RUSSIAN MARITIME REGISTER OF SHIPPING

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RULES

FOR THE CLASSIFICATION AND CONSTRUCTION OF SEA-GOING SHIPS

Part V

SUBDIVISION

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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 2018.

The present edition of the Rules is based on the 2017 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 "Hull Structure and Strength of Glass-Reinforced Plastic Ships and Boats";

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).

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As compared to the 2017 edition, the present edition of the Rules contains the following amendments.

RULES FOR THE CLASSIFICATION AND CONSTRUCTION OF SEA-GOING SHIPS

PART V. SUBDIVISION

1. Paras 1.1.2, 1.2.1, 1.4.6.1.7, 1.4.6.2, 1.6.5, 2.2.2.4, 2.7.4.4, 2.9.4, 3.3.1, 3.4.8, 3.4.13.3: the requirements have been specified to avoid ambiguous phrases such as "special consideration", "special agreement", "upon agreement with the Register";

paras 3.1.8, 3.4.9.1, 3.4.10.7 have been deleted.

2. Chapter 2.1: in para 2.1.1 the requirements have been specified in order to ensure compliance with para 3.4.3 of Section 3.

3. Editorial amendments have been made.

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PART V. SUBDIVISION

1 GENERAL

1.1 APPLICATION

1.1.1 The requirements of the present Part cover the following types of ships:

.1 passenger ships;

.2 oil tankers;

.3 fishing vessels having the length $L_1 \geqslant 100$ m and having over 100 persons on board;

.4 type "A" ships and type "B" ships with reduced freeboard as mentioned under 4.1.2.1 and 4.1.3.3 of Load Line Rules for Sea-Going Ships;

.5 chemical tankers;

.6 gas carriers;

.7 special purpose ships;

.8 supply vessels;

.9 ships intended for the carriage of radioactive agents;

.10 cargo ships having the length $L_1 \geqslant 80$ m not mentioned above;

.11 dry cargo ships having the length $L_1 < 80$ m (refer to 1.4.9);

.12 icebreakers having the length $L_1 \geqslant 50$ m;

.13 tugs having the length $L_1 \geqslant 40$ m;

.14 dredgers having the length $L_1 \geqslant 40$ m, hopper dredgers having the length $L_1 \geqslant 60$ m;

.15 salvage ships;

.16 drilling ships;

.17 lightships;

.18 Arc4 to Arc9 ice class ships;

.19 berth-connected ships used as floating hotels and/or having over 100 persons on board;

.20 bulk carriers, ore and combination carriers in service, which construction date is stated in Section 5;

.21 cargo ships having the length $L_1 < 100$ m other than bulk carriers, and a single cargo hold or cargo holds which are not separated by a bulkhead made watertight up to the freeboard deck (refer to 3.4.13).

1.1.2 For ships to which the present Part is not applicable it is recommended that all measures allowed by the type and service conditions of the ship be taken to obtain the best subdivision characteristics possible.

However, if the shipowner wishes a subdivision distinguishing mark to be introduced in the class notation, the ship shall satisfy all the requirements contained in the present Part.

1.1.3 The requirements of Section 4 are applicable to type "A" ships and type "B" ships with reduced freeboard provided compliance with 4.1 of the Load Line Rules for Sea-Going Ships as regards the subdivision of those ships is confirmed. When making calculations required by Section 4, calculations as required by Sections 2 and 3 may be considered.

1.2 DEFINITIONS AND EXPLANATIONS

1.2.1 Definitions and explanations relating to 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.

Damage waterline is the waterline of a damaged ship with one or more adjacent compartments flooded.

The depth D is the least vertical distance measured from the top of the plate keel or from the line where the inner surface of shell plating abuts upon the bar keel, to the inner line of bulkhead deck abutting to the side. In ships having rounded gunwales, this distance is measured to the point of intersection of the continued inner surfaces of bulkhead deck steel plating and the side shell plating at side, as though the gunwale were of angular design. In non-metal ships the above-said shall be referred to the outer surfaces of the deck and plating.

Moulded depth is measured in the same way as the depth D, but up to the top of the freeboard beam.

Subdivision load line is the load line of an intact ship, which is used in determining the subdivision of the ship.

Trim is the difference between the draught forward and the draught aft, where the draughts are measured at the forward and aft terminals respectively, disregarding any rake of keel.

Subdivision length L_s is the greatest projected moulded length of that part of the ship at or below deck or decks limiting the vertical extent of flooding with the ship at the deepest subdivision draught.

The ship length L_{ice} is the ship length on the waterline corresponding to the draught d_{ice}.

The ship length L_1 is 96 per cent of the total length on a waterline at 85 per cent of the least moulded depth or the length from the fore side of the stem to the axis of rudder stock on that waterline if that be greater.

Permeability index of a space (permeability) μ is the proportion of the immersed volume of that space which can be occupied by water.

Aft terminal is the aft limit of the subdivision length.

Forward terminal is the forward limit of the subdivision length.

Keel line is a line parallel to the slope of the keel passing amidships through:

.1 the top of the keel at centreline or line of intersection of the inside of shell plating with the keel if a bar keel extends below that line, on a ship with a metal shell; or

.2 in wood and composite ships, the distance is measured from the lower edge of the keel rabbet. When the form at the lower part of the midship section is of a hollow character, or where thick garboards are fitted, the distance is measured from the point where the line of the flat of the bottom continued inward intersects the centreline amidships.

Machinery spaces are spaces between the watertight boundaries of a space containing the main and auxiliary propulsion machinery, including boilers, generators and electric motors primarily intended for propulsion.

Amidships is at the middle of the length L_1.

Light service draught d_l is the service draught corresponding to the lightest anticipated loading and associated tankage, including, however, such ballast as may be necessary for stability and/or immersion. Passenger ships shall include the full complement of passengers and crew on board.

Draught d is the vertical distance from the keel line at mid-length to the waterline in question.

The ship draught d_{ice} is the smallest ship draught out of: a draught corresponding to the waterline serving as the upper boundary of the ice strengthening of the hull, or a draught at which the requirements for ice damage trim and stability are met, as contained in 3.4.10.

Deepest subdivision draught d_s is the waterline which corresponds to the summer load line draught of the ship.

A compartment is an inner space limited by the ship bottom, sides, bulkhead deck and two adjacent transverse watertight bulkheads or a peak bulkhead and an extremity.

Bulkhead deck in a passenger ship means the uppermost deck at any point in the subdivision length L_s to which the main bulkheads and the ship's shell are carried watertight and the lowermost deck from which passenger and crew evacuation will not be impeded by water in any stage of flooding for damage cases defined in Section 2. The bulkhead deck may be a stepped deck. In a cargo ship the freeboard deck may be taken as the bulkhead deck.

The deepest subdivision load line is the waterline, which corresponds to the deepest draught permitted by applicable subdivision requirements.

Mid-length is the mid-point of the subdivision length of a ship.

Equalization of a ship is the process of eliminating or reducing heel and/or trim.

Breadth B is the greatest moulded breadth of the ship at or below the deepest subdivision draught.

Partial subdivision draught d_p is the light service draught plus 60 per cent of the difference between the light service draught and the deepest subdivision draught.

1.2.2 In all calculated cases of flooding only one hole in the hull is assumed and only one free surface of sea water which penetrated after the accident. In this case the hole is considered to have the shape of a rectangular parallelepiped.

1.2.3 All linear dimensions used in the present Section are taken in meters.

1.3 SCOPE OF SURVEY

1.3.1 The provisions pertaining to the procedure of classification, survey of ships under construction and classification surveys, as well as the requirements for the technical documentation to be submitted to the Register for review are contained in General Regulations for the Classification and Other Activity and in Part II "Technical Documentation" of the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships.

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

.1 check of compliance of the structural measures taken to ensure subdivision of the ship with the requirements specified in 1.1.6 and 2.7, Part II "Hull", Section 7, Part III "Equipment, Arrangements and Outfit", Sections 2, 4, 5 and 7.1 to 7.11, 10.1, 10.2, 10.4, 12.1, Part VIII "Systems and Piping";

.2 consideration and approval of Information on Damage Trim and Stability, Flooding Detection System Manual (refer to 3.4.11.4), Damage Control Plan, as well as consideration of Information on the Effect of Flooding (to be duly noted), as stipulated in 1.4.9;

.3 checking of correct assignment and marking of additional load lines corresponding to subdivision load lines;

.4 examination and approval of the computer installed on board the ship and the relevant software where it is used for assessing damage trim and stability.

1.4 GENERAL TECHNICAL REQUIREMENTS

1.4.1 The ship subdivision shall be the most effective bearing in mind the service of the ship. The degree of subdivision shall vary proceeding from the area of navigation, ship length and number of persons on

board so that the highest subdivision degree would be characteristic of ships of the greatest length engaged for the most part in the carriage of passengers and of those navigating in the Arctic and the Antarctic.

1.4.2 In no case shall any subdivision load line be assigned above the deepest subdivision load line in seawater determined on the basis of the ship hull safety or in accordance with the Load Line Rules for Sea-Going Ships.

The subdivision load line assigned to the ship is marked on its sides and recorded in the documents of the Register as required by the Load Line Rules for Sea-Going Ships.

1.4.3 The volumes and areas shall, in all cases, be calculated to moulded lines. The volumes and free surfaces of water which penetrates the compartments of reinforced-concrete, plastic, wood and composite ships shall be calculated to inboard hull lines.

1.4.4 When determining the initial metacentric height of a damaged ship, corrections for the effect of free surfaces of liquid cargoes, ship stores and ballast water shall be taken into account in the same manner as in the case of calculating the intact stability of a ship in compliance with 1.4.7, Part IV "Stability".

When plotting static stability curves for a damaged ship, the enclosed superstructures, trunks, deckhouses, angles of flooding through openings in ship's sides, decks, hull and superstructure bulkheads considered open as well as corrections for free surfaces of liquid cargoes shall be taken into account in the same manner as in the case of plotting curves for an intact ship in compliance with 1.4.9, Part IV "Stability".

Superstructures, trunks and deckhouses which sustain damage may only be taken into account with the permeability specified in 1.6, or ignored. The openings in such structures leading to spaces, which are not flooded, are considered open at appropriate angles of heel only when regular weathertight means of closing are not fitted.

1.4.5 When calculating damage trim and stability, account shall be taken of changes in the initial ship loading (intact ship) due to liquid cargoes being replaced by sea water in damaged tanks, taking into consideration that in the flooded tanks below the damage waterline the free surface of those cargoes disappears.

1.4.6 Ships to which the present Part is applicable shall be provided with approved Information on Damage Trim and Stability with compartments flooded and with Damage Control Plan. These documents are intended to provide ship's officers with clear information on the ship's watertight subdivision and equipment related to maintaining the boundaries and effectiveness of the subdivision so that, in the event of damage to the ship causing flooding, proper precautions can be taken to prevent progressive flooding through openings therein and effective action can be taken quickly to mitigate and, where possible, recover the ship's loss of stability.

Information on Damage Trim and Stability and Damage Control Plan shall be clear and easy to understand. They shall not include information, which is not directly relevant to damage control, and shall be provided in the working language of the ship. If the ship's working languages are not Russian and English, a translation into one of these languages shall be included.

1.4.6.1 Information on Damage Trim and Stability shall include the following:

.1 data on the ship, including its dimensions and permissible draughts on clear water and in ice conditions, its longitudinal section, deck and double-bottom plans, typical cross-sections with indication of all watertight bulkheads and enclosures with openings therein, means of their closure and drives, openings of air and ventilation pipes;

.2 information necessary to maintain the stability of an intact ship sufficient to withstand, in accordance with the requirements of the present Part, the most dangerous extent of damage; instructions on loading and ballasting the ship, including recommendations on distributing cargo in the holds, stores and ballast in a manner reasonable as regards the subdivision adopted and satisfying at the same time the requirements for the trim, stability and strength of the ship; brief list of requirements for damage trim and stability;

.3 curve of maximum permissible vertical position of centre of gravity of the ship (limiting moments or minimum metacentric heights) plotted taking into the account the requirements of this Part and Part IV "Stability". For ships, which have to fulfil the requirements of Section 2, a curve of maximum permissible vertical positions of centre of gravity (or minimum metacentric heights) shall be determined from considerations related to the subdivision index, in the following manner:

minimum metacentric heights (or maximum permissible vertical positions of centre of gravity) for the three draughts d_s, d_p and d_l are equal to metacentric heights (or vertical positions of centre of gravity) of corresponding loading cases used for the calculation of factor s_i;

minimum metacentric heights vary linearly between d_s and d_p and between d_p and d_l respectively;

if the subdivision index is calculated for different trims, the curve of maximum permissible vertical positions of centre of gravity shall be established considering the above trims;

.4 list of results of symmetrical and unsymmetrical flooding calculations with data on initial and damage draught, heel, trim and metacentric

height both before and after taking measures for the equalization of the ship or for improving its stability as well as measures recommended for these procedures and the period of time required. Parameters of static stability curves anticipated under the worst flooding conditions shall also be included. Where necessary, for **Arc4** to **Arc9** ice class ships, the information on the characteristics of ice unsinkability, damage trim and stability shall be indicated when sustaining design ice damage;

.5 general instructions for controlling the effects of damage, such as:

immediately closing all watertight and weathertight closing appliances;

establishing the locations and safety of persons on board, sounding tanks and compartments to ascertain the extent of damage and repeated soundings to determine rates of flooding;

cautionary advice regarding the cause of any list and of liquid transfer operations to lessen list and/or trim, and the resulting effects of creating additional free surfaces and of initiating pumping operations to control the ingress of seawater;

.6 details of the locations of flooding detection systems, sounding devices, tank vents and overflows which do not extend above the weather deck, pump capacities, piping diagrams, instructions for operating cross-flooding systems, means of accessing and escaping from watertight compartments below the bulkhead deck for use by damage control parties, and alerting ship management and other organizations to stand by and to co-ordinate assistance, if required;

.7 locations of non-watertight openings with non-automatic closing devices through which progressive flooding might occur as well as guidance on the possibility of non-structural bulkheads and doors or other obstructions retarding the flow of entering seawater to cause at least temporary conditions of unsymmetrical flooding.

1.4.6.2 Damage Control Plan shall be made on the scale acceptable for operation, but not less than 1:200. For passenger ships, the Damage Control Plan shall be permanently exhibited or readily available on the navigation bridge, as well as in the ship's control station, safety centre or equivalent. On cargo ships the Plan shall be permanently exhibited or be readily available on the navigation bridge, in the cargo control room, ship's control station etc.

The plan shall include inboard profile, plan views of each deck and double bottom, as well as transverse sections to the extent necessary to visually and unambiguously show the following:

.1 the watertight compartments and tanks boundaries;

.2 the locations and arrangements of cross-flooding systems, blow-out plugs and any mechanical means to correct list due to flooding, together with the locations of all valves and remote controls, if any;

.3 the locations of all internal watertight closing appliances including, on ro-ro ships, internal ramps or doors acting as extension of the collision bulkhead and their controls and the locations of their local and remote controls, position indicators and alarms. The locations of those watertight closing appliances, which are not allowed to be opened during the navigation, shall be clearly indicated;

.4 the locations of all doors in the shell of the ship, including position indicators, leakage detection and surveillance devices;

.5 the locations of all external watertight closing appliances in cargo ships, position indicators and alarms;

.6 the locations of all weathertight closing appliances in local subdivision boundaries above the bulkhead deck and on the lowest exposed weather decks, together with locations of controls and position indicators, if applicable;

.7 the locations of all bilge and ballast pumps, their control positions and associated valves.

1.4.7 Information on Damage Trim and Stability shall be compiled on the basis of the Information on Stability. The procedure of extending the validity of the Information on Damage Trim and Stability from one ship to another is similar to that of extending the validity of Information on Stability as specified in 1.4.11.2, Part IV "Stability". Information on Damage Trim and Stability may be incorporated in Information on Intact Stability as a separate section.

1.4.8 For estimation of the ship damage trim and stability it is recommended to use the onboard computer. The associated software shall have Type Approval Certificate issued by the Register.

A computer is not equivalent to Information on Damage Trim and Stability. Information on Damage Trim and Stability and Damage Control Plan shall be kept on board in printed form. Onboard damage stability software developed for the specific ship and approved by the Register may be used by properly trained ship's officers only as a rapid means to supplement Information on Damage Trim and Stability and Damage Control Plan for effective damage control.

Where rapid access to shore-based computerized support organization, recognized by RS, which makes damage stability and residual strength assessments is provided on board, this may be used to supplement Information on Damage Trim and Stability. In such a case the contact information for gaining rapid access to shore-based computerized support organization together with a list of information required for making damage stability and residual strength assessments shall be included in Information on Damage Trim and Stability.

1.4.9 Dry cargo ships having the length $L_1 < 80$ m instead of Information on Damage Trim and Stability shall be provided with Damage Control Plan and Information on the Effect of Flooding. This Information shall contain data and documentation listed in 1.4.6.1 and results of damage trim and stability calculations when engine room and every cargo space are flooded. The calculations shall be made for two draughts one of which shall be the summer load line draught. The maximum permissible position of ship's centre of gravity shall be taken according to Information on Stability. Permeabilities of cargo spaces shall be taken with regard to the cargoes intended to be carried and shall be within 0,60 to 0,90. The Information shall contain a summary table of calculation results with indication of critical factors, as well as details given in 1.4.6.1.5.

1.4.10 Every ship shall have draught scales prominently marked at bow and stern. Where the draught scales are so placed that they are not clearly visible or where service conditions impede reading the indications of the scale the ship shall be provided with a reliable draught measurement system whereby the forward and aft draughts can be easily determined.

1.5 SATISFACTORY SUBDIVISION

1.5.1 The subdivision of a ship can be considered satisfactory as regards the present Part, if:

.1 the attained subdivision index A, determined in accordance with 2.3, is not less than the required subdivision index R calculated in accordance with 2.2 and if, in addition, the partial indices A_s, A_p and A_l are not less than $0{,}9R$ for passenger ships and $0{,}5R$ for cargo ships;

.2 the requirements under 1.5.1.1 are not applicable to ships for which in Section 2 there are no instructions for determining the indices A and/or R;

.3 damage trim and stability are in accordance with Section 3, considering 3.3.6.

1.5.2 A subdivision distinguishing mark is introduced in the class notation of the ship in accordance with 2.2.4, Part I "Classification" provided under all design loading conditions corresponding to the type of ship concerned its subdivision is considered satisfactory according to 1.5.1, damage trim and stability comply with the requirements of 3.3 when any single ship compartment or any adjacent ship compartments are flooded throughout the ship's length in accordance with the introduced subdivision distinguishing mark, and the compliance of structural measures related to the subdivision of the ship with the requirements of 1.1.6 and 2.7, Part II "Hull" and in Section 7, Part III "Equipment, Arrangements and Outfit" is ensured.

When, in accordance with 3.4 the number of floodable compartments is changed throughout the ship length, the lowest value shall be stated in the subdivision distinguishing mark.

1.5.3 Additional conditions under which a subdivision distinguishing mark shall be introduced in the class notation are specified in 3.4.

1.6 PERMEABILITY INDEX

1.6.1 In the calculations of damage trim and stability the permeability index of flooded space shall be assumed equal to:

.1 0,85 for spaces occupied by machinery, electric generating sets and processing equipment on fishing vessels and factory ships;

.2 0,95 for accommodation spaces and empty spaces including empty tanks;

.3 0,6 for the spaces intended for dry stores.

1.6.2 Permeability of flooded tanks with liquid cargo or liquid stores or water ballast is determined based on the assumption that all the cargo is discharged from the tank and sea water is ingressed taking into consideration the permeability index being equal to 0,95.

1.6.3 The permeability index of the spaces intended for solid cargoes is given below in the appropriate paragraphs of Sections 2 to 5.

1.6.4 The permeability index of spaces may be assumed lower than specified above only in case a special calculation is performed which is approved by the Register.

When performing such special calculations for cargo spaces including refrigerating ones, the permeability index of net cargo shall be assumed equal to 0,6, and that of the cargo in containers, trailers, roll trailers and lorries shall be assumed equal to 0,71.

1.6.5 Where the arrangement of spaces or the service conditions of the ship are such that the necessity to apply other permeability indices is evident, the calculations shall be made considering those rigid permeability indices.

2 PROBABILITY ESTIMATION OF SUBDIVISION

2.1 GENERAL

2.1.1 The requirements of the present Section apply to cargo ships having the length $L_1 \geqslant 80$ m and to all passenger ships regardless of their length except those ships, whose types are specified in 1.1.1.2, 1.1.1.3, 1.1.1.5, 1.1.1.6, 1.1.1.8, 1.1.1.9, 1.1.1.19, 1.1.1.20, ships specified in 1.1.1.4, if not intended for the carriage of deck cargo, as well as nuclear ships and nuclear floating facilities.

Ships as mentioned in 1.1.1.7 shall comply with the requirements of the Section as specified in 3.4.3.

2.1.2 When checking the probabilistic requirements for such ships the regulations of Explanatory Notes to SOLAS Chapter II-1 shall be taken into consideration (refer to Collection of Regulating Documents, book nineteen, 2010).

2.2 REQUIRED SUBDIVISION INDEX *R*

2.2.1 The subdivision of a ship is considered sufficient if the attained subdivision index A, determined in accordance with 2.3, is not less than the required subdivision index R calculated in accordance with 2.2.2 and if, in addition, the partial indices A_s, A_p and A_l are not less than $0{,}9R$ for passenger ships and $0{,}5R$ for cargo ships.

2.2.2 For all ships to which the damage stability requirements of this Chapter apply, the degree of subdivision to be provided shall be determined by the required subdivision index R, as follows:

.1 in the case of cargo ships having the length $L_s > 100$ m

$$R = 1 - 128/(L_s + 152);$$

.2 in the case of cargo ships having the length $80 \text{ m} \leqslant L_s \leqslant 100$ m

$$R = 1 - [1/(1 + \frac{L_s}{100} \times \frac{R_0}{1 - R_0})]$$

where R_0 = value R as calculated in accordance with formula in 2.2.2.1;

.3 in the case of passenger ships

$$R = 1 - 5000/(L_s + 2{,}5N + 15225)$$

where $N = N_1 + 2N_2$;
N_1 = number of persons for whom lifeboats are provided;
N_2 = number of persons (including officers and crew) the ship is permitted to carry in excess of N_1;

.4 where the conditions of service are such that compliance with 2.2.2.3, on the basis of $N = N_1 + 2N_2$, is impracticable and where the convincing substantiation is submitted, that a suitably reduced degree of hazard exists, a lesser value of N may be taken but in no case less than $N = N_1 + N_2$.

2.3 ATTAINED SUBDIVISION INDEX *A*

2.3.1 The attained subdivision index A is obtained by the summation of the partial indices A_s, A_p and A_l calculated for the draughts d_s, d_p and d_l in accordance with the following formula:

$$A = 0{,}4A_s + 0{,}4A_p + 0{,}2A_l. \qquad (2.3.1\text{-}1)$$

Each partial index is a summation of contributions from all damage cases taken in consideration, using the following formula:

$$A = \sum p_i s_i \qquad (2.3.1\text{-}2)$$

where i = each compartment or group of compartments under consideration;
p_i = probability that only the compartment or group of compartments under consideration may be flooded, disregarding any horizontal subdivision, as defined in 2.4;
s_i = probability of survival after flooding the compartment or group of compartments under consideration, and includes the effect of any horizontal subdivision, as defined in 2.5.

2.3.2 In the calculation of A, the level trim shall be used for the deepest subdivision draught and the partial subdivision draught. The actual service trim shall be used for the light service draught. If in any service condition, the trim variation in comparison with the calculated trim is greater than 0,5 per cent of L_s, one or more additional calculations of A shall be submitted for the same draughts but different trims so that, for all service conditions, the difference in trim in comparison with the reference trim used for one calculation will be less than 0,5 per cent of L_s.

2.3.3 When determining the positive righting lever of the residual stability curve, the constant displacement method of calculation shall be used.

2.3.4 The summation indicated by the above formula shall be taken over the ship's subdivision length L_s for all cases of flooding in which a single compartment or two or more adjacent compartments are involved. In the case of unsymmetrical arrangements, the calculated A value shall be the mean value obtained from calculations involving both sides. Alternatively, it shall be taken as that corresponding to the side which evidently gives the least favourable result.

2.3.5 Wherever wing compartments are fitted, contribution to the summation indicated by For-

mula (2.3.1-2) shall be taken for all cases of flooding in which wing compartments are involved. Additionally, cases of simultaneous flooding of a wing compartment or group of compartments and the adjacent inboard compartment or group of compartments, but excluding damage of transverse extent greater than one half of the ship breadth *B*, may be added. For the purpose of 2.3, transverse extent is measured inboard from ship's side, at right angle to the centreline at the level of the deepest subdivision draught.

2.3.6 In the flooding calculations carried out according to the regulations, only one breach of the hull and only one free surface need to be assumed. The assumed vertical extent of damage shall extend from the baseline upwards to any watertight horizontal subdivision above the waterline or higher. However, if a lesser extent of damage will give a more severe result, such extent shall be assumed.

2.3.7 If pipes, ducts or tunnels are situated within the assumed extent of damage, arrangements shall be made to ensure that progressive flooding cannot thereby extend to compartments other than those assumed flooded. However, the Register may permit minor progressive flooding if it is demonstrated that its effects can be easily controlled and the safety of the ship is not impaired.

2.4 CALCULATION OF THE FACTOR p_i

2.4.1 The factor p_i for a compartment or group of compartments shall be calculated in accordance with 2.4.1.1.1 and 2.4.1.1.2 using the following symbols:

j = aftmost damage zone number involved in the damage starting with No.1 at the stern;

n = number of adjacent damage zones involved in the damage;

k = number of a particular longitudinal bulkhead as barrier for transverse penetration in a damage zone counted from shell towards the centreline. The shell has $k = 0$;

$x1$ = distance from the aft terminal of L_s to the aft end of the zone in question;

$x2$ = distance from the aft terminal of L_s to the forward end of the zone in question;

b = mean transverse distance in metres measured at right angles to the centreline at the deepest subdivision loadline between the shell and an assumed vertical plane extended between the longitudinal limits used in calculating the factor p_i and which is a tangent to, or common with, all or part of the outermost portion of the longitudinal bulkhead under consideration. This vertical plane shall be so orientated that the mean transverse distance to the shell is a maximum, but not more than twice the least distance between the plane and the shell. If the upper part of a longitudinal bulkhead is below the deepest subdivision loadline the vertical plane used for determination of b is assumed to extend upwards to the deepest subdivision waterline. In any case, b shall not be taken greater than $B/2$.

If the damage involves a single zone only:

$$p_i = p(x1_j, x2_j)[r(x1_j, x2_j, b_k) - r(x1_j, x2_j, b_{k-1})].$$

If the damage involves two adjacent zones:

$$p_i = p(x1_j, x2_{j+1})[r(x1_j, x2_{j+1}, b_k) - r(x1_j, x2_{j+1}, b_{k-1})] - p(x1_j, x2_j)[r(x1_j, x2_j, b_k) - r(x1_j, x2_j, b_{k-1})] - p(x1_{j+1}, x2_{j+1})[r(x1_{j+1}, x2_{j+1}, b_k) - r(x1_{j+1}, x2_{j+1}, b_{k-1})].$$

If the damage involves three or more adjacent zones:

$$p_i = p(x1_j, x2_{j+n-1})[r(x1_j, x2_{j+n-1}, b_k) - r(x1_j, x2_{j+n-1}, b_{k-1})] - p(x1_j, x2_{j+n-2})[r(x1_j, x2_{j+n-2}, b_k) - r(x1_j, x2_{j+n-2}, b_{k-1})] - p(x1_{j+1}, x2_{j+n-1})[r(x1_{j+1}, x2_{j+n-1}, b_k) - r(x1_{j+1}, x2_{j+n-1}, b_{k-1})] + p(x1_{j+1}, x2_{j+n-2})[r(x1_{j+1}, x2_{j+n-2}, b_k) - r(x1_{j+1}, x2_{j+n-2}, b_{k-1})]$$

where $r(x1, x2, b_0) = 0$.

2.4.1.1 The factor $p(x1, x2)$ shall be calculated according to the following formulae:

overall normalized max damage length: $J_{max} = 10/33$;

knuckle point in the distribution: $J_{kn} = 5/33$;

cumulative probability at J_{kn}: $p_k = 11/12$;

maximum absolute damage length: $l_{max} = 60$ m;

length where normalized distribution ends: $L^* = 260$ m;

probability density at $J = 0$:

$b_o = 2(p_k/J_{kn} - (1 - p_k)/(J_{max} - J_{kn}))$.

When $L_s \leqslant L^*$:

$J_m = \min\{J_{max}, l_{max}/L_s\}$;

$J_k = J_m/2 + (1 - \sqrt{1 + (1 - 2p_k)b_0 J_m + 1/4 b_0^2 J_m^2})/b_0$;

$b_{12} = b_0$.

When $L_s > L^*$:

$J_m^* = \min\{J_{max}, l_{max}/L^*\}$;

$J_k^* = J_m^*/2 + (1 - \sqrt{1 + (1 - 2p_k)b_0 J_m^* + 1/4 b_0^2 J_m^{*2}})/b_0$;

$J_m = J_m^* L^*/L_s$;

$J_k = J_k^* L^*/L_s$;

$b_{12} = 2[p_k/J_k - (1 - p_k)/(J_m - J_k)]$;

$b_{11} = 4(1 - p_k)/[(J_m - J_k)J_k] - 2p_k/J_k^2$;

$b_{21} = -2(1 - p_k)/(J_m - J_k)^2$;

$b_{22} = -b_{21} J_m$;

the non-dimensional damage length:

$$J = (x2 - x1)/L_s;$$

the normalized length of a compartment or group of compartments:

J_n shall be taken as the lesser of J and J_m.

2.4.1.1.1 Where neither limits of the compartment or group of compartments under consideration coincides with the aft or forward terminals:

$J \leqslant J_k$:

$p(x1, x2) = p_1 = 1/6[J^2(b_{11}J + 3b_{12})]$;

$J > J_k$:

$$p(x1, x2) = p_2 = -1/3 b_{11} J_k^3 + 1/2(b_{11}J - b_{12})J_k^2 + b_{12} J J_k - 1/3 b_{21}(J_n^3 - J_k^3) + 1/2(b_{21}J - b_{22})(J_n^2 - J_k^2) + b_{22} J(J_n - J_k).$$

2.4.1.1.2 Where the aft limit of the compartment or group of compartments under consideration coincides with the aft terminal or the forward limit of the compartment or group of compartments under consideration coincides with the forward terminal:

$J \leqslant J_k$:

$p(x1,x2) = 1/2(p_1 + J)$;

$J > J_k$:

$p(x1,x2) = 1/2(p_2 + J)$.

2.4.1.1.3 Where the compartment or groups of compartments considered extends over the entire subdivision length L_s:

$p(x1, x2) = 1$.

2.4.1.2 The factor $r(x1,x2,b)$ shall be determined by the following formulae:

$$r(x1,x2,b) = 1 - (1 - C)[1 - G/p(x1,x2)]$$

where $C = 12J_b(-45J_b + 4)$;
$J_b = b/(15B)$.

2.4.1.2.1 Where the compartment or groups of compartments considered extends over the entire subdivision length L_s:

$$G = G_1 = 1/2b_{11}J_b^2 + b_{12}J_b.$$

2.4.1.2.2 Where neither limits of the compartment or group of compartments under consideration coincides with the aft or forward terminals:

$$G = G_2 = -1/3b_{11}J_0^3 + 1/2(b_{11}J - b_{12})J_0^2 + b_{12}JJ_0$$

where $J_0 = \min(J, J_b)$.

2.4.1.2.3 Where the aft limit of the compartment or group of compartments under consideration coincides with the aft terminal or the forward limit of the compartment or group of compartments under consideration coincides with the forward terminal:

$$G = 1/2(G_2 + G_1J).$$

2.5 CALCULATION OF THE FACTOR s_i

2.5.1 The factor s_t shall be determined for each case of assumed flooding, involving a compartment or group of compartments, in accordance with the following notations and the provisions in this regulation.

θ_e is the equilibrium heel angle in any stage of flooding, in degrees;

θ_v is the angle, in any stage of flooding, where the righting lever becomes negative, or the angle at which an opening incapable of being closed weathertight becomes submerged;

GZ_{max} is the maximum positive righting lever, in m, up to the angle θ_v;

Range is the range of positive righting levers, in deg., measured from the angle θ_e. The positive range shall be taken up to the angle θ_v;

Flooding stage is any discrete step during the flooding process, including the stage before equalization (if any) until final equilibrium has been reached.

2.5.1.1 The factor s_t, for any damage case at any initial loading condition, d_i, shall be obtained from the formula

$$s_i = \min(s_{intermediate,i} \text{ or } s_{final,i} \times s_{mom,i})$$

where $s_{intermediate,t}$ = probability to survive all intermediate flooding stages until the final equilibrium stage, and is calculated in accordance with 2.5.2;
$s_{final,i}$ = probability to survive in the final equilibrium stage of flooding. It is calculated in accordance with 2.5.3;
$s_{mom,i}$ = probability to survive heeling moments, and is calculated in accordance with 2.5.4.

2.5.2 The factor $s_{intermediate,i}$ is applicable only to passenger ships (for cargo ships $s_{intermediate,i}$ shall be taken as unity) and shall be taken as the least of the s-factors obtained from all flooding stages including the stage before equalization, if any, and shall be calculated as follows:

$$s_{intermediate,i} = [(GZ_{max}/\theta,\theta 5)(Range/7)]^{1/4}$$

where GZ_{max} shall not be taken as more than 0,05 m and *Range* as not more than 7°. $s_{intermediate} = 0$, if the intermediate heel angle exceeds 15°. Where cross-flooding fittings are required, the time for equalization shall not exceed 10 min.

2.5.3 The factor $s_{final,i}$ shall be obtained from the formula

$$s_{final,i} = K[(GZ_{max}/\theta,12)(Range/16)]^{1/4}$$

where GZ_{max} shall not be taken as more than 0,12 m;
Range shall not be taken as more than 16°;
$K = 1$, $\theta_e \leqslant \theta_{min}$;
$K = 0$, $\theta_e \geqslant \theta_{max}$;
$K = \sqrt{(\theta_{max} - \theta_e)/(\theta_{max} - \theta_{min})}$,

otherwise,

where θ_{min} is 7° for passenger ships and 25° for cargo ships;
θ_{max} is 15° for passenger ships and 30° for cargo ships.

2.5.4 The factor $s_{mom,i}$ is applicable only to passenger ships (for cargo ships $s_{mom,i}$ shall be taken as unity) and shall be calculated at the final equilibrium from the formula

$$s_{mom,i} = (GZ_{max} - \theta,\theta 4)Displacement/M_{heei}$$

where *Displacement* = intact displacement at the subdivision draught;
M_{heei} = maximum assumed heeling moment as calculated in accordance with 2.5.4.1;
$s_{mom,i} \leqslant 1$.

2.5.4.1 The heeling moment M_{heel} shall be calculated as follows:

$$M_{heel} = \max\{M_{passenger}, M_{wind}, M_{survivalcraft}\}.$$

2.5.4.1.1 $M_{passenger}$ is the maximum assumed heeling moment resulting from movement of passengers, and shall be obtained as follows:

$$M_{passenger} = (0{,}075N_p)(0{,}45B)$$

where N_p = maximum number of passengers permitted to be on board in the service condition corresponding to the deepest subdivision draught under consideration;
B = beam of the ship.

Alternatively, the heeling moment may be calculated assuming the passengers are distributed with **4** persons per m^2 on available deck areas towards one side of the ship on the decks where muster stations are located and in such a way that they produce the most adverse heeling moment. In doing so, a weight of 75 kg per passenger shall be assumed.

2.5.4.1.2 M_{wind} is the maximum assumed wind force acting in a damage situation

$$M_{wind} = (PAZ)/9806$$

where P = 120 N/m^2;
A = projected lateral area above waterline;
Z = distance from centre of lateral projected area above waterline to $T/2$;
T = ship's draught, d_i.

2.5.4.1.3 $M_{survivaicraft}$ is the maximum assumed heeling moment due to the launching of all fully loaded davit-launched survival craft on one side of the ship. It shall be calculated using the following assumptions:

all lifeboats and rescue boats fitted on the side to which the ship has heeled after having sustained damage shall be assumed to be swung out fully loaded and ready for lowering;

for lifeboats which are arranged to be launched fully loaded from the stowed position, the maximum heeling moment during launching shall be taken;

a fully loaded davit-launched liferaft attached to each davit on the side to which the ship has heeled after having sustained damage shall be assumed to be swung out ready for lowering;

persons not in the life-saving appliances which are swung out shall not provide either additional heeling or righting moment;

life-saving appliances on the side of the ship opposite to the side to which the ship has heeled shall be assumed to be in a stowed position.

2.5.5 Unsymmetrical flooding shall be kept to a minimum consistent with the efficient arrangements. Where it is necessary to correct large angles of heel, the means adopted shall, where practicable, be self-acting, but in any case where controls to equalization devices are provided they shall be operable from above the bulkhead deck. These fittings together with their controls shall be approved by the Register[1]. Suitable information concerning the use of equalization devices shall be supplied to the master of the ship.

2.5.5.1 Tanks and compartments taking part in such equalization shall be fitted with air pipes or equivalent means of sufficient cross-section to ensure that the flow of water into the equalization compartments is not delayed.

2.5.5.2 In all cases, s_i shall be taken as zero in those cases where the final waterline, taking into account sinkage, heel and trim, immerses:

.1 the lower edge of openings through which progressive flooding may take place and such flooding is not accounted for in the calculation of factor s_i. Such openings shall include air-pipes, ventilators and openings which are closed by means of weathertight doors or hatch covers; and

.2 any part of the bulkhead deck in passenger ships considered a horizontal evacuation route for compliance with Part VI "Fire Protection".

2.5.5.3 The factor s_i shall be taken as zero if, taking into account sinkage, heel and trim, any of the following occur in any intermediate stage or in the final stage of flooding:

.1 immersion of any vertical escape hatch in the bulkhead deck intended for compliance with Part VI "Fire Protection";

.2 any controls intended for the operation of watertight doors, equalization devices, valves on piping or on ventilation ducts intended to maintain the integrity of watertight bulkheads from above the bulkhead deck become inaccessible or inoperable;

.3 immersion of any part of piping or ventilation ducts carried through a watertight boundary that is located within any compartment included in damage cases contributing to the attained index A, if not fitted with watertight means of closure at each boundary.

2.5.5.4 However, where compartments assumed flooded due to progressive flooding are taken into account in the damage stability calculations multiple values of $s_{intermediate,i}$ may be calculated assuming equalization in additional flooding phases.

2.5.5.5 Except as provided in 2.5.5.3.1, openings closed by means of watertight manhole covers and flush scuttles, small watertight hatch covers, remotely operated sliding watertight doors, side scuttles of the non-opening type as well as watertight access doors and hatch covers required to be kept closed at sea need not be considered.

2.5.6 Where horizontal watertight boundaries are fitted above the waterline under consideration the s-value calculated for the lower compartment or group of compartments shall be obtained by multi-

[1]Refer to IMO resolution MSC.245(83).

plying the value as determined in 2.5.1.1 by the reduction factor v_m according to 2.5.6.1, which represents the probability that the spaces above the horizontal subdivision will not be flooded.

2.5.6.1 The factor v_m shall be obtained from the formula

$$v_m = v(H_{j,n,m},d) - v(H_{j,n,m-1},d)$$

where $H_{j,n,m}$ = least height above the baseline, in m, within the longitudinal range of $x1_{(j)}...x2_{(j+n-1)}$ of the mth horizontal boundary which is assumed to limit the vertical extent of flooding for the damaged compartments under consideration;

$H_{j,n,m-1}$ = least height above the baseline, in metres, within the longitudinal range of $x1_{(j)}...x2_{(j+n-1)}$ of the $(m-1)$th horizontal boundary which is assumed to limit the vertical extent of flooding for the damaged compartments under consideration;

j = aft terminal of the damaged compartments under consideration;

m = each horizontal boundary counted upwards from the waterline under consideration;

d = draught in question as defined in 1.2;

$x1$ and $x2$ = terminals of the compartment or group of compartments considered in regulation 2.4.

The factors $v(H_{j,n,m},d)$ and $v(H_{j,n,m-1},d)$ shall be obtained from the formulae:

$v(H,d) = 0{,}8(H - d)/7{,}8$ if $(H_m - d)$ is less than, or equal to 7,8 m;

$v(H,d) = 0{,}8 + 0{,}2[(H - d) - 7{,}8]/4{,}7$ in all other cases

where $v(H_{j,n,m},d)$ shall be taken as 1, if H_m coincides with the uppermost watertight boundary of the ship within the range $(x1_{(j)}...x2_{(j+n-1)})$, and $v(H_{j,n,0},d)$ shall be taken as 0.

In no case shall v_m be taken as less than zero or more than 1.

2.5.6.2 In general, each contribution dA to the index A in the case of horizontal subdivisions is obtained from the formula

$$dA = p_i[v_1 s_{\min 1} + (v_2 - v_1)s_{\min 2} + ... + (1 - v_{m-1})s_{\min m}]$$

where v_m = the v-value calculated in accordance with 2.5.6.1;

$s_{\min}$ = the least s-factor for all combinations of damages obtained when the assumed damage extends from the assumed damage height H_m downwards.

2.6 PERMEABILITY

2.6.1 For the purpose of the subdivision and damage stability calculations of the regulations, the permeability of each general compartment or part of a compartment shall be as follows:

Spaces	Permeability
Appropriated to stores	0,60
Occupied by accommodation	0,95
Occupied by machinery	0,85
Void spaces	0,95
Intended for liquids	0 or 0,95[1]

[1]Whichever results in the more severe requirement.

2.6.2 For the purpose of the subdivision and damage stability calculations of the regulations, the permeability of each cargo compartment or part of a compartment shall be as follows:

Spaces	Permeability at draught d_s	Permeability at draught d_p	Permeability at draught d_l
Dry cargo spaces	0,70	0,80	0,95
Container spaces	0,70	0,80	0,95
Ro-ro spaces	0,90	0,90	0,95
Cargo liquids	0,70	0,80	0,95

2.6.3 Other figures for permeability may be used if substantiated by calculations.

2.7 SPECIAL REQUIREMENTS CONCERNING PASSENGER SHIP STABILITY

2.7.1 A passenger ship intended to carry 400 or more persons shall have watertight subdivision abaft the collision bulkhead so that $s_i = 1$ for the three loading conditions on which is based the calculation of the subdivision index and for a damage involving all the compartments within $0{,}08L_1$ measured from the forward perpendicular.

2.7.2 A passenger ship intended to carry 36 or more persons shall be capable of withstanding damage along the side shell to an extent specified in 2.7.3.3. Compliance with this regulation shall be achieved by demonstrating that s_i, as defined in 2.5, is not less than 0,9 for the three loading conditions on which is based the calculation of the subdivision index.

2.7.3 The damage extent to be assumed when demonstrating compliance with 2.7.2, shall be dependent on both N as defined in 2.2, and L_s as defined in 1.2, such that:

.1 the vertical extent of damage shall extend from the ship's moulded baseline to a position up to 12,5 m above the position of the deepest subdivision draught as defined in 1.2, unless a lesser vertical extent of damage were to give a lower value of s_i, in which case this reduced extent shall be used;

.2 where 400 or more persons shall be carried, a damage length of $0{,}03L_s$ but not less than 3 m shall be assumed at any position along the side shell, in conjunction with a penetration inboard of $0{,}1B$ but not less than 0,75 m measured inboard from the ship side, at right angle to the centreline at the level of the deepest subdivision draught;

.3 where less than 400 persons are carried, damage length shall be assumed at any position along the shell side between transverse watertight bulkheads provided that the distance between two adjacent transverse watertight bulkheads is not less than the assumed damage length. If the distance between adjacent transverse watertight bulkheads is less than the assumed damage length, only one of these bulkheads shall be considered effective for the purpose of demonstrating compliance with 2.7.2;

.4 where 36 persons are carried, a damage length of $0{,}015L_s$ but not less than 3 m shall be assumed, in conjunction with a penetration inboard of $0{,}05B$ but not less than 0,75 m;

.5 where more than 36, but less than 400 persons are carried the values of damage length and penetration inboard, used in the determination of the assumed extent of damage, shall be obtained by linear interpolation between the values of damage length and penetration which apply for ships carrying 36 persons and 400 persons as specified in 2.7.3.2 and 2.7.3.4.

2.7.4 Passenger ships carrying 36 or more persons shall be provided with flooding detection systems giving an audible and visual alarm for watertight spaces below the bulkhead deck. Any watertight spaces that are separately equipped with a liquid level monitoring system (such as fresh water, ballast water, fuel, etc.), with an indicator panel or other means of monitoring at the navigation bridge (and the safety centre if located in a separate space from the navigation bridge), are excluded from these requirements.

2.7.4.1 A flooding detection system shall be fitted in all watertight spaces below the bulkhead deck of the passenger ship that have a volume, in m^3, that is more than the ship's moulded displacement per 1 cm immersion at deepest subdivision draught or have a volume more than 30 m^3, whichever is greater.

2.7.4.2 The number and location of flooding detection sensors shall be sufficient to ensure that any substantial water ingress is detected under reasonable angles of trim and heel. To accomplish this, flooding detection sensors shall generally be installed as indicated below:

.1 vertical location — sensors shall be installed as low as practical in the watertight space;

.2 longitudinal location — in watertight spaces located forward of the mid-length, sensors shall generally be installed at the forward end of the space; and in watertight spaces located aft of the mid-length, sensors shall generally be installed at the aft end of the space. For watertight spaces located in the vicinity of the mid-length, consideration shall be given to the appropriate longitudinal location of the sensor. In addition, any watertight space of more than $L_s/5$ in length or with arrangements that would seriously restrict the longitudinal flow of water shall be provided with sensors at both the forward and aft ends;

.3 transverse location — sensors shall generally be installed at the centreline of the space (or alternatively at both the port and starboard sides). In addition, any watertight space that extends the full breadth of the ship or with arrangements that would seriously restrict the transverse flow of water shall be provided with sensors at both the port and starboard sides.

2.7.4.3 Where a watertight space extends in height over more than one deck, there shall be at least one flooding detection sensor at each deck level. This provision is not applicable in cases where a continuous flood level monitoring system is installed.

2.7.4.4 For watertight spaces with unusual arrangements or in other cases where these guidelines would not achieve the intended purpose, the number and location of flooding detection sensors is subject to revision to achieve the intended purpose.

2.7.4.5 The sensors shall be installed where they are accessible for testing, maintenance and repair.

2.7.4.6 On ships the Flooding Detection System Manual shall be provided, which includes, as a minimum:

.1 the flooding detection system specification, including a list of procedures for checking the operability, as far as practicable, of each element at any stage of the ship service;

.2 the Type Approval Certificate issued for the flooding detection system;

.3 the single-line diagram of the flooding detection system with the location of equipment indicated in the ship's general arrangement plan;

.4 the instructions indicating the location, securing, protection and testing of the flooding detection system equipment;

.5 the procedures to be followed in case of failure of the flooding detection system;

.6 the maintenance requirements for the flooding detection system equipment.

The Manual shall be in the working language of the ship officers, as well as in English.

2.7.4.7 The flooding detection system shall comply with 7.10.3 and 7.10.4, Part XI "Electrical Equipment".

2.7.5 Passenger ships having the length $L_1 \geqslant 120$ m or having three or more main vertical zones shall be provided with:

.1 onboard damage stability software approved by RS; or

.2 rapid access to shore-based computerized support organization, recognized by RS, which makes damage stability and residual strength assessments, for the purpose of providing operational information to the master for safe return to port after flooding casualty.

2.7.6 In case of flooding of any watertight compartment the requirements of 2.2.6.8, Part VI "Fire Protection" shall be met.

2.8 TIMBER DECK CARGO IN THE CONTEXT OF DAMAGE STABILITY REQUIREMENTS

2.8.1 Timber deck cargo means the following cargo carried on an uncovered part of a freeboard or superstructure deck: sawn wood or lumber, cants, logs, poles, pulpwood and other types of timber in loose or packaged forms, except wood pulp or similar cargo.

2.8.2 Timber deck cargo shall be properly stowed and secured.

2.8.3 The height and extent of the timber deck cargo shall be at least stowed to the standard height of one superstructure.

2.8.4 The permeability of the timber deck cargo shall be not less than 25 per cent of the volume occupied by the cargo up to one standard superstructure.

2.8.5 The Information on Stability and Information on Damage Trim and Stability for ships with timber deck cargoes may be supplemented by additional curve of maximum permissible vertical positions of centre of gravity or minimum metacentric heights covering the timber draught range considering maximum permissible vertical position of centre of gravity or minimum metacentric height at the deepest timber subdivision draught and the partial timber subdivision draught. The minimum metacentric heights shall be varied linearly between the deepest timber subdivision draught and the partial timber subdivision draught, and between the partial timber subdivision draught and the light service draught, respectively. Where timber freeboards are not assigned the deepest and partial draughts shall relate to the summer load line. This curve shall apply to ships carrying timber deck cargo only.

2.8.6 When considering the vertical extent of damage, the upper deck may be regarded as a horizontal subdivision. Thus when calculating damage cases are limited vertically to the upper deck with the corresponding v-factor, the timber deck cargo may be considered to remain buoyant with an assumed permeability of 0,25 at the deepest and partial draught. For damage extending above the upper deck the timber deck cargo buoyancy in way of the damage zone shall be ignored.

2.9 BOTTOM DAMAGE

2.9.1 Any part of a passenger ship or a cargo ship that is not fitted with a double bottom shall be capable of withstanding bottom damages, as specified in 2.9.3, in that part of the ship.

2.9.2 In the case of unusual bottom arrangements in a passenger ship or a cargo ship, it shall be demonstrated that the ship is capable of withstanding bottom damages as specified in 2.9.3.

2.9.3 Compliance with 2.9.1 or 2.9.2 shall be achieved by demonstrating that s_i, when calculated in accordance with 2.5, is not less than 1 for all service conditions when subject to a bottom damage assumed at any position along the ship's bottom and with an extent specified in 2.9.3.2 below for the affected part of the ship:

.1 flooding of such spaces shall not render emergency power and lighting, internal communication, signals or other emergency devices inoperable in other parts of the ship;

.2 assumed extent of damage is specified in Table 2.9.3.2;

.3 if any damage of a lesser extent than the maximum damage specified in 2.9.3.2 would result in a more severe condition, such damage shall be considered.

2.9.4 In case of large lower holds in passenger ships, double bottom height shall be increased for not more than $B/10$ or 3 m, whichever is less, or bottom damages may be calculated for these areas, in accordance with 2.9.3, but assuming an increased vertical extent.

Table 2.9.3.2

	For 0,3 L_1 from the forward perpendicular of the ship	Any other part of the ship
Longitudinal extent	1/3 $L_1^{2/3}$ or 14,5 m, whichever is less	1/3 $L_1^{2/3}$ or 14,5 m, whichever is less
Transverse extent	$B/6$ or 10 m, whichever is less	$B/6$ or 5 m, whichever is less
Vertical extent measured from the keel line	$B/20$ or 2 m, whichever is less	$B/20$ or 2 m, whichever is less

3 DAMAGE TRIM AND STABILITY

3.1 GENERAL

3.1.1 Under all loading conditions to be encountered in service and which are in agreement with the purpose of the ship (icing disregarded), the trim and stability of an intact ship shall be sufficient for satisfying damage trim and stability requirements.

3.1.2 Requirements for the ship trim and stability shall be considered satisfied if, in case of damage mentioned in 3.2 and 3.4, with the number of compartments flooded as mentioned in 3.4, and the permeability determined in accordance with 1.6, calculations made in conformity with 3.1.3 to 3.1.7 indicate that the requirements of 3.3 and 3.4 are satisfied.

3.1.3 Calculations to confirm compliance with the requirements of 3.3 and 3.4 as regards damage trim and stability shall be performed for such a number of loading conditions to be encountered in service and being the most unfavourable from the point of view of trim and stability (within the range of draughts up to the deepest subdivision load line and cargo distribution stipulated by the design), such distribution and extent of damage, to be determined in accordance with 3.2 and 3.4, that, proceeding from those calculations, one could assure that in all other cases the damaged ship would be in a better condition as regards damage stability, the residual freeboard, distance from the damage waterline to openings through which the ship may be flooded and heeling angles. Besides, the following shall be considered: the actual configuration of damaged compartments, their permeabilities, type of covers, whether intermediate decks, platforms, double sides, longitudinal and transverse bulkheads are provided sufficiently watertight as to render the flow of water through the ship completely or temporarily impossible.

3.1.4 Where the distance between two consecutive main transverse bulkheads is less than the longitudinal extent of design damage, the relevant compartment shall, at the discretion of the designer, be added to any of the adjacent compartments when checking damage stability. For non-passenger ships deviation from this provision may be granted where the arrangement of the bulkhead is in agreement with the condition $A \geqslant R$.

Forepeak and afterpeak are considered to be separate compartment regardless of the length.

3.1.5 Where two adjacent compartments are separated from each other by a stepped bulkhead, the bulkhead shall be held for damaged when the flooding of any of the two compartments is considered.

Where the length of the step does not exceed one frame or 0,8 m, whichever is less, or where the step is formed by floors of the double bottom, this requirement may be dispensed with in case of non-passenger ships.

3.1.6 If any damage of a lesser extent than stated in 3.2 and 3.4 might result in a more severe condition as regards damage trim and stability, such a damage shall be considered when making check calculations for damage trim and stability.

3.1.7 Where there are pipes, ducts or tunnels in the area of assumed damage, these shall be so designed that no water enters compartments which are considered not flooded.

3.1.8 The arrangements for righting the ship after damage shall be approved by the Register and shall be self-acting as far as practicable.

Where controllable cross-flooding arrangements are available, side-valve control stations shall be located above the bulkhead deck.

3.2 EXTENT OF DESIGN DAMAGE

3.2.1 Except cases specially provided for, including those stated in 3.1.6, the following extent of side damage shall be assumed when making damage trim and stability calculations to confirm compliance with 3.3 and 3.4:

.1 longitudinal extent: $1/3L_1^{2/3}$ or 14,5 m (whichever is less);

.2 transverse extent measured inboard of ship side at right angles to the centreline at the level of the deepest subdivision load line: 1/5 of the ship breadth B or 11,5 m (whichever is the less);

.3 vertical extent: from the base line upwards without limit.

3.2.2 The requirements of 3.3 shall be complied with in case of simultaneous flooding of all compartments located forward of collision bulkhead.

3.3 REQUIREMENTS FOR DAMAGE TRIM AND STABILITY CHARACTERISTICS

3.3.1 In the final stage of flooding, the initial metacentric height of a ship in the upright condition determined by the constant displacement method, shall not be less than 0,05 m before appropriate measures to increase the metacentric height are taken.

For non-passenger ships, a positive metacentric height below 0,05 m may be permitted for the upright condition in the final stage of flooding.

3.3.2 For unsymmetric flooding the angle of heel shall not exceed:

20° before equalization measures and cross-flooding fittings being used;

12° after equalization measures and cross-flooding fittings being used.

3.3.3 The static stability curve of a damaged ship shall have a sufficient positive lever arm section. In the final stage of flooding, cross-flooding fittings disregarded, and after the equalization of the ship, a length of positive lever arm curve, flooding angle considered, shall be ensured not less than 20°. The angle of submersion of the openings specified in 1.4.5.3, Part IV "Stability", and openings, which are not equipped with watertight or weathertight covers through which water may spread to intact compartments may be taken as flooding angle.

The maximum lever arm shall be at least 0,1 m within this length, i.e. within the heel angle equal to the static one plus 20°.

The positive lever arm section within the said extent shall not be less than 0,0175 m·rad.

In the intermediate stages of flooding, the maximum lever arm of the static stability curve shall be at least 0,05 m, and the length of its positive section shall not be less than 7°.

3.3.4 Before, during and after equalization, the damage waterline shall be at least 0,3 m or $0,1+(L_1-10)/150$ m (whichever is less) below the openings in the bulkheads, decks and sides through which progressive flooding could take place. Such openings include the outlets of air and vent pipes and those which are closed by means of weathertight doors and covers.

These do not necessarily include:

.1 non-opening side and deck scuttles;

.2 manholes having covers with closely space bolts;

.3 cargo tank hatchways in tankers;

.4 remotely controlled sliding doors, watertight doors with indication systems (except ships specified in 1.1.1.2, 1.1.1.5, 1.1.1.**6** and 1.1.1.8) and access hatches normally closed at sea;

.5 openings in subdivision bulkheads intended for the passage of vehicles during cargo handling operations which are permanently closed with strong watertight covers while at sea. Such openings are only permitted for ro-ro ships.

The position and arrangement of closures of openings shall meet the requirements of Section 7, Part III "Equipment, Arrangement and Outfit".

The location of spaces for emergency sources of electrical power shall comply with the requirements of **9**.2.1, Part XI "Electrical Equipment".

3.3.5 For cargo ships, immersion of the bulk-head deck and, moreover, of the weather deck is permitted.

3.3.6 The requirements of 3.3.1 to 3.3.5 apply to ships specified in 3.4 considering the additional requirements for damage trim and stability specific for each ship type.

For ships not mentioned in 3.4 the requirements of 3.3.1 to 3.3.5 apply, if, at the shipowner's request, the ship's class notation provides for the subdivision distinguishing mark.

3.4 ADDITIONAL REQUIREMENTS FOR DAMAGE TRIM AND STABILITY

3.4.1 Roll-on/roll-off ships similar to passenger ships.

3.4.1.1 Where vehicles accompanied by personnel of more than 12 persons including passengers (if any) shall be carried by roll-on/roll-off ships, such ships, irrespective of their length, shall be considered equal to passenger ships in respect of all relevant requirements for subdivision bearing in mind the deviation stated in 3.3.4.5, if applicable according to 7.12.1.1, Part III "Equipment, Arrangements and Outfit".

3.4.2 Icebreakers and fishing vessels.

3.4.2.1 In Table 3.4.2.1 the number of compartments is indicated after the flooding of which the requirements of 3.3 for damage stability considering damage as defined in 3.2 shall be satisfied. Arctic ships of ice classes Icebreaker**6** or Icebreaker7, which perform icebreaking operations periodically, as defined in 2.2.3.3.3, Part I "Classification" shall only comply with the requirements for damage stability specified in 3.4.2.2 at damage extent and its position as defined in 3.4.2.3 and 3.4.2.4. Damage as defined in 3.2 is not considered for the above mentioned ships.

Table 3.4.2.1

Type of ship	Length L_1, in m	Number of floodable compartments
Icebreakers	50 and upwards	1
Fishing vessels having over 100 persons on board	100 and upwards	1

3.4.2.2 Damage stability of Icebreaker**6** to Icebreaker**9** ice class ships shall be such that $s_i=1$ for all loading conditions in case of ice damage specified in **3**.4.2.**3**, in positions as defined in **3**.4.2.4.

3.4.2.3 For the purpose of damage trim and stability calculations, the following extent of ice damage shall be assumed:

1. longitudinal extent $0,045L_{ice}$ if the centre of damage lies forward of the point of maximum beam on the waterline related to draught d_{ice}, and $0,015L_{ice}$ in other areas;

2. damage depth 0,76 m as measured along the normal to the shell at any point in the area of assumed damage;

3. vertical extent the lesser of $0{,}2d_{ice}$, or of longitudinal extent;

4. location of ice damage from the base line to the level of $1{,}2d_{ice}$ and within L_{ice}; and

5. the vertical extent of damage may be assumed from the base line to the level of $1{,}2d_{ice}$.

3.4.2.4 Damage as defined in 3.4.2.3 shall be assumed at any position along the side shell in the ice damage area.

3.4.3 Special purpose ships.

3.4.3.1 Special purpose ships shall comply with the requirements of Section 2 related to passenger ships, and special personnel shall be considered passengers. Where the ship is certified to carry less than 240 persons, the requirements of 2.7 are not applicable.

3.4.3.2 The required subdivision index R shall be calculated as follows:

.1 where the ship is certified to carry 240 persons or more, the R-value shall be assigned in compliance with 2.2.2.3;

.2 where the ship is certified to carry not more than 60 persons, the R-value shall be assigned as $0{,}8R$ determined in compliance with 2.2.2.3; and

.3 for more than 60 (but not more than 240) persons, the R-value shall be determined by linear interpolation between the R-values given in 3.4.3.2.1 and 3.4.3.2.2.

3.4.4 Tugs, dredgers, salvage ships and lightships.

3.4.4.1 If a single compartment is flooded, the requirements of 3.3 for damage trim and stability shall be satisfied for the following types of ships:

tugs having the length $L_1 \geqslant 40$ m;

dredgers having the length $L_1 \geqslant 40$ m;

rescue ships and lightships irrespective of length;

hopper dredgers having the length $L_1 \geqslant 60$ m.

3.4.4.2 Bucket dredgers shall comply with the requirements of 3.3 if a single compartment is flooded in way of the bucket opening. The depth of the damage is assumed equal to 0,76 m.

3.4.4.3 Where hopper dredgers and hopper barges are concerned, damage conditions may not be considered corresponding to ship condition after spoil discharge from one side.

3.4.5 Oil tankers and chemical tankers.

3.4.5.1 The damage trim and stability of oil tankers and chemical tankers shall satisfy the requirements of **3.3** both for the case of side and bottom damage.

3.4.5.2 Extent of bottom damage:

.1 the longitudinal extent shall be $1/3L_1^{2/3}$ or 14,5 m (whichever is less) within $0{,}3L_1$ from the forward perpendicular (from the foremost point of the length L_1) and $1/3L_1^{2/3}$ or 5 m (whichever is less) through the rest of the ship length;

.2 the transverse extent shall be $B/6$ or 10 m (whichever is less) within $0{,}3L_1$ from the forward perpendicular and $B/6$ or 5 m (whichever is less) through the rest of the ship length;

.3 the vertical extent, measured from the moulded line of the shell at centreline, shall be $B/15$ or 6 m (whichever is less).

3.4.5.3 In addition to 3.4.5.2, bottom shell damage shall be considered for oil tankers with a deadweight of 20 000 t and upwards, having touched the ground, the extent of damage being as follows:

.1 length of $0{,}6L_1$ from the forward perpendicular for ships having a deadweight of 75 000 t and upwards, and $0{,}4\ L_1$ from the forward perpendicular for ships having a deadweigth below 75 000 t;

.2 breadth $B/3$ anywhere in the bottom.

3.4.5.4 Damage trim and stability requirements shall be satisfied for the following locations of side and bottom damage:

.1 oil tankers:

where the length $L_1 > 225$ m — anywhere along the ship length;

where the length $225 \geqslant L_1 > 150$ m — anywhere in the ship length except for the engine room when this is located aft. In this case, the engine room shall be considered a separate floodable compartment;

where the length $L_1 \leqslant 150$ m — anywhere in the ship length between consecutive transverse bulkheads except for the engine room;

where the substances of the Category *C* are carried under the provisions of Annex II to MARPOL 73/78, as for chemical tankers 3;

.2 chemical tankers:

chemical tanker 1 — anywhere along the ship length;

chemical tanker 2 having the length $L_1 > 150$ m — anywhere along the ship length;

chemical tanker 2 having the length $L_1 \leqslant 150$ m — anywhere in the ship length except for the engine room where this is located aft. In this case, the engine room shall be considered a separate floodable compartment;

chemical tanker 3 having the length $L_1 > 225$ m — anywhere along the ship length;

chemical tanker 3 having the length $225 \geqslant L_1 \geqslant 125$ m — anywhere in the ship length except for the engine room where this is located aft. In this case, the engine room shall be considered a separate floodable compartment;

chemical tanker 3 having the length $L_1 < 125$ m — anywhere along the ship length except for the engine room where this is located aft. Nevertheless, damage trim and stability calculations for the conditions of the engine room flooded shall be submitted to the Register for review.

3.4.5.5 Ships which do not comply with the requirements for damage trim and stability when their

engine room is flooded, as stipulated by 3.4.5.4.1 and 3.4.5.4.2, are not assigned a subdivision distinguishing mark in their character of classification.

3.4.5.6 In the final stage of unsymmetric flooding before equalization measures and cross-flooding fittings being used, the angle of heel shall not exceed 25° (or 30° where the bulkhead deck is not immersed). After equalization measures, the heeling angle shall not exceed 17°.

3.4.6 **Gas carriers.**

For gas carriers, the requirements of 3.4.5 apply except for the following details:

.1 damage trim and stability requirements shall be satisfied when side and bottom damage is sustained as stated below:

gas carriers 1G — anywhere along the ship length;

gas carriers 2G having the length $L_1 > 150$ m — anywhere along the ship length;

gas carriers 2G having the length $L_1 \leqslant 150$ m or below — anywhere along the ship length except the engine room where this is located aft. In this case the engine room shall be considered a separate floodable compartment;

gas carriers 2PG — anywhere in the ship length between subdivision bulkheads;

gas carriers 3G having the length $L_1 \geqslant 80$ m — anywhere in the ship length between subdivision bulkheads;

gas carriers 3G having the length $L_1 < 80$ m — anywhere in the ship length between subdivision bulkheads except the engine room where this is located aft. However, damage trim and stability calculations for the case of the engine room being flooded shall be submitted for the consideration of the Register. No subdivision distinguishing mark shall be introduced in the character of classification if damage trim and stability requirements are not met;

.2 the longitudinal extent of bottom damage shall be assumed equal to $1/3L_1^{2/3}$ or 14,5 m, whichever is less, over the full ship length;

.3 the vertical extent of a bottom damage shall be assumed equal to $B/15$ or 2 m, whichever is less.

3.4.7 **Drilling ships.**

With any single compartment flooded, drilling ships shall comply with the requirements of 3.3, unless more stringent requirements are put forward by the shipowner.

Drilling ships shall have sufficient reserve of damage stability to withstand the wind heeling moment produced by wind with a speed of 25,8 m/s (50 knots) acting from any direction. Under these conditions the final waterline after flooding shall be located below the lower edge of any opening through which the intact compartments may be flooded by the sea.

3.4.8 **Ships intended for the carriage of radioactive agents.**

The requirements for damage trim and stability of the ships carrying packaged irradiated nuclear fuel or high-level radioactive wastes with the total radioactivity above 2×10^6 TBq or plutonium with the total radioactivity 2×10^5 TBq and above shall be met in the case of the calculated damage anywhere along the ship length.

The possible probability estimation of the ship subdivision may be considered being an alternative to the requirements indicated.

For ships carrying radioactive agents the required subdivision index R shall be determined in compliance with 2.2. Thus, for cargo ships less than 80 m in length the value of the required subdivision index R shall be determined as for a ship of 80 m in length. In any case, for ships carrying radioactive agents with the total radioactivity above 2×10^6 TBq or plutonium with the total radioactivity above 2×10^5 TBq, the required subdivision index shall be equal to $R + 0{,}2(1 - R)$, but not less than 0,6, where R is determined in compliance with 2.2.2.1 and 2.2.2.2. For ships less than 80 m in length, the value of required subdivision index R shall be determined by the formula

$$R = 1 - [1/(1 + 0{,}8R_0/(1 - R_0)] \qquad (3.4.8)$$

where R_0 is the value of R, calculated in compliance with 2.2.2.1.

3.4.9 **Supply vessels.**

3.4.9.1 The extent of damage:

.1 longitudinal extent shall be $1/3L_1^{2/3}$ for ships with length $L_1 \geqslant 80$ m, 3 m plus 3 per cent of the ship's length for ships with the length (L_1) greater than 43 m. For those with length (L_1) not greater than 43 m, 10 per cent of the ship's length;

.2 transverse extent of damage shall be assumed as 0,76 m and $B/20$ (but not less than 0,76 m) with length $L_1 \geqslant 80$ m, measured inboard from the side of the ship perpendicularly to the centerline at the level of the summer load waterline;

.3 vertical extent: from the underside of the cargo deck, or the continuation thereof, for the full depth of the ship.

3.4.9.2 A transverse watertight bulkhead extending from the ship's side to a distance inboard as specified in 3.4.9.1.2 or more measured perpendicularly to the centerline at the level of the summer load line joining longitudinal watertight bulkheads may be considered as a transverse watertight bulkhead for the purpose of the damage trim and stability calculations.

3.4.9.3 Where a transverse watertight bulkhead is located within the transverse extent of assumed damage and is stepped in way of a double bottom or side tank by more than 3,0 m, the double bottom or side tanks adjacent to the stepped portion of the transverse watertight bulkhead shall be considered as damaged.

3.4.9.4 In the final stage of unsymmetrical flooding the angle of heel shall not exceed 15° before equalization measures are taken and cross-flooding fittings are used. This angle may be increased up to 17° if no deck immersion occurs.

3.4.9.5 Number of floodable compartments.

The damage stability requirements of 3.3 shall be met in the case of single compartment flooding proceeding from the extent of damage stated under 3.2.1.1, 3.2.1.3 and 3.4.9.1.

3.4.9.6 Ships complying with the requirements of 3.4.9.1 only will receive no subdivision distinguishing mark in the character of classification.

3.4.9.7 If preferred by the shipowner, a supply vessel may receive a subdivision distinguishing mark with the number of floodable compartments indicated in the class notation. In this case, the transverse extent of damage shall be assumed in accordance with 3.2.1.2. The number of compartments at the flooding of which the damage trim and stability requirements shall be met shall be determined by the shipowner.

3.4.10 Arc4 to Arc9 ice class ships.

3.4.10.1 The requirements of this paragraph apply to all **Arc4** to **Arc9** ice class ships. The damage trim and stability requirements shall be met as far as the draught d_{ice} is concerned except for the requirement of 3.4.10.2.

3.4.10.2 Where the extent of damage is in accordance with 3.2, within range of the summer load line draught assigned to the ship the damage trim and stability requirements of 3.3 shall be met if a single compartment is flooded in the following ice class ships:

Arc7 to **Arc9** irrespective of the ship's length;

Arc5 and **Arc6** with the ship length $L_1 \geqslant 120$ m.

The subdivision distinguishing mark [1] shall be introduced in the character of classification of such ships.

3.4.10.3 **Arc4** to **Arc9** ice class ships (irrespective of their length) shall comply with the requirements of 3.3 with relevant ice damage stated in 3.4.10.4 and the number of floodable compartments given in 3.4.10.5.

Where compliance with the requirements of other Sections of this Part also testifies to 3.4.10 being complied with, no additional damage trim and stability calculations need be made for damage conditions mentioned under 3.4.10.4 and 3.4.10.5.

3.4.10.4 For the purpose of damage trim and stability calculations, the following extent of ice damage shall be assumed:

.1 longitudinal extent $0{,}045L_{ice}$, if the centre of damage lies within $0{,}4L_{ice}$ from the forward perpendicular, and $0{,}015L_{ice}$ in other areas;

.2 damage depth 0,76 m as measured along the normal to the shell at any point in the area of assumed damage;

.3 vertical extent $0{,}2d_{ice}$;

.4 location of damage from the base line to the level of $1{,}2d_{ice}$ within L_{ice}.

3.4.10.5 When performing damage trim and stability calculations, the number of floodable compartments shall be determined proceeding from the location of the assumed ice damage listed in Table 3.4.10.5.

Table 3.4.10.5

Nos.	Ship types and/or their ice classes	Location of ice damage mentioned under 3.4.10.4
1	**Arc7** to **Arc9** ice class ships except fishing vessels	Anywhere in the ice damage area
2	Passenger ships allowed to carry over 400 passengers including the crew	Ditto
3	Special purpose ships allowed to carry over 400 passengers including the crew	—"—
4	Ships intended for the carriage of radioactive agents	—"—
5	Chemical tankers	—"—
6	Oil tankers	—"—
7	Gas carriers	—"—
8	Drilling ships	—"—
9	Salvage ships of ice classes **Arc5** to **Arc9**	—"—
10	Fishing vessels of ice classes **Arc7** to **Arc9**	Between watertight bulkheads, platforms, decks and plating[1]
11	**Arc5** and **Arc6** ice class ships not mentioned in 2 to **9**	Between watertight bulkheads, platforms, decks and plating[1]. With the hull length $L_1 < 100$ m it is permitted not to comply with the requirements for damage trim and stability where engine room located aft is flooded in case of ice damage The same refers to the flooding of engine rooms of tugs less than 40 m in length irrespective of the engine room location
12	Arc4 ice class ships not mentioned in 2 to **9**	Between watertight bulkheads, platforms, decks and plating[1]. With the hull length $L_1 < 125$ m it is permitted not to comply with the requirements for damage trim and stability where engine room located aft is flooded in case of ice damage. The same refers to the flooding of engine rooms of tugs less than 40 m in length irrespective of the engine room location

[1]Where the distance between two consecutive watertight structures is less than the extent of damage, relative adjacent compartments shall be considered a single floodable compartment when checking damage trim and stability.

3.4.10.6 In all cases, irrespective of the requirements stated in items 11 and 12 of Table **3.4**.10.5, the calculations of damage trim and stability for the case of the engine room being flooded shall be submitted for the consideration of the Register.

3.4.10.7 Ships conforming with the requirements of **3.4**.10.3 to **3.4**.10.6 only will receive no subdivision distinguishing mark in the character of classification.

3.4.11 Bulk carriers, ore carriers and combination carriers.

3.4.11.1 Bulk carriers having the length L_1 of 150 m and upwards, which carry solid bulk cargoes with density of 1000 kg/m^3 and above, shall meet the requirements of **4.4** at flooding of any cargo hold bounded by the side shell only or being double side skin construction with the width less than $B/5$ or 11,5 m (whichever is the less) in all cases of draught up to the summer load line.

3.4.11.2 When calculating damage stability the following permeabilities shall be taken:

0,90 for loaded holds;

0,95 for empty holds.

Ships assigned with the reduced freeboard in accordance with Section **4** are regarded of satisfying the requirements of **3.4**.11.1.

Information on compliance with these requirements shall be included in the Information on Stability and Strength for the Ship Loaded with Solid Bulk Cargoes other than Grain as required by 1.4.9.7, Part II "Hull".

3.4.11.3 Ships are fitted with flooding detection sensors:

.1 in each cargo hold, giving audible and visual alarms, one when the water level above the inner bottom in the hold reaches a height of 0,5 m high, and another at a height not less than 15 per cent of the cargo hold depth but not more than 2,0 m; it is allowed to use one detector instead of two provided its design allows to give alarm at both levels of hold flooding. The detectors are fitted in the aft end of the cargo hold as close to the centerline, as practicable, or above its lowest part where the inner bottom is not parallel to the designed waterline. If detectors cannot be placed within a distance equal to one corrugation space or one bulkhead vertical stiffener space from the centerline, they shall be located at both the port and starboard sides of the cargo hold;

.2 in any ballast tank forward of the collision bulkhead required in 1.1.6, Part II "Hull" giving an audible and visual alarm when the liquid in the tank reaches a level not exceeding 10 per cent of tank capacity;

.3 in any dry or void space other than a chain cable locker, any part of which extends forward of the foremost cargo hold, giving an audible and visual alarm at a water level of 0,1 m above the deck. Such alarms need not be provided in enclosed spaces, the volume of which does not exceed 0,1 per cent of the ship's maximum displacement volume.

Detectors in cargo holds shall be protected by a robust construction from damage by cargoes or mechanical handling equipment associated with bulk carrier operations.

3.4.11.4 On ships the Flooding Detection System Manual shall be provided, which includes, as a minimum:

.1 the flooding detection system specification, including a list of procedures for checking the operability, as far as practicable, of each element at any stage of the ship service;

.2 the Type Approval Certificate issued for the flooding detection system;

.3 the single-line diagram of the flooding detection system with the location of equipment indicated in the ship's general arrangement plan;

.4 the instructions indicating the location, securing, protection and testing of the flooding detection system equipment;

.5 list of cargoes in which 50 per cent mixture with seawater detectors protected by guard remain operable;

.6 the procedures to be followed in case of failure of the flooding detection system;

.7 the maintenance requirements for the flooding detection system equipment.

The Manual shall be in the working language of the ship officers, as well as in English.

3.4.11.5 The flooding detection system shall meet the requirements of 7.10, Part XI "Electrical Equipment".

3.4.12 Berth-connected ships.

3.4.12.1 Damage stability requirements stated in **3.3** shall be complied with in the case of any single flooded compartment lying along the ship periphery and having the length not less than the length of damage given in **3.4**.12.2.2.

3.4.12.2 For the purpose of damage trim and stability calculations, the following extent of damage shall be assumed:

.1 transverse extent measured from the inner skin at right angles to the centreline on the level of the deepest waterline permitted by the load line — 0,76 m;

.2 longitudinal extent — $1/6L_1^{2/3}$ or 7,2 m (whichever is less);

.3 vertical extent in accordance with **3.2**.1.**3**.

3.4.12.3 No subdivision distinguishing mark will be introduced in the character of classification of berth-connected ships which comply solely with the requirements of **3.4**.12 and for which regard to **3.4**.12.2 shall be taken.

3.4.12.4 If the depth of waters on which the berth-connected ship floats is such that the lowermost deck accessible to passengers cannot be im-

mersed not to mention capsizing of the ship, the requirements of this Section may be waived.

3.4.13 Cargo ships having the length $L_1 < 100$ m other than bulk carriers.

3.4.13.1 Single hold cargo ships other than bulk carriers shall comply with the present requirements not later than the date of the first intermediate or renewal survey of the ship, whichever comes first, but, anyway, not later than 31 December 2009.

3.4.13.2 Ships having the length $L_1 < 80$ m, or $L_1 < 100$ m if constructed before 1998, and a single cargo hold below the freeboard deck or cargo holds below the freeboard deck which are not separated by at least one bulkhead made watertight up to that deck, shall be fitted in such space or spaces with flooding detection sensors, which give an audible and visual alarm at the navigation bridge when the water level above the inner bottom in the cargo hold reaches a height of not less than 0,3 m, and another when such level reaches not more than 15 per cent of the mean depth of the cargo hold.

3.4.13.3 Flooding detection sensors shall be fitted at the aft end of the hold, or above its lowest part where the inner bottom is not parallel to the designed waterline. If sensors cannot be placed within a distance equal to one corrugation space or one bulkhead vertical stiffener space from the centerline, they shall be located at both sides of the cargo hold. Where webs or partial watertight bulkheads are fitted above the inner bottom, the fitting of additional sensors may be required. It is allowed to use one sensor vertically instead of two provided its design allows giving alarm at both levels of hold flooding.

3.4.13.4 The flooding detection sensors need not be fitted in ships complying with the requirements of 3.4.11.3, or in ships having watertight side compartments each side of the cargo hold length extending vertically at least from inner bottom to freeboard deck.

3.4.13.5 The flooding detection system shall comply with the requirements of 7.10, Part XI "Electrical Equipment".

3.4.13.6 Flooding Detection System Manual shall be provided on board the ship, which shall be developed in compliance with the requirements of 3.4.11.4.

4 SPECIAL REQUIREMENTS FOR TYPE "B" SHIPS WITH REDUCED FREEBOARD AND FOR TYPE "A" SHIPS

4.1 GENERAL

4.1.1 This Section applies to type "A" and type "B" ships specified in 1.1.3.

The requirements of the Section shall be fulfilled irrespective of meeting the requirements of other Sections by these ships.

4.1.2 The requirements are considered fulfilled where it is demonstrated by calculations that a ship being in assumed loading condition specified in 4.2 after the flooding of the number of compartments required by 4.1.3 to 4.1.5 caused by damages stipulated in 4.3 remains afloat and in a condition of equilibrium it meets the requirements of 4.4.

4.1.3 For type "A" ships having the length $L_1 > 150$ m, when they are assigned a freeboard less than that of the appropriate ships of the type "B" the requirements of this Chapter shall be complied with in the case of any single compartment being flooded.

4.1.4 For type "B" ships having the length $L_1 > 100$ m for which the permitted reduction of tabular freeboard does not exceed 60 per cent of the difference between its values as per Tables 4.1.2.3 and 4.1.3.2 of the Load Line Rules for Sea-Going Ships, the following cases of flooding shall be considered:

.1 any single compartment with the exception of the engine room;

.2 any single compartment including the engine room where the ship length $L_1 > 150$ m.

4.1.5 Type "B" ships having the length $L_1 > 100$ m, for which the permitted reduction in the tabular freeboard exceeds 60 per cent of the difference between its values as per Tables 4.1.2.3 and 4.1.3.2 of the Load Line Rules for Sea-Going Ships shall be considered for the following cases of flooding:

.1 any two adjacent compartments, except for the engine room;

.2 any two adjacent compartments and the engine room considered separately in ships having the length $L_1 > 150$ m.

4.1.6 The following permeabilities shall be assumed in calculations required by 4.1.2:

0,95 for any floodable compartments and spaces, except for the engine room;

0,85 for floodable engine room.

The permeability value of 0,95 is applicable to cargo spaces and tanks as well which shall be considered full when determining the height of the ship centre of gravity in conformity with 4.2.3.

4.1.7 In addition to the requirements of 4.1.4 and 4.1.5, ships intended for carriage of deck cargoes shall comply with the requirements of Section 2. Height of the centre of gravity used for demonstration of compliance with the requirements of 4.4 during the deterministic analysis of damage stability shall be equal to the height of the centre of gravity used for calculation of damage stability at probabilistic assessment at assumption of the highest loadline. The diagram of ultimate elevation of the ship centre of gravity (limiting moments or minimum metacentric heights) with deck cargo drawn taking into consideration the fulfilment of the requirements of Section 2 shall be included into the Information on Stability and Information on Damage Trim and Stability.

4.2 TRIM AND LOADING CONDITION OF THE SHIP PRIOR TO DAMAGE

4.2.1 All cases of flooding shall be analyzed under one assumed initial loading condition of the ship, as specified in 4.2.2 to 4.2.4.

4.2.2 The ship is considered to be loaded by homogeneous cargo to its summer load line draught in sea water on an even keel.

4.2.3 The height of the centre of gravity of the ship shall be calculated for the following assumed loading condition:

.1 all cargo spaces, except for those under 4.2.3.2, including the anticipated in service, partly filled spaces are considered to be fully loaded with dry cargo and to be 98 per cent loaded with liquid cargo;

.2 where the ship when loaded to the summer load line shall operate with some spaces not loaded or filled with dry or liquid cargo, such spaces shall be assumed empty provided that the height of the centre of gravity of the ship, calculated with regard to empty compartments is not less than that calculated on the assumption that all the spaces are occupied with cargoes;

.3 the amount of every type of the ship's stores and consumable liquids is taken to be equal to 50 per cent of the full capacity. Tanks, except for those under 4.2.4.2, are assumed to be empty or completely filled, the distribution of the stores in the tanks resulting in the highest position of the centre of gravity of the ship. The centres of gravity of the contents of the tanks mentioned in 4.2.4.2 are taken to be in the centres of gravity of their volumes;

.4 ballast water tanks shall normally be considered to be empty and no free surface correction shall be made for them;

.5 loading of the ship as regards consumable liquids and ballast water shall be estimated on the basis of the following values of their density, in t/m^3:

Sea water	1,025
Fresh water	1,000
Fuel oil	0,950
Diesel oil	0,900
Lubricating oil	0,900

4.2.4 In estimating the height of the centre of gravity of the ship account shall be taken of the effect of free surfaces of liquids:

.1 for liquid cargo, proceeding from loading specified in 4.2.3.1;

.2 for consumable liquids, proceeding from the assumption that for every type of liquid at least one centreline tank or one transverse pair of tanks have free surfaces. To be taken into consideration are the tanks or the combination of tanks where the effect of free surfaces is the greatest.

It is recommended that the correction for free surfaces effect be taken into account in accordance with 1.4.7, Part IV "Stability."

4.3 EXTENT OF DAMAGE

4.3.1 The vertical extent of damage shall be assumed from the base line upwards without limit.

4.3.2 The transverse extent of damage measured inboard from the ship's side, at a right angle to the centreline at the level of the summer load waterline shall be assumed equal to one-fifth of the breadth of the ship or 11,5 m, whichever is the less.

4.3.3 If any damage of lesser extent than indicated in 4.3.1 and 4.3.2 would result in a more severe condition, such damage shall be assumed in the calculations.

4.3.4 Transverse bulkheads are considered effective if the distance between them or between the transverse planes passing through the nearest portions of the stepped bulkheads is at least $1/3L_1^{2/3}$ or 14,5 m, whichever is the less. In case of lesser distance, one or more of these bulkheads shall be assumed as non-existent.

4.3.5 When one compartment is flooded, with due regard for provisions of 4.3.4, main transverse bulkheads are considered not to be damaged if they have no steps more than 3 m in length.

In case these bulkheads are provided with steps more than 3 m in length, the two compartments adjacent to such bulkheads shall be considered as flooded.

The extent of damage may be limited by transverse bulkheads of a side tank in case its longitudinal bulkheads are beyond the transverse extent of damage.

Where a side tank or a double bottom tank is divided by a transverse bulkhead located more than 3 m from a main transverse bulkhead, both tanks divided by such bulkhead shall be considered as flooded.

The following compartments shall be considered as flooded:

A+D, B+E, C+E+F (Fig. 4.3.5-1);
A+D+E, B+E, C+F (Fig. 4.3.5-2);
A+D, B+D+E, C+F (Fig. 4.3.5-3);
A+B+D, B+D+E, C+F (Fig. 4.3.5-4).

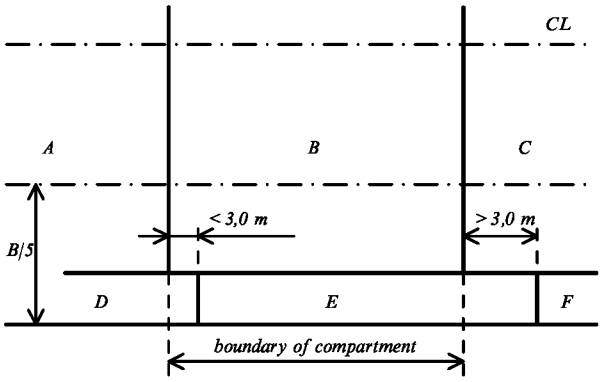


Fig. 4.3.5-1

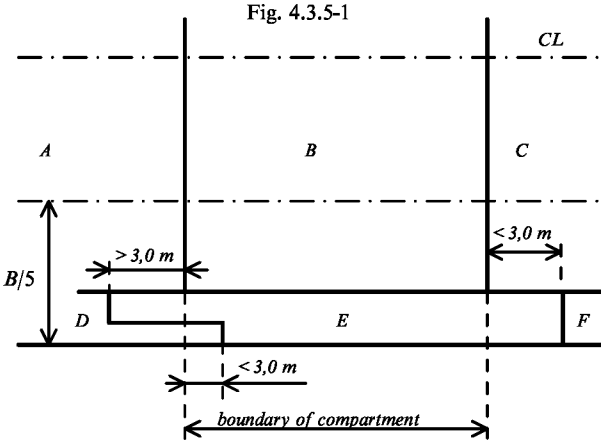


Fig. 4.3.5-2

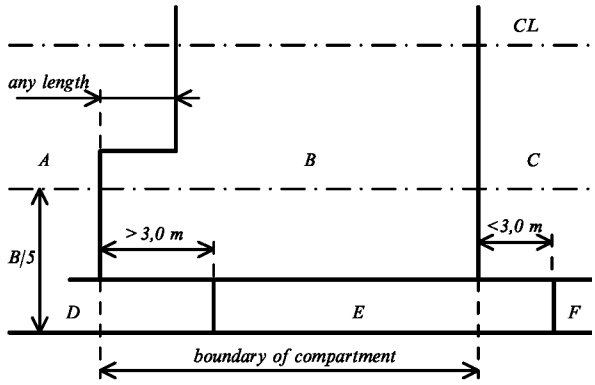


Fig. 4.3.5-3

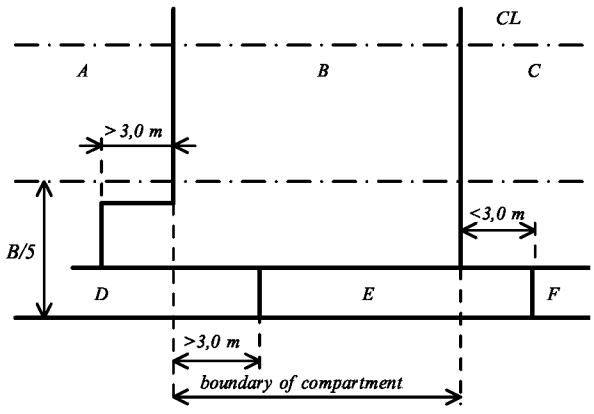


Fig. 4.3.5-4

Where the forecastle is arranged above the fore cargo hold, subject to the condition that the forecastle bulkhead is located not more than 3 m aft from the forward bulkhead of the hold and watertightness of the stepped deck structure is ensured the bulkhead shall be considered to be continuous and not to be damaged.

4.3.6 Where a side tank has openings into a hold, it shall be considered as communicating with the hold even where such openings are fitted with closing appliances. This provision is applicable to ships carrying liquid cargoes, except in case of sluice valves fitted in bulkheads between tanks and where the valves are controlled from above the bulkhead deck.

4.3.7 Where pipes, ducts or tunnels are located within the assumed extent of damage, satisfactory arrangements shall be provided to preclude the possibility of progressive flooding through them to other spaces beyond the limits assumed for the calculations of the damage stability of the ship.

4.3.8 In case of two-compartment flooding the requirements of 4.3.1 to 4.3.4, 4.3.6 and 4.3.7 shall be met.

4.4 DAMAGE TRIM AND STABILITY

4.4.1 The metacentric height of the damaged ship prior to taking measures for the increase thereof shall be positive.

4.4.2 The angle of heel due to unsymmetrical flooding prior to the beginning of the equalization of the ship shall not exceed 15°. If no part of the deck immerses, the increase of heel up to 17° may be allowed.

4.4.3 The final damage waterline having regard to heel and trim prior to the beginning of the equalization of the ship shall not be above the lower edge of openings indicated in 3.3.4, through which progressive flooding may take place.

4.4.4 When any part of the bulkhead deck beyond the limits of the flooded compartments immerses, or the margin of damage stability is doubtful, damage stability at large angles of heel shall be investigated. It shall be shown that the value of a maximum arm of the righting lever curve of a damaged ship is not less than 0,1 m within the rated extent (20°) in association with a range of the curve with positive arms of at least 20°, the area of the positive portion of the curve being not less than 0,0175 m·rad.

5 REQUIREMENTS FOR SHIPS IN SERVICE

5.1 BULK CARRIERS, ORE CARRIERS AND COMBINATION CARRIERS

5.1.1 Bulk carriers with single side shell the design of which complies with the requirements of 3.3.1.6.1, Part II "Hull", having the length $L_1 \geqslant 150$ m, carrying solid bulk cargoes with a density of 1000 kg/m^3 and above, constructed on July 1999 or after that date, shall comply with the requirements of 4.4 at flooding of any cargo hold under all the loading cases up to the summer load line. The bulk carrier, which forward cargo hold is confined by the outer plating or double side skin construction with a width less than 760 mm with a length $L_1 \geqslant 150$ m built before 1 July 1999 carrying hard bulk cargoes with density of 1780 kg/m^3 and more, shall comply with the requirements of 4.4 while flooding the fore cargo hold in all cases of loading up to the summer load line not later than the date of survey assigned in relation to the ship age:

.1 for ships which age at 1 July 1998 is 20 years and more, the date of the first intermediate (the second or the third annual survey) or the first special survey, which shall be carried out after 1 July 1998 is accepted, whichever is earlier;

.2 for ships which age at 1 July 1998 is 15 years and more but less then 20 years, the date of the first special survey which shall be carried out after 1 July 1998 but not later than 1 July 2002 is accepted;

.3 for ships which age at 1 July 1998 is less than 15 years, the date of the third special survey or the date when the ship's age becomes equal to 15 years is accepted, whichever is later.

5.1.2 The following values of permeabilities shall be taken for the damage stability calculations:

0,90 for loaded holds;

0,95 for empty holds.

5.1.3 The ships which do not comply with the requirements of 5.1.1 may be acquitted from this requirement provided the following conditions are met:

.1 the programme of the fore hold annual survey is replaced by the programme approved at the full scale intermediate survey in accordance with Section 2, Part III "Additional Surveys of Ships in Relation to their Purpose and Hull Material" of the Rules for the Classifications Surveys of Ships in Service;

.2 the visual and audible alarm shall be fitted in the wheelhouse for signalling in case of:

flooding over two metres above the double bottom in the stern part of each cargo hold;

filling of bilge well of each hold up to the upper level.

Such signalling system shall meet the requirements of Part XI "Electrical Equipment";

.3 the ship shall be supplied with detailed information on the effect of the phased flooding of cargo hold and detailed instructions in accordance with Section 8 of ISM Code.

Information shall include the data and documentation stated in 1.4.6.1 and the results of damage trim and stability calculations at stage-by-stage compartment flooding under all conditions of loading to the summer load line on an even keel. When the ship meets the requirements of 4.4 at a lesser draught, the document shall contain a diagram of maximum heights of the centre of gravity of the ship (limiting moments or minimum metacentric heights) plotted with due regard to the trim and ship load. The strength of the bulkhead shall be taken into consideration. The information shall contain a summary table of calculation results with indication of critical factors and the data given in 1.4.6.1.5.

5.1.4 The ships which are assigned with the reduced freeboard in accordance with Section 4 are considered compliant with the requirements 5.1.1.

5.1.5 Information on compliance with the requirements of 5.1.1 to 5.1.3 shall be included in the Booklet required by 1.4.9.7, Part II "Hull".

5.1.6 Ships built before 1 July 2004 shall meet the requirements of 3.4.11.3 to 3.4.11.5 not later than the date of the first periodical survey of a ship conducted after 1 July 2004.

5.1.6.1 If flooding detection sensors cannot be placed in the aft end of the cargo hold within a distance less than or equal to $B/6$ from the centerline, they shall be located at both the port and starboard sides of the cargo hold.

5.1.6.2 The upper sensor only may be fitted in cargo holds of the ships being subject to the requirement of 5.1.3; the ships not complying with the requirement of 5.1.3.2 on 1 January 2004 shall be fitted with flooding detection sensors in cargo holds in accordance with 3.4.11.3.1 (considering 5.1.6.1).

APPENDIX 1

GUIDELINES FOR THE PREPARATION OF SUBDIVISION AND DAMAGE STABILITY CALCULATIONS

1 GENERAL

1.1 Purpose of the Guidelines

1.1.1 These Guidelines serve the purpose of simplifying the process of the damage stability analysis, as experience has shown that a systematic and complete presentation of the particulars results in considerable saving of time during the approval process.

1.1.2 A damage stability analysis serves the purpose to provide proof of the damage stability standard required for the respective ship type. At present, two different calculation methods, the deterministic concept and the probabilistic concept are applied.

1.2 Scope of analysis and documentation on board

1.2.1 The scope of subdivision and damage stability analysis is determined by the required damage stability standard and aims at providing the ship's master with clear intact stability requirements and limitations. In general, this is achieved by determining *KG*-respective *GM*-limit curves, containing the admissible stability values for the draught range to be covered.

1.2.2 Within the scope of the analysis thus defined, all the required damage conditions depending on the ship's type and purpose as well as potential damage conditions in service will be determined. Depending on the type, purpose and size of ship, this may involve a considerable amount of analyses.

1.2.3 The necessity to provide the crew with the relevant information regarding the subdivision of the ship is expressed. Therefore Damage Control Plan (refer to 1.4.6.2) shall be developed and permanently exhibited for the guidance of the officers in charge. In addition, Information on Damage Trim and Stability shall be available on board (refer to 1.4.6.1).

2 DOCUMENTS FOR SUBMISSION

2.1 General details to be included in the documentation on board

2.1.1 The documentation shall include, as a minimum, the following details: principal dimensions, ship type, designation of intact conditions, designation of damage conditions and *KG*-respective *GM*-limit curve.

2.2 General documents

2.2.1 For the checking of the input data, the following shall be submitted:

.1 main dimensions;

.2 lines plan, plotted or numerically;

.3 hydrostatic data and cross curves of stability (including drawing of the buoyant hull);

.4 definition of ship spaces and compartments with moulded volumes, centres of gravity and permeability;

.5 layout plan for all watertight structures and bulkheads with all internal and external opening points including their connected spaces, and reference to the source materials used in measuring the spaces, such as general arrangement plan and subdivision plan. The subdivision limits, longitudinal, transverse and vertical, shall be included;

.6 light service condition;

.7 load line draught;

.8 coordinates of opening points with their level of tightness (e.g., weathertight or unprotected);

.9 watertight door location coordinates with pressure calculation;

.10 side contour and wind profile;

.11 cross and down flooding devices and the calculations thereof according to IMO resolution MSC.362(92) with information about diameter, valves, pipe lengths and coordinates of inlet/outlet;

.12 pipes in damaged area when the destruction of these pipes results in progressive flooding;

.13 damage extensions and definition of damage cases.

2.3 Special documents

To confirm damage stability calculation results the following documentation shall be submitted.

2.3.1 Documentation.

2.3.1.1 Initial data:

.1 subdivision length L_s;

.2 initial draughts and the corresponding *GM*-values (operational metacentric height);

.3 required subdivision index *R*;

.4 attained subdivision index *A* with a summary table of all contributions for all damaged zones.

2.3.1.2 Results for each damage case, which contributes to the index *A*:

.1 draught, trim, heel, *GM* in damaged condition;

.2 dimension of the damage with probabilistic values *p*, *v* and *r*;

.3 righting lever curve (including GZ_{max} and *range*) with factor of survivability s;

.4 list of critical weathertight and unprotected openings with their angle of immersion;

.5 details of the ship spaces and compartments with amount of in-flooded water/lost buoyancy with their centres of gravity.

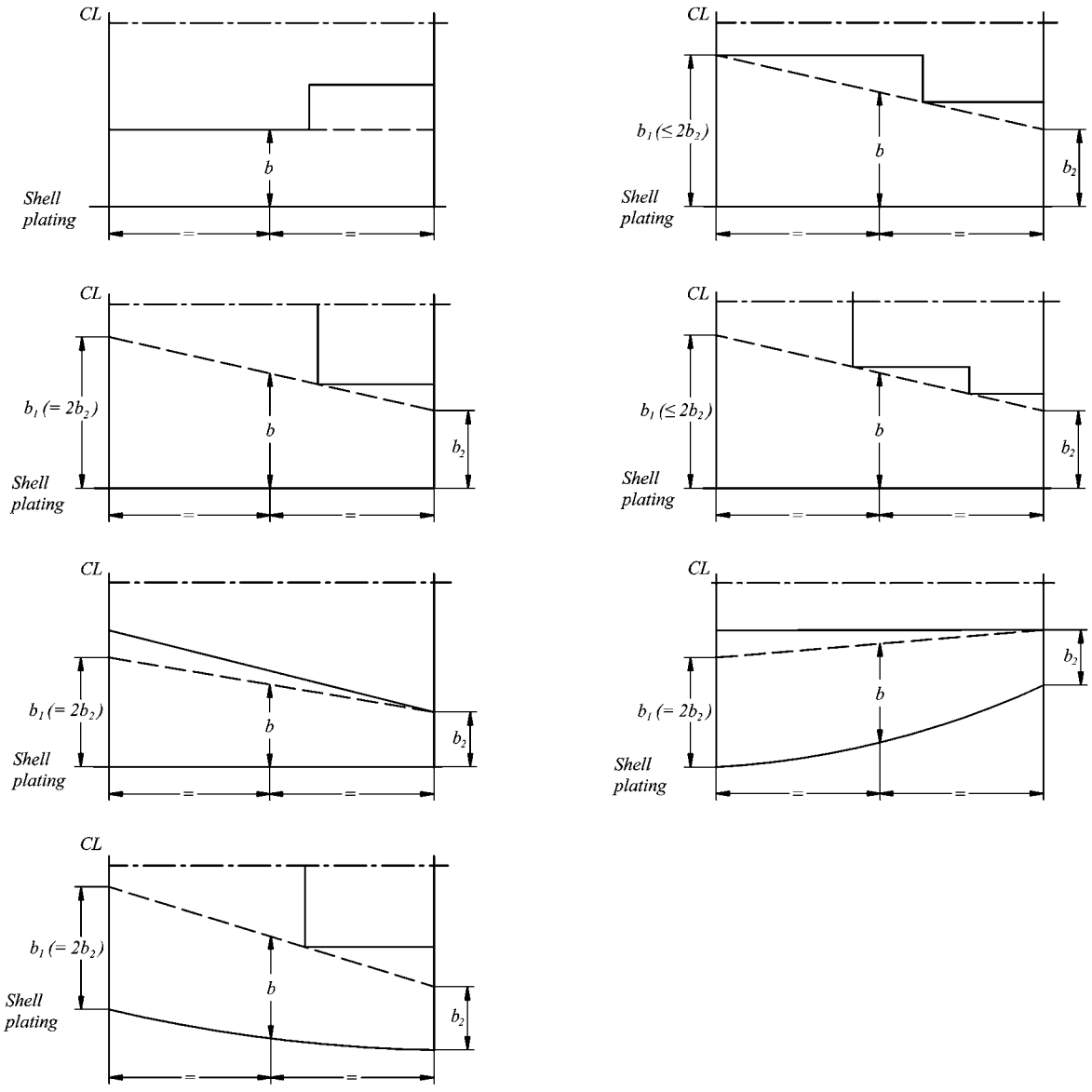
2.3.1.3 In addition to the requirements of 2.3.1.2, particulars of non-contributing damages ($s_i = 0$ and $p_i > 0{,}00$) shall also be submitted for passenger ships and ro-ro ships fitted with long lower holds including full details of the calculated subdivision factors.

2.3.2 Special consideration.

For intermediate conditions, as stages before cross-flooding or before progressive flooding, an appropriate scope of the documentation covering the aforementioned items is needed in addition.

APPENDIX 2

DETERMINATION OF THE MOULDED PENETRATION DEPTH *b*



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