RUSSIAN MARITIME REGISTER OF SHIPPING

RULES
FOR THE CLASSIFICATION AND CONSTRUCTION OF SEA-GOING SHIPS

PART IV
STABILITY

Saint-Petersburg
Edition 2019

Rules for the Classification and Construction of Sea-Going Ships of Russian Maritime Register of Shipping have been approved in accordance with the established approval procedure and come into force on 1 January 2019.

The present edition of the Rules is based on the 2018 edition taking into account the amendments developed immediately before publication.

The unified requirements, interpretations and recommendations of the International Association of Classification Societies (IACS) and the relevant resolutions of the International Maritime Organization (IMO) have been taken into consideration.

The Rules are published in the following parts:

Part I "Classification";

Part II "Hull";

Part III "Equipment, Arrangements and Outfit";

Part IV "Stability";

Part V "Subdivision";

Part VI "Fire Protection";

Part VII "Machinery Installations";

Part VIII "Systems and Piping";

Part IX "Machinery";

Part X "Boilers, Heat Exchangers and Pressure Vessels";

Part XI "Electrical Equipment";

Part XII "Refrigerating Plants";

Part XIII "Materials";

Part XIV "Welding";

Part XV "Automation";

Part XVI "Structure and Strength of Fiber-Reinforced Plastic Ships";

Part XVII "Distinguishing Marks and Descriptive Notations in the Class Notation Specifying Structural and Operational Particulars of Ships";

Part XVIII "Common Structural Rules for Bulk Carriers and Oil Tankers". The text of the Part is identical to that of the IACS Common Structural Rules;

Part XIX "Additional Requirements for Structures of Container Ships and Ships, Dedicated Primarily to Carry their Load in Containers". The text of the Part is identical to IACS UR S11A "Longitudinal Strength Standard for Container Ships" (June 2015) and S34 "Functional Requirements on Load Cases for Strength Assessment of Container Ships by Finite Element Analysis" (May 2015).

Parts I — XVII are published in electronic format in Russian and English. In case of discrepancies between the Russian and English versions, the Russian version shall prevail.

Parts XVIII — XIX are published in electronic format in English only.

As compared to the 2018 edition, the present edition of the Rules contains the following amendments.

RULES FOR THE CLASSIFICATION AND CONSTRUCTION OF SEA-GOING SHIPS

PART IV. STABILITY

1. Chapter 1.4: para 1.4.1 has been amended to avoid repetition of the requirements contained in 3.8, Part II "Technical Documentation" of the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships;

para 1.4.2.1 has been amended;

para 1.4.7.7 (in the Russian version only) has been amended considering IMO resolution MSC.267(85) "International Code on Intact Stability".

2. Chapter 1.5: paras 1.5.2.2.2, 1.5.5 have been amended considering IMO resolution MSC.267(85) "International Code on Intact Stability";

in paras 1.5.13 and 1.5.14 the requirements have been specified.

3. Chapter 2.1: para 2.1.4.1 has been amended.

4. Chapter 3.3: para 3.3.7.1 has been amended;

paras 3.3.7.2 and 3.3.7.3 have been renumbered as paras 3.3.7.3 and 3.3.7.2 accordingly;

existing paras 3.3.7.2 (in the Russian version only) and 3.3.7.3 have been amended.

5. Chapter 3.5: para 3.5.10 has been amended.

6. Chapter 3.7: new paras 3.7.1.3 and 3.7.3.5 have been introduced considering IMO resolution MSC.415(97).

7. Chapter 3.8: para 3.8.4.7 has been deleted; para 3.8.4.8 has been renumbered as para 3.8.4.7;

paras 3.8.7.2, 3.8.7.3 have been amended in connection with exception of the requirement for the angle of vanishing stability.

8. Chapter 3.10: para 3.10.5 has been amended.

9. Chapter 4.1: new para 4.1.1.5 has been introduced considering IMO resolution MSC.415(97).

10. Chapter 4.2: para 4.2.1 has been amended.

11. APPENDIX 3 "IMO RESOLUTION MSC.415(97) REQUIREMENTS FOR THE STABILITY OF ANCHOR HANDLING VESSELS, TUGS, ESCORT TUGS, FLOATING CRANES AND CRANE SHIPS" has been introduced.

12. Editorial amendments have been made.

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PART IV. STABILITY

PART IV. STABILITY

1 GENERAL

1.1 APPLICATION

1.1.1 The requirements of the present Part apply to decked ships[1] sailing in displacement condition. As to sailing ships navigating under sails the requirements of the present Part apply to them as far as it is reasonable and practicable.

1.1.2 Unless expressly provided otherwise, the requirements of the present Part apply to ships in service as far as it is reasonable and practicable, but it is, however, compulsory for ships which undergo reconstruction, major repair, alteration or modification if their stability is impaired as a result.

Stability of ships under 24 m in length after reconstruction, major repair, alteration or modification shall comply either with the requirements of this Part or with the requirements applied to such ships before reconstruction, major repair, alteration or modification.

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

1.1.4 Based on technical background submitted by the designer, containing assessment of stability, seaworthiness, flooding and conditions of particular operational area, the values required by this Part may be reduced.

1.2 DEFINITIONS AND EXPLANATIONS

1.2.1 Definitions and explanations concerning the general terminology of the Rules are given in Part I "Classification".

For the purpose of the present Part the following definitions and explanations have been adopted.

Amplitude of roll is an assumed rated amplitude of roll.

Moulded depth is the vertical distance measured amidships from the top of plate keel or from the point where the inner surface of shell plating abuts upon the bar keel to the top of the beam of the uppermost continuous deck, i.e. of the deck below which the volume of the ship's hull is taken into account in stability calculations. In ships having a rounded gunwale, the moulded depth is measured to the point of intersection of moulded lines of the uppermost continuous deck and side, the lines extending so as if the gunwale were of angular design. If the uppermost continuous deck is stepped and the raised part of the deck extends over the point at which the moulded depth shall 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.

Hydrostatic curves are curves of the ship's lines plan particulars.

Wind pressure is an assumed rated pressure of wind.

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 the present Part for ship's stability.

Length of ship is the length as defined in the Load Line Rules for Sea-Going Ships.

Liquid cargoes 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.

Stores are fuel, fresh water, provision, oil, expendable supplies, etc.

Grain means 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.

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[1]In Section 1 of this Part the term "ship" also includes a floating crane, crane ship dock, transport pontoon and berth-connected ship, unless expressly provided otherwise.

B o o k l e t is Stability Booklet.

W e l l is an open space on the upper deck not longer than 30 % of the length of the ship, bounded by superstructures and a continuous bulwark provided with freeing ports.

H e e l i n g m o m e n t d u e t o w i n d p r e s s u r e is an assumed rated moment caused by wind pressure.

A m i d s h i p s is at the middle of the ship's length.

B u l k c a r g o is grain and non-grain cargo constituted by separate particles and loaded without packaging.

S u p e r s t r u c t u r e is a decked structure on the uppermost 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 greatest breadth of the ship. A raised quarter deck is regarded as a superstructure.

H o m o g e n e o u s c a r g o is cargo having constant stowage rate.

C a p s i z i n g m o m e n t is an assumed rated minimum heeling moment by which the ship is capsized.

O p e n i n g s c o n s i d e r e d t o b e o p e n 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 Section 7, Part III "Equipment, Arrangements and Outfit" as to their strength, weathertightness and efficiency. Small openings such as those for passing wires or chains, tackle and anchors, and also holes of scuppers, discharge and sanitary pipes shall 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 shall be assumed open if they can be considered a source of significant flooding.

D e c k t i m b e r c a r g o is a timber cargo carried on open parts of the freeboard deck or superstructure. The said term does not apply to the wood-pulp or similar cargo.

P a s s a g e is navigation of a ship outside the prescribed area of navigation.

V o y a g e is navigation of a ship belonging to the technical fleet within the prescribed area of navigation.

W i n d a g e a r e a is the projected lateral area of the above-water portion of the ship (except for a floating crane or crane ship) on the centreline with the ship in the upright position.

C o r r e c t i o n f o r f r e e s u r f a c e s is a cor-rection allowing for a decrease in the ship's stability due to the effect of free surfaces of liquid cargoes.

D e c k h o u s e is a decked structure on the upper deck or superstructure deck with its side plating, on one side at least, being inboard of the shell plating by more than 4 % of the greatest breadth of the ship measured amidships to the outside of frames and having doors, windows and other similar openings in external bulkheads.

S i s t e r s h i p s are ships built at the same yard according to the same drawings.

A s p e c i a l f a c i l i t y is a system permanently installed in the ship for rapid estimation of her initial stability (e.g. heeling tanks with angle-of-inclination indicators) and approved by the Register for measurement of angles of inclination during the inclining test.

L i g h t s h i p is a fully ready ship less deadweight. Water ballast is included in the deadweight.

A n g l e o f f l o o d i n g is the angle of heel at which the ship's interior spaces are flooded by water through openings considered to be open or openings which may be opened as required by operation conditions of the ship in working position.

U n i v e r s a l d i a g r a m is a diagram of ship's stability with a non-uniform scale of abscissae proportional to the heeling angle sines, a set of cross-curves of 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.

B r e a d t h o f s h i p is the maximum breadth measured on the summer load line from outside of frame to outside of frame in a ship with metal shell and to the outer surface of the hull in a ship with the shell of any other material.

Various symbols used in the present are given in the Table at the end of the present Part.

1.3 SCOPE OF SURVEY

1.3.1 General provisions pertaining to the procedure of classification and surveys, as well as the requirements for the technical documentation submitted to the Register for review and approval are contained in General Regulations for the Classification and Other Activity and in Part I "Classification".

1.3.2 For every ship subject to the requirements of the present Part, the Register shall carry out the following:

.1 prior to the commencement of ship's construction and conversion:

consideration and approval of technical documentation relating to ship's stability;

.2 during ship's construction, conversion and trials:

supervision of the inclining test and light-weight check;

consideration and approval of the Stability Booklet;

consideration and approval of Guidelines for Safe Ballast Water Exchange at Sea;

.3 during special surveys for the purpose of class renewal and after repair or modernization:

inspections to check for changes in the light-ship weight distribution in order to conclude whether the Stability Booklet is still applicable;

for passenger ships and fishing vessels, determination of light-ship weight experimentally and supervision of the inclining test and light-weight check.

1.4 GENERAL TECHNICAL REQUIREMENTS

1.4.1 All calculations shall be made by the methods generally accepted in naval architecture.

1.4.2 Calculation of cross-curves of stability.

1.4.2.1 For ships operating with permanent considerable initial trim, cross-curves of stability shall be calculated with due regard for this trim upon agreement with the Register.

Cross-curves of stability shall be calculated with due regard to the accompanying trim.

In the presence of port-starboard asymmetry (including deck spaces), the most unfavourable righting lever curve shall be used.

1.4.2.2 When calculating the cross-curves of stability, full account may be taken of those tiers of superstructure which:

.1 meet the requirements of 7.5, Part III "Equipment, Arrangements and Outfit" for the first tier of superstructure (counting from the freeboard deck); side scuttles as concerns the efficiency of their closures shall be in compliance with 7.2.1.3 to 7.2.1.5 of the said Part;

.2 have an access for the crew from the above deck to the working spaces inside these superstructures, as well as to the engine room by other means during the whole period when the openings in the superstructure bulkheads are closed.

If a midship bridge or poop complies with the requirements of 7.5, Part III "Equipment, Arrangements and Outfit", but the doors in their bulkheads provide the only exits to the deck, and the upper edge of the sills of the superstructure doors in a fully loaded ship immerses at a heeling angle less than 60°, the effective height of superstructures shall be assumed to be half their actual height and the superstructure doors assumed to be closed. If the upper edge of the door sills of a fully loaded ship immerses at a heeling angle equal to or over 60°, its effective height above the freeboard deck is taken to be its actual height.

1.4.2.3 When calculating the cross-curves of stability, account may also be taken of those tiers of deckhouse which:

.1 meet the requirements of 7.5, Part III "Equipment, Arrangements and Outfit" for the first tier of deckhouse (counting from the freeboard deck); side scuttles as concerns the efficiency of their closures shall be in compliance with 7.2.1.3 to 7.2.1.5 of the said Part;

.2 have an additional exit to the deck above.

With the aforesaid conditions satisfied, account is taken of full height of the deckhouses. If they meet the requirements of 7.5, Part III "Equipment, Arrangements and Outfit", but there is no additional exit to the deck above, such deckhouses shall not be taken into account in calculations of the cross-curves of stability, however, any deck openings inside such deckhouses are assumed as closed, irrespective of whether they are fitted with closures or not. The deckhouses whose closures do not comply with the requirements set forth in 7.5, Part III "Equipment, Arrangements and Outfit" shall not be considered in calculations of the cross-curves of stability. Any deck openings inside them are regarded as closed only if their coamings and means of closing comply with the requirements of 7.3, 7.7 to 7.10, Part III "Equipment, Arrangements and Outfit".

Deckhouses on decks above the freeboard deck shall not be taken into account when calculating the cross-curves of stability.

1.4.2.4 In ships with hatch covers meeting the requirements of Section 7, Part III "Equipment, Arrangements and Outfit", the volumes of hatches located on the freeboard deck may be taken into account.

1.4.2.5 The cross-curves of stability shall have a small-scaled scheme of superstructures and deckhouses taken into account, specifying the openings considered to be open.

The point shall be indicated in relation to which the cross-curves of stability are calculated.

1.4.3 Arrangement of compartments.

A drawing of watertight compartments 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 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 (refer to 3.1.2).

1.4.5 Arrangement of doors, companionways and side scuttles. Angle of flooding.

1.4.5.1 The arrangement plan of doors and companionways shall include all doors and companionways to exposed decks, as well as 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.

1.4.5.3 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 calculations of cross-curves of stability for each ship. Openings for ventilation of machinery spaces, openings for ventilation of passenger spaces and other openings, which shall be open to allow air inside the ship when navigating in rough weather, shall be assumed open even if fitted with weathertight covers.

1.4.6 Calculation of windage area of a ship (except for a floating crane or crane 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 centreline, 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 ship design makes the carriage of it possible.

For ships having auxiliary sails, the projected lateral areas of rolled up sails shall be taken into account separately according to the ship's profile plan and included in the total projected lateral area of the continuous surfaces.

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 be taken into account by increasing the total projected lateral area of continuous surfaces calculated for draught d_{min} by 5 % and the statical moment of this area by 10 % with respect to the base plane.

The projected lateral areas of discontinued surfaces of ships subjected to icing is taken into account by increasing the projected lateral area and its statical moment of continuous surfaces calculated for draught d_{min} under icing conditions by 10 and 20 % or 7,5 and 15 %, respectively, depending upon the ice weight allowance stated in 2.4. 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 container 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 approximate 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 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:

Filling factor	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 Table 1.4.6.2 depending upon the ratio z_0/b_0 where z_0 is the height of the point of shrouds fastening to the mast over the bulwark; b_0 is the distance between the shrouds at bulwark.

Table 1.4.6.2

Filling factors

z_0/b_0	3	4	5	6	7	8	9	10	11	12	13	14
Filling factors:												
no icing	0,14	0,18	0,23	0,27	0,31	0,35	0,4	0,44	0,48	0,52	0,57	0,61
icing	0,27	0,34	0,44	0,51	0,59	0,66	0,76	0,84	0,91	1,0	1,0	1,0

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., a flow coefficient shall be taken equal to 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 calculation.

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

1.4.6.3 The arm of windage area z for determining the heeling moment due to wind pressure in accordance with 2.1.4 shall be defined as a distance, in metres, between the centre of the windage area and the actual waterline plane 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 coordinates of the centre of gravity for a plane figure.

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

1.4.7 Calculation of the liquid cargo effect.

1.4.7.1 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.

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

Free surface effects for small tanks may be ignored under condition specified in 1.4.7.7

1.4.7.2 The tanks to be considered at determining the correction for free surfaces may be referred to one of the two categories, namely:

tanks with a permanent filling level (for example, cargo tank with liquid cargo, water ballast tank). Corrections for free surfaces shall be determined for actual filling level prescribed for each tank;

tanks with a variable filling level (for example, consumable liquids, such as fuel, oil, fresh water as well as liquid cargo and ballast at reception, consumption and transfer operations). Except for the cases stipulated in 1.4.7.4, corrections for free surfaces shall have the maximum values specified within the lower and upper filling boundaries of each tank, provided by the recommendations for ship's operation.

1.4.7.3 Tanks for every type of liquid cargo and ballast, in which according to the operational conditions may simultaneously be free surfaces, as well as anti-heeling tanks and tanks of roll stabilizing system regardless of the tanks categories shall be included in the number of tanks to be considered at calculation of the liquid cargo effect on stability. For consideration of the free surfaces effect, it is necessary to compile the design combination of single tanks or their combinations per each type of liquid cargo. It is necessary to select tanks, which have the maximum free surfaces effect, out of possible operational combinations of tanks per the separate types of liquid cargoes and ballast, or single tanks. The obtained design combination of tanks applies to all loading conditions, except docking, irrespective of the actual availability of free surfaces, including the ship with full stores. At that, angles of heel, for which the maximum corrections are determined, shall be selected with respect to the stability criteria applied to the ship (considering the requirements for subdivision, damage trim and stability, if applicable).

1.4.7.4 For a ship engaged in liquids transfer operation, correction for free surfaces at any stage of the operation may be determined for the actual filling level of the tank at a given stage of transfer.

1.4.7.5 Corrections to the initial metacentric height and the righting lever curve shall be calculated separately as follows.

1.4.7.5.1 Corrections to the initial metacentric height Δm_h shall be determined as a product of liquid cargoes densities by intrinsic transverse moments of inertia of free surfaces in tanks, calculated for a ship's position without heel in compliance with the categories of tanks specified in 1.4.7.2.

1.4.7.5.2 Corrections to the righting arms may be determined by one of two following methods depending on the rate of variation of a free surface area in a tank at inclination of a ship and on the stability reserve:

.1 correction calculation based on using the actual heeling moment due to the liquid flow in tanks for each angle of ship's heel under consideration;

.2 correction calculation based on using the intrinsic transverse moment of inertia of free surfaces in tanks for a ship's position without heel corrected for each angle of ship's heel θ under consideration by multiplying by $\sin\theta$.

1.4.7.6 The Stability Booklet shall contain only a method used for the calculation of corrections to the righting arms. If instructions on manual assessment of stability for a non-typical loading case provide for an alternative method, the instructions shall include an example of correction for free surfaces calculation with explanation of reasons of different results of manual correction calculation and of calculations by the adopted method.

1.4.7.7 The tanks complying with the following condition may not be included in the calculation

$$\Delta M_{30} < 0{,}01\Delta_{min}; \qquad (1.4.7.7\text{-}1)$$

for floating cranes, the tanks complying with the following condition may not be included in the calculation

$$\Delta M_{15} < 0{,}02\Delta_{min} \qquad (1.4.7.7\text{-}2)$$

where ΔM_{30}, ΔM_{15} = heeling moments due to liquids flow at angles of heel equal to 30° and 15°.

Aggregate correction ΔM_{15} for tanks not included in the calculation shall not exceed $0{,}05\Delta_{min}$. Otherwise, appropriate corrections shall be considered in the calculation.

Usual residues of liquids in emptied tanks shall not be considered in the calculations provided, that the total number of these residues shall not result in considerable increase of the free surfaces effect on ship's stability.

1.4.8 Loading conditions.

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

1.4.8.2 For the types of ships which are not covered by special provisions of Section 3, the loading conditions to be examined shall be as follows:

.1 ship in fully loaded condition with full stores;

.2 ship in fully loaded condition with 10 % of stores;

.3 ship without cargo, with full stores;

.4 ship without cargo, with 10 % of stores.

1.4.8.3 If the loading conditions anticipated in normal service of a ship as regards stability are less favourable than those listed in 1.4.8.2 or specified in Section 3, 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 weight.

1.4.8.5 In all cases of loading which might occur in the ship's service, except those specified in 1.4.8.2.1 and expressly provided in Section 3, the weight of ballast water may be included in the deadweight of the ship, where necessary.

1.4.9 Curves of stability.

1.4.9.1 Stability curves calculated with due allowance for the corrections of free surfaces shall be plotted for all loading conditions under consideration.

1.4.9.2 If there are openings considered to be open in the ship's sides, upper deck or superstructures through which water can penetrate inside the hull, the stability curves are considered effective up to the angle of flooding. At the inclinations of the ship exceeding the angle of flooding, the ship may be regarded to have entirely lost her stability and the curves of stability at this angle are cutting short.

1.4.9.3 If the spread of water coming to a superstructure through openings considered to be open is limited only by this superstructure or a part thereof, such superstructure or its part shall be considered as non-existent at the angles of heel exceeding the angle of flooding. In this case, the righting lever curve becomes stepped and that of dynamical stability broken.

1.4.10 Design data relating to stability checking and summary tables.

1.4.10.1 For ships under investigation, 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, heeling when turning as also that due to icing, etc.) shall be submitted to the Register for review.

1.4.10.2 For all design loading conditions, summary tables presenting the results of calculations of displacement, position of the centre of gravity, initial trim and stability, as well as summary tables of results of stability checking for the compliance with the requirements of the present Part shall be drawn up.

1.4.11 Requirements for Stability Booklet.

1.4.11.1 To provide adequate stability of ships in service, the Stability Booklet approved by the Register and containing the following data shall be issued for each ship:

.1 particulars of ship;

.2 information on how the ship conforms to stability criteria and directions based on the Register requirements for stability, to prevent the ship capsizing;

.3 recommendations concerning stability and other instructions for safe service;

.4 stability data for typical, predetermined loading conditions;

.5 advice and documents necessary to estimate trim and stability of the ship for any cases of full and partial loading which might occur in the ship's service.

The trim and stability of the ship shall be determined by calculation;

.6 instructions concerning the operation of cross-flooding arrangements.

The Stability Booklet shall be drawn up in accordance with the provisions of Appendix 1 to the present Part.

1.4.11.2 The Stability Booklet shall be compiled with regard to the ship's inclining test data.

For ships where the inclining test may be substituted by the light-weight check in compliance with 1.5.2.1, to be used in the Booklet are the light-ship displacement and longitudinal center of gravity derived from the light-weight check in conjunction with the light-ship vertical center of gravity derived from the inclining test.

For ships, whose light-ship properties deviation is within the limits specified in 1.5.2.2, to be used in the Booklet are the light-ship displacement and longitudinal center of gravity derived from the light-weight check in conjunction with the higher of either the lead ship's (previous sister ship's) vertical center of gravity or the calculated value.

For ships, whose light-ship properties deviation is within the limits specified in 1.5.3, to be used in the Booklet are the light-ship displacement and longitudinal center of gravity derived from the light-weight check in conjunction with the higher of either the light-ship vertical center of gravity derived from the inclining test prior to conversion or the design vertical center of gravity following the conversion.

For ships where inclining test may be omitted in compliance with 1.5.7, to be used in the Booklet are the light-ship displacement and longitudinal center of gravity derived from the light-weight check in conjunction with the light-ship vertical center of gravity determined according to 1.5.7. It shall be stated in the Booklet that the ship has been subjected to light-weight check instead of inclining test, and the light-ship vertical center of gravity has been calculated in compliance with 1.5.7.

1.4.11.3 Where bulk cargoes other than grain are carried, a special Booklet as per SOLAS regulation IV/7.2 (specifying the information on stability and strength during loading, unloading and stowage of bulk cargoes other than grain) shall be available on board, which shall be drawn in accordance with 1.4.9.7, Part II "Hull".

1.4.12 Requirements for onboard stability instrument.

Where the ship's trim and stability is determined using software, the latter shall be approved by the Register in accordance with the requirements of Section 12, Part II "Technical Documentation" of the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships; requirements relating to hardware are set out in Appendix 2, Part II "Hull" of these Rules.

Availability of the onboard software approved by the Register to control the ship's trim and stability shall not be a substitute for any section of the approved Stability Booklet.

The procedure of using software shall be specified in the User Manual for the onboard stability instrument. The Manual shall be written in the user native language and translated into English. The Manual shall contain a statement that the serviceability of the onboard stability instrument shall be checked by the crew prior to its use.

1.4.13 Requirements for the Guidelines for Safe Ballast Water Exchange at Sea.

When ships in service call ports which require ballast water exchange at sea in advance, they shall have the Guidelines for Safe Ballast Water Exchange at Sea developed according to the Instruction for the Development of Guidelines for Safe Ballast Water Exchange at Sea.

1.5 INCLINING TESTS AND LIGHT-WEIGHT CHECKS

1.5.1 To be inclined are:

.1 series-built ships as per 1.5.2;

.2 every ship of non-series construction;

.3 ships after major repair, alteration or modification as per 1.5.3;

.4 ships after installation of permanent solid ballast as per 1.5.4;

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

.6 passenger ships in service at intervals not exceeding five years if stipulated by 1.5.5.

.7 fishing vessels in service (of 30 m in length and less) at intervals not exceeding fifteen years and fishing vessels over 30 m in length if stipulated by 1.5.5.

1.5.2 Out of the series of ships under construction at each shipyard the following ships shall be inclined:

.1 the first ship, then every fifth ship of the series (i.e. sixth, eleventh, etc.). For other ships of the series, upon agreement with the Administration (for each particular ship), the inclining test may be substituted by the light-weight check in accordance with 1.5.14;

.2 a series-built ship if structural alterations therein compared with the first ship of the series, as shown by the calculation, result in:

.2.1 the changes of the light-ship displacement: for $L \leqslant 50$ m — exceeding 2 %, for $L \geqslant 160$ m — exceeding 1 % (for intermediate length — the acceptable deviation is determined by linear interpolation); or

.2.2 the deviation of the light-ship longitudinal centre of gravity exceeding 0,5 % of the length of the lead ship[1]; or

.2.3 the increase of the light-ship vertical centre of gravity exceeding simultaneously 4 cm (10 cm in the case of floating cranes and crane ships) and the value determined by the formulae:

$$\delta z_g = 0{,}1 \frac{\Delta_1}{\Delta_0} l_{max}; \qquad (1.5.2.2.3\text{-}1)$$

$$\delta z_g = 0{,}05 \frac{\Delta_1}{\Delta_0} h \qquad (1.5.2.2.3\text{-}2)$$

where Δ_0 = light-ship displacement, in t;
Δ_1 = ship's displacement under the most unfavourable loading condition as regards the value of h or l_{max}, in t;
l_{max} = maximum righting arm under the most unfavourable design loading condition as regards its value;
h = corrected metacentric height under the most unfavourable design loading condition as regards its value,

whichever is the less;

.2.4 violation of the requirements of the present Part for design loading conditions with $z_g = 1{,}2 z_{g2} - 0{,}2 z_{g1}$, where z_{g1} (z_{g2}) is design light-ship vertical centre of gravity prior to (after) structural changes; z_g is an assumed light-ship vertical centre of gravity.

Such ship shall be considered the first ship of a new series as regards stability, and the inclining test procedure of the subsequent ships shall comply with the requirements of 1.5.2.1.

1.5.3 After major repair, alteration and modification to be inclined are ships, in which structural changes, as shown by calculation, result in:

.1 change of load (total mass of load removed and added) by more than 6 % of the light-ship displacement; or

.2 change in the light-ship displacement by more than 2 % or 2 t, whichever is greater; or;

.3 the deviation of the light-ship longitudinal centre of gravity exceeding 1 % of the ship's subdivision length L_s; or

[1]For ships to which the requirements of Section 2, Part V "Subdivision" apply it is necessary to use the subdivision length as defined in Part V "Subdivision".

.4 increase in the light-ship vertical centre of gravity by more than the value obtained as per 1.5.2.2.3; or

.5 violation of the requirements of the present Part for design loading conditions as specified in 1.5.2.2.4.

If no inclining test is required upon results of the calculation, the light-weight check shall be carried out in accordance with 1.5.14.

Irrespective of the calculations submitted, the Register may require in compliance with 1.5.1.5 the inclining test of the ship to be performed, proceeding from the technical condition of the ship.

1.5.4 After installation of the permanent solid ballast each ship shall be inclined.

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

1.5.5 Light-weight check (experimental determination of the light-ship displacement and the longitudinal centre of gravity) shall be effected periodically for finding whether according to the 1.5.1.6 and 1.5.1.7 the inclining test is required for:

.1 passenger ships;

.2 fishing vessels over 30 m in length after 10 years in service from the date of build or last inclining test.

Light-weight check shall be carried out at intervals not more than five years.

If a change in the light-ship displacement by more than 2 % or in longitudinal centre of gravity by more than 1 % of the ship's length[1] as compared to the approved Stability Booklet is found out as a result of the light-weight check then the ship shall be inclined.

1.5.6 Where the inclining test results for the ship built show that the light-ship vertical centre of gravity exceeds design value to the extent that involves the violation of the requirements of the present Part, calculations with explanation of the reasons of such differences shall be attached to the Inclining Test Report.

Based on the investigation analysis of the documents submitted, or in case such documents are not available, the Register may require the repeated (check) inclining test of the ship to be performed. In this case, both Inclining Test Reports shall be submitted to the Register for review.

1.5.7 Except for the ships engaged on international voyages, at the shipowner's wish the Register may substitute the inclining test of a newly built ship by the light-weight check provided an increase of a light-ship vertical centre of gravity by 20 % as against the design value will not result in the violation of the requirements of the present Part.

If the light-weight check results show that the deviation of the light-ship displacement exceeds 2 % of the design value or the deviation of the light-ship longitudinal center of gravity exceeds 1 % of the ship's subdivision length L_s, the explanatory calculation of such difference shall be attached to the Light-Weight Check Report.

1.5.8 Ship's loading during the inclining test shall be as far as practicable close to the light-ship displacement. The mass of missing loads shall be not more than 2 % of the light-ship displacement, and the mass of surplus loads less inclining ballast and ballast according to 1.5.9, 4 %.

1.5.9 The metacentric 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 carefully pressed up.

1.5.10 To determine angles of inclination during the inclining test not less than three pendulums of at least 3 m in length shall be provided onboard. For ships under 30 m in length only two pendulums of at least 2 m in length may be used.

One or more pendulums may be substituted by other measuring devices approved by the Register.

1.5.11 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.

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[1]For passenger ships it is necessary to use the subdivision length as defined in Part V "Subdivision".

The inclining test shall be considered satisfactory performed, provided:

.1 for each measurement the following condition is fulfilled:

$$|h_i - h_k| \leqslant 2\sqrt{\frac{\Sigma(h_i - h_k)^2}{n-1}} \qquad (1.5.11.1)$$

where h_i = metacentric height obtained by individual measurement;
$h_k = \Sigma h_i/n$ 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.

No more than one measurement is excluded from the calculation;

.2 probable error of the test

$$t_{\alpha n}\sqrt{\frac{\Sigma(h_i - h_k)^2}{n(n-1)}}$$

fulfils the condition

$$t_{\alpha n}\sqrt{\frac{\Sigma(h_i - h_k)^2}{n(n-1)}} \leqslant 0{,}02(1 + h_k) \text{ if } h_k \leqslant 2 \text{ m}; \qquad (1.5.11.2\text{-}1)$$

and

$$t_{\alpha n}\sqrt{\frac{\Sigma(h_i - h_k)^2}{n(n-1)}} \leqslant 0{,}01(4 + h_k) \text{ if } h_k > 2 \text{ m}. \qquad (1.5.11.2\text{-}2)$$

Factor $t_{\alpha n}$ is taken from Table 1.5.11.2;

Table 1.5.11.2

Factor $t_{\alpha n}$

n	$t_{\alpha n}$	n	$t_{\alpha n}$
8	5,4	13	4,3
9	5,0	14	4,2
10	4,8	15	4,1
11	4,6	16	4,0
12	4,5		

.3 the following condition is fulfilled considering h and l_{max} under the most unfavorable design loading conditions:

$$t_{\alpha n}\sqrt{\frac{\Sigma(h_i - h_k)^2}{n(n-1)}}\,\frac{\Delta_0}{\Delta_1} \leqslant \varepsilon, \text{ where } \varepsilon = 0{,}05h \text{ or } 0{,}10 l_{max}, \qquad (1.5.11.3)$$

whichever is less, but not less than 4 cm;

.4 total number of satisfactory measurements is not less than 8.

1.5.12 Where the requirements of 1.5.11 are not fulfilled, the value of the metacentric height less the probable error of the test obtained as per 1.5.11.2 shall be taken for calculations.

1.5.13 The inclining test shall be performed in accordance with the Instructions on Inclining Test (refer to Appendix 5 to Section 2 of the Guidelines on Technical Supervision of Ships under Construction) in the presence of the RS surveyor.

1.5.14 The light-weight check shall be carried out in accordance with the Instructions on Inclining Test (refer to Appendix 6 to Section 2 of the Guidelines on Technical Supervision of Ships under Construction) in the presence of the RS surveyor.

The light-weight check is carried out with the aim to:

.1 determine the necessity of conducting the inclining test in accordance with 1.5.5;

.2 correct the Stability Booklet for ships of the series and after conversion as specified in 1.4.11.2;

.3 determine the light-ship properties of the ship exempted from the inclining test in accordance with 1.5.7.

1.6 CONDITIONS OF SUFFICIENT STABILITY

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

.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 Section 2;

.2 numerical values of the parameters of the righting lever 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;

.3 the effect of consequences of probable icing upon stability shall be taken into account in compliance with Section 2;

.4 stability of a ship shall comply with additional requirements of Section 3.

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

1.6.3 For ships to which the requirements of Part V "Subdivision" are applicable, the intact stability shall be sufficient to meet these requirements in damaged condition.

1.6.4 Stability of ships which have distinguishing mark for ships carrying equipment for fire fighting aboard other ships in their class notation shall be considered to be sufficient in the course of fire fighting operations, if in case when all the monitors operate simultaneously with the maximum supply rate in the direction corresponding to the minimum stability of the ship, the static heeling angle does not exceed 5°.

In determining the heeling moment, the vertical distance between the monitor axis and the midpoint of the mean draft is assumed to be the heeling lever. Where the ship is fitted with a thruster, the design heeling moment shall be increased by a value of the moment which occurs during operation of the thruster, in relation to the midpoint of the ship's draft.

1.6.5 When permanent restrictions on the area of navigation imposed on a ship are expanded or changed, the seaworthiness shall be additionally verified according to the risk assessment methodology for evaluation of loss of the ship's dynamic stability, specified in the Collection of Regulating Documents. Book Twenty Four, 2016.

1.7 PASSAGE OF SHIPS FROM ONE PORT TO ANOTHER

1.7.1 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.

1.7.2 The Register may permit the passage of a ship which stability cannot be raised up to that required by 1.7.1 provided that the weather restrictions correspond to its stability.

2 GENERAL REQUIREMENTS FOR STABILITY

2.1 WEATHER CRITERION[1]

2.1.1 The requirements for stability set forth in the present Part are differentiated depending upon the ship's area of navigation.

Definitions of restricted areas of navigation are given in 2.2.5, Part I "Classification".

2.1.2 Stability of ships of unrestricted service and of restricted areas of navigation **R1**, **R2**, **R2-RSN**, **R2-RSN(4,5)** and **R3-RSN** shall be considered sufficient as to weather criterion K, if the requirements of 2.1.2.5 are met under the assumed effects of wind and seas mentioned below, and:

.1 the ship is under the effect of a wind of steady speed and direction perpendicular to the ship's centerline, to which the lever l_{w1} of wind heeling moment corresponds (refer to Fig. 2.1.2.1);

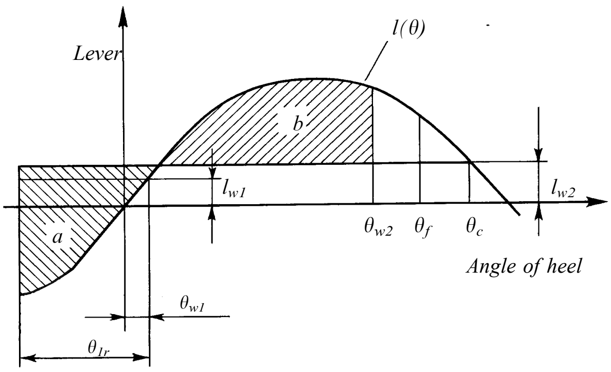


Fig. 2.1.2.1

.2 by the static heeling angle θ_{w1} resulting from steady wind and corresponding to the first point of intersection between the horizontal straight line l_{w1} and the curve of righting levers $l(\theta)$, the ship heels to the weather side under the effect of waves, to an angle equal to the roll amplitude θ_{1r} (refer to Fig. 2.1.2.1);

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

.4 the areas a and b are determined and compared, which are shaded in Fig. 2.1.2.1. The area b is formed by a righting lever curve $l(\theta)$, a horizontal straight line corresponding to the heeling lever l_{w2} and the heeling angle θ_{w2}=50°, or the angle of flooding θ_f or the heeling angle θ_c, corresponding to the second point of intersection between the straight line l_{w2} and the righting lever curve, whichever angle is less.

The area a is formed by the righting lever curve, straight line l_{w2} and heeling angle equal to $\theta_{w1} - \theta_{1r}$;

.5 the ship stability is considered sufficient by the weather criterion $K = b/a$, provided the area b is equal to or greater than the area a, i.e. $K \geqslant 1$.

2.1.3 The static heeling angle θ_{w1} due to steady wind shall not exceed 16° or an angle equal to 0,8 of the open deck edge immersion angle, whichever is less.

The requirements for the static heeling angle of timber carriers and container ships are given in 3.3 and 3.10.

2.1.4 Calculation of heeling lever due to wind pressure.

2.1.4.1 The heeling lever l_{w1}, in m, shall be adopted constant for all heeling angles and shall be determined by the formula

[1]When calculating the weather criterion, the results of model tests may be used carried out in compliance with the requirements of Interim Guidelines for Alternative Assessment of the Weather Criterion (refer to Collection of Regulating Documents, book eighteen, 2008).

$$l_{w1} = p_v A_v z_v / 1000 g\Delta \qquad (2.1.4.1\text{-}1)$$

where p_v = wind pressure, in Pa, to be determined from Table 2.1.4.1 proceeding from the area of navigation;
z_v = arm of windage area to be adopted equal to the vertical distance between the windage area centre A_v and the centre of the underwater hull lateral area projected on the centreline or, approximately, the half of the ship draught;
A_v = windage area, in m^2, to be determined in accordance with 1.4.6;
Δ = ship displacement, in t;
g = gravitational acceleration, equal to 9,81 m/s^2.

Table 2.1.4.1

Wind pressure p_v

Area of navigation	Assumed wind pressure p_v, in Pa	m
Unrestricted	504	0,5
Restricted **R1**	353	0,5
Restricted **R2**	252	0,52
Restricted **R2-RSN**	252	0,52
Restricted **R2-RSN(4,5)**	166	0,54
Restricted **R3-RSN**	119	0,55

The heeling lever l_{w2} shall be determined by the formula

$$l_{w2} = (1 + m) l_{w1} \qquad (2.1.4.1\text{-}2)$$

where m = wind gustiness addition.

2.1.4.2 For fishing vessels having a length between 24 and 45 m, the wind pressure value in Formula (2.1.4.1-1) may be ascertained from Table 2.1.4.2 proceeding from the distance Z between the windage area centre and the waterline.

Table 2.1.4.2

Z, in m	1	2	3	4	5	$\geqslant 6$
p_v, in Pa	316	386	429	460	485	504

2.1.4.3 Ships whose stability with respect to the weather criterion does not comply with the requirements for the ships of restricted area of navigation **R2**, may be allowed to operate as ships of restricted area of navigation **R3** with additional restrictions, taking into account the peculiarities of the area and the nature of service.

The requirements for stability of floating cranes and crane ships are stipulated in 4.1.

2.1.5 Calculation of roll amplitude.

2.1.5.1 The roll amplitude, in deg., for a round-bilged ship shall be determined by the formula

$$\theta_{1r} = 109 k X_1 X_2 \sqrt{rS} \qquad (2.1.5.1)$$

where k = factor taking into account the effects of bilge and/or bar keels and determined in accordance with 2.1.5.2; k shall be adopted equal to 1 where the keels are not mounted;
X_1 = dimensionless factor to be adopted from Table 2.1.5.1-1 proceeding from the breadth-to-draught (B/d) ratio;
X_2 = dimensionless factor to be adopted from Table 2.1.5.1-2 proceeding from the block coefficient $C_в$ of the ship;
r = $0{,}73 + 0{,}6(z_g - d)/d$, while r shall not be adopted greater than 1;
S = dimensionless factor to be adopted from Table 2.1.5.1-3 proceeding from the area of navigation and the roll period T to be determined by the formula

$$T = 2cB/\sqrt{h}$$

where $c = 0{,}373 + 0{,}023B/d - 0{,}043L_{wl}/100$;
h = metacentric height corrected for the effect of free surfaces of liquid cargoes;
L_{wl} = length of ship on the waterline.

Table 2.1.5.1-1

Factor X_1

B/d	$\leqslant 2{,}4$	2,6	2,8	3,0	3,2	3,4	3,5	3,6	4,0	4,5	5,0	5,5	6,0	$\geqslant 6{,}5$
X_1	1,00	0,96	0,93	0,90	0,86	0,82	0,80	0,79	0,78	0,76	0,72	0,68	0,64	0,62

Table 2.1.5.1-2

Factor X_2

$C_в$	$\leqslant$0,45	0,50	0,55	0,60	0,65	$\geqslant$0,70
X_2	0,75	0,82	0,89	0,95	0,97	1,00

Table 2.1.5.1-3

Factor *S*

Area of navigation	*T*, in s									
	$\leqslant$5	6	7	8	10	12	14	16	18	$\geqslant$20
Unrestricted	0,100	0,100	0,098	0,093	0,079	0,065	0,053	0,044	0,038	0,035
Restricted **R1, R2, R2-RSN, R2-RSN(4,5), R3-RSN**	0,100	0,093	0,083	0,073	0,053	0,040	0,035	0,035	0,035	0,035

2.1.5.2 For ships with bilge keels or bar keel, or both, the factor k shall be adopted from Table 2.1.5.2 proceeding from the $A_k/L_{wl}B$ ratio in which A_k denotes the total area, in m^2, of bilge keels or the lateral projected area of the bar keel, or the sum of both areas.

For **Arc4** to **Arc9** ice class ships, the bilge keels shall be ignored.

Table 2.1.5.2

Factor *k*

$A_k/L_{wl}B$,%	0	1,0	1,5	2,0	2,5	3,0	3,5	$\geqslant$4,0
k	1,00	0,98	0,95	0,88	0,79	0,74	0,72	0,70

2.1.5.3 When calculating the roll amplitude by Formula (2.1.5.1), coefficient k for sharp-bilged ships shall be adopted equal to 0,7.

2.1.5.4 The roll amplitudes of ships equipped with anti-rolling devices shall be determined without regard for the operation of the latter.

2.1.5.5 In Tables 2.1.5.1-1 — 2.1.5.2 the intermediate values shall be determined by linear interpolation. The calculated roll amplitude values shall be rounded to integer degrees.

2.1.5.6 The tables and formulas used in calculation of roll amplitude are obtained for ships having the following parameters: $B/d \leqslant 6{,}5$; $0{,}7 < z_g/d < 1{,}5$; $T \leqslant 20s$. For ships with parameters outside of the above limits the roll amplitude may be determined with model experiments according to the procedure described in Collection of Regulating Documents, book eighteen, 2008.

2.2 RIGHTING LEVER CURVE

2.2.1 The area under the righting lever curve shall not be less than 0,055 m·rad up to the heeling angle of 30° and not less than 0,09 m·rad up to the heeling angle of 40°, or up to the angle of flooding θ_f, whichever is the less. Additionally, the area between the heeling angles of 30° and 40°, or between 30° and θ_f, if $\theta_f < 40°$, shall not be less than 0,03 m·rad.

The maximum righting arm $l_{\max}$ shall be not less than 0,25 m for ships with $L \leqslant 80$ m and 0,20 m for ships with $L \geqslant 105$ m at the heeling angle $\theta_m \geqslant 30°$. For intermediate values of L, the arm value shall be determined by linear interpolation.

The angle corresponding to the maximum of the righting lever curve may be reduced to the value determined in accordance 2.2.2.

Where the righting lever curve has two maxima due to the influence of superstructures or deckhouses, the first maximum from the upright position shall occur at the angle of heel not less than 25°.

2.2.2 Ships with ratio $B/D > 2$ are allowed to navigate having the angle corresponding to the maximum righting arm, reduced as compared to that required under 2.2.1 by a value determined by the formula

$$\Delta\theta_{max} = 40^\circ \left(\frac{B}{D} - 2\right)(K - 1)0,5. \qquad (2.2.2)$$

Where $B/D > 2,5$ and $K > 1,5$, the ratio $B/D = 2,5$ and $K = 1,5$ shall be adopted. The value of $\Delta\theta_{max}$ shall be rounded off to the nearest integer.

2.2.3 A ship shall comply with the aforesaid requirements when the correction for free surfaces is taken into account in righting lever curves in accordance with the provisions of 1.4.7.

2.2.4 The angle of flooding shall be not less than 50°. For ships having a lesser angle the navigation may be permitted as for ships of restricted area of navigation depending upon the value of wind pressure endured when checking stability for compliance with the weather criterion.

2.2.5 The requirements for the righting lever curve of floating cranes and crane ships, refer to 4.1.

2.3 METACENTRIC HEIGHT

2.3.1 For all ships under all loading conditions, except for the light-ship condition, the value of corrected initial metacentric height shall be not less than 0,15 m.

The minimum corrected initial metacentric height may have other value in cases specified in Section 3.

2.3.2 Initial stability 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.

2.4 ALLOWANCE FOR ICING

2.4.1 For ships intended for winter navigation within winter seasonal zones set up by Load Line Rules for Sea-Going Ships, stability with due regard for icing, as specified in this Chapter, shall be checked in addition to the main loading conditions. In the calculation, account shall be taken of increase in displacement, height of the centre of gravity and windage area due to icing. The stability calculation under icing shall be carried out for the worst loading condition as to stability. When checking stability under icing, the mass of the ice is considered as an overload and is not included in the ship's deadweight.

When verifying the stability of floating cranes and crane ships, the allowance for icing shall be made in accordance with 4.1, and of timber carriers — in accordance with 3.3.7.

2.4.2 When determining the heeling and capsizing moments for ships navigating in winter seasonal zones to the north of latitude 66°30′ N and to the south of latitude 60°00′ S, as also in winter in the Bering Sea, the Sea of Okhotsk and in the Tatarski Strait, the assumed ice weight allowance shall be as specified in 2.4.3 and 2.4.4.

2.4.3 The mass of ice per square metre of the total area of horizontal projection of exposed weather decks shall be assumed to be 30 kg. 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 not taken into account separately.

For ships with framing fitted above open deck sections, allowance shall be made for an additional mass of ice having the thickness equal to the main framing height.

2.4.4 The mass of ice per square metre of the windage area shall be assumed to be 15 kg. In this case, the windage area and the height of the centre of gravity shall be determined for a draught d_{min}, as specified in 1.4.6, but without the allowance for icing.

2.4.5 In other areas of the winter seasonal zone, the ice weight allowance for winter time shall be assumed to be equal to half of those specified in 2.4.3 and 2.4.4.

2.4.6 The mass of ice and vertical moment calculated in compliance with 2.4.3 — 2.4.5 cover all loading conditions when drawing up the Booklet.

2.4.7 For the righting lever curves plotted with the allowance for icing the maximum righting arm for ships of restricted area of navigation shall be at least 0,2 m at an angle of heeling 25°.

2.4.8 For ships navigating in winter in the regions of the Black and Asov Seas northwards of the parallel of latitude 44°00′ N, as well as in the region of the Caspian Sea northwards of the parallel of latitude 42°00′ N the icing shall be taken into account in compliance with 2.4.5.

3 ADDITIONAL REQUIREMENTS FOR STABILITY[1]

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 condition, with full number of class and unberthed passengers and their effects, and full stores without liquid ballast;

.2 ship in the fully loaded condition, with the full number of class and unberthed passengers and their effects, but with 10 % of stores;

.3 ship without cargo, but with the full number of class and unberthed passengers and their effects and with full stores;

.4 ship in the same loading condition as in 3.1.1.3, but with 10 % of stores;

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

.6 ship in the same loading condition as in 3.1.1.5, but with 10 % of stores;

.7 ship in the same loading condition as in 3.1.1.2, but with 50 % of stores.

When checking stability for the compliance with the weather criterion, class passengers shall be assumed to be in their accommodation and unberthed passengers on their decks. The stowage of cargo in holds, 'tween decks and on decks is assumed as for normal service conditions of the ship. Stability with an allowance for icing shall be checked with no passengers on exposed decks.

3.1.2 The stability of passenger ships shall be such that in the eventual case of crowding of passengers to one side on the upper deck accessible for passengers, as near the bulwark as possible, the angle of static heel does not exceed 10°.

3.1.3 The angle of heel on account of turning shall not exceed 10°. In addition, the angle of heel on account of crowding of passengers to one side of the promenade decks normally at their disposal on turning shall not exceed 12°.

3.1.4 The heeling moment on turning circle, in kN·m, shall be determined by the formula

$$M_R = 0{,}20\frac{v^2 \cdot \Delta}{L_{wl}}\left(z_g - \frac{d}{2}\right) \qquad (3.1.4)$$

where v = ship's service speed, in m/s;
Δ = displacement, in t;
L_{wl} = length of ship on the waterline.

3.1.5 When calculating ship's stability on turning and for heeling caused by crowding of passengers to one side, no account shall be taken of wind and rolling effects.

3.1.6 When determining admissible distribution of passengers crowding to one side on their promenade decks, it shall 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.

3.1.7 When determining the area where crowding of passengers may be permitted, the passages between benches shall be included in the calculation with factor 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.

3.1.8 For the purpose of determination of the angle of heel caused by crowding of passengers to one side, the mass of each passenger shall be assumed to be 75 kg. The assumed density of distribution of passengers is 4 persons per square metre of the free area of the deck. The height of the centre of gravity for standing passengers shall be assumed equal to 1,0 m above the deck level (account may be taken, if necessary, of camber and sheer of deck) and that for sitting passengers 0,3 m above the seats.

[1]For additional requirements for ships under 24 m in length, refer to 3.9.

3.1.9 All calculations of the static heeling angle 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.

3.2 DRY CARGO SHIPS

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

.1 ship having a draught to the summer load line with homogeneous cargo filling cargo holds, 'tween decks, coaming spaces and trunks of cargo hatches, with full stores, but without liquid ballast;

.2 ship in the same condition as in 3.2.1.1, but with 10 % of stores and, where necessary, with liquid ballast;

.3 ship without cargo, but with full stores;

.4 ship in the same condition as in 3.2.1.3, but with 10 % of stores.

3.2.2 Where cargo holds of a ship in the loading conditions as under 3.2.1.3 and 3.2.1.4 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 ship's store tanks is taken into account in compliance with the provisions of 1.4.7 and that in holds with liquid ballast in accordance with their actual filling.

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

.1 ship having a draught to the summer load line (with regard to 3.2.1.1); with holds and 'tween decks filled by homogeneous cargo, with deck cargo, full stores and liquid ballast, if necessary;

.2 ship in the same loading condition as in 3.2.1.1, but with 10 % of stores.

3.2.4 The corrected initial metacentric height of ro-ro ships in the loaded condition, with icing disregarded, shall not be less than 0,2 m.

3.2.5 If, during stability verification, it is found out that the value of one of the parameters $\sqrt{h}/B$ and B/d, during stability verification, it is found out that the value of one of the parameters 0,08 and 2,5 respectively, the ship's stability shall be checked additionally on the basis of the acceleration criterion K^* in accordance with 3.12.3. In so doing, if the calculated acceleration value a_{cal} (in fractions of g) is in excess of the maximum permissible one, the ship operation under appropriate loading conditions may be allowed provided the restrictions given in Table 3.12.4 are observed.

In the case of a ship in the ballast condition no check of the acceleration criterion may be effected.

3.2.6 In transporting non-cohesive bulk cargoes like grain having an angle of repose less than or equal to 30° as specified in the International Maritime Solid Bulk Cargoes Code (IMSBC Code) the stability shall comply with the provisions of Rules for the Carriage of Grain and the requirements of the Administration.

3.2.7 Bulk carriers of less than 150 m in length shall be fitted with the onboard stability instrument complying with the requirements of 1.4.12.

3.3 TIMBER CARRIERS

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

.1 ship carrying timber cargo with a prescribed stowage rate (if stowage rate of timber cargo is not specified, the calculation of stability shall be made assuming μ=2,32 m^3/t) in holds and on deck and having a draught to the summer timber load line, without ballast (taking account of 3.2.1.1), with full stores;

.2 ship in the same loading condition as in 3.3.1.1, but with 10 % of stores and, where necessary, with liquid ballast;

.3 ship with timber cargo, having the greatest stowage rate specified, in holds and on deck, with full stores, without ballast;

.4 ship in the same loading condition as in 3.3.1.3, but with 10 % of stores and, where necessary, with liquid ballast;

.5 ship without cargo, but with full stores;

.6 ship in the same loading condition as in 3.3.1.5, but with 10 % of stores.

3.3.2 The stowage of timber cargo in timber carriers shall comply with the requirements of the Load Line Rules for Sea-Going Ships as well as with the provisions of the Stability Booklet or special instructions.

3.3.3 When calculating the cross-curves of stability for timber carrier, the volume of timber cargo on deck may be included in the calculation with full breadth and height and permeability of 0,25 corresponding to the stowed lumber.

3.3.4 The 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. The latter two values specify the permeability range for the stowed round timber where the larger log diameter corresponds to the higher permeability.

3.3.5 The corrected initial metacentric height of timber carriers shall be not less than 0,1 m all through the voyage with loading conditions as mentioned under 3.3.1.1 — 3.3.1.4, and not less than 0,15 m with loading conditions as mentioned in 3.3.1.5 and 3.3.1.6.

With loading conditions as mentioned under 3.3.1.1 — 3.3.1.4, the righting lever curve of timber carriers shall be in compliance with the following specific requirements:

the area under the righting lever curve shall not be less than 0,08 m·rad up to the heeling angle of 40°, or up to the angle of flooding θ_f, whichever is the less;

the maximum righting arm shall be not less than 0,25 m.

The static heeling angle due to steady wind shall not exceed 16°; criterion of 0,8 of the deck edge immersion angle is not applicable to timber carriers.

3.3.6 Stability calculations for a ship carrying deck timber cargo for the most unfavorable loading condition out of those specified in 3.3.1.1 — 3.3.1.4 shall be performed with regard to possible increase in mass of the deck timber cargo due to absorption of water.

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

3.3.7 Allowance for icing (ice accretion).

3.3.7.1 For ships carrying deck timber cargo, intended for operation in the areas where icing is required to be considered, as well as navigating in winter within winter seasonable zones stability calculations shall be carried out with regard to possible icing in accordance with 2.4.

3.3.7.2 In stability calculations the ice weight allowance for upper surface of the deck timber cargo shown in Fig. 3.3.7.2 is calculated according to 3.3.7.3. The ice weight allowance for the rest upper and side surface areas of deck timber cargo is taken in accordance with 2.4.

3.3.7.3 The ice accretion weight w, in kg/m^2, may be taken as follows:

$$w = 30\,\frac{2{,}3(15{,}2L - 351{,}8)}{l_{FB}} f_{tl} \frac{l_{bow}}{0{,}16L} \qquad (3.3.7.3)$$

where l_{FB} = freeboard height, in mm;
f_{tl} = timber and lashing factor = 1,2;
l_{bow} = length of bow flare region, to be taken as the distance from the longitudinal position at which the maximum breadth occurs on a water line located 0,5 m below the freeboard deck at side to the foremost point of the bow at that waterline.

3.3.8 If a timber carrier is used for the carriage of other kinds of cargo, its stability shall be checked in compliance with the provisions of Section 2 and 3.2. Cross-curves of stability shall be calculated taking no account of deck timber cargo.

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

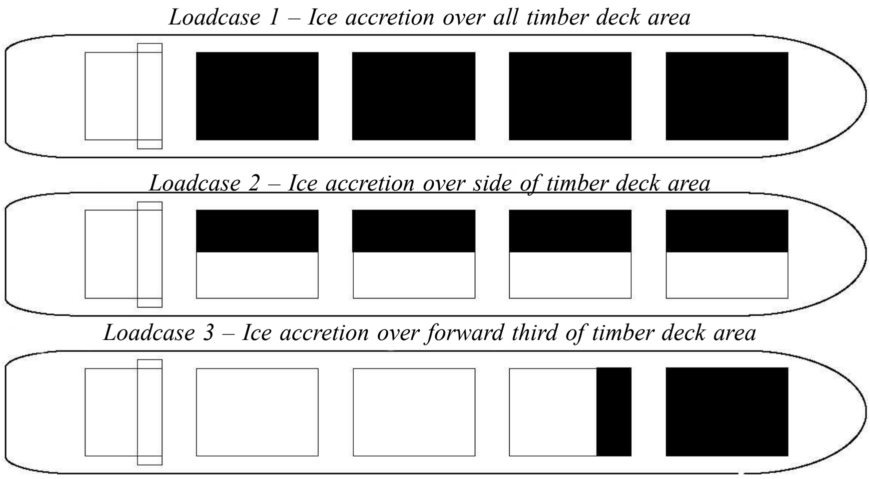


Fig. 3.3.7.2 Ice accretion load cases for timber deck cargoes

In case the stowage of deck timber cargo does not comply with 3.3.2 with respect to fulfillment of the requirements of Load Line Rules for Sea-Going Ships, the buoyancy of timber deck cargo shall not be taken into consideration in the calculations of stability, while the ship stability shall comply with the requirements of 2.1 — 2.3.

3.3.10 Double bottom tanks of timber carriers where fitted within the midship half-length of the ship shall have adequate watertight longitudinal subdivision.

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;

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

.3 ship without cargo, but with full stores;

.4 ship in the same loading condition as in 3.4.1.3, but with 10 % of stores.

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.

Where coamings are fitted on the open parts of the tanker's decks for prevention of cargo spillage forming an enclosed space (well), such space shall be considered as filled with sea water and it shall be taken into account in calculation of correction to the initial metacentric height.

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 without liquid ballast.

3.4.3 The requirements of 3.4.2 apply to oil recovery ships as well.

3.4.4 Stability of tankers having cargo tank or ballast tank breadths more than 60 % of the ship's breadth shall comply with the following additional requirements during cargo loading/unloading operations, including the intermediate stages thereof.

3.4.4.1 When the cargo loading/unloading operations are performed in port the corrected initial metacentric height shall be not less than 0,15 m and the extent of positive intact stability shall be not less than 20°.

3.4.4.2 When the cargo loading/unloading operations are performed at sea and on roadstead all requirements of this Part shall be met.

3.4.4.3 When determining correction for the effect of free surfaces of liquids an allowance shall be simultaneously made for maximum free surface effects in all cargo, ballast and consumable tanks.

3.4.4.4 If the requirements of 3.4.4.1 and 3.4.4.2 are not met, provided the requirements of 3.4.4.3 are complied with, instructions covering the operational restrictions to satisfy the said requirements shall be included into the Stability Booklet.

3.4.4.5 Instructions referred to in 3.4.4.4 shall be formulated with consideration for the following:

they shall be in a language understood by the crew member in charge of loading/unloading operations and shall be translated into English;

they shall not require more complicated mathematical calculations than those provided in the other sections of the Stability Booklet;

they shall indicate the list of cargo and ballast tanks which may simultaneously have free surfaces at any stage of loading/unloading operations;

they shall include typical versions of loading/unloading operations to satisfy the stability requirements under any loading condition specified in the Stability Booklet. The versions shall contain lists of cargo and ballast tanks which may simultaneously have free surfaces during various stages of loading/unloading operations;

they shall provide instructions necessary for independent pre-planning loading/unloading operations, including:

maximum heights of the ship's centre of gravity in graphical and/or tabular form which enables control of compliance with the requirements of 3.4.4.1 and 3.4.4.2;

the method of expeditious assessment of effect produced on the stability by the number of tanks which simultaneously have free surfaces at any stage of loading/unloading operations;

description of means available on board for control and monitoring loading/unloading operations from the viewpoint of the effects on stability;

the method used to monitor loading/unloading operations and to give early warning of possible impeding the stability criteria;

description of means available to suspend loading/unloading operations if the stability criteria are under the threat of being impeded;

information on the possibility and procedure of using shipboard computer and various automated systems to monitor loading/unloading operations (including systems of monitoring tank filling, shipboard computer software by which calculations of trim and stability are performed, etc.);

they shall provide for corrective actions to be taken in case of unexpected technical difficulties which can emerge in the course of loading/unloading operations and in case of emergency.

3.4.4.6 Provisions of the instructions formulated in accordance with 3.4.4.5 shall be specified in the Stability Booklet and also in the computer software available on board, by which trim and stability calculations are performed. A copy of the instructions shall be kept at the loading/unloading control station.

3.4.5 The requirements below are applied to oil tankers of deadweight 5000 and more. The requirements of 3.4.4 are not applicable to the above ships.

3.4.5.1 Each oil tanker shall comply with requirements set forth in 3.4.5.1.1 — 3.4.5.1.2 (considering instructions in 3.4.5.1.3 and 3.4.5.1.4) for any operation draught under the worst possible loading and ballasting conditions (in accordance with good operation practice) including intermediate stages of operations with liquids. Under all conditions it is considered that there is a free surface of liquid in ballast tanks.

3.4.5.1.1 At port the corrected initial metacentric height shall be not less than 0,15 m.

3.4.5.1.2 At sea:

.1 corrected initial metacentric height shall be not less than 0,15 m;

.2 the righting lever curve shall comply with the requirements of 2.2.1.

3.4.5.1.3 While calculating stability, each cargo tank is considered to be filled up to the level, at which the sum of the cargo volume moment in relation to the main plain and the inertia moment of free surface at the heel of 0° reaches its maximum. The density of cargo shall correspond to the available cargo deadweight at the displacement at which the transverse metacentre over the main plain reaches its minimum at 100 % of stores and 1 % of the total water ballast capacity. In calculations shall be accepted the maximum value of inertia moment of the liquid free surface in ballast tanks. In calculations of the initial metacentric height, the correction for free surface of liquids shall be based on the respective inertia moments of the free surfaces at upright ship position. The righting arms may be corrected on the basis of actual corrections for the free surface effect for each angle of heeling.

3.4.5.1.4 As an alternative to the loading condition specified by 3.4.5.1.3, stability is permitted to be checked at all possible combinations of cargo and ballast tank loading. In so doing, the following shall be suggested:

when making calculations, the mass, centre of gravity co-ordinates and heeling moments due to liquid overflow shall correspond to the real contents of all tanks;

the calculations shall be made considering the following assumptions:

the draughts shall be varied between the light-ship draught and scantling draught specified;

consideration shall be given to the ship loading conditions with consumables including but not restricted to fuel oil, diesel oil and fresh water corresponding to 97 %, 50 % and 10 % content;

for each draught, distribution and amount of the ship's consumables, the available deadweight shall comprise ballast water and cargo such that all combinations between the maximum ballast and minimum cargo and vice versa are covered. In all cases, the number of ballast and cargo tanks loaded shall be chosen to reflect the worst combination of centre of gravity applicate and correction for free surfaces from the stability standpoint. Operational limits on the number and list of tanks, simultaneously having free surfaces, or their exclusion are not permitted. All ballast tanks shall have at least 1 % content;

consideration shall be given to cargo densities between the lowest and highest values intended to be carried;

when checking all the combinations of the ship's loading, the interval of the parametric variation shall be such that the worst conditions from the stability standpoint shall be checked. A minimum of 20 intervals for the range of cargo and ballast content, between 1 % and 99 % of total capacity, shall be examined. More closely spaced intervals near critical parts of the range may be necessary.

3.4.5.2 Implementation of the requirements of 3.4.5.1 shall be ensured by design measures. For the combination carriers additional simple operation instructions may be allowed. This instructions shall:

.1 be approved by the Register;

.2 contain the list of cargo and ballast tanks which may have free surfaces during any operations with liquids and in the range of possible densities of cargo, still the above mentioned stability criteria are met;

.3 be easily understandable for the officer responsible for operations with liquids;

.4 provide possibility of planning the sequence of operations with cargo and ballast;

.5 enable to compare real stability figures with the required criteria presented in graphics and tables;

.6 do not require comprehensive mathematical calculations from the officer responsible for operations with liquids;

.7 contain instructions in respect of corrective actions to be fulfilled by the officer responsible for the operations with liquids in case of deviations from recommended figures and in case of accidents;

.8 be highlighted in the Stability Booklet and hang out in the cargo operations control station and put into the ship software performing stability calculations.

3.4.6 All oil tankers shall be fitted with a stability instrument, approved by the Register, capable of verifying compliance with intact and damage stability requirements.

3.5 FISHING VESSELS

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

.1 departure for fishing grounds with full stores;

.2 arrival at a 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;

.3 arrival at a port from fishing grounds with 20 % of catch in holds or on deck (if provision is made in the design for stowage of cargo on deck), 70 % of ice and salt rating and 10 % of stores;

.4 departure from fishing grounds with full catch and amount of stores ensuring the ship's draught up to the load line.

3.5.2 The amount of full catch is determined depending on the ship's type, capacity of cargo spaces and stability characteristics. It shall correspond to the load line position and shall be specified in stability calculations, as well as in the Booklet.

3.5.3 For net fishing vessels, allowance shall be made for wet fishing nets on deck loading conditions as in 3.5.1.2 — 3.5.1.4.

3.5.4 Stability of a ship, while being on fishing grounds, shall be checked for compliance with the weather criterion for the following loading conditions: a vessel engaged in fishing, with no catch in holds and the hatches of the holds open, catch and wet nets stowed on deck, 25 % of stores and full amount of ice and salt. For vessels where nets and catch are hauled in with the help of cargo booms, account shall also be taken of cargo which is hoisted, with the cargo weight equal to the boom safe working load. The amount of catch allowed to be stowed on deck shall be specified both in the vessel's design and the Booklet.

3.5.5 The ship's amplitude of roll in the loading condition specified in 3.5.4 is assumed to be 10° and the angle of heel at which the coaming of a cargo hatch immerses is regarded as the angle of the ship's flooding through openings considered open. Wind pressure in this loading condition for vessels of unrestricted service is assumed as that for ships of restricted area of navigation **R1**, the wind pressure for vessels of restricted area of navigation **R1** as that for ships of restricted area of navigation **R2**, the wind pressure for vessels of restricted area of navigation **R2** as that for these ships reduced by 30 %.

For ships having a length between 24 and 45 m, the initial wind pressure shall be adopted from Table 2.1.4.1.

3.5.6 For ships in the loading condition of 3.5.4 and for which the requirements for the righting lever curve limited by the angle of flooding cutting it short cannot be met, the heeling angle at which progressive flooding of fish holds may occur through hatches remaining open during fishing operations shall not be less than 20°.

3.5.7 The corrected initial metacentric height under the light ship loading condition, shall be not less than 0,05 m or 0,003*B*, whichever is the greater.

For single-deck ships, the corrected initial metacentric height shall not be less than 0,35 m. However, in case of ships with continuous superstructures and those which length exceeds 70 m, the corrected initial metacentric height may be reduced to 0,15 m.

3.5.8 Under all loading conditions, the ship's stability shall conform to 3.1.2 — 3.1.5, 3.1.7 — 3.1.9 where the ships are used for processing fish and other living resources of the sea and have a crew on board of more than 12 persons engaged in catching and processing only. From the point of the above requirements the crew members in question are regarded as passengers.

3.5.9 In the case of icing the parameters of the righting lever curve shall be in conformity with 2.2.

3.5.10 If the catch is carried in bulk, it is considered as liquid cargo. The effect of liquid cargo is taken into account in compliance with the requirements of 1.4.7.

3.5.11 Stability of sea fishing vessels of less than 24 m in length shall be checked with regard to the requirements set out in 3.9 of this Part of the Rules and Part IV "Stability and Freeboard" of the Rules for the Classification and Construction of Small Sea Fishing Vessels.

3.6 SPECIAL PURPOSE SHIPS

3.6.1 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 shall be checked for the following loading conditions:

.1 ship with special personnel, full stores, and full cargo of tare and salt on board;

.2 ship with special personnel, 10 % of stores, and full cargo of its production on board;

.3 ship in the same loading condition as in 3.6.1.2, but with 20 % of production and 80 % of tare and salt on board;

.4 ship in the same loading condition as in 3.6.1.1, but with 25 % of stores and the cargo being processed on board.

3.6.2 The stability of research, expeditionary, hydrographic, training and similar ships shall be checked for the loading conditions below:

.1 ship with special personnel and full stores on board;

.2 ship in the same loading condition as in 3.6.2.1, but with 50 % of stores on board;

.3 ship in the same loading condition as in 3.6.2.1, but with 10 % of stores on board;

.4 ship in the same loading conditions as in 3.6.2.1 — 3.6.2.3, but with full cargo on board if the carriage of the latter is envisaged.

3.6.3 The stability of special purpose ships shall be in accordance with 3.1.2 — 3.1.5, 3.1.7 — 3.1.9. From the point of view of the above requirements special personnel shall be regarded as passengers.

3.6.4 For special purpose ships that are similar to supply vessels, the requirements for the righting lever curve may be reduced, as stated in 3.11.5.

3.6.5 For whale factory ships, fish factory ships and other ships used for processing the living resources of the sea, the requirements of 3.5.7 concerning the initial metacentric height apply.

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 3.5.9 for the righting lever curve in the case of icing apply.

3.7 TUGS[1]

3.7.1 General.

3.7.1.1 Stability of tugs shall be checked for the following loading conditions:

.1 ship with full stores;

.2 ship with 10 % of stores and for tugs provided with cargo holds, additionally;

.3 ship with full cargo in holds and full stores;

.4 ship with full cargo in holds and 10 % of stores.

3.7.1.2 In addition to compliance with the requirements of Section 2, the tugs shall have sufficient dynamic stability to withstand the heeling effect of an assumed transverse jerk of the tow line under the same loading conditions, that is the angle of dynamic heeling θ_{d1} due to assumed jerk of the tow line shall not exceed the limits given below.

3.7.1.3 To confirm sufficient stability of tugs intended for harbour, coastal or ocean-going towing operations, the checking may be done in compliance with the requirements specified in Section 2, Appendix 3.

3.7.2 Tugs for harbour and coastal towing operations.

3.7.2.1 The angle of dynamic heel for tugs shall not be greater than the angle of flooding or capsizing, whichever is less.

To meet this requirement, the following condition shall be satisfied:

$$K_1 = \sqrt{l_{d\,caps}/l_{d\,h}} \geqslant 1{,}00 \qquad (3.7.2.1)$$

where $l_{d\,caps}$ = arm of dynamical stability defined as an ordinate of the dynamic stability curve for a tug at the angle of heel equal to the angle of flooding (refer to 3.7.2.3) or capsizing θ_{caps} determined disregarding roll, whichever is less, in m;

$l_{d\,h}$ = dynamic heeling arm characterizing the assumed jerk effect of the tow line, in m.

[1]Stability requirements for escort tugs — refer to Section 2, Part XVII "Distinguishing Marks and Descriptive Notations in the Class Notation Specifying Structural and Operational Particulars of Ships".

3.7.2.2 The dynamic heeling arm l_{dh}, in m, shall be determined by the formula

$$l_{dh} = l'_v \left(1 + 2\frac{d}{B}\right)\frac{b^2}{(1+c^2)(1+c^2+b^2)} \qquad (3.7.2.2\text{-}1)$$

where l'_v = the height of the velocity hydraulic pressure head, in m. The values of l'_v are obtained from Table 3.7.2.2 depending on the power N_e of the ship's main engines;

Table 3.7.2.2

Height of velocity hydraulic pressure head l'

N_e, in kW	l' in m	N_e, in kW	l' in m
0 — 150	0,0862	900	0,147
300	0,0903	1050	0,18
450	0,096	1200	0,22
600	0,104	1350	0,268
750	0,122	1500 and over	0,319

$$c = 4{,}55 x_H / L; \qquad (3.7.2.2\text{-}2)$$

$$b = \frac{(z_H/B) - a}{e} \qquad (3.7.2.2\text{-}3)$$

where a and e are determined by the formulae:

$$a = \frac{0{,}2 + 0{,}3(2d/B)^2 + \frac{z_g}{B}}{1 + 2\frac{d}{B}}; \qquad (3.7.2.2\text{-}4)$$

$$e = 0{,}145 + 0{,}2\frac{z_g}{B} + 0{,}06\frac{B}{2d}. \qquad (3.7.2.2\text{-}5)$$

3.7.2.3 When checking stability of tugs for the tow line jerk effect, the angle of flooding shall be determined assuming that all doors leading to engine and boiler casings and to the upper deck superstructures, as well as the doors of all companionways to the spaces below the upper deck, irrespective of their design, are open.

3.7.2.4 When checking stability of tugs for the tow line jerk effect, no account shall be taken of icing and free surfaces of liquid cargoes.

3.7.2.5 If special appliances are available for shifting the towline downwards or abaft, with the tow line athwartships, the point of tow line passage through such appliances may be accepted as the towing hook suspension point.

3.7.3 Tugs for ocean-going towing operations.

3.7.3.1 The angle of heel for tugs due to the tow line jerk under rolling shall not exceed the angle corresponding to the maximum of the righting lever curve or the angle of flooding, whichever is less.

To satisfy this condition the following requirement shall be met:

$$K_2 = \sqrt{l_{d\,\max}/l_{dh}} - \Delta K \geqslant 1{,}0 \qquad (3.7.3.1\text{-}1)$$

where $l_{d\max}$ = ordinate of the dynamical stability curve at an angle of heel corresponding to the maximum of the righting lever curve or the angle of flooding, whichever is less, in m·rad;

l_{dh} = dynamic heeling arm determined in compliance with 3.7.2.2, with l'_v assumed to be 0,20 m;

ΔK = component of K_2 used to allow for the effect of rolling on resultant angle of heel and determined by the formula

$$\Delta K = 0{,}03\theta_{2r}\left[\frac{1+c^2}{b} - \frac{1}{e}\left(a - \frac{z_g}{B}\right)\right]\sqrt{\frac{h_0}{1+2\frac{d}{B}}} \qquad (3.7.3.1\text{-}2)$$

where $\theta_{2r} = k\theta_{1r}$, in deg.;

k, θ_{1r} = determined in compliance with 2.1.5;

c, b, a, e = are determined in accordance with 3.7.2.2.

The requirements of 3.7.2.3 are not applicable to tugs for ocean-going towing operations.

3.7.3.2 When checking stability of tugs:

.1 the requirement of 3.7.2.5 is valid;

.2 for righting lever curves with two maxima or an extended horizontal region, the value of the angle at the first maximum or that corresponding to the middle of the horizontal region shall be taken as the angle of maximum specified in 3.7.3.1;

.3 stability for the tow line jerk effect shall be checked taking no account of the free surfaces of liquid cargoes.

3.7.3.3 When checking stability of tugs for compliance with the requirements of Section 2 and this Chapter, the ice weight allowance are assumed to be:

.1 for tugs specially designed for salvage operations, twice as much those given in 2.4;

.2 for other tugs, in accordance with 2.4.

3.7.3.4 Where a tug for ocean-going towage may be used for harbor or coastal towing operations, its stability shall comply with the requirements of 3.7.2.

3.7.3.5 To confirm sufficient stability of anchor handling vessels, the checking may be done in compliance with the requirements specified in Section 1, Appendix 3.

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 Zone 1 — coastal zone up to 20 miles from the coast;

.2 Zone 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 shall 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 3.8.2.1.1, 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 3.8.2.2.1, but with 10 % of stores.

For hopper dredgers equipped with grab cranes additional loading conditions, such as 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 due regard to initial heel shall be considered. These conditions shall be considered for a vessel with 10 % of stores and full stores, both with spoil and without it.

N o t e s : 1. The mass of spoil in the grab is taken to be $1,6V$ t where V is the volume of the grab, in m^3.

2. The quantity of spoil in the hopper and the position of the centre of gravity shall 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 being secured for sea;

.2 vessel in the same loading condition as in 3.8.2.3.1, but with 10 % of stores.

N o t e . 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 $2V$ t where V is the full volume of the bucket, in 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 3.8.2.4.1, but with 10 % of stores.

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

N o t e s : 1. Spoil pipeline within the 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 $1,6V$ t where V is the volume of the grab (bucket), in m^3.

3.8.3 Calculation of cross-curves of stability and inclining test.

3.8.3.1 When calculating cross-curves of 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, Part III "Equipment, Arrangements and Outfit".

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 shall be calculated having regard to the area of navigation prescribed to the vessel concerned. To be stated both in the specification and in the Stability Booklet are the conditions of voyages, if any (ballast water available, extent to which the dredging gear is dismantled, the position of the ladder, the possibility of spoil transportation in the hopper beyond the limits of 20-mile coastal zone, etc.). The dredgers equipped with a ladder may undertake voyages in the unrestricted area of navigation only with the bucket chain dismantled.

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

.1 in Zone 1 wind pressure shall be taken: for vessels of unrestricted service as for ships of restricted area of navigation **R1**; for vessels of restricted area of navigation **R1** as for this area, but reduced by 25 %; for other areas of navigation, as for restricted area of navigation **R2**; amplitude of roll, as for restricted areas of navigation;

.2 in Zone 2 wind pressure and amplitude of roll shall be taken in accordance with area of navigation prescribed for the vessel concerned.

3.8.4.3 Amplitude of roll of the dredgers shall be determined in compliance with 2.1.5.

For restricted areas of navigation **R1** and **R2**, the amplitude of roll determined by the Formula (2.1.5.1) shall be multiplied by factor X_3, the value of which is taken from Table 3.8.4.3.

For hopper dredges and hopper barges having bottom recesses for flaps factor X_1 is adopted from Table 2.1.5.1-1 for the ratio B/d, multiplied by coefficient $(\nabla+\nabla_v)/\nabla$, where ∇ is the volume displacement of the vessel with no regard to bottom recess, in m^3; ∇_v is the volume of bottom recess, in m^3.

Table 3.8.4.3

Factor X_3

$\sqrt{h_0/B}$	0,04	0,05	0,06	0,07	0,08	0,09	0,1	0,11	0,12	0,13	0,14	0,15	0,16	0,17	0,18	0,19	0,2
X_3	1,27	1,23	1,16	1,08	1,05	1,04	1,03	1,02	1,01	1,0	1,0	1,01	1,03	1,05	1,07	1,10	1,13

3.8.4.4 Stability of dredgers and hopper dredgers equipped with grab cranes when additional loading conditions (refer to 3.8.2.2) are considered shall meet the requirements of 4.1.

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 the conditions specified in 3.8.2.2.1 and 3.8.2.2.2:

.1 where the spoil in the hopper has a density less than 1,3 t/m^3 with the amplitude of roll of 10° with regard to the static heeling angle equal to the sum of the static heeling due to spoil discharge θ_{sp} and the static heeling resulting from steady wind θ_{w1} in accordance with 2.1.2.2;

.2 where the spoil in the hopper has a density equal to, or more than 1,3 t/m^3, with due regard to the dynamic character of discharge, with an amplitude of roll equal to the sum of 10° and the amplitude of vessel's rolling θ_{3r} with respect to static heeling which, in its turn, is equal to the sum of heeling due to spoil discharge θ_{sp} and the heeling resulting from steady wind θ_{w1} in accordance with 2.1.2.2.

The value of θ_{3r}, in deg., is determined by the formula

$$\theta_{3r} = 0{,}2\theta_{sp}. \qquad (3.8.4.5.2)$$

3.8.4.6 Transverse centre of gravity y_g, in m, when discharging half the spoil from one side out of fully loaded hopper, is determined by the formula

$$y_g = Py/(2\Delta) \qquad (3.8.4.6\text{-}1)$$

where P = total mass of spoil in the hopper, in t;
y = transeverse centre of gravity of spoil discharged from one side, in m;

$$\Delta = \Delta_{max} - P/2 \qquad (3.8.4.6\text{-}2)$$

where Δ_{max} = vessel's displacement prior to spoil discharge, in t.

3.8.4.7 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 lever of statical and dynamical stability is determined for the constant displacement and position of the spoil centre of gravity in the hopper;

.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 lever of statical and dynamical stability is 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 com-munication with sea water, that is flaps or valves are open. The lever of statical and dynamical stability is 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 centreline 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 centreline.

3.8.7 Righting lever curve.

3.8.7.1 The righting lever curve of hopper dredgers and hopper barges during voyages and under working conditions shall meet the requirements of 2.2.

3.8.7.2 The maximum righting lever of dredgers equipped with bucket ladder for all loading conditions specified in 3.8.2, as well as when taking account of icing, for vessels:

operating in Zone 1 — shall be not less than 0,25 m;

during voyages, passages and when operating in Zone 2 — shall be not less than 0,4 m;

at a heeling angle θ_{max} shall be $\geqslant 25°$.

3.8.7.3 For dredgers equipped with bucket ladder with B/D > 2,5, angle θ_{max} may be reduced as compared to that required under 3.8.7.2 by the value $\Delta\theta_{max}$ calculated according to the following formula depending on *B/D* ratio and the weather criterion *K* and provided that every 1° reduction accounts for increase of l_{max} by 0,01 m in relation to the normative value:

$$\Delta\theta_{max} = \frac{25°(B/D - 2{,}5)(K - 1)}{2} \qquad (3.8.7.3.1)$$

where *B/D* > 3,0, *B/D* = 3,0 shall be assumed, and where *K* > 1,5, *K* = 1,5 shall be assumed.
The value of $\Delta\theta_{max}$ is rounded to the integer.

For dredgers of unrestricted area of navigation, the reduction of angle θ_{max} is not permitted.

3.9 SHIPS UNDER 24 M IN LENGTH

3.9.1 When determining the cross-curves of stability, it is possible to take into consideration deckhouses of the first tier only which conform to 1.4.2.3.1 and from which there is either an additional exit to the deck above or exits to both the sides.

3.9.2 Stability as to weather criterion shall not be checked. However, for the operation of the ships, restrictions on the distance to the port of refuge and the sea state shall be introduced.

For small ships, restrictions on the area and conditions of navigation shall be set down and included in the Stability Booklet:

.1 for ships of less than 15 m in length and passenger ships of less than 20 m in length restricted area of navigation **R3** may be prescribed.

For ships 15 — 20 m in length, other than passenger ships, an area of navigation not higher than **R2** may be prescribed.

For ship 20 — 24 m in length, other than passenger ships, an area of navigation not higher than **R1** may be prescribed;

.2 non-passenger ships of less than 15 m in length may proceed to sea and be en route at sea state not more than 4, ships 15 — 20 m in length — not more than 5; ships 20 — 24 m — not more than 6;

.3 passenger ships of less than 20 m in length may proceed to sea and be en route at sea state not more than 3; ships 20 — 24 m — not more than 4;

.4 having regard to stability and seaworthiness of ships and depending on the reliable provision of the area of navigation concerned with forecasts, as well as on the operating experience for ships of similar type and the same or approximately the same dimensions, available for this area of navigation, the Register may change the restrictions on the area of navigation and permissible sea state specified in 3.9.2.1 — 3.9.2.3;

.5 when determining maximum permissible sea state for small craft carried on depot ships (for example, small fishing boats carried on mother ships), in addition to the provisions of 3.9.2.2 and 3.9.2.3, maximum sea state at which the craft can be safely lifted on board the depot ship shall be taken into account;

.6 additional restrictions may be introduced in zones of special sea conditions.

Referred to such zones are:

zones of surf (breaking) waves;

zones of local abrupt increase in wave height and steepness (bars in estuaries, tossing, etc.).

Zones of special sea conditions are set on the basis of the data of local hydrometeorological and hydrographic offices.

3.9.3 The angle of flooding shall be not less than 40°.

3.9.4 The righting lever curve of a fishing vessel, when on fishing grounds, under the loading conditions stated in 3.5.4 may not conform to the requirements of 2.2.1 for the maximum arm. Under those loading conditions, the maximum righting arm shall be not less than 0,2 m.

3.9.5 Under all loading conditions, the corrected initial metacentric height shall be not less than 0,5 m, except for the light-ship condition (refer to 2.3.1) and the fishing vessels when under loading conditions stated in 3.5.4 for which it shall be not less than 0,35 m.

3.9.6 The initial stability of fishing vessels hauling in the nets and catch with cargo booms shall be sufficient (under loading conditions stated in 3.5.4 as well) to ensure that the static heel angle of the ship when handling the nets and operating the cargo boom at its maximum outreach would not exceed 10° or the angle at which the deck is immersed (whichever is less).

3.9.7 Operation of the ships under conditions of eventual icing shall not, in general, be permitted.

Where due to the mode of operation and purpose the possibility of sailing into regions where icing might occur cannot be completely rulled out for a ship, the values of initial metacentric height and other parameters of righting lever curves drawn taking icing into consideration shall not be less than those stated in 2.2, 3.9.3 and 3.9.5.

3.9.8 The Stability Booklet shall include indications of the permissible speed and angle of rudder shifting in turning. The permissible values of initial turning speed and angle of rudder shifting shall be determined by tests during acceptance trials of the leading ship assuming that the list of the ship in steady turning shall not exceed:

.1 for non-passenger ships, the angle at which the freeboard deck is immersed or 12°, whichever is less;

.2 for passenger ships, taking account additionally of the effect of the simulated heeling moment due to passengers crowding to one side (to be determined in accordance with 3.1.2), the angle at which the freeboard deck is immersed or 15°, whichever is less.

The Register may apply the provisions of 3.9.8.2 to the stability of non-passenger ships (for instance, when persons not belonging to the ship's crew are on board).

The requirements of 3.1.3 and 3.1.4 are not applicable to ships of less than 24 m in length.

3.9.9 The initial stability of passenger ships shall be checked for conformity with 3.1.2. The angle of heel due to passengers crowding to one side shall not be greater than the angle corresponding to 0,1 m freeboard before the deck is immersed or 12°, whichever is less.

If necessary, the Register may apply the requirements of 3.1.2 to the stability of non-passenger ships (for instance, when persons are on board who are not members of the regular crew). In this case, the heel is determined on the assumption that all persons crowd to one side who are not engaged in handling the ship.

3.9.10 In the Stability Booklet it shall be specified that when the ship is under way in following seas, with the wave length equal to, or exceeding the length of the ship, its speed v, in knots, shall not be greater than determined by the formula

$$v = 1{,}4\sqrt{L} \tag{3.9.10}$$

where L = length of the ship, in m.

3.10 CONTAINER SHIPS

3.10.1 In calculating stability of container ships, the vertical centre of gravity position of each container shall be taken equal to half the height of the container of the type concerned.

3.10.2 Stability of container ships shall be checked for the following loading conditions:

.1 ship with maximum number of containers, each loaded container having the mass equal to one and the same part of the maximum gross mass for each type of containers, with full stores at the draught up to the summer load line;

.2 ship in the same loading condition as in 3.10.2.1, but with 10 % of stores;

.3 ship with maximum number of containers, each loaded container having the mass equal to 0,6 of the maximum gross mass for each type of containers, with full stores;

.4 ship in the same loading condition as in 3.10.2.3, but with 10 % of stores;

.5 ship with containers, each loaded container having the mass equal to the maximum gross mass for each type of containers, with full stores at the draught up to the summer load line;

.6 ship in the same loading condition as in 3.10.2.5, but with 10 % of stores;

.7 ship with maximum number of empty containers, but with full stores;

.8 ship in the same loading condition as in 3.10.2.7, but with 10 % of stores;

.9 ship with no cargo, but with full stores;

.10 ship in the same loading condition as in 3.10.2.9, 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 shall be considered.

3.10.3 If other loading conditions different from those listed in 3.10.2 are provided in the technical assignment, stability calculations shall also be made for such conditions with full stores and 10 % of stores.

3.10.4 Stability of container ships for any loading condition with containers shall be such that a heeling angle on steady turning or under the effect of continuous beam wind as determined from the statical stability curve does not exceed half the angle at which the freeboard deck immerses; in any case, the heeling angle shall not exceed 16°.

Where the deck cargo of containers is located on cargo hatch covers only, the angle at which the hatch coaming edge or a container 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).

3.10.5 The heeling moment on steady turning, in kN·m, is determined by the formula

$$M_R = 0{,}2 \frac{v_0^2 \cdot \Delta}{L_{wl}} \left(z_g - \frac{d}{2}\right) \tag{3.10.5}$$

where v_0 = ship's operational speed, in m/s;
Δ = displacement, in t.

3.10.6 The moment lever due to wind pressure used to determine the heeling angle according to 3.10.4 shall be determined by Formula (2.1.4.1-1) in which p_v is taken equal to that for ships of unrestricted service given in Table 2.1.4.1.

3.10.7 All calculations of statical heeling angle under the effect of beam wind or turning shall be made with no regard for icing, but having regard for the free surface effect of liquid cargoes as required by 1.4.7.

3.10.8 Where the requirement of 3.10.4 to the value of the angle of heel at steady turning of a ship at operational speed cannot be complied with, the Stability Booklet shall contain the maximum permissible ship's speed prior to steady turning, determined at a condition of not exceeding the angle of heel specified in 3.10.4.

3.10.9 Container ships shall be equipped with tanks or other specific facilities approved by the Register, which permit to check the initial stability of the ship, bearing in mind the Register approved requirements for the in-service inclining test.

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

Where, acting in line with 3.10.2.1 and 3.10.2.5, it is not possible to load the ship to the summer load line the ship may be considered for the relevant loading conditions at the maximum draught possible.

3.11 SUPPLY VESSELS

3.11.1 The requirements of this Chapter apply to supply vessels.

3.11.2 The stability of supply vessels shall be checked considering the trim that accompanies the inclination.

3.11.3 In addition to the loading conditions listed in 1.4.8.2, the stability of supply vessels shall be checked for the following loading conditions:

.1 ship with full stores and full deck cargo having the greatest volume per weight unit, prescribed by the technical assignment in the most unfavourable case of distribution of the rest of the cargo (when pipes are carried as deck cargo — taking the water entering the pipes into consideration);

.2 ship in the same loading condition as under 3.11.3.1, but with 10 % of stores.

3.11.4 The volume of water V_a lingering in the pipes carried on deck shall be determined by Formula (3.11.4) proceeding from the total volume of the pipe pile V_{at} and the ratio of the freeboard amidships l_{FB} to the ship's length L

$$V_a = \begin{cases} 0{,}3V_{at}, & \text{if } \dfrac{l_{FB}}{L} \leqslant 0{,}015; \\ \left(0{,}5 - \dfrac{40\, l_{FB}}{3L}\right)V_{at}, & \text{if } 0{,}015 < \dfrac{l_{FB}}{L} \leqslant 0{,}03; \\ 0{,}1V_{at}, & \text{if } \dfrac{l_{FB}}{L} > 0{,}03. \end{cases} \quad (3.11.4)$$

The volume of a pipe pile shall be regarded as the sum of the inner volumes of the pipes and spaces between them.

Where the pipes are plugged or where the pipe pile is higher than 0,4 of the draught, the design value for the volume of water in the pipes may be reduced. Such reduction shall be calculated by the designer and submitted to the Register for review.

3.11.5 The requirements of 2.2.1 may be replaced by the following:

.1 the area under the righting lever curve shall be not less than 0,07 m·rad up to the heeling angle corresponding to the maximum of the righting lever curve θ_{max}, when θ_{max}=15° and not less than 0,055 m·rad, when the angle corresponding to the maximum of the righting lever curve $\theta_{max} \geqslant 30°$.

For intermediate values of θ_{max}, the area under the righting lever curve, in m·rad, shall be determined by the formula

$$A_{max} = 0{,}055 + 0{,}001(30° - \theta_{max});$$

.2 the area under the righting lever curve between the heeling angles of 30° and 40°, or, when $\theta_f < 40°$, between 30° and θ_f shall be not less than 0,03 m·rad;

.3 the righting lever shall be at least 0,20 m at a heeling angle $\theta \geqslant 30°$;

.4 the angle corresponding to the maximum of righting lever curve shall be not less than 15°.

3.11.6 When the effect of icing is computed, the upper surface of the deck cargo shall be considered as the deck, and its lateral area projection above the bulwark — as a part of the design windage area. The ice weight allowance shall be assumed in accordance with 2.4.

3.11.7 For 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 by the formula

$$M_{ice} = \sum_{i=1}^{k} m_{ice_i}\, n_i \quad (3.11.7)$$

where m_{ice_i} = mass of ice per one pipe, obtained from Table 3.11.7;
n_i = quantity of pipes of the i-th diameter;
k = number of standard pipe sizes with regard to diameter.

When calculating the mass of ice on the outer surfaces of a pipe pile, the area of the upper and the side surfaces shall be determined taking the curvature of the pipe surface in the pile into consideration. The ice weight allowance is adopted in accordance with 2.4.

3.11.8 A minimum freeboard at the stern of at least 0,005L shall be maintained in all operating conditions.

3.11.9 Supply vessels which may be engaged in towing operations as well shall comply with 3.7.

Besides, arrangements for quick releasing of the tow line shall be provided on board.

3.11.10 Supply vessels which may be engaged in operation of lifting the anchors of mobile offshore drilling units as well shall comply with the requirements of 4.1.

Table 3.11.7

Pipe diameter, in m	0,05	0,1	0,2	0,3	0,4	0,5	0,6
Ice mass per one pipe, in kg	0,2	2,1	26,7	125	376	899	1831
Note. For pipes of intermediate diameters, the mass of ice is determined by interpolation.							

3.11.11 The requirements of the present Chapter are applicable to other types of vessels fit for carrying pipes as deck cargo.

3.12 SHIPS OF RIVER-SEA NAVIGATION

3.12.1 Stability of ships of river-sea navigation (restricted areas of navigation **R2-RSN**, **R2-RSN(4,5)** and **R3-RSN** according to 2.2.5, Part I "Classification") shall meet the requirements of Sections 1 and 2, as well as additional requirements of Section 3 (depending on the purpose of the ship).

Besides, the stability of dry cargo ships shall be checked by acceleration criterion in compliance with 3.12.3.

3.12.2 The stability of dry cargo ships of the restricted area of navigation **R2-RSN** shall be checked for the loading conditions listed in 3.2, as well as for the case of holds partly filled with heavy cargoes (ore, scrap metal, etc.) at the draught to the load line.

3.12.3 The stability as concerns the acceleration criterion K^* is considered satisfactory if in the loading condition under consideration the calculated acceleration (in fractions of g) does not exceed the permissible value, i.e. the following condition is fulfilled:

$$K^* = 0{,}3/a_{cal} \geqslant 1 \qquad (3.12.3)$$

where a_{cal} = calculated value of acceleration (in fractions of g) determined by the formula

$$a_{cal} = 0{,}0105 \frac{h_0}{c^2 B} k_\theta \theta_{1r}$$

where θ_{1r} = calculated amplitude of roll determined in accordance with 2.1.5, in deg.;
c = inertia coefficient determined in accordance with 2.1.5.1;
h_0 = initial metacentric height regardless of the correction for the liquid cargo free surfaces;
k_θ = coefficient, taking account of the peculiarities of roll for ships of river-sea navigation, adopted from the Table 3.12.3.

Table 3.12.3

Coefficient k_θ

B/d	$\leqslant 2{,}5$	3,0	3,5	4,0	4,5	5,0	5,5	6,0	$\geqslant 6{,}5$
k_θ	1,0	1,08	1,11	1,11	1,20	1,30	1,45	1,56	1,61

3.12.4 In case of the ship's operation with the the critetion $K^* < 1$, an additional wave height restriction shall be introduced. The permissible wave height with 3 % probability of exceeding level is estimated proceeding from the value of the criterion K^* as given in Table 3.12.4. The specific loading conditions with $K^* < 1$ shall be stated in the Stability Booklet.

Table 3.12.4

K^*	1,0 — 0,75	0,75 and less
Permissible wave height with 3 % probability of exceeding level, in m	5,0	4,0

4 REQUIREMENTS FOR THE STABILITY OF FLOATING CRANES, CRANE SHIPS, TRANSPORT PONTOONS, DOCKS AND BERTH-CONNECTED SHIPS

4.1 FLOATING CRANES AND CRANE SHIPS[1]

4.1.1 General.

4.1.1.1 The requirements of the Chapter cover floating cranes and crane ships for which the hook load mass exceeds 0,02Δ, in t, under one type of loading conditions at least, as stipulated in 4.1.3.1, or at least one of the following conditions is met:

$$|y_g| > 0{,}05h; \qquad (4.1.1.1\text{-}1)$$

or

$$|x_g - x_c| > 0{,}025H. \qquad (4.1.1.1\text{-}2)$$

Compliance with the requirements of the Chapter may be demanded by the Register even where the above conditions are not met.

4.1.1.2 As far as unique (single-time, episodical) cargo-handling operations are concerned, particular requirements for the stability of floating cranes and crane ships may be omitted or lowered, if a project of the operations is developed and it is demonstrated that special technical and organizational measures have been taken to avoid certain dangerous situations (load drop, etc.).

4.1.1.3 The design centre of gravity position of the load on the hook shall be assumed at the point of its suspension from the boom. If cargo-handling operations are carried out using a compound catenary suspension, i.e. two hooks (bifilar suspension), three hooks (trifilar suspension), etc., or the crane structure has an anti-swaying device, or the movement of suspended cargo is limited within the considered range of the floating crane/crane ship inclination angles, the stability shall be verified bearing in mind the actual shift of the cargo mass centre at inclination.

Boom radius is the distance between a vertical line drawn through the cargo suspension point with the floating foundation in the upright position and trimmed on an even keel, and determined up to:

axis of the slewing crane structure rotation;

axis of rotation joint of the non-slewing crane structure boom.

For non-slewing crane structures intended for boom operation in the longitudinal plane, the stability shall be verified with regard for the possibility of unsymmetrical loading on the hooks.

4.1.1.4 The requirements of this Chapter apply to other types of ships equipped with cranes or booms which meet the requirements specified in 4.1.1.1. When the ship's stability is verified in compliance with the requirements of Sections 2 and 3, the verification of stability as per 4.1.9 is not required.

4.1.1.5 To confirm sufficient stability of ships covered by the provisions of this Chapter, the checking may be done in compliance with the requirements specified in Section 1, Appendix 3.

4.1.2 Design conditions:

.1 working condition (cargo-handling operations and carriage of cargo in the assigned area of navigation and with the boom not secured for sea);

.2 voyage (navigation and lay-up within assigned area of navigation including both with cargo on deck and/or in hold and with the boom secured for sea);

.3 non-working condition (lay-up in port with machinery out of operation under the most unfavourable loading conditions in respect of stability and with the boom positions when there is no load on the hook);

.4 passage (navigation outside the assigned area of navigation after conversion on the basis of the RS-approved project).

[1]Relevant paragraphs of the Chapter contain precise instructions concerning the applicability of the paragraphs to both floating cranes and crane ships, exclusively to floating cranes or exclusively to crane ships respectively. In the absence of such instructions in the paragraph headings and texts, the requirements will be equally applicable to floating cranes and crane ships.

4.1.3 Loading conditions.

4.1.3.1 Under working condition stability shall be verified without regard for icing and with liquid ballasting where necessary, for the following loading conditions:

.1 maximum hook load with the maximum jib radius for the load at the specified slewing angle of the crane structure φ with regard to the centreline of the floating crane/crane ship:

with full load and full stores;

with full load and 10 % of stores;

without load and with full stores;

without load and with 10 % of stores;

.2 no hook load, highest position of the crane structure boom at the specified slewing angle of the boom φ:

with full load and full stores;

with full load and 10 % of stores;

without load and with full stores;

without load and with 10 % of stores;

.3 load drop, i.e. a quick release of the crane structure boom from the load suspended from the hook. In case of load drop, to be verified are the most unfavourable loading conditions with regard to stability, taking into consideration the possibility of unsymmetrical cargo stowage on deck and/or in the hold.

4.1.3.2 During a voyage the stability shall be verified (taking up liquid ballast where necessary) for the following loading conditions:

with full load and full stores;

with full load and 10 % of stores;

without load and with full stores;

without load and with 10 % of stores.

Where a deck cargo of hollow structures or pipes is carried, the mass of water therein shall be considered assuming the caves in the structures (taking account of their possible icing) and the pipes to be filled with water, in accordance with 3.11.4 and 3.11.7.

4.1.3.3 Under non-working condition stability shall be verified for the most unfavourable loading conditions with regard to stability out of those mentioned under 4.1.3.1.2.

4.1.3.4 For floating cranes/crane ships engaged in winter traffic in winter seasonal zones established by the Load Line Rules for Sea-Going Ships, stability during a voyage/passage and under non-working condition shall be verified with due regard for icing and for the most unfavourable loading conditions as regards stability out of those mentioned under 4.1.3.1.2 and 4.1.3.2. In this case, the ice weight allowance shall be adopted in accordance with 4.1.7.

4.1.4 Stability curves calculation.

The arms of stability curves can be calculated taking into account the hook load immersing in water during the inclinations of the floating crane/crane ship.

4.1.5 Calculation of windage area.

4.1.5.1 The designed windage area component A_{vi}, in m^2, is:

.1 a projected area restricted by the outline of a structure, item of machinery, arrangement, etc. in the case of bulk structures, deck machinery, arrangements, etc.;

.2 a projected area restricted by the structure outline with apertures between girders deducted, in case of a lattice type structure;

.3 projected area of fore beam where the beam spacing is less than the fore beam height, in the case of the structure of a boom, crane body frame, etc. comprising several beams of equal height located one after another (refer to Fig. 4.1.5.1.3); or

total projected area of the fore beam plus 50 % of the areas of subsequent beams, if the beam spacing is equal to, or greater than, the beam height, but is not less than the double height of the beam; or

total projected area of all beams, if the beam spacing is equal to, or greater than, the beam double height.

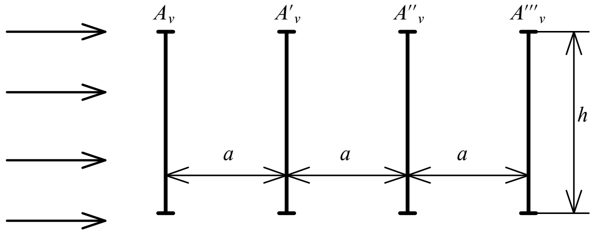


Fig. 4.1.5.1.3:
$a < h$: $A_{vi} = A_v = A'_v = A''_v = A'''_v$;
$h \leqslant a < 2h$: $A_{vi} = A_v + 0{,}5(A'_v + A''_v + A'''_v)$;
$a \geqslant 2h$: $A_{vi} = A_v + A'_v + A''_v + A'''_v$

If the beams are not equal in height, parts of subsequent beams not overlapped by those lying in front of them shall be fully taken into account;

.4 for a number of ropes of the same diameter arranged one after another at the distance a (refer to Fig. 4.1.5.1.4-1), the projected area shall be determined by the formula

$$A_{vi} = A_v \frac{1 - K_a^N}{1 - K_a} \qquad (4.1.5.1.4\text{-}1)$$

where A_v = projected area of a single rope;
N = number of ropes;
K_a = factor to be taken from Table 4.1.5.1.4 on the basis of the a/d_r relationship (where d_r is the rope diameter).

Table 4.1.5.1.4

Factor K_a

a/d_r	3	4	5	6	7	8	9	10	20	30	40	50
K_a	0,444	0,492	0,531	0,564	0,592	0,616	0,638	0,657	0,780	0,844	0,883	0,909

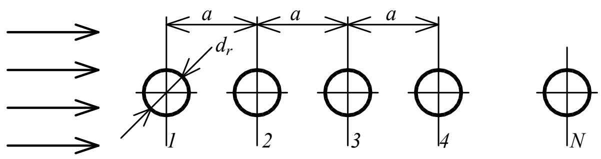


Fig. 4.1.5.1.4-1

Where the angle α between the rope axis and the wind velocity vector is not equal to 90° (refer to Fig. 4.1.5.1.4-2)

$$A_{vi} = A_v \sin^2\alpha \qquad (4.1.5.1.4\text{-}2)$$

shall be adopted.

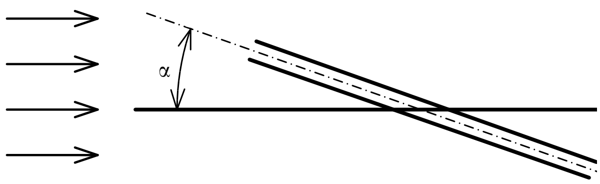


Fig. 4.1.5.1.4-2

4.1.5.2 The design arms of windage area z_w, z'_w, in m, shall be determined by the formulae:
under the effect of constant wind

$$z_w = \frac{\Sigma k_i n_i A_{vi} z_i}{\Sigma k_i n_i A_{vi}}; \qquad (4.1.5.2\text{-}1)$$

under the effect of squall

$$z'_w = \frac{\Sigma k_i A_{vi} z_i}{\Sigma k_i A_{vi}} \qquad (4.1.5.2\text{-}2)$$

where i = number of the windage area component A_{vi};
z_i = elevation of the centre of gravity of area component A_{vi} above waterline, in m;
k_i = aerodynamic flow coefficient for component A_{vi};
n_i = zone coefficient for component A_{vi}.

The values of A_v, z_w, z'_w may be determined taking trim into consideration.

4.1.5.3 For some windage area components, the aerodynamic flow coefficients k_i are given in Table 4.1.5.3.

Table 4.1.5.3

Aerodynamic flow coefficient k_i

Windage area components	k_i
Trusses and continuous beams	1,4
Above-water part of the hull, superstructures, deckhouses, rectangular cabins, balance weights of crane structure and other box structures with smooth outside surfaces	1,2
Isolated truss structures (crane, boom) made of:	
beams	1,5
tubular components	1,3
Tubular structures (depending on the product of the calculated dynamic wind velocity head q, in Pa, and by the square of the tube diameter d_p, in m) at:	1,2
$qd_p^2 \leqslant 10$ N;	1,2
$qd_p^2 \geqslant 15$ N.	0,7
Cargo ropes at:	
$d_r \leqslant 20$ mm;	1,2
$d_r > 20$ mm.	1,0
Deck machinery and small items on deck	1,4
Cargo (if no data are available for substantiated flow coefficient)	1,2

Notes: 1. The dynamic wind velocity head q is related to the wind pressure p by the ratio $p = k_i q$ where k_i is the aerodynamic flow coefficient.
2. For intermediate values of qd_p^2, the k_i values shall be determined by linear interpolation.
3. The values of k_i for structural elements not specified in the Table shall be assumed equal to 1,5.
4. The value of q corresponds to the design condition of the floating crane/crane ship under consideration according to Table 4.1.8.6-1 or Table 4.1.10.2.

4.1.5.4 The height (zone) coefficient $n_i = (V_{hi}/V_v)^2$ with regard to the increase of wind velocity V_{hi}, in m/s, according to the height of the upper border of the zone above the waterline, in which the i-th component of the windage area A_{vi} lies shall be determined by the formula

$$n_i = (V_{hi}/V_v)^2 = [1 + 2{,}5\ln(h_{vi}/10)\sqrt{(0{,}71 + 0{,}071 V_v)\cdot 10^{-3}}\,]^2 \qquad (4.1.5.4)$$

where V_v = design wind velocity, in m/s (average wind velocity during 10 min at a height of 10 m above sea surface);
V_{hi} = wind velocity, in m/s, within the zone at the height h_{vi} above sea surface;
h_{vi} = above-water height, in m, of the upper border of the zone in which the i-th component of the windage area A_{vi} lies (where $h_{vi} < 10$ m, the coefficient n_i = 1,00).

For particular wind velocities corresponding to different service regimes of floating sea structures, the values of the n_i coefficient can be found in Table 4.1.5.4.

4.1.5.5 For each design condition of the floating crane/crane ship (working condition, non-working condition, voyage, passage), it is recommended that the windage area of non-continuous surfaces (rails, spars, rigging and various miscellaneous surfaces) shall be taken into account by increasing the maximum total windage area of continuous surfaces by 2 % with regard to coefficients k_i and n_i, and by increasing the static moment of this area by 5 %.

Under icing conditions this increase shall be taken 4 % and 10 % or by 3 % and 7,5 %, respectively, depending on the ice weight allowance for areas lying up to 30 m above the waterline.

The values of non-continuous surface windage areas and of static moments of these areas shall be calculated for minimal draught and, where necessary, be recalculated for particular loading conditions and the relevant condition of the floating crane/crane ship.

Table 4.1.5.4

Height (zone) coefficient n_i

Height above sea level, in m	V_v, in m/s		
	25,8	36,0	51,5
10	1	1	1
20	1,182	1,208	1,242
30	1,296	1,339	1,396
40	1,379	1,435	1,510
50	1,446	1,513	1,602
60	1,502	1,578	1,680
70	1,550	1,633	1,746
80	1,592	1,682	1,805
90	1,630	1,726	1,858
100	1,664	1,766	1,905
110	1,695	1,802	1,949
120	1,723	1,836	1,990
130	1,750	1,867	2,027
140	1,775	1,896	2,062
150	1,798	1,924	2,095
160	1,820	1,949	2,126
170	1,840	1,973	2,155
180	1,860	1,996	2,183
190	1,879	2,018	2,209
200	1,896	2,039	2,235
210	1,913	2,059	2,259
220	1,929	2,078	2,282
230	1,945	2,097	2,304
240	1,960	2,114	2,326
250	1,974	2,131	2,346

4.1.5.6 The design windage area of the cargo on hook is determined by its actual outline with due regard for its aerodynamic coefficient and maximum lifting height, i.e. as stipulated in 4.1.5.1 taking account of the provisions of 4.1.5.3 and 4.1.5.4.

The centre of the wind pressure to the cargo on the hook shall be assumed at the point of the load suspension to the boom.

With no actual data available, the design windage area of cargo on the hook is adopted from Table 4.1.5.6.

4.1.6 Roll amplitude calculation.

4.1.6.1 General.

The roll amplitude shall be obtained from model tests or determined in accordance with 4.1.6.2, 4.1.6.3, 4.1.6.4[1].

Model tests to obtain roll amplitudes shall be carried out and their results shall be processed in accordance with the RS-approved procedures.

Where the hook load mass exceeds 0,1Δ for a particular loading condition, the roll amplitude shall be determined with regard for the effect of cargo swinging according to the RS-approved procedure.

Wave height with 3 % probability of exceeding level $h_{3\%}$, in m, shall be adopted as follows:

from Table 4.1.8.6-2 in working condition on the basis of wave intensity at which cargo-handling operations are permitted;

---

[1]The roll amplitude is obtained from model tests with 1,1 % probability of exceeding level.

from Table 4.1.10.2 during the voyage or passage of a floating crane proceeding from the area of navigation assigned.

The roll amplitude of a crane ship during a voyage or passage shall be determined in accordance with 4.1.6.4.

Calculated roll amplitude values determined in accordance with 4.1.6 shall be rounded to the tenth part of a degree in working condition and to whole degrees during voyage or passage.

Table 4.1.5.6

Windage area of cargo k_iA_{vi}

Cargo mass, in t	k_iA_{vi}, in m^2	Cargo mass, in t	k_iA_{vi}, in m^2
10	12	300	81
20	18	350	88
30	22	400	96
40	26	500	108
50	29	600	120
60	33	700	130
80	38	800	140
100	44	900	150
120	48	1000	159
140	53	1500	200
160	57	2000	235
180	61	2500	265
200	64	3000	295
225	69	3500	322
250	73	4000	348
275	77	5000	380

Note. For intermediate values of cargo mass, the values of k_i, A_{vi} shall be determined by linear interpolation.

4.1.6.2 The roll amplitude of a floating crane in a working condition, during the voyage or passage of a floating crane/crane ship.

4.1.6.2.1 The roll amplitude θ_r, in deg., of a floating crane in its calculated conditions as mentioned under 4.1.2.1, 4.1.2.2 and 4.1.2.4 (i.e. in working condition, during voyage and passage), and of a crane ship in working condition shall, under all loading conditions under consideration, be determined by the formula

$$\theta_r = \theta_{r0} X_4 X_5 \qquad (4.1.6.2.1)$$

taking into consideration the instructions given in 4.1.6.2.2 — 4.1.6.2.9 and 4.1.6.3.

4.1.6.2.2 The function θ_{r0}, in deg., shall be determined by the formula

$$\theta_{r0} = (Y + \delta\theta_r)Z. \qquad (4.1.6.2.2)$$

The function θ_{r0} and calculated roll amplitude shall be assumed equal to zero where the parameter $W = h_{3\%}/\sqrt{C_B B d} \leqslant 0{,}1$.

4.1.6.2.3 The values of the function Y shall be adopted from Table 4.1.6.2.3-2 proceeding from the parameters W and K. The K parameter shall be determined by the formula

$$K = [G - 0{,}505(P - 2{,}4)]/P^2. \qquad (4.1.6.2.3\text{-}1)$$

The parameter G shall be determined by the formula

$$G = \frac{z_g - d}{\sqrt{C_B B d}}. \qquad (4.1.6.2.3\text{-}2)$$

The parameter P shall be adopted from Table 4.1.6.2.3-1 proceeding from the values of expression $(z_m - d)/\sqrt{C_B B d}$.

Table 4.1.6.2.3-1

Parameter *P*

$\frac{z_m-d}{\sqrt{C_B B d}}$	0,3	0,4	0,5	0,6	0,7	0,8	0,9	1,0	1,2
P	1,89	1,99	2,07	2,15	2,23	2,30	2,37	2,44	2,56
$\frac{z_m-d}{\sqrt{C_B B d}}$	1,4	1,6	1,8	2,0	2,5	3,0	3,5	4,0	4,5
P	2,67	2,77	2,87	2,96	3,17	3,36	3,52	3,67	3,82
Note. z_m = metacentric height, in m.									

Table 4.1.6.2.3-2

Function *Y*, in deg.

Parameter W	Parameter K					
	0,00	0,04	0,08	0,10	0,12	0,14
0,1	0,24	0,10	0,05	0,04	0,04	0,04
0,2	2,83	1,58	0,40	0,27	0,23	0,23
0,6	21,60	22,90	13,85	7,71	3,41	1,14
1,0	28,15	37,53	38,73	26,07	12,74	5,93
1,4	30,18	42,31	53,37	45,02	28,05	13,61

4.1.6.2.4 The function $\delta\theta_r$, in deg., shall be determined by the formula

$$\delta\theta_r = \{[(A_4 X + A_3)X + A_2]X + A_1\}X \quad (4.1.6.2.4\text{-}1)$$

where X = factor to be determined by the formula

$$X = 10(F + 0{,}813K - 0{,}195) \quad (4.1.6.2.4\text{-}2)$$

where the parameter F shall be determined by the formula

$$F = n\frac{\sqrt{h}}{B}\sqrt[4]{C_B B d} \quad (4.1.6.2.4\text{-}3)$$

where n = factor depending on the slewing angle of the crane structure φ (refer to 4.1.3.1) and determined by the formula

$$n = \frac{0{,}414}{\sqrt{1 + 0{,}564\sin^2\varphi}}, \quad (4.1.6.2.4\text{-}4)$$

as well as in accordance with 4.1.6.2.9-1.

The factors A_1, A_2, A_3, A_4 shall be adopted from Table 4.1.6.2.4 proceeding from the parameters W and K.

4.1.6.2.5 The function Z shall be adopted from Table 4.1.6.2.5 proceeding from the parameters K, P and W.

4.1.6.2.6 The factor X_4 shall be adopted from Table 4.1.6.2.6 proceeding from the ratio $\theta_{r0}/(\theta_v - \theta_0)$ where $\theta_v - \theta_0$ is the angle range of positive static stability.

4.1.6.2.7 The factor X_5 shall be adopted from Table 4.1.6.2.7 proceeding from the ratio C_{CL}/C_{WL} where C_{CL} is the lateral area coefficient, and C_{WL} is the waterline area coefficient.

4.1.6.2.8 Where the floating crane/crane ship has bilge keels, the roll amplitude θ'_r, in deg., shall be determined by the formula

$$\theta'_r = K_{BK}\theta_r. \quad (4.1.6.2.8\text{-}1)$$

The factor K_{BK} shall be adopted from Table 4.1.6.2.8 proceeding from the parameter m_{BK}, to be determined by the formula

$$m_{BK} = \frac{1}{2}\,\frac{A_k}{C_B L B d}\,\sqrt{(z_g + d)^2 + B^2} \quad (4.1.6.2.8\text{-}2)$$

where A_k = total (on both sides) area of bilge keels, in m^2;
L = hull length of floating crane/crane ship, in m.

For crane ships of ice classes **Arc4** to **Arc9**, the bilge keels shall be ignored.

Table 4.1.6.2.4

Factors A_1, A_2, A_3, A_4

Parameter W	A_i	Parameter K					
		0,00	0,04	0,08	0,10	0,12	0,14
0,1	A_1	0,61	0,18	0,08	0,08	0,09	0,10
	A_2	0,65	0,07	0,12	0,07	−0,02	0,08
	A_3	−1,00	−0,33	0,51	0,15	−0,47	0,09
	A_4	−2,30	−0,53	0,65	0,15	−0,65	0,12
0,2	A_1	2,21	4,14	1,23	0,61	0,58	0,57
	A_2	−2,82	−4,83	3,62	0,94	−0,14	1,02
	A_3	2,88	−31,90	8,57	2,06	−3,57	3,74
	A_4	4,66	−31,44	7,76	2,19	−4,84	5,60
0,6	A_1	−17,51	−0,48	22,15	20,28	16,27	4,90
	A_2	14,25	−37,97	−18,40	6,86	−16,30	19,34
	A_3	123,01	68,09	−16,97	72,58	−204,08	52,58
	A_4	−83,49	112,34	13,24	168,08	−264,50	43,24
1,0	A_1	−36,34	−42,33	−0,84	51,49	27,78	19,65
	A_2	38,54	45,08	−220,45	−61,11	14,01	−52,77
	A_3	110,50	108,83	−58,65	−329,54	198,88	−231,50
	A_4	123,15	−220,03	348,71	−390,73	371,65	−200,83
1,4	A_1	−40,61	−60,76	−55,09	14,98	39,93	29,55
	A_2	50,44	103,44	−185,31	−184,15	−132,82	−66,33
	A_3	117,86	67,17	170,10	−9,26	−224,91	32,57
	A_4	194,79	−230,32	250,47	247,05	−37,89	356,57

Table 4.1.6.2.5

Function Z

Parameter P	Parameter W	Parameter K					
		0,00	0,04	0,08	0,10	0,12	0,14
2,1	0,1	2,17	1,59	1,56	1,95	2,71	4,51
	0,2	2,23	1,55	1,35	1,58	2,11	4,38
	0,6	3,44	1,59	1,10	1,08	1,06	3,52
	1,0	4,34	1,73	1,28	1,33	1,28	2,56
	1,4	2,30	1,65	1,25	1,28	1,51	2,05
2,5	0,1	1,22	1,21	1,47	1,89	2.36	3,15
	0,2	1,27	1,20	1,28	1,55	1,96	2,81
	0,6	1,32	1,23	1,03	0,97	1,00	1,77
	1,0	1,26	1,27	1,19	1,05	0,72	1,09
	1,4	1,26	1,24	1,16	1,02	0,68	0,51
2,9	0,1 — 1,4	1	1	1	1	1	1
3,3	0,1	0,77	0,85	0,87	0,81	0,68	0,58
	0,2	0,89	0,88	0,91	0,92	0,84	0,62
	0,6	0,84	0,88	0,93	1,03	1,06	0,81
	1,0	0,84	0,81	0,83	0,91	0,94	0,99
	1,4	0,87	0,84	0,87	0,92	0,91	1,02
3,7	0,1	0,61	0,77	0,84	0,75	0,49	0,37
	0,2	0,64	0,82	0,94	0,97	0,87	0,49
	0,6	0,70	0,82	0,98	1,21	1,41	1,04
	1,0	0,72	0,69	0,78	1,00	1,13	1,44
	1,4	0,77	0,77	0,84	1,00	1,00	1,46

4.1.6.2.9 The peculiarities of floating crane/crane ship mass distribution and those of the area of navigation may be considered when determining the roll amplitude:

.1 where the inertia coefficient c is known in the formula of the roll period $T = 2cB/\sqrt{h}$, the value of the factor n in Formula (4.1.6.2.4-3) can be replaced by a value determined as

$$n = 1/(4{,}6c); \qquad (4.1.6.2.9.1)$$

Table 4.1.6.2.6

Factor X_4

$\frac{\theta_{r0}}{\theta_v - \theta_0}$	X_4
0	1,000
0,2	0,878
0,4	0,775
0,6	0,668
0,8	0,615
1,0	0,552
1,2	0,449
1,4	0,453
1,6	0,413
1,8	0,379
2,0	0,349
2,2	0,323
2,4	0,300
2,6	0,279
2,8	0,261
3,0	0,245

Table 4.1.6.2.7

Factor X_5

$\frac{C_{CL}}{C_{WL}}$	X_5
0,60	0,326
0,65	0,424
0,70	0,553
0,75	0,646
0,80	0,756
0,85	0,854
0,90	0,932
0,95	0,983
1,00	1,000
1,05	0,983
1,10	0,932
1,15	0,854
1,20	0,756
1,25	0,646
1,30	0,553
1,35	0,424

Table 4.1.6.2.8

Factor K_{BK}

m_{BK}	K_{BK}
0	1,00
0,025	0,882
0,050	0,779
0,075	0,689
0,100	0,607
0,125	0,535
0,135 and over	0,500

.2 where the frequency of the maximum of wave spectral density ω_m, in s^{-1}, in known, which is characteristic of a particular area of navigation with the specified wave height with 3 % probability of exceeding level $h_{3\%}$, the roll amplitude θ_r, in deg., determined by Formula (4.1.6.2.1) can be specified using the formula

$$\theta_r = \theta_{r0} X_4 X_5 K_C \qquad (4.1.6.2.9.2\text{-}1)$$

where K_C, in $m \cdot s^{-2}$, shall be determined by the formula

$$K_C = 0{,}27\omega_m^2 h_{3\%}, \qquad (4.1.6.2.9.2\text{-}2)$$

while in Tables 4.1.6.2.3-2, 4.1.6.2.4 and 4.1.6.2.5, the value $(1/K_C)(h_{3\%}/\sqrt{C_B B d}) = (1/K_C)W$ shall be used instead of the value $W = h_{3\%}/\sqrt{C_B B d}$.

4.1.6.3 Corrections to the roll amplitude of a floating crane during the voyage/passage.

Where the roll amplitude θ_r or θ'_r of a floating crane during the voyage/passage, obtained in accordance with 4.1.6.2 or 4.1.6.2.8, respectively exceeds the angle of deck immersion θ_d or the emersion angle of a bilge middle on a midship frame θ_b, at which the middle of bilge at amidships frame comes out of water the design roll amplitude θ''_r, in deg., shall be determined by the following formulae:

at $\theta_d < \theta_r \leqslant \theta_b$

$$\theta''_r = (\theta_d + 5\theta_r)/6; \qquad (4.1.6.3\text{-}1)$$

at $\theta_b < \theta_r \leqslant \theta_d$

$$\theta''_r = (\theta_b + 5\theta_r)/6; \qquad (4.1.6.3\text{-}2)$$

at $\theta_r > \theta_b$ and $\theta_r > \theta_d$

$$\theta''_r = (\theta_d + \theta_b + 4\theta_r)/6. \qquad (4.1.6.3\text{-}3)$$

4.1.6.4 Roll amplitude of a crane ship during voyage/passage.

The roll amplitude of a crane ship during voyage/passage under any loading conditions considered shall be determined in accordance with 2.1.5.

The roll amplitude of a crane ship equipped with anti-rolling devices shall be determined without regard for their operation.

4.1.7 Allowance for icing.

For areas lying up to 30 m above the waterline, allowance for icing shall be made on the basis of the provisions of 2.4.1 — 2.4.6 and 2.4.8. For areas lying higher than 10 m above the waterline, the ice weight allowance shall be adopted at half the value stated under 2.4.3 and 2.4.4.

The windage area and the height of the centre of the windage area above the waterline shall be determined as follows:

in accordance with 4.1.3.2 under loading conditions with the smallest draught out of those verified;

in accordance with 4.1.3.3 under loading conditions chosen for stability verification purposes.

When pipes or other deck cargoes are carried, their icing shall be considered in accordance with 3.11.6 and 3.11.7 adopting the ice weight allowance stated above.

4.1.8 Stability of a floating crane/crane ship in working condition.

4.1.8.1 Stability shall be considered adequate provided that:

.1 the heeling angle θ_{d2}, in deg., due to the combined effect of the initial heeling moment (from hook load, balance weight, anti-heel ballast, etc.) θ_0, in deg., due to wind θ_s (refer to 4.1.8.4) and roll θ_r, in deg., does not exceed the angle of deck edge immersion or the middle of the bilge emergence in way mid-section, whichever is less. In any case, the following conditions shall be observed:

$$\theta_0 + \theta_s \leqslant \begin{cases} 0,2(\theta_v - \theta_0) + 2^\circ \\ 10^\circ \end{cases}; \qquad (4.1.8.1.1\text{-}1)$$

$$\theta_r \leqslant \begin{cases} 0,15(\theta_v - \theta_0) - 1^\circ \\ 5^\circ \end{cases}. \qquad (4.1.8.1.1\text{-}2)$$

The above acceptable heel angles static (θ_0+θ_s) and dynamic (θ_r) shall not exceed relevant angles at which reliable operation of the crane structure is ensured. These angles shall be in conformity with the delivery specifications of the crane structure and/or with its maintenance manual;

.2 the vertical distance between the lower edges of openings by which the flooding angle is determined in operation and the waterline corresponding to the static heel and trim is not less than 0,6 m or 0,025B, whichever is greater;

.3 the area A_{max}, in m·rad, of the righting lever curve, between the angles θ_0 and θ_m is in conformity with the following conditions:

$$A_{max} \geqslant \begin{cases} 0,115 - 0,00075(\theta_v - 20^\circ) \\ 0,100 \end{cases}; \qquad (4.1.8.1.3)$$

.4 if $\theta_{max} - \theta_0 \geqslant 10^\circ$ and $\theta_v - \theta_0 \geqslant 20^\circ$;

.5 if maximum righting arm l_{max} of a floating crane/crane ship equipped with an automatic anti-heel system is not less than 0,25 m where this system fails to operate;

.6 if capsizing moment (refer to 4.1.8.7) determined with regard to the combined effect of load drop and roll is at least twice the heeling moment due to wind pressure. The value of $g\Delta l_{max}$ shall be twice as great as the heeling moment at least. In the case of floating cranes/crane ships equipped with an anti-heel system, the system shall be considered non-working after load drop, and the anti-heel ballast shall be considered to remain in the same position in which it was at the moment of load drop;

.7 the lower edges of openings considered to be open during the operation of the floating crane/crane ship are above the waterline by the value of h_f (being not less than 0,6 m or 0,025B, whichever is greater) under conditions of dynamic heel θ_{d3}, in deg., due to the combined effect of load drop, wind and roll.

The height h_f shall be determined by the formula

$$h_f = (z_f - d)\cos\theta_{d3} - y_f \sin\theta_{d3} \tag{4.1.8.1.7}$$

where y_f, z_f = the ordinate and the applicate, in m, respectively, of the lower edge of the opening in question;
d = draught after load drop, in m.

4.1.8.2 If a floating crane/crane ship shall be engaged in handling a submerged cargo having a mass greater than 0,1Δ, in t, under particular loading conditions, the Register may require calculations to be made to demonstrate that the safety of the floating crane/crane ship against capsizing is ensured for the case of submerged load drop.

4.1.8.3 Where a floating crane/crane ship does not comply with the above requirements when it has a hook load of a mass equal to the full cargo-lifting capacity of the crane structure, the cargo-lifting capacity may be limited by a value at which the requirements of the present Section are met.

4.1.8.4 The heeling angle of a floating crane/crane ship θ_{d2} due to the combined effect of initial heeling moment, wind and roll shall be determined by Formulae (4.1.8.4.1-2) or (4.1.8.4.2-2) proceeding from the critical value of the parameter G_{cr} to be determined by the formula below with C = 1,0:

$$G_{cr} = \{[(z'_w - 0{,}34z_w)/\sqrt{C_B B d}] - 0{,}34Cf_1 - f_3\}/f_2 \tag{4.1.8.4}$$

where f_1, f_2, f_3 = factors to be adopted from Tables 4.1.8.4-1 and 4.1.8.4-2.

Table 4.1.8.4-1

Factor f_1

Parameter P	θ_0, in deg.					
	0	2	4	6	8	10
2,0	0,43	0,44	0,42	0,36	0,27	0,18
2,2	0,64	0,67	0,62	0,47	0,33	0,22
2,4	0,88	0,96	0,92	0,58	0,39	0,26
2,6	1,18	1,28	1,02	0,69	0,46	0,31
2,8	1,53	1,68	1,22	0,80	0,52	0,35
3,0	1,95	2,06	1,43	0,91	0,58	0,39
3,2	2,43	2,48	1,64	1,02	0,64	0,43
3,4	2,99	2,89	1,87	1,13	0,71	0,48
3,6	3,62	3,30	2,09	1,24	0,77	0,52
3,8	4,32	3,71	2,33	1,35	0,83	0,56

Note. The intermediate values of f_1 shall be determined by linear interpolation.

Table 4.1.8.4-2

Factors f_2, f_3

P^2	Factors		P^2	Factors	
	f_2	f_3		f_2	f_3
4,0	0,600	0,027	9,0	0,750	0,214
4,5	0,625	0,051	9,5	0,759	0,229
5,0	0,646	0,073	10,0	0,767	0,243
5,5	0,663	0,095	10,5	0,774	0,256
6,0	0,682	0,115	11,0	0,781	0,269
6,5	0,693	0,133	11,5	0,787	0,282
7,0	0,708	0,152	12,0	0,792	0,295
7,5	0,720	0,167	13,0	0,803	0,320
8,0	0,731	0,185	14,0	0,813	0,344
8,5	0,741	0,198			

Note. The intermediate values of f_2 and f_3 shall be determined by linear interpolation.

4.1.8.4.1 If the parameter

$$G \leqslant 0{,}9G_{cr} \tag{4.1.8.4.1-1}$$

it is inherent in pontoon cranes; then

$\theta_{d2} = \theta_0 + \theta_s + \theta_r$, in deg., (4.1.8.4.1-2)

where θ_0, θ_s shall be determined by the formulae:

$\theta_0 = 57{,}3 y_g / h$; (4.1.8.4.1-3)

$\theta_s = 57{,}3 M_v / g\Delta h$ (4.1.8.4.1-4)

where M_v shall be determined by Formula (4.1.8.5.1), and the angle θ_r shall be determined in accordance with 4.1.6.2.

4.1.8.4.2 If the parameter

$G \geqslant 1{,}1 G_{cr}$ (4.1.8.4.2-1)

it is inherent in crane ships, which lines are similar to those of conventional ships; then

$\theta_{d2} = \theta_0 + \theta'_s + \theta_r$, in deg., (4.1.8.4.2-2)

where θ'_s shall be determined by the formula

$\theta'_s = 100 M'_v / g\Delta h$ (4.1.8.4.2-3)

where M'_v shall be determined by Formula (4.1.8.5.2).

The directions of the angles θ_0, θ_s, θ'_s, θ_r shall be assumed to coincide. For a floating crane/crane ship, which shall not operate at rough sea, the angle θ_r shall be adopted equal to zero.

4.1.8.5 The heeling moments M_v, M'_v, in kN·m, shall be determined by:

.1 Formula (4.1.8.5.1) where the value of the parameter G is in compliance with condition (4.1.8.4.1-1)

$M_v = 0{,}6 q (z_w + f_1 \sqrt{C_B B d}) \Sigma k_i n_i A_{vi}$; (4.1.8.5.1)

.2 Formula (4.1.8.5.2) where the value of the parameter G is in compliance with condition (4.1.8.4.2-1)

$M'_v = q[z'_w - f_2(z_g - d) - f_3 \sqrt{C_B B d}] \Sigma k_i A_{vi}$; (4.1.8.5.2)

.3 either of Formulae (4.1.8.5.1) or (4.1.8.5.2) which yields the greater heeling angle, provided the following condition is met:

$0{,}9 G_{cr} < G < 1{,}1 G_{cr}$. (4.1.8.5.3)

4.1.8.6 The values of the rated wind velocity head q and the wave height with 3 % probability of exceeding level $h_{3\%}$ shall be adopted from Tables 4.1.8.6-1 and 4.1.8.6-2 according to the weather restrictions assigned.

Table 4.1.8.6-1

Design wind velocity head q in squall

Wind restriction assigned, in numbers	q, in kPa
1	0,02
2	0,03
3	0,05
4	0,09
5	0,15
6	0,23
7	0,35
8	0,50

Table 4.1.8.6-2

Wave height with 3 % probability of exceeding level $h_{3\%}$

Wave restriction assigned, in numbers $h_{3\%}$,	in m
1	0,25
2	0,75
3	1,25
4	2,00
5	3,50
6	6,00

4.1.8.7 Recommendations concerning the capsizing moment and dynamic heeling angle determination for a floating crane/crane ship in working condition with load drop are given in 1.1, Appendix 2.

The heeling angle before load drop shall be adopted, equal to

$$\theta'_{d2} = \theta_0 + \theta_r. \tag{4.1.8.7}$$

4.1.8.8 The effect of anchoring and mooring upon the stability of a floating crane/crane ship in working condition may be considered using the RS-approved procedure.

4.1.8.9 When the crane structure is tested by the hook load with the mass exceeding the design one, the stability of the floating crane/crane ship shall be verified with regard to the actual mass of the test load. It shall be demonstrated that the floating crane/crane ship safety against capsizing is ensured by the development of special procedures at least, including weather restrictions.

4.1.9 Stability of a floating crane/crane ship during voyage.

4.1.9.1 Stability shall be considered sufficient (taking into account 4.1.3.4) if:

.1 the range of righting lever curve between the angles θ_0 and θ_v is 40° at least;

.2 the area of righting lever curve is not less than 0,160 m·rad, between the angles θ_0 and θ_1, the latter angle being obtained from the formula

$$\theta_1 \geqslant 15° + 0{,}5(\theta_v - 40°); \tag{4.1.9.1.2}$$

.3 the capsizing moment determined with regard to roll and flooding angle is not less than the heeling moment, i.e. $M_c \geqslant M_v$.

For recommendations concerning the capsizing moment determination procedure during voyage, refer to 1.2, Appendix 2.

4.1.9.2 The heeling moments M_v, M'_v, in kN·m, shall be detemined by:

.1 Formula (4.1.9.2.1) where the value of the parameter G is in conformity with condition (4.1.8.4.1-1) at its critical value detemined by Formula (4.1.8.4) with C = 0,5

$$M_v = 0{,}6q(z_v + 0{,}5f_1\sqrt{C_B B d})\Sigma k_i n_i A_{vi}; \tag{4.1.9.2.1}$$

.2 Formula (4.1.8.5.2) where the value of the parameter G is in conformity with condition (4.1.8.4.2-1) at its critical value detemined by Formula (4.1.8.4) with C=0,5;

.3 either of the Formulae (4.1.9.2.1) or (4.1.8.5.2) which yields the greater heeling angle, provided condition (4.1.8.5.3) is met with C=0,5.

4.1.9.3 Factor f_1 shall be adopted from Table 4.1.8.4-1 proceeding from the value of the parameter P and with regard for the angle θ_0. The values of factors f_2 and f_3 shall be adopted from Table 4.1.8.4-2.

4.1.9.4 For a floating crane, the wind velocity head q and the wave height with 3 % probability of exceeding level $h_{3\%}$ shall be adopted from Table 4.1.10.2. If the floating crane shall operate in a particular geographical region, q and $h_{3\%}$ may be specially adopted for that region.

4.1.9.5 For a crane ship, the wind velocity head q shall be adopted from Table 4.1.10.2.

4.1.10 Stability of a floating crane/crane ship during passage.

4.1.10.1 Where a floating crane/crane ship shall undertake a passage through sea regions lying beyond the prescribed area of navigation, a plan of such passage shall be prepared.

4.1.10.2 Stability shall be checked with due regard for 4.1.3.4 under loading conditions stipulated in 4.1.3.2 and taking into account the preparation arrangements specified in the passage plan (including possible partial or complete dismantling of the crane structure), and is considered to be adequate, if the requirements of 4.1.9 for conditions of passage areas are met.

The design wind velocity head q and wave height with 3 % probability of exceeding level $h_{3\%}$ shall to be adopted from Table 4.1.10.2.

4.1.11 Stability of a floating crane/crane ship in non-working condition.

4.1.11.1 Stability is considered adequate, if the capsizing moment is at least 1,5 times greater than the heeling moment under loading conditions in accordance with 4.1.3.3 and in the absence of rolling (θ_r=0°) giving regard to 4.1.3.4.

4.1.11.2 The capsizing and heeling moments shall be determined in accordance with 4.1.9 for q=1,4 kPa. In case mentioned under 4.1.9.2.1, the capsizing moment shall be determined in accordance

Table 4.1.10.2

Wind velocity head q and wave height with 3 % probability of exceeding level $h_{3\%}$

Area of navigation through which voyage or passage is made	q, in kPa	$h_{3\%}$, in m
Unrestricted	1,40	11,0
Restricted **R1**	1,00	6,0
Restricted **R2**	0,80	6,0
Restricted **R3**	0,60	In accordance with restrictions stated in the Classification Certificate

with 1.3 of Appendix 2, and in case mentioned under 4.1.9.2.2, it shall be determined in accordance with 1.2 of Appendix 2 for θ_r=0°.

4.2 PONTOONS

4.2.1 This Chapter applies to ships with descriptive notations **pontoon for technological services** and **pontoon for transportation services** in the class notation.

4.2.2 Loading conditions.

4.2.2.1 Stability of a pontoon shall be checked for the following loading conditions:

.1 with full load;

.2 without load;

.3 with full load and icing.

4.2.2.2 When carrying timber cargo, the stability calculation shall be made with regard to possible addition in mass of timber cargo due to water absorption as under 3.3.7.

4.2.2.3 When carrying pipes, the stability calculation shall be made with regard to trapped water in the pipes as under 3.11.4.

4.2.3 Calculation of cross-curves of stability.

When calculating the cross-curves of stability for a pontoon carrying timber cargo, the volume of timber cargo may be included in the calculation with full breadth and height and permeability of 0,25.

4.2.4 Allowance for icing.

4.2.4.1 Ice weight allowance shall be adopted as under 2.4.

4.2.4.2 When carrying timber cargo, ice weight allowance shall be adopted as under 3.3.7.

4.2.4.3 When carrying pipes, icing is determined as under 3.11.7.

4.2.5 Stability of a pontoon.

4.2.5.1 Stability of a pontoon shall be considered sufficient:

.1 if the area under the righting lever curve up to the angle of heel θ_m is not less than 0,08 m·rad;

.2 if the static angle of heel due to wind heeling moment determined according to 4.2.5.2 does not exceed half the angle of immersion of the deck;

.3 if the range of righting lever curve is not less than:

20° for $L \leqslant 100$ m;

15° for $L > 150$ m.

For intermediate values of L, the range of stability is determined by linear interpolation.

4.2.5.2 The heeling moment M_v, in kN·m, is determined by the formula

$$M_v = 0{,}001 p_v z_v A_v \qquad (4.2.5.2)$$

where p_v = wind pressure equal to 540 Pa;
z_v = arm of windage area determined according to 2.1.4.1;
A_v = windage area, in m^2, determined according to 1.4.6.

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 emersion.
4.3.2 Calculation of liquid cargo effect shall 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 emersed 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 dynamic angle of heel of a floating dock, in deg., if it does not exceed the angle of immersion of the pontoon deck, shall be determined by the formula

$$\theta = 1{,}17 \cdot 10^{-2} p_v A_v z / (\Delta h) \qquad (4.3.3.3)$$

where z = distance from the centre of the windage area to the plane of the waterline of floatation;
p_v = wind pressure, in Pa;
Δ = displacement, in t.

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 dynamically applied heeling moment, in kN·m, determined by the formula

$$M_v = 0{,}001 p_v A_v z. \qquad (4.3.3.4)$$

4.3.3.5 Wind pressure is assumed to be 1700 Pa.
4.3.3.6 Wind pressure may be taken from Table 4.3.3.6-1 depending upon the prescribed geographical area of the floating dock operation according to Fig. 4.3.3.6.
To account for the increase of 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 4.3.3.6-1 are multiplied by the relevant zone coefficients from Table 4.3.3.6-2.
In this case, the values of p_v, A_v and z are determined for each 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).

Table 4.3.3.6-1

Wind pressure for top zone of 0 — 10 m above the actual waterline p, in Pa

Geographical area of floating dock service (refer to Fig. 4.3.3.6)	2	3	4	5	6	7
Pressure p, in Pa	460	590	730	910	1110	1300

Table 4.3.3.6-2

Zone coefficient n_i

Height above the waterline (zone boundary), in m	n_i	Height above the waterline (zone boundary), in m	n_i
10	1,0	50 — 60	1,75
10 — 20	1,25	60 — 70	1,84
20 — 30	1,4	70 — 80	1,94
30 — 40	1,55	80 — 90	2,02
40 — 50	1,69	90 — 100	2,1

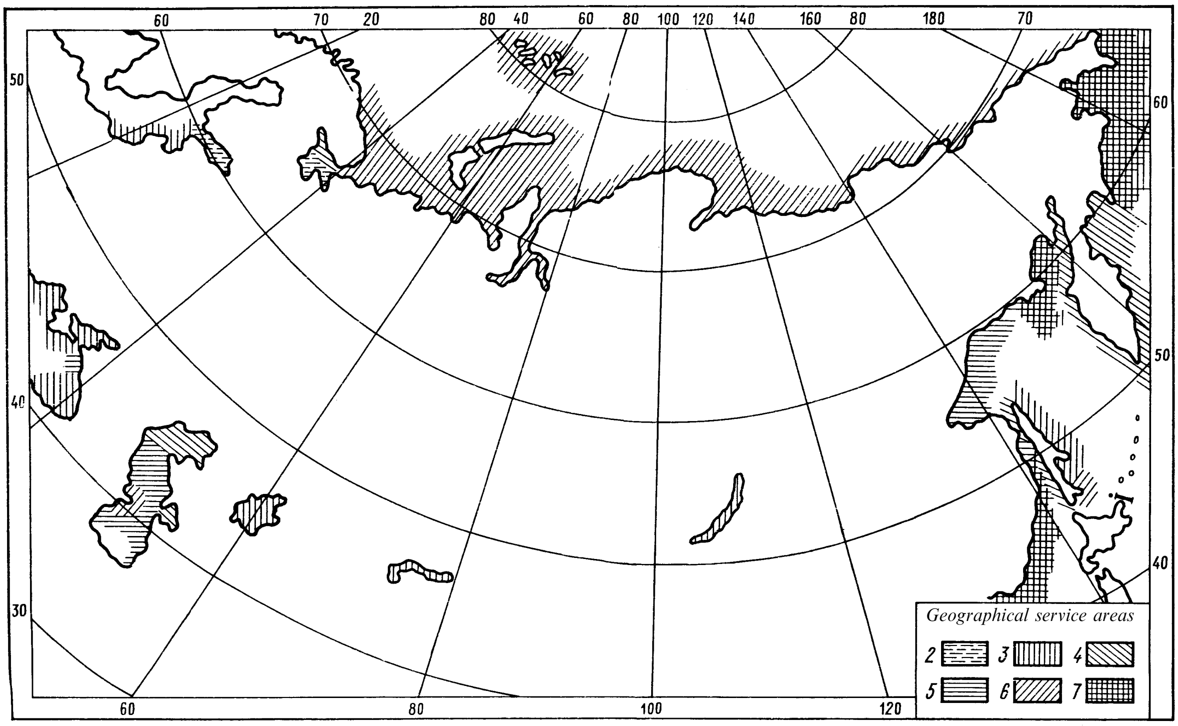


Fig. 4.3.3.6

4.3.3.7 With geographical service area of the floating dock prescribed, the wind pressure may be taken for this particular area.

4.3.3.8 With several geographical service areas of the floating dock prescribed, maximum wind pressure for these areas shall be taken.

4.3.3.9 The angle of trim, in deg., of the floating dock shall be determined by the formula

$$\psi = 57{,}3 M_{\psi}/(\Delta H). \qquad (4.3.3.9)$$

4.3.4 Stability of a floating dock during submersion or emersion.

4.3.4.1 Stability of a floating dock shall be checked in the process of submersion or emersion for the most unfavourable case, as regards stability, of the supported ship displacement, moment of windage area of the dock — ship system and dock ballasting with the cranes not in operation, without icing.

4.3.4.2 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.

4.3.4.3 The angle of heel of the floating dock shall be determined in conformity with 4.3.3.3 and 4.3.3.4.

4.3.4.4 Specific wind pressure is assumed to be 400 Pa.

4.3.5 The arm of windage area shall be determined according to 1.4.6.3.

4.3.6 These requirements apply to floating docks having sufficiently reliable positioning system.

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 2.3 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 by 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 heel, 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 shall not exceed 10°.

APPENDIX 1

INSTRUCTIONS ON DRAWING UP THE STABILITY BOOKLET

1 GENERAL

1.1 Each ship shall be provided with the Stability Booklet[1] in order to assist the master and the control authorities in maintaining stability of the ship during service in compliance with the requirements of international agreements, the Administration and these Rules.

Formal observance of the provisions contained in the Booklet does not relieve the master of the responsibility for the stability of the ship.

1.2 The present Instructions contain provisions concerning the form and contents of the Booklet.

The scope of the Booklet may vary depending on the type, purpose, stability reserve and service area of a ship.

The form of the Booklet shall comply with the present Instructions.

1.3 The Booklet shall contain the following sections:

.1 Particulars of ship;

.2 Guidance to the master;

.3 Technical information;

.4 Reference information.

The contents of the sections are given below.

1.4 The Booklet shall have an identification number.

1.5 Each sheet (page) of the Booklet shall be marked with the identification number of the Booklet, the number of the sheet (page) and the total number of sheets (pages). The numbering of sheets (pages) shall be continuous, including plans and drawings.

Tables, plans and drawings are not allowed to have identical numbers.

1.6 The front page shall contain:

.1 name of the document: Stability Booklet;

.2 identification number;

.3 name of ship;

.4 IMO number.

1.7 The front page shall be succeeded by a table of contents.

1.8 For ships engaged on international voyages, the Booklet and the drawings and plans included shall be translated into English.

1.9 The Booklet shall list the documents on the basis of which it was drawn up.

1.10 The Booklet shall contain a record of familiarization with the document.

2 PARTICULARS OF SHIP

2.1 The Section shall contain the following information:

.1 ship's name;

.2 type of ship (dry cargo ship, oil tanker, etc.);

.3 purpose of ship (for what kind of cargo the ship is designed according to specification);

.4 name of builder and hull number;

.5 date on which the keel was laid, date of completion of construction, date of conversion;

.6 ship's class, classification society and RS number;

[1]Hereinafter referred to as "the Booklet".

.7 ship's flag;

.8 port of registry;

.9 principal dimensions (length, breadth, depth; where the bulkhead deck does not coincide with the upper deck, the depth up to the bulkhead deck shall be stated);

.10 service area and restrictions imposed (sea state, distance to port of refuge, seasons, geographical service areas, etc.).

For dredgers and floating cranes, restrictions for both operating and voyage conditions shall be stated;

.11 draughts to the summer load line and summer timber load line, diagram of the load line marks and the corresponding displacement and deadweight;

.12 speed;

.13 type of anti-rolling devices; dimensions of bilge keels, if any;

.14 inclining test data, on which the Booklet is based (light-ship displacement and center of gravity coordinates for light-ship condition), place and date of the inclining test with the reference to the Inclining Test Report approved by the RS Branch Office or another body. If the data for the light-ship condition have been assumed based on the results of the light-weight check taking into consideration the results of the inclining test performed on a sister ship, the data on the ship light-weight check and on the inclining test performed on a sister ship, including the name and serial number of this ship shall be stated in the Booklet; the data shall contain reference to the Light-Weight Check Reports and Inclining Test Reports approved by the RS Branch Office or another body;

.15 a sketch showing the quantity and location of solid ballast, if any, on board;

.16 ship inertia coefficient C in the formula for determining the roll period $\tau = CB/\sqrt{h_0}$ to be calculated on the basis of the roll period, if determined, during the inclining test;

.17 other data deemed necessary by the developer of the Booklet (for instance, carrying capacity of the ship, designed trim, stores endurance).

3 GUIDANCE TO THE MASTER

3.1 General.

3.1.1 The Chapter shall contain the following information:

.1 statement of the purpose of the document, i.e. to provide the necessary information to the master for ensuring the ship's trim and stability during loading, unloading, ballasting and other operations for which the ship is intended, and to provide guidance on and methods for satisfying the requirements of normative documents;

.2 list of normative documents (IMO, IACS, Administration, rules of RS and other classification societies) on the basis of which the Booklet was drawn up;

.3 list of stability criteria applicable to the ship with sketches (where necessary) and indication of criteria (criterion) limiting the ship's stability, damage stability criteria included, where these are applicable to the ship and limiting with regard to intact stability;

.4 general instructions to the master to exercise good maritime practice, having regard to the season of the year, the navigational area and weather forecasts, and to take the appropriate action as to speed and course warranted by the prevailing conditions; the instructions shall be developed considering the Revised Guidance to the Master for Avoiding Dangerous Situations in Following and Quartering Seas (refer to Collection of Regulating Documents. Book Eighteen, 2008);

.5 general instructions to the effect that the stability criteria (except for the criteria relevant to the carriage of grain and non-cohesive bulk cargoes) do not take possible cargo shifting into consideration and to prevent such cargo shifting one shall be guided by approved documents regulating the securing and stowage of cargo;

.6 explanations on the use of optional information included in the document at the discretion of the shipowner. It shall be stated that such information falls under the responsibility of the shipowner.

3.2 Terms, symbols and units.

3.2.1 The Chapter shall contain the following information:

.1 a table of symbols showing the terms and symbols used in the Stability Booklet, relevant explanations (where necessary) and the units of measurement. The unit system shall be uniform throughout the document and it shall be the same as the unit system adopted for the Damage Stability Booklet.

The main symbols to be used in the Stability Booklet are given in Table 3.2.1.1;

.2 a sketch (refer to Fig. 3.2.1.2) explaining the main symbols.

Table 3.2.1.1

Main symbols

Nos.	Term	Symbol	International symbol
1	Length	L	L
2	Breadth	B	B
3	Depth	D	D
4	Draught	d	d
5	Freeboard	f	f
6	Displacement volume	∇	∇
7	Displacement weight	Δ	Δ
8	Center of gravity:	G	G
8.1	abscissa	x_g	x_g (XG)
8.2	ordinate	y_g	y_g (YG)
8.3	applicate	z_g	KG
9	Center of buoyancy:	C	C
9.1	abscissa	x_c	XB
9.2	applicate	z_c	KB
10	Abscissa of centre of flotation	x_f	x_f (XF)
11	Elevation of metacenter above base line:		
11.1	transverse	z_m	KMT
11.2	longitudinal	ZM	KML
12	Metacentric height:		
12.1	transverse	h	GM
12.2	longitudinal	H	GML
13	Righting lever	l	GZ
14	Cross curve lever	l_K	l_K (KL)

3.3 General explanations to the Stability Booklet.

3.3.1 The Chapter shall contain explanations and guidance pertinent to all the sections of the Stability Booklet concerning the use of the following technical data:

.1 coordinate system. The coordinate system for determining mass moments, volumes, buoyancy, draughts, shall be uniform throughout the Stability Booklet, and it shall be the same as the coordinate system adopted for the Damage Stability Stability Booklet and the design documentation;

.2 rules for the signs of heel and trim;

.3 applicability of hydrostatic data with regard to trim;

.4 applicability of stability limits with regard to trim;

.5 permissible windage area of deck cargo;

.6 accuracy of calculations and interpolation, and other guidance proceeding from the contents of the Stability Booklet.

3.4 Operation of the ship.

3.4.1 The Chapter shall contain the following information:

.1 data on the light ship with regard to its trim, stability and strength. If the light ship has a heel and a trim due to asymmetrical distribution of equipment, instructions shall be given on stowing the ballast, stores and cargo so as to eliminate the heel and reduce the trim. It shall be stated that elimination of heel by appropriate stowage of solid bulk cargo is not permitted;

.2 principles on the basis of which instructions on consuming the stores were drawn up; distribution of 50 % and 10 % of stores; effect of stores consumption on the vertical centre of gravity of the ship; specific instructions on consuming the stores with indication of conditions proceeding from which the consumption pattern shall be applied (stability, trim and damage stability requirements);

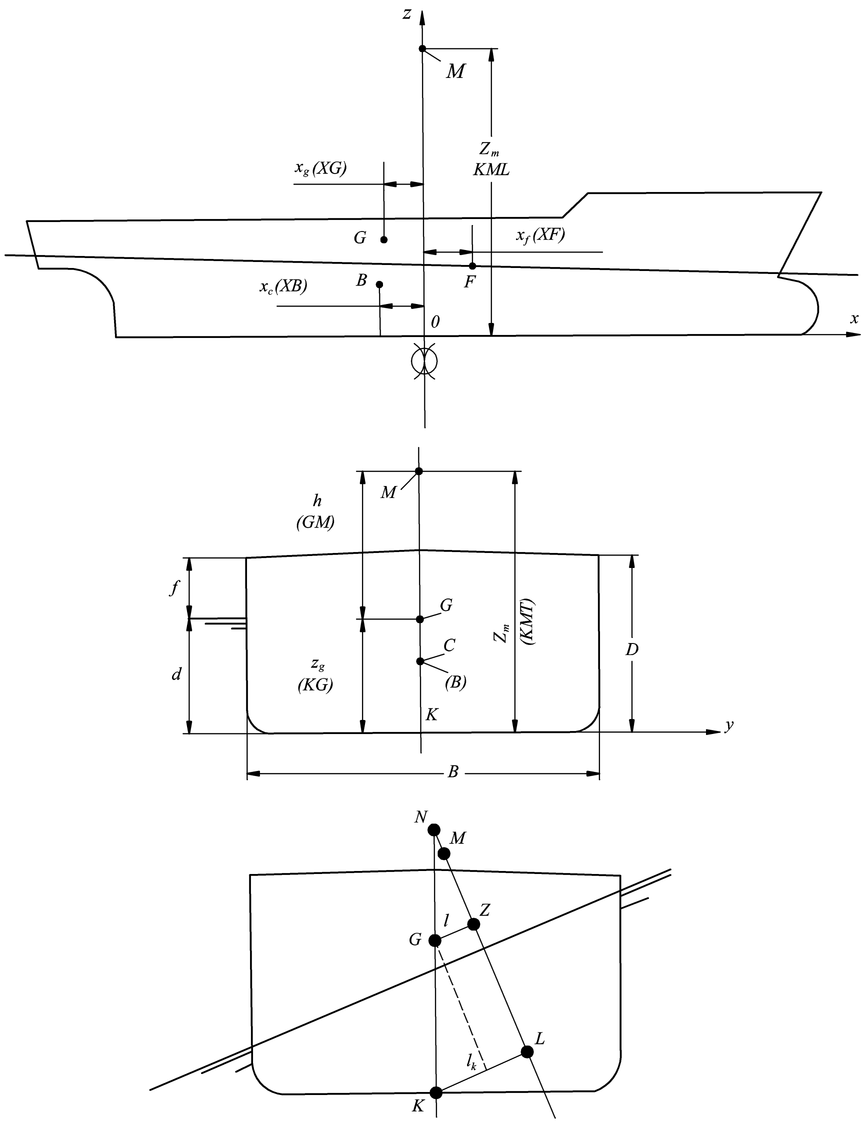


Fig. 3.2.1.2

.3 the procedure for taking ballast during voyage for the compensation of increase of the vertical centre of gravity due to stores consumption; instructions on weather conditions under which ballasting is permitted;

.4 the principal ballast patterns for the carriage of heavy deck cargo, like containers, or light cargo in the hold, like ro/ro-vehicles, and explanations to the patterns;

.5 information regarding the effect of hoisted crane booms, filled swimming pool or other heavy top masses on the ship's stability;

.6 operating limits concerning loading, unloading, ballasting and distribution of cargo shall be listed and explained, as for example:

.6.1 draught limits and, in particular, statement that the ship's draught shall not exceed the value corresponding to the freeboard according to the ship's Load Line Certificate;

.6.2 statement that the height of the ship's centre of gravity shall not exceed the maximum allowable value;

.6.3 statement that the shear forces and bending moments shall not exceed the maximum allowable values;
.6.4 minimum draught forward and aft with regard to seaworthness and bridge visibility;
.6.5 numerical values of deck cargo dimensions with regard to bridge visibility;
.6.6 maximum draught forward due to minimum bow height requirement;
.6.7 maximum mass for container stacks;
.6.8 permissible load for plating, decks and hatch covers on which cargo is stowed;
.6.9 maximum mass per hold for bulk cargo;
.6.10 ship's speed on the turn;
.6.11 permissible quantities of fish on the deck of fishing vessels;
.6.12 deck areas of passenger ships to which the access of passengers is prohibited;
.6.13 restrictions to the application of anti-rolling devices;
.6.14 directions for the use of anti-heeling tanks;
.6.15 other limitations proceeding from the ship's purpose and construction;
.7 list of openings which shall be closed when at sea to prevent the flooding of spaces in hull, superstructures or deckhouses which shall be taken into consideration for stability calculation purposes. Where necessary, a diagram of the openings shall be attached;
.8 instructions for the case of damage to bilge keels;
.9 general instructions concerning tanks which shall be either emptied or pressed up, except for those tanks out of which or into which liquid is taken. An instruction to the effect that the number of tanks with free surfaces shall be reduced to a minimum;
.10 general instructions to the effect that the heeling of a ship adversely effects stability and, therefore, efforts shall be made to maintain the ship in the upright position;
.11 instructions to the effect that the cargo shall be secured in accordance with the approved Cargo Securing Manual or in accordance with the recommendations of the master for the safe methods of stowing and securing the carried cargo (for fishing vessels);
.12 instructions to the effect that trimming is necessary in compliance with the IMSBC Code (during transportation of bulk cargoes);
.13 measures to ensure stability when, during a voyage or passage, the ships enter a region where the navigating conditions are more severe than those specified when assigning the area of navigation to the ship (provided such measures are necessary);
.14 instructions for preserving ship's stability when water is used for fire extinguishing;
.15 restrictions and instructions aimed at insuring an intact stability sufficient to satisfy the damage trim and stability requirements of the Register where these are compulsory for the ship in question;
.16 recommendations to the master which shall include recommendations for choosing the direction and speed with regard to the seaway having regard to the danger of parametric resonance of rolling when carrying deck cargo and/or at low initial stability, for minimum draught forward, manoeuvring directions (for instance, permissible speed with regard to heel on the turn for ships carrying containers on deck), recommendations for icing control, scale of forward and aft draught variations as a result of taking cargo on board the ship, directions for operating of heavy derricks (if installed on board the ship), etc.

Recommendations to the master for maintaining sufficient stability, including information deemed useful by the developer. They shall not be overburdened with well-known provisions of good maritime practice.

3.5 Typical loading conditions.

3.5.1 The Chapter shall contain the following information:
.1 plan of tanks, cargo spaces, machinery space, spaces intended for crew and passengers; the numbers and names shall be the same as in the ship documentation;
.2 tables showing the distribution of stores and ballast among tanks under typical loading conditions with indication of mass and centre of gravity coordinates of the tanks as well as of relevant moments. The numbers and names of the tanks shall be the same as those to be found in plan referred to in 3.5.1.1. The tanks with regard to which corrections for free surfaces were made, taken into consideration for typical loading conditions at 100 %, 50 % and 10 % filling, shall be indicated in the tables;

.3 mass and centre of gravity position, adopted for calculation purposes, of mass groups, such as passengers with their luggage and crew with their luggage, mass and centre of gravity position of cargo items (vehicles, containers, etc.);

.4 typical loading conditions including the following:

.4.1 light-ship condition;

.4.2 docking condition;

.4.3 loading conditions required by the RS rules, loading conditions for all cargoes mentioned in the specification; marginal conditions of the ship operation in accordance with its purpose to be encountered in practice and conditions of commencement of ballasting during the voyage for the purpose of maintaining stability;

.5 a summary table of typical loading conditions.

The summary table shall include:

.5.1 name of the loading condition;

.5.2 displacement;

.5.3 trim parameters of the ship (forward and aft draught, draught at perpendiculars, mean draught, trim);

.5.4 coordinates of the centre of gravity;

.5.5 free surface correction value to the initial metacentric height;

.5.6 initial metacentric height with regard to the free surface correction;

.5.7 height of the centre of gravity of the ship with regard to the free surface effect;

.5.8 permissible values of the height of the ship's centre of gravity;

.5.9 standardized parameters and stability criteria (weather criterion, static stability curve parameters, angle of heel due to passengers crowding to one side or angle of heel on the turn, etc.) and their permissible values;

.5.10 angle of flooding through opening considered to be open in accordance with the present Part.

3.5.2 As typical loading conditions are used to assess the cargo carrying capabilities of the ship, a limited number of conditions with 50 % stores shall be included in the typical loading conditions.

3.5.3 As a rule, the stability calculation for typical loading conditions shall be made for mean draught with initial trim disregarded.

3.5.4 Typical loading conditions shall be presented on special forms. In one and the same form, two or more loading conditions may be entered which may differ in the quantity of stores and ballast, characterizing the variations of loading during the voyage.

3.5.5 A form shall contain:

.1 description (name) of typical loading condition;

.2 drawing showing the location of basic mass groups on the ship that shall be included in the displacement; a plan and directions for the stowage of deck cargo;

.3 table for determining the ship's weight, coordinates of its centre of gravity and relevant mass moments with regard to coordinate planes including the weight moments and centre of gravity positions of particular mass groups and of the light ship, and where icing is concerned, taking the ice weight into consideration; correction for the free surface effect of liquid stores and ballast shall be given in the table;

.4 displacement;

.5 ship's draught at forward and aft perpendiculars, mean draught, draught at centre of waterline area, draught at draught marks; draught statements shall refer to bottom of keel, which shall be clearly indicated;

.6 moment to change trim one unit;

.7 longitudinal position of centre of buoyancy;

.8 longitudinal position of centre of gravity;

.9 longitudinal position of centre of waterline area;

.10 trim over perpendiculars;

.11 total correction for the effect of free surfaces of liquids;

.12 vertical position of the transverse metacentre (for trimmed condition if trim exceeds 0,5 % of the length of the ship);

.13 height of the ship's centre of gravity, its correction to free surface effect and the corrected value;

.14 initial metacentric height adopted with regard for free surface effect;

.15 permissible value of the height of the ship's centre of gravity or of the metacentric height determined on the basis of the RS rules, and the comparison with the corresponding value obtained;

.16 stability criteria required for the ship in question by the RS rules (weather criterion for the particular loading condition, standardized parameres of righting lever curve, heel angles due to passengers crowding to one side, etc.);

.17 table of righting arms;

.18 righting lever curve plotted with regard for free surface effect, the flooding angle indicated (the scales used in the diagrams shall be the same for all loading conditions);

.19 statement of the ship's stability under the particular loading condition;

.20 information, where applicable, with regard to operating limits, ballasting during voyage, water soaking of deck cargo, limitations to stowage factor of cargo, limitations to average container masses per tier; restrictions to the usage of heavy equipment and of swimming pools; and any other important aspects.

3.5.6 Notwithstanding the fact that for the carriage of grain a ship shall have a separate Grain Stability Stability Booklet drawn up in accordance with the Rules for the Carriage of Grain, typical loading conditions shall contain grain loading conditions, without regard to the shifting (where applicable).

3.6 Evaluation of stability for non-typical loading conditions.

3.6.1 Where an approved computer and programs for the evaluation of stability are available on board the ship, general data regarding the computer, the programs and the programmer, and the information on the approval of the programs shall be given (by whom, when and for what period they were approved).

3.6.2 Notwithstanding a computer being available on board the ship, the "manual" method of calculation and evaluation of stability shall be explained in detail. The explanation shall contain a description of the calculations sequence. As a rule, the description shall include six sections.

3.6.2.1 The first Section shall contain:

.1 calculation of displacement and of the coordinates of the ship's centre of gravity;

.2 determination of mean draught and comparison with permissible draught according to load line;

.3 determination of correction for free surface effect of liquid stores;

.4 height of the centre of gravity corrected for free surface effect of liquid stores;

.5 comparison of the value obtained for the height of the centre of gravity with the permissible value and condition of sufficient stability;

.6 actions and measures to be taken if the condition of sufficient stability is not fulfilled.

A note shall be made when describing the method of calculation adopted for this Section that the calculation shall be presented in the form of a table. The constants adopted (for instance, lightship weight, crew, etc.) shall be specified and entered in the table. The numbers of the tables, diagrams, etc. from which data for the calculation are taken shall be indicated in the text. The recommended table form is given below (refer to Table 3.6.2.1.6).

If containers, vehicles, etc., are carried, auxiliary table forms for determining the weight and the coordinates of the centre of gravity of the cargo and explanations with regard to the use of the tables shall be given.

Instructions concerning allowance for icing shall be given.

3.6.2.2 The second Section shall contain:

.1 calculation of trim;

.2 actions and measures to be taken if the trim exceeds permissible values;

.3 calculation of draughts at draught marks.

Calculations sequence, adopted formulae, tables, curves, charts, diagrams and references to their numbers shall be given in the text of the Section.

Table 3.6.2.1.6

Stability verification and draught calculation

Nos.	Type of loading	Mass, in t	Abscissa x_g, in m	Moment M_x, in t·m (3)×(4)	Applicate z_g, in m	Moment M_z, in t·m (3)×(6)	Moment of free surface of liquid $M_{f.s}$, in tm
1	Light ship	×	×	× ×	×	× ×	
2	Crew	×	×	× ×	×	× ×	
3							
n	Displacement	Δ		ΣM_x		ΣM_z	$\Sigma M_{f.s}$
1	Abscissa of ship centre of gravity $x_g=\frac{\Sigma M_x}{\Delta}=\frac{(5)}{(3)}$						________ m
2	Centre of gravity elevation above moulded base plane $z_g=\frac{\Sigma M_z}{\Delta}=\frac{(7)}{(3)}$						________ m
3	Correction for free surface effect of liquid stores $\frac{\Sigma M_{f.s.}}{\Delta}=\frac{(8)}{(3)}$						________ m
4	Corrected centre of gravity elevation above moulded base plane $z_{g_{\text{исп}}}=z_g+\frac{\Sigma M_{f.s.}}{\Delta}$						________ m
5	Permitted centre of gravity elevation above moulded base plane						________ m
6	By the value of M_x as per diagram (table) of forward and aft draughts: draught at forward perpendicular d_f draught at aft perpendicular d_a draught amidships $d_{\otimes}=\frac{d_f+d_a}{2}$						 ________ m ________ m ________ m

3.6.2.3 The third Section shall contain instructions for the calculation of the righting lever curve, formulae, references to the numbers of tables, curves, charts and diagrams.

The calculations shall be tabulated. The recommended table form is given below (Table 3.6.2.3).

Provision shall be made for a form for plotting the righting lever curve (Fig. 3.6.2.3).

Where an approved computer and programs for the evaluation of stability are available on board the ship, this Section is optional.

Table 3.6.2.3

Table for righting lever curve calculation

Angle of heel, θ°	5	10	15	20	30	40	50	60	70	80
Sinθ°										
Arm of form l_f										
$z_{gcorr}\sin\theta°$										
Arm of static stability curve $l=l_f-z_{gcorr}\sin\theta°$										

3.6.2.4 The fourth Section shall contain:

explanation, in the text and graphic form, for determining the weather criterion;

instructions for the calculation, formulae, references to the numbers of tables, curves, charts and diagrams used.

This Section may be optional in the following cases:

the weather criterion is not a limiting one;

an approved computer and programs enabling the calculation of the weather criterion are available on board the ship.

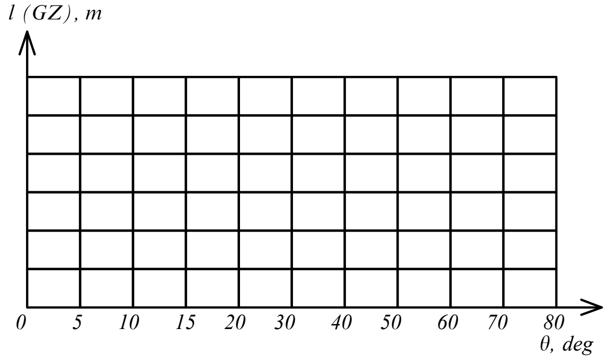


Fig. 3.6.2.3

3.6.2.5 The fifth Section shall contain instructions for calculating the angle of heel due to the effect of wind and/or angle of heel on the turn (if applicable). The formulae and norms adopted in the calculations shall be given.

3.6.2.6 The sixth Section shall contain a calculated example and a detailed explanation of the calculation and the evaluation of stability for a non-typical loading condition.

3.6.2.7 If the ship is equipped with an approved installation for performing in-service inclining tests, a guidance for performing such inclining tests shall be given in accordance with the operation manual of the installation.

Guidance for determining the ship's stability in service shall enable the master to determine the actual stability of the ship with adequate accuracy and without undue loss of time. This Section shall contain:

.1 instructions on the conditions and procedure for carrying out the in-service inclining test using the facilities available on board the ship (automatic systems for measuring and control of trim and stability, equalizing tanks, calibrated tanks for measuring stability and heel by means of a load the weight of which is known, etc.);

.2 data to assess the precision of measurements during the in-service inclining test and to estimate the quality of the test as a whole;

.3 instructions and materials to control initial metacentric height by measuring the roll period;

.4 explanations for the master concerning the assessment of the ship's stability by means of the above procedures.

3.6.2.8 The Section shall contain forms on which independent calculations can be made.

4 TECHNICAL INFORMATION

4.1 All drawings, diagrams, curves and tables shall be named and numbered.

The Section shall contain the following information:

.1 the ship's general arrangement plan;

.2 capacity plan.

The capacity plan shall show the layout of cargo spaces, tanks, stores, machinery spaces and crew and passenger accommodation. Cargo spaces and tanks shall bear names and numbers adopted on board the ship. In addition, the plan shall present:

.2.1 coordinate axes;

.2.2 frames, frame spacing and numbering;

.2.3 location of draught marks;

.2.4 diagram of the load line marks showing the position of the deck line relative to the ship, draught to the summer load line, draught to the summer timber load line (if any) and corresponding freeboards;

.2.5 deadweight scale.

It is permitted to incorporate the general arrangement plan and the capacity plan into a single plan;

.3 cargo space information.

Information on each cargo space shall include:

.3.1 name and number;

.3.2 location (frames);

.3.3 volume at 100 % filling;

.3.4 coordinates of the centre of volume;

.3.5 bale cargo capacity and grain capacity;

.3.6 permissible load for plating;

.3.7 permissible cargo mass for bulk carriers;

.3.8 on oil tankers, volume at 98 % filling and the corresponding moment of inertia of the free surface;

.3.9 for dry cargo holds intended for the carriage of solid bulk cargoes, volume and coordinates of the centre of gravity depending on the level of filling;

.3.10 on container ships and ships equipped for the carriage of containers, container stowage plan (including deck containers) on the basis of which one can calculate the masses and the position of the centre of gravity of containers in the assumed loading condition. Maximum stack masses and maximum stack heights of containers shall be specified in the plan. A sketch shall be presented to confirm that the requirement for bridge visibility is fulfilled;

.3.11 on roll-on/roll-off ships, vehicle stowage plan;

.3.12 stowage plan for the deck cargo of timber with regard to the stowage factor and the requirements for bridge visibility;

.4 tank space information.

Information on each tank space, including cargo tanks, shall include:

.4.1 name and number of tank;

.4.2 location (frames);

.4.3 volume, volumetric centre coordinates and the moment of inertia of the free surface depending on the level of filling.

Intervals of 0,10 m shall, as a rule, be adopted for the level of liquid. In justified cases a greater interval may be adopted;

.5 hydrostatic particulars.

Hydrostatic particulars shall be calculated for the ship on even keel or design trim (without deflection) against displacement over a range from light ship to 115 % of the displacement to the load line. The draught intervals shall be 0,05 m. In justified cases, a greater interval may be adopted. The particulars shall be presented in the form of a table.

If the ship is intended for operation with a trim exceeding $\pm 0{,}5$ % of the ship's length, additional tables of hydrostatic particulars shall be presented for a suitable range of trim. The trim interval shall not exceed 1 % of the ship's length.

Draught statements shall refer to bottom of keel;

.6 cross-curves of stability data.

Cross-curves of stability data shall be provided for heeling angles up to 20° at 5° intervals, and from 20° to 80° at 10° intervals. The displacement range shall correspond to that in 4.1.5; draught (displacement) intervals shall be 2 % of the draught (displacement) range. Cross-curves of stability values shall be presented in the form of a table. The table shall be supplemented by a sketch showing the ship's watertight spaces, which were taken into account for the calculation.

If the ship is intended for operation with a trim exceeding ±0,5 % of the ship's length, additional tables of cross-curves of stability shall be presented for the ship with a trim. The trim interval shall not exceed 1 % of the ship's length.

If the buoyancy of the deck cargo is taken into account when performing stability calculations, an additional separate cross-curves of stability table and a relevant sketch shall be drawn up.

Cross-curves of stability calculations shall be performed having regard to the accompanying trim;

.7 solid cargo information.

If solid cargo is stowed on board the ship, a sketch shall be presented showing the stowage of the ballast, with a specification containing information on the weight of each ballast group and the coordinates of the centre of gravity;

.8 information for stability control.

Information for stability control shall include permissible values of the height of the centre of gravity of the ship (or of permissible metacentric heights) depending on displacement (draught). The information shall be presented in the form of a table.

The information may include more than one table for different conditions of the ship's operation (for instance, for operation without deck cargo, with timber cargo on board the ship, with deck cargoes of timber having different permeabilities, under conditions of icing, when carrying one or two or three tiers of containers on deck, etc.). The permissible values of the height of the ship's centre of gravity shall be calculated with regard to subdivision requirements and damage trim and stability requirements where such requirements are compulsory for a ship.

If the ship is intended for operation with a trim exceeding $\pm 0,5$ % of the ship's length, additional tables (diagrams) of permissible values of the height of the center of gravity of the ship with the trim shall be presented. The trim interval shall not exceed 1 % of the ship's length; the tables (diagrams) shall specify the trim range they apply to.

Where necessary, a table shall be presented containing minimum values of the height of the ship's centre of gravity at which the requirements of the Rules for the acceleration criterion are fulfilled;

.9 information on angles of flooding.

Information on flooding angles in the form of a table (tables) proceeding from displacement or draught with a plan of openings assumed to be open. The names of the openings and their coordinates shall be indicated. Openings for ventilation of machinery spaces which ensure operation of machinery and its maintenance and which may not be closed in rough weather shall be assumed to be open;

.10 tables showing free surface correction values for liquid cargoes.

Free surface correction values to the initial metacentric height and righting levers for liquid cargoes, in tabular form;

.11 a diagram of forward and aft draughts.

A diagram (or table) of forward and aft draughts (at perpendiculars) plotted on a graph of displacement versus the longitudinal static mass moment of the ship. The diagram shall enable the master to speedily determine the draughts at forward and aft perpendiculars;

.12 a diagram (or table) correlating the draughts at perpendiculars with the draughts at draught marks;

.13 data for direct calculation of weather criterion on the basis of the static or dynamic stability curves. If the weather criterion is not a limiting one, the data mentioned above shall be presented in the Section 5 of the Appendix.

5 REFERENCE INFORMATION

5.1 This Section shall contain information, which may be useful for the master, Port Administration and the Administration when resolving matters connected with the ship's stability.

The Section shall contain:

.1 a detailed diagram of permissible heights of the ship's centre of gravity, including curves for each of the stability criteria applicable to the ship in question. Resulting curves of permissible heights of the ship's centre of gravity shall be highlighted on the diagram;

.2 data for direct calculation of weather criterion on the basis of the static or dynamic stability curves (at the discretion of the developer);

.3 a copy of the Inclining Test Report for the ship or its prototype and a copy of the Light-Weight Check Report (if any);

.4 any other data included in the Booklet at the discretion of the shipowner.

5.2 Booklet for floating cranes.

5.2.1 For floating cranes, the Booklet shall contain data on their stability as regards the rated criteria for various boom radii and various loads on the hook (by mass and windage area) including loading conditions in which the stability becomes unsatisfactory by any criterion (criteria).

5.2.2 For floating cranes which stability in case of load drop is limited by the angle of flooding in the working condition, the Booklet shall contain requirements for reliable battening down of openings which shall not be permanently open during cargo-handling operations.

5.2.3 Because of the variety of their loading conditions, data on the stability of floating cranes shall be presented in a simple and obvious form (for instance, in tables and diagrams characterizing the loading and stability of the floating crane in each of the loading conditions).

5.2.4 In the case of floating cranes with luffing booms, the following rule shall be applied: in order to reduce the influence of external forces upon the floating crane the boom shall be lowered to the lowest position (secured for sea) on completion of cargo-handling operations.

5.2.5 In case of floating cranes with slewing cranes and a cargo platform on deck it is not recommended to perform cargo-handling operations when under way (e.g. carriage of loads hanging on the hook semi-submerged or raised above water: small ships, metal structures, etc.). Where this is performed by floating cranes of any type, restrictions on the area of navigation and weather shall be specified for such a voyage in each case, and arrangements shall be made for reliable securing to prevent the boom, hanger and the hanging load from swinging. The possibility of a voyage with a load on the hook shall be confirmed by calculation and approved by the Register in each case.

5.3 The Booklet for the tug shall include a direction to the effect the maneuvering close to a stopped ship without casting off a tow rope is dangerous at the current speed above 1,3 m/s.

APPENDIX 2

DETERMINATION OF CAPSIZING MOMENT FOR A FLOATING CRANE

1.1 Determination of capsizing moment and the angle of dynamical heel in working condition in case of load drop.

To determine the capsizing moment and the angle of dynamical heel after load drop, the curve of dynamical stability (to arm scale) shall be constructed for the loading condition under consideration, but without load on hook. In case the floating crane centre of gravity after the load drop does not coincide with the centreline, the curve shall be constructed with regard to angle of heel θ'_0 due to unsymmetrical loading (including also unsymmetrical arrangement of cargo on deck). A portion of the curve shall be constructed in the negative angle area. To be plotted to the left from the origin of the coordinates is the initial angle of heel θ'_{d2} of the floating crane with a load on the hook, equal to the sum of the amplitude of roll θ_r in the working condition and the angle of statical heel θ_0 when the load is lifted (Fig. 1.1).

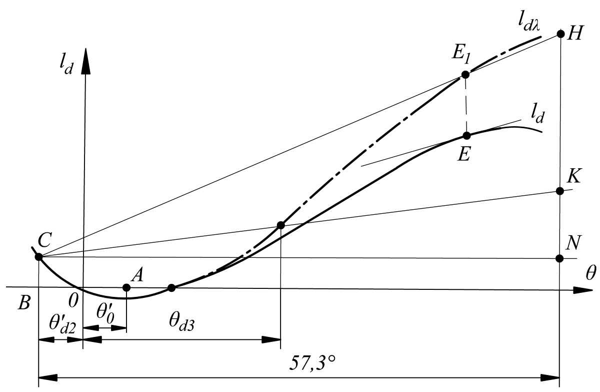


Fig. 1.1 Determination of capsizing moment and the angle of dynamical heel at the indication after load drop

The appropriate point C is fixed on the curve. The curve of the reduced arms is plotted to the right from the origin of the coordinates above the curve of statical stability, whose ordinates, in m, are determined by the formula

$$l_{d\lambda} = l_d + \delta l_\lambda \tag{1.1-1}$$

where δl_λ = correction taking into account damping forces to be obtained in compliance with 1.4 of the present Appendix.

The secant CE_1 is drawn from the point C so that the point of its intersection E_1 with the reduced arm curve lies on the same vertical line with point E, in which the straight line parallel to the secant touches the curve. From point C segment CN equal to 57,3° is laid off parallel to the axis of abscissae. From point N the perpendicular is erected up to its intersection with the secant at point H. Segment NH is equal to the arm of the capsizing moment, in kN·m, with due regard for damping to be determined by the formula

$$M_{c\lambda} = g\Delta\overline{NH} \tag{1.1-2}$$

where Δ = displacement, in t.

From point N segment NK is laid off equal to the arm of the heeling moment, in m, to be determined by the formula

$$NK = M_v / g\Delta \tag{1.1-3}$$

where M_v = heeling moment due to wind pressure, in kN·m.

Points C and K are connected by the straight line, whose point of intersection with the curve of reduced arms determines the angle of dynamical heel θ_{d3} at the inclination after load drop.

Stability may be checked taking no account of damping. In this case, the curve of reduced arms is not constructed, but the tangent is drawn from point C to the curve of dynamical stability. The angle of dynamical heel θ_{d3} is determined by the point of intersection of straight line CK with the curve.

1.2 Determination of capsizing moment during voyage.

1.2.1 The capsizing moment M_c of the floating crane under the effect of rolling and steady wind may be determined both by the curve of dynamical stability and the righting lever curve, some portions of which are constructed for negative angles.

When using the curve of dynamical stability the positions of initial point A and point A_1 (Fig. 1.2.1) are so selected that tangent AC is parallel to the tangent A_1K and the difference of angles of heel corresponding to points A_1 and A is equal to the amplitude of roll.

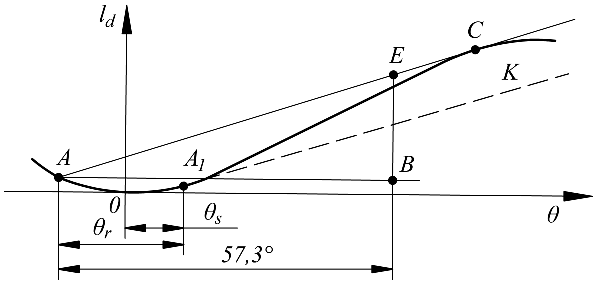


Fig. 1.2.1 Determination of capsizing moment of a floating crane secured for sea from the curve of dynamical stability

Angle θ_s obtained therefrom corresponds to the angle of statical heel due to limiting wind pressure, and segment BE is equal to the capsizing moment if the curve of dynamical stability is plotted to scale of moments, and to the arm of the capsizing moment, if the curve of dynamical stability is plotted to scale of arms.

In the latter case, the capsizing moment, in kN·m, is determined by the formula

$$M_c = \Delta\overline{BE}. \qquad (1.2.1)$$

1.2.2 When the righting lever curve is used, the capsizing moment can be determined assuming the work of the capsizing moment and that of the righting moment to be equal and taking account of the effect of rolling and statical heel due to limiting wind pressure (Fig. 1.2.2). For this purpose, the righting lever curve is continued in the region of negative angles for such a portion that straight line MK parallel to the axis of abscissae cuts off the cross-hatched areas S_1 and S_2 equal to each other and the difference of angles corresponding to points A_1 and A is equal to the amplitude of roll.

Ordinate 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 righting arms are plotted along the axis of ordinates.

1.2.3 If the curves of statical and dynamical stability are cut short at the angle of flooding, the capsizing moment shall be determined with regard to statical heel and the amplitudes of roll as specified in 1.2.1 and 1.2.2, yet the reserve of stability S_2 is restricted to the angle of flooding θ_f.

Capsizing moment M_c' is determined similar to the moment M_c, provided the amplitude of roll θ_r in Fig. 1.2.2 is plotted in way of negative abscissa values from the reference point.

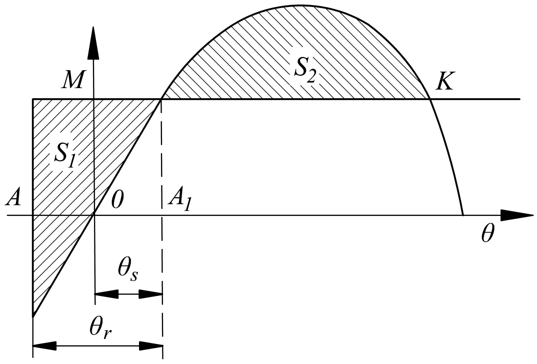


Fig. 1.2.2 Determination of the capsizing moment of a floating crane secured for sea from the righting lever curve

1.3 Determination of capsizing moment in non-working condition.

The capsizing moment is determined from the righting lever curve (Fig. 1.3) for non-working loading condition with due regard for the free surface effect as well as the initial angle of heel θ'_0 due to the boom turn in the plane of the frame for floating cranes and crane ships with slewing cranes.

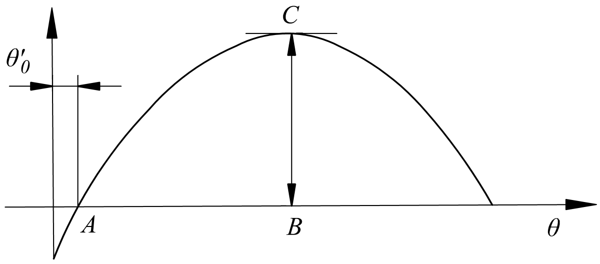


Fig. 1.3 Determination of capsizing moment in non-working condition

Segment *CB* is equal to the capsizing moment if the curve is plotted to scale of moments, and to the arm of the capsizing moment l_{max} if the curve is plotted to scale of arms. In the latter case, the capsizing moment, in kN·m, shall be determined by the formula

$$M_c = g\Delta l_{max} \tag{1.3}$$

where Δ = displacement, in t.

1.4 Determination of the correction to the curve of dynamical stability, taking account of damping forces.

Correction δl_λ, in m, taking account of damping forces shall be determined by the formula

$$\delta l_\lambda = l_\lambda \sqrt{C_B B d}\,(\theta_p/57{,}3)^2 F_5 \tag{1.4-1}$$

where B = breadth of the ship, in m;
d = moulded draught of the ship, in m;
C_B = block coefficient of the ship;
θ_p = double swing value counting from the angle equal to the initial heel at the moment of load drop, in deg.;
l_λ = factor determined by the formula

$$l_\lambda = F_0\left(F_1 + \frac{z_g - d}{\sqrt{C_B B d}} F_2\right) + \frac{z_g - d}{\sqrt{C_B B d}} F_3 + F_4 \tag{1.4-2}$$

where z_g = centre of gravity height above the base line, in m;
F_0 is taken from Fig. 1.4 depending on characteristic F and P;
F is determined by Formula (4.1.6.2.4-3);
F_1, F_2, F_3, F_4 are taken from Table 1.4-1 depending on P;
F_5 = factor obtained from Table 1.4-2 depending on the ratio $(\theta_d + \theta'_{d2})/\theta_p$
where θ_d = angle of deck immersion.

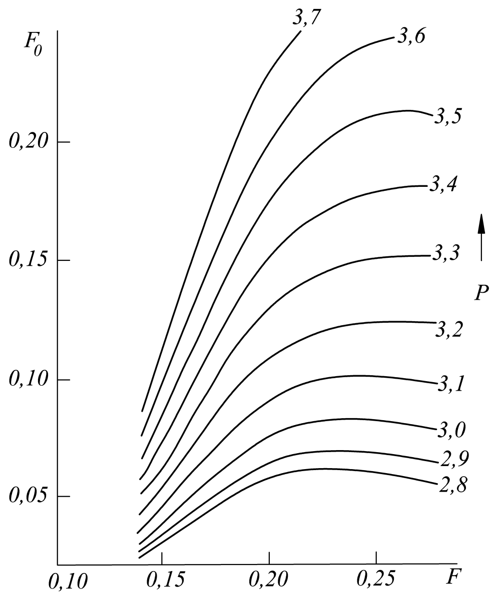


Fig. 1.4

Table 1.4-1

Factors F_1, F_2, F_3, F_4

P	F_1	F_2	F_3	F_4
2,8	1,987	— 3,435	0,0725	— 0,021
2,9	2,087	—3,313	0,0856	— 0,028
3,0	2,144	— 3,097	0,1007	— 0,037
3,1	2,157	— 2,823	0,1150	— 0,047
3,2	2,138	— 2,525	0,1273	— 0,057
3,3	2,097	— 2,230	0,1357	— 0,067
3,4	2,043	— 1,955	0,1417	— 0,076
3,5	1,982	— 1,711	0,1454	— 0,084
3,6	1,921	— 1,497	0,1474	— 0,091
3,7	1,861	— 1,312	0,1475	— 0,097

Table 1.4-2

Factor F_5

$\frac{\theta_d + \theta'_{d_2}}{\theta_p}$	F_5	$\frac{\theta_d + \theta'_{d_2}}{\theta_p}$	F_5
1,0	1,0	0,5	1,5
0,9	1,053	0,4	1,626
0,8	1,138	0,3	1,747
0,7	1,253	0,2	1,862
0,6	1,374		

APPENDIX 3

IMO RESOLUTION MSC.415(97) REQUIREMENTS FOR THE STABILITY OF ANCHOR HANDLING VESSELS, TUGS, ESCORT TUGS, FLOATING CRANES AND CRANE SHIPS

Prior to coming into force of IMO resolution MSC.415(97) the requirements specified in this Appendix may be used for checking stability of anchor handling vessels, tugs, escort tugs, floating cranes and crane ships.

1 ANCHOR HANDLING VESSELS

1.1 Heeling lever.

1.1.1 A heeling lever HL_θ, in m, generated by the tension applied to the tow line shall be calculated as:

$$HL_\theta = (M_{AH}/\Delta_2)\cos\theta$$

where $M_{AH} = F_p(h \cdot \sin\alpha \cdot \cos\beta + y \cdot \sin\beta)$;

$F_v = F_p \cdot \sin\beta$;

F_p = permissible tow line tension, in tm, which can be applied to the vessel during operation while working through specified towing pins. F_p shall in no circumstance be taken as greater than F_d;

F_d = design maximum tow line tension, in tm, the maximum winch towing line pull or maximum static winch brake holding force, whichever is greater;

β = vertical angle, in deg., between the waterline and the vector at which the tow line tension is applied determined at the maximum heeling moment angle and calculated as

$\mathrm{arctg}(y/(h \cdot \sin\alpha))$;

β shall be taken not less than

$\arccos(1{,}5B_p/(F_p \cdot \cos\alpha))$;

B_p = maximum continuous pull (bollard pull), in tm;

h = vertical distance, in m, from the centre the propulsive force acts on the vessel 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 tow line transverse movement;

α = horizontal angle, in deg., between the centreline and the vector at which the tow line tension is applied to the vessel in the upright position;

y = transverse distance, in m, from the centreline to the outboard point at which the tow line tension is applied to the vessel, calculated as

$y_0 + x \cdot \tan\alpha$;

y shall be taken not greater than $B/2$;

y_0 = transverse distance, in m, between the vessel centreline to the inner part of the towing pin or any physical restriction of the transverse tow line movement;

x = longitudinal distance, in m, between the stern and the towing pin or any physical restriction of the transverse tow line movement;

B = breadth of the vessel, in m;

Δ_2 = displacement of a vessel, including action of the vertical loads added F_v, at the centreline in the stern of the vessel;

1.2 Permissible tow line tension.

1.2.1 The calculated permissible tow line tension shall not be greater than the value specified in 1.2.2.

1.2.2 Permissible tow line tension as function of α, defined in 1.1 can be calculated by direct stability calculations, provided that the following conditions are met:

.1 the heeling lever is calculated as defined in 1.1 for each α;

.2 all the stability criteria specified in 1.3 are met;

.3 α shall not be taken less than 5°, except for the case specified in 1.2.3;

.4 intervals of α shall be not be more than 5°, except for the cases where permissible tow line tension does not exceed values calculated for more unfavourable values of α.

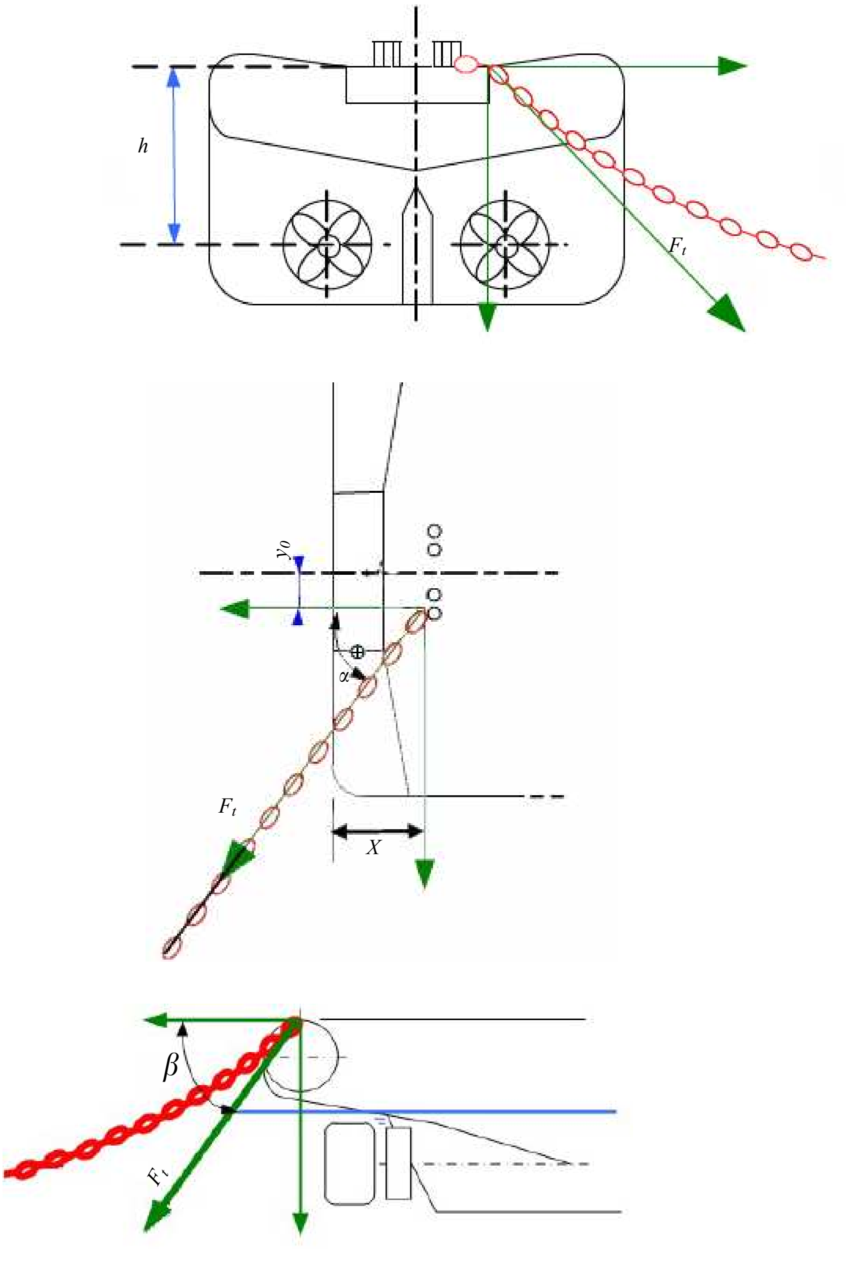


Fig. 1.1.1 Diagram showing the positions of angles α and β and distances *h*, *x* and *y*.
F_t shows the vector of the applied tow line tension

1.2.3 For operations to retrieve a stuck anchor, in which the vessel is on station above the anchor and the vessel has low or no speed, α may be taken as less than 5°.

1.3 Stability criteria.

1.3.1 Stability of a vessel during anchor handling operations shall comply with the criteria specified in this Chapter. In other operating conditions the vessel's stability shall comply with the criteria specified in Section 2 to the present Part and other applicable criteria.

1.3.2 The area between the righting lever curve and the heeling lever curve calculated in accordance with 1.1.1 and determined from the first intersection of the two curves, to the angle of the second intersection or the angle of down-flooding, whichever is less, shall not be less than 0,070 m·rad.

1.3.3 The maximum righting lever between the righting lever curve and the heeling lever curve calculated in accordance with 1.1.1 shall be at least 0,2 m.

1.3.4 The static angle at the first intersection between the righting lever curve and the heeling lever curve calculated in accordance 1.1.1 shall not be greater than:

.1 the angle at which the righting lever equals half of the maximum righting lever;

.2 the deck edge immersion angle;

.3 15°,

whichever is less.

1.3.5 A minimum freeboard at stern, on centreline, of at least $0{,}005L$ shall be maintained in all loading conditions, including vertical loads added (as per the definition of displacement Δ_2 given in 1.1.1). In the event of the anchor retrieval operation specified in 1.2.3, a lower minimum freeboard may be accepted provided that due precautions are indicated in the operation plan.

1.4 Stability of anchor handling vessels shall be checked for the following loading conditions in addition to those specified in 1.4.8.2 of the present Part:

.1 loading condition at the maximum draught at which anchor handling operations may occur, with 67 % of stores;

.2 loading condition at the minimum draught at which anchor handling operations may occur, with 10 % of stores.

1.5 Stability of anchor handling vessels shall be checked for all towing pins with relevant maximum allowable tow line tension, and other structural elements restricting the tow line movement.

1.6 For anchor handling vessels in loading conditions specified in 1.4 when applying the design tension F_d, for the towing pin nearest to centerline, stability criteria specified in 1.2.2 shall be met as a minimum for α equal to 5°.

1.7 Stability instrument.

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

.1 software checking the permissible tension on the basis of the permissible tension curves;

.2 software performing direct stability calculations to check compliance with the relevant criteria, for a given loading condition (before application of the tow line tension force), a given tension and a given tow line position (defined by angles α and β).

2 TUGS AND ESCORT TUGS

2.1 Heeling lever.

2.1.1 The heeling lever, in m, occurring during towing operations is calculated as follows:

.1 a transverse heeling moment is generated by the maximum transverse thrust exerted by the tug's propulsion and steering systems and the corresponding opposing tow line pull;

.2 the heeling lever HL_θ, in m, as a function of the heeling angle θ, shall be calculated according to the following formula:

$$HL_\theta = \frac{BP \cdot C_T \cdot (h \cdot \cos\theta - r \cdot \sin\theta)}{g \cdot \Delta}$$

where BP = maximum continuous pull (bollard pull), in kN;

$C_T = 0{,}5$, for tugs with non-azimuth propulsion units;

$C_T = 0{,}9/(1 + l/L)$, for tugs with azimuth propulsion units installed at a single point along the length. C_T shall not be less than 0,7 for tugs with azimuth stern drive towing over the stern or tractor tugs towing over the bow, and not less than 0,5 for tugs with azimuth stern drive towing over the bow or tractor tugs towing over the stern;

for tugs with other propulsion and towing arrangements, the value of C_T shall be determined in accordance with the procedure approved by the Register;

Δ = displacement, in t;

l = longitudinal distance, in m, between the towing point and the vertical centreline of the propulsion unit;

h = vertical distance, in m, between the towing point and the horizontal centreline of the propulsion unit;
g = gravitational acceleration, in m/s^2, to be taken as 9,81;
r = transverse distance, in m, between the centreline and the towing point;
L = length of the tug, in m.

The towing point (being the location where the tow line force is applied to the tug) may be a towing hook, staple, fairlead or equivalent fitting serving for fastening or restricting the movement of the tow line.

2.1.2 The heeling lever HL_θ, in m, caused by the tow line jerk, shall be calculated according to the following formula:

$$HL_\theta = C_1 C_2 V^2 A_p \frac{h \cdot \cos\theta - r \cdot \sin\theta + C_3 \cdot d}{2 \cdot g \cdot \Delta}$$

where $C_1 = 2{,}8(\frac{L_S}{L_{pp}} - 0{,}1)$ $0{,}1 \leqslant C_1 \leqslant 1{,}00$;

$C_2 = (\frac{\theta}{3\theta_D} + 0{,}5)$ $C_2 \leqslant 1{,}00$;

θ_D = deck edge immersion angle, in deg., calculated according to the formula $\theta_D = \mathrm{arctg}(\frac{2f}{B})$;

C_3 = distance from the centre of lateral projected area of the underwater hull A_p to the waterline as fraction of the draught related to the heeling angle, in m;

$C_3 = (\frac{\theta}{\theta_D}) \cdot 0{,}26 + 0{,}30$ $0{,}50 \leqslant C_3 \leqslant 0{,}83$;

γ = specific gravity of water, in t/m^3;
V = lateral velocity, in m/s, to be taken as 2,57 (5 knots);
A_p = lateral projected area of the underwater hull on the centerline, in m^2;
r = transverse distance between the centreline and the towing point, in m;
L_S = longitudinal distance, in m, from the aft perpendicular to the towing point;
d = draught of the tug, in m.

The towing point (being the location where the towline force is applied to the tug) may be a towing hook, staple, fairlead or equivalent fitting serving for fastening or restricting the movement of the tow line.

2.2 Heeling lever for escort operations.

2.2.1 For the evaluation of the stability particulars during escort operations, the tug 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 tow line force as shown in Fig. 2.2.1.

2.2.2 At design stage, the steering force, breaking force, heeling angle and heeling lever may be determined by model test or calculation. On completion of the tug's construction, the values of maximum steering force and maximum heeling angle of the tug are specified by full scale tests or numerical simulations in accordance with the procedure approved by the Register.

2.2.3 For each loading condition, the evaluation of the equilibrium positions shall be performed over the applicable escort speed range, whereby the speed of the assisted ship through the water shall be considered (the typical escort speed range is 6 — 10 knots).

2.2.4 For each relevant combination of loading condition and escort speed, the maximum heeling lever shall be used for the evaluation of the stability particulars.

2.2.5 For the purpose of stability calculations, the heeling lever shall be taken as constant.

2.3 Stability criteria.

2.3.1 Stability of tugs during harbour, coastal or ocean-going towing operations shall comply with the criteria specified in this Chapter in addition to those given in Section 2 of the present Part and other applicable criteria.

2.3.2 For tugs engaged in harbour, coastal or ocean-going towing operations, the area A contained between the righting lever curve and the heeling lever curve occurring during towing calculated in accordance with 2.1.1, measured from the heeling angle θ_e to the angle of the second intersection θ_c, or the angle of down-flooding θ_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 heeling angle $\theta = 0$ to the heeling angle θ_e.

θ_e = heeling angle, in deg., at first intersection between the heeling lever and righting lever curves;

θ_f = angle of down-flooding, in deg. In stability calculations, openings fitted with weathertight closing devices, which may be required to keep open for operational reasons (doors leading to machinery and boiler trunks or to upper deck superstructures, as well as the doors to all companionways of spaces located below the upper deck) shall be taken into account;

θ_c = heeling angle, in deg., at second intersection between the heeling lever and righting lever curves.

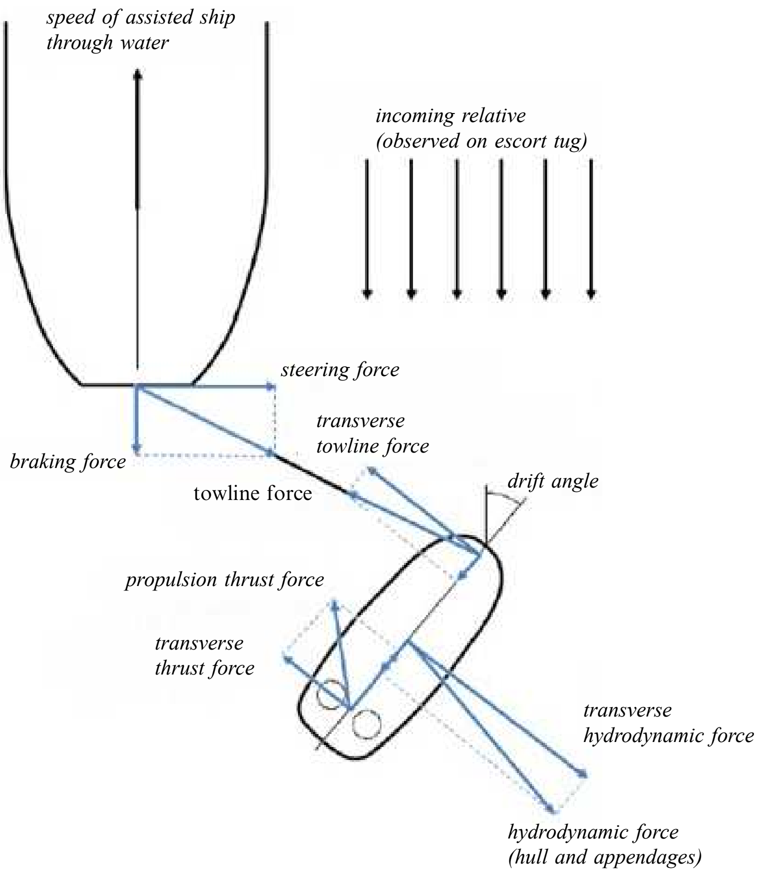


Fig. 2.2.1

2.3.3 For tugs engaged in harbour, coastal or ocean-going towing operations, the first intersection between the righting lever curve and the heeling lever curve occurring due to tow line jerk calculated in accordance with 2.1.2 shall occur at an angle of heeling less than the angle of down-flooding θ_f.

2.3.4 For escort tugs, the maximum heeling lever determined in accordance with 2.2 shall comply with the following criteria:

.1 $A \geqslant 1,25 \cdot B$;

.2 $C \geqslant 1,40 \cdot D$;

.3 $\theta_e \leqslant 15°$

where A = righting lever curve area measured from the heeling angle θ_e to a heeling angle of 20° (refer to Fig. 2.3.4-1);
B = heeling lever curve area measured from the heeling angle θ_e to a heeling angle of 20° (refer to Fig. 2.3.4-1);
C = righting lever curve area measured from the zero heel to the heeling angle θ_d (refer to Fig. 2.3.4-2);
D = heeling lever curve area measured from zero heel to the heeling angle θ_d (refer to Fig. 2.3.4-2);
θ_e = heeling angle, in deg., corresponding to the first intersection between heeling lever curve and the righting lever;
θ_d = heeling angle, in deg., corresponding to the second intersection between heeling lever curve and the righting lever curve or the angle of down-flooding, whichever is less.

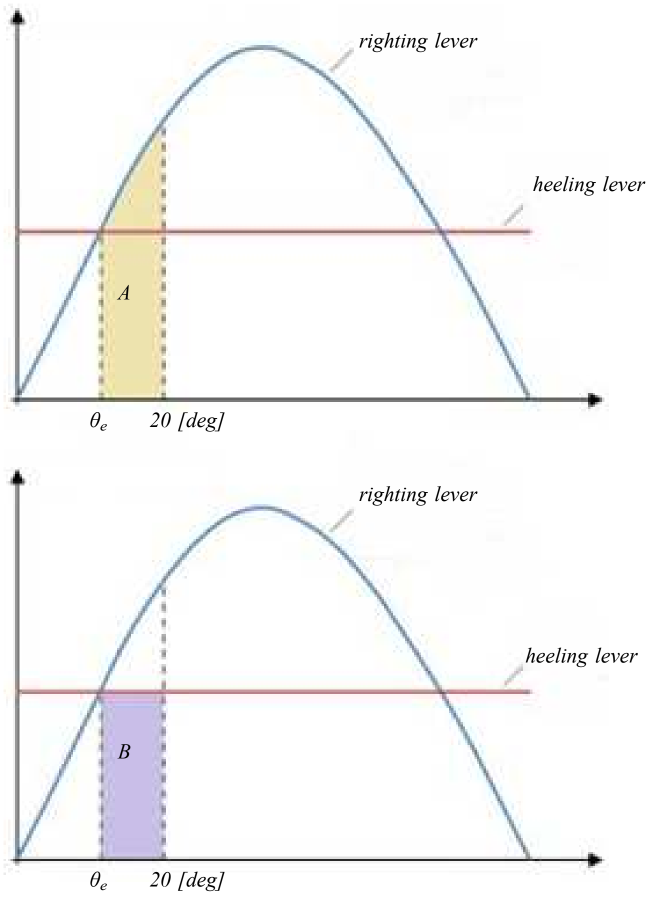


Fig. 2.3.4-1

2.3.5 A minimum freeboard at stern, of at least 0,005*L*, measured on centerline, shall be maintained in all loading conditions.

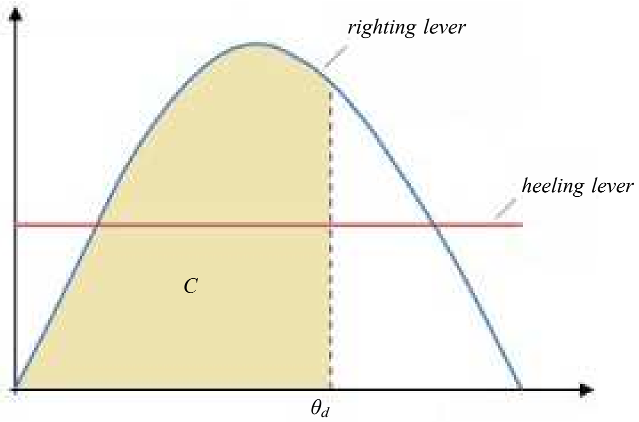
2.4 Stability of tugs engaged harbour, coastal or ocean-going towing operations and escorting operations shall be checked in the following loading conditions in addition to those specified in 1.4.8.2 of the present Part:

.1 maximum operational draught at which towing or escorting operations may be carried out, with 100 % of stores;

.2 minimum operational draught at which towing or escorting operations may be carried out, with 10 % of stores;

.3 intermediate condition with 50 % of stores.

2.5 For tugs engaged in harbour, coastal or ocean-going towing operations, for anchor handling vessels, floating cranes/crane ships, the weight of cargo, chains, spare tow lines and tow lines for towing winches shall be taken into account for given loading conditions.



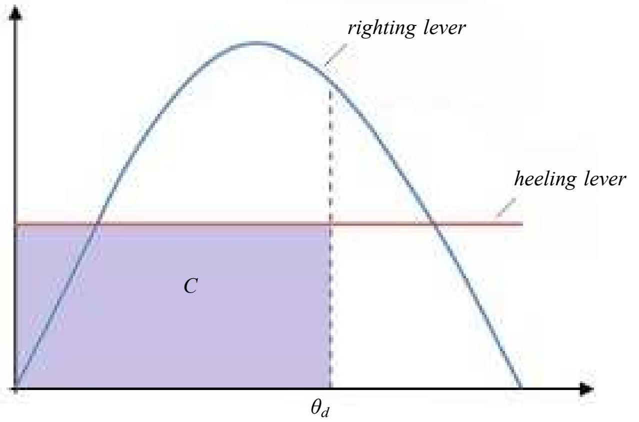


Fig. 2.3.4-2

3 FLOATING CRANES/CRANE SHIPS

3.1 Application.

3.1.1 The provisions of this Chapter shall apply to ships (floating cranes/crane ships) engaged in lifting operations, including those involving the lifting of the ship's own structures or lifting of cargoes, in which the maximum heeling moment due to the lift is greater than that calculated by the following formula:

$$M_L = 0{,}67 \cdot \Delta \cdot GM \cdot (\frac{f}{B})$$

where M_L = value for the heeling moment, in tm, induced by the load in the cargo handling gear;
GM = metacentric height, in m, with free surface correction, including the effect of the load in the cargo handling gear;
f = minimum freeboard, in m, measured from the upper side of the weather deck to the waterline;
B = breadth of the ship, in m;
Δ = displacement of the ship, including the lift load, in t.

The provisions of this Chapter shall also apply to ships which are engaged in lifting operations where the increase of the ship's vertical centre of gravity (VCG) due to the lifted weight is greater than 1 %.

The calculations shall be done for the most unfavourable loading condition, for which the use of cargo handling gear is possible.

3.1.2 For the purpose of this Section, waters that are not exposed are those where the environmental impact on the lifting operation is negligible. Otherwise, waters shall be considered exposed. In general, waters that are not exposed are calm stretches of water, i.e. estuaries, roadsteads, bays, lagoons; where the wind fetch (an area with no physical obstacles, where wind can pass along the water in straight direction) is 6 miles or less.

3.2 Load and vertical centre of gravity for different types of lifting operations.

3.2.1 In the calculations of stability during lifting operations involving cargo handling gear 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 cargo handling gear;

.2 the transverse distance y is the transverse distance between the point at which the vertical load is applied to the cargo handling gear and the ship centreline in the upright position;

.3 the vertical height of the load KG_{load} is taken as the vertical distance from the point at which the vertical load is applied to the cargo handling gear to the baseline in the upright position;

.4 the change of centre of gravity of the cargo handling gear shall be taken into account in calculations.

3.2.2 In the calculations of stability during lifting operations not involving cargo handling gear 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 shall be the maximum allowed 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 cargo handling gear and the ship's centreline in the upright position;

.3 the vertical height of the load KG_{load} is taken as the vertical distance from the point at which the vertical load is applied to the cargo handling gear to the baseline in the upright position.

3.3 Stability criteria.

3.3.1 The stability criteria specified in this Chapter, as well as the criteria set forth in 3.4 — 3.5 or 3.7, as applicable, shall be satisfied for all loading conditions where lifting operations are possible, with the cargo handling gear and its load at the most unfavourable positions, as regards stability. For the purpose of this Chapter and 3.4, the displacement and centre of gravity of the ship shall be calculated taking into account the weight and the centre of gravity (COG) of the cargo handling gear and its load.

3.3.2 Stability of ships during the lifting operations specified in 3.1.1, shall comply with the following stability criteria in addition to those set forth in Section 2 of the present Part and other applicable criteria:

.1 the equilibrium heeling angle shall not be greater than the allowable static heeling angle at which the reliable operation of the cargo handling gear is ensured;

.2 during lifting operations in non-exposed waters, the minimum distance between the water level and the highest continuous deck taking into account trim and heel at any position along the length of the ship, shall not be less than 0,5 m;

.3 during lifting operations in exposed waters, the minimum distance between the waterline and the highest continuous deck taking into account trim and heel at any position along the length of the ship shall not be less than 1 m or the highest significant wave height ($0,75 \cdot h_{3\%}$), in m, at which the operation is possible, whichever is greater.

3.4 Lifting operations conducted under environmental and operational limitations.

3.4.1 For stability checking during lifting operations carried out within clearly defined limitations specified in 3.4.1.1, the stability criteria set forth in 3.4.1.2 may be applied instead of the criteria given in 3.3:

.1 the limits of the environmental conditions shall include at least the following:

the maximum height of the wave of 3 % probability of exceeding level height $h_{3\%}$;

the maximum wind speed (1 min sustained at 10 m above sea level);

the limits of the operational conditions shall include at least the following:

the maximum duration of the lift;

limitations in ship speed;

limitations in traffic/traffic control;

.2 stability of the ship shall be checked at the most unfavourable position of the cargo handling gear with the lifted load, as regards stability, for compliance with the following criteria:

.2.1 the corner of the highest continuous deck shall not be submerged;

.2.2 $A_{RL} \geqslant 1,40 \cdot A_{HL}$

where A_{RL} = the area under the 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 θ_1 to the angle of down-flooding θ_f or the angle of vanishing stability θ_R or the second intersection of the righting lever curve with the wind heeling lever curve, whichever is less (refer to Fig. 3.4.1.2);

A_{HL} = 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 3.4.1.1 (refer to Fig. 3.4.1.2);

.2.3 the area under the righting lever curve from the equilibrium heeling angle θ_1 to the down-flooding angle θ_f or 20°, whichever is less, shall be at least 0,03 m·rad.

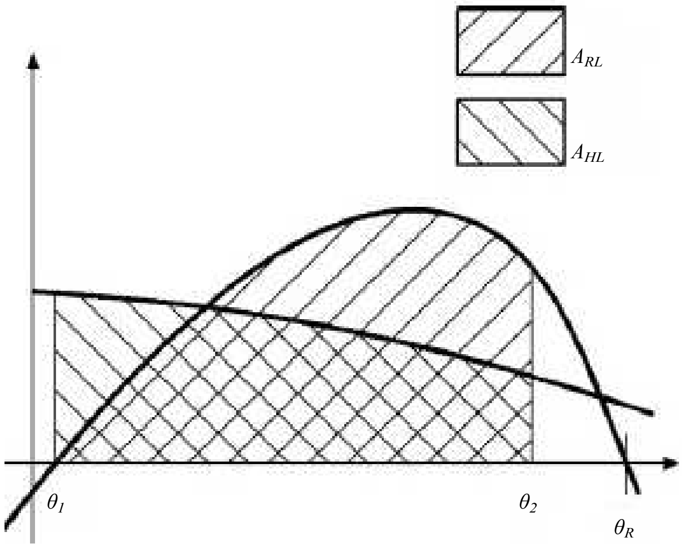


Fig. 3.4.1.2

3.5 Sudden loss of hook load.

3.5.1 Stability of a ship engaged in a lifting operation shall be sufficient to withstand the sudden loss of the hook load, considering the most unfavourable, as regards stability, point at which the hook load may be applied to the ship. To ensure the sufficient stability, 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 Fig. 3.5.1, by an amount given by the following:

Area 2 ⩾ 1,40 *Area* 1, for lifting operations in waters that are exposed;
Area 2 ⩾ 1,00 *Area* 1, for lifting operations in waters that are not exposed

where l_1 = righting lever (l) curve for the condition before loss of crane load, corrected for crane heeling moment and for the righting moment provided by the counter ballast if applicable;

l_2 = righting lever (l) curve for the condition after loss of crane load, corrected for the transverse moment provided by the counter ballast if applicable;

θ_{e2} = equilibrium heeling angle after loss of crane load, in deg.;

θ_f = angle of down-flooding, in deg., or the heeling angle corresponding to the second intersection between heeling and righting lever curves, whichever is less.

The calculation of the curve shall include the ship's true transverse centre of gravity as function of the heeling angle.

3.6 Alternative method of stability calculation.

3.6.1 The criteria specified in 3.6 may be applied to ships engaged in lifting operations, as determined by 3.1.1 as an alternative to the criteria in 3.3 — 3.5. For the purpose of this Chapter and 3.7, 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.

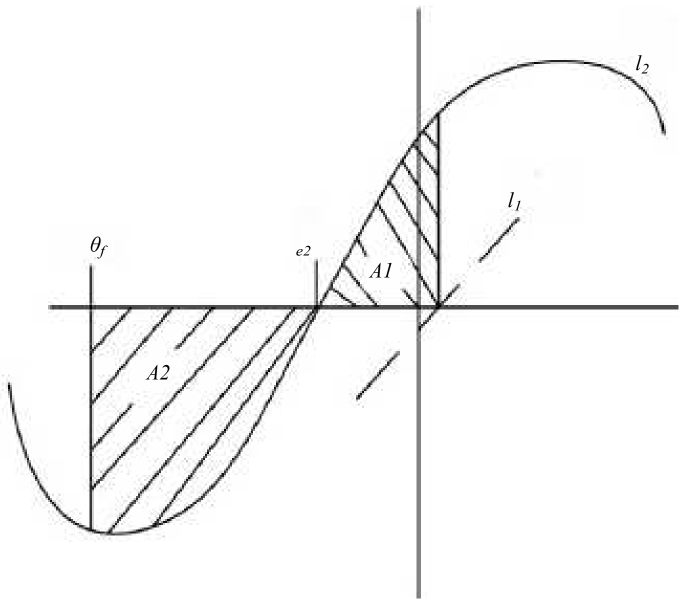


Fig. 3.5.1

3.6.2 The heeling moment applied to the ship due to a lift and the associated heeling lever shall be calculated using the following formulae:

$$HM_\theta = P_L \cdot y \cdot \cos\theta;$$

$$HL_\theta = HM_\theta \div \Delta$$

where HM_θ = heeling moment, in tm, due to the lift at;
P_L = vertical load of the lift, in t, as defined in 3.2.1.1;
y = transverse distance of the lift, in m, as defined in 3.2.1.2;
θ = heeling angle, in deg.;
HL_θ = heeling lever, in m, due to the lift at ;
Δ = displacement of the ship, in t, with the load of the lift.

3.6.3 For application of the criterion specified in 3.7 involving the sudden loss of load of the lift in which counter-ballast is used, the heeling levers shall be calculated using the following formulae:

$$CHL_1 = \frac{(P_L \cdot y - CBM) \cdot \cos\theta}{\Delta};$$

$$CBHL_2 = \frac{CBM \cdot \cos\theta}{(\Delta - P_L)}$$

where CBM = heeling moment, in tm, 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;
$CBHL_2$ = heeling lever, in m, due to the counter-ballast heeling moment at the displacement corresponding to the ship without the load of the lift.

3.7 Alternative stability criteria.

3.7.1 Stability of a ship during lifting operations specified in 3.1.1 shall comply with the criteria set forth in this Chapter. In other conditions stability shall comply with the criteria specified in Section 2 of the present Part and other applicable criteria:

.1 the residual righting area below the righting lever and above the heeling lever curve between θ_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;

0,053 m·rad, if lifting operations are performed in waters that are not exposed;

.2 the equilibrium heeling angle shall be limited to the lesser of the following:
.2.1 10°;
.2.2 the angle of immersion of the highest continuous deck;
.2.3 the allowable value of trim/heel, at which the reliable operation of the crane device is ensured.
3.7.2 Stability of a ship engaged in a lifting operation shall be sufficient to withstand the sudden loss of the hook load, considering the most unfavourable, as regards stability, point at which the hook load may be applied to the ship. To ensure the sufficient stability, the area on the side of the ship opposite from the lift (Area 2) in Fig. 3.7.2 shall be greater than the residual area on the side of the lift (Area 1) in Fig. 3.7.2, by an amount given by the following:

$$Area\ 2 - Area\ 1 > K$$

where K = 0,037 m·rad, for a lifting operation in waters that are exposed;
K = 0,0 m·rad, for a lifting operation in waters that are not exposed;
$l(1)$ = righting lever curve at the displacement corresponding to the ship without hook load;
$l(2)$ = righting lever curve at the displacement corresponding to the ship with hook load;
Area 2 = residual area between $l(1)$ and $CBHL_2$ up to the lesser of the down-flooding angle or the second intersection of $l(2)$ and $CBHL_2$;
Area 1 = residual area below $l(1)$ and above $CBHL_2$ up to the angle of the first intersection between the righting lever curve and the heeling lever curve θ_e.

The calculation of the curve shall include the ship's true transverse centre of gravity as function of the heeling angle.

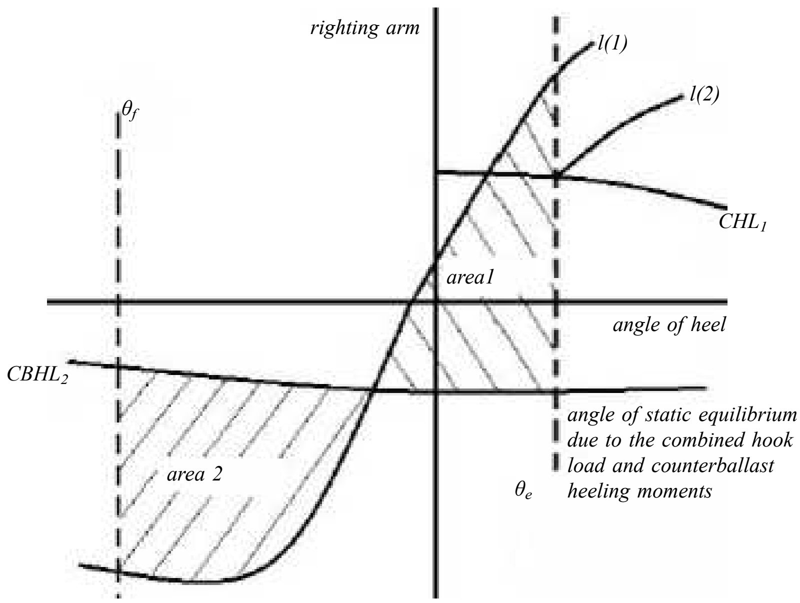


Fig. 3.7.2

3.8 Model tests or direct calculations.
3.8.1 Model tests or direct calculations, performed in accordance with the procedure approved by the Register, to confirm that the ship's stability is sufficient to withstand sudden loss of hook load, may be allowed as an alternative to complying with the requirements of 3.5 and 3.7.2, provided that:
.1 the effects of wind and waves are taken into account;
.2 the maximum dynamic roll amplitude of the ship after loss of load will not cause immersion of unprotected openings.
3.9 Stability of ships engaged in lifting operations shall be checked for loading conditions reflecting the operational limitations of the ship. Use of counter ballast, if applicable, shall be considered. The ship's

stability in the event of the sudden loss of the hook load shall comply with the requirements specified for such situations.

3.10 The criteria specified in 3.3 — 3.5 and 3.7, as applicable, shall be satisfied for all loading conditions intended for lifting and with the hook load at the most unfavourable positions, as regards stability. For each loading condition, the weight and centre of gravity of the load being lifted, the cargo handling gear, and counter ballast, if any, shall be taken into account. The most unfavourable position may be chosen at the position where the total of the transverse and vertical moment is the greatest. Stability shall also be checked for loading conditions corresponding to other possible boom positions and counter ballast with different filling level.

TABLE OF SYMBOLS FOR THE VALUES ADOPTED IN PART IV "STABILITY"

Symbol	Description
A_v	Windage area
A_k	Area of bilge keels
A_{vi}	An item windage area
$A_{\max}$	The area under the positive range of righting lever curve up to the maximum angle
B	Breadth
b_0	Distance between shrouds at a bulwark
C_B	Block coefficient
C_{CL}	Lateral area coefficient
C_{WL}	Waterline area coefficient
D	Depth
d	Draught
$d_{\min}$	Draught related to the minimum loading condition of the ship specified by these Rules
g	Gravitational acceleration
h	Initial corrected transverse metacentric height
h_0	Initial uncorrected transverse metacentric height
$h_{3\%}$	Wave height of 3 % probability
H	Initial corrected longitudinal metacentric height
K	Weather coefficient
K^*	Acceleration coefficient
K_1	Factor related to tow line jerk for tugs engaged in harbor and coastal towing operations
K_2	Factor related to tow line jerk for tugs engaged in ocean-going towing operations
k	Factor taking into account the effect of bilge keels and/or bar keels
k_i	Aerodynamic flow coefficient for a windage area component
L	Length
L_s	Subdivision length
L_{wl}	Waterline length
l	Righting lever
l_{bow}	Length of bow flare region
l_d	Dynamic stability curve lever
$l_{d\ \max}$	Dynamic stability curve lever on an angle of heel equal to angle of maximum of righting lever curve or down-flooding angle, whichever is less
$l_{d\ cr}$	Dynamic stability curve lever due to jerk of a towline
$l_{d\ caps}$	Dynamic stability curve lever for a tug on a down-flooding angle or capsizing angle, whichever is less
l_{FB}	Freeboard height
$l_{\max}$	Maximum righting lever
l_{w1}	Heeling lever due to steady wind
l_{w2}	Heeling lever due to gust
l'_v	Height of the velocity hydraulic pressure
M_c	Capsizing moment
M_R	Heeling moment due to circulation
M_v	Heeling moment due to steady wind
M_l	Weight of ice inside the pipe pile
M_ψ	Trimming moment due to crane weight with maximum load for the most unfavourable crane arrangement on a floating dock
N_e	Power of a ship's main engine
n_i	Zone coefficient taking into account wind velocity change depending on the height of windage area component centre
P	Weight of spoil in a hopper
p_v	Wind pressure
q	Wind velocity
T	Rolling period
V	Volume
v	Ship speed
V_a	Volume of water in a pipes pile
V_{at}	Volume of pipes pile
v_s	Ship speed before steady turning
x_H	Longitudinal distance from tow hook suspension point to ship's centre of gravity
x_c	Longitudinal center of buoyancy
x_g	Longitudinal center of gravity
y_g	Transverse center of gravity
z_g	Vertical center of gravity
z_H	Height of tow hook suspension point above the base line
z_i	Windage area lever which is equal to the height of centre of windage area component above the actual waterline
z_m	Vertical metacenter

Table — continued

Symbol	Description
z_v	Windage area lever which is equal to the vertical distance from the centre of windage area of the ship to the centre of the underwater lateral area or approximately to a point at half the mean draught
z_w	Windage area lever of a floating crane due to steady wind
z'_w	Windage area lever of a floating crane due to gust
z_0	Height of a point of shrouds fastening to a mast over a bulwark
Δ	Displacement
$\mathrm{z}_{\max}$	Displacement related to the maximum loading condition of the ship specified by these Rules
$\Delta_{\min}$	Displacement related to the minimum loading condition of the ship specified by these Rules
Δ_0	Lightship displacement
Δ_1	Ship's displacement in the most unfavourable loading condition regarding h or $l_{\max}$ values
ΔK	Component of K_2 taking into account the effect of rolling on a resultant angle of heel
Δm_h	Initial metacentric height correction
ΔM_0	Free surface heeling moment for angle of heel
θ	Angle of heel
θ_b	Angle of bilge middle emersion
θ_d	Angle of deck immersion
θ_{d1}	Angle of dynamic heel of a tug due to jerk of a tow line
θ_{d2}	Angle of heel of a floating crane/crane ship due to combined effect of initial heeling moment, steady wind and rolling
θ'_{d2}	Angle of heel of a floating crane/crane ship before load drop which is equal to the sum of angles θ_0 and θ_r minus θ_s
θ_f	Down-flooding angle
$\theta_{\max}$	Angle of heel where the maximum of righting lever curve occurs
θ_{sp}	Angle of heel due to spoil discharge
θ_r	Rolling amplitude of floating crane/crane ship
θ'_r	Rolling amplitude of floating crane/crane ship taking into account bilge keels
θ''_r	Rolling amplitude of floating crane/crane ship during voyage/passage taking into account bilge middle emersion at midsection or deck immersion
θ_s	Angle of heel of a floating crane due to steady wind heeling moment
θ'_s	Angle of heel of a crane ship which hull shape is similar to the ship lines, exposed to gust heeling moment
θ_v	Righting lever curve vanishing angle
θ_{w1}	Angle of static heel due to steady wind
θ_{caps}	Capsizing angle which is equal to abscissa of the tangency point of dynamic stability curve and tangent to it passing through origin of the coordinates
θ_0	Angle of initial static heel
θ_{1r}	Rolling amplitude
θ_{2r}	Rolling amplitude taking into account bilge keels
θ_{3r}	Rolling amplitude of a dredger with respect to a statical inclination after spoil discharge from a side
μ	Stowage factor
ψ	Angle of trim

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