$

where:

$P$ = total mass of spoil in the hopper, in [t]

$Y$ = distance from the centre of gravity of spoil discharged from one side to the centre line, in [m]

$\Delta = \Delta_{max} - \frac{P}{2} \quad (3.8.4.6-2)$

3.8.4.7 The vessel's curves of statical and dynamical stability, in $m$, are calculated from the formulae:

$$GZ_1 = GZ - Y_G \cdot \cos \theta, \quad (3.8.4.7-1)$$

$$l_1 = l - Y_G, \quad (3.8.4.7-2)$$

where:

$GZ$ and $l$ = arms of statical and dynamical stability with the ship's displacement $\Delta_{max}$ calculated assuming that the vessel's centre line and corrected due to the free surface effect, in [m].

3.8.4.8 When spoil is discharged by long chute or conveyor methods, stability of a dredger shall be checked for the case of statical action of the moment due to the mass forces of the long chute or the conveyor (in the athwartship plane) filled with spoil (with no regard to the waves and wind effects).

In this case, the vessel's stability is considered to be adequate, if maximum statical heel is not more than the angle of flooding or the angle at which the freeboard becomes equal to 300 mm, whichever is less.

3.8.5 Effect of liquid cargoes

When calculating the effect of liquid cargoes as specified in 1.4.7 for hopper dredgers and hopper barges, it shall be assumed that:

.1 for a vessel with spoil having density over 1.3 t/m$^3$ the spoil is regarded as solid, non-overflowing cargo. The arms of statical
and dynamical stability are determined for the constant displacement and the spoil centre of gravity;

.2 for a vessel with spoil having density equal to, or less than, 1.3 t/m^3 the spoil is regarded as liquid cargo. The arms of statical and dynamical stability are determined at the variable displacement and position of the spoil centre of gravity, taking account of the spoil flowing overboard and reduction of the vessel's draught.

No such calculation is carried out if the vessel is provided with a longitudinal bulkhead in the hopper, the spoil in the latter case being regarded as solid cargo;

.3 for a vessel without spoil, the hopper is in communication with sea water, that is flaps or valves are open. The arms of statical and dynamical stability are determined for the constant displacement (as for a damaged vessel).

3.8.6 Effect of dredging gear icing

When estimating the effect of icing of vessels of dredging fleet, the horizontal projection of dredging gear is added to the area of horizontal projection of decks (the centre line projection being included in the windage area). The vertical moment due to this additional ice load is determined by the centre of gravity elevation of the projection of the dredging gear in its working or secured for sea position to the centre line.

3.8.7 Curve of statical stability

3.8.7.1 The curve of statical stability of hopper dredger and hopper barges during voyages and under working conditions is to meet requirements of Head 2.1.

3.8.7.2 The curve of statical stability of dredgers equipped with bucket ladder for all loading conditions specified in 3.8.2, as well as when taking account of icing, shall comply with the following requirements:

.1 the angle of vanishing stability \( \theta_v \) shall be not less than 50°;

.2 the maximum arm of the curve with angle \( \theta_m \) being not less than 25° is not to be less than:

- 0.25 m - when operating in zone referred to in 3.8.1.1,
- 0.40 m - during voyages, passages to larger area of navigation and when operating in area referred to in 3.8.1.2.

3.8.7.3 For bucket dredgers having B/D>2.5, angles \( \theta_v \) and \( \theta_m \) may be reduced as compared to those required in 3.8.7.2 by the following values:

.1 for the angle of vanishing stability, by a value determined to the Table 3.8.7.3 depending on the B/D ratio and weather criterion K;

<table>
<thead>
<tr>
<th>B/D</th>
<th>1.0</th>
<th>1.1</th>
<th>1.2</th>
<th>1.3</th>
<th>1.4</th>
<th>1.5 and over</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5 and less</td>
<td>0</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2.6</td>
<td>0</td>
<td>0.25</td>
<td>0.50</td>
<td>0.75</td>
<td>1.00</td>
<td>1.25</td>
</tr>
<tr>
<td>2.7</td>
<td>0</td>
<td>0.50</td>
<td>1.00</td>
<td>1.50</td>
<td>2.00</td>
<td>2.50</td>
</tr>
<tr>
<td>2.8</td>
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<td>0.75</td>
<td>1.50</td>
<td>2.25</td>
<td>3.00</td>
<td>3.75</td>
</tr>
<tr>
<td>2.9</td>
<td>0</td>
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<td>2.00</td>
<td>3.00</td>
<td>4.00</td>
<td>5.00</td>
</tr>
<tr>
<td>3.0 and over</td>
<td>0</td>
<td>1.25</td>
<td>2.50</td>
<td>3.75</td>
<td>5.00</td>
<td>6.25</td>
</tr>
</tbody>
</table>

Note: Values \( \Delta \theta \), in degrees, shall be rounded off to the nearest integer number.

.2 for the angle corresponding to the maximum arm of the curve \( \theta_m \), by a value equal to half the reduction value of the angle of vanishing stability;

.3 for dredgers of unrestricted service the reduction of angles \( \theta_m \) and \( \theta_v \) is not permitted.

3.9 CONTAINER SHIPS (UP TO 100 M IN LENGTH)

3.9.1 In calculating stability of container ships up to 100 m in length the vertical centre of gravity position of each container shall be taken equal to half the height of the container of the type concerned.

3.9.2 Stability of container ships up to 100 m in length shall be checked for the following loading conditions:

.1 a ship with maximum number of containers with full stores and where necessary, with liquid ballast at the draught up to the summer load line. The mass of containers is assumed as the same percentage of maximum gross mass of each type of container;

.2 a ship in the same loading condition as in 3.9.2.1 but with 10 % of stores;

.3 a ship with maximum number of containers having the mass equal to 0.6 of the maximum mass for each type of containers with full stores and, where necessary, with liquid ballast;

.4 a ship in the same loading condition as in 3.9.2.3, but with 10 % of stores;

.5 a ship with full stores, where necessary, with the liquid ballast, with a number of containers which correspond to the loading condition of the ship at the draught up to the summer load line. The mass of containers is assumed as maximum gross mass of each type of container;
.6 a ship in the same loading condition as in 3.9.2.5, but with 10 % of stores;
.7 a ship with maximum number of empty containers, but with full stores and with liquid ballast,
.8 a ship in the same loading condition as in 3.9.2.7 but with 10 % of stores;
.9 a ship with no cargo, but with full stores,
.10 a ship in the same loading condition as in 3.9.2.9 but with 10 % of stores.

When determining the arrangement of containers on board under the loading conditions mentioned above, the allowable loads upon the hull structures should be considered.

3.9.3 If other loading conditions other than those referred to in 3.9.2 are provided, stability is to be checked for such conditions with full stores and 10 % of stores and with liquid ballast, where necessary.

3.9.4 In addition to requirements as defined in Head 2.1, stability of container ships for any loading condition with containers shall be such that a statical heeling angle on steady turning or under the effect of beam wind determined from the stability curve does not exceed half the angle at which the freeboard deck immerses. In any case, the heeling angle shall not exceed 15°.

Where the deck cargo of containers is located on cargo hatch covers only, on agreement with the Register, the angle at which the hatch coaming edge or container lower edge is immersed, whichever angle is less, may be adopted instead of the angle at which the upper deck edge is immersed (provided the containers protrude beyond the coaming in question).

3.9.5 The heeling moment on steady turning shall be calculated by the formula (3.1.6).

3.9.6 The heeling angle due to wind effect shall be determined according to item 2.1.5 - Weather criteria.

In determining the statical heeling angle due to wind effect, it is assumed that the ship is in upright position.

3.9.7 All calculations of statical heeling angle due to the effect of beam wind or turning shall be made with no regard for icing, but having regard to the free surfaces effect of liquid cargoes as required in 1.4.7.

3.9.8 The corrected initial metacentric height of container ships under loading conditions with containers on board and icing disregarded is not to be less than 0.15 m.

3.9.9 Container ships shall be equipped with tanks or other specific facilities approved by the Register, permitting to check the initial stability of a ship.

3.9.10 The requirements of the present Part are applicable to ships of other types appropriated for the carriage of cargoes in containers on deck.

If, as required in items 3.9.2.1 and 3.9.2.3 the ship cannot be loaded up to the summer load line, the maximum possible draught for that loading condition shall be taken in consideration.

3.10 CONTAINERSHIPS GREATER THAN 100 M IN LENGTH

3.10.1 Application

These requirements apply to container ships greater than 100 m as defined in 1.2.50. They may also be applied to other cargo ships with considerable flare or large waterplane areas instead of the criteria set in 2.1.3.

3.10.2 Intact stability

3.10.2.1 The area under the righting lever curve (GZ curve) shall not be less than 0.009/C metre-radians up to θ = 30° angle of heel and not less than 0.016/C metre-radians up to θ = 40° or the angle of flooding θ_f (as defined in 2.1.3) if this angle is less than 40°.

3.10.2.2 Additionally, the area under the righting lever curve (GZ curve) between the angles of heel of 30° and 40° or between 30° and θ_f, if this angle is less than 40°, shall not be less than 0.006/C metre-radians.

3.10.2.3 The righting lever GZ shall be at least 0.033/C m at an angle of heel equal or greater than 30°.

3.10.2.4 The maximum righting lever GZ shall be at least 0.042/C m.

3.10.2.5 The total area under the righting lever curve (GZ curve) up to the angle of flooding θ_f shall not be less than 0.029/C metre-radians.
3.10.2.6 In the above criteria the form factor $C$ shall be calculated using the formula and figure 3.10-1:

$$C = \frac{d \cdot D'}{B_m^2} \cdot \sqrt{\frac{d}{KG}} \cdot \left(\frac{C_B}{C_w}\right)^2 \cdot \sqrt{\frac{100}{L}}$$

where:

- $d$ = mean draught [m]
- $D'$ = moulded depth of the ship, corrected for defined parts of volumes within the hatch coamings according to the formula:
- $D' = D + h \left(\frac{2b - B_D}{B_D}\right) \left(\frac{2 \sum l_H}{L}\right)$ as defined in fig. 3.10-1

- $D'$ = moulded depth of the ship [m]
- $B_D$ = moulded breadth of the ship [m]
- $KG$ = height of the centre of mass above base, corrected for free surface effect, not to be taken as less than $d$, in [m]
- $C_B$ = block coefficient
- $C_w$ = waterplane coefficient
- $l_H$ = length of each hatch coaming within L/4 forward and aft from amidships, in [m]
- $b$ = mean width of hatch coamings within L/4 forward and aft from amidships, in [m]
- $L$ = length of the ship, in [m]
- $B_m$ = breadth of the ship on the waterline at half mean draught, in [m]
- $h$ = mean height of hatch coamings within L/4 forward and aft from amidships, in [m] (see 3.10-1)

The shaded areas in figure (3.10-1) represent partial volumes within the hatch coamings considered contributing to resistance against capsizing at large heeling angles when the ship is on a wave crest.

3.10.3 The use of electronic loading and stability instrument is encouraged in determining the ship's trim and stability during different operational conditions.

### 3.11 OPEN-TOP CONTAINERSHIPS

3.11.1 Open-top containership means a containership especially designed so that one or more of the cargo holds need not be fitted with hatch covers.

3.11.2 Stability of an Open-top containership should satisfy the requirements of Head 2.1 of this part of the Rules, taking into account the effect on stability of the free surfaces in all open holds.

3.11.3 Where freeing ports are fitted, for determination of flooding angle they are considered as closed if effective means of closure to prevent the accidental ingress of water are provided.

3.11.4 With all open holds completely filled with water (permeability of 0.70 for container holds) to the level of the
top of the hatch coaming or, in the case of ship fitted with cargo hold freeing ports, to the level of those ports, the stability of the fully loaded ship in the intact condition should meet the survival criteria (with factor s = 1) of Chapter II-1 part B-1 of SOLAS 1974, as amended.

3.11.5 For the condition with flooded holds and an intact ship the free surfaces may be determined as follows: The holds are fully loaded with containers. The seawater enters the containers and will not pour out during heeling. This condition should be simulated by defining the amount of water in the containers as fixed weight items. The free surface surrounding the containers is then flooded with seawater. This free space should be evenly distributed over the full length of the open cargo holds.

3.11.6 For any case of intermediate conditions of hold flooding, the prescribed stability criteria should be proved by calculation.

3.12 OFFSHORE SUPPLY VESSELS

3.12.1 The provisions given hereunder apply to offshore supply vessels of 24 m to 100 m in length.

Stability requirements on offshore supply vessels of more than 100 m in length will be in each case considered separately by the Register, but in general, should be of the level stated in Head 2.1.

3.12.2 Where a ship other than an offshore supply vessel, as defined in 1.2.47, is employed on a similar service, the Register shall determine the extent to which compliance with the provisions of the Rules is required.

3.12.3 Access to the machinery space shall, if possible, be arranged within the forecastle. Any access to the machinery space from the exposed cargo deck should be provided with two watertight closures. Access to spaces below the exposed cargo deck shall preferably be from a position within or above the superstructure deck.

3.12.4 The area of freeing ports in the side bulwarks of the cargo deck shall at least meet the requirements of regulation 27 of the International Convention on Load Lines, 1966 with Protocol of 1988, as amended. The disposition of the freeing ports shall be carefully considered to ensure the most effective drainage of water trapped in pipe deck cargoes or in recesses at the after end of the forecastle. In vessels operating in areas where icing is likely to occur, no shutters shall be fitted in the freeing ports.

3.12.5 Special attention shall be given to adequate drainage of pipe stowage positions, having regard to the individual characteristics of the vessel. However, the area provided for drainage of the pipe stowage positions shall be in excess of the required freeing port area in the cargo deck bulwarks and shall not be fitted with shutters.

3.12.6 The arrangement of cargo stowed on deck shall be such as to avoid any obstruction of the freeing ports or of the areas necessary for the drainage of pipe stowage positions to the freeing ports.

3.12.7 Stability of offshore supply vessels shall be checked for the following standard loading conditions:

- .1 Vessel in fully loaded departure condition with cargo distributed below deck and with cargo specified by position and weight on deck, with full stores and fuel, corresponding to the worst service condition in which all the relevant stability criteria are met.
- .2 Vessel in fully loaded arrival condition with cargo as specified in .1, but with 10% stores and fuel.
- .3 Vessel in ballast departure condition, without cargo but with full stores and fuel.
- .4 Vessel in ballast arrival condition, without cargo and with 10% stores and fuel remaining.
- .5 Vessel in the worst anticipated operating condition.

3.12.8 The assumptions for calculating loading conditions should be as follows:

- .1 If a vessel is fitted with cargo tanks, the fully loaded conditions of 3.12.7.1 and 3.12.7.2 shall be modified, assuming first the cargo tanks full and then the cargo tanks empty.
- .2 If in any loading condition water ballast is necessary, additional diagrams shall be calculated, taking into account the water ballast, the quantity and disposition of which should be stated in the stability booklet.
- .3 In all cases when deck cargo is carried a realistic stowage weight shall be assumed and stated in the stability information, including the height of the cargo and its centre of gravity.
- .4 Where the pipes are carried on deck, the volume of the trapped water \( V_a \) shall be determined according to the formula (3.12.8.4) depending upon total volume of pipes bundle, \( V_{at} \), and ratio of freeboard at the midship, \( f \), to the length of the vessel \( L \).

The volume of the pipes bundle should be taken as the internal volume of the pipes plus the volume between pipes.

\[
V_a = \begin{cases} 
0.3 \cdot V_{at} & \text{if } \frac{f}{L} \leq 0.015 \\
0.1 \cdot V_{at} & \text{if } \frac{f}{L} > 0.03 \\
& \text{by linear interpolation of } V_a \text{ values above,} \\
& \text{if } 0.015 < \frac{f}{L} < 0.03 \\
& \text{5 Reducing of the design value for the volume of water in the pipes, where they are plugged or where the pipe pile is higher.}
\end{cases}
\]
The stability of offshore supply vessels is to be checked considering the actual trim during the inclination (“free-trim method”).

The stability criteria given in 2.1 should apply to all offshore supply vessels except those having characteristics that render compliance with 2.1 impracticable.

The following equivalent criteria are required where a vessel’s characteristics render compliance with 2.1 impracticable, as in the case of the vessels having B/D > 2:

1. The area under the curve of righting levers (GZ curve) shall not be less than 0.070 metre-radians up to an angle of 15° when the maximum righting lever (GZ) occurs at 15° and 0.055 metre-radians up to an angle of 30° when the maximum righting lever (GZ) occurs at 30° or above. Where the maximum righting lever (GZ) occurs at angles of between 15° and 30°, the corresponding area under the righting lever curve should be:

\[ 0.055 + 0.001 (30° - \theta_{max})^\ast \text{[m rad]} \]

2. The area under the righting lever curve (GZ curve) between the angles of heel of 30° and 40°, or between 30° and \( \theta_f \) (as defined in 2.1.3) if this angle is less than 40°, shall be not less than 0.03 metre-radians.

3. The righting lever (GZ) shall be at least 0.20 m at an angle of heel equal to or greater than 30°.

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

5. The initial transverse metacentric height (GM) shall not be less than 0.15 m.

In addition to the equivalent criteria stated above, the weather criterion referred to in item 3.12.17 shall be satisfied also.

Reference is made also to 2.1.2.3 to 2.1.2.5 and 1.6.1.

When the effect of icing is computed, the upper surface of the deck cargo is to be considered as the deck, and its lateral area projection above the bulwark - as a part of the design windage area. The icing allowance is to be assumed in accordance with Head 2.2 “Allowance for Icing”.

For offshore supply vessels operating in areas where icing is possible, the ice and water in the pipes shall be considered simultaneously when making stability calculations for the carriage of pipes on deck. The icing of pipes carried on deck shall be determined as follows: the mass of ice \( M_{ice} \) inside the pipe pile is determined from the formula:

\[ M_{ice} = \sum_{i=1}^{k} n_i m_{ice} \]

where:
- \( m_{ice} \) = mass of ice per one pipe, obtained from table 3.12.14.
- \( n_i \) = quantity of pipes of the i-th diameter.
- \( k \) = number of standard pipe sizes with regard to diameter.

<table>
<thead>
<tr>
<th>Pipe diameter (m)</th>
<th>0.05</th>
<th>0.1</th>
<th>0.2</th>
<th>0.3</th>
<th>0.4</th>
<th>0.5</th>
<th>0.6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ice mass per pipe (kg)</td>
<td>0.2</td>
<td>2.1</td>
<td>26.7</td>
<td>125</td>
<td>376</td>
<td>899</td>
<td>1831</td>
</tr>
</tbody>
</table>

Note: For pipes of intermediate diameters, the mass of ice is determined by interpolation.

When calculating the mass of ice on the outer surfaces of a pipes bundle, the area of the upper and the side surfaces should be determined taking the curvature of the pipe surface in the bundle into consideration. The rate of icing is adopted in accordance with 2.2.

For icing computation of a bundle of pipes, its whole net volume according to 3.12.8.4 shall be taken in consideration. If special devices against icing are provided on board, the calculated criteria of icing may be reduced in accordance with the Register on the warranted request of the designer of the vessel or shipowner.

Supply vessels that may be engaged in towing operations and/or anchor handling operations are to comply also with requirements of Head 3.7 and/or Head 3.15.

Arrangements for quick releasing of the tow line shall be provided on board.

Towing hook requirements are stated in the Rules, Part 3 - Hull equipment, item 5.5, and towing winches structural requirements are stated in the Rules, Part 9 - Machines.

The heeling moment due to wind pressure \( M_v \) and the roll amplitude of the supply vessel are to be determined in accordance with procedures agreed with the Register, but in general, the values in 2.1.5 should be used as guidance.

A minimum freeboard at the stern of at least 0.005 \( L \) should be maintained in all operating conditions.

\( \ast \theta_{max} \) is the angle of heel in degrees at which the righting lever curve reaches its maximum.
3.13* CARGO SHIPS CARRYING GRAIN IN BULK

The intact stability of ships engaged in the carriage of grain shall comply with the requirements of the International Code for the Safe Carriage of Grain in Bulk adopted by resolution MSC.23(59) *

3.14 HIGH-SPEED CRAFT

3.14.1 Dynamically Supported Crafts (DSC)

Dynamically supported craft (DSC), as is defined in 1.2.49 of this part of the Rules, constructed before 1 January 1996 shall be in compliance with stability requirements of IMO Res. A.373(X) as amended.

3.14.2 High Speed Crafts, according to 1994 HSC Code

High speed craft, as is defined in 1.2.48 of this part of the Rules, the keel of which is laid or which is at a similar stage of construction on or after 1 January 1996 but before 1 July 2002 shall be in compliance with stability requirements of IMO Res. MSC.36(63) as amended.

3.14.3 High Speed Crafts, according to 2000 HSC Code

Any high speed craft, as is defined in 1.2.48 of this part of the Rules, irrespective of its date of construction, which has undergone repairs, alterations or modifications of major character; and a high-speed craft constructed on or after 1 January 2002, shall be in compliance with stability requirements set in the Rules, Part 28 - High-speed craft (equivalent to IMO Res. MSC.97(73) as amended).

3.15 SHIPS ENGAGED IN ANCHOR HANDLING OPERATIONS

3.15.1 Application

3.15.1.1 The provisions given hereunder apply to ships engaged in anchor handling operations.

3.15.1.2 A wire means a dedicated line (wire rope, synthetic rope or chain cable) used for the handling of anchors by means of an anchor handling winch.

3.15.2 Loading conditions

3.15.2.1 For a ship engaged in an anchor handling operation, the standard loading conditions shall be as follows, in addition to the standard loading conditions for a cargo ship in item 3.2.1:

1. service loading condition at the maximum draught at which anchor handling operations may occur with the heeling levers as defined in item 3.15.3 for the line tension the ship is capable of with a minimum of 67% stores and fuel, in which all the relevant stability criteria as defined in item 3.15.5 are met;

2. service loading condition at the minimum draught at which anchor handling operations may occur with the heeling levers as defined in item 3.15.3 for the line tension the ship is capable of with 10% stores and fuel, in which all the relevant stability criteria as defined in item 3.15.5 are met.

3.15.2.2 For ships engaged in anchor handling operations, the compliance with the relevant stability criteria shall be made for each set of towing pins and its associated permissible line tensions, including any physical element or arrangement that can restrict the line movement. Also, the allowance shall be made for the anticipated weight of cargo on and below deck, chain in lockers, anticipated type of wire or rope on storage reels and wire on the winches when calculating loading conditions.

3.15.2.3 For ships engaged in anchor handling operations, the reference loading conditions in sub-item 3.15.2.1 shall meet the stability criteria in item 3.15.5 when applying the design tension $F_D$ for the tow pin set nearest to centreline, as a minimum for the lowest $\alpha$ equal to 5 degrees.

3.15.2.4 If a ship operates in zones where ice accretion is likely to occur, allowance for icing should be made in accordance with the provisions of Head 2.2 (Allowance for icing).

3.15.3 Heeling lever for towing operations

3.15.3.1 A heeling lever, $HL_\phi$, generated by the action of a heeling moment caused by the vertical and horizontal components of the tension applied to the wire shall be calculated as:

$$HL_\phi = \frac{M_{UL}}{A_2} \cdot \cos \phi$$

where:

- $M_{UL}$ - displacement of a loading condition, including action of the vertical loads added ($F_v$), at the centreline in the stern of ship;
- $\alpha$ - the horizontal angle between the centreline and the vector at which the wire tension is applied to the ship in the upper right position, positive outboard;
- $\beta$ - the vertical angle between the waterplane and the vector at which the wire tension is applied to the ship, positive downwards, shall be taken at the maximum heeling moment angle as $\tan^{-1} \left(\frac{y}{h \sin \alpha}\right)$, but not less than $\cos^{-1} \left(\frac{1}{2} \cdot \frac{BP}{(FP \cdot \cos \alpha)}\right)$, using consistent units;
- $F_D$ - the Bollard pull that is the documented maximum continuous pull obtained from a static pull test on sea trial, carried out in accordance with annex A of MSC/Circ.884 or an equivalent standard acceptable to the Register.

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*Refer to part C of Chapter VI of the 1974 SOLAS Convention as amended by resolution MSC.23(59)
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**FP** - (Permissible tension) the wire tension which can be applied to the ship as loaded while working through a specified tow pin set, at each $\alpha$, for which all stability criteria can be met; $F_P$ shall in no circumstance be taken as greater than $F_{d}$.

**$F_d$** - (Design maximum wire tension) the maximum winch wire pull or maximum static winch brake holding force, whichever is greater;

$h$ - the vertical distance (m) from the centre the propulsive force acts on the ship to either:
- the uppermost part at the towing pin, or
- a point on a line defined between the highest point of the winch pay-out and the top of the stern or any physical restriction of the transverse wire movement;

$y$ - the transverse distance (m) from the centreline to the outboard point at which the wire tension is applied to the ship given by:
$$y_0 + x \cdot \tan \alpha; \text{ but not greater than } B/2;$$

$B$ - moulded breadth (m);

$y_o$ - the transverse distance (m) between the ship centreline to the inner part of the towing pin or any physical restriction of the transverse wire movement;

$x$ - the longitudinal distance (m) between the stern and the towing pin or any physical restriction of the transverse wire movement.

**Figure 3.15-1**

Diagrams showing the intended meaning of parameters $\alpha$, $\beta$, $x$, $y$ and $h$. $F_t$ shows the vector of the applied wire tension.

### 3.15.4 Heeling lever for escort operations

**3.15.4.1** The permissible tension as function of $\alpha$, defined in item 3.15.3, shall not be greater than the tension given by sub-item 3.15.4.2.

**3.15.4.2** Permissible tension as function of $\alpha$ can be calculated by direct stability calculations, provided that the following are met:

1. the heeling lever shall be taken as defined in item 3.15.3 for each $\alpha$;
2. the stability criteria in item 3.15.5, shall be met;

3. $\alpha$ shall not be taken less than 5 degrees, except as permitted by sub-items 3.15.4.3; and
4. Intervals of $\alpha$ shall not be more than 5 degrees, except that larger intervals may be accepted, provided that the permissible tension is limited to the higher $\alpha$ by forming working sectors.

**3.15.4.3** For the case of a planned operation to retrieve a stuck anchor in which the ship is on station above the anchor and the ship has low or no speed, $\alpha$ may be taken as less than 5 degrees.
3.15.5 Stability criteria

3.15.5.1 For the loading conditions intended for anchor handling, but before commencing the operation, the stability criteria given in items 2.1.3 to 2.1.5 shall apply. During operation, under the action of the heeling moment, the criteria under sub-items 3.15.5.2 to 3.15.5.4 shall apply.

3.15.5.2 The residual area between the righting lever curve and the heeling lever curve calculated in accordance with item 3.15.3 shall not be less than 0.070 metre-radians. The area is determined from the first intersection of the two curves, \( \phi_e \), to the angle of the second intersection, \( \phi_c \), or the angle of down-flooding, \( \phi_f \), whichever is less.

3.15.5.3 The maximum residual righting lever \( \text{GZ} \) between the righting lever curve and the heeling lever curve calculated in accordance with item 3.15.3 shall be at least 0.2 m.

3.15.5.4 The static angle at the first intersection, \( \phi_e \), between the righting lever curve and the heeling lever curve calculated in accordance with item 3.15.3 shall not be greater than:

1. the angle at which the righting lever equals 50% of the maximum righting lever;
2. the deck edge immersion angle; or
3. 15 degrees, whichever is less.

3.15.5.5 A minimum freeboard at stern, on centreline, of at least 0.005 \( \Delta \), shall be maintained in all operating conditions, with a displacement given by \( \Delta_c \), as defined in item 3.15.3. In the case of the anchor retrieval operation covered by sub-item 3.15.4.3, a lower minimum freeboard may be accepted provided that due consideration has been given to this in the operation plan.

3.15.6 Constructional precautions against capsizing

3.15.6.1 A stability instrument may be used for determining the permissible tension and checking compliance with relevant stability criteria. Two types of stability instrument may be used on board:

- either a software checking the intended or actual tension on the basis of the permissible tension curves; or
- a software performing direct stability calculations to check compliance with the relevant criteria, for a given loading condition (before application of the tension force), a given tension and a given wire position (defined by angles \( \alpha \) and \( \beta \)).

3.15.6.2 Access to the machinery space, excluding emergency access and removal hatches, should, if possible, be arranged within the forecastle. Any access to the machinery space from the exposed cargo deck shall be provided with two weathertight closures. Access to spaces below the exposed cargo deck should preferably be from a position within or above the superstructure deck.

3.15.6.3 The area of freeing ports in the side bulwarks of the cargo deck shall at least meet the requirements of regulation 24 of the International Convention on Load Lines, 1966 or the Protocol of 1988 relating thereto, as amended, as applicable. The disposition of the freeing ports shall be carefully considered to ensure the most effective drainage of water trapped in working deck and in recesses at the after end of the forecastle. In ships operating in areas where icing is likely to occur, no shutters shall be fitted in the freeing ports.

3.15.6.4 The winch systems shall be provided with means of emergency release.

3.15.6.5 For ships engaged in anchor handling operations the following recommendations for the anchor handling arrangements shall be considered:

1. stop pins or other design features meant to impede the movement of the wire further outboard shall be installed; and
2. the working deck shall be marked with contrasting colours or other identifiers such as guide pins, stop pins or similar easily identifiable points that identify operational zones for the line to aid operator observation.

3.15.7 Operational procedures against capsizing

3.15.7.1 A comprehensive operational plan should be defined for each anchor handling operation, according to the guidelines given in item 3.15.9 and Appendix 6, where at least, but not only, the following procedures and emergency measures shall be identified:

1. environmental conditions for the operation;
2. winch operations and movements of weights;
3. compliance with the stability criteria, for the different expected loading conditions;
4. permissible tensions on the winches as function of \( \alpha \); in accordance with item 3.15.9 and Appendix 6;
5. stop work and corrective procedures; and
6. confirmation of the master's duty to take corrective action when necessary.

3.15.7.2 The arrangement of cargo stowed on deck shall be such as to avoid any obstruction of the freeing ports or sudden shift of cargo on deck.

3.15.7.3 Counter-ballasting to correct the list of the ship during anchor handling operations shall be avoided.

3.15.8 Stability booklet

3.15.8.1 Besides the general information required for all ships, set in sub-item 1.5.1.3, the stability booklet for ships engaged in anchor handling operations shall contain additional information on:

1. maximum bollard pull, winch pull capacity and brake holding force;
2. details on the anchor handling arrangement such as location of the fastening
point of the wire, type and arrangement of towing pins, stern roller, all points or elements where the tension is applied to the ship;

3. identification of critical downflooding openings;

4. guidance on the permissible tensions for each mode of operation and for each set of towing pins, including any physical element or arrangement that can restrict the wire movement, as function of all relevant stability criteria; and

5. recommendations on the use of roll reduction systems.

3.15.8.2 Curves (or tables) of the permissible tension as a function of permissible KG (or GM) are to be provided for the draught (or displacement) and trim values covering the intended anchor handling operations. The curves (or tables) shall be developed under the following assumptions:

1. the maximum allowable KG from the approved stability booklet;

2. information of permissible tension curve or table for each set of towing pins, including any physical element or arrangement that can restrict the line movement as function of the stability limiting curve shall be included;

3. where desirable, a permissible tension curve or table should be provided for any specific loading condition;

4. the draught (or displacement), trim and KG (or GM) to be taken into consideration are those before application of the tension; and

5. where tables are provided that divide the operational, cautionary, and stop work zones, referred to in sub-item 3.15.9.2 ("Green", "Yellow" or "Amber", "Red" colour codes, respectively) the limiting angles associated with physical features of the stern, including the roller, may be used to define the boundaries between the operational and cautionary zones (green/yellow boundary) and the cautionary and stop work zones (yellow/red boundary).

3.15.9 Operational and planning manuals

3.15.9.1 To assist the master an operational and planning manual containing guidelines for planning and performing specific operations shall be provided on board. The guidelines shall contain sufficient information to enable the master to plan and operate the ship in compliance with the applicable requirements contained in this part of the Rules. The following information shall be included as appropriate:

1. anchor handling arrangements, including:
   - detail arrangement of anchor handling deck equipment (winches, wire stoppers, towing pins, etc.);
   - typical arrangement of cargo on deck (anchors, wires, chain cables, etc.);
   - chain lockers used for mooring deployment;
   - anchor handling/towing winch;
   - tugger winches;
   - stern roller, including lateral limits on both ends;
   - lifting appliances, if any and if forming a physical restriction as per sub-item 3.15.2.2; and
   - typical paths of wires between winches and stern roller, showing the limit sectors; and

2. detailed data of the permissible tensions, stability limiting curves, and recommendations for calculating ship’s loading conditions including sample calculations.

3.15.9.2 An operation plan shall be agreed to by the master of the ship and a copy archived on a remote location before the operation commences. Guidelines and procedures to define a step-wise operational plan for a specific operation shall contain instructions for:

1. identifying and calculating loading conditions for all relevant stages of operation, taken into account the expected fuel and stores consumption, alterations on deck load, effects of deployment or recovering of the wire on the winches and chain lockers;

2. planning ballast operations;

3. defining the most favourable consumption sequence and identifying the most onerous situations;

4. identifying the possibility or prohibition of using the roll reduction systems in all operational stages;

5. operation with open chain lockers, e.g. additional loading conditions for asymmetric filling or other measures to reduce the possibility of flooding;

6. collect updated weather forecasts, and to define environmental conditions for anchor handling operations;

7. the use of limiting stability curves and intended tensions;

8. defining the stop work limits:
   - permissible tensions and operational sectors for $\alpha$;
   - heeling angles in compliance with the stability criteria; and
   - environmental conditions;

9. implement and define corrective and emergency procedures;

10. define:
   - an operational zone in which normal operations up to the permissible tension are to occur (i.e. a "Green" zone);
   - a cautionary zone (i.e. a "Yellow" or "Amber" zone) where operations may be reduced or halted to assess the ship's options to return to the operational or Green Zone: the cautionary zone shall be not less than an angle of
10 degrees unless Table A6-1 in Appendix 6 provides otherwise; and

c a "Stop work" zone (i.e. a "Red" zone) in which the operation shall be stopped, for which, in normal operations, the yellow/red boundary shall not exceed 45 degrees or the point at which the wire rises above the deck.

Notwithstanding this, due consideration may be given to different operations from typical anchor handling operations where the planned operation ensures the safety of the ship; and the examples of presentation of permissible tensions are presented in item 2 of Appendix 6.

3.15.9.3 To aid the definition of permissible tensions and zones based on the availability of tension monitoring and an onboard stability instrument, the self-explaining table is provided in item 1 of Appendix 6.

3.16 SHIPS ENGAGED IN LIFTING OPERATIONS

3.16.1 Application

3.16.1.1 The provisions given hereunder apply to ships the keel of which is laid or which is at a similar stage of construction* on or after 1 January 2020 engaged in lifting operations and to ships converted to carry out lifting operations after this date.

3.16.1.2 The provisions of this Head shall be applied to operations involving the lifting of the ship's own structures or for lifts in which the maximum heeling moment due to the lift is greater than that given in the following:

\[ M_{h} = 0.67 \cdot A \cdot GM \cdot (f/B) \]

where:

- \( M_{h} \) - Threshold value for the heeling moment, in (t.m), induced by the (lifting equipment and) load in the lifting equipment;
- \( GM \) - The initial metacentric height, in (m), measured from the upper side of the weather deck to the waterline;
- \( f \) - the moulded breadth of the ship, in (m); and
- \( B \) - the displacement of the ship, including the lift load, in (t).

The provisions of this Head also apply to ships which are engaged in lifting operations where no transverse heeling moment is induced and the increase of the ship's vertical centre of gravity (VCG) due to the lifted weight is greater than 1%.

The calculations shall be completed at the most unfavourable loading conditions for which the lifting equipment is intended to be used.

3.16.1.3 For the purpose of this Head, waters that are not exposed are those where the environmental impact on the lifting operation is negligible. Otherwise, waters are to be considered exposed. In general, waters that are not exposed are calm stretches of water, i.e. estuaries, roadsteads, bays, la-goons; where the wind fetch is six nautical miles or less. Ships classed for navigation area 7 or 8 should be regarded as operating in waters that are not exposed.

3.16.2 Loading conditions

3.16.2.1 For ships engaged in lifting, loading conditions reflecting the operational limitations of the ship, while engaged in lifting shall be included in the stability booklet. Use of counter ballast, if applicable, shall be clearly documented, and the adequacy of the ships stability in the event of the sudden loss of the hook load shall be demonstrated.

3.16.2.2 The criteria stated in paragraphs 3.16.4, 3.16.5, 3.16.6 or 3.16.8, as applicable, shall be satisfied for all loading conditions intended for lifting and with the hook load at the most unfavourable positions. For each loading condition, the weight and centre of gravity of the load being lifted, the lifting appliance, and counter ballast, if any, should be included. The most unfavourable position may be obtained from the load chart and is chosen at the position where the total of the transverse and vertical moment is the greatest. Additional loading conditions corresponding to various boom positions and counter ballast with different filling level (if applicable) may need to be checked.

3.16.2.3 For ships engaged in lifting operations, allowance shall be made for the anticipated weight of cargo on and below deck, anticipated type of wire or rope on storage reels and wire on the winches when calculating loading conditions.

3.16.2.4 If a ship operates in zones where ice accretion is likely to occur, allowance for icing shall be made in accordance with the provisions of Head 2.2 (Allowance for icing).

3.16.3 Load and vertical centre of gravity for different types of lifting operations

3.16.3.1 In lifting operations involving a lifting appliance consisting of a crane, derrick, sheerlegs, a-frame or similar:

1. the magnitude of the vertical load (\( P_{L} \)) shall be the maximum allowed static load at a given outreach of the lifting appliance;

2. the transverse distance \( (y) \) is the transverse distance between the point at which the vertical load is applied to the lifting appliance and the ship centreline in the upright position;

3. the vertical height of the load \((KG_{\text{load}})\) is taken as the vertical distance from the

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*A similar stage of construction means the stage at which:
- construction identifiable with a specific ship begins; and
- assembly of that ship has commenced, comprising at least 50 tonnes or 1% of the estimated mass of all structural material, whichever is less.

** Wind fetch is an unobstructed horizontal distance over which the wind can travel over water in a straight direction.
point at which the vertical load is applied to the lifting appliance to the baseline in the upright position; and

4 the change of centre of gravity of the lifting appliance(s) need to be taken into account.

### 3.16.3.2

In lifting operations not involving a lifting appliance consisting of a crane, derrick, sheerlegs, a-frame or similar, which involve lifting of fully or partially submerged objects over rollers or strong points at or near a deck-level:

1 the magnitude of the vertical load \( P_L \) should be the winch brake holding load;

2 the transverse distance \( y \) is the transverse distance between the point at which the vertical load is applied to the ship and the ship centreline in the upright position; and

3 the vertical height of the load \( \text{KG load} \) is taken as the vertical distance from the point at which the vertical load is applied to the ship to the baseline in the upright position.

### 3.16.4 Stability criteria

#### 3.16.4.1

The stability criteria included herein, or the criteria contained in items 3.16.5, 3.16.6 or 3.16.8, as applicable shall be satisfied for all loading conditions intended for lifting with the lifting appliance and its load at the most unfavourable positions. For the purpose of this section, the lifting appliance and its load(s) and their centre of gravity (COG) shall be included in the displacement and centre of gravity of the ship, in which case no external heeling moment/heeling lever is applied.

#### 3.16.4.2

All loading conditions utilized during the lifting operations are to comply with the stability criteria given in items 2.1.3 to 2.1.5 of this part of the Rules. During the lifting operation, as determined by item 3.16.1, the following stability criteria shall also apply:

1. the equilibrium heel angle, \( \varphi_1 \), shall not be greater than the maximum static heeling angle for which the lifting device is designed and which has been considered in the approval of the loading gear;

2. during lifting operations in non-exposed waters, the minimum distance between the water level and the highest continuous deck enclosing the watertight hull, taking into account trim and heel at any position along the length of the ship, shall not be less than 0.50 m; and

3. during lifting operations in exposed waters, the residual freeboard shall not be less than 1.00 m or 75% of the highest significant wave height \( H_s \), in (m), encountered during the operation, whichever is greater.

### 3.16.5 Lifting operations conducted under environmental and operational limitations

#### 3.16.5.1

For lifting conditions carried out within clearly defined limitations set forth in sub-item .1, the intact criteria set forth in sub-item .2 may be applied instead of the criteria included in item 3.16.4.

1 The limits of the environmental conditions shall specify at least the following:
   - the maximum significant wave height, \( H_s \);
   - the maximum wind speed (1 minute sustained at 10 m above sea level).

   The limits of the operational conditions should specify at least the following:
   - the maximum duration of the lift;
   - limitations in ship speed; and
   - limitations in traffic/traffic control.

2 The following stability criteria shall apply with the lifted load is at the most unfavourable position:
   - the corner of the highest continuous deck enclosing the watertight hull shall not be submerged;

   \[ A_{RL} \geq 1.4 \cdot A_{HL} \]

   where:
   - \( A_{RL} \) - The area under the net righting lever curve, corrected for crane heeling moment and for the righting moment provided by the counter ballast if applicable, extending from the equilibrium heeling angle, \( \varphi_1 \), to the angle of down flooding, \( \varphi_F \), the angle of vanishing stability, \( \varphi_R \), or the second intersection of the righting lever curve with the wind heeling lever curve, whichever is less, see figure 3.16-1;
   - \( A_{HL} \) - The area below the wind heeling lever curve due to the wind force applied to the ship and the lift at the maximum wind speed specified in sub-item 3.16.5.1.1, see figure 3.16-1.

3 The area under the net righting lever curve from the equilibrium heel angle, \( \varphi_1 \), to the down flooding angle \( \varphi_F \) or 20°, whichever is less, shall be at least 0.03 m rad.

![Figure 3.16-1 – Intact criteria under environmental and operational limitations](image-url)
3.16.6 Sudden loss of hook load

3.16.6.1 A ship engaged in a lifting operation and using counter ballasting shall be able to withstand the sudden loss of the hook load, considering the most unfavourable point at which the hook load may be applied to the ship (i.e. largest heeling moment). For this purpose, the area on the side of the ship opposite to the lift (Area 2) shall be greater than the residual area on the side of the lift (Area 1), as shown in figure 3.16-2, by an amount given by the following:

Area 2 > 1.4 × Area 1 - for lifting operations in waters that are exposed;
Area 2 > 1.0 × Area 1 - for lifting operations in waters that are not exposed.

3.16.7 Alternative method

3.16.7.1 The criteria in item 3.16.8 may be applied to a ship engaged in a lifting operation, as determined by item 3.16.1, as an alternative to the criteria in item 3.16.4 through item 3.16.6, as applicable. For the purpose of this section and the stability criteria set out in item 3.16.8, the lifted load which causes the ship to heel is translated for the purpose of stability calculation to a heeling moment/heeling lever which is applied on the righting lever curve of the ship.

3.16.7.2 The heeling moment applied to the ship due to a lift and the associated heeling lever shall be calculated using the following formulae:

\[ HM_\phi = P_L \cdot y \cdot \cos \phi / \Delta \]

where:
\[ HM_\phi \] - the heeling moment, in (t.m), due to the lift at \( \phi \);
\[ P_L \] - the vertical load, in (t), of the lift, as defined in 3.16.3.1.1;
\[ y \] - the transverse distance, in (m), of the lift, metres, as defined in 3.16.3.1.2;
\[ \phi \] - the angle of heel;
\[ HL_\phi \] - the heeling lever, in (m) due to the lift at \( \phi \); and
\[ \Delta \] - the displacement of the ship, including the lift load, in (t).

3.16.7.3 For application of the criteria contained in item 3.16.8 involving the sudden loss of load of the lift in which counter-ballast is used, the heeling levers that include the counter-ballast shall be calculated using the following formulae:

\[ CHL_1 = (P_L \cdot y - CBM) \cdot \cos \phi / \Delta \]
\[ CBHL_2 = CBM \cdot \cos \phi / (\Delta - P_L) \]

where:
\[ CBM \] - the heeling moment, in (t.m), due to the counter-ballast;
\[ CHL_1 \] - combined heeling lever, in (m), due to the load of the lift and the counter-ballast heeling moment at the displacement corresponding to the ship with the load of the lift; and
\[ CBHL_2 \] - heeling lever, in (m), due to the counter-ballast heeling moment at the displacement corresponding to the ship without the load of the lift.

3.16.7.4 The equilibrium heel angle \( \phi_e \) referred to in 3.16.8 means the angle of first intersection between the righting lever curve and the heeling lever curve.

3.16.8 Alternative stability criteria

3.16.8.1 For the loading conditions intended for lifting, but before commencing the operation, the stability criteria given in items 2.1.3 to 2.1.5 of this part of the Rules shall be complied with. During the lifting operation, as determined by item 3.16.1, the following stability criteria shall apply:

1. the residual righting area below the righting lever and above the heeling lever curve between \( \phi_e \) and the lesser of 40° or the angle of the maximum residual righting lever shall not be less than:
   - 0.080 m rad, if lifting operations are performed in waters that are exposed;
\[ \text{Area 2} - \text{Area 1} > K \]

where:

- \( K = 0.037 \text{ m rad} \), for a lifting operation in waters that are exposed;
- \( K = 0.0 \text{ m rad} \), for operation in waters that are not exposed.

\( GZ(1) \) - The righting arm curve at the displacement corresponding to the ship without hook load;

\( GZ(2) \) - The righting arm curve at the displacement corresponding to the ship with hook load;

\( \text{Area 2} \) - residual area between \( GZ(1) \) and CBHL up to the lesser of the down-flooding angle or the second intersection of \( GZ(2) \) and CBHL;

\( \text{Area 1} \) - residual area below \( GZ(1) \) and above CBHL up to \( \phi_e \).

### 3.16.9 Model tests or direct calculations

Model tests or direct calculations, performed in accordance with a methodology acceptable to the Register, that demonstrate the survivability of the ship after sudden loss of hook load, may be allowed as an alternative to complying with the requirements of item 3.16.6 or 3.16.8.2, provided that:

1. the effects of wind and waves are taken into account; and
2. the maximum dynamic roll amplitude of the ship after loss of load will not cause immersion of unprotected openings.

### 3.16.10 Operational procedures against capsizing

Ships should avoid resonant roll conditions when engaged in lifting operations.

### 3.16.11 Stability booklet

For ships engaged in lifting operations, for which this Head applies, additional documentation shall be included in the stability booklet:

1. maximum heeling moment for each direction of lift/inclination as a function of the counter-ballast heeling moment, if used, the draught, and vertical centre of gravity;
2. where fixed counter ballast is used, the following information shall be included:
   1. weight of the fixed counter ballast; and
   2. centre of gravity (LCG, TCG, VCG) of the fixed counter ballast;
3. loading conditions over the range of draughts for which lifting operations may be conducted with the maximum vertical load of the lift. Where applicable, righting lever curves for both before and after load drop should be presented for each loading condition;
4. limitations on crane operation, including permissible heeling angles, if provided;
5. operational limitations, such as:
   1. Maximum Safe Working Load (SWL);
   2. maximum radius of operation of all derricks and lifting appliances;
   3. maximum load moment; and
   4. environmental condition affecting the stability of the ship;
6. instructions related to normal crane operation, including those for use of counter ballast;
7. instructions such as ballasting/de-ballasting procedures to righting the ship following an accidental load drop;
8. identification of critical down-flooding openings;
9. recommendations on the use of roll reduction systems;
The guidelines shall contain sufficient information to enable the Master to plan and operate the ship in compliance with the applicable requirements contained in this Code. The following information shall be included as appropriate:

1. lifting arrangements, capabilities and procedures to operate the lifting systems; and
2. detailed data concerning the ship's lifting capability, operational limitations, limitations of cargo capacities, stability limiting curves and recommendations for calculating ship's loading conditions including sample calculations.

3.16.12.2 The guidelines shall contain sufficient information to define a step-wise operational plan for a specific operation shall contain instructions for:

1. identifying and calculating loading conditions for all relevant stages of operation, taking into account the alterations on deck load, effects of deployment or recovering of the line on the winches (in particular for deep water lifting);
2. planning ballast or counter ballast operations;
3. identifying the possibility to use the roll reduction systems in all operational stages;
4. collecting latest weather forecasts in order to define the environmental conditions for the intended lifting operation;
5. using limiting stability curves, if applicable;
6. defining the stop work limits;
7. defining and implementing corrective and emergency procedures.

3.17 COMMERCIAL YACHTS

3.17.1 The provisions given hereunder apply to commercial yachts of 24 m to 80 m in length L, and which are not certified to carry more than 12 passengers, where:

<table>
<thead>
<tr>
<th>L</th>
<th>is length as defined in item 1.2.2 of this part of the Rules; and</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Commercial yacht&quot;</td>
<td>means a yacht which is not a pleasure yacht.</td>
</tr>
</tbody>
</table>

3.17.2 All yachts from item 3.17.1 shall comply with stability criteria set in Head 2.1 of this part of the Rules.

Stability requirements on commercial yachts of more than 80 m in length L will be in each case considered separately by the Register, but in general, should be of the level stated above.

3.17.3 For yachts restricted to operating in areas within 60 NM from a safe haven, the alternative weather criterion set in Appendix 4 of this part of the Rules may be used instead of the requirements of item 2.1.5.

However, the value of K, calculated according to item 1.2 of that Appendix, shall not be less than 1.5 for a yacht engaged on international voyages.

3.17.4 The provisions of Section 1 and Section 2 should be satisfied as appropriate.

Additional requirements of Head 3.1 shall be implemented also, for loading conditions stated in 3.17.5.

3.17.5 Stability of yacht shall be checked for the following loading conditions:

1. yacht in the fully loaded departure condition, having a draught to the summer load line, with 100% of stores and fuel, all crew, and with full number of passengers with their luggage and provisions needed;
2. yacht in the fully loaded arrival condition, with crew, full number of passengers and their luggage and provisions, but with only 10% stores and fuel remaining.

3. yacht without passengers, but with all crew and with full stores and fuel.

4. yacht in the minimum operating condition, with the minimum number of crew, and with 10% of stores and fuel.

3.17.6 On completion of loading of the yacht and prior to its departure, the Master shall check that the weight items loaded, number of persons on board, and the readings of drafts and trim of the particular loading case, are all inside the range of values corresponding to the loading cases from the approved stability booklet. This requirement should be used instead of the one set in item 3.1.15.

3.17.7 As an equivalent provision to requirement of item 3.1.14, datum draught marks shall be provided at the bow and stern, port and starboard, and be adequate for assessing the condition and trim of the yacht. Such draught marks may be single datum lines.

The marks shall be permanent and easily read but need not be of contrasting colour to the hull. The marks need not indicate more than one draught at each position and shall be above, but within 1000 mm, of the deepest load waterline.

The draught to which marks relate shall be indicated either above the mark on the hull and/or in the yacht’s stability information booklet. The position of the marks shall be verified at initial placement by the Register.
4 REQUIREMENTS FOR THE STABILITY OF PONTOONS, PONTOON-CRANES, DOCKS AND BERTH-CONNECTED SHIPS

4.1 PONTOONS

4.1.1 The provisions of this Head apply to sea-going pontoons. A pontoon is considered to be of the following characteristics:

1. non self-propelled;
2. unmanned;
3. carrying only deck cargo;
4. having a block coefficient of \( C_B > 0.9 \);
5. having a breadth/depth ratio of \( B/D \geq 3 \);
6. having no hatchways in the deck except small manholes closed with gasketed covers.

4.1.2 An inclining experiment is not normally required for a pontoon, provided a conservative value of the lightship vertical centre of gravity (KG) is assumed for the stability calculations. The KG can be assumed at the level of the main deck although it is recognised that a lesser value could be acceptable if fully documented. The lightship displacement and longitudinal centre of gravity should be determined by calculation based on draught and density readings.

4.1.3 Stability computation of a pontoon shall be performed for all possible loading cases in the service, covering the full range of operating draughts and trims.

4.1.4 No account should be taken of the buoyancy of deck cargo (except for adequately secured timber).

4.1.5 When carrying timber cargo, the following requirements shall be met:

1. the stability calculation shall be made with regard to possible addition in mass of timber cargo due to water absorption, as in 3.3.7;
2. when calculating the arms of form stability, the volume of timber cargo may be included in the calculation with full breadth and height and permeability of 0.25.

4.1.6 When carrying pipes, the stability calculation shall be made with regard to trapped water in the pipes, as in 3.12.8.4.

4.1.7 In performing wind heel calculations:

1. the wind pressure shall be constant and for general operations be considered to act on a solid mass extending over the length of the cargo deck and to an assumed height above the deck;
2. the centre of gravity of the cargo shall be assumed at a point mid-height of the cargo;
3. the wind lever shall be taken from the centre of the deck cargo to a point at one half the mean draught; and
4. the windage area shall be calculated according to guidance in 1.4.6.

4.1.8 Allowance for icing shall be calculated with regard to following:

1. rates of icing shall be adopted as under 2.4;
2. when carrying timber cargo, rates of icing shall be adopted as under 3.3.6;
3. when carrying pipes, icing is determined as under 3.12.14.

4.1.9 Stability requirements

4.1.9.1 Stability of a pontoon shall be considered sufficient:

1. if the area under the righting lever curve up to the angle of maximum righting lever or the downflooding angle, whichever is less, is not less than 0.08 metre-radians;
2. if the static angle of heel due to a uniformly distributed wind load of 540 Pa (wind speed 30 m/s) does not exceed an angle corresponding to half the freeboard for the relevant loading condition, where the lever of wind heeling moment is measured from the centroid of the windage area to half the draught;
3. if the range of stability is not less than:
   - \( 20^\circ \) for \( L \leq 100 \text{ m} \);
   - \( 15^\circ \) for \( L \geq 150 \text{ m} \).

For intermediate values of \( L \), the range of stability is determined by linear interpolation.

4.1.9.2 The downflooding angle shall be taken as the angle at which an opening through which progressive flooding may take place is immersed. This would not be an opening closed by a watertight manhole cover or air pipes fitted with an automatic closure.

4.1.9.3 For the pontoon of less than 24 m in length and intended for navigation area notations 6, 7 and 8, the Register may allow not to compute the righting lever curve for grater angles if for all loading conditions the initial metacentric height \( MG_0 \) has a value of not less than 0.35 m.

4.2 FLOATING CRANES

4.2.1 Working conditions

The operation of floating (pontoon) crane (cargo handling and carriage of deck cargo) is permitted in the restricted areas of navigation.
4.2.2 Loading conditions

.1 with full load on its hook at the maximum loading moment:
  – with full cargo load and full stores;
  – with full cargo load and 10% of stores;
  – without load and with full stores;
  – without load and with 10% of stores.

.2 without load on the hook and with boom in its highest position:
  – with full cargo load and full stores;
  – with full cargo load and 10% of stores;
  – without load and with full stores;
  – without load and with 10% of stores.

.3 in case of load drop.

The boom position of the slewing crane is assumed to be in the plane perpendicular to the centre line.

For non-slewing cranes intended for boom operation in the longitudinal plane possibility of unsymmetrical loading on the hooks, if it is permitted by the design of crane, is to be taken into account.

The design centre of gravity position of the load on hook is assumed to be at the point of its suspension to the boom.

For the case of load drop stability is to be checked for the most unfavourable loading condition as regards stability with a load on hook taking account of possible unsymmetrical distribution of cargo on deck.

4.2.2.2 During the voyage, the stability of a floating crane shall be checked with due regard for icing and with the boom secured for sea, under the following loading conditions:

.1 with full load and full stores;

.2 with full load and 10% of stores;

.3 without load and with full stores;

.4 without load and with 10% of stores.

4.2.3 Stability of a pontoon-crane in navigation

4.2.3.1 A floating crane while in navigation, transfer operations and in all conditions without load on hook, shall satisfy all provisions for stability of pontoons set in 4.1, with windage area calculated as in 1.4.6.5. Loading conditions that should be considered are those specified in 4.2.2.1.2 and 4.2.2.2.

4.2.3.2 Where a floating crane is to undertake a passage through sea regions lying beyond the prescribed area of navigation, a plan of such passage shall be prepared which is subject to special consideration by the Register in each case.

4.2.4 Additional intact stability criteria for a floating crane

4.2.4.1 The requirements of this item apply to ships with the service notation floating crane and specify the criteria these ships are to satisfy during cargo lifting in addition to those in 4.1.

4.2.4.2 Intact stability criteria during cargo lifting

The following intact stability criteria are to be complied with:

- $\theta_c \leq 15^\circ$
- $GZ_c \leq GZ_{\text{max}}$
- $A_1 \geq 0.4 A_{\text{tot}}$

where:

$\theta_c$ = heeling angle of equilibrium, corresponding to the first intersection between heeling and righting arms (see Fig. 4.2.4.2)

$GZ_c$, $GZ_{\text{max}}$ = as defined in Fig. 4.2.4.2

$A_{\text{tot}}$ = total area, meter-radians, below the righting lever curve.

In the above criteria, the heeling arm, corresponding to the cargo lifting, is to be obtained, in m, from the following formula:

$$b = \frac{P \cdot d - Z \cdot z}{\Delta}$$

where:

$P$ = cargo lifting weight, in [t]
$d$ = transversal distance, in [m], of lifting cargo to the longitudinal plane (see Fig. 4.2.4.2)
$Z$ = weight, in [t], of ballast used for righting the pontoon, if applicable (see Fig. 4.2.4.2)
$z$ = transversal distance, in [m], of the center of gravity of $Z$ to the longitudinal plane (see Fig. 4.2.4.2)

$\Delta$ = displacement, in [t], at the loading condition considered.

The above check is to be carried out considering the most unfavourable situations of cargo lifting and the most unfavourable loading condition of those in 4.2.2.1.1, with the initial metacentric height $GM_0$ corrected according to the requirements in 1.4.7.

4.2.4.3 Intact stability criteria in the event of sudden loss of cargo during lifting

The case of a hypothetical loss of cargo during lifting due to a break of the lifting cable is to be considered.

In this case, the following intact stability criteria are to be complied with:

- $\frac{A_2}{A_1} \geq 1$
- $\theta_R - \theta_2 \geq 20^\circ$

where:
\[ A_1 = \text{area, in meter-radians, contained between the righting lever and the heeling arm curves, measured from the heeling angle } \theta_1 \text{ to the heeling angle } \theta_C \text{ (see Fig. 4.2.4.3)} \]

\[ A_2 = \text{area, in meter-radians, contained between the righting lever and the heeling arm curves, measured from the heeling angle } \theta_C \text{ to the heeling angle } \theta_2 \text{ (see Fig. 4.2.4.3)} \]

**Figure 4.2.4.2 – Cargo lifting**

- \( \theta_1 = \) heeling angle of equilibrium during lifting (see Fig. 4.2.4.3)
- \( \theta_C = \) heeling angle of equilibrium, corresponding to the first intersection between heeling and righting arms (see Fig. 4.2.4.3)
- \( \theta_2 = \) heeling angle of flooding, to be taken not greater than 30° (angle in correspondence of which the loaded cargo on deck is assumed to shift (see Fig. 4.2.4.3)
- \( \theta_R = \) heeling angle of loss of stability, corresponding to the second intersection between heeling and righting arms (see Fig. 4.2.4.3)

**Figure 4.2.4.3 – Cargo loss**
4.3 FLOATING DOCKS

4.3.1 Stability of floating docks shall be checked for the following loading conditions:
.1 floating dock when supporting a ship;
.2 floating dock during submersion and immersion.

4.3.2 Calculation of liquid cargo effect is to be made in conformity with 1.4.7. The correction factor for the effect of free surfaces of liquid ballast shall be calculated at tank filling levels corresponding to the actual ones under loading condition in question.

4.3.3 Stability of a floating dock when supporting a ship

4.3.3.1 Stability shall be checked of fully immersed dock with a supported ship under conditions of maximum lifting capacity and moment of sail of the dock - ship system without icing.

4.3.3.2 Stability is considered to be adequate provided:
.1 angle of heel with dynamically applied heeling moment due to wind pressure according to 4.3.3.5 or 4.3.3.6 does not exceed the permissible heeling angle for dock cranes in non-operating condition or 4°, whichever is less;
.2 angle of heel with dynamically applied heeling moment due to wind pressure according to 4.3.4.4 does not exceed the angle at which safe operation of cranes is ensured;
.3 angle of trim with statically applied trimming moment due to crane weight with maximum load for the most unfavourable service case of their arrangement does not exceed the angle at which efficient operation of cranes is ensured or the angle of pontoon deck immersion, whichever is less.

4.3.3.3 The angle of heel of a floating dock, in degrees, if it does not exceed the angle of immersion of the pontoon deck, is to be determined from the formula

\[
\theta = 0.115 \rho_{v} \cdot A_{v} \cdot \frac{Z}{(\Delta h)} \quad (4.3.3.3)
\]

4.3.3.4 An angle of heel of floating dock, if it exceeds the angle of immersion of the pontoon deck, is determined from statical or dynamical stability curve when the dock is affected by the heeling moment, in [kNm], obtained from the formula

\[
M_{v} = 0.001 \cdot \rho_{v} \cdot A_{v} \cdot Z \quad (4.3.3.4)
\]

4.3.3.5 Specific wind pressure is assumed to be 1700 Pa.

4.3.3.6 Specific wind pressure may be taken less than specified in 4.3.3.5 depending upon the prescribed geographical area of the floating dock operation upon special consideration by the Register in each case.

To account for the increase of specific wind pressure with regard to the elevation of some top zones of windage area in the dock - ship system above the actual waterline the wind pressure values from Table 4.3.3.6 are multiplied by the relevant zone coefficients from Table 4.1.4.4.

In this case, the values of \( \rho_{v}, A_{v} \) and \( Z \) are determined for all height zone separately, the sum of their products for all height zones comprising windage area of the dock – ship system is included in formulae (4.3.3.3) and (4.3.3.4).

4.3.3.7 With geographical service area of the floating dock prescribed, the specific wind pressure may be taken for this particular area.

4.3.3.8 With several geographical service areas of the floating dock prescribed, maximum specific wind pressure for these areas is to be taken.

4.3.3.9 The angle of trim, in deg., of the floating dock is to be obtained from the formula:

\[
\psi = 57.3 \cdot \frac{M_{v}}{\Delta \lambda} \quad (4.3.3.9)
\]

4.3.4 Stability of a floating dock during submersion or emersion

.1 Stability of a floating dock is to be checked in the process of submersion or emersion for the most unfavourable case, as regards stability, of the supported ship displacement, moment of sail of the dock - ship system and dock ballasting with the cranes not in operation, without icing.

.2 Stability is considered to be adequate if the angle of heel with dynamically applied heeling moment due to wind pressure does not exceed the permissible heeling angle for dock cranes in non-operating condition or 4°, whichever is less.

.3 The angle of heel of the floating dock is to be determined in conformity with 4.3.3.3 and 4.3.3.4.

.4 Specified wind pressure is assumed to be 400 Pa.

4.3.5 The arm of windage area is to be determined according to 1.4.6.3. On agreement with the Register, in each particular case the arm of windage area \( z \) may be assumed as the elevation of the windage area centre of the dock - ship system above the supporting point of the floating dock in the system of its restraint.

4.3.6 These requirements apply to floating docks having sufficiently reliable system of restraint.

4.4 BERTH-CONNECTED SHIPS

4.4.1 The stability of a berth-connected ship is considered sufficient provided:
.1 the metacentric height complies with the requirements of item 2.1.4, with due regard for the distribution of passengers among decks likely to occur in service;

.2 the angle of heel under dynamically applied wind heeling moment as determined from Formula (4.3.3.3) with due regard for the provisions of 4.3.3.5 - 4.3.3.8 (for the case of a berth-connected ship) does not exceed the maximum permissible value.

4.4.2 Under dynamically applied wind heeling moment, the ship stability is checked for the most unfavourable loading conditions as regards stability.

4.4.3 As the maximum permissible angle, the angle is assumed at which the freeboard deck or fender edge immerses or the middle of the bilge comes out from water, whichever is less.

These angles are determined considering the immersion or emergence of the ship when inclined to final angles of heel and the actual position of deck edge, fenders and the middle of the bilge. The maximum permissible angle is not to exceed $10^\circ$.
APPENDIX 1
INSTRUCTIONS ON DRAWING UP
THE STABILITY BOOKLET

1 These instructions present general guidelines on purpose and contents of the Stability Booklet, and have to be regarded as additionally recommendations besides mandatory provisions for the Stability information, set in 1.5.1. As for ships differing in their types, size, purpose, available stability reserve, area of navigation and crew, the scope and form of the Stability Booklet shall be most carefully chosen and agreed with the Register.

2 The aim of the Stability booklet is to assist the master of a ship in maintaining adequate stability of a ship during service in compliance with the requirements of this part of the Rules as well as to ensure it in cases when the ship gets into the conditions more severe than those specified in the Rules. Formal observance of the provisions of the Stability book does not relieve the master of responsibility for the stability of the ship.

3 The format of the Stability booklet and the information included will vary depending on the ship type and operation. Stability booklet should include more detailed information as:

3.1 a general description of the ship;
3.2 instructions on the use of the Stability booklet;
3.3 general arrangement plan showing watertight compartments, closures, position of permanent ballast, etc.;
3.4 all operational restrictions imposed on the ship, as are allowable deck loading, minimum fore and aft draughts, etc.;
3.5 data of the downflooding points, with diagram of downflooding angles related to various ship's draughts;
3.6 hydrostatic curves or tables and cross curves of stability;
3.7 capacity plan, with the freeboard mark and data of freeboard, draughts, deadweights and displacements;
3.8 free surface data for each tank;
3.9 information on permissible loading, such as maximum KG or minimum MG curve or table;
3.10 data on stability for different loading conditions;
3.11 a brief description of the stability calculation done including assumptions;
3.12 general precautions for preventing unintentional flooding;
3.13 information concerning the use of any special cross-flooding fittings with descriptions of the ship under damage conditions which may require cross-flooding;
3.14 any other necessary guidance for the safe operation of the ship under normal and emergency conditions;
3.15 inclining test report;
3.16 detailed summery of the Stability booklet.

4 The content of the Stability booklet may be divided in four parts which contain the following:

4.1 general characteristic of the ship's stability and recommendations on maintaining it (see 9);
4.2 data on stability for typical loading conditions (see 9);
4.3 data and guidance for independent estimation of the ship's stability in comparison with those permitted by the Rules (see 12);
4.4 other data for more accurate determination of the ship's stability, draught, heel and trim (see 13).

5 Such a grouping of the Stability booklet data as presented in 4 is not compulsory. Individual parts of the Stability booklet may be extended or omitted, in each particular case. With low-skilled crew (e.g. on small ships), it may be reasonable at the discretion of the designers or owner to divide the data available into two booklets containing:

5.1 instructions on maintenance of stability which do not involve any calculations (with a reserve of stability over that required in this part of the Rules),
5.2 sufficiently detailed data for the quick estimation of stability by calculation, using maximum KG or minimum GM curve.

6 As a supplement to the approved Stability booklet, a loading instrument provided on board may be used to facilitate the stability calculations. It is desirable that the input/output form in the computer be similar to the one in the Stability booklet so that the operators will easily gain familiarity with the use of the Stability booklet. A simple and straightforward instruction manual with characteristic examples of the calculations should be provided with the loading instrument. Calculations for four approved loading conditions from the final Stability booklet must be added to the manual as a test example.

7 It is recommended to provide in the Stability booklet a form for notes of a surveyor to the Register on extending the validity of the Stability booklet or indicating a need to correct it.

8 The general characteristics of stability shall include an area of navigation and, for ships of restricted area of navigation, limitations on an area and seasons of navigation and weather.

It is advisable to specify a standard defining permissible stability of a ship (as required by the Rules) and appropriate hazardous situations. It is also desirable to specify standards providing the ship with a considerable reserve of stability.

For specific types of ships operating under steady conditions, it is recommended to give simple and easy to understand instructions on limiting permissible cases of loading according to the stores available on board (e.g. permissible amount of homogenous timber deck cargo on timber carriers with fully loaded holds; permissible amount of fish on deck of fishing vessels, etc.).
Guidelines for taking and consuming of liquid cargoes in compliance with the method of taking account of the free surface effect adopted in the Stability booklet shall be provided.

It is desirable to provide recommendations on operation of a particular ship, such as, instructions for carriage of bulk cargoes, detection of hazardous icing and icing control, manoeuvring, towing, maintenance of intact stability sufficient to ensure damage stability, passage of the ship through the areas with more severe conditions of navigation than those required for the area of navigation prescribed to the ship, etc. However, this part of the Stability booklet need not be overfilled with the well-known provisions of seamanship.

Stability data of the offshore supply vessels should contain for each loading condition the maximum possible mass of deck cargo, its centre of gravity and side area, and when the pipes are loaded on deck their permissible quantity and measures.

Special purpose ships, dynamically supported craft and novel craft should be provided with additional information in the Stability booklet such as design limitations, maximum speed, worst intended weather conditions or other information regarding the handling of the craft that the master needs to operate the ship safely. Data on adequate use of roll damping arrangements, if any, shall be provided.

Stability booklet of ships under 20 m in length shall include the data on permissible initial turning speed and angle of rudder shifting in compliance with 1.5.1.8 as well as data about permissible speed on the following waves in accordance 1.5.1.9.

For fishing vessels under 20 m in length, Stability booklet on stability shall include the data on permissible weight of the catch loaded on the deck.

Stability booklet for floating cranes shall contain the data on their stability as regard rated criteria for various boom radii and various loads on the hook (as concerns mass and windage areas) including those loading conditions under which stability by any criterion becomes unsatisfactory. For floating cranes whose stability in case of load drop is limited by the angle of loading in working condition, the Stability booklet shall include requirements for reliable closing of the openings which are not permanently closed in the process of cargo handling operations. Stability booklet shall also contain other special instructions such as: preparing of a floating crane for navigation to the working position; preparing of a floating crane for the carriage of loads hoisted on the hook, either raised above water or semi-submerged; the conditions on use to be complied with; etc. Due to different loading conditions of the floating cranes, data about their stability should be shown very simply and clearly, i.e. in forms of tables and/or schemes for each loading case and working condition.

The second part shall contain data on typical loading condition. In addition to mandatory design cases provided in this part of the Rules, it is recommended to include a number of loading conditions not covered by the Rules, but specific to the operation of a particular ship.

The data on typical cases are recommended to be presented in forms similar to those for an independent estimation of stability given in the third part of Stability booklet. It is recommended to provide the following data in those forms: stowage plan for cargoes and stores on board with data on the ship's draught, design tables with computation of mass loads for the particular case, effect of free surfaces and correlation of the ship's stability obtained with that permissible by the Rules, as well as the curve of statical stability with metacentic height specified. It is desirable to provide brief explanation with the data on typical loading conditions of a ship.

It is recommended that a summary table of result data on stability for typical conditions of loading is appended to the Stability booklet.

The typical loading conditions shall be specified with no regard for possible shifting and properties of cargo, taking into account its density only.

These typical loading conditions shall be supplemented with the note indicating that when carrying bulk cargoes, technical requirements and other appropriate instructions regarding loading of bulk cargoes should be applied.

11 The third part of the Stability booklet shall enable the master to determine with sufficient accuracy in the shortest time possible whether the stability of the ship meets the requirements of this part of the Rules.

11.1 It is recommended therefore to provide in the Stability booklet a diagram (or a table) of maximum permissible statical moments of the ship's mass loads depending on the displacement, deadweight or draught of the ship with which all requirements of the Rules for the ship's stability are satisfied. The diagram of statical moment may incorporate not one, but two or several limiting curves for various cases of the ship's service (e.g. with and without icing, with general or timber cargo on board etc.). The statical moment of the ship's loading is determined with respect to the base plane or other reference plane parallel to it. The curves of constant values of the metacentric height shall also be plotted in the diagrams of statical moments.

11.2 Instead of the diagram (or the table) of statical moments it is permissible to present in the Stability booklet diagrams or tables of allowable values of maximum elevation of the ship's centre of gravity (or deadweight) or the minimum metacentric height also depending on displacement, deadweight, or draught of the ship.

11.3 As an aid to the master in determining co-ordinates of the centres of gravity for individual cargoes taken in or off, it is advisable to provide this part of the Stability booklet with a plan of the ship's cargo spaces specifying co-ordinates of the centres of gravity for these spaces (it is preferably to present this plan to a scale larger in height than in length).
11.4 Stability booklet shall contain the table of correction for metacentric height due to the effect of free surfaces of liquid as well as ballasting specifications of tanks.

11.5 To reduce calculations to be performed by the master it is recommended to include in the Stability booklet a table of masses and co-ordinates of the centre of gravity for a ship without cargo, but with normally stowed stores in various quantities.

11.6 The third part of the Stability booklet shall also include proper methodical instructions explaining the master how to use the data therein and perform calculations. It is recommended to use the forms for calculations of typical conditions of loading as examples.

11.7 The third part of the Stability booklet shall include materials enabling the master to determine the ship's stability in case of the carriage of timber cargo with permeability considerably differing from 0.25.

12 The forth part (which is recommended to be separated into another booklet) is intended for a more accurate determination of all factors of the ship's stability, draught, side and longitudinal heeling for unusual cargo loading when the stability may be close to upper limit i.e. if there is no reserve in stability of the ship.

The following materials can serve this purpose:

12.1 a universal curve of statical stability with a sinusoidal scale of abscissa (angles of heeling);

12.2 a summary diagram of rated standards of stability (diagram of statical moments presenting the curves for constant values of various stability factor, such as maximum arms of the curve of statical stability, its angles of vanishing stability and the peak position, the weather criterion, limiting wind force sustained by the ship etc.);

12.3 diagram of fore and aft draughts in co-ordinates of displacement (or deadweight) and the statical moments of the ship's loading with the respect to length;

12.4 a curve, table or scale for determining stability of the ship by the period of roll with instructions on measuring the period of roll;

12.5 a plan showing the arrangement of openings considered as open and a diagram (or table) of flooding angles depending on the ship's displacement, deadweight or draught.

13 Stability booklet for a tug shall provide instructions to the master as to possible case of the ship's operation in the areas where water flow velocities over 1.3 m/s, are observed.
APPENDIX 2
DETERMINATION OF CAPSIZING MOMENT

1 DETERMINATION OF THE CAPSIZING MOMENT OF PASSENGER, CARGO AND FISHING VESSELS

1.1 The capsizing moment $M_c$ taking into account the effect of rolling can be determined using either a curve of dynamical or of statical stability.

When determining the capsizing moment, the following two cases may take place:

1.1.1 The curves of statical and dynamical stability are not cut short by the angle of flooding. Irrelevant of the shape of the curve, i.e. is it smooth or stepped (statical), or interrupted (dynamical), the capsizing moment should be determined as follows:

- when the curve of dynamical stability is used, auxiliary point $A$ is to be found on its first.

For this purpose the amplitude of roll is plotted along the abscissa to the right of the origin of the co-ordinates and its related point $A'$ is fixed on the curve of dynamical stability (Fig. 1.1.1.1.). Then a straight line parallel to the axis of abscissas is drawn through point $A'$ and segment $A'A$ equal to the double amplitude of roll is laid off along it to the left of the auxiliary point $A'$ ($A'A = 2 \cdot \theta_r$).

![Fig. 1.1.1.1](image_url)

Determination capsizing moment using the curve of dynamical stability

Point $A$ located symmetrically to point $A'$ is referred to below as the initial one. From the initial point $A$, a tangent $\overline{AC}$ to the curve of dynamical stability is drawn and segment $\overline{AB}$ equal to one radian (57.3°) is laid off from $A$ on the straight line parallel to the axis of abscissas. From point $B$, perpendicular $\overline{BE}$ is erected up to its intersection with tangent $\overline{AC}$ at point $E$. Segment $\overline{BE}$ is equal to the capsizing moment, if the curve of dynamical stability is plotted to scale of work, or to the arm of the capsizing moment, if the curve of dynamical stability is plotted to scale of arms. In the latter case, to determine the capsizing moment $M_c$, the value of the segment $\overline{BE}$, in metres, shall be multiplied by corresponding buoyancy of a ship $\Delta \cdot g$:

$$M_c = \Delta \cdot g \cdot \overline{BE} \quad [\text{kNm}] \quad (1.1.1.1)$$

- when the curve of statical stability is used, the capsizing moment can be determined assuming the work of the capsizing and the righting moments to be equal and taking into account the effect of rolling. For this purpose, the curve of statical stability is continued into the region of negative abscissa for a length equal to the amplitude of roll (fig. 1.1.1.2) and such a straight line $\overline{MK}$ parallel to the axis of abscissas is chosen with which cross-hatched areas $S_1$ and $S_2$ are equal. Ordinate $\overline{OM}$ will correspond to the capsizing moment, if moments are plotted along the axis of ordinates, or to the arm of the capsizing moment, if arms of stability are plotted along the axis.

In the latter case to determine the capsizing moment ordinate $\overline{OM}$ in meters shall be multiplied by the ship's buoyancy:

$$M_c = \Delta \cdot g \cdot \overline{OM} \quad [\text{kNm}] \quad (1.1.1.2)$$

![Fig. 1.1.1.2](image_url)

Determination of capsizing moment using the curve of statical stability

1.1.2 The curves of statical and dynamical stability are cut short at the angle of flooding. The capsizing moment is then determined by one of the methods given below:

- when the curve of dynamical stability is used, the capsizing moment is then determined as specified in 1.1.1.1, i.e. position...
of the initial point A is found (Fig. 1.1.2.1). A tangent to the curve of dynamical stability is drawn from the initial point A, which is possible only when the angle of heel corresponding to the point of tangency is less than the angle of flooding. The capsizing moment or its arm is determined by using the tangent and the same method as in the first case referred to above.

If it is impossible to draw the tangent, the straight line passing through the top final point F of the curve of dynamical stability, corresponding to the angle of flooding, is drawn from the initial point A. A straight line parallel to the axis of abscissas is also drawn from the same initial point A and segment $AB$ equal to one radian ($57.3^\circ$) is laid off on this straight line. From point B perpendicular $BE$ is erected up to its intersection with the inclined straight line $AF$ at the point E. Segment $BE$ is equal to the capsizing moment required, if work is plotted along the axis of ordinates on the curve of dynamical stability, or is equal to the arm of the capsizing moment, if arms of dynamical stability is plotted along the axis of ordinates. In the latter case, the capsizing moment is determined by the formula (1.1.1.1).

![Fig. 1.1.2.1](image)

**Fig. 1.1.2.1**

Determination of capsizing moment from the curve of dynamical stability taking account of the angle of flooding

When curve of statical stability is used, the capsizing moment for the angle of flooding $\theta_f$ is determined as follows:

The curve of statical stability is continued into the region of negative abscissas to a length equal to the amplitude of roll (Fig. 1.1.2.2) and such a straight line $MK$ parallel to the axis of abscissas is chosen with which cross-hatched areas $S_1$ and $S_2$ are equal. Ordinate $OM$ will correspond to the capsizing moment $M_c$ or its arm depending upon the method used for constructing the curve. In the latter case, the capsizing moment is determined by the formula (1.1.1.2).

![Fig. 1.1.2.2](image)

**Fig. 1.1.2.2**

Determination of capsizing moment from the curve of statical stability taking into account the angle of flooding

2 DETERMINATION OF CAPSIZING MOMENT FOR DREDGERS

2.1 To determine the capsizing moment, a curve of dynamical stability of the ship after spoil discharge is plotted in compliance with the formula 3.8.4.7-2 of this part of the Rules, continued partially into the region of negative angles of heeling. From point A corresponding to the minimum on the curve (heeling angle $\theta_{BC}$) a segment equal to the amplitude of roll $\theta_r$ is laid off to the left along the axis of abscissas (Fig. 2.1-1).

The amplitude of roll $\theta_r$ in this case is assumed to be $10^\circ$. The corresponding point C is fixed on the curve and tangent $CE$ is drawn from this point to the right part of the curve.

![Fig. 2.1-1](image)

**Fig. 2.1-1**

Determination of capsizing moment for dredgers
From point C segment $CN$ equal to one radian (57.3°) is laid off parallel to the axis of abscissas and a perpendicular is erected from the point N up to its intersection with the tangent at point H. Segment $NH$ is equal to the arm of the capsizing moment which is determined by the formula:

$$M_c = \Delta \cdot g \cdot NH \quad \text{[kNm]} \quad (2.1)$$

![Fig. 2.1-2](image)

Determination of capsizing moment for dredgers taking into account the angle of flooding

If the angle of flooding $\theta_f$ proves to be less than the angle of heel corresponding to the point E of the curve (see fig. 2.1-1) the secant $CF$ shall be drawn from the point C to the right part of the curve as shown in Fig. 2.1-2.

In this case, the arm of capsizing moment will be determined by segment $NK$.

If point F on the curve (Fig. 2.1-2) corresponding to the angle of flooding is below point $F_1$, where the curve intersects straight line $CN$, the stability of the ship is regarded to be unsatisfactory.

If no curve of dynamical stability is available, the minimum capsizing moment is determined from the curve of statical stability (Fig. 1.1.1.2) as in 1.1.1 of this Appendix, taking into account initial statical heel.
APPENDIX 3
INSTRUCTIONS FOR DETERMINATION OF THE SHIP'S CENTRE OF GRAVITY BY INCLINING TEST

1 GENERAL

These instructions contain the method of performing the inclining test which is recommended to meet the requirements set forth in this part of the Rules, Head 1.7.

Upon the agreement with the Register, other method for performing the inclining test may be permitted if it is proved that the accuracy of the inclining test results are equivalent to those obtained by the recommended method.

The inclining test shall be carried out in the presence of a surveyor to the Register, who will state the inclining test data into the form "Record of inclining test".

2 WEATHER CONDITIONS AND SHIP'S POSITION DURING THE TEST

The inclining test shall be carried out in calm weather and smooth water with no stream. The wind velocity shall not be over 3 m/s.

The ship shall be brought into such position where the effects of wind, waves, streams, tides and sea traffic are minimised. The depth of water under the hull shall be sufficient to ensure that the hull will be entirely free of the bottom. The tide conditions and the trim of the ship during the test should be considered.

When the test is to be carried out under less favourable conditions, that is, with freeze (wind), on slightly rippled water surface or when there is a stream, the ship's bow shall be kept to the wind, or stream by means of two force mooring lines (e.g. mooring buoy) which are as long as practicable and clamped together below the side hawses to avoid the effect of each mooring line. However, to carry out the test under these conditions is not recommended.

3 MOORING ARRANGEMENTS

The mooring arrangement should ensure that the ship will be free to list without restraint for a sufficient period of time to allow a satisfactory reading of the heeling angle, due to each weight shift, to be recorded.

The ship should be held by lines at the bow and the stern, attached to bollards and/or cleats on the deck, as close as possible to the centreline of the ship and as near the waterline as practical. Where the ship can be moored to one side only, it is good practice to supplement the bow and stern lines with two spring lines in order to maintain positive control of the ship. The leads of the spring lines should be as long as practicable. Cylindrical camels should be provided between the ship and the dock. All mooring lines shall be such as to avoid as much as possible the effect of external forces which might affect the ship during the inclining test. Prior to any measurement during the inclining test, the mooring lines shall be veered away so as to prevent them from interfering with free inclination of the ship under test and to ensure that the ship shall not touch the pier and camels or ships close by.

If the ship is held off the pier by the combined effect of the wind and current, a superimposed heeling moment will act on the ship throughout the test. For steady conditions this will not affect the results. Gusty winds or uniformly varying wind and/or current will cause these superimposed heeling moments to change, which may require additional test points to obtain a valid test. The need for additional test points can be determined by plotting test points as they are obtained.

If the ship is pressed against the fenders by wind and/or current, all lines should be slack. The cylindrical camels will prevent binding, however, there will be an additional superimposed heeling moment due to the ship bearing against the camels. This condition should be avoided where possible but, when used, consideration should be given to pulling the ship free of the dock and camels and letting the ship drift as readings are taken.

The mooring arrangement should be submitted to the Register representative for review prior to the test.

If a floating crane is used for handling inclining weights, it shall not be moored to the ship.

4 PREPARING THE SHIP FOR THE TEST

The ship to be tested shall be, whenever possible, in light condition but with full equipment. All components of the equipment and spare parts in their regular places where they are expected to be during the ship's service.

Objects which are likely to shift when the ship inclines shall be secured. All tanks for water, liquid ballast, lubricants, fuel oil (except for service tanks) and other liquids shall generally be completely empty. Any tanks containing liquids shall be accurately sounded and the soundings recorded.

Installations, equipment and objects onboard which are not included in the final ship's weight but are used for the construction of the ship only, shall be removed from the ship.

Boilers shall be filled up with water to their working level. With boilers drained, the weight of water in the boilers shall enter the list of missing loads.

Prior to performing the test, measures shall be taken to make sure that all holds, engine room and boiler room are drained and cleaned and that all weights and objects on board have been taken into account.

In exceptional cases, when draining of individual tanks is not practicable, special care shall be taken to determine the value and position of free surfaces so as to take them into account in the metacentric height computations, as is stated in Head 5 of this Appendix.

Filling up of individual tanks is permissible but provisions shall be made to prevent the formation of "air pockets". However, it is not recommended, because air pockets are difficult to remove from between structural members of a tank.
In flat bottom ships, after pumping out liquids from the hull, the liquids remained below suction wells shall be stripped till complete draining.

In ship with deadrise, having inclined bottom, where liquid cannot be pumped out dry, water in a quantity up to 5 cm in height is permitted to remain amidships in the wedge-shaped part of the ship. In winter, the inclining test shall be performed provided the ship's hull has not iced.

The initial angle of heel shall not exceed 0.5°, equalising the trim is not necessary.

Prior to initial survey, all compartments shall be open, clean, and dry, tanks well ventilated and gas-free, movable or suspended items shall be secured and their position documented, pendulums in place, weights onboard and in place, a crane or other method for moving weights shall be available, and the necessary plans and equipment shall be available.

5  FREE SURFACE AND TANKAGE

When tanks must be left slack, it is desirable that the sides of the tanks be parallel vertical planes and the tanks be regular (i.e. rectangular, trapezoidal, etc.) when viewed from above, so that the free surface moment of the liquid can be accurately determined. For example, the free surface moment of the liquid in a tank with parallel vertical sides can be readily calculated by the formula:

\[ M_{fs} = lb^2\rho_i/12 \]  [m]

Where:

- \( l \) = length of tank [m]
- \( b \) = breadth of tank [m]
- \( \rho_i \) = specific gravity of liquid in tank \([t/m^3]\]

Free surf. correction = \( \frac{\sum M_{fs}(x)}{\Delta} \)  [m]

When ballast water is used as inclining weight, the actual transverse and vertical movements of the liquid shall be calculated taking into account the change of heel of the ship. Free surface corrections as defined in this paragraph shall not apply to the inclining tanks.

The number of slack tanks should normally be limited to one port/starboard pair or one centreline tank.

To avoid pocketing, slack tanks should normally be of regular (i.e. rectangular, trapezoidal, etc.) cross section and be 20% to 80% full if they are deep tanks and 40% to 60% full if they are double-bottom tanks. These levels ensure that the rate of shifting of liquid remains constant throughout the heel angles of the inclining test. If the trim changes as the ship is inclined, then consideration should also be given to longitudinal pocketing. Slack tanks containing liquids of sufficient viscosity to prevent free movement of the liquids, as the ship is inclined (such as bunker at low temperature), should be avoided since the free surface cannot be calculated accurately. A free surface correction for such tanks should not be used unless the tanks are heated to reduce viscosity. Communication between tanks shall never be allowed. Cross-connections, including those via manifolds, shall be closed. Equal liquid levels in slack tank pairs can be a warning sign of open cross connections. A bilge, ballast, and fuel oil piping plan can be referred to, when checking for cross connection closures.

If a tank is filled up for the purpose of neglecting the free surface effect, it shall be “pressed up”. “Pressed up” means completely full with no voids caused by trim or inadequate venting. Anything less than 100% full, for example the 98% condition regarded as full for operational purposes, is not acceptable. Preferably, in that case the ship should be rolled from side to side to eliminate entrapped air before taking the final sounding. Special care should be taken when pressing fuel oil tanks to prevent accidental pollution.

When emptying tanks, as recommended to neglecting the free surface effect, it is generally not sufficient to simply pump tanks until suction is lost. Enter the tank after pumping to determine if final stripping with portable pumps or by hand is necessary. The exceptions are very narrow tanks or tanks where there is a sharp deadrise, since free surface would be negligible. Since all empty tanks should be inspected, all manholes should be open and the tanks well ventilated and certified as safe for entry. A safety testing device shall be on hand to test for sufficient oxygen and minimum toxic levels. A certified marine chemist’s certificate certifying that all fuel oil and chemical tanks are safe for human entry should be available, if necessary.

6-A  TEST WEIGHTS

When the inclining test is carried out by weight shifting, weight shall be taken on board in the quantity resulting in the angle of inclination of 2 to 4°.

Cast iron pigs, grate bars, steel ingots or bags filled with sand etc. may be used as test weight.

Each piece of weight for the inclining test is to be weighted in front of a Register representative and subsequently marked with an identification number and its measured weight. The weight taken on board for the inclining test shall be divided into two or four groups and arranged on the upper deck symmetrically with respect to the centre of gravity of the actual waterline area.

Precautions should be taken to ensure that the decks are not overloaded during weight movements. If deck strength is questionable then a structural analysis should be performed to determine if existing framing could support the weight.

6-B  INCLINING TANKS

Where the use of solid weights to produce the inclining moment is demonstrated to be impracticable, as in large ships, the movement of ballast water may be permitted as an alternative method. This acceptance would be granted for a specific test only, and approval of the test procedure by the Register is required. As a minimal prerequisite for acceptability, the following conditions are required:

1 inclining tanks should be well-sided and free of large stringers or other internal
members that create air pockets. Other tank geometries may be accepted at the
discretion of the Register;
.2 tanks shall be directly opposite to maintain
ship's trim;
.3 specific gravity of ballast water shall be
measured and recorded;
.4 pipelines to inclining tanks shall be full. If
the ship's piping layout is unsuitable for
internal transfer, portable pumps and
pipes/hoses may be used;
.5 blanks must be inserted in transfer mani-
folds to prevent the possibility of liquids
being leaked during transfer. Continuous
valve control must be maintained during the
test;
.6 all inclining tanks must be manually
sounded before and after each shift;
.7 vertical, longitudinal and transverse cen-
tres should be calculated for each move-
ment;
.8 accurate sounding/ullage tables must be
provided. The ship's initial heel angle
shall be established prior to the incline in
order to produce accurate values for vol-
umes and transverse and vertical centres of
gravity for the inclining tanks at every an-
gle of heel. The draught marks amidships
(port and starboard) should be used when
establishing the initial heel angle;
.9 verification of the quantity shifted may be
achieved by a flow meter or similar de-
vice; and
.10 the time to conduct the inclining must be
evaluated. If time requirements for transfer
of liquids are considered too long, water
may be unacceptable because of the possi-
bility of wind shifts over long periods of
time.

7 SURPLUS AND MISSING LOADS

Prior to performing the inclining test, lists of all
missing and surplus loads on board shall be drawn up as re-
gards their amount and composition provided in the design for
the lightweight condition, specifying their positions aboard
recording the distance from the ship's centre line and base line
and from the aft perpendicular.

The weights and co-ordinates of missing loads
shall be determined with the greatest possible accuracy. Total
weight of the missing loads shall not be over 2 % and that of
surplus loads (not including the weight for test, not over 4 %
of the ship displacement.

It is in the best interest of safety to be on the
safe side when estimating missing and surplus loads, so the
following rules of thumb should be followed:
.1 when estimating weights to be added:
   .1.1 estimate high for items to be added
   high in the ship; and
   .1.2 estimate low for items to be added
   low in the ship;
.2 when estimating weights to be removed:
   .2.1 estimate low for items to be removed
   from high in the ship; and
   .2.2 estimate high for items to be re-
   moved from low in the ship;
.3 when estimating weights to be relocated:
   .3.1 estimate high for items to be relocat-
   ed to a higher point in the ship; and
   .3.2 estimate low for items to be relocat-
   ed to a lower point in the ship.

8 MEASUREMENT OF DRAUGHTS,
FREEBOARD AND CALCULATION OF
DISPLACEMENT

Draughts and freeboard of a ship shall be meas-
ured with the greatest possible accuracy prior to performing
the inclining test.

To ensure the greatest possible accuracy of
draught measurement in calm sea, it is advisable to use a glass
tube open on both ends, immersing one end of the tube to a
certain depth into water.

For measuring the draught in small ships (tugs,
motor boats etc.) make sure that the number of persons on
board during the measurement is the same as during the in-
clining test.

Draughts shall be measured by the aft and fore
draught marks from both sides of a ship, eliminating the effect
of initial heeling by taking an arithmetical mean value. When
possible, readings should be taken from a small boat. It should
have low freeboard to permit accurate observation of the read-
ings.

In addition to such a measurement, measuring of
the ship's freeboard shall be carried out from both sides in the
transverse plane passing through the midship perpendicular
i.e. through the centre of the freeboard ring. A document certi-
fying correctness of draught marks shall be available on
board.

Where on the ship's sides no draught marks are
signed, in addition to the freeboard on the midship section, the
freeboards fore and aft on both sides as the ship shall be
measured from the upper edge of the deck to the sea level
measuring by the perpendicular drawn from the relevant point
on deck to the sea level. The locations for each freeboard
reading should be clearly marked. The longitudinal location
along the ship shall be accurately determined and recorded
since the (moulded) depth at each point will be obtained from
the ship's lines. All freeboard measurements should include a
reference note clarifying the eventual inclusion of the coam-
ing in the measurement and the related coaming height.

The specific gravity of the flotation water shall
be determined at this time. Samples should be taken from a
sufficient depth of the water to ensure a true representation of
the flotation water and not merely surface water, which could
contain fresh water from run-off of rain. A hydrometer shall
be placed in a water sample and the specific gravity read and
recorded. For large ships, it is recommended that samples of
the flotation water be taken forward, midship, and aft and the
readings averaged. For small ships, one sample taken from
midships should be sufficient. The temperature of the water
should be taken and the measured specific gravity corrected
for deviation from the standard, if necessary. A correction to water specific gravity is not necessary if the specific gravity is determined at the inclining experiment site. Correction is necessary if specific gravity is measured when sample temperature differs from the temperature at the time of the inclining (e.g., if check of specific gravity is done at the office).

When calculating displacement arithmetic mean value of measurements taken on both sides, port and starboard, as provided for measurement of draught by draught marks shall be taken into account. When the freeboard depths are not measured at the places which correspond to the positions of fore and aft perpendiculars, the exact position of measurement shall be indicated lengthwise.

Correctness of draught i.e. freeboard measuring shall be checked immediately by plotting the relevant waterline on the lines drawing. If this check-up proves that measurement points are not in alignment, re-measuring shall be carried out to the method which provided to be more accurate.

It shall be remembered that in some ships sagging or hogging due to the ship's bending are likely to occur. When calculating displacement, it shall be taken into account that draught marks are drawn from the lower edge of the keel, while the draught for determining the displacement is calculated using the hydrostatic curves, or the Bonjean scale, from the base plane which does not generally coincide with the lower edge of the keel. In order to plot the ship’s waterline on the lines drawing, the freeboard readings shall be converted to moulded draughts. Similarly, the draught mark readings shall be corrected from extreme (bottom of keel) to moulded (top of keel) before plotting. Any discrepancy between the freeboard/draught readings shall be resolved.

If the vessel has trim, displacement may be calculated using Bonjean scale or using displacement correction per 2 cm of trim, and in a case of even keel the easiest way of displacement determination is from hydrostatic diagram or tables.

The distance of draught marks from fore and aft perpendicular shall be taken in consideration during plotting waterline on the Bonjean scale.

On the basis of the volume displacement \( V \), displacement and buoyancy are determined using the formula:

\[
\Delta = \rho \cdot g \cdot k \cdot V_o \quad [t]
\]
\[
\Delta \cdot g = \rho \cdot g \cdot k \cdot V_o = \gamma \cdot \nabla \quad [kN],
\]

where:

- \( \rho \) = density \([t/m^3]\),
- \( g \) = gravity, \([m/s^2]\),
- \( \gamma \) = specific gravity of water determined to the water sample, \([kN/m^3]\) \((\gamma = \rho \cdot g)\)
- \( k \) = coefficient which takes into account volume of appendages and shell plating.

9 DETERMINATION OF INCLINING ANGLES

To determine angles of inclination use may be made of pendulums, U-tubes, inclinographs and other special devices.

9.1 PENDULUMS

When using a pendulum, its length should be as great as possible and chosen as appropriate for a particular ship. The pendulums shall be long enough to give a measured deflection, to each side of upright, of at least 15 cm. For large ships it is advisable to have it 4.0 ÷ 5.0 m long. On smaller ships, where there is insufficient headroom to hang long pendulums, the 15 cm deflection should be obtained by increasing the test weight so as to increase the heel. In that case, the pendulum is not to be less than 2.0 m.

There shall be provided not less than two pendulums but three are recommended. The places of suspension are to be distributed lengthwise and to be spaced as much as possible.

Hemp thread of not more than 1 mm in thickness, or steel wire of not more than 0.25 mm in thickness, may be used as line.

When hemp thread is used, it shall be loaded prior to test as to avoid its subsequent elongation and possible touching of the vessel bottom.

To faster damp swinging of the pendulum, the pendulum usually being a cylinder with four symmetrically fitted wings, shall be immersed into a vessel filled with water or oil. Care shall be taken that the readings of pendulum inclination can be taken not before the water surface if the tank is smooth.

To take readings of the pendulum deflections, a wooden batten with scale shall be mounted transversally above the vessel as close to the pendulum as possible making sure that the line does not touch it.

A wooden batten with scale shall be long enough to ensure that the extreme pendulum deflection which might occur during the test, is within the wooden batten length.

Horizontally of the wooden batten shall be checked by the spirit level and it shall be adjusted by screws or keys for adjustment.

To facilitate readings of plumb line deflections and their recording, a tape with millimeter scale may be attached to the batten.

Vessel with the wooden batten shall be arranged so as to ensure that the pendulum at the ship's vertical position reaches about the batten what presents the measurement No.1 Reference measurement point 0 shall be indicated optionally at the extremely left or right end of the batten. (fig. 9.1.1).

The pendulums should be in place prior to the scheduled time of the inclining test.

When the test is carried out under the favourable weather conditions which ensure an absolute damping of the pendulum swinging, only one-deflection of each pendulum shall be recorded during the measuring (Fig. 9.1.2) and after the readings are taken, it shall be indicated in the appropriate line of column 6 of the Table "Pendulum Readings", stated in the form “Record of inclining test”.

The initial deflection of pendulum which correspond to the initial position of test weight (measurement Nos. 1, 5 and 9) shall be determined by the formula:
\[ s_p = \frac{1}{3} (s_1 + s_5 + s_9), \]

"0" shall be indicated in the column 7 in the line referring to these measurements.

Actual deflections of the pendulum upon other measurements (nos. 2, 3, 4, 6, 7, 8) shall be determined so that value \( s_p \) is deducted from the reference deflection from the measurement point "0", e.g., for measurement no.4:

\[ s_{04} = s_4 - s_p = s_4 - \frac{1}{3} (s_1 + s_5 + s_9) \]

and shall be indicated in the column 7 of the relevant table.

When the test is carried out under bad weather conditions (see Head 2 of this Appendix) then during the course of each measurement for each particular pendulum, the sequence of elongations in compliance with Fig. 9.1.3 (e.g. for no.2 measurement) shall be recorded and after their readings on the wooden batten with scale, they shall be indicated under item 4 of the relevant table.

Sum of the readings from each line shall be indicated in the column 5, while the mean deflection in column no.6 shall be determined so as to divide the sum by the number of readings. Further determination of the initial and pendulum deflections is analogous to the treatment specified for the test carried out under the favourable weather conditions.

The angle of inclining both of each test weight shifting and pendulum shall be determined by the formula:

\[ \tan \delta \theta_i = \frac{s_i}{\lambda} \]

where:

- \( s_i \) = real pendulum deflection from the column 7 of the stated table, [mm],
- \( \lambda \) = the pendulum length from the place of suspension to the upper edge of the wooden batten with scale, [mm].

When performing the test, some readings may turn out to be inaccurate for some reason and thus shall not be taken into account in dealing with the test data.

In order to find out such inaccurate readings, it is advisable to draw a control diagram where the values of heeling moments are drawn in the ordinate in an appropriate scale and the corresponding pendulum deflections measured for each pendulum separately in the abscissa. Theoretically, the points plotted in that way shall be located on an inclined straight line passing through the origin of ordinates.

An example of plotting the control diagram is shown in Fig. 9.1.4. The points located from this line more than 4% shall be rejected. Number of inaccurate measurements which may be tolerated, depending on reasons which have caused such inaccuracies, shall be agreed with the Register in each particular case.

It is recommended that in the course of inclining test zero points are to be checked up (measurements 0, 5 and 9), i.e. to check up whether the pendulum has been restored in the relevant measurements as close as possible to the initial position. Departure of 4% may be accepted.
Fig. 9.1.2

Fig. 9.1.3

measuring No. 2

elongation of the measuring No. 2
9.2 U-TUBES

Determination of inclining angles by means of U-tubes is recommended for ships where the pendulums of appropriate length which enable as reliable data as possible cannot be mounted due to insufficient depth of space.

For this purpose, two glass tubes of 1.0 - 1.5 m in length and 10 - 20 mm in diameter shall be taken and connected with an appropriate hose (Fig. 9.2.1). Tubes and hoses shall be mounted vertically on the ship's sides in the same transverse plane and at the same height from the deck. The horizontal distance between the legs of the U-tube should be sufficient to obtain a level difference of at least 15 cm between the upright and the maximum inclination to each side. After the glass tubes are mounted, coloured water shall be poured in one glass tube so that the water level reaches half height of the tube. When pouring water into tube, care shall be taken that air bubbles do not remain in the tube to avoid inaccuracies of measurement. If temperatures below 0°C are expected, the liquid should be a mixture of water and an anti-freeze additive.

Readings of water height differences in glass U-tubes shall be recorded, both for each particular measurement and for each pendulum individually, in the column 7, table "Readings of pendulum deflections".

Angle of inclination for each test weight shifting shall be determined by the formula:

\[ \tan \theta = \frac{h}{b}, \]

where:
- \( h \) = water head differences in the port and starboard U-tube, in [mm].
- \( b \) = distance between centrelines of port and starboard U-tubes, in [mm].

9.3 INCLINOGRAPHS AND OTHER SPECIAL DEVICES

These devices shall be prepared for the inclining test and shall be used in accordance with their operating instructions.

Devices shall be of a type approved by the Register and shall be calibrated, having linear performance over the excepted range of inclining angle. Number and arrangement of devices shall be agreed with the Register.
PERFORMING THE INCLINING TEST BY THE METHOD OF WEIGHT SHIFTING

Weight for the inclining test shall be shifted, in the case of four weight groups, as indicated in Fig. 10.1.

In each inclination make sure that nothing interferes the heeling of the ship and that the shifting of each weight group does not change because it might cause the change of statical moments of weight shifting and the inaccuracy of results.

Measurements nos. 1, 5 and 9, 2 and 6, 3 and 7, 4 and 8, respectively, shall mutually correspond as these measurements correspond to the same positions of the ballast at the same distance of ballast centre of gravity from the ship's centreline.

All crew members on board ship indispensable to carry out the activities regarding inclining test shall take their positions on board as agreed and shall keep their positions during the recording of pendulum deflections or taking any other necessary data.
11 DETERMINATION OF METACENTRIC HEIGHT

Individual metacentric height for the measurement nos. 1, 2, 3, 5, 6 and 7, respectively, shall be determined by the formula:

\[
GM_i = \frac{P_i \cdot e_i}{\Delta \cdot g \cdot \text{tg} \delta \theta_i}
\]

where:

- \( p_i \) = test weight, [kN],
- \( e_i \) = arm of the weight shifting, [m],
- \( \Delta \) = ship's displacement, [t],
- \( g \) = gravity, \([ \text{m/s}^2] \),
- \( \text{tg} \delta \theta_i \) = mean value of \( \text{tg} \) of angle of heel for the relevant measurement; equals the arithmetical mean value of \( \text{tg} \) of angles of heel of all pendulums used for that measurement.

It is recommended that the metacentric height of the ship during the inclining test prior to the corrections due to eventual free surfaces effects of liquids, is to be determined from the individual metacentric heights by the curve \( GM = f(\theta) \).

12 DETERMINATION OF THE PERIOD OF ROLL

Determination of the rolling period of a ship is recommended to be carried out in each inclining test, especially for fishing vessels.

The main means for determination of the rolling period is recording of the ship's damped swinging using gyroscopic or timing inclinographs. If these devices are not available, use of not less than three stop watches is permissible.

For this purpose the ship may be swung by running of the crew or by placing some cargo instantly on the deck side.

The period of roll \( T \) [s], is determined as the arithmetical mean of as large a number of the ship's swinging as possible.

When determining the period of roll, it is advisable to steer the ship from the shore or bring her perpendicular to the shore in deep water away from other ships.

13 TAKING INTO ACCOUNT EFFECT OF THE TRIM

If the ship's trim during the inclining test differs by more than 0.005 L from that taken when calculating the curves of the lines drawing, the latter shall not be used when treating the inclining test results.

In this case, co-ordinates of the ship's centre of gravity in the \( X_{B'} \) axes (in connection with the ship) shall be determined using the following formula:

\[
X_{C'} = X_{B'} - (BM_{B'} - GM) \sin \psi
\]
\[ \overline{BM}_\psi = K_{B\psi} + (\overline{BM}_\psi - \overline{GM}) \cos \psi \]

The co-ordinates \( X_{B\psi} \) and \( K_{B\psi} \) are determined using the Bonjean scale by the method of numerical integration.

The metacentric radius \( M_{\psi} \) with due regard to trim is calculated from the lines drawing with the actual waterline drawn in it, using the following formulae:

\[ \frac{\overline{BM}_\psi}{V_{o\psi}} = I_{o\psi}, \quad I_{o\psi} = \frac{2}{3} \delta L \cdot \sum y_{\psi}^3 \]

where:
- \( I_{o\psi} \) = transversal moment of inertia of WL, trim \( \psi \), [m\(^4\)],
- \( \delta L \) = theoretical frame spacing, [m],
- \( y_{\psi} \) = actual waterline ordinate; [m],
- \( V_{o\psi} \) = ship's displacement determined by Bonjean scale with the draught up to actual waterline (taking no account of appendages) [m\(^3\)],
- \( \overline{GM} \) = ship metacentric height, [m],
- \( \psi \) = trim angle, in [degrees],
- \( \sum \) = denotes symbolically algebraic sum of ordinates cubes \( y_{\psi} \) determined by the numerical integration.
APPENDIX 4
ALTERNATIVE WEATHER CRITERION

1.1 For the vessels with navigation area notations 5, 6, 7 and 8, the alternative weather criterion to that prescribed in 2.1.5 may be allowed by the Register. It is described further in this Appendix.

1.2 Stability of ships of restricted areas of navigation shall be considered sufficient as to weather criterion K, if the heeling moment \( M_v \) due to wind pressure in the worst loading condition is equal or below the capsizing moment \( M_c \), that is:

\[ M_v \leq M_c \]

or

\[ K = \frac{M_c}{M_v} \geq 1.00 \]  

(1.2)

For ships specially intended for operation on heavy seas (for example, weather observation ships) the value of weather criterion K is subject to special consideration by the Register.

However, for all ships intended to operate during whole year period, it is recommended that this value should not be less than 1.50.

1.3 At the discretion of the Register, the ships whose stability characteristics do not comply with some of the requirements set in this part of the Rules may be allowed to operate as ships of restricted area of navigation with additional restrictions taking into account the peculiarities of the area and the nature of service.

1.4 The heeling moment due to wind pressure \( M_v \) is assumed to be equal to the product of wind pressure \( p_v \) by windage area \( A_v \) and by the distance \( h_v \) between the centre of windage area and the actual waterline plane.

\[ M_v = 0.001 \, p_v \cdot A_v \cdot h_v \]  

(1.4)

where:

- \( M_v \) – wind load heeling moment [kNm],
- \( p_v \) – specific wind pressure [Pa],
- \( A_v \) – windage area [m²],
- \( h_v \) – arm of windage area [m].

The wind heeling moment is taken as constant value for total range of heeling.

1.5 Specific wind pressure value \( p_v \) shall be calculated according to the Table 1.5 depending on the arm of windage area. For intermediate values, \( p_v \) should be obtained by interpolation.

1.6 CALCULATION OF AMPLITUDE OF ROLL

1.6.1 The amplitude of roll of a round-bilged ship having no bilge and bar keels is calculated by the formula:

\[ \theta_{ir} = X_1 \cdot X_2 \cdot Y \]  

(1.6.1)

where:

- \( \theta_{ir} \) – amplitude of roll of a round-bilged ship [deg]
- \( X_1 \) – non-dimensional factor that shall be taken from the table 1.6.1-2 depending on the ratio, \( \frac{B}{d} \)
- \( X_2 \) – non-dimensional factor that shall be taken from the table 1.6.1-3, depending on the ship’s block coefficient \( C_b \)
- \( Y \) – factor [deg]

1.6.1.1 Values of the factor \( Y \) shall be taken from table 1.6.1-1, depending on the ratio:

\[ \frac{\sqrt{GM_o}}{B} \]  

(1.6.1.1)

where:

- \( B \) = breadth of a ship [m],
- \( GM_o \) = initial metacentric height without correction for free surface effects [m].

1.6.2 The amplitude of roll of a ship provided with bilge keels or bar keel or both shall be calculated by the formula:

\[ \theta_{ir} = X_3 \cdot \frac{GM_o}{B} \]  

(1.6.2)
\[ \theta_{2r} = k \cdot \theta_r \]  
\[ \theta_{2r} = \text{amplitude of roll of a ship provided with keels [deg]}, \]
\[ k = \text{coefficient in the Table 1.6.2-1, depending on the ratio of } A_k \text{ over product of } L \text{ and } B, \]
\[ A_k = \text{total area of bilge keels or an area of lateral projection of the bar keel, or a sum of both of these areas [m}^2]. \]

Bilge keels are not to be taken into consideration where ships in their class notation have ice category marks 1AS, 1A and 1B.

Table 1.6.1-1
Values of factor Y

<table>
<thead>
<tr>
<th>[ \frac{\sqrt{\frac{GM_o}{B}}}{2} ]</th>
<th>0.04</th>
<th>0.05</th>
<th>0.06</th>
<th>0.07</th>
<th>0.08</th>
<th>0.09</th>
<th>0.10</th>
<th>0.11</th>
<th>0.12</th>
<th>0.13</th>
</tr>
</thead>
<tbody>
<tr>
<td>Restricted area 5-8</td>
<td>16.0</td>
<td>17.0</td>
<td>19.7</td>
<td>22.8</td>
<td>25.4</td>
<td>27.6</td>
<td>29.2</td>
<td>30.5</td>
<td>31.4</td>
<td>32.0</td>
</tr>
</tbody>
</table>

Table 1.6.1-2
Values of factor \( X_1 \)

<table>
<thead>
<tr>
<th>( \frac{A_k}{L \cdot B} )</th>
<th>0</th>
<th>1.0</th>
<th>1.5</th>
<th>2.0</th>
<th>2.5</th>
<th>3.0</th>
<th>3.5</th>
<th>4.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factor ( X_1 )</td>
<td>1.00</td>
<td>0.98</td>
<td>0.96</td>
<td>0.95</td>
<td>0.93</td>
<td>0.91</td>
<td>0.90</td>
<td>0.88</td>
</tr>
</tbody>
</table>

Table 1.6.1-3
Values of factor \( X_2 \)

<table>
<thead>
<tr>
<th>( C_b )</th>
<th>0.45 and less</th>
<th>0.50</th>
<th>0.55</th>
<th>0.60</th>
<th>0.65</th>
<th>0.70 and more</th>
</tr>
</thead>
<tbody>
<tr>
<td>( X_2 )</td>
<td>0.75</td>
<td>0.82</td>
<td>0.89</td>
<td>0.95</td>
<td>0.97</td>
<td>1.00</td>
</tr>
</tbody>
</table>

1.6.3 The amplitude of roll for a ship having sharp bilges shall be assumed to be equal 70% of that calculated by the formula 1.6.1.

1.6.4 The amplitude of roll for ships equipped with anti-rolling devices shall be determined taking no account of operation of these devices.

1.6.5 The calculated values of amplitude of roll shall be rounded off to integer value, in degrees.

1.6.6 The capsizing moment may be determined by any method approved by the Register. A recommended procedure for determination of the capsizing moment is referred to in Appendix 2.
APPENDIX 5
STABILITY CALCULATIONS PERFORMED BY STABILITY INSTRUMENTS

1.1 GENERAL

This Appendix is applicable to software which calculates the stability of actual conditions and which is installed on ships and on units subject to compliance with the requirements of this part of the Rules.

The use of onboard computers for stability calculations is not a requirement of class.

Stability software installed onboard shall cover all mandatory class and statutory intact and damage stability requirements applicable to the ship. The software is subject to approval by the Register Active and passive systems are defined in 1.2 of this Appendix. These requirements cover passive systems and the off-line operation mode of active systems only. General requirements are stated in item 1.5.2 of this part of the Rules.

1.2 CALCULATION SYSTEMS

1.2.1 A passive system requires manual data entry.

1.2.2 An active system replaces partly the manual entry with sensors reading and entering the contents of tanks, etc.

1.2.3 Any integrated system which controls or initiates actions based on the sensor-supplied inputs is not within the scope of this part of the Rules, except for the part calculating the stability.

1.3 TYPES OF STABILITY SOFTWARE

Four types of calculations performed by stability software are acceptable depending upon a vessel’s stability requirements:

Type 1 - software calculating intact stability only (for vessels not required to meet a damage stability criterion);

Type 2 - software calculating intact stability and checking damage stability on basis of a limit curve (e.g., for vessels applicable to SOLAS part B-1 damage stability calculations, etc.) or checking all the stability requirements (intact and damage stability) on the basis of a limit curve;

Type 3 - software calculating intact stability and damage stability by direct application of pre-programmed damage cases based on the relevant Conventions or Codes for each loading condition (for some tankers etc.).

Type 4 - software calculating damage stability associated with an actual loading condition and actual flooding case, using direct application of user defined damage, for the purpose of providing operational information for safe return to port (SRtP).

Damage stability of both Type 3 and Type 4 stability software shall be based on a hull form model, that is, directly calculated from a full three-dimensional geometric model.

1.4 FUNCTIONAL REQUIREMENTS

1.4.1 GENERAL REQUIREMENTS for any type of stability software

1.4.1.1 The calculation program shall present relevant parameters of each loading condition in order to assist the Master in his judgement on whether the ship is loaded within the approved limits. The following parameters shall be presented for a given loading condition:

1. detailed deadweight data items including centre of gravity and free surfaces, if applicable;

2. trim; list;

3. draught at the draught marks and perpendiculars;

4. summary of loading condition displacement, VCG, LCG and, if applicable, TCG;

5. table showing the righting lever versus heeling angle including trim and draught;

6. down-flooding angle and corresponding down-flooding opening (not applicable for Type 2 software which uses limit curve for checking all the stability requirements. However, if intact stability criteria are given in addition to the limit curve, downflooding angle and the corresponding downflooding opening shall be indicated); and

7. compliance with stability criteria: Listings of all calculated stability criteria, the limit values, the obtained values and the conclusions (criteria fulfilled or not fulfilled) (not applicable for Type 2 software which uses limit curve for checking all the stability requirements. However, if intact stability criteria are given in addition to the limit curve, the limit values, the obtained values and the conclusion shall be indicated).
1.4.1.2 A clear warning should be given on screen and in hard copy printout if any of the limitations are not complied with.

Loading limitations shall include, but may not be limited to:
- Trim, draught, liquid densities, tank filling levels, initial heel;
- Use of limit KG/GM curves in conjunction with above for Type 2;
- Restrictions to the stowage height for timber where timber load lines are assigned.

1.4.1.3 Type 3 software is to include pre-defined relevant damage cases according to the applicable rules for automatic check of a given loading condition.

1.4.1.4 The data and time of a saved calculation shall be part of the screen and in hard copy printout in a clear unambiguous manner.

1.4.1.5 Each hard copy printout should contain identification of the calculation program including version number.

1.4.1.6 Units of measurement are to be clearly identified and used consistently within a loading calculation.

1.4.1.7 For Type 3 and Type 4 software, the system shall be pre-loaded with a detailed computer model of the complete hull, including appendages, all compartments, tanks and the relevant parts of the superstructure considered in the damage stability calculation, wind profile, down-flooding and up-flooding openings, cross-flooding arrangements, internal compartment connections and escape routes, as applicable and according to the type of stability software.

1.4.1.8 For Type 1 and Type 2 software, in case a full three dimensional model is used for stability calculations, the requirements of the computer model are to be as per sub-item 1.4.1.7 above to the extent as applicable and according to the type of stability software.

1.4.2 FURTHER REQUIREMENTS for type 4 stability software

1.4.2.1 The normal (Type 1, 2 and 3) and SRtP (Type 4) software need not be “totally separated”. Where the normal and SRtP software are not totally separated:
- The function of switching between normal software and Type 4 software shall be provided;
- The actual intact loading condition is to be the same for both functions (normal operation and SRtP); and
- The SRtP module needs only to be activated in case of an incident.

Approval of Type 4 (SRtP) software is for stability only.

1.4.2.2 In passenger ships which are subject to SRtP and have an onboard stability computer and shore-based support, such software need not be identical.

1.4.2.3 Each internal space shall be assigned its permeability as shown in the table found at the next page, unless a more accurate permeability has been reflected in the approved stability information.

1.4.2.4 The system shall be capable of accounting for applied moments such as wind, lifeboat launching, cargo shifts and passenger relocation.

1.4.2.5 The system shall account for the effect of wind by using the method in SOLAS regulation II-1/7-2.4.1.2 as the default, but allow for manual input of the wind speed/pressure if the on-scene pressure is significantly different (P = 120 N/m2 equates to Beaufort 6; approximately 13.8 m/s or 27 knots).

1.4.2.6 The system shall be capable of assessing the impact of open main watertight doors on stability (e.g. for each damage case provided for verification, additional damage stability calculation shall be done and presented, taking into account any watertight door located within the damaged compartment(s)).

1.4.2.7 The system shall utilize the latest approved lightship weight and centre of gravity information.

1.4.2.8 The output of the software is to be such that it provides the master with sufficient clear unambiguous information to enable quick and accurate assessment of the stability of the vessel for any actual damage, the impact of flooding on the means of escape and the controls of devices necessary for managing and/or controlling the stability of the ship.

When the actual loading condition is input in the SRtP software, the following output (intact stability) shall be available:
- deadweight data;
- lightship data;
- trim;
- heel;
- draft at the draft marks and perpendiculars;
- summary of loading condition displacement, VCG, LCG and, if applicable, TCG;
- downflooding angle and corresponding downflooding opening;
- free surfaces;
- GM value;
- GZ values relevant to an adequate range of heeling (not less than 60°) available indicatively at the following intervals: 0 5 10 15 20 25 30 40 50 60 deg;
- compliance with relevant intact stability criteria (i.e. 2008 IS Code): listing of all calculated intact stability criteria, the limiting values, the obtained values and the evaluation (criteria fulfilled or not fulfilled);
- GM/KG limiting curve according to SOLAS, Ch II-1, Regulation 5-1.
Spaces & Permeability

<table>
<thead>
<tr>
<th>Spaces</th>
<th>Default</th>
<th>Full</th>
<th>Partially filled</th>
<th>Empty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Container Spaces</td>
<td>0.95</td>
<td>0.70</td>
<td>0.80</td>
<td>0.95</td>
</tr>
<tr>
<td>Dry Cargo spaces</td>
<td>0.95</td>
<td>0.70</td>
<td>0.80</td>
<td>0.95</td>
</tr>
<tr>
<td>Ro-Ro spaces</td>
<td>0.95</td>
<td>0.90</td>
<td>0.90</td>
<td>0.95</td>
</tr>
<tr>
<td>Cargo liquids</td>
<td>0.95</td>
<td>0.70</td>
<td>0.80</td>
<td>0.95</td>
</tr>
<tr>
<td>Intended for consumable liquids</td>
<td>0.95</td>
<td>0.95</td>
<td>0.95</td>
<td>0.95</td>
</tr>
<tr>
<td>Stores</td>
<td>0.95</td>
<td>0.60</td>
<td>(0.60)</td>
<td>0.95</td>
</tr>
<tr>
<td>Occupied by machinery</td>
<td></td>
<td></td>
<td></td>
<td>0.85</td>
</tr>
<tr>
<td>Void spaces</td>
<td></td>
<td></td>
<td></td>
<td>0.95</td>
</tr>
<tr>
<td>Occupied by accommodation</td>
<td></td>
<td></td>
<td></td>
<td>0.95</td>
</tr>
</tbody>
</table>

When the actual loading condition is associated to the actual damage case(s) due to the casualty, the following output (damage stability) shall be available:
- trim;
- heel;
- draft at the draft marks and perpendiculars;
- progressive flooding angle and corresponding progressive flooding openings;
- $G_M$ value;
- $G_Z$ values relevant to an adequate range of heeling (not less than 60°) available indicatively at the following intervals: 0 5 10 15 20 25 30 40 50 60 deg;
- compliance with stability criteria: listing of all calculated stability criteria, the limit values, the obtained values and the conclusions (criteria fulfilled or not fulfilled);
- the survivability criteria for Type 4 software (SRtP) are left to the discretion of the Administration;
- relevant flooding points (unprotected or weathertight) with the distance from the damage waterline to each point;
- list of all flooded compartments with the permeability considered;
- amount of water in each flooded compartment;
- escape route immersion angles;
- a profile view, deck views and cross-sections of the ship indicating the flooded waterplane and the damaged compartments.

1.4.2.9 For ro-ro passenger ships there shall be algorithms in the software for estimating the effect of water accumulation on deck (WOD) (e.g. 1. In addition to the predefined significant wave height taken from the approved stability document, calculations with two additional significant wave heights shall be submitted for checking the correctness of the algorithms in the software for estimating the effect of WOD).

1.5 ACCEPTABLE TOLERANCES

Depending on the type and scope of programs, the acceptable tolerances are to be determined differently, according to following paragraphs 1.5.1 or 1.5.2. Deviation from these tolerances should not be accepted unless the Register considers that there is a satisfactory explanation for the difference and that there will be no adverse effect on the safety of the ship.

The accuracy of the results should be determined using an independent program or the approved stability booklet with identical input.

Examples of pre-programmed input data include the following:

- Hydrostatic data: Displacement, LCB, LCF, VCB, KMt and MCT versus draught.
- Stability data: $K_N$ or $M_S$ values at appropriate heel/trim angles versus displacement, stability limits.
- Compartment data: Volume, LCG, VCG, TCG and FSM/Grain heeling moments vs level of the compartment’s contents.

Examples of output data include the following:

---

* This paragraph applies to Ro-Ro Passenger ships subject to the Stockholm Agreement (IMO Circular Letter No. 1891)
Hydrostatic data: Displacement, LCB, LCF, VCB, KMt and MCT versus draught as well as actual draughts, trim.

Stability data: FSC (free surface correction), GZ-values, KG, GM, KG/GM limits, allowable grain heeling moments, derived stability criteria, e.g. areas under the GZ curve, weather criteria.

Compartment data: Calculated Volume, LCG, VCG, TCG and FSM/Grain heeling moments vs level of the compartment’s contents.

The computational accuracy of the calculation program results shall be within the acceptable tolerances, specified in 5.1 or 5.2, of the results using an independent program or the approved stability information with identical input.

1.5.1 Programs which use only pre-programmed data from the approved stability booklet as the basis for stability calculations should have zero tolerances for the printouts of input data. Output data tolerances are to be close to zero, however, as small differences associated with calculation rounding or abridged input data are acceptable. Additional differences associated with the use of hydrostatic and stability data for trims and the method calculating free surface moments that differ from those in the approved stability booklet are acceptable subject to review by the Register.

1.5.2 Programs which use hull form models as their basis for stability calculations should have tolerances for the printouts of basic calculated data established against either data from the approved stability booklet or data obtained using the Register’s approval model. Acceptable tolerances shall be in accordance with the following table:

<table>
<thead>
<tr>
<th>Hull form dependent</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Displacement</td>
<td>+/- 2%</td>
</tr>
<tr>
<td>Longitudinal center of buoyancy, from AP</td>
<td>+/- 1% / 50 cm</td>
</tr>
<tr>
<td>Vertical center of buoyancy</td>
<td>+/- 1% / 5 cm</td>
</tr>
<tr>
<td>Transverse center of buoyancy</td>
<td>+/- 0.5% of B / 5 cm</td>
</tr>
<tr>
<td>Longitudinal center of flotation, from AP</td>
<td>+/- 1% / 50 cm</td>
</tr>
<tr>
<td>Moment to trim 1 cm</td>
<td>+/- 2%</td>
</tr>
<tr>
<td>Transverse metacentric height</td>
<td>+/- 1% / 5 cm</td>
</tr>
<tr>
<td>Longitudinal metacentric height</td>
<td>+/- 1% / 50 cm</td>
</tr>
<tr>
<td>Cross curves of stability</td>
<td>+/- 5 cm</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Compartment dependent</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume or deadweight</td>
<td>+/- 2%</td>
</tr>
<tr>
<td>Longitudinal center of gravity, from AP</td>
<td>+/- 1% / 50 cm</td>
</tr>
<tr>
<td>Vertical center of gravity</td>
<td>+/- 1% / 5 cm</td>
</tr>
<tr>
<td>Transverse center of gravity</td>
<td>+/- 0.5% of B / 5 cm</td>
</tr>
<tr>
<td>Free surface moment</td>
<td>+/- 2%</td>
</tr>
<tr>
<td>Shifting moment</td>
<td>+/- 5%</td>
</tr>
<tr>
<td>Level of contents</td>
<td>+/- 2%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Trim and stability</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Draughts (forward, aft, mean)</td>
<td>+/- 1% / 5 cm</td>
</tr>
<tr>
<td>GMt (both solid and corrected for free surfaces)</td>
<td>+/- 1% / 5 cm</td>
</tr>
<tr>
<td>GZ values</td>
<td>+/- 5% / 5 cm</td>
</tr>
<tr>
<td>Downflooding angle</td>
<td>+/- 2°</td>
</tr>
<tr>
<td>Equilibrium angles</td>
<td>+/- 1°</td>
</tr>
<tr>
<td>Distance from WL to unprotected and weathertight openings, or other relevant point, if applicable</td>
<td>+/- 5% / 5 cm</td>
</tr>
<tr>
<td>Areas under righting arm curve</td>
<td>+/- 5% or 0.0012 mrad</td>
</tr>
</tbody>
</table>
1.6 APPROVAL PROCEDURE

1.6.1 Conditions of approval of the onboard software for stability calculations

The onboard software used for stability calculations is subject to approval, which is to include:
- verification of type approval, if any;
- verification that the data used is consistent with the current condition of the ship (refer to paragraph 1.6.2);
- verification and approval of the test conditions;
- verification that the software is appropriate for the type of ship and stability calculations required;
- verification of functional requirements under sub-item 1.4.1.2.

The satisfactory operation of the software with the onboard computer(s) for stability calculations is to be verified by testing upon installation (refer to section 1.8). A copy of the approved test conditions and the operation manual for the computer/software are to be available on board.

1.6.2 Specific approval

1.6.2.1 Upon application for data verification, minimum of four loading conditions shall be agreed between the Register and the applicant, all taken from the ship’s approved stability booklet, which are to be used as the test conditions. For ships carrying liquids in bulk, at least one of the conditions shall include partially filled tanks. For ships carrying grain in bulk, one of the grain loading conditions shall include a partially filled grain compartment. Within the test conditions each compartment shall be loaded at least once. The test conditions normally are to cover the range of load draughts from the deepest envisaged loaded condition to the light ballast condition and should include at least one departure and one arrival condition.

For Type 4 stability software for SRtP, at least three damage cases shall be examined by the Register, each of them associated with at least three loading conditions taken from the ship’s approved stability information. Output of the software is to be compared with results of corresponding load / damage case in the approved damage stability booklet or an alternative independent software source.

1.6.2.3 The following data, submitted by the applicant, shall be consistent with arrangements and most recently approved lightship characteristics of the ship according to current plans and documentation on file with the Register, subject to possible further verification on board:
1. Identification of the calculation program including version number;
2. Main dimensions hydrostatic particulars and, if applicable, the ship’s profile;
3. The position of the forward and aft perpendiculars, and if appropriate, the calculation method to derive the forward and aft draughts at the actual position of the ship’s draught marks;
4. Ship’s lightweight and centre of gravity derived from the most recently approved inclining experiment or light weight check;
5. Lines plan, offset tables or other suitable presentation of hull form data including all relevant appendages, if necessary for the Register to model the ship;
6. Compartment definitions, including frame spacing, and centres of volume, together with capacity tables (sounding/ullage tables), free surface corrections, if appropriate; and
7. Cargo and consumables distribution for each loading condition.

Verification by the Register does not absolve the applicant and shipowner of responsibility for ensuring that the information programmed into the onboard computer software is consistent with the current condition of the ship.

1.6.3 General Approval:

1.6.3.1 Upon application to the Register for general approval of the calculation program, the Register may provide the applicant with test data consisting of two or more design data sets, each of which is to include a ship’s hull form data, compartmentation data, lightship characteristics and deadweight data, in sufficient detail to accurately define the ship and it’s loading condition. Acceptable hull form and compartment data may be in the form of surface coordinates for modeling the hull form and compartment boundaries, e.g: a table of offsets, or in the form of pre-calculated tabular data, e.g: hydrostatic tables, capacity tables, etc., depending upon the form of data used by the software being submitted for approval. Alternatively, the
general approval may be given based on at least two test ships agreed upon between the Register and the applicant.

1.6.3.2 In general, the software is to be tested for two types of ships for which approval is requested, with at least one design data set for each of the two types. Where approval is requested for only one type of ship, a minimum of two data sets for different hull forms of that type of ship are required to be tested. For calculation software which is based on the input of hull form data, design data sets shall be provided for three types of ships for which the software is to be approved, or a minimum of three data sets for different hull forms if approval is requested for only one type of ship. Representative ship types which require different design data sets due to their hull forms, typical arrangements, and nature of cargo include: tanker, bulk carrier, container ship, and other dry cargo and passenger ships. The test data sets shall be used by the applicant to run the calculation program for the test ships. The results obtained (together with the hydrostatic data and cross-curve data developed by the program, if appropriate) shall be submitted to the Register for the assessment of the program’s computational accuracy. The Register shall perform parallel calculations using the same data sets and a comparison of these results will be made against the applicant’s submitted program’s results.

1.7 OPERATION MANUAL

A simple and straightforward operation manual, written in the same language as the stability booklet, is to be provided, containing descriptions and instructions, as appropriate, for at least the following:
- installation;
- function keys;
- menu displays;
- input and output data;
- required minimum hardware to operate the software;
- use of the test loading conditions;
- computer-guided dialogue steps; and
- list of warnings.

An operating manual in electronic format may be provided in addition to the written manual.

1.8 INSTALLATION TESTING

1.8.1 To ensure correct working of the computer after the final or updated software has been installed, it is the responsibility of the ship’s Master to have test calculations carried out according to the following pattern in the presence of a Register’s surveyor. From the approved test conditions at least one load case (other than light ship) shall be calculated.

Note: Actual loading condition results are not suitable for checking the correct working of the computer.

1.8.2 Normally, the test conditions are permanently stored in the computer. Steps to be performed:
- Retrieve the test load case and start a calculation run; compare the stability results with those in the documentation.
- Change several items of deadweight (tank weights and the cargo weight) sufficiently to change the draught or displacement by at least 10%. The results are to be reviewed to ensure that they differ in a logical way from those of the approved test condition.
- Revise the above modified load condition to restore the initial test condition and compare the results. Confirm that the relevant input and output data of the approved test condition have been replicated.
- Alternatively, one or more test conditions shall be selected and the test calculations performed by entering all deadweight data for each selected test condition into the program as if it were a proposed loading. The results shall be verified as identical to the results in the approved copy of the test conditions.

1.9 PERIODICAL TESTING

1.9.1 It is the responsibility of the ship’s Master to check the accuracy of the onboard computer for stability calculations at each annual survey by applying at least one approved test condition. If a Register’s surveyor is not present for the computer check, a copy of the test condition results obtained by the computer check is to be retained on board as documentation of satisfactory testing for the surveyor’s verification.

1.9.2 At each special survey this checking for all approved test loading conditions is to be done in presence of the surveyor.

1.9.3 The testing procedure shall be carried out in accordance with section 1.8.

1.10 OTHER REQUIREMENTS

1.10.1 Protection against unintentional or unauthorised modification of programs and data shall be provided.

1.10.2 The program shall monitor operation and activate an alarm when the program is incorrectly or abnormally used.

1.10.3 The program and any data stored in the system shall be protected from corruption by loss of power.

1.10.4 Error messages with regard to limitations such as filling a compartment beyond capacity or more than once, or exceeding the assigned load line, etc., shall be included.

1.10.5 If any software related to stability measures such as sea keeping abilities of the vessel, evaluation of in-service inclining experiments and processing the results for further calculation, as well as the evaluation of roll period measurements, is installed on board, such software shall be reported to the Register for consideration.

1.10.6 Program functionalities shall include mass and moment calculations with numerical and graphical presentation of the results, such as initial stability values,
righting lever curve, areas under the righting lever curve and range of stability.

1.10.7 All input data from automatically measuring sensors, such as gauging devices or draught reading systems shall be presented to the user for verification. The user shall have the possibility to override faulty readings manually.
APPENDIX 6
PERMISSIBLE TENSIONS AND ZONES FOR USE IN ANCHOR HANDLING OPERATIONS

1 GUIDANCE FOR DEFINITION OF PERMISSIBLE TENSIONS AND ZONES

To aid the definition of permissible tensions and zones based on the availability of tension monitoring and an onboard stability instrument the following table is provided.

<table>
<thead>
<tr>
<th>Permissible tension, $F_p$:</th>
<th>Tension monitoring is not available</th>
<th>Tension monitoring is available but no stability instrument is available</th>
<th>Both tension monitoring and a stability instrument is available</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design Maximum Line Tension, $F_p$, in the operational zone.</td>
<td>$F_p$ as described in Stability Booklet, the operational planning guidelines, or the specific operational plan.</td>
<td>$F_p$ as calculated by the Stability Instrument for the actual loading condition.</td>
<td></td>
</tr>
<tr>
<td>First $\alpha$ should be 5°. The only permissible tension is the Design maximum wire tension, $F_d$. Figures in the table will be $F_d$ for $\alpha$ for which $F_p \geq F_d$. The cautionary zone would include positions where $F_d &gt; F_p \geq$ maximum winch wire pull. The stop work zone is every other position where $F_p &lt;$ the maximum winch wire pull. If criteria is not fulfilled at $\alpha = 5^\circ$ anchor handling should not be performed without winch modification.</td>
<td>Tables may be prepared for different values of draft, trim, KG or GM, or specific predefined loading conditions. Values in the table should range from $\alpha = 0$ to $\alpha = 90^\circ$. A table should identify $F_p$ at critical points and the table should be provided for each set of towing pins.</td>
<td>Tables or curves provided in the stability booklet may be used where $F_p$ throughout the nonspecific operational zone exceeds the maximum anticipated wire tension; otherwise, tables or curves calculated for the actual loading condition must be developed.</td>
<td></td>
</tr>
</tbody>
</table>
### Availability of Tension Monitoring and an onboard Stability Instrument

<table>
<thead>
<tr>
<th>Tension monitoring is not available</th>
<th>Tension monitoring is available but no stability instrument is available</th>
<th>Both tension monitoring and a stability instrument is available</th>
</tr>
</thead>
<tbody>
<tr>
<td>The operational zone should be defined as the sector between the two outboard α values for which ( F_p \geq F_d ). The cautionary zone should be defined as the sector between the ( \alpha ) at which ( F_p = F_d ) and ( \alpha ) at which ( F_p = ) maximum winch wire pull. The stop work zone should cover every other position. The sectors should be documented in the Stability Booklet, the operational planning guidelines, or the specific operational plan. The sector diagram may be prepared for multiple loading conditions. If the limiting ( \alpha ) is less than 5° anchor handling operations should not be performed without winch modifications.</td>
<td>The zones may be developed based on normal operational practices contained in the operational planning guidelines, e.g. the operational zone on the stern roller, cautionary zone for not more than 15° past the stern roller and the red zone otherwise or developed for a specific operation where the outboard ( \alpha ) values at which ( F_p = ) maximum anticipated wire tension minus 10° defines the operational zone, if ( \alpha ) is greater than 20°. If this ( \alpha ) is less than 20°, the operational zone is defined as the sector between ( 1/2 ) the outboard ( \alpha ) values at which ( F_p = ) maximum anticipated wire tension. In each case, the operational zone must be identified for the anticipated wire tension.</td>
<td>The zones may be developed based on normal operational practices contained in the operational planning guidelines, e.g. the operational zone on the stern roller, cautionary zone for not more than 15° past the stern roller and the red zone otherwise or developed for a specific operation where the outboard ( \alpha ) values at which ( F_p = ) maximum anticipated wire tension minus 10° defines the operational zone, if ( \alpha ) is greater than 20°. If this ( \alpha ) is less than 20°, the operational zone is defined as the sector between ( 1/2 ) the outboard ( \alpha ) values at which ( F_p = ) maximum anticipated wire tension. In each case, the operational zone must be identified for the anticipated wire tension.</td>
</tr>
</tbody>
</table>
2 RECOMMENDED MODEL FOR GRAPHIC OR TABULAR PRESENTATION OF PERMISSIBLE TENSIONS FOR USE IN ANCHOR HANDLING OPERATIONS

2.1 The insertion of a recommended model for the presentation of permissible tensions as function of $\alpha$ might be beneficial for a universal information standard. This uniform presentation will facilitate the circulation and the familiarization of the operators with the ship and its equipment.

2.2 A possible graphic presentation of the permissible tension is here included as an example, both table and diagram format.

![Permissible Wire Tension Table for a Sample AHTS](image)

**Figure A6-1**
Permissible tension table for ship with 3 tow points
Figure A6-2
Illustration of the operational, cautionary, and stop work zones (coded respectively "Green", "Yellow" and "Red" zones)
Figure A6-3
Permissible tension sector diagram based on standard alpha values (5°, 10°, 15°, 90°)
## SYMBOLS, UNITS AND MEANING OF THE VALUES ADOPTED IN THE RULES

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Unit</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta \cdot g$</td>
<td>kN</td>
<td>Buoyancy of ship</td>
</tr>
<tr>
<td>$\Delta$</td>
<td>t</td>
<td>Displacement</td>
</tr>
<tr>
<td>$V_o$</td>
<td>m³</td>
<td>Displacement volume without appendages</td>
</tr>
<tr>
<td>$V$</td>
<td>m³</td>
<td>Displacement volume with appendages</td>
</tr>
<tr>
<td>$\Delta_{\text{min}} \cdot g$</td>
<td>kN</td>
<td>Buoyancy corresponding to the minimum loading condition of the ship specified by the Rules</td>
</tr>
<tr>
<td>$\Delta_{\text{max}} \cdot g$</td>
<td>kN</td>
<td>Buoyancy of the ship at the summer load waterline</td>
</tr>
<tr>
<td>$\Delta_{l} \cdot g$</td>
<td>kN</td>
<td>Lightship buoyancy</td>
</tr>
<tr>
<td>$\Delta_{1} \cdot g$</td>
<td>kN</td>
<td>Buoyancy of the ship in the worst loading condition with respect to GM or $GZ_m$</td>
</tr>
<tr>
<td>$\rho$</td>
<td>t/m³</td>
<td>Density</td>
</tr>
<tr>
<td>$g$</td>
<td>m/s²</td>
<td>Gravity</td>
</tr>
<tr>
<td>$\gamma$</td>
<td>kN/m³</td>
<td>Specific gravity ($\gamma = \rho \cdot g$)</td>
</tr>
<tr>
<td>$\mu$</td>
<td>m³/t</td>
<td>Specific volume</td>
</tr>
<tr>
<td>$A_k$</td>
<td>m²</td>
<td>Total overall area of bilge keels, or area of the lateral projection of the bar keel, or sum of these areas</td>
</tr>
<tr>
<td>$A_v$</td>
<td>m²</td>
<td>Windage area</td>
</tr>
<tr>
<td>$B$</td>
<td>m</td>
<td>Breadth of the ship at the summer load waterline</td>
</tr>
<tr>
<td>$C_B$</td>
<td>–</td>
<td>Block coefficient</td>
</tr>
<tr>
<td>$c_B$</td>
<td>–</td>
<td>Tank block coefficient</td>
</tr>
<tr>
<td>$D$</td>
<td>m</td>
<td>Depth, moulded</td>
</tr>
<tr>
<td>$d$</td>
<td>m</td>
<td>Draught up to summer load waterline</td>
</tr>
<tr>
<td>$d_{\text{min}}$</td>
<td>m</td>
<td>Draught for minimum ship loading condition</td>
</tr>
<tr>
<td>$GM_o$</td>
<td>m</td>
<td>Initial metacentric height without correction for free surfaces effect</td>
</tr>
<tr>
<td>$GM$</td>
<td>m</td>
<td>Initial metacentric height corrected for free surfaces effect</td>
</tr>
<tr>
<td>$GZ$</td>
<td>m</td>
<td>Arm of statical stability corrected for free surfaces effect</td>
</tr>
<tr>
<td>$GZ_m$</td>
<td>m</td>
<td>Maximum arm of statical stability corrected for free surfaces effect</td>
</tr>
<tr>
<td>$h_v$</td>
<td>m</td>
<td>Distance of centre of windage area above the corresponding waterline</td>
</tr>
<tr>
<td>$K$</td>
<td>–</td>
<td>Weather criterion</td>
</tr>
<tr>
<td>$k$</td>
<td>–</td>
<td>Factor allowing for effect of bilge keels</td>
</tr>
<tr>
<td>$KG$</td>
<td>m</td>
<td>Centre of gravity elevation above base line</td>
</tr>
<tr>
<td>$L$</td>
<td>m</td>
<td>Length of the ship as specified by the Rules</td>
</tr>
<tr>
<td>$l_o$</td>
<td>m</td>
<td>Arm of dynamical stability without correction for free surfaces effect</td>
</tr>
<tr>
<td>$l$</td>
<td>m</td>
<td>Arm of dynamical stability corrected for free surfaces effect</td>
</tr>
<tr>
<td>$l_{\text{max}}$</td>
<td>m</td>
<td>Ordinate of curve of dynamical stability at the angle of heel equal to angle of the maximum of statical stability curve or angle of flooding, whichever is lesser</td>
</tr>
<tr>
<td>$l_F$</td>
<td>m</td>
<td>Form arm with respect to the centre of buoyancy</td>
</tr>
<tr>
<td>$l_K$</td>
<td>m</td>
<td>Form arm with respect to the base line</td>
</tr>
<tr>
<td>$l_B$</td>
<td>m</td>
<td>Form arm with respect to metacentre</td>
</tr>
<tr>
<td>$l_F$</td>
<td>m</td>
<td>Form arm with respect to arbitrary pole</td>
</tr>
<tr>
<td>$M_C$</td>
<td>kN</td>
<td>Capsizing moment</td>
</tr>
<tr>
<td>$M_t$</td>
<td>kN</td>
<td>Heeling moment due to wind pressure</td>
</tr>
<tr>
<td>$M_{h1}$</td>
<td>kN</td>
<td>Heeling moment due to passenger crowding</td>
</tr>
<tr>
<td>$M_{h2}$</td>
<td>kN</td>
<td>Heeling moment due to turning</td>
</tr>
<tr>
<td>$M_{h3}$</td>
<td>kN</td>
<td>Heeling moment due to load shifting</td>
</tr>
<tr>
<td>$M_{h3,30}$</td>
<td>kN</td>
<td>Heeling moment due to liquid overflowing at ship's heel of 30°</td>
</tr>
<tr>
<td>$m_n$</td>
<td>kN</td>
<td>Correction of stability coefficient for liquid free surfaces effect in tanks</td>
</tr>
<tr>
<td>$P$</td>
<td>kN</td>
<td>Weight of inboard cargo</td>
</tr>
<tr>
<td>$p_v$</td>
<td>Pa</td>
<td>Specific calculated wind pressure</td>
</tr>
<tr>
<td>$q$</td>
<td>Pa, kPa</td>
<td>Calculated wind velocity head</td>
</tr>
<tr>
<td>$\theta$</td>
<td>degree</td>
<td>Angle of heel</td>
</tr>
<tr>
<td>$\theta_c$</td>
<td>degree</td>
<td>Capsizing angle</td>
</tr>
<tr>
<td>$\theta_v$</td>
<td>degree</td>
<td>Angle of vanishing stability</td>
</tr>
<tr>
<td>$\theta_h$</td>
<td>degree</td>
<td>Angle of coming out of water of bilge middle</td>
</tr>
<tr>
<td>$\theta_d$</td>
<td>degree</td>
<td>Angle of deck immersion</td>
</tr>
<tr>
<td>$\theta_2$</td>
<td>degree</td>
<td>Heeling angle of equilibrium during load lifting</td>
</tr>
</tbody>
</table>

Continued table

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Unit</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>$k$</td>
<td>–</td>
<td>Factor allowing for effect of bilge keels</td>
</tr>
<tr>
<td>$KG$</td>
<td>m</td>
<td>Centre of gravity elevation above base line</td>
</tr>
<tr>
<td>$L$</td>
<td>m</td>
<td>Length of the ship as specified by the Rules</td>
</tr>
<tr>
<td>$l_o$</td>
<td>m</td>
<td>Arm of dynamical stability without correction for free surfaces effect</td>
</tr>
<tr>
<td>$l$</td>
<td>m</td>
<td>Arm of dynamical stability corrected for free surfaces effect</td>
</tr>
<tr>
<td>$l_{\text{max}}$</td>
<td>m</td>
<td>Ordinate of curve of dynamical stability at the angle of heel equal to angle of the maximum of statical stability curve or angle of flooding, whichever is lesser</td>
</tr>
<tr>
<td>$l_F$</td>
<td>m</td>
<td>Form arm with respect to the centre of buoyancy</td>
</tr>
<tr>
<td>$l_K$</td>
<td>m</td>
<td>Form arm with respect to the base line</td>
</tr>
<tr>
<td>$l_B$</td>
<td>m</td>
<td>Form arm with respect to metacentre</td>
</tr>
<tr>
<td>$l_F$</td>
<td>m</td>
<td>Form arm with respect to arbitrary pole</td>
</tr>
<tr>
<td>$M_C$</td>
<td>kN</td>
<td>Capsizing moment</td>
</tr>
<tr>
<td>$M_t$</td>
<td>kN</td>
<td>Heeling moment due to wind pressure</td>
</tr>
<tr>
<td>$M_{h1}$</td>
<td>kN</td>
<td>Heeling moment due to passenger crowding</td>
</tr>
<tr>
<td>$M_{h2}$</td>
<td>kN</td>
<td>Heeling moment due to turning</td>
</tr>
<tr>
<td>$M_{h3}$</td>
<td>kN</td>
<td>Heeling moment due to load shifting</td>
</tr>
<tr>
<td>$M_{h3,30}$</td>
<td>kN</td>
<td>Heeling moment due to liquid overflowing at ship's heel of 30°</td>
</tr>
<tr>
<td>$m_n$</td>
<td>kN</td>
<td>Correction of stability coefficient for liquid free surfaces effect in tanks</td>
</tr>
<tr>
<td>$P$</td>
<td>kN</td>
<td>Weight of inboard cargo</td>
</tr>
<tr>
<td>$p_v$</td>
<td>Pa</td>
<td>Specific calculated wind pressure</td>
</tr>
<tr>
<td>$q$</td>
<td>Pa, kPa</td>
<td>Calculated wind velocity head</td>
</tr>
<tr>
<td>$\theta$</td>
<td>degree</td>
<td>Angle of heel</td>
</tr>
<tr>
<td>$\theta_c$</td>
<td>degree</td>
<td>Capsizing angle</td>
</tr>
<tr>
<td>$\theta_v$</td>
<td>degree</td>
<td>Angle of vanishing stability</td>
</tr>
<tr>
<td>$\theta_h$</td>
<td>degree</td>
<td>Angle of coming out of water of bilge middle</td>
</tr>
<tr>
<td>$\theta_d$</td>
<td>degree</td>
<td>Angle of deck immersion</td>
</tr>
<tr>
<td>$\theta_2$</td>
<td>degree</td>
<td>Heeling angle of equilibrium during load lifting</td>
</tr>
</tbody>
</table>

2020
### Continued table

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Unit</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \theta_d )</td>
<td>degree</td>
<td>Heeling angle of loss of stability, corresponding to the second intersection between heeling and righting arms</td>
</tr>
<tr>
<td>( \theta_{BC1} )</td>
<td>degree</td>
<td>Static angle of heel after spoil discharge</td>
</tr>
<tr>
<td>( \theta_{ip} )</td>
<td>degree</td>
<td>Amplitude of roll for round bilge ship</td>
</tr>
<tr>
<td>( \theta_2 )</td>
<td>degree</td>
<td>Amplitude of roll for ship with keels</td>
</tr>
<tr>
<td>( \theta_3 )</td>
<td>degree</td>
<td>Maximum amplitude of roll of a suction dredger with respect to statical inclination immediately after spoil is discharged from one side</td>
</tr>
<tr>
<td>( v_{08} )</td>
<td>knot</td>
<td>Turning speed assumed to be 80 per cent of full speed</td>
</tr>
<tr>
<td>( v_s )</td>
<td>knot</td>
<td>Speed of straight-line movement of a ship</td>
</tr>
<tr>
<td>( v_t )</td>
<td>m³</td>
<td>Tank volume</td>
</tr>
<tr>
<td>( l_t; b_t; h_t )</td>
<td>m</td>
<td>Tank overall length, breadth and height</td>
</tr>
<tr>
<td>( X_1; X_2; X_3; X_{1,2} )</td>
<td>–</td>
<td>Non-dimensional coefficient for determination amplitude of roll</td>
</tr>
<tr>
<td>( X_H )</td>
<td>m</td>
<td>Longitudinal distance between tow hook suspension point and centre of gravity of ship</td>
</tr>
<tr>
<td>( Y )</td>
<td>degree</td>
<td>Factor for determination of amplitude of roll</td>
</tr>
<tr>
<td>( y )</td>
<td>m</td>
<td>Cargo centre of gravity ordinate from centre line</td>
</tr>
<tr>
<td>( y_G )</td>
<td>m</td>
<td>Distance of the centre of gravity of the load from centre line of the ship</td>
</tr>
<tr>
<td>( Z_H )</td>
<td>m</td>
<td>Elevation of tow hook suspension point above moulded base plane</td>
</tr>
</tbody>
</table>