PART V. SUBDIVISION

1. GENERAL

1.1 APPLICATION

1.1.1 The requirements of this Part shall cover the following types of ships:

.1 passenger ships;

.2 oil tankers;

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

.4 type A ships and type B ships with reduced freeboard as specified in 4.1.2.1 and 4.1.3.1 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 $L_1 \geq 80$ 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 $L_1 \geq 50$ m;

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

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

.15 salvage ships;

.16 drilling ships;

.17 lightships;

.18 ships having the ice strengthening marks **Ice4, Ice5** and **Ice6** in the class notation;

.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 specified 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).

.22 ro-ro passenger ships – a passenger ship carrying more than 12 passengers and having closed or open ro-ro spaces or spaces of special category as defined in 1.5.4.3, 1.5.4.4 and 1.5.9, Part VI "Fire Protection", "Rules for the Classification and Construction of Sea-Going Ships".

Ferryboats that are via ferry crossing engaged on regular carriages of passengers and carriage of vehicles with oil in tanks on open and/or closed deck and/or railway rolling stock with horizontal loading and discharging shall be referred to ro-ro passenger ships.

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 specified herein.

The applicability of this Part to nov-

el ships shall be defined as agreed with the Register.

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

1.1.4 Conformity of passenger ship with distinguishing marks **A**, **A-R1, A-R2**, **A-R2-RS**, **A-R2-S**, **B-R3-S**, **B-R3-RS**, **C**-**R3-S**, **C**-**R3-RS**, **D-R3-S**, **D-R3-RS** in the class notation with provisions of Directive 2009/45/EC of the European Parliament and of the Council of 6 May 2009 on Safety Rules and Standards for Passenger Ships, entered into force on 15 July 2009 (amended by Commission Directive 2010/36/EU of 1 June 2010), hereinafter refereed as Directive 2009/45/EU, shall be assessed in accordance with requirements of 2.6.1 of General Regulations for Technical Supervision with application of these Rules and/or special requirements of these Rules depending on the class notation mark of the ship, both for new and existing (see 2.6.1.1.4.2 or 2.6.1.1.4.3 of the General Regulations for Technical Supervision correspondingly) ships stipulated in certain items with or without reference to the class notation marks of a ship upon fulfillment of the following requirements:

- n e w s h i p s w i t h d i s t i n - g u i s h i n g m a r k s **A**, **A-R1, A-R2**, **A-R2-RS**, **A-R2-S** in the class notation – all applicable requirements of this Part taking into account references to the class notation of a ship, where there are partic-

ular requirements to stipulated marks in certain items;

− e x i s t i n g s h i p s w i t h d i s - t i n g u i s h i n g m a r k s **B**-**R3-S**, **B-R3-RS** i n t h e c l a s s n o t a t i o n b e i n g n o n r o - r o p a s s e n g e r s h i p s , c o n s t r u c t e d o n o r a f - t e r 2 9 A p r i l 1 9 9 0 **-** 1.7.3.3 to 1.7.3.6, 1.7.3.9 *),

*) *in case of unsymmetrical flooding the angle of heel shall not be more than 7°, in exceptional cases the Register may additionally permit heeling corresponding to the unsymmetrical moment, except for a case when the final heel exceeds 15°;*

− n e w s h i p s w i t h d i s t i n - g u i s h i n g m a r k s **B**-**R3-S**, **B-R3-RS,** **C**-**R3-S**, **C-R3-RS** and **D-R3-S, D-R3-RS** i n t h e c l a s s n o t a t i o n a n d e x - i s t i n g s h i p s w i t h d i s t i n g u i s h - i n g m a r k s **B-R3-S**, **B - R3-RS** i n t h e c l a s s n o t a t i o n – 1.3.2, 1.4.10, 1.7.1, 1.7.2.1, 1.7.2.3, 1.7.2.4, 1.7.2.5*), 1.7.3.1, 1.7.3.2, 1.7.3.7, 1.7.3.8, 1.7.3.9, 1.7.3.10, 1.7.3.11;

*) *e x i s t i n g s h i p s w i t h d i s - t i n g u i s h i n g m a r k s* **B - R3-S***,* **B - R3-RS** *i n t h e c l a s s n o t a t i o n b e i n g n o n r o - r o s h i p s - The factor of subdivision shall be equal to 1.0.*

− e x i s t i n g s h i p s w i t h d i s - t i n g u i s h i n g m a r k s **B - R3-S***,* **B-R3-RS** i n t h e c l a s s n o t a t i o n - 1.7.2.6.1, 1.7.2.6.2, 1.7.2.6.3, 1.7.2.6.4, 1.7.2.6.5;

− n e w s h i p s w i t h d i s t i n - g u i s h i n g m a r k s **B - R3-S***,* **B-R3-RS, C - R3-S***,* **C-R3-RS** and **D-R3-S, D-R3-RS** i n t h e c l a s s n o t a t i o n - 1.7.2.6;

− e x i s t i n g r o - r o p a s s e n -

ger ships carrying 400 and more passengers with distinguishing marks **B - R3-S**, **B-R3-RS**, **C - R3-S**, **C-R3-RS** and **D-R3-S, D-R3-RS** in the class notation − 1.7.4,

− new ro-ro passenger ships, including those ships carrying 400 passengers and more with distinguishing marks **B - R3-S**, **B-R3-RS**, **C - R3-S**, **C-R3-RS** and **D-R3-S, D-R3-RS** in the class notation − 1.7.4

− ships with distinguishing marks **B - R3-S**, **B-R3-RS**, **C - R3-S**, **C-R3-RS** and **D-R3-S, D-R3-RS** in the class notation, carrying 400 passengers and more, other than ro-ro ships constructed on or after 1 January 2003 − 1.7.5.

1.2 DEFINITIONS AND EXPLANATIONS

1.2.1 Definitions and explanations related to the general terminology of the Rules are given in General Regulations for Technical Supervision and Part I, "Classification", "Rules for the Classification and Construction of Sea-Going Ships"[1].

This Part shall have the following definitions and explanations:

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

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

Compartment is an inner space limited by the ship bottom, sides, bulk-

head deck and two adjacent transverse watertight bulkheads or a peak bulkhead and an extremity.

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

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 surface of the deck and plating.

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

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.

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

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.

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 heel.

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[1] Hereinafter referred to as Part I "Classification".

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;

.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 hollow, 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. In case of unusual arrangements, the limits of machinery spaces are defined as agreed with the Register.

Amidships is at the middle of the length L_1.

Deepest subdivision load line is the subdivision load line which corresponds to the deepest draught permitted by applicable subdivision requirements.

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.

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

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

Ship draught d_{ice} is the smallest 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 provided by 3.4.10.

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 at 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.

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

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.

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

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

1.2.3 All linear dimensions used herein 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 Technical Supervision and Part I, Classification.

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

.1 check for 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 Pipelines";

.2 consideration and approval of the Information on Damage Trim and Stability, Flooding Detection System Manual provided by 3.4.11.4, Damage Control Plan and consideration of the Information on the Effect of Flooding (to be duly noted) as defined 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 onboard 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 taking in account 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 ship of the greatest length mostly engaged 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 as per 1.4.7, Part IV "Stability".

When plotting static stability curves

for a damaged ship, the enclosed super-structures, 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 intact ship as per 1.4.9, Part IV "Stability".

Superstructures, trunks and deck-houses which sustain damage only may be taken into consideration with the per-meability 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 considering that in the flooded tanks below the damage waterline the free surface of those cargoes disappears.

1.4.6 Ships to which this Part applies shall be provided with approved (by the Register) 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 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 language used in Information on Damage Trim and Stability with compartments flooded and with Damage Control Plan is not one of the official IMO languages, those documents shall be translated into English.

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 compliance with the requirements hereof, 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 ship' gravity (limiting moments or minimum metacentric heights) plotting considering the requirements of this Part and Part IV "Sta-

bility".

For ships in relation to which the requirements of Section 2 apply, a curve of maximum permissible vertical positions of centre of gravity (or minimum metacentric heights) shall be determined considering the subdivision index as follows:

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 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 ships with **Ice4** to **Ice6** ice strengthening, 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:

immediate 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 heel and liquid transfer operations to lessen heel 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, tanks 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 coordinate 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. The necessity to apply this requirement is determined by the Register for each particular ship.

1.4.6.2 Damage Control Plan shall be made on a 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, if any, at the place of the crew alarm post.

On cargo ships the Plan shall be permanently exhibited or be readily available on the navigation bridge. Moreover, the Plan shall be permanently exhibited or be readily available in the cargo control room, ship's control station etc.

The necessity to submit isometric drawings as for the Damage Control Plan is determined by the Register for each particular ship.

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

.1 watertight compartments and tanks boundaries;

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

.3 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 on the plan;

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

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

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

.7 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 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 corresponding software shall be approved by the Register.

A computer is not equivalent to Information on Damage Trim and Stability. Information on Damage Trim and Stability in case of compartments flooding 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 the Register, which makes damage stability and residual strength assessments is provided on board, this may be used to supplement Information on Dam-

age 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 documents 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 on consequences of compartments flooding 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 as per 2.3, is not less than the required subdivision index R calculated in compliance 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 as per 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 as per 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 Section 7, Part III "Equipment, Arrangements and Outfit" is ensured.

When, in compliance 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 0.60 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 expediency of the application of other permeability indices

resulting in more severe requirements is evident, the Register is entitled to require the application of those permeability indices.

1.7 REQUIREMENTS FOR SUBDIVISION AND STABILITY OF PASSENGER SHIPS WITH DISTINGUISHING MARKS B-R3-S, B-R3-RS, C-R3-S, C-R3-RS and D-R3-S, D-R3-RS IN THE CLASS NOTATION

1.7.1 Passenger ships with distinguishing marks **B-R3-S**, **B-R3-RS**, **C-R3-S**, **C-R3-RS** and **D-R3-S, D-R3-RS** in the class notation may comply with the requirements of this subsection instead of the requirements given in 1.5 and 2.7.

1.7.2 Subdivision

1.7.2.1 Every ship shall be subdivided by bulkheads, which shall be watertight up to the bulkhead deck, into watertight compartments the maximum length of which shall be calculated according to the specific requirements given below.

Every other portion of the internal structure which affects the efficiency of the subdivision of the ship shall be watertight.

1.7.2.2 Floodable length

.1 The floodable length at a given point is the maximum portion of the length of the ship, having its centre at the point in question, which can be flooded, under the assumption for permeability given in 1.7.2.4, without the ship being submerged beyond the margin line.

.2 In case of a ship not having a continuous bulkhead deck, the floodable length at any point may be determined to an assumed continuous margin line which at no point is less than 76 mm below the top of the deck at side to which the bulkheads concerned and the shell are carried watertight.

.3 Where a portion of an assumed margin line is appreciably below the deck to which bulkheads are carried, the Register may permit a limited relaxation in the watertightness of those portions of the bulkheads which are above the margin line and immediately under the higher deck.

1.7.2.3 Permissible length of compartments

The maximum permissible length of a compartment having its centre at any point in the ship's length is obtained from the floodable length by multiplying the latter by an appropriate factor called factor of subdivision.

1.7.2.4 Permeability

The definite assumptions referred to in 1.7.2.2 relate to the permeability of the spaces below the margin line.

In determining the floodable length, the assumed average permeability of the spaces below the margin line shall be as indicated in the Table 1.7.3.7.1

1.7.2.5 Subdivision factor

The factor of subdivision shall be:

1.0 when the number of persons the ship is certified to carry is less than 400, and

0.5 when the number of persons the ship is certified to carry is 400 or more.

1.7.2.6 Special requirements concerning ship subdivision

.1 Where in a portion or portions of a ship the watertight bulkheads are carried to a higher deck in the remainder of the ship and it is desired to take advantage of this higher extension of the bulkheads in calculating the floodable length, separate margin line may be used for each such portion of a ship, provided that:

- the sides of the ships are extended throughout the ship's length to the deck corresponding to the upper margin line and all openings in the shell plating below this deck throughout the length of the ship are treated as being below a margin line for the purposes of 7.2.1, Part III "Equipment, Arrangements and Outfit", and

- the two compartments adjacent to the 'step' in the bulkhead deck are each within the permissible length corresponding to their respective margin lines, and, in addition, their combined length does not exceed twice the permissible length based on the lower margin line.

.2 A compartment may exceed the permissible length as provided by 1.7.2.3, provided the combined length of each pair of adjacent compartments to which the compartment in question is common does not exceed either the floodable length or twice permissible length, whichever is the less.

.3 A main transverse bulkhead may be recessed, provided that all parts of the recess lie inboard of vertical surfaces on both sides of the ship, situated at a distance from the shell plating equal to one fifth of the breadth of the ship and measured at right angles to the centreline at the level of the deepest subdivision load line.

Any part of a recess which lies outside these limits shall be dealt with a step in accordance with 1.7.2.6.6.

.4 Where a main transverse bulkhead is recessed or stepped, an equivalent plane bulkhead shall be used in determining the subdivision.

.5 Where a main transverse watertight compartment contains local subdivision and the Register is satisfied that,

after any assumed side damage extending over a length of 3.0 m plus 3 per cent of the length of the ship, or 11 m, or 10 per cent of the length of the ship, whichever is the less, the whole volume of the main compartment will not be flooded, a proportionate allowance may be made in the permissible length otherwise required for such compartment without consideration of the additional subdivision.

In such a case the volume of the effective buoyancy assumed on the undamaged side shall not be greater than that assumed on the damaged side.

It can be provided subject to non-contradiction with the requirements of 1.7.3.

.6 A main transverse bulkhead may be stepped provided that it meets one of the following conditions:

.6.1 the combined length of the two compartments, separated by the bulkhead in question, does not exceed either 90 per cent of the floodable length or twice the permissible length, except that, in ships having a factor of subdivision equal to one, the combined length of the two compartments in question shall not exceed the permissible length;

.6.2 additional subdivision is provided in way of the step to maintain the same measure of safety as that secured by a plane bulkhead;

.6.3 the compartment over which the step extends does not exceed the permissible length corresponding to a margin line taken 76 mm below the step.

.7 In ships of 100 m in length and upwards, one of the main transverse bulkheads abaft the forepeak shall be fitted at a distance from the forward perpendicular which is not greater than the permissible length.

.8 If the distance between two adjacent main transverse bulkheads or their equivalent plane bulkheads or the distance between the transverse plane passing through the nearest stepped portions of the bulkheads, is less than 3.0 m plus 3 per cent of the length of the ship, or 11 m, or 10 per cent of ship's length (whichever is the less), only one of these bulkheads shall be regarded as forming part of the subdivision of the ship.

.9 Where the required factor of subdivision is equal to 0.5, the combined length of any two adjacent compartments shall not exceed the floodable length.

1.7.3 Damage stability of a passenger ship with distinguishing mark B-R3-S, B-R3-RS, C-R3-S, C-R3-RS and D-R3-S, D-R3-RS in the class notation

1.7.3.1 Sufficient intact stability shall be provided in all service conditions so as to enable the ship to withstand the final stage of flooding of any one main compartment which is required to be within the floodable length.

.1 Where two adjacent main compartments are separated by a bulkhead which is stepped under the conditions of 1.7.2.6.6.1, the intact stability shall be adequate to withstand the flooding of those two adjacent main compartments.

.2 Where the factor of subdivision is equal to 0.50, the intact stability shall be adequate to withstand the flooding of any two adjacent main compartments.

1.7.3.2 The requirements of 1.7.3.1 shall be determined by calculations which are in accordance with paragraphs 1.7.3.7 and 1.7.3.9, which take into consideration the proportions and design characteristics of the ship, and the arrangement and configuration of the damaged compartments.

In making these calculations the ship is to be assumed in the worst anticipated service conditions as regards stability.

Where it is proposed to fit decks, inner skins or longitudinal bulkheads of sufficient tightness to seriously restrict the flow of water, then, proper consideration is given to such restrictions in the calculations.

1.7.3.3 The stability required in the final condition after damage, and after equalization where provided, shall be determined as follows:

.1 The positive residual righting lever curve shall have a minimum range of 15° beyond the angle of equilibrium.

This range may be reduced to a minimum 10°, in the case where the area under the righting lever curve is that specified in 1.7.3.3.2 increased by the ratio "15/range" where the range is expressed in degrees.

.2 The area under the righting lever curve shall be at least 0.015 m·rad measured from the angle of equilibrium to the lesser of:

.2.1 angle at which progressive flooding occurs; or

.2.2 22° (measured from the upright) in the case of one compartment flooding, or 27° (measured from the upright) in the case of the simultaneous flooding of two or more adjacent compartments.

.3 A residual righting lever is to be obtained within the range of positive stability, taking into account the greatest of the following heeling moments:

.3.1 the crowding of all passengers towards one side;

.3.2 the launching of all fully loaded davit-launched survival craft on one side;

.3.3 due to wind pressure as calculated by the formula:

GZ = (heeling moment / displacement) + 0.04 (m).

However, in no case is this righting lever to be less than 0.10 m.

.4 For the purposes of calculating the heeling moments in paragraph 1.7.3.3.3, the following assumptions shall be made:

.4.1 moments due to crowding of passengers:

- four persons per m^2;

- a mass of 75 kg per each passenger;

- passengers are distributed 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.

.4.2 moments due to launching of all fully loaded davit-launched survival craft on one side of the ship:

.4.2.1 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;

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

.4.2.3 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;

.4.2.4 persons not in the life-saving appliances which are swung out shall not

provide either additional heeling or righting moment;

.4.2.5 lifesaving 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.

.4.3 moments due to wind pressure:

- for the ship with distinguishing mark **B**-**R3-RSN**: a wind pressure with 120 Pa to be applied;

- for the ship with distinguishing mark **C**-**R3-RSN** and **D**-**R3**: the wind pressure with 80 Pa to be applied;

- the area applicable shall be projected lateral area of the ship above the waterline corresponding to the intact condition;

- moment arm shall be vertical distance from a point at one half of the mean draft corresponding to the intact condition to the centre of gravity of the lateral area.

1.7.3.4 When major progressive flooding occurs, that is when it causes a rapid reduction in the righting lever of 0.04 m or more, the righting lever curve is to be considered as terminated at the angle the progressive flooding occurs. The range and area referred to in 1.7.3.3.1 and 1.7.3.3.2 shall be measured to that angle.

1.7.3.5 In case when progressive flooding is limited and not worsened and leads to slow change of the permissible righting lever curve less than 0.04 m, the part of the remaining curve shall be partially cut off in advance considering the progressive flooding.

1.7.3.6 In intermediate stages of flooding, the maximum righting lever shall be at least 0.05 m, and the range of positive righting levers shall be at least 7°. In all cases, only one breach in the hull and only one free surface shall be assumed.

1.7.3.7 For the purpose of making damage stability calculations, the following shall be taken:

.1 the volume and surface permeabilities as per the Table 1.7.3.7.1

Higher surface permeabilities are to assumed in respect of spaces which, in the vicinity of the damage waterline, contain no substantial quantity of accommodation or machinery and spaces which are not generally occupied by any substantial quantity of cargo or stores.

Table 1.7.3.7.1

Spaces	Permeability (%)
Appropriated to cargo and stores	60
Occupied by accommodation	95
Occupied by machinery	85
Intended for liquids	0 or 95 (*)

(*) Whichever results in the more severe requirements.

.2 the following assumed extent of damages:

.2.1 longitudinal extent: 3.0 m plus 3 per cent of the length of the ship, or 11.0 m or 10 per cent of the length of the ship, whichever is the less;

.2.2 transverse extent (measured inboard from the ship's side, at right angles to the centreline at the level of the deepest subdivision load line): a distance of 1/5 of the ship's breadth; and

.2.3 vertical extent - from the base line upwards without limit;

.2.4 if any damage of lesser extent than indicated in 1.7.3.7.2 would result in a more severe condition regarding heel or loss of metacentric height, such damage shall be assumed in the calculations.

1.7.3.8 Unsymmetrical flooding is to be kept to a minimum consistent with 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 cross-flooding fittings are provided they shall be operable from above the bulkhead deck.

For the ships with distinguishing mark **B-R3-S, B-R3-RS, C-R3-S, C-R3-RS** and **D-R3-SN, D-R3-RSN** in the class notation the maximum angle of heel after flooding but before equalization shall not exceed 15°.

Where cross flooding fittings are required, the time for equalization shall not exceed 15 minutes.

Suitable information concerning the use of cross flooding fittings shall be supplied to the master of the ship.

1.7.3.9 The final conditions of the ship after damage and, in the case of un-symmetrical flooding, after equalization measures have been taken shall be as follows:

.1 in the case of symmetrical flooding there shall be a positive residual metacentric height of at least 0.05 m as calculated by the constant displacement method;

.2 in case of unsymmetrical flooding, the angle of heel for one-compartment flooding shall not exceed:

7° − for ships with distinguishing mark **B-R3-S, B-R3-RSN** in the class notation; and

12° − for the ships with distinguishing mark **C-R3-S, C-R3-RS** and **DR3-S, D-R3-RS** in the class notation.

In the case of simultaneous flooding of two adjacent compartments the angle of heel up to 12° can be allowed for the ships with distinguishing mark **B-R3-S, B-R3-RS** in the class notation provided that the factor of subdivision is not more than 0.5 in the flooded part of the ship.

.3 in no case shall the margin line be submerged at the final stage of flooding.

If it is considered that the margin line may become submerged at intermediate stage of flooding, the Register may require such investigations and arrangements as it considers necessary for the safety of the ship.

1.7.3.10 The ship's master shall be supplied with the data necessary to maintain sufficient intact stability under service conditions to enable the ship to withstand the critical damage.

In the case of ships having cross flooding fittings the master of the ship shall be informed on the conditions of stability on which the calculations of heel are based and be warned that excessive heeling might result should the ship sustain damage when in a less favourable condition.

The data to enable the master to maintain sufficient intact stability shall include information which indicates the maximum permissible height of the ship's centre of gravity above keel, or alternatively the minimum permissible metacentric height for a range of draughts or displacements sufficient to include all service conditions.

On completion of loading of the ship and prior to its departure, the master shall define the ship's trim and stability and also ascertain and record in the ship's log book that the ship is in compliance with stability criteria in the corresponding regulations.

The ship's stability shall be always determined via calculations. It is permitted to use electronic loading and stability computer or equivalent means for this purpose.

1.7.3.11 No relaxation from the requirements for damage stability may be considered by the Register, unless it is shown that the intact metacentric height in any service condition necessary to meet these rules is excessive for the service intended.

Relaxation from the requirements for damage stability shall be permitted only in exceptional cases and provided that the Register is to be satisfied that the proportions, arrangements and other characteristics of the ship are the most favourable to stability after damage which can practically and reasonably be adopted in the particular circumstances.

1.7.4 Damage stability of a ro-ro passenger ship with the distinguishing mark B-R3-S, B-R3-RS, C-R3-S, C-R3-RS and D-R3-S, D-R3-RS in the class notation

1.7.4.1 Stability of a ro-ro passenger ship with the distinguishing mark **B-R3-S, B-R3-RS, C-R3-S, C-R3-RS** and **D-R3-S, D-R3-RS** in the class notation required at the final stage after the damage due to collision, and after equalization shall comply with the requirements of this Chapter.

1.7.4.2 Stability of a ro-ro passenger ship, including the ro-ro passenger ships certified to carry 400 persons or more with the distinguishing mark **B-R3-S, B-R3-RS, C-R3-S, C-R3-RS** and **D-R3-S, D-R3-RS** in the class notation required at the final stage after the damage due to collision, and after equalization shall comply with the requirements of **3.4.14.2** and **3.4.14.24**.

1.7.5 Special requirements for passenger ships with distinguishing mark B-R3-S, B-R3-RS, C-R3-S, C-R3-RS and D-R3-S, D-R3-RS in the class notation certified to carry 400 persons or more other than ro-ro passenger ships

Passenger ships with the distinguishing mark **B-R3-S, B-R3-RS, C-R3-S, C-R3-RS** and **D-R3-S, D-R3-RS** in the class notation certified to carry 400 persons or more other than ro-ro passenger ships, shall comply with the requirements of 1.7.3.3 and 1.7.3.6 in case of assumed damage applied anywhere within the ship's length *L*.

1.7.6 Passenger ships with distinguishing mark **B-R3-S**, **B-R3-RS**, **C-R3-S**, **C-R3-RS** and **D-R3-SN**, **D-R3-RSN** in the class notation of the length less than 24 m may comply with the requirements of 1.7.3 or 1.5.

2. PROBABILITY ESTIMATION OF SUBDIVISION

2.1 GENERAL

2.1.1 Requirements of the present Section apply to cargo ships having the length $L_1 \geq 80$ 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 to 1.1.1.9, 1.1.1.19, 1.1.1.20, 1.7, 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.

When checking the probabilistic requirements for such ships (except those ships specified in 1.7), the IMO Resolution MSC.281(85) Explanatory Notes to the SOLAS Chapter II-1 Subdivision and Damage Stability Regulations shall be taken into account.

2.2 REQUIRED SUBDIVISION INDEX *R*

2.2.1 The subdivision of a ship is considered sufficient if the attained subdivision index *A,* determined as per 2.3, is not less than the required subdivision index *R,* calculated in compliance with 2.2.2 and if, in addition, the partial indices A_s, A_p and A_l, are not less than 0.9 *R* for passenger ships and 0.5 *R* 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 for cargo ships having the length $L_s > 100$ m:

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

.2 for cargo ships having the length 80 m $\leq L_s \leq 100$ m:

$$R = 1 - \{1/[1 + (0.01 L_s \times R_0/1 - R_0)]\}$$

where R_0 is a value *R* calculated as per the formula given in 2.2.2.1;

.3 for passenger ships:

$$R = 1 - [5000/(L_s + 2.5 N + 15225)],$$

where $N = N_1 + 2N_2$;

N_1 is a number of persons for whom lifeboats are provided;

N_2 is a 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 Register considers 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 draughts under the following formula:

$$A = 0.4A_s + 0.4A_P + 0.2A_l, \quad (2.3.1-1)$$

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

$$A = \sum p_i s_i, \qquad (2.3.1-2)$$

where *i* represents each compartment or group of compartments under consideration;

p_i, accounts for the 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 accounts for the 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.

In the calculation of *A,* 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* are to 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 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 Formula (2.3.1-2) shall be taken for all cases of flooding in which wing compartments are involved. Moreover, cases of simultaneous flooding of a wing compartment or group of compartments and the adjacent inboard compartment or group of compartments may be added, but excluding damage of transverse extent greater than one half of the ship breadth *B*.

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 is to 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 located 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 easily controlled and 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 notations:

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

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

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

x_1 is the distance from the aft terminal of L_s to the aft end of the zone in question;

x_2 is the distance from the aft terminal of L_s to the forward end of the zone in question;

b is the mean transverse distance in metres measured at right angle to the centreline at the deepest subdivision load line 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 dis-

tance to the shell is a maximum, but not more twice the least distance between the plane and the shell.

If the upper part of a longitudinal bulkhead is below the deepest subdivision load line the vertical plane used for determination of b is assumed to extend upwards to the deepest subdivision water-line. 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:

critical 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 $J = 0$:
$b_0 = 2[(p_k/J_{kn}) - (1 - p_k)/(J_{max} - J_{kn})]$.

when $L_s \leq L^*$:
$J_m = \min(J_{max}, l_{max}/L_s)$,
$J_k = J_m/2 + \{1 - [1 + (1 - 2p_k)b_0 J_m + 1/4\, b_0{}^2 J_m{}^2]^{1/2}\}/b_0$,
$b_{12} = b_0$.

When $L_s > L^*$:
$J_m^* = \min(J_{max}, l_{max}/L_s)$,
$J_k^* = J_m^*/2 + \{1 - [1 + (1 - 2p_k)b_0 J_m^* + 1/4\, b_0{}^2 J_m^{*2}]^{1/2}\}/b_0$,
$J_m = J_m^* L^*/L_s$,
$J_k = J_k^* L^*/L_s$,
$b_{12} = 2[p_k/J_k - (1 - p_k)(J_m - J_k)]$,
$b_{11} = 4(1 - p_k)/[(J_m - J_k)J_k] - 2p_k/J^2{}_k$,
$b_{21} = -2(1 - p_k)/(J_m - J_k)^2$,
$b_{22} = -b_{21} J_m$;

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:

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

$J > J_k$:
$p(x2, x1) = p2 = -1/3\,b11 J.k + 1/3(b11 J - b12)J.k + b12 JJk - 1/3\,b21(J.n - J.k) + 1/2(b12 J - b22)(J.n - J.k) + b22 J(Jn - Jk)$.

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:

$J \le J_k$:
$p(x2,x1) = 1/2(p_1 + J)$,

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

2.4.1.1.3 Where the compartment or groups of compartments under consideration extends over the entire subdivision length L_s:
$p(x2,x1) = 1$.

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

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

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

2.4.1.2.1 Where the compartment or group of compartments under consideration extends over the entire subdivision length L_s:

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

2.4.1.2.2 Where neither limits of the compartment or group of compartments under consideration coincides with the aft or forward terminals:
$G = G_2= -1/3\ b_{11}J^3_0+1/2(b_{11}J - b_{12})J^2_0 + b_{12}\, JJ_b$,
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_i shall be determined for each case of assumed flooding, involving a compartment or group of compartments pursuant to the following notations and provisions.

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

θ_v is the heel angle at 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 lever, in deg., measured from the angle θ_e. The positive range is to 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_i for any damage case at any initial loading condition d_i shall be obtained from the formula

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

where $s_{intermediate.i}$ is the probability to survive all intermediate flooding stages until the final equilibrium stage. It is calculated as per 2.5.2;

$s_{final.i}$ is the probability to survive in the final equilibrium stage of flooding. It is calculated as per 2.5.3;

$s_{mom.i}$ is the probability to survive heeling moments, and is calculated as per 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:

$S_{intermediate.i}= [(GZ_{max}/0.05)\times(Range/7)]^{\frac{1}{4}}$,

where GZ_{max} shall not be taken as more than 0.05 m and *Range* as not more than 7°, $s_{intermediate\ pi} = 0$, 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

$$S_{final.i} = K [(GZ_{max}/0.12) \times (Range/16)]^{1/4},$$

where GZ_{max} shall not be taken as more than 0.12 m;

Range shall not be taken as more than 16°;

$K = 1$, where $\theta_e \leq \theta_{min}$;

$K = 0$, where $\theta_e \geq \theta_{min}$;

$K = [(\theta_{max} - \theta_e) \times (\theta_{max} - \theta_{min})]^{1/2}$ - in other cases,

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 by the formula

$$S_{mom.i} = (GZ_{max} - 0.04) \times (Displacement/M_{heel}),$$

where *Displacement* is the intact displacement at the subdivision draught;

M_{heel} is the maximum assumed heeling moment as calculated in compliance with 2.5.4.1;

$S_{mom.i} \leq 1$.

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, ton per meter, and shall be obtained as follows:

$$M_{passenger} = (0.075 N_p)0.45B,$$

where N_p is the maximum number of passengers permitted to be on board in the service condition corresponding to the deepest subdivision draught under consideration;

B is the beam of the ship.

Alternatively, the heeling moment may be calculated assuming the passengers are distributed with 4 persons per m² 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 heeling moment from wind force, in t/m, acting in a damage situation:

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

where $P = 120$ N/m²;

A is a projected lateral area above waterline;

Z is the distance from centre of lateral projected area above waterline to $T/2$;

T is the ship's draught, d_i.

2.5.4.1.3 $M_{survivalcraft}$ 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 lever;

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 is to 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 cross-flooding fittings are provided they shall be operable from above the bulkhead deck.

These fittings together with their controls shall be approved by the Register[2]. Suitable information concerning the use of cross-flooding fittings 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 compartment is not delayed.

2.5.5.2 The factor s_i shall be taken as zero in those cases where the final waterline, considering 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 airpipes, ventilators and openings which are closed by means of weathertight doors or hatch covers; and

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

2.5.5.3 Factor s_i shall be taken as zero if, taking into account sinkage, heel and trim, any of the following occurs at any intermediate or 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 non-opening type as well as watertight access doors and hatch covers required to be kept closed at sea need not be considered.

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[2] Refer to IMO Resolution MSC.245(83)

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 multiplying the value determined in 2.5.1.1 by the reduction factor v_m as per 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 $H_{j,n,m}$ is the least height above the baseline, in m, within the longitudinal range of $xl_{(j)}...x2_{(j+n-1)}$ of the *m*-th horizontal boundary which is assumed to limit the vertical extent of flooding for the damaged compartments under consideration;

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

j signifies the aft terminal of the damaged compartments under consideration;

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

d is the draught in question as defined in 1.2;

*x*l and *x*2 represent the terminals of the compartment or group of compartments defined in 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 м;

$v(H,d) = 0.8 + 0.2[(H - d)/-7.8]/4.7$ 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 $xl_{(j)}...x2_{(j+n-1)}$ 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 As a rule, each contribution *dA* to the index *A* in the case of horizontal subdivisions is obtained from the formula:

$$dA = _{Pi}[v_l s_{min1} + (v_2 - v_1) s_{min2} +...+ $$
$$+ (1 - v_{m-1}) s_{min\ m}],$$

where v_m is the *v* value calculated as per 2.5.6.1;

s_{min} is 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, the permeability of each general compartment or part of a compartment shall comply with Table 2.6.1.

2.6.2 For the purpose of the subdivision and damage stability calculations, the permeability of each cargo compartment or part of a compartment shall comply with Table 2.6.2.

Table 2.6.1

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 consequences

Table 2.6.2

Spaces	Permeability at draught:		
	d_s	d_p	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 supported 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. 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 depend 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 $0.03\ L_s$, 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 centerline 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 two adjacent transverse watertight bulkheads is less than the assumed damage length, only one of these bulkheads shall be considered effective in 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 fewer 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 (at 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 m³, that is more than the ship's moulded displacement per 1 cm immersion at deepest subdivision draught or have a volume more than 30 m³, 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 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 spaces and service purpose of the ship.

In addition, any watertight space of more than 0.2 L_s 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 special consideration by the Register.

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

.1 onboard damage stability software approved by the Register (Classification Society); or

.2 rapid access to shore-based computerized support organization recognized by the Register, which makes damage stability and residual strength assessments to provide the ship's master

with the information on safe return to port after flooding.

2.7.4.6 Flooding Detection System Manual shall be provided on ships, 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 state/official language, 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".

2.8 DAMAGE STABILITY FOR SHIPS INTENDED TO CARRY TIMBER DECK CARGO

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 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 If the upper deck is regarded as a horizontal subdivision when considering the vertical extent of damage, thus, when the 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 a way of the damage zone shall be ig-

nored.

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.

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 changes 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 as per 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, the Register may require an increased double bottom height of not more than $B/10$ or 3 m, whichever is the less, measured from the keel line.

Alternatively, bottom damages may be calculated for these areas in compliance with 2.9.3, but assuming an increased vertical extent.

Table 2.9.3.2

Calculated damage	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 the less)	$^1/_3\, L_1^{2/3}$ or 14.5 m (whichever is the less)
Transverse extent	$B/6$ or 10 m (whichever is the less)	$B/6$ or 5 m (whichever is the less)
Vertical extent measured from the keel line	$B/20$ or 2 m (whichever is the less)	$B/20$ or 2 m (whichever is the 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 agreements 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 as per 1.6, calculations made in compliance 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 com-

pliance with the requirements of 3.3 and 3.4 as for 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 relaxation from this provision may be granted where the arrangement of the bulkhead is in agreement with the condition $A \geq R$.

Forepeak and afterpeak are considered to be separate compartments 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.

If $A \geq R$, or where the length of the step does not exceed one frame or 0.8 m, whichever is the 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 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 For non-passenger ships the equalization time will be established as agreed with the Register proceeding from the ship type.

3.1.9 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: $^1/_3 L_1^{2/3}$ or 14.5 m (whichever is the less);

.2 transverse extent measured inboard from the ship's side at right angle 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 At 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 at the final stage of flooding as agreed with the Register.

3.3.2 The angle of heel for unsymmetrical flooding 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. At 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 which are not equipped with watertight or weathertight covers through which water may spread to intact compartments may be taken as a 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.

At 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 the 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 water-tight 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, Arrangements 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 bulkhead deck and, moreover, of the weather deck is permitted.

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

For the ships not specified 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 to subdivision considering the provisions of 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 adjacent 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.

3.4.2.2 The icebreakers with the length L_1 from 50 up to 75 m in the areas with inner skin may comply with the requirements of 3.3 in case of one compartment flooded. The subdivision mark $\boxed{1}$ shall be added to the class notation of such ships.

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 $0.045\,L_{ice}$, if the centre of damage lies forward of the point of maximum beam on the waterline related to draught d_{ice} and $0.015\,L_{ice}$ in other areas;

.2 damage length 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 $0.2\,d_{ice}$ or of longitudinal extent (whichever is the less);

.4 location of ice damage from the base line to the level of $0.2\,d_{ice}$ and within L_{ice}; and

.5 the vertical extent of damage may be assumed from the base line to the level of $0.2\,d_{ice.}$

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.

Table 3.4.2.1

Type of ship	Length L_1, in m	Number of adjacent floodable compartments
Icebreakers	50 and upwards	2
Fishing vessels having over 100 persons on board	100 and upwards	1

3.4.3 Special purpose ships

3.4.3.1 Special purpose ships are to comply with the requirements of Section 2 related to passenger ships and special personnel shall be considered passengers.

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 required subdivision index shall be assigned as per 2.2.2.3;

.2 where the ship is certified to carry not more than 60 persons, the required subdivision index shall be assigned as $0.8R$ determined in compliance with 2.2.2.3;

.3 for more than 60 (but not more than 240) persons, the required subdivision index 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 $L_1 \geq 40$ m;

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

rescue ships and lightships irrespective of length;

hopper dredgers having the length L_1 $\geq$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 $^1/_3 L_1^{2/3}$ or 14.5 m (whichever is the less) within $0.3L_1$ from the forward perpendicular and $^1/_3 L_1^{2/3}$ or 5 m (whichever is the less) through the rest of the ship length;

.2 the transverse extent shall be $B/6$ or 10 m (whichever is the less) within $0.3L_1$ from the forward perpendicular and $B/6$ or 5 m (whichever is the less) through the rest of 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 the less).

3.4.5.3 In addition to 3.4.5.2, bottom shell damage shall be considered for oil tankers with 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 deadweight of 75 000 t and upwards, and $0.4L_1$ from the forward perpendicular for ships with deadweight below 75 000 t;

.2 breadth $B/3$ anywhere in the bot-

tom.

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 the ship length;

where the length $150 < L_1 \leq 225$ 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 $L_1 \leq 150$ m – anywhere in the ship length between consecutive transverse bulkheads except for the engine room;

where the substances of the Category Y are carried as per 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 $L_1 \leq 150$ 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 $L_1 = 125 - 225$ 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 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 provided by 3.4.5.4.1 and 3.4.5.4.2, are not assigned a subdivision distinguishing mark in their class notation.

3.4.5.6 At the final stage of unsymmetrical 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 $L_1 \leq 150$ m – 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 bulk-

heads;

gas carriers 3G having the length $L_1 \geq 125$ m – anywhere in the ship length between subdivision bulkheads;

gas carriers 3G having the length $L_1 < 125$ 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 class notation if damage trim and stability requirements are not met;

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

Damage trim and stability of ships intended for the carriage of packaged irradiated nuclear fuel, plutonium and high level radioactive wastes with the total radioactivity below 4000 TBq shall in each case be specially considered by the Register.

The requirements for the damage trim and stability of ships carrying packaged irradiated nuclear fuel or high level radioactive wastes with the total radioactivity below $2 \cdot 10^6$ TBq or plutonium with the total radioactivity below $2 \cdot 10^5$ TBq, shall be met for the case of specified damage anywhere along the ship length between the consecutive transverse bulkheads.

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

As agreed with the Register 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 by the Register. In any case, for ships carrying radioactive agents with the total radioactivity above $2 \cdot 10^6$ TBq or plutonium with the total radioactivity above $2 \cdot 10^5$ TBq, the required subdivision index shall be equal to

$R = R_0 + 0.2 (1 - R_0)$, but not less than 0.6,

where R_0 is the value of R calculated as per 2.2.1.1 and 2.2.2.2.

For ships where $L_s < 80$ m, the value of required subdivision index R shall be determined by the formula

$R = 1 - [1/(1 + 0.8 R_0/(1 - R_0)], \quad (3.4.8)$

where R_0 is the value of R calculated in

compliance with 2.2.1.1.

3.4.9 Supply vessels

3.4.9.1 The requirements of the present Chapter apply to all supply vessels having the length $L_1 = 100$ m and less.

The subdivision and damage stability of supply vessels having a length over 100 m shall in each case be specially considered by the Register.

3.4.9.2 The extent of damage

In damage trim and stability calculations the damage of extent shall be as follows:

.1 longitudinal extent shall be $\frac{1}{3}$ $L_1^{2/3}$ for the ships with length $L_1 \geq 80$ m; for the ships with length $L_1 > 43$ m, the longitudinal extent shall be 3 m $+ 0.03L_1$, and for the ships with length $L_1 \leq 43$ m, the longitudinal extent shall be $0.10L_1$;

.2 transverse extent of damage shall be assumed for as $B/20$ (but not less than 0.76 m) with length $L_1 \geq 80$ m, measured inboard from the side of the ship at right angle to the centreline 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.

3.4.9.3 A transverse watertight bulkhead extending from the ship's side to a distance inboard as specified in 3.4.9.2.2, or more measured at right angle to the centreline at the level of the summer load line joining longitudinal watertight bulkhead for the purpose of the damage trim and stability calculations.

3.4.9.4 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 water-tight bulkhead shall be considered as damaged.

3.4.9.5 At the final stage of unsymmetrical flooding the angle of heel shall not exceed 15° (or 17°, if no deck immersion occurs) before equalization measures are taken and cross-flooding fittings are used.

3.4.9.6 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 3.4.9.2.

3.4.9.7 Ships complying with the requirements of 3.4.9.2 only, will receive no subdivision distinguishing mark in the class notation.

3.4.9.8 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 as per 3.2.1.2. The number of compartments at the flooding of which the damage trim and stability requirements are to be met shall be determined by the shipowner.

3.4.10 Ships with ice strengthening marks of categories Ice4, Ice5 and Ice6

3.4.10.1 The requirements of this paragraph apply to all ice strengthened ships of categories **Ice4**, **Ice5** and **Ice6**. 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 compliance 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 ships having the following distinguishing marks in the class notation:

ice category mark **Ice 6** irrespective of ship length;

ice category mark **Ice 5** with the ship length $L_1 \geq 120$ m.

The subdivision distinguishing mark $\boxed{1}$ shall be introduced in the class notation of such ships.

3.4.10.3 Ships with the ice strengthening marks for categories **Ice 4, Ice 5** and **Ice 6** (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 given in Table 3.4.10.5.

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 For oil tankers, chemical tankers 2 and 3, gas carriers 2G and 3G below or equal to 150 m in length, the necessity of considering a simultaneous flooding of the engine room and an adjacent compartment shall be specially considered by the Register.

Table 3.4.10.5 **Location of assumed ice damage of the ships subject to the purpose and ice strengthening category**

No.	Purpose of ship and/or ice strengthening category	Location of ice damage specified in 3.4.10.4
1	2	3
1	Ice-strengthened ships of **Ice6** category, 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	Ditto
4	Ships intended for the carriage of radioactive agents	Ditto

End of Table 3.4.10.5

1	2	3
5	Chemical tankers	Ditto
6	Oil tankers	Ditto
7	Gas carriers	Ditto
8	Drilling ships	Ditto
9	Ice-strengthened salvage ships with ice categories **Ice5** and **Ice6**	Ditto
10	Ice-strengthened fishing vessels and refrigerated fish carriers with ice categories **Ice6**	Between watertight bulkheads, platforms, decks and plating[1]
11	Ice-strengthened ships with ice category **Ice5** 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	Ice-strengthened ships with ice category **Ice4,** 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.

3.4.10.8 Ships conforming with the requirements of 3.4.10.3 to 3.4.10.7 only will receive no subdivision distinguishing mark in the class notation.

3.4.11 Bulk carriers, ore carriers and combination carriers

3.4.11.1 Bulk carriers having the length L_1 150 m and upwards, which carry solid bulk cargoes with density 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 as per 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 as follows:

.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 above the inner bottom); 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 centreline, 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 centreline, 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 The 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 assumed 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 the less);

.3 vertical extent – as per 3.2.1.3;

3.4.12.3 No subdivision distinguishing mark will be introduced in the class notation 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.

3.4.13.4 If the depth of waters on which the berth-connected ship floats is such that the lower-most deck accessible to passengers cannot be immersed not to mention capsizing of the ship, the requirements of this Section may be waived.

3.4.13 Cargo ships having the length less than 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 less than 80 m, or, if constructed before 1998 – less than 100 m, 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 centreline, they shall be located at both sides of the cargo hold. Where webs or partial watertight bulkheads are fitted above the inner bottom, the Register may require the fitting of additional sensors. 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".

3.4.14 Ro-ro passenger ships

3.4.14.1 Ro-ro passenger ship stability required at the final stage after the damage caused by collision and after equalization shall comply with the requirements of this paragraph in addition to 3.4.1.

3.4.14.2 The existing ro-ro passenger ships shall comply with the requirements of this paragraph within the terms as pro-

vided by Article 7 of the Directive 2003/25/EC of the European Parliament and of the Council of 14 April 2003 considering amendments and additions as per the Commission Directive 2005/12/EC of 18 February 2005 of the European Parliament and of the Council on specific stability requirements for ro-ro passenger ships.

3.4.14.3 In addition to 1.2.1 the following definitions and explanations have been adopted in this paragraph:

D r a i n a g e s y s t e m means a system providing removal of seawater from the ro-ro deck that comes due to the stormy conditions or damage to a ship.

R e s i d u a l f r e e b o a r d (f_r) is the minimum distance between the damaged ro-ro deck and the final waterline (after equalisation measures if any have been taken) in way of the assumed damage after examining all possible damage scenarios in determining, without taking into account the additional effect of the sea water accumulated on the damaged ro-ro deck.

S i g n i f i c a n t w a v e h e i g h t (h_S) is the average height of the highest wave heights measured between the wave hollow and wave top. The figures of significant wave heights shall be those which are not exceeded by a probability of more than 10 % on a yearly basis.

Significant wave height (h_S) shall be used in determining the height of water on ro-ro deck (h_w) when applying the specific stability requirements*.

R o - r o d e c k means a deck in closed or open ro-ro cargo spaces or special ro-ro spaces as defined in 1.5.4.3 ÷ 1.5.4.4 and 1.5.9, Part VI "Fire Protection" of the Rules.

R o - r o p a s s e n g e r s h i p means a ship carrying more than 12 passengers, having closed or open ro-ro cargo spaces or special category spaces as defined in 1.5.4.3 ÷ 1.5.4.4 and 1.5.9, Part VI "Fire Protection".

Ferryboats that are via ferry crossing engaged on regular carriages of passengers and carriage of vehicles with oil in tanks on open and/or closed deck and/or railway rolling stock with horizontal loading and discharging shall be also referred to ro-ro passenger ships.

R e g u l a r s e r v i c e means a series of ro-ro passenger ship crossings serving traffic between the same two or more ports, which is operated either

according to a published timetable; or

with crossings so regular or frequent that they constitute a recognisable systematic series.

S p e c i f i c s t a b i l i t y r e q u i r e m e n t s means the requirements based on the method**, calculating the height of water on the ro-ro deck after the damage under the two basic parameters: residual freeboard (f_r) and significant wave height on the territory of the ship (h_S).

S O L A S S t a b i l i t y S t a n d a r d means the requirements providing a level of safety equivalent to the specific stability requirements established for ships operating in sea areas where the significant wave height (h_S) is equal to or less than 1.5 m.

S t a b i l i t y s t a n d a r d f o r r o - r o p a s s e n g e r s h i p s i n d a m a g e d c o n d i t i o n means the requirements to take into account the effect of water accumulation on the ro-ro deck and to enable the ship to survive in more severe states than the SOLAS standard, up to 4 m significant wave heights.

Stockholm Agreement means the Agreement concluded at Stockholm on 28 February 1996 in pursuance of SO-LAS 95 Conference Resolution 14 "Regional agreements on specific stability requirements for ro-ro passenger ships", adopted on 29 November 1995.

Freeing ports means scuppers providing to free the water accumulated due to stormy conditions or damage of the ship from the ro-ro deck directly overboard.

* When determining significant wave height (h_S), the wave heights given on the maps or list of sea areas are to be used.

In compliance with clause 21, Articles 4 and 5 of the Directive 2003/25/EC of the European Parliament and of the Council of 14 April 2003 considering amendments and additions as per the Commission Directive 2005/12/EC of 18 February 2005 of the European Parliament and of the Council, each Member State should determine and update, if necessary, the sea areas under their jurisdiction, of the significant wave height (h_S), delimiting the zones for the all-year-round and, where appropriate, restricted periodical operation of ro-ro passenger ships.

Significant wave heights (h_S) for seasonal operation shall be determined by the host State Administration in agreement with the other country whose port is included in the ship's route.

** Refer to Annexes to the Stockholm Agreement and Directive 2003/25/EC of the European Parliament and of the Council of 14 April 2003 considering amendments and additions as per the Commission Directive 2005/12/EC of 18 February 2005 of the European Parlia-

ment and of the Council on specific stability requirements for ro-ro passenger ships.

3.4.14.4 Ro-ro passenger ship's stability in the final condition after damage due to collision and after equalization shall be determined considering the effect of water that may be accumulated on the first ro-ro deck or special cargo space above the waterline and to enable the ship to survive in more severe states than the SOLAS standard, up to 4 m significant wave heights.

3.4.14.5 The stability required in the final condition after damage, and after equalization shall be determined as follows as per the SOLAS stability standard:

.1 The positive residual righting lever curve shall have a minimum range of 15° beyond the angle of equilibrium.

This range may be reduced to a minimum of 10°, in the case where the area under the righting lever curve is that specified in paragraph **3.4.14.4.3**, multiplied by the ratio "15/range", where the range is expressed in degrees.

.2 The area under the righting lever curve shall be at least 0.015 m·rad, measured from the angle of equilibrium to the lesser of:

.2.1 the angle at which progressive flooding occurs; or

.2.2 22° (measured from the upright) in the case of one-compartment flooding, or 27° (measured from the upright) in the case of the simultaneous flooding of two adjacent compartments.

.3 A residual righting lever *GZ*, in m, is to be calculated by the formula:

GZ = (heeling moment/displacement) + 0.04 (**3.4.14.4.4**),

shall be within the range of positive stability, taking into account the greatest of the following heeling moments:

.3.1 the crowding of all passengers towards one side;

.3.2 the launching of all fully loaded davit-launched survival craft on one side;

.3.3 due to wind pressure.

However, in no case is this righting lever to be less than 0.10 m.

.4 For the purpose of calculating the heeling moments given in paragraph **3.4.14.4.4**, the following assumptions shall be made:

.4.1 moments due to crowding of passengers:

- four persons per m^2;
- a mass of 75 kg per each passenger;
- passengers are distributed 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.

.4.2 moments due to launching of all fully loaded davit-launched survival craft on one side of the ship:

.4.2.1 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;

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

.4.2.3 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;

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

.4.2.5 lifesaving 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.

.4.3 moments due to wind pressure:

a wind pressure of 120 Pa (120 N/m^2), to be applied,

where:

- the area applicable shall be the projected lateral area of the ship above the waterline corresponding to the intact condition;

- the moment arm shall be the vertical distance from a point at one half of the mean draught corresponding to the intact condition to the centre of gravity of the lateral area.

3.4.14.6 The conditions for stability required by SOLAS stability standard, refer to paragraph **3.4.14.5**, are to be complied with considering the effect of sea water that may be accumulated on the first ro-ro deck or special cargo space (hereinafter referred to "damaged ro-ro deck") above the deepest subdivision load line in a way of damage.

3.4.14.7 The accumulated water is added as a liquid load with one common surface inside all compartments which are assumed flooded on the damaged ro-ro deck.

The height of water (h_w) on deck is dependent on the residual freeboard (f_r) after damage, and is measured in way of the damage (refer to Fig. 3.4.14.7-1).

No account should be taken of the effect of the hypothetical volume of water assumed to have accumulated on the

damaged ro-ro deck when calculating the residual freeboard (f_r).

The amount of assumed accumulated sea water shall be calculated on the basis of a water surface having a fixed height above:

the lowest point of the ro-ro deck edge of the damaged compartment, if the edge of the damaged ro-ro deck is not submerged (refer to Fig. 3.4.14.7-2 a));

or

if the ro-ro deck edge of the damaged compartment is submerged, then the calculation is based on a fixed height above the still water surface at all heel and/or trim angles (refer to Fig 3.4.14.7-2 b)).

If $f_r \geq 2.0$ m, no water is assumed on the damaged ro-ro deck.

If $f_r \leq 0.3$ m, the height h_w on the damaged ro-ro deck is assumed to be 0.5 m.

If 0.3 m $\leq f_r < 2.0$ m, the height h_w on the damaged ro-ro deck shall be obtained by linear interpolation.

3.4.14.8 When a high efficiency drainage system is installed, the reduce of the permissible height (h_w) of water surface may be allowed.

Note: Means for drainage of water can only be considered as effective if these means are of a capacity to prevent large amounts of water from accumulating on the damaged ro-ro deck i.e. many thousands of tonnes per hour.

* Damage provided by SOLAS Stability Standard.

A-A (Scheme determining the size of a freeboard)
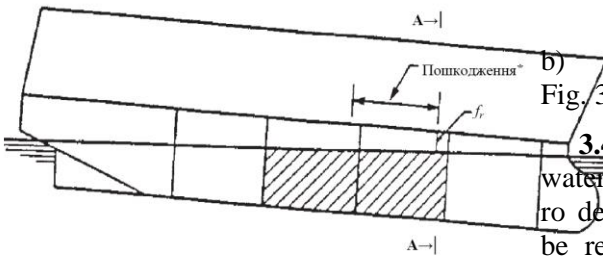

Fig. 3.4.14.7-1

a)

b)
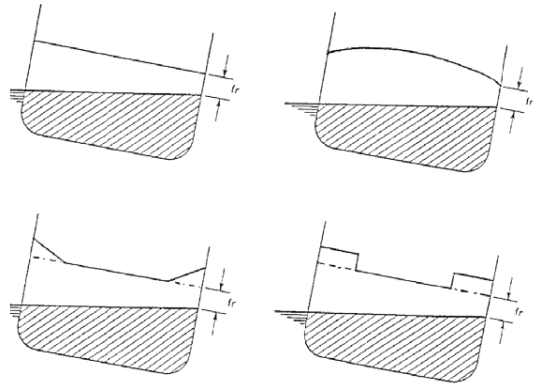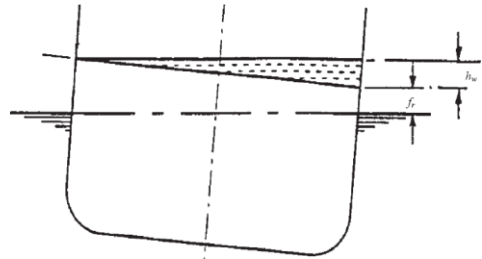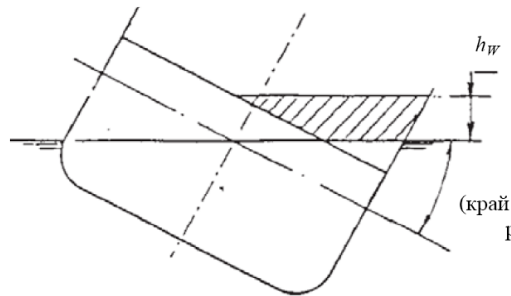
Fig. 3.4.14.7-2

3.4.14.9 The height of accumulated water (h_w), permitted on the damaged ro-ro deck as per **3.4.14.6** ÷ **3.4.14.7**, may be reduced for ships in geographically

defined restricted areas of operation with the significant wave height (h_S) by substituting such height (h_w) of accumulated water on the damaged ro-ro deck by the following:

if the significant wave height (h_S), in the area concerned, is 1.5 m or less, then no additional water is assumed to accumulate on the damaged ro-ro deck, that is $h_w = 0.0$ m;

If the significant wave height (h_S) in the area concerned is 4.0 m or more, then the height of the assumed accumulated water on the damaged ro-ro deck (h_w) shall be the value calculated in accordance with paragraph **3.4.14.7**;

if 1.5 m $\leq h_S < 4.0$ m, the intermediate water height permitted on the damaged ro-ro deck (h_w) shall be determined by linear interpolation,

subject to the following:

the area of operation and rate of the significant wave height (h_S) comply with the requirements of the State Administration;

the areas of operation and part of the year for which a certain value of the significant wave height (h_S) has been established are entered on ship's certificate.

3.4.14.10 In calculations the following shall be considered:

- the height of the accumulated water (h_w), permitted on the damaged ro-ro deck, is kept constant, therefore the amount of added water is variable as it is dependent upon the heeling angle and whether at any particular heeling angle the deck edge is immersed or not (refer to Fig 3.4.14.10);

- the assumed permeability of the damaged deck spaces is to be taken as 0.90 (refer to MSC/Circ.649), whereas

other assumed flooded spaces permeabilities are to be those prescribed in 2.6.

3.4.14.11 If the calculations to demonstrate compliance with the Stability standard for ro-ro passenger ships in damaged condition relate to a significant wave height less than 4.0 m ($h_S < 4.0$ m) that restricting significant wave height must be recorded in the vessel's passenger ship safety certificate.

3.4.14.12 As an alternative to comply with the stability requirements as per **3.4.14.6** ÷ **3.4.14.7**, or **3.4.14.9** ÷ **3.4.14.10**, the specific stability requirements can be accepted by model tests carried out for an individual ship that will certify that ro-ro passenger ship will not capsize under particular circumstances.

The model test requirements are detailed in the Directive 2003/25/EC of the European Parliament and of the Council of 14 April 2003 considering amendments and additions as per the Commission Directive 2005/12/EC of 18 February 2005 of the European Parliament and of the Council on specific stability requirements for ro-ro passenger ships.

The model test as for compliance with specific stability requirements for ro-ro passenger ships shall be according to the test programme and method to be in accordance with the provisions of the Directive 2005/12/EC of 18 February 2005 of the European Parliament and of the Council approved by the Register in the presence of a representative of the Register.

Reference to acceptance of the results of the model test as an equivalence to compliance with the requirements of **3.4.14.6** ÷ **3.4.14.7**, or **3.4.14.9** ÷ **3.4.14.10** by calculations as for specific

stability requirements of ro-ro passenger ships, and the significant wave height (h_S) used in model tests shall be entered on the ship's certificate.
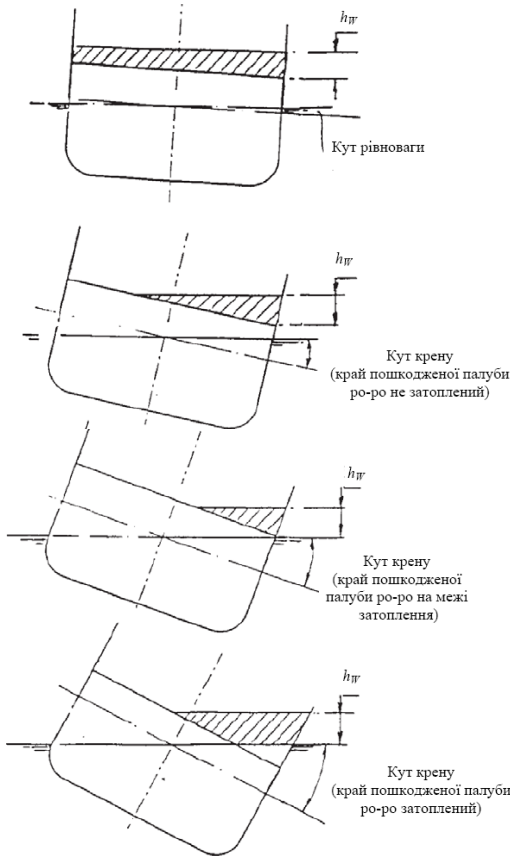

Fig. 3.4.14.10

3.4.14.13 SOLAS stability standard (refer to **3.4.14.3**), limiting operational curve(s) *KG* or *GM*, may not remain applicable in cases where "water on deck" is assumed under the terms of this paragraph and it may be necessary to determine revised limiting curve(s) which take into account the effects of this added water.

To this effect sufficient calculations corresponding to an adequate number of operational draughts and trims must be carried out.

Note: Revised limiting operational *KG/GM* curves may be derived by iteration, whereby the minimum excess *GM* resulting from damage stability calculations with water on deck is added to the input *KG* (or deducted from the *GM*) used to determine the damaged freeboards (f_r), upon which the quantities of water on deck are based, this process being repeated until the excess *GM* becomes negligible.

It is anticipated that operators would begin such an iteration with the maximum *KG*/minimum *GM* which could reasonably be sustained in service and would seek to manipulate the resulting ro-ro deck bulkhead arrangement to minimize the excess *GM* derived from damage stability calculations with water on deck.

3.4.14.14 For assessing the effect of the volume of the assumed accumulated sea water on the damaged ro-ro deck as per **3.4.14.6** ÷ **3.4.14.7** or **3.4.14.9** ÷ **3.4.14.10**, the following conditions shall be considered:

- a transverse or longitudinal bulkhead shall be considered intact in the event of side collision damage if all parts of it lie inboard of vertical surfaces on both sides of the ship, which are situated at a distance from the shell plating equal to $^1/_5\,B$ and measured at right angles to the centreline at the level of the deepest subdivision load line;

- in cases where the ship's hull is structurally partly widened for compliance with the stability requirements, the resulting increase of the value $^1/_5\,B$ shall

not cause the relocation of any existing structural parts or any existing penetrations of the main transverse watertight bulkheads below the bulkhead ro-ro deck, piping systems, etc., which were acceptable prior to widening.

3.4.14.15. The tightness of transverse or longitudinal bulkheads which are taken into account as effective to confine the assumed accumulated sea water in the compartment(s) concerned in the damaged ro-ro deck, shall be commensurate with drainage system, and shall withstand hydrostatic pressure in accordance with the results of the damage calculation.

Such bulkheads/barriers shall be not less than 4 meters, if the water height on the damaged ro-ro deck is $h_w > 0.5$ m.

In other cases, the height of a bulkhead/barrier shall be calculated by the following formula:

$B_h = 8 \times h_w$ (3.4.14.15.).

where:

B_h is a height of a bulkhead/barrier, in m;

h_w is the water height, in m.

In no case is the height of the bulkhead/barrier to be less than 2.2 m.

However, in case of a ship with hanging car decks, the minimum height of the bulkhead/barrier shall be not less than the height to the underside of the hanging deck when it its lowered position. It should be noted that any gaps between the top edge of the bulkhead/barrier and the underside of the plating must be "plated-in" in the transverse or longitudinal direction as appropriate.

Bulkheads/barriers with a height less than that specified above, and special arrangements, such as full-width hanging decks and wide side casings, may be ac-

cepted if model tests are carried out in accordance with **3.4.14.12**, to confirm that the alternative design ensures to prevent progressive flooding within the required stability range (refer to **3.4.14.4.5**).

N o t e : This range may be reduced to 10° provided the corresponding area under the curve complies with the requirements of **3.4.14.4.5**.

3.4.14.16 Transverse or longitudinal bulkheads/barriers in the lower part up to the level provided for h_w, which are fitted and taken into account to confine the movement of assumed accumulated water on the damaged ro-ro deck need not be strictly "watertight" subject to the drainage provisions being capable of preventing an accumulation of water on the "other side" of the bulkhead/barrier.

In such cases where scuppers become inoperative as a result of a loss of positive difference of water levels other means of passive drainage must be provided.

3.4.14.17 The effect of the volume of the assumed accumulated sea water need not be taken into account for any compartment of the damaged ro-ro deck, provided that such a compartment has on each side of the deck freeing ports evenly distributed along the sides of the compartment complying with the following formula:

$A \geq 0.3 \cdot l$ (3.4.14.17).

where:

A is the total area of freeing ports on each side of the ro-ro deck of the ship's compartment, m^2;

l is the length of the compartment, in m.

If the freeing ports are provided for ships which require the buoyancy of the whole or part of the superstructure of the ro-ro deck, the freeing ports shall be fitted with closing flaps to prevent water entering, but allowing water to drain.

Such closing flaps must be self-operating and it must be shown that they do not restrict outflow to a significant degree. Any significant efficiency reduction must be compensated by the fitting of additional openings so that the required area is maintained.

In cases where scuppers become inoperative as a result of a loss of positive difference of water levels in compartment and overboard, other means of passive drainage must be provided.

3.4.14.18 The ship shall maintain a residual freeboard of at least 1.0 m in the worst damage condition without taking into account the effect of the assumed volume of water on the damaged ro-ro deck.

For the freeing ports to be considered effective the minimum distance from the lower edge of the freeing port to the damaged waterline shall be at least 1.0 m (refer to Fig. 3.4.14.18).

The calculation of the minimum distance shall not take into account the effect of any additional water on deck.
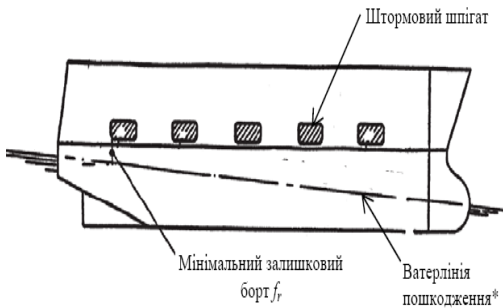
*Damage waterline – waterline in the final condition after damage and equalization of the ship.

Fig. 3.4.14.18

3.4.14.19 Freeing ports must be sited as low as possible in the side bulwark or shell plating.

The lower edge of the freeing port opening must be no higher than 2 cm above the bulkhead deck and the upper edge of the opening no higher than 0.6 m.

Such freeing ports, if required, shall comply with the requirements of **3.4.14.17**.

Note: Spaces fitted with freeing ports or similar openings, shall not be included as intact spaces in the derivation of the intact and damage stability curves.

3.4.14.20 The statutory extent of damage under the SOLAS stability standard is to be applied along the length of the ship.

As per 1.2.2, in all calculated cases of flooding only one hole in the hull that may not affect any bulkhead or may only affect a bulkhead below the bulkhead deck or only bulkhead above the bulkhead deck or various combinations and only one free surface of sea water which penetrated after the accident is assumed.

In this case the hole is considered to have the shape of a rectangular parallelepiped.

The assumed extent of damage shall be considered as per Table 3.4.14.20.

Table 3.4.14.20

No.	Calculated damage	Extent of damage
1	Longitudinal extent	3.0 m plus 0.03 L_1 or 11.0 m (whichever is

		the less)[1]
2	Transverse extent[2]	$^1/_5\,B$
3	Vertical extent	From the base line upwards without limit
4	Any damage	Any damage of lesser extent than indicated in No.1, No.2 and No.3, would result in a more severe condition regarding heel or loss of metacentric height, such damage shall be assumed in the calculations.

[1] If the required subdivision factor is equal or less than 0.33, the assumed longitudinal extent of damage shall be increased in such a way, if necessary, to enable the damage to cover any two consecutive main transverse watertight bulkheads.

[2] Measured at right angle to the centreline at the level of the deepest subdivision load line.

3.4.14.21 When a bulkhead above the ro-ro deck is assumed damaged, both compartments bordering the bulkhead shall be assumed flooded to the same height of water surface as calculated in paragraphs **3.4.14.6 ÷ 3.4.14.7** or **3.4.14.9 ÷ 3.4.14.10**.

3.4.14.22 All transverse and longitudinal bulkheads/barriers which constrain the assumed accumulated amount of water must be in place and secured at all times when the ship is at sea.

3.4.14.23 In those cases where the transverse bulkhead/barrier is damaged the accumulated water on deck shall have a common surface level on both sides of the damaged bulkhead/barrier at the height h_w (refer to Fig. 3.4.14.23).

3.4.14.24 The ship's master shall be supplied with the data necessary to maintain sufficient intact stability under service conditions to enable the ship to withstand the assumed damage.

In the case of ships having cross flooding fittings the master of the ship shall be informed on the conditions of stability on which the calculations of heel are based and be warned that excessive heeling might result should the ship sustain damage when in a less favourable condition.

The data to enable the master to maintain sufficient intact stability shall include information which indicates the maximum permissible height of the ship's centre of gravity above keel (*KG*), or alternatively the minimum permissible metacentric height (*GM*) for a range of draughts or displacements sufficient to include all service conditions.

This information shall show the influence of different trims taking into account the operation limitations.

h_w
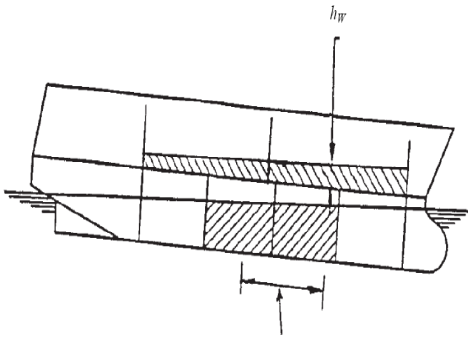
Пошкодження, обумовлене Стандартом
остійності SOLAS *
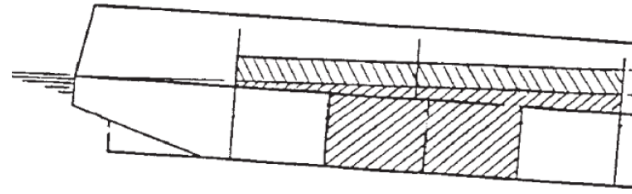
b) edge of a ro-ro deck is submerged
(damage as per a))

Fig. 3.4.14.23.

*Refer to 3.4.14.7.
a) edge of a ro-ro deck is not submerged

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 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, 4.1.4 or 4.1.5, caused by damages stipulated by 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 more than 150 m, when they are assigned a freeboard less than that of the appropriate ships of 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 more than 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 4.1.3.2 and 4.1.2.3 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 is more than 150 m.

4.1.5 Type *B* ships having the length L_1 more than 100 m for which the permitted reduction in the tabular freeboard exceeds 60 per cent of the difference between its values as per Tables 4.1.3.2 and 4.1.2.3 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 compartments and the engine room considered separately in ships having the length more than 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 cargo 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 load line.

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 fulfillment 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 without trim and to its summer load line draught in sea water.

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 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 ships when loaded to the summer load line is to operate with some spaces not loaded or filled with 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 loaded with cargo;

.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, and 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 (refer to the IMO Resolution MSC.345(91);

.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. The tanks or combination of tanks where the effect of free surfaces is the greatest shall be taken into account.

It is recommended that the correction for free surfaces effect be taken into consideration as per 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 $^1/_5$ 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 $^1/_3 L_1^{2/3}$ 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 bulkhead is 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).

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 watertight 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.
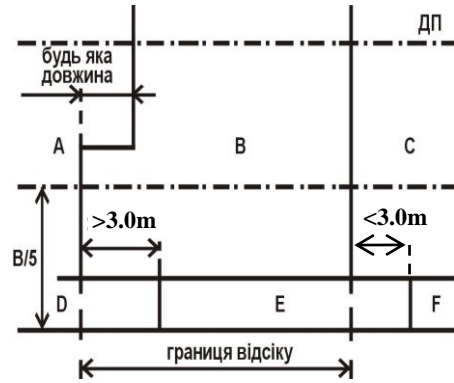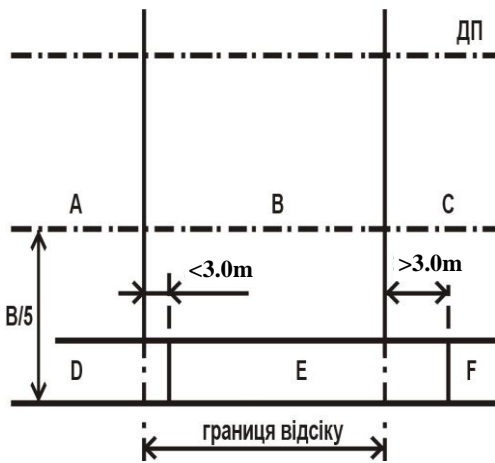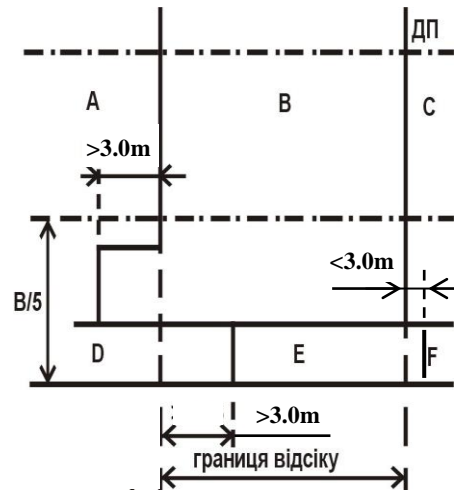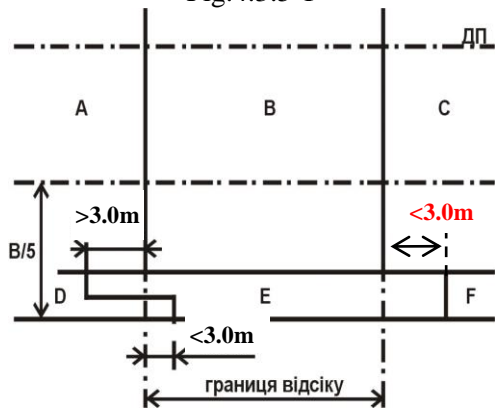

Fig.4.3.5-1

Fig.4.3.5-2

Fig.4.3.5-3

Fig.4.3.5-4

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 ship's equalization shall not exceed 15°. If no part of the bulkhead 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 ship's equalization 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 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 20º, 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_1 150 m and above, carrying solid bulk cargoes with a density of 1000 kg/m^3 and above, constructed on 1 July 1999 or later that date, shall comply with the requirements of 4.4 at flooding of any forward cargo hold under all 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_1 150 m and above, built before 1 July 1999 carrying solid bulk cargoes with density of 1780 kg/m^3 and above, 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's 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 than 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 as per Section 5 "Additional Surveys of Ships in Relation to their Purpose, Cargo Transported and

Hull Material" of the Rules for the Classification 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 as per Section 8 of the International Safety Management Code (ISM Code).[3]

Information shall include the data and documents specified 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 as per Section 4 are considered compliant with the requirements of 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 1.4.8.7, 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 requirements of 5.1.3.2 on 1 January 2004 shall be fitted with flooding detection sensors in cargo holds as per 3.4.12.3.1 (considering 5.1.6.1).

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[3] Refer to IMO Resolution A.741(18) as amended.

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 type of a ship. At present, two different calculation methods, the deterministic concept and the probabilistic concept are applied.

1.2 Scope of analysis and documents 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.

In general, this is achieved by determining *KG*-respective *GM*-limit curves (minimum operational metacentric height), containing the admissible stability values for the draught range to be covered.

1.2.2 Within the scope of analysis thus defined, all the possible or required damage conditions depending on the damage stability criteria to get the required stability standard will be determined. Depending on the type and size of a ship, this may involve a considerable amount of analysis.

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

2 Documents for submission
2.1 General details to be included in the documents on board
2.1.1 The documents 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 righting lever curves, including cross curves of stability (as well as drawing of buoyant hull included into righting lever calculations);

.4 definition of ships 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 data and documents shall be submitted.

2.3.1 Documents

2.3.1.1 Initial data:

.1 subdivision length;

.2 initial draughts and the corresponding *GM*-values;

.3 required subdivision index *R*; and

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

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

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

.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 to index *A* ($s_i=0$ and $p_i > 0.00$) shall 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

2.3.2.1 For intermediate conditions, as stages before cross-flooding or before progressive flooding, additional damage trim and stability calculations shall be submitted in the scope covering the aforementioned items.

DETERMINATION OF THE MOULDED PENETRATION DEPTH
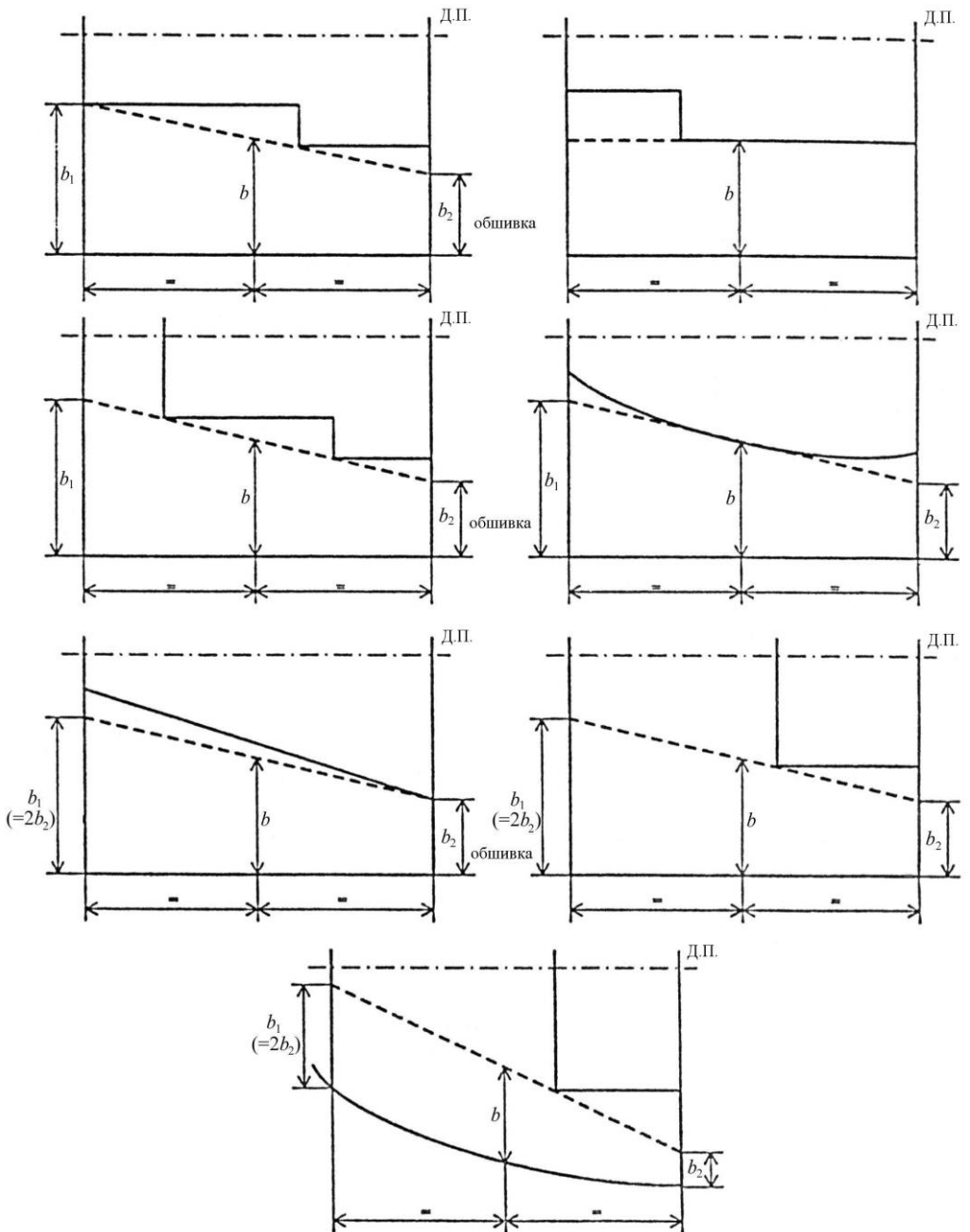
Fig. 2.1

N o t e s   t o Fig.2.1: 1. Each drawing given in Fig. 2.1 represents an area of a single damage at the waterline d_s, the longitudinal bulkhead is a location of the outer bulkhead being lower than d_s +12.5 m.

2. The penetration depth b is measured at level-keel draught under the deepest subdivision load line d_s as a transverse distance from the side at right angle to the centreline at the level of longitudinal limiting construction (watertight bulkhead).

3. If the watertight bulkhead does not provide an area parallel to the plating, the size b shall be determined via the assumed line dividing the area up to the shell under the ratio b_1/b_2, as $\frac{1}{2} \leq b_1/b_2 \leq 2$.