

RULES
FOR THE CLASSIFICATION OF
SHIPS

PART 5 – SUBDIVISION
January 2020

CROATIAN REGISTER OF SHIPPING

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

RULES FOR THE CLASSIFICATION OF SHIPS
Part 5 – SUBDIVISION
edition January 2020

have been adopted on 20th December 2019 and shall enter into force on 1st January 2020

**REVIEW OF AMENDMENTS IN RELATION TO PREVIOUS
EDITION OF THE RULES**

RULES FOR THE CLASSIFICATION OF SHIPS
Part 5 – SUBDIVISION

All major changes in respect to the Rules for the classification of ships, Part 5 – Subdivision, edition 2013, as last amended by Amendments No. 3, edition July 2017, including corrigenda No. 1, throughout the text are shaded (if any).

Items not being indicated as corrected have not been changed.

The grammar and print errors, have been corrected throughout the Rules and are not subject to above indication of changes.

This Part of the Rules includes the requirements of the following international Organizations:

International Maritime Organization (IMO)

- Conventions:** International Convention for the Safety of Life at Sea 1974 (SOLAS 1974) and all subsequent amendments up to and including the 2018 amendments (MSC. 436(99))
Protocol of 1988 relating to the International Convention for the Safety of Life at Sea 1974, as amended (SOLAS PROT 1988).
International Convention on Load Lines, 1966, and Protocol of 1988, as amended up to and including the 2012 amendments (MSC. 345(91)).
International Convention for the Prevention of Pollution from Ships 1973, as modified by the Protocol of 1978 thereto (MARPOL 73/78) and all subsequent amendments up to and including the 2011 amendments (MEPC. 201(62)).
- Resolutions:** MSC. 235(82), as amended by MSC. 335(90); MSC. 421(98); MSC. 436(99)
- Codes:** International Code of Safety for High-Speed Craft (HSC Code), MSC. 36(63), MSC. 97(73)
Code of Safety for Dynamically Supported Craft, A.373(X)
Code of Safety for Special Purpose Ships, 2008, MSC. 266(84)

International Association of Classification Societies (IACS)

- Unified Interpretations:**
CC7; LL 63(Rev.2, 2008); LL 65(Rev.2, 2008); LL 69(Rev.1, 2008); LL 75(Rev.1, 2009); MPC93 (Rev.1, 2016); SC 161(Rev.1, 2008)
- Recommendations (Rec.):**
No.110 (Rev.1, 2010)

- EU Directives:**
Directive 2003/25/EC of the European Parliament and of the Council of 14 April 2003 as amended by Commission Directive 2005/12/EC of 18 February 2005.

Content:

Page

1	GENERAL	1
1.1	APPLICATION	1
1.2	DEFINITIONS AND EXPLANATIONS	1
1.3	SCOPE OF SUPERVISION	2
1.4	GENERAL TECHNICAL REQUIREMENTS	3
1.5	ADDITIONAL CLASS NOTATION FOR SHIPS COMPLYING SUBDIVISION REQUIREMENTS	4
1.6	DOCUMENTATION	4
2	SUBDIVISION AND DAMAGE STABILITY OF PASSENGER SHIPS AND CARGO SHIPS	5
2.1	APPLICATION	5
2.2	DEFINITIONS	5
2.3	DOCUMENTATION	6
2.4	REQUIRED SUBDIVISION INDEX <i>R</i>	6
2.5	ATTAINED SUBDIVISION INDEX <i>A</i>	6
2.6	CALCULATION OF THE FACTOR p_i	7
2.7	CALCULATION OF THE FACTOR S_i	8
2.8	PERMEABILITY	11
2.9	SPECIAL REQUIREMENTS CONCERNING PASSENGER SHIP STABILITY	11
2.10	SYSTEM CAPABILITIES AND OPERATIONAL INFORMATION AFTER A FLOODING CASUALTY ON PASSENGER SHIPS	12
2.11	DOUBLE BOTTOMS IN PASSENGER SHIPS AND CARGO SHIPS OTHER THAN TANKERS	12
2.12	PASSENGER SHIPS CARRYING GOODS VEHICLES AND ACCOMPANYING PERSONNEL	13
2.13	INTERNAL WATERTIGHT INTEGRITY OF PASSENGER SHIPS ABOVE THE BULKHEAD DECK	13
2.14	INTEGRITY OF THE HULL AND SUPERSTRUCTURE, DAMAGE PREVENTION AND CONTROL ON RO-RO PASSENGER SHIPS	14
2.15	ASSIGNING, MARKING AND RECORDING OF SUBDIVISION LOAD LINES FOR PASSENGER SHIPS	14
2.16	DAMAGE CONTROL INFORMATION	14
2.17	PERIODICAL OPERATION AND INSPECTION OF WATERTIGHT DOORS, ETC., IN PASSENGER SHIPS	15
2.18	PREVENTION AND CONTROL OF WATER INGRESS, ETC.	15
2.19	SPECIAL REQUIREMENTS FOR RO-RO PASSENGER SHIPS	16
2.20	ADDITIONAL REQUIREMENTS FOR PREVENTION AND CONTROL OF WATER INGRESS, ETC., IN CARGO SHIPS	17
2.21	TIMBER DECK CARGO IN THE CONTEX OF DAMAGE STABILITY REQUIREMENTS	17
3	SPECIFIC STABILITY REQUIREMENTS FOR RO-RO PASSENGER SHIPS TO WHICH DIRECTIVE 2009/45/EC APPLIES	18
3.1	GENERAL	18
3.2	SPECIFIC STABILITY REQUIREMENTS	19
3.3	MODEL TEST METHOD	20
4	SPECIAL REQUIREMENTS FOR TYPE B SHIPS WITH REDUCED FREEBOARD	23
4.1	APPLICATION	23
4.2	INITIAL CONDITION OF LOADING	23
4.3	DAMAGE ASSUMPTIONS	24
4.4	CONDITION OF EQUILIBRIUM	25
4.5	SHIPS WITH ASSIGNED REDUCED FREEBOARD INTENDED TO CARRY DECK CARGO	26
5	DAMAGE STABILITY REQUIREMENTS APPLICABLE TO BULK CARRIERS	27
6	SPECIAL PURPOSE SHIPS	28
6.1	APPLICATION	28
6.2	DEFINITIONS	28
6.3	SUBDIVISION AND DAMAGE STABILITY	28
7	OFFSHORE SUPPLY VESSELS	29
7.1	APPLICATION	29
7.2	DEFINITIONS	29
7.3	SUBDIVISION AND DAMAGE STABILITY, GENERAL	29

7.4	DAMAGE ASSUMPTIONS.....	29	
7.5	DAMAGE STABILITY CRITERIA.....	30	
7.6	ASSUMPTIONS FOR CALCULATING DAMAGE STABILITY.....	30	
7.7	SUBDIVISION	31	
8	HIGH SPEED CRAFTS.....	32	
8.1	DYNAMICALLY SUPPORTED CRAFTS (DSC)	32	
8.2	HIGH SPEED CRAFTS, ACCORDING TO HSC 1994	32	
8.3	HIGH SPEED CRAFTS, ACCORDING TO HSC 2000	32	
9	TANKERS	33	
9.1	SUBDIVISION AND STABILITY	33	
9.2	DAMAGE ASSUMPTIONS.....	33	
9.3	DAMAGE STABILITY CRITERIA.....	34	
9.4	ASSUMPTION FOR CALCULATING DAMAGE STABILITY	34	
9.5	STABILITY INFORMATION	34	
9.6	ACCIDENTAL OIL OUTFLOW PERFORMANCE	35	
9.7	DAMAGE STABILITY VERIFICATION OF PARTICULAR LOADING CASE ON NEW TANKERS	39	
10	COMMERCIAL YACHTS.....	42	
10.1	APPLICATION.....	42	
10.2	SUBDIVISION	42	
10.3	DAMAGE STABILITY.....	43	
APPENDIX 1 INDICATIVE GUIDELINES FOR APPLICATION OF THE REQUIREMENTS SET OUT IN			
SECTION 3			44
1	APPLICATION.....	44	
2	MODEL TESTING	52	

1 GENERAL

1.1 APPLICATION

1.1.1 The requirements of this part of Rules apply to ships of following types:

- .1 Passenger ships engaged on international voyage;
- .2 cargo ships;
- .3 oil tankers;
- .4 chemical tankers;
- .5 special purpose ships;
- .6 supply vessels;
- .7 high speed crafts;
- .8 ro-ro passenger ships on which is applicable Directive 2003/25/EC as amended;
- .9 commercial yachts, with $L > 24$ m.

1.1.2 Passenger ships engaged on national service navigation on which the Directive 2009/45/EC, as amended, is applied, are to be in compliance with requirements for subdivision stated in the Directive.

1.1.3 For the purpose of this Part of the Rules a cargo ship, whenever built, which is converted to a passenger ship shall be treated as a passenger ship constructed on the date on which such a conversion commences.

1.1.4 The expression 'alterations and modifications of a major character' means, in the context of cargo ship subdivision and stability, any modification to the construction which affects the level of subdivision of that ship. Where a cargo ship is subject to such modification, it shall be demonstrated that the A/R ratio calculated for the ship after such modifications is not less than the A/R ratio calculated for the ship before the modification. However, in those cases where the ship's A/R ratio before modification is equal to or greater than unity, it is only necessary that the ship after modification has an A value which is not less than R, calculated for the modified ship.

1.1.5 All ships which undergo repairs, alternations, modifications and outfitting related thereto shall continue to comply with at least the requirements previously applicable to these ships. Such ships, if constructed before the date on which any relevant regulations of this Part of the Rules enter into force, shall, as a rule, comply with the requirements for ships constructed on or after that date to at least the same extent as they did before undergoing such repairs, alterations, modifications or outfitting. Repairs, alterations and modifications of a major character and outfitting related thereto shall meet the requirements for ships constructed on or after the date on which any relevant regulations of this Part of the Rules enter into force, in so far as the *Register* deems reasonable and practicable.

1.1.6 The *Register* may, if it considers that the sheltered nature and conditions of the voyage are such as to render the application of any specific requirements of this Part of the Rules unreasonable or unnecessary, exempt from those requirements individual ships or classes of ships engaged in national service navigation.

1.1.7 It is recommended to undertake all measures which permit the assignment and service conditions of the ship to attain the best subdivision characteristics for the ships which are not subjected to the requirements of the this part of the Rules.

Besides, if the shipowner requests to assign a subdivision mark in a sign of the ship's class, it should satisfy the requirements of this Part of the Rules.

The *Register* considers and decides in each particular case about the appliance of this Part of the Rules concerning the ships of novel design.

1.2 DEFINITIONS AND EXPLANATIONS

Definitions and explanations relating to the general terminology of the Rules, are given in the *Rules, Part 1 - General Requirements, Chapter 1 - General Information*.

For the purpose of the present Part of the *Rules* the following definitions have been applied:

1.2.1 Length (L) – is the length as defined in the International Convention on Load Lines in force.

1.2.2 Freeboard deck – is the deck as defined in the International Convention on Load Lines in force.

1.2.3 Forward perpendicular – is the forward perpendicular as defined in the International Convention on Load Lines in force.

1.2.4 Amidship – is at the middle of the length (L).

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

- .1 the top of the keel at centerline or line of intersection of the inside of shell plating with the keel if a bar keel extends below that line, on a ship with a metal shell; or
- .2 in wood and composite ships, the distance is measured from the lower edge of the keel rabbet. When the form at the lower part of the midship section is of a hollow character, or where thick garboards are fitted, the distance is measured from the point where the line of the flat of the bottom continued inward intersects the centerline amidships.

1.2.6 Bulkhead deck – in a passenger ship means the uppermost deck to which the main bulkheads and the ship's shell are carried watertight. The bulkhead deck may be a stepped deck. In a cargo ship not subject to the provisions of item 2.1.5 but constructed on or after 1 January 2009, the freeboard deck may be taken as the bulkhead deck.

1.2.7 The margin line – is a line draw at least 76 mm below the upper surface of the bulkhead deck at side.

1.2.8 Permeability of a space – is the proportion of the immersed volume of that space which can be occupied by water. The volume of a space which extends above the margin line shall be measured only to the only to the height of that line.

1.2.9 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 the case of unusual arrangements, the *Register* may define the limits of the machinery spaces.

1.2.10 Passenger spaces - are those spaces which are provided for the accommodation and use of passengers, excluding baggage, store, provision and mail rooms.

1.2.11 Volumes and areas - in all cases volumes and areas shall be calculated to moulded lines.

1.2.12 Weathertight - means that in any sea conditions water will not penetrate into the ship.

1.2.13 Watertight - means having scantlings and arrangements capable of preventing the passage of water in any direction under the head of water likely to occur in intact and damaged conditions. In the damaged condition, the head of water is to be considered in the worst situation at equilibrium, including intermediate stages of flooding.

1.2.14 Design pressure - means the hydrostatic pressure for which each structure or appliance assumed watertight in the intact and damage stability calculations is designed to withstand.

1.2.15 Deadweight - is the difference in tonnes between the displacement of a ship in water of a specific gravity of 1.025 at the draught corresponding to the assigned summer freeboard and the lightweight of the ship.

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

1.2.17 Oil tanker - is the oil tanker defined in regulation 1 of Annex 1 of the Protocol of 1978 relating to the International Convention for the Prevention of Pollution from Ships, 1973.

1.2.18 Ro-ro passenger ship - means a passenger ship with ro-ro cargo spaces or special category spaces as follows:

- .1 **Ro-ro cargo spaces** - are spaces normally subdivided in any way and extending to either a substantial length or the entire length of the ship in which goods (packed or in bulk, in or on rail or road cars, vehicles (including road or rail tankers), trailers, containers, pallets, demountable tanks or in or on similar stowage units or other receptacles) can be loaded and unloaded normally in a horizontal direction.
- .2 **Open ro-ro cargo spaces** - either open at both ends, or open at one end and provided with adequate natural ventilation effective over their entire length through permanent openings in the side plating or deckhead to the satisfaction of the *Register*.
- .3 **Closed ro-ro cargo spaces** - are ro-ro cargo spaces which are neither open ro-ro cargo spaces nor weather decks.

.4 **Weather deck** - is a deck which is completely exposed to the weather from above and from at least two sides.

.5 **Special category spaces** - are those enclosed spaces above or below the bulkhead deck intended for the carriage of motor vehicles with fuel in their tanks for their own propulsion, into and from which such vehicles can be driven and to which passengers have access.

1.2.19 Internal watertight integrity - is the capability of internal structures and their closing appliances to prevent progressive flooding to volumes assumed as a buoyant or intact.

The internal watertight integrity includes position and type of closing appliances, alarms, indicators, remote controls and signboards fitted to such appliances.

Further, watertight closing of pipes, ducts and tunnels in the damage penetration zone is regarded as a part of the internal watertight integrity.

1.2.20 Progressive flooding - is ingress of water through internal openings to compartments assumed to be intact.

1.2.21 Downflooding angle related to intact stability - is the minimum heel angle where an external opening without weathertight closing appliances is submerged.

1.2.22 Downflooding angle related to damage stability - is the minimum heel angle where an external opening without watertight closing appliance is submerged.

1.2.23 Damage zone - is the zone of the ship where the stipulated damage can be assumed. The stipulated damage is defined in the applicable damage stability requirements.

1.2.24 Residual stability - is the positive range of the righting level curve after damage with external heeling levers taken into account.

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

1.3 SCOPE OF SUPERVISION

1.3.1 The provisions relating to the procedure of supervision during construction, surveys and classification of ships, as well as the requirements for the technical documentation to be submitted for consideration of *Register*, are contained in the *Rules for the classification of ships, Part 1 - General requirements*.

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

- .1 checking the compliance of the structural measures taken to ensure subdivision in accordance with requirements specified in the *Rules, Part 2 - Hull*, Sections 7 and 10, the *Rules, Part 3 - Hull Equipment*, Section 7 and the *Rules, Part 8 - Piping* relative items;

- .2 checking and approval of the calculation for subdivision and damaged stability;
- .3 checking of the correct assignment and marking of additional load lines at ship's sides corresponding to the subdivision loadline.

1.4 GENERAL TECHNICAL REQUIREMENTS

1.4.1 Any approved subdivision loadline shall not be placed above the waterline corresponding to the minimum freeboard in salt water, which may be assigned to a ship in accordance with the requirements of the *International Convention on Load Lines 1966 and Protocol of 1988*, as amended.

The position of the subdivision loadline determined for the given ship shall be recorded in ships documents by the *Register*.

Subdivision load lines shall be marked at the ship's sides.

1.4.2 In all cases the volumes and areas shall be calculated to moulded lines. The volumes and free surfaces of the water penetrated into compartments of reinforced concrete, plastic, wood and composite ships, shall be calculated to the inner shell areas.

1.4.3 When determining the initial metacentric height of a damaged ship, the correction for the effect of free surfaces of liquid cargoes, ship's stores and ballast water shall be taken into account in the same manner as in the case of calculating the intact stability of a ship, in accordance with the requirements of the *Rules, Part 4 - Stability*, 1.4.7.

When plotting the statical stability curves for a damaged ship, enclosed superstructures, trunks, deck houses and deck cargo, angles of flooding through openings in ship's sides, deck and hull and superstructure bulkheads, considered to be open, as well as the correction for the effect of free surfaces of liquid cargoes, shall be calculated in the same manner as for the elaboration of curves for an intact ship, in accordance with the requirements of the *Rules, Part 4 - Stability*, item 1.4.2.

The superstructures, trunks and deck houses, which have sustained damage, may be taken into account only with regard to the permeability factor, specified in 2.8.1 or need not be taken into consideration at all. The openings inside such structures leading to the spaces which will not be flooded, are considered to be open at appropriate angles of heel only in cases when regular watertight means for closing thereof are not fitted.

1.4.4 When calculating damage stability and trim, account shall be taken on the changes of draught, heeling angle and trim due to replacing liquid cargo by sea water in damaged tanks.

1.4.5 The ships to which the present Part of the Rules is applicable shall be provided with the approved Information on damage stability, draught, side inclination and trim in case of compartment flooding. This information shall enable the master in different conditions of ship's operation, to take into account the requirements concerning subdivision and to es-

timate the state of the ship in the case of flooding of its compartments and to take measures for maintaining the damaged ship afloat.

The Information shall contain the following data:

- .1 data on the ship, its longitudinal section, deck and double bottom plans as well as typical cross-section with indication of all watertight bulkheads and enclosures with openings therein, method and means for their closing as well as diagram arrangements of systems necessary for the survival of damaged ship;
- .2 instructions necessary for maintenance of stability of an intact ship sufficient to withstand the most dangerous extent of damage in accordance with the present Part of the Rules; instructions on loading and ballasting the ship, including the recommendations on distributing the cargo in holds with regard to subdivision, meeting at the same time the requirements for trim, stability and strength of a ship. In order to maintain sufficient damage stability, the Information shall include the maximum permissible height of the ship's centre of gravity above keel (KG) or alternatively the minimum permissible metacentric height (MG) for a range of draughts and displacements, requested according to *Rules for the classification of ships Part 4 - Stability*, 1.5.1;
- .3 survey of the results of the symmetrical and unsymmetrical flooding calculations with the data on initial and damage draught, keel, trim and metacentric height both before and after taken measures for equalization of a ship or improvement of its stability. Parameters of the statical stability curves provided under the worst flooding conditions shall also be shown. For the ships to which Section 2 of the present Part of the Rules is applicable, it is sufficient to present the documentation stated in 2.3.1;
- .4 procedures recommended for the measures for equalization of a ship or improvement of its stability and the period of time required for that procedures, as well as other data on structural measures to ensure ship's subdivision, instructions for use of the cross-flooding arrangements and other emergency appliances;
- .5 possible consequences of flooding due to particular features of ships and the advisable and prohibited actions of the crew in the course of service of ship and in case of damage involving flooding.

1.4.6 The information on damaged stability shall be compiled on the basis of the data contained in the Stability Book stated in the *Rules, Part 4 - Stability*, 1.5.1.

1.4.7 Information on damage stability of a ship is allowed to be included in the Intact stability book as a separate chapter.

1.4.8 If the computer installed on the ship is used to estimate uprighting ship's procedure after damage or calculate damage stability, the computer as well as programme used shall be approved by the *Register*.

The use of the computer shall not substitute the information on damage stability.

1.5 ADDITIONAL CLASS NOTATION FOR SHIPS COMPLYING SUBDIVISION REQUIREMENTS

1.5.1 As additional class notation the letters **SD** shall be marked according to the *Rules, Part 1 - General requirements, Chapter 1 – General information* - if damage stability calculations for any computed cases satisfy requirements of this Part of the Rules.

1.6 DOCUMENTATION

- 1.6.1** Documentation for approval:
- Preliminary Damage Stability Calculations
 - Final Damage Stability Calculations *
 - Damage Control Plan
- 1.6.2** Documentation for information:
- Internal Watertight Integrity Plan

* Not required in case of approved limit curves, or if approved lightweight data are not less favourable than estimated lightweight data.

2 SUBDIVISION AND DAMAGE STABILITY OF PASSENGER SHIPS AND CARGO SHIPS

2.1 APPLICATION

2.1.1 Unless expressly provided otherwise, the requirements in Heads 2.3 to 2.19 shall apply to passenger ships.

2.1.2 For cargo ships, the requirements in Heads 2.3 to 2.21 shall apply as follows:

.1 Requirements of Heads 2.4 to 2.8 6 shall apply to cargo ships having a length (L) of 80 m and upwards, but may exclude those ships subject to the following instruments developed by the International Maritime Organization (IMO) and shown to comply with the subdivision and damage stability requirements of that instrument:

.1 Annex I to MARPOL, except that combination carriers (as defined in SOLAS regulation II-2/3.14) with type B freeboards shall be in compliance with requirements of Heads 2.4 to 2.8; or

.2 the International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk (IBC Code); or

.3 the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code); or

.4 the damage stability requirements of regulation 27 of the 1966 Load Lines Convention as applied in compliance with resolutions A.320(IX) and A.514(13), provided that in the case of cargo ships to which regulation 27(9) applies, main transverse watertight bulkheads, to be considered effective, are spaced according to paragraph (12)(f) of resolution A.320(IX), except that ships intended for the carriage of deck cargo shall be in compliance with requirements of Heads 2.4 to 2.8; or

.5 the damage stability requirements of regulation 27 of the 1988 Load Lines Protocol, except that ships intended for the carriage of deck cargo shall be in compliance with requirements of Heads 2.4 to 2.8; or

.6 the subdivision and damage stability standards in other instruments developed by the IMO.

.2 Unless expressly provided otherwise, the requirements of Heads 2.11 to 2.21 shall apply to cargo ships.

2.1.3 This Section should not apply to fast ship, as it is defined in 2.21 of the *Rules, Part 1 – General requirements, Chapter 1 – General information*. The requirements referred to in Section 8 of this Part of the Rules should be applied instead.

2.1.4 The *Register* may, for a particular ship or group of ships, accept alternative methodologies if it is satisfied that at least the same degree of safety as represented by these regulations is achieved.

2.1.5 Unless expressly provided otherwise, this Section shall apply to ships:

.1 for which the building contract is placed on or after 1 January 2020; or

.2 in the absence of a building contract, the keel of which is laid or which are at a similar stage of construction on or after 1 July 2020; or

.3 the delivery of which is on or after 1 January 2024.

2.1.6 Unless expressly provided otherwise, ships not subject to the provisions of item 2.1.5 shall fulfil:

.1 the requirements applicable to construction date of these ships, set in appropriate sections of previous editions of this Part of the Rules; and

.2 the requirement of item 2.16.5 of this Part of the Rules.

2.1.7 Ships shall be as efficiently subdivided as is possible having regard to the nature of the service for which they are intended. The degree of subdivision shall vary with the subdivision length (L_S) of the ship and with the service, in such manner that the highest degree of subdivision corresponds with the ships of greatest subdivision length (L_S), primarily engaged in the carriage of passengers.

2.1.6 Where it is proposed to fit decks, inner skins or longitudinal bulkheads of sufficient tightness to seriously restrict the flow of water, the *Register* shall be satisfied that proper consideration is given to beneficial or adverse effects of such structures in the calculations.

2.2 DEFINITIONS

For the purpose of this Section, and additionally to Head 1.2, unless expressly provided otherwise:

2.2.1 Subdivision length (L_S) of the ship - 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.

2.2.2 Aft terminal - is the aft limit of the subdivision length.

2.2.3 Forward terminal - is the forward limit of the subdivision length.

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

2.2.5 Draught (d) - is the vertical distance from the keel line at amidships.

2.2.6 Deepest subdivision draught (d_s) - is the summer load line draught of the ship.

2.2.7 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 should include the full complement of passengers and crew on board.

2.2.8 Partial subdivision draught (d_p) - is the light service draught plus 60% of the difference between the light service draught and the deepest subdivision draught.

2.2.9 Trim - is the difference between the draught forward and the draught aft, where the draughts are measured at the forward and aft perpendiculars respectively, as defined in the International Convention on Load Lines in force, disregarding any rake of keel.

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

2.2.11 For the purpose of this chapter, the term 'a similar stage of construction' means the stage at which:

- .1 construction identifiable with a specific ship begins; and
- .2 assembly of that ship has commenced comprising at least 50 tonnes or one per cent of the estimated mass of all structural material, whichever is less.

2.3 DOCUMENTATION

2.3.1 The following documentation is to be submitted for approval:

- calculation of subdivisions indices R and A;
- damage stability calculations for the flooding cases included in the calculation of A;
- stability information as required in regulation 1.5.1 Rules, Part 4 - Stability;
- damage control plan.

2.3.2 The following documentation is to be submitted for information only:

- internal watertight integrity plan.

2.4 REQUIRED SUBDIVISION INDEX R^*

2.4.1 The subdivision of a ship is considered sufficient if the attained subdivision index A , determined in accordance with Head 2.5, is not less than the required subdivision index R calculated in accordance with this Head 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.

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

- .1 In the case of cargo ships greater than 100 m in length (L_s):

$$R = 1 - \frac{128}{L_s + 152}$$

and

- .2 In the case of cargo ships not less than 80 m in length (L) and not greater than 100 m in length (L_s):

$$R = 1 - \left[1 / \left(1 + \frac{L_s}{100} \cdot \frac{R_o}{1 - R_o} \right) \right]$$

where R_o is the value R as calculated in accordance with the formula in sub-item .1

- .3 In the case of passenger ships:

Persons on board	R
$N < 400$	$R = 0.722$
$400 \leq N \leq 1350$	$R = N / 7580 + 0.66923$
$1350 < N \leq 6000$	$R = 0.0369 \cdot \ln(N + 89.048) + 0.579$
$N > 6000$	$R = 1 - (852.5 + 0.03875 \cdot N) / (N + 5000)$

where:

N = total number of persons on board.

2.5 ATTAINED SUBDIVISION INDEX A

2.5.1 An attained subdivision index A is obtained by the summation of the partial indices A_s , A_p and A_l , weighted as shown and calculated for the draughts d_s , d_p and d_l , defined in Head 2.2, in accordance with the following formula:

$$A = 0.4A_s + 0.4A_p + 0.2A_l$$

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

$$A = \sum p_i \cdot s_i$$

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 Head 2.6,
- 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 Head 2.7.

* See MSC/Circ. 651, Explanatory notes for part B-1 SOLAS, Chapter II-1.

2.5.2 As a minimum, the calculation of A shall be carried out at the level trim for the deepest subdivision draught d_s and the partial subdivision draught d_p . The estimated service trim may be used for the light service draught d_l . If, in any anticipated service condition within the draught range from d_s to d_l , the trim variation in comparison with the calculated trims is greater than 0.5% of L , one or more additional calculations of A are to be performed for the same draughts but including sufficient trims to ensure that, for all intended service conditions, the difference in trim in comparison with the reference trim used for one calculation will be not more than 0.5% of L . Each additional calculation of A shall comply with item 2.4.1.

2.5.3 When determining the positive righting lever (GZ) of the residual stability curve in the intermediate and final equilibrium stages of flooding, the displacement used should be that of the intact loading condition. All calculations should be done with the ship freely trimming.

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

2.5.5 Wherever wing compartments are fitted, contribution to the summation indicated by the formula shall be taken for all cases of flooding in which wing compartments are involved. Additionally, cases of simultaneous flooding of a wing compartment or group of compartments and the adjacent inboard compartment or group of compartments, but excluding damage of transverse extent greater than one half of the ship breadth B , may be added. For the purpose of this regulation, transverse extent is measured inboard from ship's side, at right angle to the centreline at the level of the deepest subdivision draught.

2.5.6 In the flooding calculations carried out according to this Section of the Rules, 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 is to be assumed.

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

2.6 CALCULATION OF THE FACTOR p_i

2.6.1 The factor p_i for a compartment or group of compartments shall be calculated in accordance with items 2.6.2 and 2.6.3, using the following notations:

- j = the aftmost damage zone number involved in the damage starting with no.1 at the stern;
- n = the number of adjacent damage zones involved in the damage;
- k = is the number of a particular longitudinal bulkhead as barrier for transverse penetration in a damage zone counted from shell towards the centreline. The shell has $k = 0$;
- x_1 = the distance from the aft terminal of L_s to the aft end of the zone in question;
- x_2 = the distance from the aft terminal of L_s to the forward end of the zone in question;
- b = the mean transverse distance in metres measured at right angles to the centreline at the deepest subdivision draught between the shell and an assumed vertical plane extended between the longitudinal limits used in calculating the factor p_i and which is a tangent to, or common with, all or part of the outermost portion of the longitudinal bulkhead under consideration. This vertical plane shall be so orientated that the mean transverse distance to the shell is a maximum, but not more than twice the least distance between the plane and the shell. If the upper part of a longitudinal bulkhead is below the deepest subdivision draught the vertical plane used for determination of b is assumed to extend upwards to the deepest subdivision waterline. In any case, b is not to be taken greater than $B/2$.

If the damage involves a single zone only:

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

If the damage involves two adjacent zones:

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

If the damage involves three or more adjacent zones:

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

and where $r(x1, x2, b0) = 0$

2.6.2 The factor $p_i(x1, x2)$ is to be calculated according to the following formulae:

- Overall normalized max damage length: $J_{\max} = 10/33$
- Knuckle point in the distribution: $J_{kn} = 5/33$
- Cumulative probability at J_{kn} : $p_k = 11/12$
- Maximum absolute damage length: $l_{\max} = 60$ m
- Length where normalized distribution ends: $L^* = 260$ m
- Probability density at $J = 0$:

$$b_0 = 2 \left(\frac{p_k}{J_{kn}} - \frac{1-p_k}{J_{\max} - J_{kn}} \right)$$

When $L_s \leq L^*$:

$$J_m = \min \left\{ J_{\max}, \frac{L_{\max}}{L_s} \right\}$$

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

$$b_{12} = b_0$$

When $L_s > L^*$:

$$J_m^* = \min \left\{ J_{\max}, \frac{L_{\max}}{L^*} \right\}$$

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

$$J_m = \frac{J_m^* \cdot L^*}{L_s}$$

$$J_k = \frac{J_k^* \cdot L^*}{L_s}$$

$$b_{12} = 2 \left(\frac{p_k}{J_k} - \frac{1-p_k}{J_m - J_k} \right)$$

$$b_{11} = 4 \frac{1-p_k}{(J_m - J_k)J_k} - 2 \frac{p_k}{J_k^2}$$

$$b_{21} = -2 \frac{1-p_k}{(J_m - J_k)^2}$$

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

The non-dimensional damage length:

$$J = \frac{(x_2 - x_1)}{L_s}$$

The normalized length of a compartment or group of compartments:

J_n - is to be taken as the lesser of J and J_m

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

$J \leq J_k$:

$$p(x_1, x_2) = p_1 = \frac{1}{6} J^2 (b_{11}J + 3b_{12})$$

$J > J_k$:

$$p(x_1, x_2) = p_2 = -\frac{1}{3} b_{11}J_k^3 + \frac{1}{2} (b_{11}J - b_{12})J_k^2 + b_{12}JJ_k - \frac{1}{3} b_{21}(J_n^3 - J_k^3) + \frac{1}{2} (b_{21}J - b_{22})(J_n^2 - J_k^2) + b_{22}J(J_n - J_k)$$

2.6.2.2 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:

$J \leq J_k$:

$$p(x_1, x_2) = \frac{1}{2} (p_1 + J)$$

$J > J_k$:

$$p(x_1, x_2) = \frac{1}{2} (p_2 + J)$$

2.6.2.3 Where the compartment or groups of compartments considered extends over the entire subdivision length (L_s):

$$p(x_1, x_2) = 1$$

2.6.3 The factor $r(x_1, x_2, b)$ shall be determined by the following formulae:

$$r(x_1, x_2, b) = 1 - (1 - C) \cdot \left[1 - \frac{G}{p(x_1, x_2)} \right]$$

where:

$$C = 12 \cdot J_b \cdot (-45 \cdot J_b + 4), \text{ where}$$

$$J_b = \frac{b}{15 \cdot B}$$

2.6.3.1 Where the compartment or groups of compartments considered extends over the entire subdivision length (L_s):

$$G = G_1 = \frac{1}{2} b_{11}J_b^2 + b_{12}J_b$$

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

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

where

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

2.6.3.3 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:

$$G = \frac{1}{2} (G_2 + G_1J)$$

2.7 CALCULATION OF THE FACTOR s_i

2.7.1 The factor s_i shall be determined for each case of assumed flooding, involving a compartment or group of compartments, in accordance with the following notations and the provisions in this Head:

- Θ_e - is the equilibrium heel angle in any stage of flooding, in degrees;
- Θ_v - is the angle, in any stage of flooding, where the righting lever becomes negative, or the angle at which an opening incapable of being closed weathertight becomes submerged;
- GZ_{\max} - is the maximum positive righting lever, in metres, up to the angle Θ_v ;

Range - is the range of positive righting levers, in degrees, 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.

2.7.1.1 The factor s_i , for any damage case at any initial loading condition, at draught d_i , shall be obtained from the formula:

$$s_i = \text{minimum} \{ s_{\text{intermediate},i} \text{ OR } s_{\text{final},i} \cdot s_{\text{mom},i} \}$$

where:

$s_{\text{intermediate},i}$ - is the probability to survive all intermediate flooding stages until the final equilibrium stage, and is calculated in accordance with 2.7.2;

$s_{\text{final},i}$ - is the probability to survive in the final equilibrium stage of flooding. It is calculated in accordance with 2.7.3;

$s_{\text{mom},i}$ - is the probability to survive heeling moments, and is calculated in accordance with 2.7.4.

2.7.2 For passenger ships, and cargo ships fitted with cross-flooding devices, the factor $s_{\text{intermediate},i}$, is taken as the least of the s -factors obtained from all flooding stages including the stage before equalization, if any, and is to be calculated as follows:

$$s_{\text{intermediate},i} = \left[\frac{GZ_{\text{max}}}{0.05} \cdot \frac{\text{Range}}{7} \right]^{\frac{1}{4}}$$

where GZ_{max} is not to be taken as more than 0.05 m and *Range* as not more than 7° . $s_{\text{intermediate},i} = 0$, if the intermediate heel angle exceeds 15° for passenger ships and 30° for cargo ships.

For cargo ships not fitted with cross-flooding devices the factor $s_{\text{intermediate},i}$ is taken as unity, except if the Register considers that the stability in intermediate stages of flooding may be insufficient, it should require further investigation thereof.

For passenger and cargo ships, where cross-flooding fittings are required, the time for equalization shall not exceed 10 min.

2.7.3 The factor $s_{\text{final},i}$ shall be obtained from the formula:

$$s_{\text{final},i} = K \cdot \left[\frac{GZ_{\text{max}}}{TGZ_{\text{max}}} \cdot \frac{\text{Range}}{TRange} \right]^{\frac{1}{4}}$$

where:

GZ_{max} - is not to be taken as more than TGZ_{max} ;

Range - is not to be taken as more than $TRange$;

$TGZ_{\text{max}} = 0.20$ m, for ro-ro passenger ships each damage case that involves a ro-ro space,

$TGZ_{\text{max}} = 0.12$ m, otherwise;

$TRange = 20^\circ$, for ro-ro passenger ships each damage case that involves a ro-ro space,

$TRange = 16^\circ$, otherwise;

$$K = 1 \quad \text{if } \theta_e \leq \theta_{\text{min}}$$

$$K = 0 \quad \text{if } \theta_e \geq \theta_{\text{max}}$$

$$K = \sqrt{\frac{\theta_{\text{max}} - \theta_e}{\theta_{\text{max}} - \theta_{\text{min}}}} \quad \text{otherwise,}$$

where:

θ_{min} - is 7° for passenger ships and 25° for cargo ships; and

θ_{max} - is 15° for passenger ships and 30° for cargo ships.

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

$$s_{\text{mom},i} = \frac{(GZ_{\text{max}} - 0.04) \cdot \Delta}{M_{\text{heel}}}$$

where:

Δ - is the intact displacement at the respective draught (d_s , d_p or d_l);

M_{heel} - is the maximum assumed heeling moment as calculated in accordance with 2.7.5; and

$$s_{\text{mom},i} \leq 1$$

2.7.5 The heeling moment M_{heel} is to be calculated as follows:

$$M_{\text{heel}} = \text{maximum} \{ M_{\text{passenger}} \text{ OR } M_{\text{wind}} \text{ OR } M_{\text{survivalcraft}} \}$$

2.7.5.1 $M_{\text{passenger}}$ is the maximum assumed heeling moment resulting from movement of passengers, and is to be obtained as follows:

$$M_{\text{passenger}} = (0.075 \cdot N_p) \cdot (0.45 \cdot B) \quad [\text{tm}]$$

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; and

B - is the breadth of the ship as defined in item 2.2.4.

Alternatively, the heeling moment may be calculated assuming the passengers are distributed with 4 persons per square metre 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 is to be assumed.

2.7.5.2 M_{wind} is the maximum assumed wind moment acting in a damage situation:

$$M_{\text{wind}} = (P \cdot A \cdot Z) / 9.806 \quad [\text{tm}]$$

where:

$$P = 120 \text{ N/m}^2;$$

A = projected lateral area above waterline;

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

T = respective draught (d_s , d_p or d_l).

2.7.5.3 $M_{\text{survivalcraft}}$ 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:

.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;
- .2 for lifeboats which are arranged to be launched fully loaded from the stowed position, the maximum heeling moment during launching shall be taken;
 - .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 persons not in the life-saving appliances which are swung out shall not provide either additional heeling or righting moment; and;
 - .5 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.

2.7.6 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 equalization devices are provided they shall be operable from above the bulkhead deck of passenger ships and the freeboard deck of cargo ships. These fittings together with their controls shall be acceptable to the Register*. Suitable information concerning the use of equalization devices shall be supplied to the master of the ship.

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

2.7.6.2 The factor s_i is to be taken as zero in those cases where the final waterline, taking into account sinkage, heel and trim, immerses:

- .1 the lower edge of openings through which progressive flooding may take place and such flooding is not accounted for in the calculation of factor s_i . Such openings shall include air-pipes, ventilators and openings which are closed by means of weathertight doors or hatch covers; and
- .2 any part of the bulkhead deck in passenger ships considered a horizontal evacuation route for compliance with the Rules, Part 17 – Fire protection.

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

- .1 immersion of any vertical escape hatch in the bulkhead deck of passenger ships and the freeboard deck of cargo ships intend-

ed for compliance with the Rules, Part 17 – 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 of passenger ships and the freeboard deck of cargo ships become inaccessible or inoperable;
- .3 immersion of any part of piping or ventilation ducts located within the assumed extent of damage and carried through a watertight boundary if this can lead to the progressive flooding of compartments not assumed as flooded.

2.7.6.4 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.

2.7.6.5 Except as provided in 2.7.6.3.1, openings closed by means of watertight manhole covers and flush scuttles, remotely operated sliding watertight doors, sidescuttles of the non-opening type as well as watertight access doors and watertight hatch covers required to be kept closed at sea need not be considered.

2.7.7 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 as determined in 2.7.1.1 by the reduction factor v_m according to 2.7.7.1, which represents the probability that the spaces above the horizontal subdivision will not be flooded.

2.7.7.1 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 metres, within the longitudinal range of $x_{1(j)} \dots x_{2(j+n-1)}$ 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 metres, within the longitudinal range of $x_{1(j)} \dots x_{2(j+n-1)}$ of the $(m-1)^{\text{th}}$ 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 Head 2.2; and

x_1 and x_2 represent the terminals of the compartment or group of compartments considered in 2.6.1.

* Reference is made to the Recommendation on a standard method for establishing compliance with the requirements for cross-flooding arrangements in passenger ships, adopted by the IMO by resolution A.266(VIII), as may be amended.

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

$$v(H, d) = 0.8 \frac{(H-d)}{7.8}, \text{ if } (H_m-d) \leq 7.8 \text{ [m];}$$

$$v(H, d) = 0.8 + 0.2 \left[\frac{(H-d) - 7.8}{4.7} \right] \text{ in all other cas-}$$

es,

where:

$v(H_{j,n,m},d)$ is to be taken as 1, if H_m coincides with the uppermost watertight boundary of the ship within the range $(x1_{(j)} \dots x2_{(j+n-1)})$; and

$v(H_{j,n,0},d)$ is to be taken as 0.

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

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

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

where:

v_m = the v -value calculated in accordance with 2.7.7.1;

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

2.8 PERMEABILITY

2.8.1 For the purpose of the subdivision and damage stability calculations of this Section of the Rules, the permeability of each general compartment or part of a compartment shall be as follows:

Spaces	Permeability
Appropriated to stores	0.60
Occupied by accommodation	0.95
Occupied by machinery	0.85
Void spaces	0.95
Intended for liquids	0 or 0.95*
* Whichever results in the more severe requirement	

2.8.2 For the purpose of the subdivision and damage stability calculations of this Section of the Rules, the permeability of each cargo compartment or part of a compartment shall be as follows:

Spaces	Permeability at draught d_s	Permeability at draught d_p	Permeability at draught d_l
Dry cargo spaces	0.70	0.80	0.95
Container spaces	0.70	0.80	0.95
Ro-ro spaces	0.90	0.90	0.95
Cargo liquids	0.70	0.80	0.95

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

2.9 SPECIAL REQUIREMENTS CONCERNING PASSENGER SHIP STABILITY

2.9.1 A passenger ship intended to carry 400 or more persons shall have watertight subdivision abaft the collision bulkhead so that $s_i=1$ for a damage involving all the compartments within $0.08L$ measured from the forward perpendicular for the three loading conditions used to calculate the attained subdivision index A . If the attained subdivision index A is calculated for different trims, this requirement shall also be satisfied for those loading conditions.

2.9.2 A passenger ship intended to carry 36 or more persons is to be capable of withstanding damage along the side shell to an extent specified in 2.9.3. Compliance with this Head is to be achieved by demonstrating that s_i , as defined in 2.7, is not less than 0.9 for the three loading conditions used to calculate the attained subdivision index A . If the attained subdivision index A is calculated for different trims, this requirement shall also be satisfied for those loading conditions.

2.9.3 The damage extent to be assumed when demonstrating compliance with 2.9.2, is to be dependent on the total number of persons carried, and L , such that:

- 1 the vertical extent of damage is to 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 2.2, unless a lesser vertical extent of damage were to give a lower value of s_i , in which case this reduced extent is to be used;
- 2 where 400 or more persons are to be carried, a damage length of $0.03L$, but not less than 3 m is to 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 angles to the centreline at the level of the deepest subdivision draught;
- 3 where fewer than 400 persons are carried, damage length is to be assumed at any position along the shell side between transverse watertight bulkheads provided that the distance between two adjacent transverse watertight bulkheads is not less than the assumed damage length. If the distance between adjacent transverse watertight bulkheads is less than the assumed damage length, only one of these bulkheads shall be considered effective for the purpose of demonstrating compliance with 2.9.2;
- 4 where 36 persons are carried, a damage length of $0.015L$, but not less than 3 m is to be assumed, in conjunction with a penetration inboard of $0.05B$ but not less than 0.75 m; and
- 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, are to 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 previous sub-items .4 and .2.

2.10 SYSTEM CAPABILITIES AND OPERATIONAL INFORMATION AFTER A FLOODING CASUALTY ON PASSENGER SHIPS

2.10.1 Application

Passenger ships having length, as defined in 1.2.1, of 120 m or more or having three or more main vertical zones shall comply with the provisions of this Head.

2.10.2 Availability of essential systems in case of flooding damage*

A passenger ship shall be designed so that the systems specified in Reg. II-2/21.4 of the SOLAS Convention, as amended, remain operational when the ship is subject to flooding of any single watertight compartment.

2.10.3 Operational information after a flooding casualty

For the purpose of providing operational information to the Master for safe return to port after a flooding casualty, passenger ships shall have:

- .1 onboard stability computer; or;
 - .2 shore-based support,
- based on the guidelines developed by IMO**.

2.10.4 Passenger ships constructed before 1 January 2014 shall comply with the provisions in previous item 2.10.3 not later than the first renewal survey after 1 January 2025.

2.11 DOUBLE BOTTOMS IN PASSENGER SHIPS AND CARGO SHIPS OTHER THAN TANKERS

2.11.1 A double bottom shall be fitted extending from the collision bulkhead to the afterpeak bulkhead, as far as this is practicable and compatible with the design and proper working of the ship.

* Refer to the Interim Explanatory Notes for the assessment of passenger ship systems' capabilities after a fire or flooding casualty (IMO MSC.1/Circ.1369) and Unified Interpretations of SOLAS regulation II-2/21.4 (IMO MSC.1/Circ.1437).

** Refer to the *Guidelines on operational information for Masters of passenger ships for safe return to port by own power or under tow* (IMO MSC.1/Circ.1400) for ships constructed on or after 1 January 2014 but before 13 May 2016, or the *Revised guidelines on operational information for masters of passenger ships for safe return to port* (IMO MSC.1/Circ.1532/Rev.1) for ships constructed on or after 13 May 2016, or the *Guidelines on operational information for masters in case of flooding for passenger ships constructed before 1 January 2014* (MSC.1/Circ.1589).

2.11.2 Where a double bottom is required to be fitted the inner bottom shall be continued out to the ship's sides in such a manner as to protect the bottom to the turn of the bilge. Such protection will be deemed satisfactory if the inner bottom is not lower at any part than a plane parallel with the keel line and which is located not less than a vertical distance h measured from the keel line, as calculated by the formula:

$$h = B/20$$

However, in no case is the value of h to be less than 760 mm, and need not be taken as more than 2000 mm.

2.11.3 Wells:

- .1 Small wells constructed in the double bottom in connection with drainage arrangements shall not extend downward more than necessary. The vertical distance from the bottom of such a well to a plane coinciding with the keel line shall not be less than $h/2$ or 500 mm, whichever is greater, or compliance with item 2.11.7 of this regulation shall be shown for that part of the ship.
- .2 Other wells (e.g. for lubricating oil under main engines) may be permitted by the Register if satisfied that the arrangements give protection equivalent to that afforded by a double bottom complying with this Head.
 - .1 For a cargo ship of 80 m in length and upwards or for a passenger ship, proof of equivalent protection is to be shown by demonstrating that the ship is capable of withstanding bottom damages as specified in item 2.11.7. Alternatively, wells for lubricating oil below main engines may protrude into the double bottom below the boundary line defined by the distance h provided that the vertical distance between the well bottom and a plane coinciding with the keel line is not less than $h/2$ or 500 mm, whichever is greater.
 - .2 For cargo ships of less than 80 m in length the arrangements shall provide a level of safety to the satisfaction of the Register.

2.11.4 A double bottom need not be fitted in way of watertight tanks, including dry tanks of moderate size, provided the safety of the ship is not impaired in the event of bottom or side damage.

2.11.5 Any part of a cargo ship of 80 m in length and upwards or of a passenger ship that is not fitted with a double bottom in accordance with 2.11.1 or 2.11.4, as specified in 2.11.2, shall be capable of withstanding bottom damages, as specified in 2.11.7, in that part of the ship. For cargo ships of less than 80 m in length the alternative arrangements shall provide a level of safety to the satisfaction of the Register.

2.11.6 In the case of unusual bottom arrangements in a cargo ship of 80 m in length and upwards or a passenger ship, it shall be demonstrated that the ship is capable of withstanding bottom damages as specified in 2.11.7. For cargo ships of less than 80 m in length the alternative arrangements

shall provide a level of safety to the satisfaction of the *Register*.

2.11.7 Compliance with items 2.11.3.1, 2.11.3.2.1, 2.11.5 and 2.11.6 is to be achieved by demonstrating that s_i , when calculated in accordance with Head 2.7, is not less than 1 for all service conditions when subject to bottom damage with an extent specified in sub-2 below for any position in 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 shall be as follows:

	For 0.3 L from the forward perpendicular of the ship	Any other part of the ship
Longitudinal extent	$1/3 L^{2/3}$ or 14.5 m, whichever is less	$1/3 L^{2/3}$ or 14.5 m, whichever is less
Transverse extent	$B/6$ or 10 m, whichever is less	$B/6$ or 5 m, whichever is less
Vertical extent, measured from the keel line	$B/20$, to be taken not less than 0.76 m and not more than 2 m	$B/20$, to be taken not less than 0.76 m and not more than 2 m

- .3 If any damage of a lesser extent than the maximum damage specified in .2 would result in a more severe condition, such damage should be considered.

2.11.8 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 less, measured from the keel line. Alternatively, bottom damages may be calculated for these areas, in accordance with 2.11.7, but assuming an increased vertical extent.

2.12 PASSENGER SHIPS CARRYING GOODS VEHICLES AND ACCOMPANYING PERSONNEL

2.12.1 This Head applies to passenger ships designed or adapted for the carriage of goods vehicles and accompanying personnel.

2.12.2 If in such a ship the total number of passengers which include personnel accompanying vehicles does not exceed $12 + A_d/25$, where A_d = total deck area (square metres) of spaces available for the stowage of goods vehicles and where the clear height at the stowage position and at the entrance to such spaces is not less than 4 m, the provisions of 7.12 of the *Rules, Part 3 – Hull Equipment* in respect of watertight doors apply except that the doors may be fitted at any level in watertight bulkheads dividing cargo spaces. Additionally, indicators are required on the navigation bridge to show automatically when each door is closed and all door fastenings are secured.

2.12.3 The ship may not be certified for a higher number of passengers than assumed in 2.12.2, if a watertight door has been fitted in accordance with this Head.

2.13 INTERNAL WATERTIGHT INTEGRITY OF PASSENGER SHIPS ABOVE THE BULKHEAD DECK

2.13.1 The *Register* may require that all reasonable and practicable measures shall be taken to limit the entry and spread of water above the bulkhead deck. Such measures may include partial bulkheads or webs. When partial watertight bulkheads and webs are fitted on the bulkhead deck, above or in the immediate vicinity of watertight bulkheads, they shall have watertight shell and bulkhead deck connections so as to restrict the flow of water along the deck when the ship is in a heeled damaged condition. Where the partial watertight bulkhead does not line up with the bulkhead below, the bulkhead deck between shall be made effectively watertight. Where openings, pipes, scuppers, cables etc. are carried through the partial watertight bulkheads or decks within the immersed part of the bulkhead deck, arrangements shall be made to ensure the watertight integrity of the structure above the bulkhead deck.

2.13.2 All openings in the exposed weather deck shall have coamings of ample height and strength and shall be provided with efficient means for expeditiously closing them weathertight. Freeing ports, open rails and scuppers shall be fitted as necessary for rapidly clearing the weather deck of water under all weather conditions. Minimum required dimensions of these openings are stated in the *International Convention on Load Lines 1966 and Protocol of 1988*, as amended.

2.13.3 Air pipes terminating within a superstructure which are not fitted with watertight means of closure shall be considered as unprotected openings when applying provisions of sub-item 2.7.7.2.

2.13.4 Sidescuttles, gangway, cargo and fuelling ports and other means for closing openings in the shell plating above the bulkhead deck shall be of efficient design and construction and of sufficient strength having regard to the spaces in which they are fitted and their positions relative to the deepest subdivision draught.*

2.13.5 Efficient inside deadlights, so arranged that they can be easily and effectively closed and secured watertight, shall be provided for all sidescuttles to spaces below the first deck above the bulkhead deck.

* Refer to the Recommendation on strength and security and locking arrangements of shell doors on ro-ro passenger ships, adopted by the IMO by resolution A.793(19).

2.14 INTEGRITY OF THE HULL AND SUPERSTRUCTURE, DAMAGE PREVENTION AND CONTROL ON RO-RO PASSENGER SHIPS

2.14.1

- .1 Subject to the provisions of .2 and .3 of this item, all accesses that lead to spaces below the bulkhead deck shall have a lowest point which is not less than 2.5 m above the bulkhead deck.
- .2 Where vehicle ramps are installed to give access to spaces below the bulkhead deck, their openings shall be able to be closed weathertight to prevent ingress of water below, alarmed and indicated to the navigation bridge.
- .3 The *Register* may permit the fitting of particular accesses to spaces below the bulkhead deck provided they are necessary for the essential working of the ship, e.g. the movement of machinery and stores, subject to such accesses being made watertight, alarmed and indicated on the navigation bridge.

2.14.2 Indicators shall be provided on the navigation bridge for all shell doors, loading doors and other closing appliances which, if left open or not properly secured, could, in the opinion of the *Register*, lead to flooding of a special category space or ro-ro space. The indicator system shall be designed on the fail-safe principle and shall show by visual alarms if the door is not fully closed or if any of the securing arrangements are not in place and fully locked and by audible alarms if such door or closing appliances become open or the securing arrangements become unsecured. The indicator panel on the navigation bridge shall be equipped with a mode selection function "harbour/sea voyage" so arranged that an audible alarm is given on the navigation bridge if the ship leaves harbour with the bow doors, inner doors, stern ramp or any other side shell doors not closed or any closing device not in the correct position. The power supply for the indicator system shall be independent of the power supply for operating and securing the doors.

2.14.3 Television surveillance and a water leakage detection system shall be arranged to provide an indication to the navigation bridge and to the engine control station of any leakage through inner and outer bow doors, stern doors or any other shell doors which could lead to flooding of special category spaces or ro-ro spaces.

2.15 ASSIGNING, MARKING AND RECORDING OF SUBDIVISION LOAD LINES FOR PASSENGER SHIPS

2.15.1 In order that the required degree of subdivision shall be maintained, a load line corresponding to the approved subdivision draught shall be assigned and marked on the ship's sides. A ship intended for alternating modes of operation may, if the owners desire, have one or more addition-

al load lines assigned and marked to correspond with the subdivision draughts which the *Register* may approve for the alternative service configurations. Each service configuration so approved shall comply with Heads 2.4 to 2.9 independently of the results obtained for other modes of operation.

2.15.2 The subdivision load lines assigned and marked shall be recorded in the Passenger Ship Safety Certificate, and shall be distinguished by the notation P1 for the principal passenger service configuration, and P2, P3, etc., for the alternative configurations. The principal passenger configuration shall be taken as the mode of operation in which the required subdivision index *R* will have the highest value.

2.15.3 The freeboard corresponding to each of these load lines shall be measured at the same position and from the same deck line as the freeboards determined in accordance with the International Convention on Load Lines in force.

2.15.4 The freeboard corresponding to each approved subdivision load line and the service configuration, for which it is approved, shall be clearly indicated on the Passenger Ship Safety Certificate.

2.15.5 In no case shall any subdivision load line mark be placed above the deepest load line in salt water as determined by the strength of the ship or the International Convention on Load Lines in force.

2.15.6 Whatever may be the position of the subdivision load line marks, a ship shall in no case be loaded so as to submerge the load line mark appropriate to the season and locality as determined in accordance with the International Convention on Load Lines in force.

2.15.7 A ship shall in no case be so loaded that when it is in salt water the subdivision load line mark appropriate to the particular voyage and service configuration is submerged.

2.16 DAMAGE CONTROL INFORMATION

2.16.1 There shall be permanently exhibited, or readily available on the navigation bridge, for the guidance of the officer in charge of the ship, plans showing clearly for each deck and hold the boundaries of the watertight compartments, the openings therein with the means of closure and position of any controls thereof, and the arrangements for the correction of any list due to flooding. In addition, booklets containing the aforementioned information shall be made available to the officers of the ship.*

2.16.2 General precautions to be included shall consist of a listing of equipment, conditions, and operational procedures, considered by the *Register* to be necessary to maintain watertight integrity under normal ship operations.

2.16.3 Specific precautions to be included shall consist of a listing of elements (i.e. closures, security of cargo,

* Refer to the Guidelines for damage control plans and information to the master (MSC.1/Circ.1245).

sounding of alarms, etc.) considered by the *Register* to be vital to the survival of the ship, passengers and crew.

2.16.4 In case of ships to which damage stability requirements of the Heads 2.4 to 2.9 of this Part of the Rules apply, damage stability information shall provide the master a simple and easily understandable way of assessing the ship's survivability in all damage cases involving a compartment or group of compartments.**

2.16.5 For all passenger ships, constructed before, on or after 1 January 2020, a damage control drill shall take place at least every three months. The damage control drill shall satisfy the provisions set in Reg.19-1, Ch. II-1 of SOLAS Convention, as amended by IMO Res. MSC.421(98).

2.17 PERIODICAL OPERATION AND INSPECTION OF WATERTIGHT DOORS, ETC., IN PASSENGER SHIPS

2.17.1 Operational tests of watertight doors, sidescuttles, valves and closing mechanisms of scuppers, ash-chutes and rubbish-chutes shall take place weekly. In ships in which the voyage exceeds one week in duration a complete set of operational tests shall be held before the voyage commences, and others thereafter at least once a week during the voyage.

2.17.2 All watertight doors, both hinged and power operated, in watertight bulkheads, in use at sea, shall be operated daily.

2.17.3 The watertight doors and all mechanisms and indicators connected therewith, all valves, the closing of which is necessary to make a compartment watertight, and all valves the operation of which is necessary for damage control cross connections shall be periodically inspected at sea at least once a week.

2.17.4 A record of all operational tests and inspections required by this Head shall be recorded in the log-book with an explicit record of any defects which may be disclosed.

2.18 PREVENTION AND CONTROL OF WATER INGRESS, ETC.

2.18.1 All watertight doors shall be kept closed during navigation except that they may be opened during navigation as specified in 2.18.3. Watertight doors of a width of more than 1.2 m in machinery spaces as permitted by 7.12 of the Rules, Part 3 – Hull Equipment may only be opened in the circumstances detailed in particular items of that Head. Any door which is opened in accordance with this paragraph shall be ready to be immediately closed.

2.18.2 Watertight doors located below the bulkhead deck of passenger ships and the freeboard deck of cargo ships having a maximum clear opening width of more than 1.2 m shall be kept closed during navigation, except for limited periods when absolutely necessary as determined by the *Register*.

2.18.3 A watertight door may be opened during navigation to permit the passage of passengers or crew, or when work in the immediate vicinity of the door necessitates it being opened. The door must be immediately closed when transit through the door is complete or when the task which necessitated it being open is finished. The *Register* shall authorize that such a watertight door may be opened during navigation only after careful consideration of the impact on ship operations and survivability taking into account guidance issued by the IMO. A watertight door permitted to be opened during navigation shall be clearly indicated in the ship's stability information and shall always be ready to be immediately closed.

2.18.4 Portable plates on bulkheads shall always be in place before the voyage commences, and shall not be removed during navigation except in case of urgent necessity at the discretion of the master. The necessary precautions shall be taken in replacing them to ensure that the joints are watertight. Power-operated sliding watertight doors permitted in machinery spaces in accordance with 7.12 of the Rules, Part 3 – Hull Equipment shall be closed before the voyage commences and shall remain closed during navigation except in case of urgent necessity at the discretion of the master.

2.18.5 Watertight doors fitted in watertight bulkheads dividing cargo between deck spaces in accordance with 7.12 of the Rules, Part 3 – Hull Equipment shall be closed before the voyage commences and shall be kept closed during navigation. The time at which such doors are opened or closed shall be recorded in officially prescribed log-book.

2.18.6 Gangway, cargo and fuelling ports fitted below the bulkhead deck of passenger ships and the freeboard deck of cargo ships, shall be effectively closed and secured watertight before the voyage commences, and shall be kept closed during navigation.

2.18.7 The following doors, located above the bulkhead deck of passenger ships and the freeboard deck of cargo ships, shall be closed and locked before the voyage commences and shall remain closed and locked until the ship is at its next berth:

- .1 cargo loading doors in the shell or the boundaries of enclosed superstructures;
- .2 bow visors fitted in positions as indicated in .1 above;
- .3 cargo loading doors in the collision bulkhead; and
- .4 ramps forming an alternative closure to those defined in the above sub-items .1 to .3 inclusive.

2.18.8 Provided that where a door cannot be opened or closed while the ship is at the berth such a door may be opened or left open while the ship approaches or draws away from the berth, but only so far as may be necessary to enable the door to be immediately operated. In any case, the inner bow door must be kept closed.

2.18.9 Notwithstanding the requirements of sub-items 2.18.7.1 and 2.18.7.4, the *Register* may authorize that particular doors can be opened at the discretion of the master, if necessary for the operation of the ship or the embarking and disembarking of passengers when the ship is at safe anchorage and provided that the safety of the ship is not impaired.

** Refer to the *Interim Explanatory Notes to the SOLAS Ch. II-1 Subdivision and Damage Stability Regulations*, MSC.1/Circ.1226

2.18.10 The master shall ensure that an effective system of supervision and reporting of the closing and opening of the doors referred to in item 2.18.7 is implemented.

2.18.11 The master shall ensure, before any voyage commences, that an entry in the officially prescribed log-book is made of the time the doors specified in item 2.18.12 are closed and the time at which particular doors are opened in accordance with 2.18.13.

2.18.12 Hinged doors, portable plates, sidescuttles, gangway, cargo and bunkering ports and other openings, which are required by this Head to be kept closed during navigation, shall be closed before the voyage commences. The time at which such doors are opened and closed (if permissible under provisions of this Head) shall be recorded in officially prescribed log-book.

2.18.13 Where in a between-decks, the sills of any of the sidescuttles referred to in 7.2 of the Rules, Part 3 – Hull Equipment are below a line drawn parallel to the bulkhead deck at side of passenger ships and the freeboard deck at side of cargo ships, and having its lowest point 1.4 m plus 2.5% of the breadth of the ship above the water when the voyage commences, all the sidescuttles in that between-decks shall be closed watertight and locked before the voyage commences, and they shall not be opened before the ship arrives at the next port. In the application of this item the appropriate allowance for fresh water may be made when applicable.

- .1 The time at which such sidescuttles are opened in port and closed and locked before the voyage commences shall be recorded in officially prescribed log-book.
- .2 For any ship that has one or more sidescuttles so placed that the requirements of this item would apply when it was floating at its deepest subdivision draught, the Register may indicate the limiting mean draught at which these sidescuttles will have their sills above the line drawn parallel to the bulkhead deck at side of passenger ships and the freeboard deck at side of cargo ships, and having its lowest point 1.4 m plus 25% of the breadth of the ship above the waterline corresponding to the limiting mean draught, and at which it will therefore be permissible for the voyage to commence without them being closed and locked and to be opened during navigation on the responsibility of the master. In tropical zones as defined in the International Convention on Load Lines in force, this limiting draught may be increased by 0.3 m.

2.18.14 Sidescuttles and their deadlights which will not be accessible during navigation shall be closed and secured before the voyage commences.

2.18.15 If cargo is carried in spaces appropriated alternatively to the carriage of cargo or passengers, the sidescuttles and their deadlights shall be closed watertight and locked before the cargo is shipped and the time at which such scuttles and deadlights are closed and locked shall be recorded in officially prescribed log-book.

2.18.16 When a rubbish-chute, etc. is not in use, both the cover and the valve required by Section 7 of the Rules, Part 3 – Hull Equipment shall be kept closed and secured.

2.19 SPECIAL REQUIREMENTS FOR RO-RO PASSENGER SHIPS

2.19.1 Special category spaces and ro-ro spaces shall be continuously patrolled or monitored by effective means, such as television surveillance, so that any movement of vehicles in adverse weather conditions and unauthorized access by passengers thereto can be detected during navigation.

2.19.2 Documented operating procedures for closing and securing all shell doors, loading doors and other closing appliances which, if left open or not properly secured, could, in the opinion of the Register, lead to flooding of a special category space or ro-ro space, shall be kept on board and posted at an appropriate place.

2.19.3 All accesses from the ro-ro deck and vehicle ramps that lead to spaces below the bulkhead deck shall be closed before the voyage commences and shall remain closed until the ship is at its next berth.

2.19.4 The master shall ensure that an effective system of supervision and reporting of the closing and opening of such accesses referred to in 2.19.3 is implemented.

2.19.5 The master shall ensure, before the voyage commences, that an entry in the log-book, as required by 2.18.12, is made of the time of the last closing of the accesses referred to in 2.19.3.

2.19.6 Notwithstanding the requirements of 2.19.3, the Register may permit some accesses to be opened during the voyage, but only for a period sufficient to permit through passage and, if required, for the essential working of the ship.

2.19.7 All transverse or longitudinal bulkheads which are taken into account as effective to confine the seawater accumulated on the ro-ro deck shall be in place and secured before the voyage commences and remain in place and secured until the ship is at its next berth.

2.19.8 Notwithstanding the requirements of 2.19.7, the Register may permit some accesses within such bulkheads to be opened during the voyage but only for sufficient time to permit through passage and, if required, for the essential working of the ship.

2.19.9 In all ro-ro passenger ships, the master or the designated officer shall ensure that, without the expressed consent of the master or the designated officer, no passengers are allowed access to an enclosed ro-ro deck during navigation.

2.20 ADDITIONAL REQUIREMENTS FOR PREVENTION AND CONTROL OF WATER INGRESS, ETC., IN CARGO SHIPS

2.20.1 Openings in the shell plating below the deck limiting the vertical extent of damage shall be kept permanently closed while at sea.

2.20.2 Notwithstanding the requirements of item 2.20.3, the *Register* may authorize that particular doors may be opened at the discretion of the master, if necessary for the operation of the ship and provided that the safety of the ship is not impaired.

2.20.3 Watertight doors or ramps fitted to internally subdivide large cargo spaces shall be closed before the voyage commences and shall be kept closed during navigation. The time at which such doors are opened or closed shall be recorded in officially prescribed log-book.

2.20.4 The use of access doors and hatch covers intended to ensure the watertight integrity of internal openings shall be authorized by the officer of the watch.

2.21 TIMBER DECK CARGO IN THE CONTEX OF DAMAGE STABILITY REQUIREMENTS

2.21.1 For ships carrying timber deck cargoes which have to fulfil the damage stability requirements of this part of the Rules, stability information shall include, among other damage stability related issues, a curve of minimum operating metacentric height (GM) versus draught or maximum allowable vertical centre of gravity (KG) versus draught which covers the requirements in 1.5.1.3.8 of the *Rules, Part 4 – Stability*.

2.21.2 To ensure the buoyancy of timber deck cargo can be justifiably credited in damage stability calculations, the integrity of the lashed timber deck cargo shall comply with the provisions of Chapters 3 and 4 of the CODE OF SAFE PRACTICE FOR SHIPS CARRYING TIMBER DECK CARGOES, 1991 (Resolution A.715(17)).

2.21.3 The height and extent of the timber deck cargo shall be in accordance with Chapter 3.2 of the CODE OF SAFE PRACTICE FOR SHIPS CARRYING TIMBER DECK CARGOES, 1991, and shall be at least stowed to the standard height of one superstructure.

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

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

2.21.6 The above described curve(s) applicable for conditions with timber deck cargo is/are to be developed as described in 1.5.1.6 of the *Rules, Part 4 – Stability*, and con-

sidering timber deck cargo at the deepest timber subdivision draught and at the partial timber subdivision draught only.

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

2.21.8 When considering the vertical extent of damage, the upper deck may be regarded as a horizontal subdivision (in accordance with 2.7.7.1 of this part of the Rules). Thus when calculating damage cases are limited vertically to the upper deck with the corresponding *v* factor, the timber deck cargo may be considered to remain buoyant with an assumed permeability of 0.25 at the deepest and partial draught. For damage extending above the upper deck the timber deck cargo buoyancy in way of the damage zone is to be ignored.

3 SPECIFIC STABILITY REQUIREMENTS FOR RO-RO PASSENGER SHIPS TO WHICH DIRECTIVE 2009/45/EC APPLIES

3.1 GENERAL

3.1.1 Purpose

The purpose of this Section is to lay down a uniform level of specific stability requirements for ro-ro passenger ships, which will improve the survivability of this type of vessel in case of collision damage and provide a high level of safety for the passengers and the crew, according to Directive 2003/25/EC of the European Parliament and of the Council of 14 April 2003 as amended by Commission Directive 2005/12/EC of 18 February 2005.

3.1.2 Definitions

For the purpose of the present Section the following definitions have been applied:

- .1 **ro-ro passenger ship** means a ship carrying more than 12 passengers, having ro-ro cargo spaces or special category spaces, as defined in Regulation II-2/A/2, Annex I of Directive 2009/45/EC;
- .2 **a passenger** is every person other than the master and the members of the crew or other persons employed or engaged in any capacity on board a ship on the business of that ship and other than a child under one year of age;
- .3 **international Conventions** means the 1974 International Convention for the Safety of Life at Sea (the SOLAS Convention - SOLAS 90 standard), and the 1966 International Convention on Load Lines, together with Protocols and amendments thereto in force;
- .4 **regular service** means a series of ro-ro passenger ship crossings serving traffic between the same two or more ports, which is operated either:
 - (i) according to a published timetable; or
 - (ii) with crossings so regular or frequent that they constitute a recognizable systematic series;
- .5 **Stockholm Agreement** means the Agreement concluded at Stockholm on 28 February 1996 in pursuance of SOLAS 95 Conference Resolution 14 'Regional agreements on specific stability requirements for ro-ro passenger ships', adopted on 29 November 1995;
- .6 **Administration of flag State** means the competent authorities of the State whose flag the ro-ro passenger ship is entitled to fly;

- .7 **international voyage** means a sea voyage from a port of a Member State to a port outside that Member State, or vice versa;
- .8 **specific stability requirements** means the stability requirements set out in Head 3.2;
- .9 **significant wave height (h_s)** is the average height of the highest third of wave heights observed over a given period;
- .10 **residual freeboard (f_r)** is the minimum distance between the damaged ro-ro deck and the final waterline at the location of the damage, without taking into account the additional effect of the sea water accumulated on the damaged ro-ro deck;
- .11 **barriers** means the bulkheads not extending in vertical direction to the level of the deck above, thus not preventing progressive flooding to occur through the gap between the deck and the upper end of the bulkhead when the level of accumulated water in damaged compartment reach the height of the bulkhead.

3.1.3

Scope of application

- .1 The requirements of this Section shall apply to all ro-ro passenger ships operating to or from a port of an EU Member State on a regular service, regardless of their flag, except those referred to in item 3.1.4;
- .2 Ro-ro passenger ships referred to in 3.1.3.1, operating exclusively in sea areas where the significant wave height is equal to or lower than 1.5 metres are not subjected to compliance with the requirements of this section.

3.1.4

Ro-ro passenger ships to which the provisions of Section 2 apply

- .1 Ro-ro passenger ships engaged on international voyages, arranged to be built in lieu to date as defined in item 2.1.5 of this Part of the Rules, shall comply with the requirements of Section 2 of this Part of the Rules, instead of the requirements of this Section.
- .2 For the ships referred to in sub-item .1 above, when applying the provisions of item 2.7.3, the values of TGZ_{max} and $TRange$ for ro-ro passenger ship shall be used when calculating $s_{final,i}$.
- .3 Considering the sub-item .1 above, the provisions of Section 2 shall apply also to ro-ro passenger ship of category A, according to Directive 2009/45/EC, if built on or after the date according to 2.1.5.

3.1.5 Significant wave heights and sea areas

- .1 The significant wave heights (h_s) shall be used for determining the height of water on the car deck when applying the specific stability requirements contained in 3.2. The figures of significant wave heights shall be those which are not exceeded by a probability of more than 10 % on a yearly basis.
- .2 The sea areas are those as defined in Article 4 of Directive 2009/45/EC, as amended.

3.1.6 Specific stability requirements

- .1 The specific stability requirements for the ships referred to in this Section are set out in Head 3.2.
- .2 In applying the requirements set out in 3.2, the guidelines set out in Appendix 1 shall be used, in so far this is practicable and compatible with the design of the ship in question.

3.1.7 Certificate of compliance

- .1 All ships complying with the requirements referred to in 3.1.6 will be given a *Certificate of compliance with the specific stability requirements* issued by the *Register*, indicating the significant wave height up to which the ship can satisfy those requirements.
- .2 The certificate shall remain valid as long as the ship operates in an area with the same or a lower value of significant wave height.

3.2 SPECIFIC STABILITY REQUIREMENTS

3.2.1 In addition to the requirements of Reg. II-1/B/8 of the SOLAS Convention (SOLAS 90 standard) relating to watertight subdivision and stability in damaged condition, all ro-ro passenger ships referred to in 3.1.3 shall comply with the requirements of this Head.

3.2.1.1 The provisions of SOLAS Reg. II-1/B/8.2.3 shall be complied with when taking into account the effect of a hypothetical amount of sea water which is assumed to have accumulated on the first deck above the design waterline of the ro-ro cargo space or the special cargo space as defined in SOLAS Regulation II-2/3 assumed to be damaged (hereinafter referred to as 'the damaged ro-ro deck'). The other requirements of Regulation II-1/B/8 need not be complied with in the application of the stability standard contained in this Head.

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

- a) the lowest point of the deck edge of the damaged compartment of the ro-ro deck; or
- b) when the 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 trim angles; as follows:
 - 0.5 m - if the residual freeboard f_r is 0.3 m or less,
 - 0.0 m - if the residual freeboard f_r is 2.0 m or more, and

intermediate values to be determined by linear interpolation, if the residual freeboard f_r is 0.3 m or more but less than 2.0 m,

where the residual freeboard f_r is the minimum distance between the damaged ro-ro deck and the final waterline at the location of the damage in the damage case being considered without taking into account the effect of the volume of assumed accumulated water on the damaged ro-ro deck.

3.2.1.2 When a high-efficiency drainage system is installed, the *Register* may allow a reduction in the height of the water surface.

3.2.1.3 For ships in geographically defined restricted areas of operation, the *Register* may reduce the height of the water surface prescribed in accordance with point 3.2.1.1 by substituting such height of the water surface by the following:

- .1 0.0 m if the significant wave height h_s defining the area concerned is 1.5 m or less;
- .2 the value determined in accordance with 3.2.1.1 if the significant wave height h_s defining the area concerned is 4.0 m or above;
- .3 intermediate values to be determined by linear interpolation if the significant wave height h_s defining the area concerned is 1.5 m or more but less than 4.0 m,

provided that the area of operation and, if applicable, the part of the year for which a certain value of the significant wave height h_s has been established are entered on the certificates and that the *Register* is satisfied that the defined area is represented by thus stated wave height which is not exceeded with a probability of more than 10 %.

3.2.1.4 As an alternative to the requirements of 3.2.1.1 or 3.2.1.3, the *Register* may exempt application of the requirements of these sub-items and accept proof, established by model tests carried out for an individual ship in accordance with the model test method, which appears in Head 3.3, justifying that the ship will not capsize with the assumed extent of damage as provided in SOLAS Regulation II-1/B/8.4 in the worst location being considered under 3.2.1.1, in an irregular seaway, and:

- .1 reference to acceptance of the results of the model test as an equivalence to compliance with 3.2.1.1 or 3.2.1.3 and the value of the significant wave height h_s used in the model tests shall be entered on the ship's certificates;

- .2 the information supplied to the master in accordance with SOLAS regulations II-1/B/8.7.1 and II-1/B/8.7.2, as developed for compliance with SOLAS regulations II-1/B/8.2.3 to II-1/B/8.2.3.4, shall apply unchanged for ro-ro passenger ships approved according to these requirements.

3.2.2 For assessing the effect of the volume of the assumed accumulated sea water on the damaged ro-ro deck in 3.2.1, the following provisions shall prevail:

3.2.2.1 A transverse or longitudinal bulkhead shall be considered intact 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 one-fifth of the breadth of the ship, as defined in SOLAS regulation II-1/2, and measured at right angles to the centreline at the level of the deepest subdivision load line;

3.2.2.2 In cases where the ship's hull is structurally partly widened for compliance with the provisions of this Head, the resulting increase of the value of one fifth of the breadth of it is to be used throughout, but shall not govern the location of existing bulkhead penetrations, piping systems, etc., which were acceptable prior to the widening;

3.2.2.3 The tightness of transverse or longitudinal bulkheads which are taken into account as effective to confine the assumed accumulated sea water in the compartment concerned in the damaged ro-ro deck shall be commensurate with the drainage system, and shall withstand hydrostatic pressure in accordance with the results of the damage calculation. Such bulkheads shall be at least 4 m in height unless the height of water is less than 0.5 m. In such cases the height of the bulkhead may be calculated in accordance with the following:

$$B_h = \delta \cdot h_w$$

where:

B_h is the bulkhead height; and
 h_w is the height of water.

In any event, the minimum height of the bulkhead should be not less than 2.2 m. However, in case of a ship with hanging car decks, the minimum height of the bulkhead shall be not less than the height to the underside of the hanging deck when in its lowered position;

3.2.2.4 For special arrangements such as, e.g., full-width hanging decks and wide side casings, other bulkhead heights may be accepted on the basis of detailed model tests;

3.2.2.5 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:

- .1 $A \geq 0.3 l$
where A is the total area of freeing ports on each side of the deck in m², and l is the length of the compartment in m;
- .2 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;

- .3 such freeing ports shall be located within the height of 0.6 m above the damaged ro-ro deck, and the lower edge of the ports shall be within 2 cm above the damaged ro-ro deck; and
- .4 such freeing ports shall be fitted with closing devices or flaps to prevent water entering the ro-ro deck whilst allowing water which may accumulate on the ro-ro deck to drain.

3.2.2.6 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 3.2.1.1, or 3.2.1.3.

3.2.3 When determining significant wave height, the wave heights referred to in 3.1.5 of this section shall be used.

3.2.3.1 For ships which are to be operated only for a shorter season, the Administration shall determine in agreement with the other country whose port is included in the ships route, the significant wave height to be used.

3.2.4 Model tests shall be conducted in accordance with the Head 3.3.

3.3 MODEL TEST METHOD

3.3.1 Objectives

This revised model test method is a revision of the method contained in the Appendix to the Annex to resolution 14 of the 1995 SOLAS Conference. Since the entry into force of the Stockholm Agreement a number of model tests has been carried out in accordance with the test method previously in force. During these tests a number of refinements in the procedures have been identified. This new model test method aims to include these refinements and, together with the appended Guidance Notes in Appendix 1 of this Part of the Rules, provide a more robust procedure for the assessment of survivability of a damaged ro-ro passenger ship in a seaway. In the tests provided for in 3.2.1.4, of the stability requirements included in 3.2, the ship should be capable of withstanding a seaway as defined in 3.3.4, hereunder in the worst-damage-case scenario.

3.3.2 Definitions

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

- a) L_{BP} - is the length between perpendiculars
b) B - is the moulded breadth of the ship
c) T_P - is the peak period, and
d) T_Z - is the zero crossing period.

3.3.3 Ship model

3.3.3.1 The model should copy the actual ship for both outer configuration and internal arrangement, in particular all

damaged spaces having an effect on the process of flooding and shipping of water. Intact draught, trim, heel and limiting operational KG corresponding to the worst damage case should be used. Furthermore, the test case(s) to be considered should represent the worst damage case(s) defined in accordance with SOLAS Regulation II-1/8.2.3.2 (SOLAS 90) with regard to the total area under the positive GZ curve and the centreline of the damage opening should be located within the following range:

- .1 $\pm 35\%$ L_{BP} from midship;
- .2 an additional test will be required for the worst damage within $\pm 10\%$ L_{BP} from midship if the damage case referred to in 3.3.3.1 is outside of $\pm 10\%$ L_{BP} from midship.

3.3.3.2 The model should comply with the following:

- .1 length between perpendiculars L_{BP} is to be at least 3 m or a length corresponding to a model scale of 1:40, whichever is greater, and the vertical extent up to at least three superstructure standard heights above the bulkhead (freeboard) deck;
- .2 hull thickness of flooded spaces should not exceed 4 mm;
- .3 in both intact and damaged conditions, the model should satisfy the correct displacement and draught marks (T_A , T_M , T_F , port and starboard) with a maximum tolerance in any one draught mark of + 2 mm. Draught marks forward and aft should be located as near FP and AP as practicable;
- .4 all damaged compartments and ro-ro spaces should be modelled with the correct surface and volume permeabilities (actual values and distributions) ensuring that floodwater mass and mass distribution are correctly represented;
- .5 the characteristics of motion of the actual ship should be modelled properly, paying particular attention to the intact GM tolerance and radii of gyration in roll and pitch motion. Both radii should be measured in air and be in the range of $0.35B$ to $0.4B$ for roll motion, and $0.2L_{OA}$ to $0.25L_{OA}$ for pitch motion;
- .6 main design features such as watertight bulkheads, air escapes, etc., above and below the bulkhead deck that can result in asymmetric flooding should be modelled properly as far as practicable to represent the real situation; Ventilating and cross-flooding arrangements should be constructed to a minimum cross section of 500 mm^2 ;
- .7 the shape of the damage opening should be as follows:
 - a) trapezoidal profile with side at 15° slope to the vertical and the width at the design waterline defined according to SOLAS Regulation II-1/8.4.1;
 - b) isosceles triangular profile in the horizontal plane with the height equal to

B/5 according to SOLAS Regulation II-1/8.4.2. If side casings are fitted within B/5, the damaged length in way of the side casings should not be less than 25 mm;

- c) notwithstanding the provisions of a) and b) above, all compartments taken as damaged in calculating the worst damage case(s) referred to in item 3.3.3.1 should be flooded in the model tests.

3.3.3.3 The model in the flooded equilibrium condition should be heeled by an additional angle corresponding to that induced by the heeling moment $M_h = \max(M_{pass}; M_{launch}) - M_{wind}$, but in no case should the final heel be less than 1° , towards damage. M_{pass} , M_{launch} and M_{wind} are as specified in SOLAS regulation II-1/8.2.3.4.

3.3.4 Procedure for experiments

3.3.4.1 The model should be tested in a long-crested irregular seaway defined by the JONSWAP spectrum with significant wave height h_s , a peak enhancement factor $\gamma = 3.3$ and a peak period

$$T_p = 4\sqrt{h_s}$$

$$T_z = T_p / 1.285$$

h_s is the significant wave height for the area of operation, which is not exceeded by a probability of more than 10 % on a yearly basis, but limited to a maximum of 4 m.

Furthermore,

- .1 the basin width should be sufficient to avoid contact or other interaction with the sides of the basin and is recommended not to be less than $L_{BP} + 2\text{ m}$;
- .2 the basin depth should be sufficient for proper wave modelling but should not be less than 1 m;
- .3 for a representative wave realisation to be used, measurements should be performed prior to the test at three different locations within the drift range;
- .4 the wave probe closer to the wave maker should be located at the position where the model is placed when the test starts;
- .5 variation in h_s and T_p should be within $\pm 5\%$ for the three locations; and
- .6 during the tests, for approval purposes, a tolerance of $\pm 2.5\%$ in h_s , $\pm 2.5\%$ in T_p , and $\pm 5\%$ in T_z should be allowed with reference to the probe closer to the wave maker.

3.3.4.2 The model should be free to drift and placed in beam seas (90° heading) with the damage hole facing the oncoming waves, with no mooring system permanently attached to the model used. To maintain a beam sea heading of approximately 90° during the model test the following requirements should be satisfied:

- .1 heading control lines, intended for minor adjustment, should be located at the cen-

tre line of the stem and stern, in a symmetrical fashion and at a level between the position of KG and the damaged waterline; and

- .2 the carriage speed should be equal to the actual drift speed of the model with speed adjustment made when necessary.

3.3.4.3 At least 10 experiments should be carried out. The test period for each experiment should be of a duration such that a stationary state is reached, but not less than 30 min in full-scale. A different wave realisation train should be used for each experiment.

3.3.5 Survival criteria

The model should be considered as surviving if a stationary state is reached for the successive test runs as required in sub-item 3.3.4.3. The model should be considered as capsized if angles of roll of more than 30° to the vertical axis or steady (average) heel greater than 20° for a period longer than three minutes full-scale occur, even if a stationary state is reached.

3.3.6 Test documentation

3.3.6.1 The model test programme should be approved by the *Register* in advance.

3.3.6.2 Tests should be documented by means of a report and a video or other visual records containing all relevant information on the model and the test results, which are to be approved by the Administration. These should include, as a minimum, the theoretical and measured wave spectra and statistics (h_s , T_p , T_z) of the wave elevation at the three different locations in the basin for a representative realisation, and for the tests with the model, the time series of main statistics of the measured wave elevation close to the wave maker and records of model roll, heave and pitch motions, and of the drift speed.

4 SPECIAL REQUIREMENTS FOR TYPE B SHIPS WITH REDUCED FREEBOARD

4.1 APPLICATION

4.1.1 Any type 'B' ship of over 100 metres in length with assigned freeboard less than those required under paragraph (7) of Regulation 27 Convention LL66 when loaded to its summer load water-line, shall be able to withstand the flooding of any compartment or compartments, with an assumed permeability of 0.95, consequent upon the damage assumptions specified under 4.3, and shall remain afloat in a satisfactory condition of equilibrium as specified under 4.4. In such a ship, if over 150 metres in length, the machinery space shall be treated as a floodable compartment, but with a permeability of 0.85.

4.1.2 For type 'B' ships which comply with the requirements of 4.1.1, 4.2, 4.3, and 4.4 of this Section, the freeboard values from Table B of Regulation of Convention LL66, shall not be reduced by more than 60 per cent of the difference between the 'B' and 'A' tabular values for the appropriate ship lengths.

4.1.3 Any type 'B' ship with assigned freeboard less than allowed under item 4.1.2, which may be reduced up to the total difference between the values in table A and those in table B of Regulation 28 Convention LL66, shall comply with following requirements:

- .1 item 4.1.1, 4.2 and 4.4 of this Section; and
- .2 item 4.3 of this Section, provided that throughout the length of the ship any one transverse bulkhead will be assumed to be damaged, such that two adjacent fore and aft compartments shall be flooded simultaneously, except that such damage will not apply to the boundary bulkheads of a machinery space.

4.1.4 In such a ship, if over 150 metres in length, the machinery space shall be treated as a floodable compartment, but with a permeability of 0.85.

4.2 INITIAL CONDITION OF LOADING

4.2.1 The initial condition of loading before flooding shall be determined as follows:

- .1 The ship is loaded to its summer load water-line on an imaginary even keel.
- .2 When calculating the vertical centre of gravity, the following principles apply:
 - .1 Homogeneous cargo is carried.
 - .2 All cargo compartments, except those referred to under .2.3 of this sub-item, but including compartments intended to be partially filled, shall be considered fully loaded except that in the

case of fluid cargoes each compartment shall be treated as 98 per cent full.

- .3 If the ship is intended to operate at its summer load water-line with empty compartments, such compartments shall be considered empty provided the height of the centre of gravity so calculated is not less than as calculated under .2.2 of this sub-item.
- .4 Fifty per cent of the ship's total capacity of tanks and spaces fitted to contain each type of consumables and stores is allowed for. It shall be assumed that for each type of liquid, at least one transverse pair or a single centre line tank has maximum free surface, and the tank or combination of tanks to be taken into account shall be those where the effect of free surfaces is the greatest; in each tank the centre of gravity of the contents shall be taken at the centre of volume of the tank. The remaining tanks shall be assumed either completely empty or completely filled, and the distribution of consumable liquids between these tanks shall be effected so as to obtain the greatest possible height above the keel for the centre of gravity.
- .5 Ballast water tanks shall normally be considered to be empty and no free surface correction shall be made for them.
- .6 Alternative treatment for free surface may be considered when developing the final condition for application of damage specified in 4.2.2:
 - (a) Method 1 (appropriate to virtual corrections). The virtual centre of gravity for the initial condition is determined as follows:
 - I. the loading condition shall be developed in accordance with sub-items .1 to .4;
 - II. the correction for the free surfaces is added to the vertical centre of gravity;
 - III. one virtual initial condition with all compartments empty is generated on summer load line draught with level trim, using the vertical centre of gravity from the above loading condition; and
 - IV. the damage cases will be checked for compliance with the damage stability criteria using the above initial condition.
 - (b) Method 2 (appropriate to the use of actual free surface moments

according to the assumed tank fillings for damage case). The virtual centre of gravity for the initial condition is determined as follows:

- I. the loading condition shall be developed in accordance with sub-items .1 to .4;
- II. one virtual initial condition for each damage case with liquid-filled compartments may be generated on summer load line draught with level trim, using the initial virtual condition with filled compartments generated on summer load line draught with level trim. Using the vertical centre of gravity and free surface correction from the above loading condition separate calculations for each damage case are performed, only the liquid-filled compartments to be damaged are left empty before damage; and
- III. the damage cases will be checked for compliance with the damage stability criteria using above initial conditions (one initial condition for each damage case).

- .7 Weights shall be calculated on the basis of the following values for specific gravities (t/m^3):

salt water	1.025
fresh water	1.000
oil fuel	0.950
diesel oil	0.900
lubricating oil	0.900

4.3 DAMAGE ASSUMPTIONS

4.3.1 The following principles regarding the character of the assumed damage apply:

4.3.1.1 The vertical extent of damage in all cases is assumed to be from the base line upwards without limit.

4.3.1.2 The transverse extent of damage is equal to $B/5$ or 11.5 metres, whichever is the lesser, measured inboard from the side of the ship perpendicularly to the centre line at the level of the summer load water-line.

4.3.1.3 If damage of a lesser extent than specified in sub-items 4.3.1.1 and 4.3.1.2 results in a more severe condition, such lesser extent shall be assumed.

4.3.1.4 Except where otherwise required by item 4.1.3 the flooding shall be confined to a single compartment between adjacent transverse bulkheads provided the inner longitudinal boundary of the compartment is not in a position within the transverse extent of assumed damage. Transverse boundary bulkheads of wing tanks, which do not extend over the full breadth of the ship shall be assumed not be damaged, provided they extend beyond the transverse extent of assumed damage prescribed in sub-item 4.3.1.2 of this item.

Where a transverse bulkhead forming the forward or aft limit of a wing tank or double bottom tank is not in line with the main transverse bulkhead of the adjacent inboard compartment, it is considered to form a step or recess in the main transverse bulkhead.

Such a step or recess should be assumed not to be damaged provided that, either:

- the longitudinal extent of the step or recess, measured from the plane of the main transverse bulkhead, is not more than 3.0 metres, or
- any longitudinal surface forming the step or recess is located inboard of the assumed damage.

Where, otherwise, the transverse and longitudinal bulkheads bounding a main inboard compartment are entirely inboard of the assumed damage position, damage is assumed to occur between the transverse bulkheads of the adjacent wing compartment. Any step or recess in such wing tank shall be treated as indicated above.

The step formed by the after peak bulkhead and the after peak tank top shall not be regarded as a step for the purpose of this Head.

If damaged wing compartments has openings into one or several holds, such as grain feeding holes, such hold or holds shall be considered as flooded simultaneously. Similarly in a ship designated for the carriage of fluid cargoes, if a side tank has openings into adjacent compartments, such adjacent compartments shall be considered as empty and flooded simultaneously. This provision is applicable even where such openings are fitted with closing appliances, except in the case of sluice valves fitted in bulkheads between tanks and where the valves are controlled from the deck. Manhole covers with closely-spaced belts are considered equivalent to the unpierced bulkhead except in the case of openings in topside tanks making the topside tanks common to the holds.

4.3.1.5 Where the flooding of any two adjacent fore and aft compartments is envisaged main transverse watertight bulkheads shall be spaced at least $1/3L^{2/3}$ or 14.5 metres whichever is the lesser, in order to be considered effective. Where transverse bulkheads are spaced at a lesser distance, one or more of these bulkheads shall be assumed as non-existent in order to achieve the minimum spacing between bulkheads.

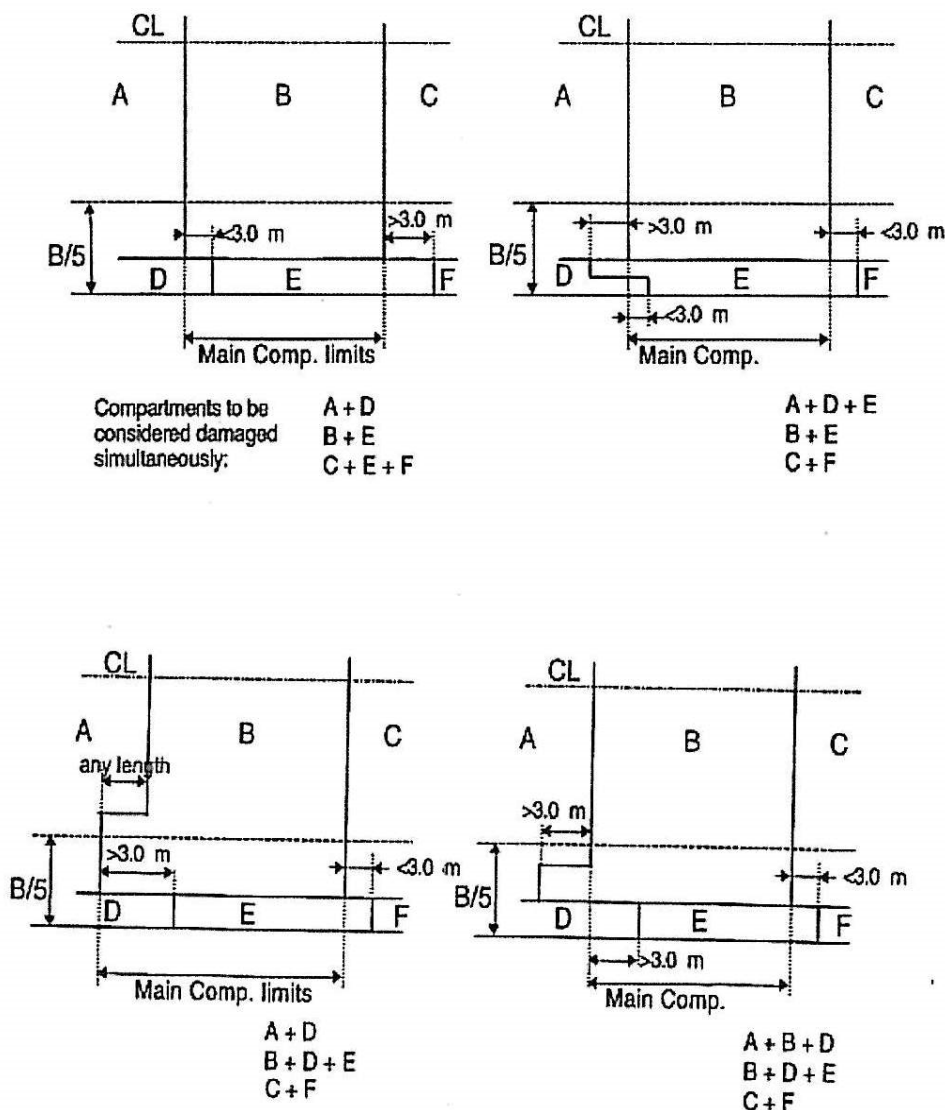


Fig. 4.3.1.4

Representative examples to clarify treatment of steps within the transverse extent of damage

4.4 CONDITION OF EQUILIBRIUM

4.4.1 The condition of equilibrium after flooding shall be regarded as satisfactory provided:

4.4.1.1 The final water-line after flooding, taking into account sinkage, heel, and trim, is below the lower edge of any opening through which progressive flooding may take place. Such openings shall include air pipes, ventilators and openings which are closed by means of watertight doors (even if they comply with Reg.12 of the *International Convention on Load Lines 1966 and Protocol of 1988*, as amended) or hatch covers (even if they comply with Reg.16 or Reg.19(4) of the *ICLL 1966 and Protocol of 1988*, as amended), and may exclude those openings closed by means of manhole covers and flush scuttles (which comply with Reg.19(4) of the *ICLL 1966 and Protocol of 1988*, as amended), remotely operated sliding watertight doors, and side

scuttles of the non-opening type (which comply with Reg.23 of the *ICLL 1966 and Protocol of 1988*, as amended).

However, in the case of doors separating a main machinery space from a steering gear compartment, watertight doors may be of a hinged, quick acting type kept closed at sea, whilst not in use, provided also that the lower sill of such doors is above the summer load waterline.

4.4.1.2 If pipes, ducts or tunnels are situated within the assumed extent of damage penetration as defined in 4.3.1.2, arrangements are to be made so that progressive flooding cannot thereby extend to compartments other than those assumed to be floodable in the calculation for each case of damage.

4.4.1.3 The angle of heel due to unsymmetrical flooding does not exceed 15 degrees. If no part of the deck is immersed, an angle of heel of up to 17 degrees may be accepted.

4.4.1.4 The metacentric height in the flooded condition is positive.

4.4.1.5 When any part of the deck outside the compartment assumed flooded in a particular case of damage is immersed, or in any case where the margin of stability in the flooded condition may be considered doubtful, the residual stability is to be investigated. It may be regarded as sufficient if the righting lever curve has a minimum range of 20 degrees beyond the position of equilibrium with a maximum righting lever of at least 0.1 metre within this range. The area under the righting lever curve within this range shall be not less than 0.0175 metre-radians.

To the satisfaction on *Register* shall be given consideration to the potential hazard presented by protected or unprotected openings which may become temporarily immersed within the range of residual stability.

4.4.1.6 The *Register* is satisfied that the stability is sufficient during intermediate stages of flooding.

4.4.1.7 Compliance with the residual stability criteria specified in sub-items .1, .3, .4 and .5 above is not required to be demonstrated in service loading conditions using a stability instrument, stability software or other approved method.

4.5 SHIPS WITH ASSIGNED REDUCED FREEBOARD INTENDED TO CARRY DECK CARGO

4.5.1 This Head pertains to ships intended to carry deck cargo and assigned or reassigned reduced freeboards in accordance with Regulation 27 of the International Convention on Load Lines, 1966 (ICLL 1966) or the ICLL 1966 as amended by the 1988 Protocol.

4.5.2 In .6 and .7 of the footnotes to 2.1.1, ships shown to comply with ICLL 1966 Regulation 27 as applied in compliance with IMO Res. A.320 (IX) and A.514 (13), may be excluded from the application of Section 2 requirements, except if they carry deck cargo.

4.5.3 Therefore ships identified in 4.5.1 above shall:

- .1 according to the assigned reduced freeboards, comply with damage stability requirements of Regulation 27 of ICLL 1966 and the 1988 Protocol to the ICLL 1966; and
- .2 according to the intended deck cargo capacity, be provided with the limiting GM or KG curve required by 1.5.1.6 of the *Rules, Part 4 – Stability*, in compliance with the probabilistic damage stability analysis of Section 2 of this part of the Rules.

4.5.4 The KG used for demonstrating compliance with the criteria in 4.5.3.1 shall be the same as that used for the criteria in 4.5.3.2 at the deepest subdivision load line.

5 DAMAGE STABILITY REQUIREMENTS APPLICABLE TO BULK CARRIERS

of equilibrium after flooding shall satisfy the relevant provisions of that Protocol.

5.1 Bulk carriers of 150 m in length and upwards of single-side skin construction, designed to carry solid bulk cargoes having a density of 1,000 kg/m³ and above, constructed on or after 1 July 1999 shall, when loaded to the summer load line, be able to withstand flooding of any one cargo hold in all loading conditions and remain afloat in a satisfactory condition of equilibrium, as specified in 5.4.

5.2 Bulk carriers of 150 m in length and upwards of double-side skin construction in which any part of longitudinal bulkhead is located within B/5 or 11.5 m, whichever is less, inboard from the ship's side at right angle to the centreline at the assigned summer load line, designed to carry solid bulk cargoes having a density of 1,000 kg/m³ and above, constructed on or after 1 July 2006 shall, when loaded to the summer load line, be able to withstand flooding of any one cargo hold in all loading conditions and remain afloat in a satisfactory condition of equilibrium, as specified in 5.4.

5.3 Bulk carriers of 150 m in length and upwards of single-side skin construction, carrying solid bulk cargoes having a density of 1,780 kg/m³ and above, constructed before 1 July 1999 shall, when loaded to the summer load line, be able to withstand flooding of the foremost cargo hold in all loading conditions and remain afloat in a satisfactory condition of equilibrium, as specified in 5.4.

5.4 Subject to the provisions of 5.7, the condition of equilibrium after flooding shall satisfy the condition of equilibrium laid down in the annex to resolution A. 320(IX) - Regulation equivalent to regulation 27 of the International Convention on Load Lines, 1966, as amended by resolution A.514(13). The assumed flooding need only take into account flooding of the cargo hold space to the water level outside the ship in that flooded condition. The permeability of a loaded hold shall be assumed as 0.9 and the permeability of an empty hold shall be assumed as 0.95, unless a permeability relevant to a particular cargo is assumed for the volume of a flooded hold occupied by cargo and a permeability of 0.95 is assumed for the remaining empty volume of the hold.

5.5 Bulk carriers constructed before 1 July 1999, which have been assigned a reduced freeboard in compliance with regulation 27(7) of the International Convention on Load Lines, 1966, as adopted on 5 April 1966, may be considered as complying with 5.3.

5.6 Bulk carriers which have been assigned a reduced freeboard in compliance with the provisions of paragraph (8) of the regulation equivalent to regulation 27 of the International Convention on Load Lines, 1966, adopted by resolution A.320(IX), as amended by resolution A.514(13), may be considered as complying with 5.1 or 5.2, as appropriate.

5.7 On bulk carriers which have been assigned reduced freeboard in compliance with the provisions of regulation 27(8) of Annex B of the Protocol of 1988 relating to the International Convention on Load Lines, 1966, the condition

6 SPECIAL PURPOSE SHIPS *

6.1 APPLICATION

The Section applies to every new special purpose ship of not less than 500 gross tonnage, constructed on or after 1 July 2010. The *Register* may also apply these provisions as far as reasonable and practicable to special purpose ships of less than 500 gross tonnage. The special purpose ships constructed before 1 July 2010 are to be in compliance with the requirements set up in previous edition of this Part of the Rules.

6.2 DEFINITIONS

For the purpose of this Section the definitions given hereunder apply:

6.2.1 Special personnel - means all persons who are not passengers or members of the crew or children of under one year of age and who are carried on board in connection with the special purpose of that ship or because of special work being carried out aboard that ship. Wherever in this Section the number of special personnel appears as a parameter it should include the number of passengers carried on board which may not exceed 12.

6.2.2 Passenger - means every person other than:

- .1 the master and the members of the crew or other persons employed or engaged in any capacity on board a ship on the business of that ship; and
- .2a children under one year of age.

6.2.3 Crew - means all persons carried on board the ship to provide navigation and maintenance of the ship, its machinery, systems and arrangements essential for propulsion and safe navigation or to provide services for other persons on board.

6.2.4 Special purpose ship - means a mechanically self-propelled ship which by reason of its function carries on board more than 12 special personnel including passengers. Where a ship carries more than 12 passengers, as defined in 6.2.2, the ship should not be considered a special purpose ship as it is a passenger ship as defined by SOLAS. Special purpose ships to which this Section applies include the following types:

- .1 ships engaged in research, expeditions and survey;
- .2 ships for training of marine personnel;
- .3 whale and fish factory ships not engaged in catching;
- .4 ships processing other living resources of the sea, not engaged in catching;
- .5 other ships with design features and modes of operation similar to ships referred to in .1 to .4 which in the opinion of the *Register* may be referred to this group.

6.3 SUBDIVISION AND DAMAGE STABILITY

6.3.1 The subdivision and damage stability of special purpose ships should in general be in accordance with the Section 2 of this Part of the *Rules* where the ship is considered a passenger ship, and special personnel are considered passengers, with an R-value calculated in accordance with sub-item 2.4.2.3 as follows:

- .1 where the ship is certified to carry 240 persons or more, the R-value is assigned as R;
- .2 where the ship is certified to carry not more than 60 persons, the R-value is assigned as 0.8R; and
- .3 for more than 60 (but not more than 240) persons, the R-value should be determined by linear interpolation between the R-values given in .1 and .2 above.

6.3.2 For special purpose ships to which 6.3.1.1 applies, the requirements of the Section 2 of this Part of the *Rules* should be applied as though the ship is a passenger ship and the special personnel are passengers. However, the provisions of the Heads 2.12 and 2.15 are not applicable.

6.3.3 For special purpose ships to which 6.3.1.2 or 6.3.1.3 applies, except as provided in 6.3.4, the provisions of the Section 2 of this Part of the *Rules* should be applied as though the ship is a cargo ship and the special personnel are crew. However, the requirements of the Heads 2.9 and 2.10 need not be applied and the provisions of the Heads 2.12 and 2.15 are not applicable.

6.3.4 All special purpose ships should comply with the provisions of the Heads 2.11, 2.16, 2.17 and SOLAS regulations II-1/13, II-1/20 and II-1/35-1, as though the ship is a passenger ship.

* Refer to Res. MSC.266(84) Code of Safety for Special Purpose Ships, 2008

7 OFFSHORE SUPPLY VESSELS *

7.1 APPLICATION

7.1.1 Every new decked offshore supply vessel of 24 m and over but not more than 100 m in length should comply with the provisions of this Section. The intact and damage stability of a vessel of more than 100 m in length should be to the satisfaction of the *Register*.

7.1.2 Provisions for offshore supply vessels carrying more than 12 industrial personnel are not included in this Section.

7.1.3 When an offshore supply vessel is used for special purposes, such as diving assistance or oceanographic surveys, the persons on board in connection with these special purposes should be treated as special personnel, as is defined in Section 6 of this Part of the Rules.

7.1.4 Vessels fitted with dynamic positioning equipment should comply with the guidelines developed by the IMO **

7.1.5 Relaxations from the requirements of this Section may be permitted by the *Register* for vessels engaged in near-coastal voyages off domestic coasts provided the operating conditions are, in the opinion of the *Register* such as to render compliance with this Section unreasonable or unnecessary.

7.1.6 Unless expressly provided otherwise, an existing offshore supply vessel should be required to comply with this Section far as is practicable in the opinion of the *Register*.

7.1.7 Where a vessel other than an offshore supply vessel, as defined in 7.2.1, is employed on a similar service, the *Register* should determine the extent to which compliance with this Section is required.

7.2 DEFINITIONS

7.2.1 **Offshore supply vessel** means a vessel:

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

7.2.2 **New vessel** means a vessel the keel of which is laid or which is at a similar stage of construction on or after 1 June 2007.

7.2.3 **Existing vessel** means a vessel which is not a new vessel.

7.2.4 The terms 'length (L) of a vessel', 'breadth (B) of a vessel', 'perpendiculars', 'weathertight' and 'summer load line' have the meanings as defined in the Protocol of 1988 relating to the International Convention on Load Lines, 1966, as amended.

7.2.5 **Offshore installation** means a marine structure located at an offshore site.

7.2.6 **Near-coastal voyage** means a voyage in the vicinity of the coast of a State as defined by the Administration of that State.

7.3 SUBDIVISION AND DAMAGE STABILITY, GENERAL

7.3.1 Taking into account, as initial conditions before flooding, the standard loading conditions required by the relevant provisions 3.12.7 and 3.12.8 in the *Rules, Part 4 – Stability* and the damage assumptions in 7.4, the vessel should comply with the damage stability criteria as specified in 7.5.

7.4 DAMAGE ASSUMPTIONS

7.4.1 Damage should be assumed to occur anywhere in the vessel's length between transverse watertight bulkheads.

7.4.2 The assumed extent of damage should be as follows:

- .1 longitudinal extent:
 - .1 for a vessel the keel of which is laid or which is at a similar stage of construction*** before 22 November 2012:
 - with length (L) not greater than 43 m: 10% of L; and
 - with length (L) greater than 43 m: 3 m plus 3% of L;
 - .2 for a vessel the keel of which is laid or which is at a similar stage of construction on or after 22 November 2012:
 - with length (L) not greater than 43 m: 10% of L;
 - with length (L) greater than 43 m and less than 80 m: 3 m plus 3% of L; and
 - with length (L) from 80 m to 100 m: $1/3L^{2/3}$;

* Refer to Res. MSC.235(82)- Guidelines for the design and Construction of offshore supply vessels, 2006 – Section 3 – Subdivision and damage stability.

** Refer to the Guidelines for vessels with dynamic positioning systems (MSC/Circ.645) and Guidelines for dynamic positioning system (DP) operator training (MSC/Circ.738).

*** A similar stage of construction means the stage at which:

- .1 construction identifiable with a specific ship begins; and
- .2 assembly of that ship has commenced comprising at least 50 tonnes or one per cent of the estimated mass of all structural material, whichever is less.

- .2 transverse extent:
- .1 for a vessel the keel of which is laid or which is at a similar stage of construction before 22 November 2012: 760 mm measured inboard from the side of the vessel perpendicularly to the centreline at the level of the summer load waterline;
 - .2 for a vessel the keel of which is laid or which is at a similar stage of construction on or after 22 November 2012:
 - with length (L) less than 80 m: 760 mm; and
 - with length (L) from 80 m to 100 m: B/20, but not less than 760 mm; The transverse extent should be measured inboard from the side of the vessel perpendicularly to the centreline at the level of the summer load waterline; and
 - .3 vertical extent: from the underside of the cargo deck, or the continuation thereof, for the full depth of the vessel.

7.4.3 For a vessel the keel of which is laid or which is at a similar stage of construction:

- .1 before 22 November 2012:
A transverse watertight bulkhead extending from the vessel's side to a distance inboard of 760 mm or more at the level of the summer load line joining longitudinal watertight bulkheads may be considered as a transverse watertight bulkhead for the purpose of the damage calculations.
- .2 on or after 22 November 2012:

For a vessel with length (L) less than 80 m, a transverse watertight bulkhead extending from the vessel's side to a distance inboard of 760 mm or more at the level of the summer load line joining longitudinal watertight bulkheads may be considered as a transverse watertight bulkhead for the purpose of the damage calculations. For a vessel with length (L) from 80 m to 100 m, a transverse watertight bulkhead extending from the vessel's side to a distance inboard of B/20 or more (but not less than 760 mm) at the level of the summer load line joining longitudinal watertight bulkheads may be considered as a transverse watertight bulkhead for the purpose of the damage calculations.

7.4.4 If pipes, ducts or tunnels are situated within the assumed extent of damage, arrangements should be made to ensure that progressive flooding cannot thereby extend to compartments other than those assumed to be floodable for each case of damage.

7.4.5 If damage of a lesser extent than that specified in 7.4.2 results in a more severe condition, such lesser extent should be assumed.

7.4.6 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 3.05 m, the double bottom or side tanks adjacent to the

stepped portion of the transverse watertight bulkhead should be considered as flooded simultaneously.

7.4.7 If the distance between adjacent transverse watertight bulkheads or the distance between the transverse planes passing through the nearest stepped portions of the bulkheads is less than the longitudinal extent of damage given in 7.4.2.1, only one of these bulkheads should be regarded as effective for the purpose of 7.4.1.

7.5 DAMAGE STABILITY CRITERIA

7.5.1 The final waterline, taking into account sinkage, heel and trim, should be below the lower edge of any opening through which progressive flooding may take place. Such openings should include air pipes and those which are capable of being closed by means of weathertight doors or hatch covers and may exclude those openings closed by means of watertight manhole covers and flush scuttles, small watertight cargo tank hatch covers which maintain the high integrity of the deck, remotely operated watertight sliding doors and sidescuttles of the non-opening type.

7.5.2 In the final stage of flooding, the angle of heel due to unsymmetrical flooding should not exceed 15°. This angle may be increased up to 17° if no deck immersion occurs.

7.5.3 The stability in the final stage of flooding should be investigated and may be regarded as sufficient if the righting lever curve has, at least, a range of 20° beyond the position of equilibrium in association with a maximum residual righting lever of at least 100 mm within this range. Unprotected openings should not become immersed at an angle of heel within the prescribed minimum range of residual stability unless the space in question has been included as a floodable space in calculations for damage stability. Within this range, immersion of any of the openings referred to in 7.5.1 and any other openings capable of being closed weathertight may be authorized.

7.5.4 The *Register* should be satisfied that the stability is sufficient during intermediate stages of flooding.

7.6 ASSUMPTIONS FOR CALCULATING DAMAGE STABILITY

7.6.1 Compliance with 7.5 should be confirmed by calculations which take into consideration the design characteristics of the vessel, the arrangements, configuration and permeability of the damaged compartments and the distribution, specific gravities and the free surface effect of liquids.

7.6.2 The permeability of compartments assumed to be damaged should be as follows:

Spaces	Permeability
Appropriated to stores	0.60
Occupied by accommodation	0.95
Occupied by machinery	0.85
Void spaces	0.95
Intended for dry cargo	0.95

The permeability of tanks should be consistent with the amount of liquid carried, as shown in the loading conditions specified in 7.3.1. The permeability of empty tanks should be assumed to be not less than 0.95.

7.6.3 The free surface effect should be calculated at an angle of heel of 5° for each individual compartment, or the effect of free liquid in a tank should be calculated over the range of positive residual righting arm, by assessing the shift of liquids by moment of transference calculations.

7.6.4 Free surface for each type of consumable liquid should be assumed for at least one transverse pair of tanks or a single centreline tank. The tank or tanks to be taken into account should be those where the effect of free surface is the greatest.

7.6.5 Alternatively, the actual free surface effect may be used provided the methods of calculation are acceptable to the *Register*.

7.7 SUBDIVISION

7.7.1 The machinery spaces and other working and living spaces in the hull should be separated by watertight bulkheads.

7.7.2 Arrangements made to maintain the watertight integrity of openings in watertight subdivisions should comply with the relevant provisions for cargo ships contained in Head 7.12 of the *Rules, Part 3 – Hull Equipment*.

7.7.3 A collision bulkhead should be fitted that complies with relevant provisions for cargo ships of Head 10.1 of the *Rules, Part 2 – Hull*.

7.7.4 An afterpeak bulkhead should be fitted and made watertight up to the freeboard deck. The afterpeak bulkhead may, however, be stepped below the freeboard deck, provided the degree of safety of the vessel as regards subdivision is not thereby diminished.

8 HIGH SPEED CRAFTS

8.1 DYNAMICALLY SUPPORTED CRAFTS (DSC)

Dynamically supported craft (DSC), as is defined in 2.31.2 of the *Rules, Part 1 – General Requirements, Chapter 1 – General information*, constructed before 1 January 1996 shall be in compliance with requirements of IMO Res. A.373(X) as amended.

8.2 HIGH SPEED CRAFTS, ACCORDING TO HSC 1994

High speed craft, as is defined in 2.31.1 of the *Rules, Part 1 – General Requirements, Chapter 1 – General information*, the keel of which is laid or which is at a similar stage of construction on or after 1 January 1996 but before 1 July 2002 shall be in compliance with requirements of IMO Res. MSC.36(63) as amended.

8.3 HIGH SPEED CRAFTS, ACCORDING TO HSC 2000

High speed craft, as is defined in 2.31.1 of the *Rules, Part 1 – General Requirements, Chapter 1 – General information*, the keel of which is laid or which is at a similar stage of construction on or after 1 July 2002 shall be in compliance with requirements of the *Rules, Part 28 – High speed craft*.

9 TANKERS

9.1 SUBDIVISION AND STABILITY*

9.1.1 Every new oil tanker shall comply with the subdivision and damage stability criteria as specified in 9.3 of this Section, after the assumed side or bottom damage as specified in 9.2 of this Section, for any operating draught reflecting actual partial or full load conditions consistent with trim and strength of the ship as well as specific gravities of the cargo. Such damage shall be applied to all conceivable locations along the length of the ship as follows:

- .1 in tankers of more than 225 m in length, anywhere in the ship's length;
- .2 in tankers of more than 150 m, but not exceeding 225 m in length, anywhere in the ship's length except involving either after or forward bulkhead bounding the machinery space located aft. The machinery space shall be treated as a single floodable compartment; and
- .3 in tankers not exceeding 150 m in length, anywhere in the ship's length between adjacent transverse bulkheads with the exception of the machinery space. For tankers of 100 m or less in length where all requirements of 9.3 of this Section cannot be fulfilled without materially impairing the operational qualities of the ship, *Register* may allow relaxations from these requirements.

Ballast conditions where the tanker is not carrying oil in cargo tanks, excluding any oil residues, shall not be considered.

9.2 DAMAGE ASSUMPTIONS

9.2.1 The following provisions regarding the extent and the character of the assumed damage shall apply:

Table 1

.1	SIDE DAMAGE	
.1.1	Longitudinal extent:	$\frac{1}{3} L^{\frac{2}{3}}$ or 14.5 metres, whichever is less
.1.2	Transverse extent (inboard from the ship's side at right angles to the centreline at the level of the summer load line):	$\frac{B}{5}$ or 11.5 metres, whichever is less
.1.3	Vertical extent:	From the moulded line of the bottom shell plating at centreline, upwards without limit

* Additionally to requirements of this Section, every tanker with L>150 m shall fulfil Damage stability requirements of regulation 27 of the 1988 Load Lines Protocol, as a type "A" ship.

Table 2

		BOTTOM DAMAGE	
.2		For 0.3 L from the forward perpendicular of the ship	Any other part of the ship
.2.1	Longitudinal extent:	$\frac{1}{3} L^{\frac{2}{3}}$ or 14.5 metres, whichever is less	$\frac{1}{3} L^{\frac{2}{3}}$ or 5 metres, whichever is less
.2.2	Transverse extent:	$\frac{B}{6}$ or 10 metres, whichever is less	$\frac{B}{6}$ or 5 metres, whichever is less
.2.3	Vertical extent:	$\frac{B}{15}$ or 6 metres, whichever is less measured from the moulded line of the bottom shell plating at centreline	$\frac{B}{15}$ or 6 metres, whichever is less measured from the moulded line of the bottom shell plating at centreline

9.2.2 Ships between 20,000 to 75,000 tons deadweight are to survive bottom-raking damage extending 0.4L measured from forward perpendicular.

Ships of 75,000 tons deadweight and above are to survive bottom-raking damage extending 0.6L measured from forward perpendicular.

For both of the above cases:

- Transverse extent: B/3 anywhere in the bottom.
- Vertical extent: Breach of the outer hull.

9.2.3 If any damage of a lesser extent than the maximum extent of damage specified in 9.2.1 and 9.2.2 would result in a more severe condition, such damage shall be considered.

9.2.4 Where the damage involving transverse bulkheads is envisaged as specified in 9.2.1 and 9.2.2, transverse watertight bulkheads shall be spaced at least at a distance equal to the longitudinal extent of assumed damage specified in 9.2.1 in order to be considered effective. Where transverse bulkheads are spaced at a lesser distance, one or more of these bulkheads within such extent of damage shall be assumed as non-existent for the purpose of determining flooded compartments.

9.2.5 Where the damage between adjacent transverse watertight bulkheads is envisaged as specified in 9.2.3, no main transverse bulkhead or a transverse bulkhead bounding side tanks or double bottom tanks shall be assumed damaged, unless:

- .1 the spacing of the adjacent bulkheads is less than the longitudinal extent of assumed damage specified in 9.2.1 ; or
- .2 there is a step or recess in a transverse bulkhead of more than 3.05 m in length, located within the extent of penetration of assumed damage. The step formed by the

after peak bulkhead and after peak tank top shall not be regarded as a step for the purpose of this regulation.

9.2.6 If pipes, ducts or tunnels are situated within the assumed extent of damage, arrangements shall be made so that progressive flooding cannot thereby extend to compartments other than those assumed to be floodable for each case of damage.

9.2.7 For the purpose of determined the extent of assumed damage in 9.2.1, suction wells may be neglected, provided such wells are not excessive in area and extend below the tank for a minimum distance and in no case more than half the height of the double bottom.

9.3 DAMAGE STABILITY CRITERIA

9.3.1 Oil tankers shall be regarded as complying with the damage stability criteria if the following requirements are met:

9.3.2 The final waterline, taking into account sinkage, heel and trim, shall be below the lower edge of any opening through which progressive flooding may take place. Such openings shall include air-pipes and those which are closed by means of weathertight doors or hatch covers and may exclude those openings closed by means of watertight manhole covers and flush scuttles, small watertight cargo tank hatch covers which maintain the high integrity of the deck, remotely operated watertight sliding doors, and sidescuttles of the non-opening type.

9.3.3 In the final stage of flooding, the angle of heel due to unsymmetrical flooding shall not exceed 25°, provided that this angle may be increased up to 30° if no deck edge immersion occurs.

9.3.4 The stability in the final stage of flooding shall be investigated and may be regarded as a sufficient if the righting lever curve has at least a range of 20° beyond the position of equilibrium in association with a maximum residual righting lever of at least 0.1 m within the 20° range; the area under the curve within this range shall not be less than 0.0175 metre radians. Unprotected openings shall not be immersed within this range unless the space concerned is assumed to be flooded. Within this range, the immersion of any of the openings listed in 9.3.2 and other openings capable of being closed weathertight may be permitted.*

9.3.5 The *Register* shall be satisfied that the stability is sufficient during intermediate stages of flooding.

9.3.6 Equalization arrangements requiring mechanical aids such as valves or cross-leveling pipes, if fitted, shall not be considered for the purpose of reducing an angle of heel or attaining the minimum range of residual stability to meet the requirements of 9.3.2, 9.3.3 and 9.3.4 and sufficient residual stability shall be maintained during all stages where

equalization is used. Space which are linked by ducts of a large cross-sectional area may be considered to be common.

9.4 ASSUMPTION FOR CALCULATING DAMAGE STABILITY

9.4.1 The requirements of 9.1 shall be confirmed by calculations which take into consideration the design characteristics of the ship, the arrangements, configuration and contents of the damaged compartments; and the distribution, specific gravities and the free surface effect of liquids. The calculations shall be based on the following:

- .1 Account shall be taken of any empty or partially filled tank, the specific gravity of cargoes carried, as well as any outflow of liquids from damaged compartments.
- .2 The permeabilities assumed for space flooded as a result of damage shall be as follows:

Space	Permeabilities
Appropriated to stores	0.60
Occupied by accommodation	0.95
Occupied by machinery	0.85
Voids	0.95
Intended for consumable liquids	0 to 0.95**
Intended for other liquids	0 to 0.90**

9.4.2 The buoyancy of any superstructure directly above the side damage shall be disregarded. The unflooded parts of superstructures beyond the extent of damage, however, may be taken into consideration provided that they are separated from the damaged space by watertight bulkheads and the requirements of 9.3 in respect of these intact space are complied with. Hinged watertight doors may be acceptable in watertight bulkheads in the superstructure.

9.4.3 The free surface effect shall be calculated at an angle of heel of 5° for each individual compartment. The *Register* may require or allow the free surface corrections to be calculated at an angle of heel greater than 5° for partially filled tanks.

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

9.5 STABILITY INFORMATION

9.5.1 The master of every new oil tankers and the person in charge of a new non-self-propelled oil tanker to

* Other openings capable of being closed weathertight do not include ventilators (complying with ILLC 19(4)) that for operational reasons have to remain open to supply air to the engine room or emergency generator room (if the same is considered buoyant in the stability calculation or protecting openings leading below) for the effective operation of the ship.

** The permeability of partially filled compartments shall be consistent with the amount of liquid carried in the compartment. Whenever damage penetrates a tank containing liquids, it shall be assumed that the contents are completely lost from that compartment and replaced by salt water up to the level of the final plane of equilibrium.

which this Section of the Rules applies shall be supplied in an approved form with:

- .1 information relative to loading and distribution of cargo necessary to ensure compliance with the provisions of this regulation; and
- .2 data on the ability of the ship to comply with damage stability criteria as determined by this regulation, including the effect of relaxation that may have been allowed under 9.1.1.1.

9.5.2 Maximum allowable VCG curve(s), for the purpose of checking damage stability compliance, are to be included in the stability manual, unless the Loading Manual includes, in approved form, all of the conditions intended to be used.

9.6 ACCIDENTAL OIL OUTFLOW PERFORMANCE

9.6.1 This Head shall apply to oil tankers delivered on or after 1 January 2010, as defined in 9.6.2.

9.6.2 *Oil tanker delivered on or after 1 January 2010* means an oil tanker:

- .1 for which the building contract is placed on or after 1 January 2007; or
- .2 in the absence of a building contract, the keel of which is laid or which is at a similar stage of construction on or after 1 July 2007; or
- .3 the delivery of which is on or after 1 January 2010; or
- .4 which has undergone a major conversion:
 - .1 for which the contract is placed on or after 1 January 2007; or
 - .2 in the absence of a contract, the construction work of which is begun on or after 1 July 2007; or
 - .3 which is completed on or after 1 January 2010.

9.6.3 For the purpose of this Head, the additional definitions shall apply, as follows:

- .1 "Load line draught (d_s)" is the vertical distance, in metres, from the moulded baseline at mid-length to the waterline corresponding to the summer freeboard to be assigned to the ship. Calculations pertaining to this Head should be based on draught d_s , notwithstanding assigned draughts that may exceed d_s , such as the tropical loadline.
- .2 "Waterline (d_B)" is the vertical distance, in metres, from the moulded baseline at mid-length to the waterline corresponding to 30% of the depth D_S .
- .3 "Breadth (B_S)" is the greatest moulded breadth of the ship, in metres, at or below the deepest load line d_s .

- .4 "Breadth (B_B)" is the greatest moulded breadth of the ship, in metres, at or below the waterline d_B .
- .5 "Depth (D_S)" is the moulded depth, in metres, measured at mid-length to the upper deck at side.
- .6 "Length (L)", "mid-length", and "deadweight (DW)" are as defined in items 1.2.1, 2.2.2 and 1.2.15, respectively.
- .7 "h" is the minimum distance between the bottom of the cargo tanks and the moulded line of the bottom shell plating measured at right angles to the bottom shell plating; it is not to be less than $h = B/15$ (m) or $h = 2.0$ m, whichever is the lesser, with minimum value of $h = 1.0$ m.

9.6.4 To provide adequate protection against oil pollution in the event of collision or stranding the following shall be complied with:

- .1 for oil tankers of 5,000 tonnes deadweight (DWT) and above, the mean oil outflow parameter shall be as follows:

$$O_M \leq 0.015 \quad \text{for } C \leq 200,000 \text{ m}^3$$

$$O_M < 0.012 + (0.003/200,000) (400,000 - C) \quad \text{for } 200,000 \text{ m}^3 < C < 400,000 \text{ m}^3$$

$$O_M \leq 0.012 \quad \text{for } C > 400,000 \text{ m}^3$$

for combination carriers between 5,000 tonnes deadweight (DWT) and 200,000 m³ capacity, the mean oil outflow parameter may be applied, provided calculations are submitted to the satisfaction of the R.O., demonstrating that after accounting for its increased structural strength, the combination carrier has at least equivalent oil out flow performance to a standard double hull tanker of the same size having a $O_M \leq 0.015$.

$$O_M \leq 0.021 \quad \text{for } C < 100,000 \text{ m}^3$$

$$O_M \leq 0.015 + (0.006/100,000) (200,000 - C) \quad \text{for } 100,000 \text{ m}^3 < C \leq 200,000 \text{ m}^3$$

where:

O_M = mean oil outflow parameter.
 C = total volume of cargo oil, in m³, at 98% tank filling

- .2 for oil tankers of less than 5,000 tonnes deadweight (DWT):

The length of each cargo tank shall not exceed 10 m or one of the following values, whichever is the greater:

- .1 where no longitudinal bulkhead is provided inside the cargo tanks:

$$\left(0.5 \frac{b_i}{B} + 0.1 \right) L \quad \text{but not to exceed } 0.2L$$

- .2 where a centreline longitudinal bulkhead is provided inside the cargo tanks:

$$\left(0.25 \frac{b_i}{B} + 0.15 \right) L \quad \text{but not to exceed } 0.2L$$

- .3 where two or more longitudinal bulkheads are provided inside the cargo tanks:

- .1 for wing cargo tanks: 0.2L
- .2 for centre cargo tanks:

- a) if $\frac{b_i}{B} \geq 0.2$ $L : 0.2L$
- b) if $\frac{b_i}{B}$ is < 0.2 :
- where no centreline longitudinal bulkhead is provided:

$$\left(0.5 \frac{b_i}{B} + 0.1\right) L$$
 - where a centreline longitudinal bulkhead is provided:

$$\left(0.25 \frac{b_i}{B} + 0.15\right) L$$

- .4 b_i is the minimum distance from the ship's side to the outer longitudinal bulkhead of the tank in question measured inboard at right angles to the centreline at the level corresponding to the assigned summer freeboard.

9.6.5 The following general assumptions shall apply when calculating the mean oil outflow parameter:

- .1 The cargo block length extends between the forward and aft extremities of all tanks arranged for the carriage of cargo oil, including slop tanks.
- .2 Where this Head refers to cargo tanks, it shall be understood to include all cargo tanks, slop tanks and fuel tanks located within the cargo block length.
- .3 The ship shall be assumed loaded to the load line draught d_s without trim or heel.
- .4 All cargo oil tanks shall be assumed loaded to 98% of their volumetric capacity. The nominal density of the cargo oil (ρ_n) shall be calculated as follows:

$$\rho_n = 1000 (DWT)/C \text{ (kg/m}^3\text{)}$$
- .5 For the purposes of these outflow calculations, the permeability of each space within the cargo block, including cargo tanks, ballast tanks and other non-oil spaces shall be taken as 0.99, unless proven otherwise.
- .6 Suction wells may be neglected in the determination of tank location provided that such wells are as small as practicable and the distance between the well bottom and bottom shell plating is not less than 0.5 h, where h is the height as defined in sub-item 9.6.3.7.

9.6.6 The following assumptions shall be used when combining the oil outflow parameters:

- .1 The mean oil outflow shall be calculated independently for side damage and for bottom damage and then combined into the non-dimensional oil outflow parameter O_M , as follows:

$$O_M = (0.4 O_{MS} + 0.6 O_{MB}) / C$$

where:

O_{MS} = mean outflow for side damage, in m^3 ; and

O_{MB} = mean outflow for bottom damage, in m^3 .

- .2 For bottom damage, independent calculations for mean outflow shall be done for 0 m and minus 2.5 m tide conditions, and then combined as follows:

$$O_{MB} = 0.7 O_{MB(0)} + 0.3 O_{MB(2.5)}$$

where:

$O_{MB(0)}$ = mean outflow for 0 m tide condition; and

$O_{MB(2.5)}$ = mean outflow for minus 2.5 m tide condition, in m^3 .

9.6.7 The mean outflow for side damage O_{MS} shall be calculated as follows:

$$O_{MS} = C_3 \sum_i^n P_{S(i)} O_{S(i)} \text{ (m}^3\text{)}$$

where:

i = represents each cargo tank under consideration;

n = total number of cargo tanks;

$P_{S(i)}$ = the probability of penetrating cargo tank i from side damage, calculated in accordance with item 9.6.9;

$O_{S(i)}$ = the outflow, in m^3 , from side damage to cargo tank i, which is assumed equal to the total volume in cargo tank i at 98% filling, unless it is proven through the application of the Guidelines developed by the IMO* that any significant cargo volume will be retained; and

C_3 = 0.77 for ships having two longitudinal bulkheads inside the cargo tanks, provided these bulkheads are continuous over the cargo block and $P_{S(i)}$ is developed in accordance with this Head. C_3 equals 1.0 for all other ships or when $P_{S(i)}$ is developed in accordance with item 9.6.11.

9.6.8 The mean outflow for bottom damage shall be calculated for each tidal condition as follows:

$$.1 \quad O_{MB(0)} = \sum_i^n P_{B(i)} O_{B(i)} C_{DB(i)} \text{ (m}^3\text{)}$$

where:

i = represents each cargo tank under consideration;

n = the total number of cargo tanks;

$P_{B(i)}$ = the probability of penetrating cargo tank i from bottom damage, calculated in accordance with paragraph 9.6.10 of this regulation;

$O_{B(i)}$ = the outflow from cargo tank i, in m^3 , calculated in accordance with sub-item 9.6.8.3; and

* Refer to the Revised Interim Guidelines for the approval of alternative methods of design and construction of oil tankers adopted by the Marine Environment Protection Committee of the IMO by resolution MEPC.110(49).

$C_{DB(i)}$ = factor to account for oil capture as defined in sub-item 9.6.8.4.

$$.2 \quad O_{MB(2.5)} = \sum_i^n P_{B(i)} O_{B(i)} C_{DB(i)} \quad (m^3)$$

where:

$i, n, P_{B(i)}$ and $C_{DB(i)}$ = as defined in sub-item 9.6.8.1 above;
 $O_{B(i)}$ = the outflow from cargo tank i , in m^3 , after tidal change

.3 The oil outflow $O_{B(i)}$ for each cargo oil tank shall be calculated based on pressure balance principles, in accordance with the following assumptions:

- .1 The ship shall be assumed stranded with zero trim and heel, with the stranded draught prior to tidal change equal to the load line draught d_s .
- .2 The cargo level after damage shall be calculated as follows:

$$h_c = \{(d_s + t_c - Z_1)(\rho_s) - (1000p)/g\} / \rho_n$$

where:

h_c = the height of the cargo oil above Z_1 , in metres;

t_c = the tidal change, in m. Reductions in tide shall be expressed as negative values;

Z_1 = the height of the lowest point in the cargo tank above baseline, in m;

ρ_s = density of seawater, to be taken as $1,025 \text{ kg/m}^3$;

p = if an inert gas system is fitted, the normal overpressure, in kPa, to be taken as not less than 5 kPa *; if an inert gas system is not fitted, the overpressure may be taken as 0;

g = the acceleration of gravity, to be taken as 9.81 m/s^2 ; and

ρ_n = nominal density of cargo oil, calculated in accordance with sub-item 9.6.5.4.

.3 For cargo tanks bounded by the bottom shell, unless proven otherwise, oil outflow $O_{B(i)}$ shall be taken not less than 1% of the total volume of cargo oil loaded in cargo tank i , to account for initial exchange losses and dynamic effects due to current and waves.

.4 In the case of bottom damage, a portion from the outflow from a cargo tank may be captured by non-oil compartments. This effect is approximated by application of the factor $C_{DB(i)}$ for each tank, which shall be taken as follows:

$C_{DB(i)}$ = 0.6 for cargo tanks bounded from below by non-oil compartments;

$C_{DB(i)}$ = 1.0 for cargo tanks bounded by the bottom shell.

9.6.9 The probability P_S of breaching a compartment from side damage shall be calculated as follows:

$$.1 \quad P_S = P_{SL} P_{SV} P_{ST}$$

where:

$P_{SL} = 1 - P_{Sf} - P_{Sa}$ = probability the damage will extend into the longitudinal zone bounded by X_a and X_f ;

$P_{SV} = 1 - P_{Su} - P_{S1}$ = probability the damage will extend into the vertical zone bounded by Z_1 and Z_u ; and

$P_{ST} = 1 - P_{Sy}$ = probability the damage will extend transversely beyond the boundary defined by y .

.2 P_{Sa} , P_{Sf} , P_{S1} , P_{Su} and P_{Sy} shall be determined by linear interpolation from the table of probabilities for side damage provided in sub-item 9.6.9.3, where:

P_{Sa} = the probability the damage will lie entirely aft of location X_a/L ;

P_{Sf} = the probability the damage will lie entirely forward of location X_f/L ;

P_{S1} = the probability the damage will lie entirely below the tank;

P_{Su} = the probability the damage will lie entirely above the tank; and

P_{Sy} = the probability the damage will lie entirely outboard of the tank.

Compartment boundaries X_a , X_f , Z_1 , Z_u and y shall be developed as follows:

X_a = the longitudinal distance from the aft terminal of L to the aftmost point on the compartment being considered, in metres;

X_f = the longitudinal distance from the aft terminal of L to the foremost point on the compartment being considered, in metres;

Z_1 = the vertical distance from the moulded baseline to the lowest point on the compartment being considered, in metres;

Z_u = the vertical distance from the moulded baseline to the highest point on the compartment being considered, in metres. Z_u is not to be taken greater than D_s ; and

Y = the minimum horizontal distance measured at right angles to the centreline between the compartment under consideration and the side shell in metres;**

* According to IACS UI MPC93 (Rev.1, 2016), if an inert gas system is fitted on tankers which are contracted for construction on or after 1 April 2009, the normal overpressure, in kPa, is to be taken as 5 kPa . The "contracted for construction" date means the date on which the contract to build the vessel is signed between the prospective owner and the shipbuilder.

** For symmetrical tank arrangements, damages are considered for one side of the ship only, in which case all "y" dimensions are to be measured from that same side. For asymmetrical arrangements refer to the Explanatory Notes on matters related to the accidental oil outflow performance, adopted by the IMO by resolution MEPC.122(52).

3 Table of probabilities for side damage

X_a/L	P_{Sa}	X_f/L	P_{Sf}	Z_l/D_S	P_{Sl}	Z_u/D_S	P_{Su}
0.00	0.000	0.00	0.967	0.00	0.000	0.00	0.968
0.05	0.023	0.05	0.917	0.05	0.000	0.05	0.952
0.10	0.068	0.10	0.867	0.10	0.001	0.10	0.931
0.15	0.117	0.15	0.817	0.15	0.003	0.15	0.905
0.20	0.167	0.20	0.767	0.20	0.007	0.20	0.873
0.25	0.217	0.25	0.717	0.25	0.013	0.25	0.836
0.30	0.267	0.30	0.667	0.30	0.021	0.30	0.789
0.35	0.317	0.35	0.617	0.35	0.034	0.35	0.733
0.40	0.367	0.40	0.567	0.40	0.055	0.40	0.670
0.45	0.417	0.45	0.517	0.45	0.085	0.45	0.599
0.50	0.467	0.50	0.467	0.50	0.123	0.50	0.525
0.55	0.517	0.55	0.417	0.55	0.172	0.55	0.452
0.60	0.567	0.60	0.367	0.60	0.226	0.60	0.383
0.65	0.617	0.65	0.317	0.65	0.285	0.65	0.317
0.70	0.667	0.70	0.267	0.70	0.347	0.70	0.255
0.75	0.717	0.75	0.217	0.75	0.413	0.75	0.197
0.80	0.767	0.80	0.167	0.80	0.482	0.80	0.143
0.85	0.817	0.85	0.117	0.85	0.553	0.85	0.092
0.90	0.867	0.90	0.068	0.90	0.626	0.90	0.046
0.95	0.917	0.95	0.023	0.95	0.700	0.95	0.013
1.00	0.967	1.00	0.000	1.00	0.775	1.00	0.000

P_{Sy} shall be calculated as follows:

$$P_{Sy} = (24.96 - 199.6 y/B_S) (y/B_S) \quad \text{for } y/B_S \leq 0.05$$

$$P_{Sy} = 0.749 + \{5 - 44.4 (y/B_S - 0.05)\} (y/B_S - 0.05) \quad \text{for } 0.05 < y/B_S < 0.1$$

$$P_{Sy} = 0.888 + 0.56 (y/B_S - 0.1) \quad \text{for } y/B_S \geq 0.1$$

P_{Sy} shall not be taken greater than 1.

9.6.10 The probability P_B of breaching a compartment from bottom damage shall be calculated as follows:

$$.1 \quad P_b = P_{BL} P_{BT} P_{BV}$$

where:

$P_{BL} = 1 - P_{Bf} - P_{Ba}$ = probability the damage will extend into the longitudinal zone bounded by X_a and X_f ;

$P_{BT} = 1 - P_{Bp} - P_{Bs}$ = probability the damage will extend into the transverse zone bounded by Y_p and Y_s ; and

$P_{BV} = 1 - P_{Bz}$ = probability the damage will extend vertically above the boundary defined by z .

.2 P_{Ba} , P_{Bf} , P_{Bp} , P_{Bs} , and P_{Bz} shall be determined by linear interpolation from the table of probabilities for bottom damage provided in sub-item 9.6.10.3, where:

P_{Ba} = the probability the damage will lie entirely aft of location X_a/L ;

P_{Bf} = the probability the damage will lie entirely forward of location X_f/L ;

P_{Bp} = the probability the damage will lie entirely to port of the tank;

P_{Bs} = the probability the damage will lie entirely to starboard of the tank; and

P_{Bz} = the probability the damage will lie entirely below the tank.

Compartment boundaries X_a , X_f , Y_p , Y_s , and z shall be developed as follows:

X_a and X_f are as defined in sub-item 9.6.9.2;

Y_p = the transverse distance from the port-most point on the compartment located at or below the waterline d_B , to a vertical plane located $B_B/2$ to starboard of the ship's centreline, in metres;

Y_s = the transverse distance from the starboard-most point on the compartment located at or below the waterline d_B , to a vertical plane located $B_B/2$ to starboard of the ship's centreline, in metres; and

z = the minimum value of z over the length of the compartment, where, at any given longitudinal location, z is the vertical distance from the lower point of the bottom shell at that longitudinal location to the lower point of the compartment at that longitudinal location, in metres.

.3 Table of probabilities for bottom damage

X_a/L	P_{Ba}	X_f/L	P_{Bf}	Y_p/B_B	P_{Bp}	Y_s/B_B	P_{Bs}
0.00	0.000	0.00	0.969	0.00	0.844	0.00	0.000
0.05	0.002	0.05	0.953	0.05	0.794	0.05	0.009
0.10	0.008	0.10	0.936	0.10	0.744	0.10	0.032
0.15	0.017	0.15	0.916	0.15	0.694	0.15	0.063
0.20	0.029	0.20	0.894	0.20	0.644	0.20	0.097
0.25	0.042	0.25	0.870	0.25	0.594	0.25	0.133
0.30	0.058	0.30	0.842	0.30	0.544	0.30	0.171
0.35	0.076	0.35	0.810	0.35	0.494	0.35	0.211
0.40	0.096	0.40	0.775	0.40	0.444	0.40	0.253
0.45	0.119	0.45	0.734	0.45	0.394	0.45	0.297
0.50	0.143	0.50	0.687	0.50	0.344	0.50	0.344
0.55	0.171	0.55	0.630	0.55	0.297	0.55	0.394
0.60	0.203	0.60	0.563	0.60	0.253	0.60	0.444
0.65	0.242	0.65	0.489	0.65	0.211	0.65	0.494
0.70	0.289	0.70	0.413	0.70	0.171	0.70	0.544
0.75	0.344	0.75	0.333	0.75	0.133	0.75	0.594
0.80	0.409	0.80	0.252	0.80	0.097	0.80	0.644
0.85	0.482	0.85	0.170	0.85	0.063	0.85	0.694
0.90	0.565	0.90	0.089	0.90	0.032	0.90	0.744
0.95	0.658	0.95	0.026	0.95	0.009	0.95	0.794
1.00	0.761	1.00	0.000	1.00	0.000	1.00	0.844

P_{Bz} shall be calculated as follows:
 $P_{Bz} = (14.5 - 67 z/D_s) (z/D_s)$ for $z/D_s \leq 0.1$,
 $P_{Bz} = 0.78 + 1.1 (z/D_s - 0.1)$ for $z/D_s > 0.1$.

P_{Bz} shall not be taken greater than 1.

9.6.11 The calculation procedure in this Head uses a simplified probabilistic approach where a summation is carried out over the contributions to the mean outflow from each cargo tank. For certain designs such as those characterized by the occurrence of steps/recesses in bulkheads/decks and for sloping bulkheads and/or a pronounced hull curvature, more rigorous calculations may be appropriate. In such cases one of the following calculation procedures may be applied:

- .1 The probabilities referred to in 9.6.9 and 9.6.10 above may be calculated with more precision through application of hypothetical sub-compartments.*
- .2 The probabilities referred to in 9.6.9 and 9.6.10 above may be calculated through direct application of the probability density functions contained in the Guidelines referred to in 9.6.7.
- .3 The oil outflow performance may be evaluated in accordance with the method described in the Guidelines referred to in 9.6.7.

9.6.12 Oil tanker delivered before 1 January 2010 shall be in compliance with the requirements set in regs.25

and 26 of Ch.4, Part A, of revised Annex 1 of MARPOL 73/78, as applicable regarding its size and date of delivery.

**9.7 DAMAGE STABILITY
VERIFICATION OF PARTICULAR
LOADING CASE ON NEW TANKERS**

9.7.1 Application

This Head applies for new oil tankers and chemical carriers contracted for construction** on or after 1st January 2010 subject to review of impact on ships undergoing approval and delivering after said date. The instructions presented in IACS Rec.No.110 „*Guideline for Scope of Damage Stability Verification on new oil tankers, chemical tankers and gas carriers*“ shall be followed.

9.7.2 Scope of stability verification

The scope of damage stability verification is determined by the required damage stability standards (applicable damage stability criteria) and aims at providing the ship’s master with a sufficient number of approved loading conditions to be used for the loading of the ship. In general, for non-approved loading conditions by the *Register*, approved KG/GM limit curve(s) or approved loading instrument software satisfying the stability requirements (intact

* Refer to the Explanatory Notes on matters related to the accidental oil outflow performance, adopted by the IMO by resolution MEPC.122(52).

** The ‘contracted for construction’ date means the date on which the contract to build the vessel is signed between the prospective owner and the shipbuilder.

and damage) for the draught range to be covered shall be used to verify compliance on board. Within the scope of the verification determined as per the above, all potential or necessary damage scenarios shall be determined and assessed taking into account the damage stability criteria. Damage stability verification and approval requires a review of submitted calculations and supporting documentation with independent check calculations to confirm damage stability calculation results comply with relevant stability criteria. Examination and approval of the loading instrument software installed on board (and to be used for assessing intact and damage stability) shall also be carried out. A loading instrument comprises hardware and software. The accuracy of the computation results and actual ship data used by the software is to be verified.

9.7.3 Operating Limits – Descriptions / Assumptions

In considering the scope of the verification to be conducted, consideration of the operating limits is needed. The following loading options should be permitted:

- .1 Service loading conditions identical to the approved loading conditions of the stability booklet (see 9.7.4); or
- .2 Service loading conditions complying with the approved intact and damage stability limiting curves (where provided) (see 9.7.5); or
- .3 Service loading conditions which have been checked with an approved onboard stability software with the capability to perform damage stability calculations (Type 2 or 3 of Appendix 5 to the *Rules, Part 4 - Stability*) either based on KG/GM limit curve(s) or based on direct damage stability assessment (see 9.7.7).

If above mentioned proof of compliance is not possible, then the intended loading conditions shall be either prohibited or be submitted for specific approval to the *Register*. Suitable instructions to this effect shall be included in the stability booklet/loading manual. An approved loading condition is one which has been specifically examined and endorsed by *Register*.

9.7.4 Matrix of permissible loading conditions

In the absence of stability software and KG/GM limit curve(s), in lieu of approved specific loading conditions, a matrix clearly listing the allowable range of loading parameters (draft, trim, KG, cargo loading pattern and SG) that the vessel is allowed to load in order to be in compliance with the applicable intact and damage stability criteria can be developed for the stability booklet when a greater degree of flexibility than that afforded by approved specific loading conditions is needed.

9.7.5 KG/GM Limit Curve(s) *

The preparation of KG/GM limit curves for tank vessels, especially for chemical tank vessels, shall include a comprehensive calculation as described in MSC/Circ.406/Rev.1, paragraph 2.1:

”A systematic investigation of damage survival characteristics should be undertaken by making calculations to obtain the minimum required GM or Maximum allowable KG at a sufficient number of draughts within the operating range to permit the construction of a series of curves of “required GM” or “allowable KG” in relation to draught and cargo tank content in way of the damage. The curves must be sufficiently comprehensive to cover operational trim requirements.”

The verification of KG/GM limit curves shall be conducted without any free surface correction. The actual loading condition uses the free surface correction (see paragraph 6.5 of IACS Rec.No.110) when comparing actual and allowable KG values.

It is to be noted that any change of filling level, draught, trim, cargo density might have a major influence to the results of a damage case; therefore the following items shall be considered carefully for the calculation of the KG/GM limit curves:

- a) Intact and damage stability criteria applicable to the vessel;
- b) The maximum required damage extent and lesser extents of damage which provide the most severe damage cases;
- c) Draught range of the vessel (up to tropical freeboard if required);
- d) Trim range of the vessel (see paragraph 6.6 of IACS Rec.No.110);
- e) Full and empty cargo tanks;
- f) Partially filled cargo tanks (consideration of increments as necessary);
- g) Minimum tank fillings in tonnes if required;
- h) Maximum/minimum densities of cargoes; and
- i) Ballast tank filling levels as necessary to achieve compliance.

Damage stability calculations, on which the KG/GM limit curve(s) is(are) based, shall be performed at the design stage. The KG/GM limit curve(s) drawn out taking stability criteria (intact and damage) into account shall be inserted in the stability booklet.

9.7.6 Initial heel

The stability booklet shall contain a note for the master to avoid initial heel greater than 1 degree. A steady heeling angle may have major influence to the stability of the vessel, especially in case of damage.

* To avoid difficulties associated with developing suitable KG/GM limit curves and their restriction on operational capacity it is recommended that an approved Type 3 stability software is fitted on board.

9.7.7 Direct calculation onboard (Stability software)

The use of stability software for stability calculations is not a class requirement. However, stability software installed onboard should cover all stability requirements (intact and damage) applicable to the ship. The following types of stability software, if approved by a classification society (according to Appendix 5 to the *Rules, Part 4 - Stability* or IACS UR L5, Rev.2, Corr.1 Nov 2006), are applicable for calculation of service loading conditions for tank vessels:

- .1 Type 2: Checking intact and damage stability on basis of a KG/GM limit curve(s) or previously approved loading conditions; and
- .2 Type 3: Checking intact and damage stability by direct application of pre-programmed damage cases for each loading condition, including capability for calculation of intermediate damage stages.

The software shall be approved by the classification society. The software is not a substitute for the approved stability documentation, but used as a supplement to facilitate stability calculations. Sufficient damages, taking into account lesser damages, and variation of draft, cargo density, tank loading patterns and extents of tank filling shall be performed to ensure that for any possible loading condition the most onerous damages have been examined according to relevant stability criteria.

The methodologies for determining compliance with relevant stability criteria shall be as set out in above mentioned guidelines.

10 COMMERCIAL YACHTS

10.1 APPLICATION

10.1.1 The provisions given hereunder apply to commercial yachts of 24 m to 80 m in length L, and which are not certified to carry more than 12 passengers, where:

L - is length as defined in item 1.2.1 of this Part of the Rules; and

Commercial yacht means a yacht which is not a pleasure yacht.

10.1.2 Stability requirements on commercial yachts of more than 80 m in length L and navigating in unrestricted area of operations will be in each case considered separately by the *Register*, but in general should meet the damage stability requirements of the SOLAS 90 for one compartment (Chapter II-1, Part B, Reg.8 [2.3] to [6]) according to the deterministic method.

10.1.3 Yachts referred to in 10.1.1 and restricted to operate in areas within 60 NM from a safe haven may be exempted of the requirements of Head 10.3 of this Section.

For those yachts, the following note shall be added to the approved stability booklet: "This vessel has not been assessed for damage stability, and therefore might not remain afloat in the event of damage or flooding."

10.2 SUBDIVISION

10.2.1 All Yachts shall have at least the following complete transverse watertight bulkheads fitted in the hull:

- One collision bulkhead;
- One after peak bulkhead;
- Two bulkheads forming the boundaries of the machinery space; for yachts with machinery space fitted astern, aft bulkhead of that space may be treated as after peak bulkhead, if it is proved by calculation that the flooding of part of the hull aft of that bulkhead will result in floating condition which satisfy the requirement of item 10.3.1.

Special subdivision arrangements generated by specific functional requirements may be considered by the *Register* on case by case basis.

10.2.2 Additional bulkheads may be required for yachts having to comply with damage stability criteria, according to requirements of Head 10.3 of this Section.

10.2.3 The transverse watertight bulkheads requested in the items 10.2.1 and 10.2.2 of this Section shall, generally, be fitted up to the bulkhead deck, as it is defined in item 1.2.6 of this Part of the Rules. Structural drawings of those bulkheads shall be to be submitted to the *Register* for approval. In general, the provisions for construction and initial tests of watertight bulkheads set in the *Rules, Part 2 – Hull* shall be followed.

10.2.4 Doors in watertight bulkheads are to be watertight doors of the approved type. The strength of the doors shall be equivalent to the surrounding bulkheads. The hand opening and hand closing devices of the door are to be operable from both sides of the door.

For yachts under 500 GT, the *Register* may accept approved hinged doors provided that for such doors indicators are fitted on the bridge showing whether the doors are open or closed. The doors are to be kept closed at sea and marked accordingly.

For yachts equal to or greater than 500 GT, approved hinged doors, with provisions stated above, may be accepted for infrequently used openings in watertight compartments where a crew member will be in immediate attendance when the door is open at sea.

If fitted, sliding watertight doors shall comply to the requirements for such doors in the *Rules, Part 3 – Hull equipment*.

10.2.5 The number of openings in watertight subdivisions is to be limited to a minimum compatible with the proper working of the yacht. Pipes and electrical cable may be carried through watertight subdivisions provided that both the watertightness and structural integrity of the bulkhead are ensured by devices suitable in the opinion of the *Register*. Details relevant to these devices and their installation on board are to be submitted to the *Register* for approval.

Lead or other heat sensitive materials may not be used in systems which penetrate watertight subdivision bulkheads and decks, where deterioration of such systems in the event of fire would impair the watertight integrity.

10.2.6 A forepeak or collision bulkhead shall be fitted and made watertight up to the bulkhead deck. This bulkhead shall be located at a distance from the forward perpendicular of not less than 5 % of the length L and not more than 3 metres plus 5 % of the length L.

- .1 Where any part of the hull below the waterline extends forward of the forward perpendicular, e. g. a bulbous bow, the distances stipulated above shall be measured from a point either:
 - at the mid-length of such extension;
 - or
 - at a distance 1,5 % of the length L forward of the forward perpendicular;
 - or
 - at a distance 3 metres forward of the forward perpendicular,
 whichever gives the smallest measurement.
- .2 Where a long forward superstructure is fitted, the forepeak or collision bulkhead shall be extended weathertight to the next full deck above the bulkhead deck.
- .3 The extension required in sub-item .3 above need not be fitted directly above the bulkhead below provided all parts of the extension are not located forward of the forward limit specified in sub-item .1 or in sub-item .2 above.

After further analysis, different arrangements than stated above may be accepted by the *Register*, on a case by case basis.

10.2.7 As far as the collision bulkhead is concerned, in general a maximum of two pipes may pass through the collision bulkhead below the bulkhead deck. Such pipes are to be fitted with suitable valves operable from above the bulkhead deck and the valve chest is to be secured at the bulkhead inside the fore peak. Such valves may be fitted on the after side of the collision bulkhead provided that they are readily accessible under all service conditions. All valves are to be of steel, bronze or other approved ductile material. As a general rule, no access is to be fitted in the collision bulkhead. Special consideration will be given in the case of yachts of particular design, for the manhole with close spaced bolts positioned as far above the maximum load waterline (summer load line).

10.2.8 An afterpeak bulkhead, and bulkheads dividing the machinery space from the accommodation spaces forward and aft, shall also be fitted and made watertight up to the bulkhead deck. The afterpeak bulkhead may, however, be stepped below the bulkhead deck, provided the same level of watertightness is kept for all parts of such bulkhead, and that the longitudinal extent of the step or recess, measured from the plane of the main transverse bulkhead, is not more than 8 % of L.

10.2.9 In all cases where they protrude fore of the after peak bulkhead, stern tubes shall be enclosed in separated watertight spaces. The stern gland shall be situated in a watertight shaft tunnel or other watertight space of moderate volume, separate from the compartment in which the stern tube is situated. For yachts under 500 GT to which 10.1.3 applies, other measures to minimise the danger of water penetrating into the yacht in case of damage to sterntube arrangements may be taken at the discretion of the *Register*.

10.2.10 The number of openings in the shell plating shall be reduced to the minimum compatible with the design and proper working of the yacht. The arrangement and efficiency of the means for closing any opening in the shell plating shall be consistent with its intended purpose and the position in which it is fitted.

The number of scuppers, sanitary discharges and other similar openings in the shell plating shall be reduced to the minimum either by making each discharge serve for as many as possible of the sanitary and other pipes, or in any other satisfactory manner. All inlets and discharges in the shell plating shall be fitted with efficient and accessible arrangements for preventing the accidental admission of water into the yacht.

In general, the requirements for shell openings set in Reg.15 [8] to [11], Ch.II-1 of the SOLAS Convention, as amended, shall be complied with.

10.2.11 Engine exhaust outlets which penetrate the hull below the freeboard deck are to be provided with means to prevent back flooding into the hull through a damaged exhaust system. For yachts operating on unrestricted service a positive means of closure is to be provided. The system is to be of equivalent construction to the hull on the outboard side to the closure.

For yachts referred to in 10.1.3 of this Section, it may be accepted that exhaust piping of equivalent construction to the hull is looped up above the waterline on the outboard side of the system to a height as close as possible to the bulkhead deck. In general, the minimum height of that loop above the maximum load waterline (summer load line) should not be less than 70 % of the corresponding freeboard. The transverse position of the inboard side of the loop should be also as close to the centerline as possible.

In any case, the material used for exhaust piping is to be suitable to withstand the temperatures reached by the exhaust.

10.2.12 A compartment located below the bulkhead deck, as it is defined in item 1.2.6 of this Part of the Rules, and having a direct access opening on the hull is to be equipped with a watertight hull door and bounded by watertight bulkheads to separate it from the other adjacent compartments located below the bulkhead deck.

Indicators shall be fitted on the bridge showing whether the doors are open or closed. The doors are to be kept closed at sea and marked accordingly. The lower part of door opening shall be above the maximum load waterline (summer load line). Doors should be of outwards opening type.

No essential equipment is to be installed in such compartment. Access opening to other internal compartments may be permitted exclusively if sliding door of approved type is fitted for closing of such opening.

10.3 DAMAGE STABILITY

10.3.1 The watertight bulkheads of the yacht to which the requirements of this Head apply shall be so arranged that minor hull damage that results in the free flooding of any one compartment, will cause the yacht to float at a waterline which, at any point, is not less than 75 mm below the weather deck, freeboard deck, or bulkhead deck if not concurrent.

10.3.2 The minor damage shall be considered to occur anywhere along the yacht's waterline length (from the baseline up to the level of the waterline), except in way of a watertight bulkhead. Only one compartment or one tank is considered as damaged at one time.

However, if a down-flooding or progressive flooding may occur through pipework, ventilation ducts, doors, hatches or any other non-watertight openings, the flooding of the concerned compartments shall be considered.

10.3.3 The damage stability calculations are to be performed using the lost buoyancy method (constant displacement).

10.3.4 The damage stability criteria for one compartment damage set in the SOLAS 90 (Chapter II-1, Part B, Reg.8 [2.3] to [6]) shall be complied with, but disregarding extent of damage assumed in paragraph [4] of that regulation, and using assumptions stated in previous items of this Head.

APPENDIX 1 INDICATIVE GUIDELINES FOR APPLICATION OF THE REQUIREMENTS SET OUT IN SECTION 3

1 APPLICATION

In line with the provisions of item 3.1.6 of Section 3 of this Part of the Rules, these guidelines shall be used in the application of the specific stability requirements set out in Head 3.2, in so far as this is practicable and compatible with the design of the ship in question. The item numbers appearing below correspond to those in Head 3.2.

3.2.1

As a first step all ro-ro passenger ships referred to in 3.1.3 of Section 3 must comply with the SOLAS 90 standard of residual stability as it applies to all passenger ships constructed on or after 29 April 1990. It is the application of this requirement that defines the residual freeboard f_r , necessary for the calculations required in 3.2.1.1.

3.2.1.1

- .1 This sub-item addresses the application of a hypothetical amount of water accumulated on the bulkhead (ro-ro) deck. The water is assumed to have entered the deck via a damage opening. This sub-item requires that the ship in addition to complying with the full requirements of the SOLAS 90 standard further complies with that part of the SOLAS 90 criteria contained in points 2.3 to 2.3.4 of Regulation

II-1/B/8 with the defined amount of water on deck. For this calculation no other requirements of Regulation II-1/B/8 need be taken into account. For example the ship does not, for this calculation, need to comply with the requirements for the angles of equilibrium or nonsubmergence of the margin line.

- 2 The accumulated water is added as a liquid load with one common surface inside all compartments which are assumed flooded on the car deck. The height h_w of water on deck is dependent on the residual freeboard f_r after damage, and is measured in way of the damage (see figure 1). The residual freeboard, is the minimum distance between the damaged ro-ro deck and the final waterline (after equalization measures if any have been taken) in way of the assumed damage after examining all possible damage scenarios in determining the compliance with the SOLAS 90 standard as required in 3.2.1. 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 f_r .
- .3 If f_r is 2.0 m or more, no water is assumed to accumulate on the ro-ro deck. If f_r is 0.3 m or less, then height h_w is assumed to be 0.5 m. Intermediate heights of water are obtained by linear interpolation (see figure 2).

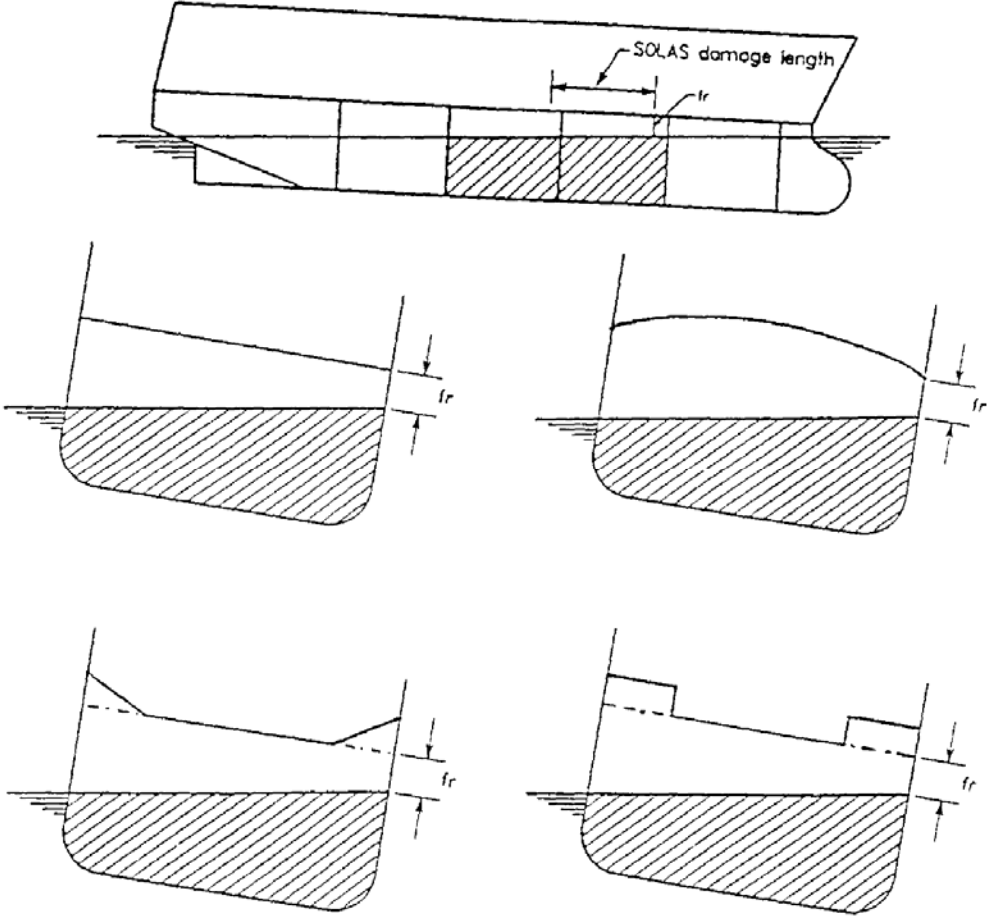
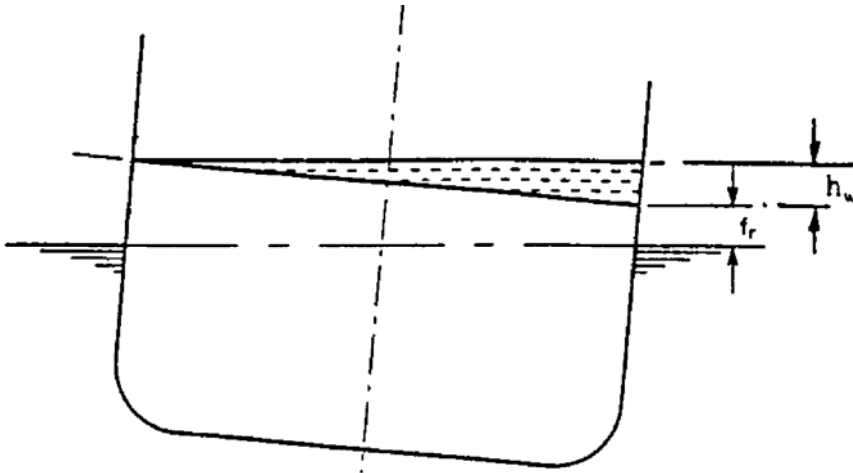


Figure 1



- 1. If $f_r \geq 2.0$ m, height of water on deck $h_w = 0.0$ m
- 2. If $f_r < 0.3$ m, height of water on deck $h_w = 0.5$ m

Figure 2

3.2.1.2

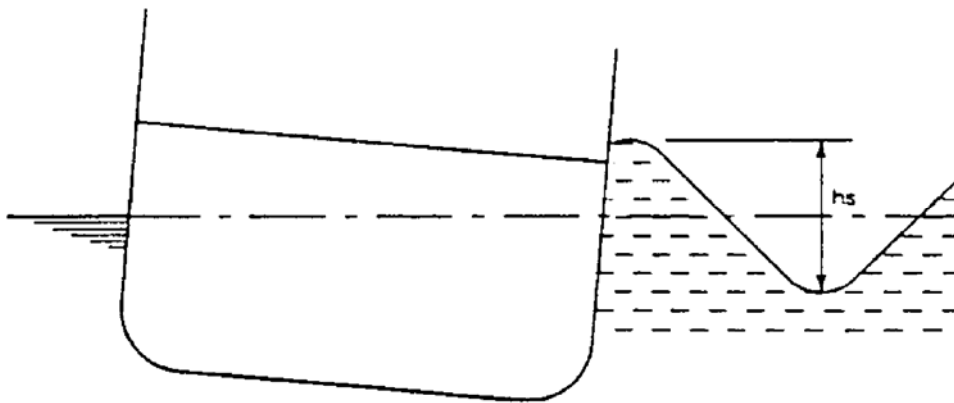
Means for drainage of water can only be considered as effective if these means are of a capacity to prevent large amounts of water from accumulating on the deck i.e. many thousands of tonnes per hour which is far beyond the capacities fitted at the time of the adoption of these regulations. Such high efficiency drainage systems may be developed and approved in the future (based on guidelines to be developed by the International Maritime Organization).

3.2.1.3

1. The amount of assumed accumulated water on deck may, in addition to any reduction in accordance with 3.2.1.1 be reduced for operations in geographically defined restricted areas. These areas are designated in accordance with the signifi-

cant wave height h_{SS} , defining the area in line with the provisions of 3.1.5 of the referred Section.

2. 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. If the significant wave height in the area concerned is 4.0 m or more then the height of the assumed accumulated water shall be the value calculated in accordance with 3.2.1.1. Intermediate values to be determined by linear interpolation (see figure 3).



1. If $h_s \geq 4.0$ m, height of water on deck shall be calculated as per Figure 2
2. If $h_s < 1.5$ m, height of water on deck $h_w = 0.0$ m

For example:

If $f_r = 1.15$ m and $h_s = 2.75$ m, height of water on deck $h_w = 0.125$ m

Figure 3

3. The height h_w 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 (see figure 4). It should be noted that the assumed permeability of the car deck spaces is to be taken as 90% (MSC/Circ.649 refers), whereas other assumed flooded

spaces permeabilities are to be those prescribed in the SOLAS Convention.

4. If the calculations to demonstrate compliance with Section 3 of this Part of the Rules, relate to a significant wave height less than 4.0 m that restricting significant wave height must be recorded on the vessel's passenger ship safety certificate.

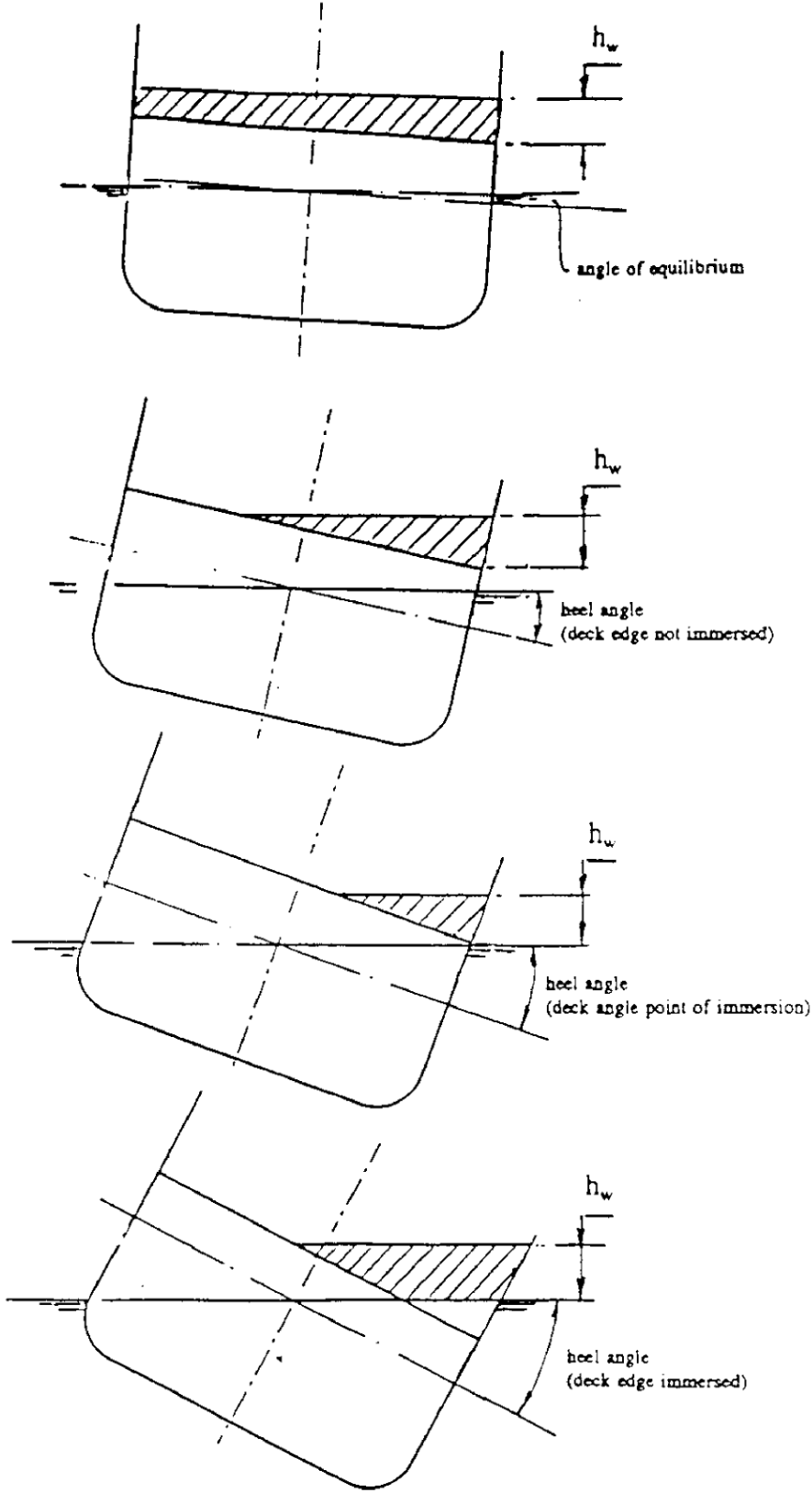


Figure 4

3.2.1.4 and 3.2.1.5

As an alternative to complying with the new stability requirements in 3.2.1.1 or 3.2.1.3, proof of compliance via model tests may be accepted. The model test requirements are detailed in the Head 3.3. Guidance notes on the model tests are contained in Head 2 of this Appendix, 'Model testing'.

3.2.1.6

Conventionally derived SOLAS 90 standard limiting operational curve(s) (KG or GM) may not remain applicable in cases where 'water on deck' is assumed under the terms of the Section 3 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_s , 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 deck bulkhead arrangement to minimise the excess GM derived from damage stability calculations with water on deck.

3.2.2.1

As for conventional SOLAS damage requirements bulkheads inboard of the $B/5$ line are considered intact in the event of side collision damage.

3.2.2.2

If side structural sponsons are fitted to enable compliance with SOLAS Regulation II-1/B/8, and as a consequence there is an increase in the breadth B of the ship and hence the vessel's $B/5$ distance from the ship's side, such modification shall not cause the relocation of any existing structural parts or any existing penetrations of the main transverse watertight bulkheads below the bulkhead deck (see figure 5).

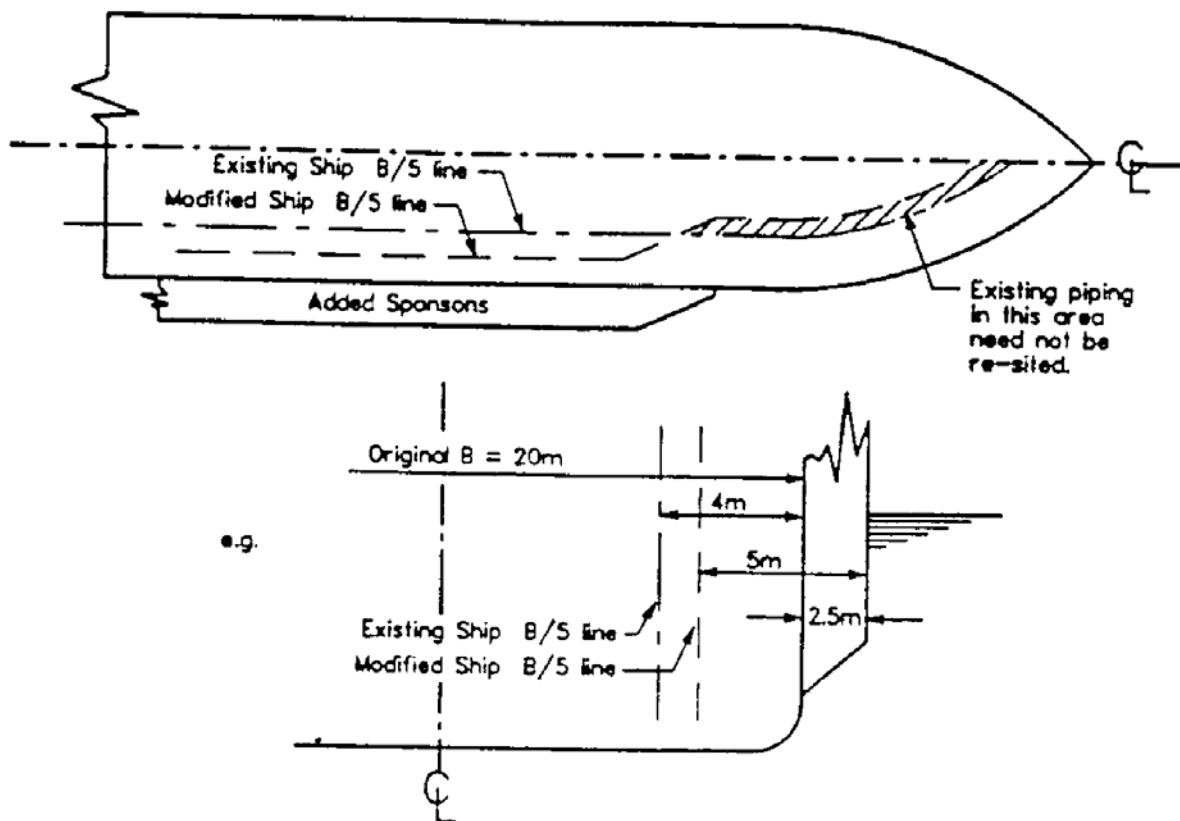


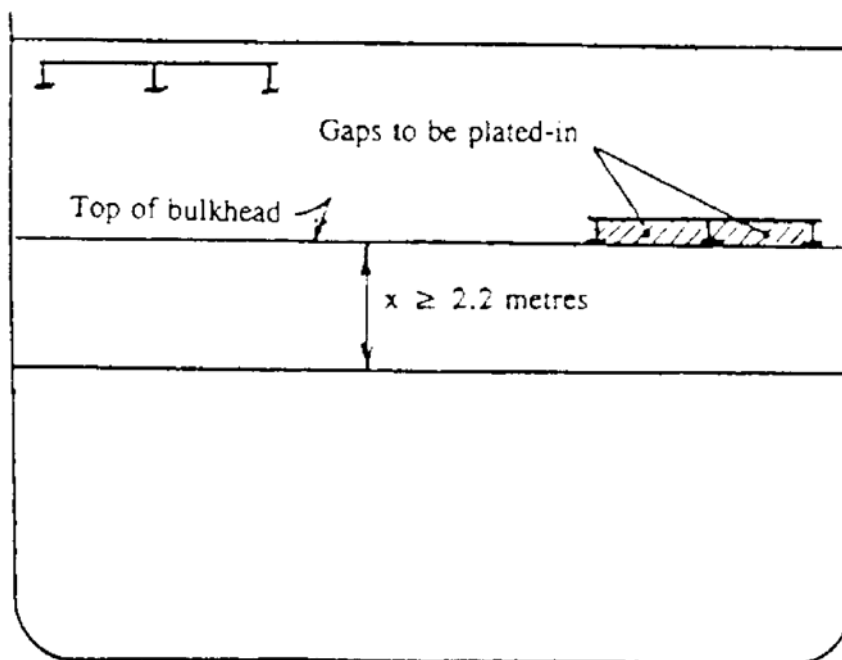
Figure 5

3.2.2.3

1. Transverse or longitudinal bulkheads/barriers 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'. Small amounts of leakage may be permitted 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.
2. The height B_h of transverse and longitudinal bulkheads/barriers shall be not less than $(8 \times h_w)$ metres, where h_w is the

height of the accumulated water as calculated by application of the residual freeboard and significant wave height (as referred to in 3.2.1.1 and 3.2.1.3). However in no case is the height of the bulkhead/barrier to be less than the greater of:

- a) 2,2 m; or
- b) the height between the bulkhead deck and the lower point of the underside structure of the intermediate or hanging car decks, when these are in their lowered position. It should be noted that any gaps between the top edge of the bulkhead and the underside of the plating must be 'plated in' in the transverse or longitudinal direction as appropriate (see figure 6).



Ship without hanging car decks

Example 1:

Height of water on deck $h_w = 0.25$ m
Minimum required height of barrier = 2.2 m

Ship with hanging deck (in way of the barrier)

Example 2:

Height of water on deck $h_w = 0.25$ m
Minimum required height of barrier = x

Figure 6

Bulkheads/barriers with a height less than that specified above, may be accepted if model tests are carried out in accordance with Head 2 of this Appendix to confirm that the alternative design ensures appropriate standard of survivability. Care needs to be taken when fixing the height of the bulkhead/barrier such that the height shall also be sufficient to prevent progressive flooding within the required

stability range. This range is not to be prejudiced by model tests.

Note: The range may be reduced to 10° provided the corresponding area under the curve is increased (as referred to in SOLAS Regulation II-1/B/8.2.3.1).

3.2.2.5-1

The area 'A' relates to permanent openings. It should be noted that the 'freeing ports' option is not suitable for ships which require the buoyancy of the whole or part of the superstructure in order to meet the criteria. The requirement is that the freeing ports shall be fitted with closing flaps to prevent water entering, but allowing water to drain.

These flaps must not rely on active means. They must be self-operating and it must be shown that they do not restrict outflow to a significant degree. Any signifi-

cant efficiency reduction must be compensated by the fitting of additional openings so that the required area is maintained.

3.2.2.5-2

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. The calculation of the minimum distance shall not take into account the effect of any additional water on deck (see figure 7).

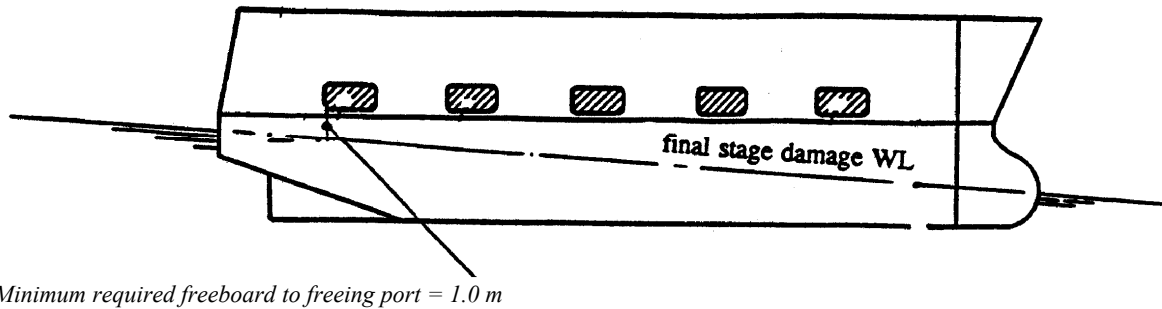


Figure 7

3.2.2.5-3

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 (see figure 8).

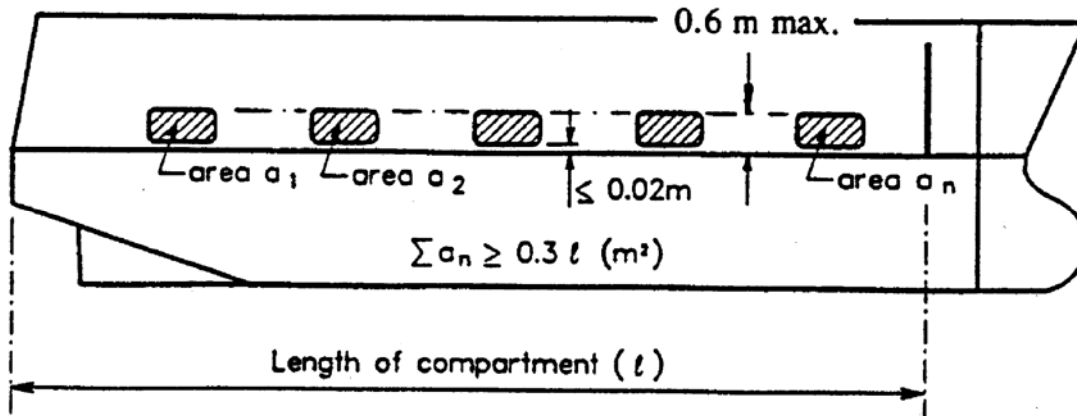
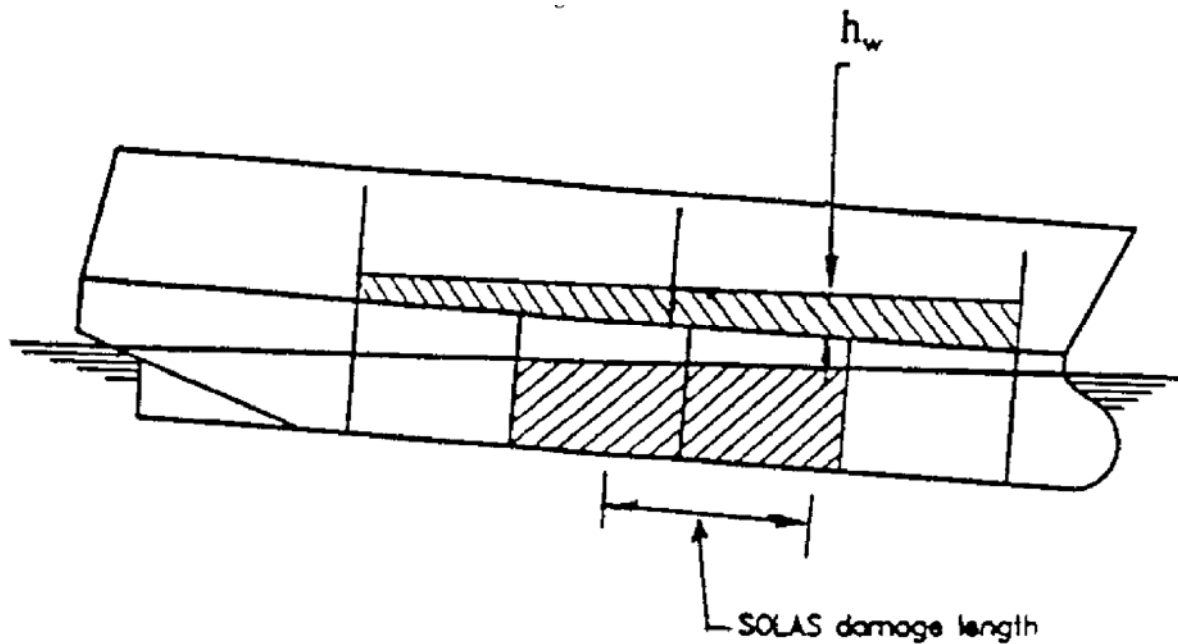


Figure 8

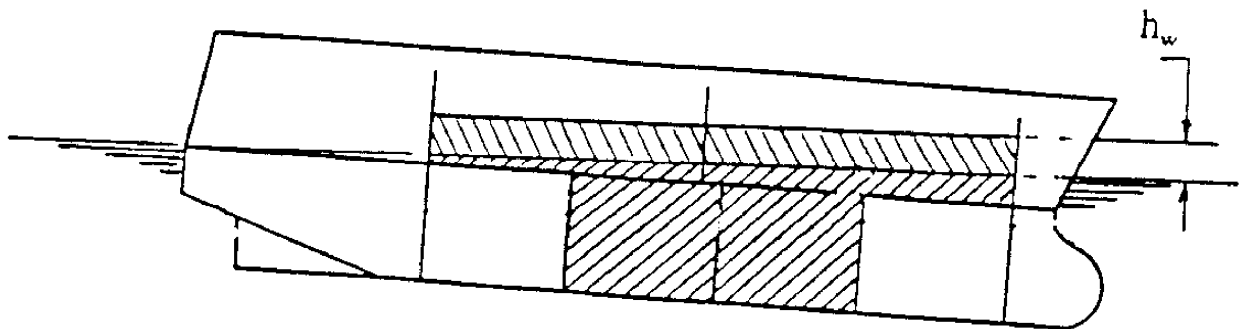
Note: Spaces to which 3.2.2.5, applies, i.e. those spaces fitted with freeing ports or similar openings, shall not be included as intact spaces in the derivation of the intact and damage stability curves.

3.2.2.6

1. The statutory extent of damage is to be applied along the length of the ship. Depending on the subdivision standard the damage 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.
2. 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. 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 (see figure 9).



Deck edge not immersed



Deck edge immersed

Figure 9

2 MODEL TESTING

The purpose of these guidelines is to ensure uniformity in the methods employed in the construction and verification of the model as well as in the undertaking and analyses of the model tests.

The contents of items 3.3.1 and 3.3.2 of the Head 3.3 are considered self-explanatory.

3.3.3 Ship model

3.3.3.1 The material of which the model is made is not important in itself, provided that the model both in the intact and damaged condition is sufficiently rigid to ensure that its hydrostatic properties are the same as those of the actual ship and also that the flexural response of the hull in waves is negligible.

It is also important to ensure that the damaged compartments are modelled as accurately as practicably possible to ensure that the correct volume of flood water is represented.

Since ingress of water (even small amounts) into the intact parts of the model will affect its behaviour, measures must be taken to ensure that this ingress does not occur.

In model tests involving worst SOLAS damages near the ship ends, it has been observed that progressive flooding was not possible because of the tendency of the water on deck to accumulate near the damage opening and hence flow out. As such models were able to survive very high sea states, while they capsized in lesser sea states with less onerous SOLAS damages, away from the ends, the limit $\pm 35\%$ was introduced to prevent this.

Extensive research carried out for the purpose of developing appropriate criteria for new vessels has clearly shown that in addition to the GM and freeboard being important parameters in the survivability of passenger ships, the area under the residual stability curve is also another major factor. Consequently in choosing the worst SOLAS damage for compliance with the requirement of 3.3.3.1, the worst damage is to be taken as that which gives the least area under the residual stability curve.

3.3.3.2 Model particulars

.1 In recognizing that scale effects play an important role in the behaviour of the model during tests, it is important to ensure that these effects are minimized as much as practically possible. The model should be as large as possible since details of damaged compartments are easier constructed in larger models and the scale effects are reduced. It is therefore required that the model length is not less than that corresponding to 1:40 scale or 3 m, whichever is greater. It has been found during tests that the vertical extent of the model can affect the results when tested dynamically. It is therefore required that the ship is modelled to at least three super

structure standard heights above the bulkhead (freeboard) deck so that the large waves of the wave train do not break over the model.

- .2 The model in way of the assumed damages must be as thin as practically possible to ensure that the amount of flood water and its centre of gravity are adequately represented. The hull thickness should not exceed 4 mm. It is recognized that it may not be possible for the model hull and the elements of primary and secondary subdivision in way of the damage to be constructed with sufficient detail and due to these constructional limitations it may not be possible to calculate accurately the assumed permeability of the space.
- .3 It is important that not only the draughts in the intact condition are verified, but also that the draughts of the damaged model are accurately measured for correlation with those derived from the damaged stability calculation. For practical reasons a tolerance of + 2 mm in any draught is accepted.
- .4 After measuring the damaged draughts it may be found necessary to make adjustments to the permeability of the damaged compartment by either introducing intact volumes or by adding weights. However it is also important to ensure that the centre of gravity of the flood water is accurately represented. In this case any adjustments made must err on the side of safety.

If the model is required to be fitted with barriers on deck and the barriers are less than the bulkhead height indicated below, the model is to be fitted with CCTV so that any 'splashing over' and any accumulation of water on the undamaged area of the deck can be monitored. In this case a video recording of the event is to form part of the test records.

The height of transverse or longitudinal bulkheads which are taken into account as effective to confine the assumed accumulated sea water in the compartment concerned in the damaged ro-ro deck should be at least 4 m in height unless the height of water is less than 0.5 m. In such cases the height of the bulkhead may be calculated in accordance with the following:

$$B_h = 8 h_w$$

where B_h is the bulkhead height; and

h_w is the height of water.

In any event, the minimum height of the bulkhead should be not less than 2.2 m. However, in the case of a ship with hanging car decks, the

minimum height of the bulkhead should be not less than the height to the underside of the hanging car deck when in its lowered position.

- .5 In order to ensure that the model motion characteristics represent those of the actual ship it is important that the model is both inclined and rolled in the intact condition so that the intact GM and the mass distribution are verified. The mass distribution should be measured in air. The transverse radius of gyration of the actual ship should be in the range $0.35B$ to $0.4B$ and the longitudinal radius of gyration should be in the range $0.2L$ to $0.25L$.

Note: While inclining and rolling the model in the damaged condition may be accepted as a check for the purpose of verifying the residual stability curve, such tests should not be accepted in lieu of the intact tests.

- .6 It is assumed that the ventilators of the damage compartment of the actual ship are adequate for unhindered flooding and movement of the flood water. However in trying to scale down the ventilating arrangements of the actual ship undesirable scale effects may be introduced in the model. In order to ensure that no such effects occur it is recommended to construct the ventilating arrangements to a larger scale than that of the model, ensuring that this does not affect the flow of water on the car deck.

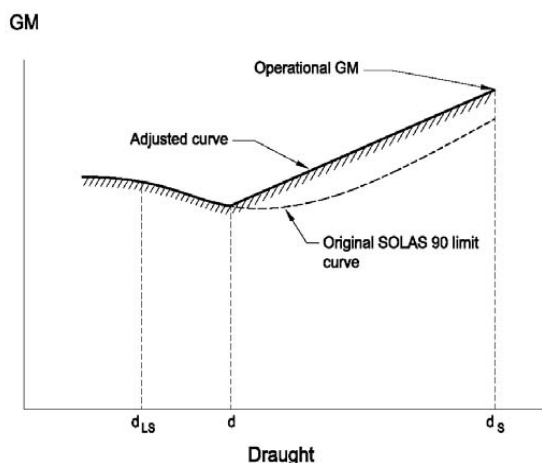
- .7 It is deemed appropriate to consider a damage shape representative of a cross section of the striking ship in the bow region. The 15° angle is based on a study of the cross section at a distance of $B/5$ from the bow for a representative selection of vessels of different types and sizes. The isosceles triangular profile of the prismatic damage shape is that corresponding to the load waterline.

Additionally in cases where side casings of width less than $B/5$ are fitted and in order to avoid any possible scale effects, the damage length in way of the side casings must not be less than 25 mm.

3.3.3.3 In the original model test method of Resolution 14 of the 1995 SOLAS Conference the effect of heeling induced by the maximum moment deriving from any of passenger crowding, launching of survival craft, wind and turning was not considered even though this effect was part of SOLAS. Results from an investigation have shown, however, that it would be prudent to take these effects into account and to retain the minimum of 1° heel towards the damage for practical purposes. It is to be noted that heeling due to turning was considered not to be relevant.

3.3.3.4 In cases where there is a margin in GM in the actual loading conditions compared to the GM limiting curve (derived from SOLAS 90), the *Register* may accept that this

margin is taken advantage of in the model test. In such cases the GM limiting curve should be adjusted. This adjustment can be done as follows:



$$d = d_S - 0,6 \cdot (d_S - d_{LS})$$

where:

d_S – is the subdivision draught; and
 d_{LS} – is the lightship draught.

The adjusted curve is a straight line between the GM used in the model test at the subdivision draught and the intersection of the original SOLAS 90 curve and draught d .

3.3.4 Procedure for experiments

3.3.4.1 Wave spectra

The JONSWAP spectrum should be used as this describes fetch- and duration- limited seas which correspond to the majority of conditions worldwide. In this respect it is important that not only the peak period of the wave train is verified but also that the zero crossing period is correct.

It is required that for every test run the wave spectrum is recorded and documented. Measurements for this recording should be taken at the probe closest to the wave making machine. It is also required that the model is instrumented so that its motions (roll, heave and pitch) as well as its attitude (heel, sinkage and trim) are monitored and recorded through-out the test.

It has been found that it is not practical to set absolute limits for significant wave heights, peak periods and zero crossing periods of the model wave spectra. An acceptable margin has therefore been introduced.

3.3.4.2 To avoid interference of the mooring system with the ship dynamics, the towing carriage (to which the mooring system is attached) should follow the model at its

actual drifting speed. In a sea state with irregular waves the drift speed will not be constant; a constant carriage speed would result in low frequency, large amplitude drift oscillations, which may affect the model behaviour.

3.3.4.3 A sufficient number of tests in different wave trains is necessary to ensure statistical reliability, i.e. the objective is to determine with a high degree of confidence that an unsafe ship will capsize in the selected conditions. A minimum number of 10 runs is considered to provide a reasonable level of reliability.

3.3.5 Survival criteria

The contents of this paragraph are considered self-explanatory.

3.3.6 Test approval

The following documents are to be part of the report to the *Register*:

- a) damage stability calculations for worst SOLAS and mid-ship damage (if different);
- b) general arrangement drawing of the model together with details of construction and instrumentation;
- c) inclining experiment and measurements of radii of gyration;
- d) nominal and measured wave spectra (at the three different locations for a representative realization and for the tests with the model from the probe closest to the wave maker);
- e) representative record of model motions, attitude and drift;
- f) relevant video recordings.

Note:

All tests must be witnessed by the *Register*.