PART II RULES FOR THE CONSTRUCTION AND CLASSIFICATION OF SHIPS IDENTIFIED BY THEIR MISSION

TITLE 21 PASSENGER SHIPS

SECTION 1 NAVAL ARCHITECTURE

CHAPTERS

CONTENTS

CHAPTER A
APPROACH

CHAPTER CONTENTS

A1. APPLICATION

100. Configuration

101. The present Title 21 applies to passenger vessels, as defined in Subchapter A2 below. The requirements of the present Title are additional to those in Part II, Title 11.

102. Passenger ships constructed on or after 1 July 2010 having length of 120 m or more or having three or more main vertical zones shall comply with the provisions of SOLAS II-2/G/21 – "*Casualty threshold, safe return to port and safe areas*."

103. Passenger ships constructed on or after 1 July 2010 having length of 120 m or more or having three or more main vertical zones shall comply with the provisions of SOLAS II-2/G/22 – "*Design criteria for systems to remain operational after a fire casualty*."

200. Aspect ratio

- See Part II, Title 11, Seciton 1

A2. DEFINITIONS

100. Terms

101. In addition to definitions of Part II, Title 11, Section 1 the following terms are used in this Section:

102. **Computational fluid dynamics (CFD)** is a field of fluid mechanics that uses numerical methods and algorithms to solve and analyse problems involving fluid flow. Computers are employed for the calculations required to simulate the interaction of liquids and gases with surfaces defined by boundary conditions.

103**. Cross-flooding:** the *cross-flooding* refers to the ballast transfer from one side to another to adjust the heeling of the vessel. See the figure F.A1.101.1 below.

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

a. **Deepest subdivision draught (ds)** is the waterline which corresponds to the summer load line draught of the ship.

b. **Light service draught (dl)** 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.

c. **Partial subdivision draught (dp)** is the light service draught plus 60% of the difference between the light service draught and the deepest subdivision draught.

105. **Hinged door:** door that pivots about a vertical or horizontal axis.

106. **Equilibrium Waterplane**: The waterplane in still water when, taking account of flooding due to an assumed damage, the weight and buoyancy forces acting on a vessel are in balance. This relates to the final condition when no further flooding takes place or after cross flooding is completed.

107. **Intermediate Waterplane:** The waterplane in still water, which represents the instantaneous floating position of a vessel at some intermediate stage between commencement and completion of flooding when, taking account of the assumed instantaneous state of flooding, the weight and buoyancy forces acting on a vessel are in balance.

108. **In-service inclining test** means an inclining test which is performed in order to verify the pre-calculated GM_C and the deadweight's centre of gravity of an actual loading condition.

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

110. **Passenger:** every person other than:

a. 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

b. A child under one year of age.

111. **Passenger spaces:** compartments used for accommodation and use of passengers, excluding baggage compartments, lockers, provision rooms, and mail compartments.

112. **Passenger vessel:** is here defined as the one that carries more than 12(twelve) passengers, according to:

a. NORMAM 01: item 301.o;

b. SOLAS: Rule IA/2.f of the Convention SOLAS 1974 and 1988 (Convention for the Safety of Life at Sea), as amended.

113. **Plan of intermediate waterline:** the plan of still water waterline, which represents the instantaneous position of the ship floating in an intermediate stage between the starting and ending of the flooding, when taking into account the instantaneous stage of flooding, the weight and buoyancy forces acting on a vessel are in balance.

114. **Plan of still water waterline:** plan of still water waterline when, taking into account the flooding due to a damage assumed, the weight and buoyancy forces acting on a ship are in balance. This is related to the final condition when no additional flooding occurs or after the "cross-flooding" is complete

115. **Short international voyage** is an international voyage in the course of which a ship is not more than 200 miles from a port or place in which the passengers and crew could be placed in safety. Neither the distance between the last port of call in the country in which the voyage begins and the final port of destination nor the return voyage shall exceed 600 miles. The final port of destination is the last port of call in the scheduled voyage at which the ship commences its return voyage to the country in which the voyage began.

116. **Sliding door:** door with horizontal or vertical motion, generally parallel to the plane of the door.

117. **Sliding Door or Rolling Door:** A door having a horizontal or vertical motion generally parallel to the plane of the door.

118. **Stability instrument** is an instrument installed on board a particular ship by means of which it can be ascertained that stability requirements specified for the ship in the Stability Booklet are met in any operational loading condition. A Stability Instrument comprises hardware and software.

119. **Subdivision length (Ls) 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.

120**. Watertigh**t: Capable of preventing the passage of water in any direction under a design head. The design head for any part of a structure shall be determined by reference to its location relative to the bulkhead deck or freeboard deck, as applicable, or to the most unfavourable equilibrium/intermediate waterplane, in accordance with the applicable subdivision and damage stability regulations, whichever is the greater. A watertight door is thus one that will maintain the watertight integrity of the subdivision bulkhead in which it is located.

FIGURE F.A2.01.1 – CROSS FLOODING

Time required for complete cross-flooding (seconds)

$$T_c = \frac{2W}{SF} \cdot \frac{\left(1-\sqrt{\frac{h_f}{H_o}}\right)}{\sqrt{2g \cdot H_o}} \cdot \frac{1}{\left(1-\frac{h_f}{H_o}\right)} \qquad (I)$$

Time required to bring vessel from an angle of $\theta°$ (or the angle of margin line immersion) to the upright

$$T_\theta = \frac{2W}{SF} \cdot \frac{\left(1-\sqrt{\frac{h_f}{H_\theta}}\right)}{\sqrt{2g \cdot H_\theta}} \cdot \frac{1}{\left(1-\frac{h_f}{H_\theta}\right)} \qquad (II)$$

Hence:

Time required from commencement of cross-flooding to $\theta°$ heel (or the angle of the margin line immersion)

$$T = T_o - T_\theta \qquad (III)$$

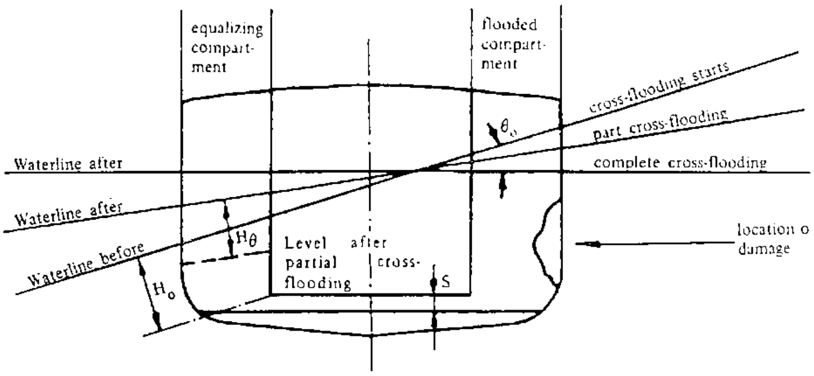


FIGURE 1

CHAPTER B

DOCUMENTS, REGULATIONS AND STANDARDS

CHAPTER CONTENTS

B1. NAVAL ARQUITECTURE DOCUMENTS

100. Documents for classification

101. The plans or documents to be submitted to the RBNA for approval or for information are listed in item B1.200.

200. Documents for approval

201. The following documents are to be presented for approval, in addition to those required by Part II, Title 11, Section 1, A2.200:

a. Plans showing the external openings and means of closure;

b. Plans showing the watertight division as well as internal openings and closing means;

c. Damage stability in accordance with Chapter II-1, Part B, Rule 8 of the SOLAS Convention as amended and the related Explanatory Notes, if applicable;

d. Damaged stability calculations in accordance with other conventions and codes applicable to the ship;

e. Damage control plan and damage control booklet containing the essential data to be maintained survivability;

f. Stability information according to the requirements of the chapter H below.

300. Documents for the construction

– See Part II, Title 11, Seciton 1

B2 REGULATION

100. Regulations of the National RBNA

101. For Brazilian Flag ships under 500 GT, the NORMAM 01 regulations emitted by DPC are comprehended by the present Rules and, in some cases, with additional details

102. The level of intact stability for ships of all sizes in any case should not be less than that provided by IMO IS Code as amended.

200. Emissions of other National RBNAs

201. The regulation emitted by National Organizations is to be submitted to RBNA for assessment. See B2.101 above.

202. For foreign flag ships, the National Regulations are applicable or, in absence of those, the regulations required in B2.102 above apply.

300. International regulation

301. For vessels under 500 GT destined to international voyages or under foreign flags, the IMO regulations apply.

Eventual points of discrepancy in regard to National Regulations applicable to the vessel are to be submitted for RBNA analysis.

102. For ships having GT equal to or larger than 500, the IMO ILLC and IS-Code regulations are applicable.

400. IACS requirements

401. The present Rules comprehend the IACS Unified Requirements (UR), and Recommendations (Rec) where applicable, as well as CSR rules for bulkers and tankers.

402. In vessels where the RBNA has received delegation to carry out statutory certification, the IACS Unified Interpretations are of mandatory use for ships having GT ≥ 500.

403. Where relevant, the present Rules comprehend the IACS Procedural Requirements (PR).

B3. TECHNICAL STANDARDS
– See Part II, Title 11, Section 1

CHAPTER D
ACTIVITIES AND SERVICES

CHAPTER CONTENTS

D1. TYPES OF ACTIVITIES AND SERVICES

100. Types in present Rules
– See Part II, Title 11, Seciton 1

200. Types for statutory surveys

201. For passenger ships with AB < 500, the statutory surveys for are in NORMAM 01 are applicable. For foreign flag ships the requirements of the National Regulations or, in the absence of those, it the IMO Conventions and Codes and associated documents.

202. For ships with AB ≥ 500, the statutory surveys for the passenger ships are to comply with SOLAS Convention (International Convention for the Safety of Life at Sea) Chapters I, II-1 and II-2.

203. For roll on / roll off ships carrying passengers or vehicles and passengers, see Part II, Title 26.

CHAPTER E
CONFIGURATIONS

CHAPTER CONTENTS

E1. BASIC ARRENGEMENT

100. Localization of the cargo space
- See Part II, Title 11, Seciton 1

200. Localization of Engine room
- See Part II, Title 11, Seciton 1

300. Localization of accommodations
- See Part II, Title 11, Seciton 1

400. Localization of passengers

401. Passenger compartments are recommended to be located above the main deck.

CHAPTER G

CAPACITIES AND SUBDIVISION

CHAPTER CONTENTS

G1. CAPACITIES

100. Volumes e volume centres

– See Part II, Title 11, Seciton 1

G2. SUBDIVISIONN

100. Compartments, tanks and void spaces

101. The subdivision bulkheads of compartments, tanks and void spaces are to take into account their nature and content, according to the requirements of the present Rules and Regulations.

102. For the requirements of subdivision for buoyancy, see Sub Chapter H4. as follows.

103. The engine room will be limited by bulkheads. In case of machinery aft, its aft bulkhead may be the aft peak bulkhead of the vessel.

104. Transportation of vehicles in cargo holds will be specially considered by RBNA. This includes the alternative of construction of a double hull. See Title 26.

105. All passengers ships with GT≥ 500 are to comply with Chapter II-1 Part B-2 of the SOLAS Convention as regards subdivision.

200. Double bottom

201. A double bottom is to 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.

202. Where a double bottom is required to be fitted the inner bottom is to 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:

$h = B/20$.

a. However, in no case is the value of h to be less than 760 mm, and need not be taken as more than 2 000 mm.

203. Small wells constructed in the double bottom in connection with drainage arrangements of holds, etc., shall not extend downward more than necessary. A well extending to the outer bottom is, however, permitted at the after end of the shaft tunnel. Other wells (e.g., for lubricating oil under main engines) may be permitted by the RBNA if satisfied that the arrangements give protection equivalent to that afforded by a double bottom complying with this regulation. In no case shall the vertical distance from the bottom of such a well to a plane coinciding with the keel line be less than 500 mm.

204. 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.

205. In the case of passenger ships which are employed in special trades for the carriage of large numbers of special trade passengers, such as the pilgrim trade, engaged in short international voyages the RBNA of the State whose flag such ships are entitled to fly if satisfied that it is impracticable to enforce compliance with the requirements of this chapter, may permit a double bottom to be dispensed with if satisfied that the fitting of a double bottom in that part would not be compatible with the design and proper working of the ship.

206. In case of unusual bottom arrangements in a passenger ship or a cargo ship, it is to be demonstrated that the ship is capable of withstanding bottom damages as specified in Chapter H, H5.600.

300. Cofferdams

301. A cofferdam is an empty space that separates adjacent compartments. A cofferdam may be arranged vertically or horizontally, properly ventilated and of sufficient size to allow its inspection.

302. The cofferdams are to be used between:

a. tanks of fuel oil and lubricating oil;

b. compartments destined for liquid hydrocarbons and freshwater compartments;

c. compartments destined for liquid hydrocarbons and tanks of liquid foam for fire extinguishing

303. Spaces provided for the shipment of flammable liquids are to be separated from accommodation and service areas by a cofferdam. When accommodations or service areas are positioned immediately above these cargo spaces, they may be exempted from a cofferdam only when the deck does not have access openings and is coated with a suitable material and recognized by the RBNA.

304. There may be an exemption when deemed impractical or exaggerated by the RBNA in relation to the characteristics and dimensions of the spaces contained in the tanks provided that:

a. the thickness of the plating between the tanks is increased, in relation to the item T11, S2, F2.600 of these Rules in 2 mm in the case of fresh water tanks and 1 mm for the other cases;

b. the sum of the throats of the weld beads at the edges of the bulkheads of the tanks is not less than the thickness of the bulkhead itself;

c. the height of water column for the structural dimensioning, as well as the height of tightness and of structural strength test are increased by 1 (one) m with respect to the item T11,S2,T6 of the present Rules.

CHAPTER H
LOADING CONDITIONS, BUOYANCY AND STABILITY

CHAPTER CONTENTS

H2. LIGHTWEIGHT

100. Lightweight determination

101. - See Part II, Title 11, Seciton 1

102. In passenger vessels with AB > 20, this determination is made by means of the inclining test.

103. In vessels with AB ≤ 20 the inclining test may be substituted by "weights and centres estimation," provided that weights and centres are assessed by measurement of drafts.

104. - See Part II, Title 11, Section 1, Chapter H, H2

H3. LOADING CONDITIONS

100. Configurations and combinations of loads

101. For a passenger ship, the loading conditions are to include:

a. ship in the fully loaded departure condition with cargo, full stores and fuel and with the full number of passengers with their luggage;

b. ship in the fully loaded arrival condition, with cargo, the full number of passengers and their luggage but with only 10% stores and fuel remaining;

c. ship without cargo, but with full stores and fuel and the full number of passengers and their luggage; and

d. ship in the same condition as above with only 10% stores and fuel remaining.

[IMO IS Code Part A Chapter 3, 3.1]

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

103. The height of the centre of gravity for passengers should be assumed equal to:

a. 1.0 m above deck level for passengers standing upright. Account may be taken, if necessary, of camber and sheer of deck;

b. 0.30 m above the seat in respect of seated passengers.

104. Passengers and luggage should be considered to be in the spaces normally at their disposal.

105. Passengers without luggage should be considered as distributed to produce the most unfavourable combination of passenger heeling moment and/or initial metacentric height, which may be obtained in practice, respectively. In this connection, it is anticipated that a value higher than four persons per square metre will not be necessary.

H4. BUOYANCY

100. Principles
- See Part II, Title 11, Seciton 1

200. Subdivision bulkheads to confine flooding

201. In addition of the bulkheads required in Chapter G, common transverse watertight bulkheads (AEC) are to be built with maximum spacing of about 20 to 25% of L.

202. As an alternative to the above paragraph the double hull construction should be considered, or a system of partial bulkheads, side transverse frames and deck transverses such as to provide equivalent transverse strength.

203. In cases requiring the calculation of damage stability or floodable length, the spacing of the bulkhead is to be determined by such calculations.

300. Vertical subdivision

301. In case of an accommodation floor below the maximum load water line, it is recommended that the distance between the vertical frames does not exceed one meter.

302. In passenger locations the above distance is to be as small as possible, preferably on the floor above the fluctuation waterline.

H5. STABILITY

100. Weight distribuition
– See Part II, Title 11, Section 1

200. Free Surface
– See Part II, Title 11, Section 1

300. Intact Stability for ships with GT ≥ 500 [SOLAS II-1/B-1/regulation 5]

301. Every passenger ship regardless of size and every cargo ship having a length (L) of 24 m and upwards, is to be inclined upon its completion and the elements of its stability determined. In addition to any other applicable requirements of the present regulations, ships having a length of 24 m and upwards constructed on or after 1 July 2010 shall as a minimum comply with the requirements of part A of the 2008 IS Code.

302. Where any alterations are made to a ship so as to materially affect the stability information supplied to the master, amended stability information is to be provided. If necessary the ship is to be re-inclined. The ship is to be re-inclined if anticipated deviations exceed one of the values specified in Part II, Title 11, Section 1, Chapter H, T2.300.

303. At periodical intervals not exceeding five years, a lightweight survey is to be carried out on all passenger ships to verify any changes in lightship displacement and longitudinal centre of gravity. The ship is to be re-inclined whenever, in comparison with the approved stability information, a deviation from the lightship displacement exceeding 2% or a deviation of the longitudinal centre of gravity exceeding 1% of Ls (see A2.119) is found or anticipated.

304. **Stability information supplied to the Master [SOLAS II-1/B-1/regulation 5-1]**

The master is to be supplied with such information satisfactory to the RBNA as is necessary to enable him by rapid and simple processes to obtain accurate guidance as to the stability of the ship under varying conditions of service. A copy of the stability information is to be furnished to the RBNA. The information should include:

a. curves or tables of minimum operational metacentric height (GM) versus draught which assures compliance with the relevant intact and damage stability requirements, alternatively corresponding curves or tables of the maximum allowable vertical centre of gravity (KG) versus draught, or with the equivalents of either of these curves;

b. instructions concerning the operation of cross-flooding arrangements; and

c. all other data and aids which might be necessary to maintain the required intact stability and stability after damage.

305. The stability information shall show the influence of various trims in cases where the operational trim range exceeds +/- 0.5% of Ls.

306. For ships with AB ≥ 500, the criteria for stability of passenger ships are to meet the requirements of SOLAS Convention Chapter II-1 Part A Rule 8, IMO IS Code as ammended, Chapter 3.1.

309. **General criteria [IS Code 2.2. to 2.2.4]**

a. The area under the righting lever curve (GZ curve) should not be less than 0.055 metre-radians up to $\phi = 30°$ angle of heel and not less than 0.09 metre-radians up to $\phi = 40°$ or the angle of down-flooding ϕf (see note) if this angle is less than 40°. Additionally, the area under the righting lever curve (GZ curve) between the angles of heel of 30° and 40° or between 30° and ϕf, if this angle is less than 40°, should not be less than 0.03 metre-radians.

Note: ϕf is an angle of heel at which openings in the hull, superstructures or deckhouses which cannot be closed weathertight immerse. In applying this criterion, small openings through which progressive flooding cannot take place need not be considered as open.

b. The righting lever GZ should be at least 0.20 m at an angle of heel equal to or greater than 30°.

c. The maximum righting arm should occur at an angle of heel preferably exceeding 30° but not less than 25°.

d. The initial metacentric height GMo should not be less than 0.15 m.

310. **Moment due to the turning [IS Code 3.1.2]**
For passenger ships, the angle of heel on account of turning should not exceed 10° when calculated using the following formula:

$$M_R = V_0^2 * \Delta * \left(KG - \frac{d}{2}\right) * L$$

where:

MR = heeling moment (kNm)
V_o = service speed (m/s)
LWL = length of ship at waterline (m)
Δ = displacement (t)
d = mean draught (m)

311. **Moment due to the crowding of passengers**: for passenger ships, the angle of heel on account of crowding of passengers to one side as defined in H3.102 to H3.105 should not exceed 10°.

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

313. A number of influences such as beam wind on ships with large windage area, icing of topsides, water trapped on deck, rolling characteristics, following seas, etc., adversely affect stability and the Administration is advised to take these into account, so far as is deemed necessary.

314. Provisions should be made for a safe margin of stability at all stages of the voyage, regard being given to additions of weight, such as those due to absorption of water and icing (details regarding ice accretion are given in chapter 5) and to losses of weight such as those due to consumption of fuel and stores.

400. Intact Stability for ships with GT < 500

401. For passenger ships with GT <500 under the Brazilian Flag, these Rules include the compliance with the criteria contained in NORMAM 01 Chapter 7 Section V.

402. For passenger ships with GT < 500 under foreign flags, National RBNA regulations apply or, in the absence of those, IMO IS Code regulations.

H6. DAMAGE STABILITY (SHIPS WITH GT ≥ 500)
[SOLAS II01/B-1/4 through B8.1]

100. General

101. The requirements of the present Subchapter H6 are to be applied to passenger ships in conjunction with the explanatory notes set out by IMO Resolution MSC281(85). The damage stability requirements that follow shall apply to all passenger ships regardless of length.

200. Required subdivision index R

201. The subdivision of a ship is considered sufficient if the attained subdivision index A, determined in accordance with H6.300, is not less than the required subdivision index R calculated in accordance with this item H6.201 and if, in addition, the partial indices As, Ap and Al shall not less than 0.9R for passenger ships.

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

a. In the case of cargo ships greater than 100 m in length (Ls):

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

(For the definition of Ls, see A2.119 above)

b. In the case of cargo ships not less than 80 m in length (Ls) and not greater than 100 m in length (Ls):

$$R = 1 - \left\{ \frac{1}{\left[1 + \left(\frac{Ls}{100} * \frac{Ro}{1-Ro}\right)\right]} \right\}$$

where Ro is the value R as calculated in accordance with the formula in H6.202.a.

c. In the case of passenger ships:

$$R = 1 - \frac{5000}{Ls + 2{,}5N + 15225}$$

where

N = N1 + 2N*2
N1 = number of persons for whom lifeboats are provided
N2 = number of persons (including officers and crew) the ship is permitted to carry in excess of N1.

d. Where the conditions of service are such that compliance with N = N1 + 2N2 is impracticable and where the RBNA considers that a suitably reduced degree of hazard exists, a lesser value of N may be taken but in no case less than N = N1 + N2.

300. Attained subdivision index A

301. The attained subdivision index A is obtained by the summation of the partial indices As, Ap and Al, (weighted as shown) calculated for the draughts ds, dp and dl defined below in accordance with the following formula:

A = 0.4As + 0.4Ap + 0.2Al

where

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

$A = \Sigma(Pi \cdot Si)$

where:

i represents each compartment or group of compartments under consideration;

Pi accounts for the probability that only the compartment or group of compartments under consideration may be flooded, disregarding any horizontal subdivision;

si accounts for the probability of survival after flooding the compartment or group of compartments under consideration, and includes the effect of any horizontal subdivision.

302. In the calculation of A, the level trim shall be used for the deepest subdivision draught and the partial subdivision draught. The actual service trim shall be used for the light service draught. If in any service condition, the trim variation in comparison with the calculated trim is greater than 0.5% of Ls, one or more additional calculations of A are to be submitted for the same draughts but different trims so that, for all service conditions, the difference in trim in comparison with the reference trim used for one calculation will be less than 0.5% of Ls.

303. When determining the positive righting lever (GZ) of the residual stability curve, the displacement used should be that of the intact condition. That is, the constant displacement method of calculation should be used.

304. The summation indicated by the above formula shall be taken over the ship's subdivision length (Ls) 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.

305. 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.

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

307. 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 RBNA 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.

308. The attained subdivision index A is not to be less than the required subdivision index R. In addition, the partial indexes As, Ap and Al are not to be less than 0,9R.

400. Calculation of the factor Pi

401. The factor Pi for a compartment or group of compartments shall be calculated below 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 centre line. The shell has k = 0;

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

x2 = the distance from the aft terminal of Ls 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 loadline between the shell and an assumed vertical plane extended between the longitudinal limits used in calculating the factor pi 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 load line 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:

$pi = p(x1_j,x2_j)*[r(xl_j,x2_j,bk) – r(x1_j, x2_j, bk-1)]$

If the damage involves two adjacent zones:

pi = - p (x1j,x2j* [r(x1j,x2j,bk) - r(x1j,x2j,bk-1)] +p*(x1j+1,x2j+1*[r(x1j+1,x2j+1,bk)-r(x1j+1,x2j+1,bk-1)]

where r(x1, x2, b0) = 0

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

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

Overall normalized max damage length: Jmax = 10/33

Knuckle point in the distribution: Jkn = 5/33

Cumulative probability at Jkn: pk = 11/12

Maximum absolute damage length: lmax = 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:

$$J = \frac{(x2 - x1)}{L_s}$$

The normalized length of a compartment or group of compartments:

Jn is to be taken as the lesser of J and Jm

J < Jk:
$p(x1, x2) = p1 = 1/6\ J^2\ (b11J + 3b12)$

J > Jk:

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

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

$$J \le J_k:$$
$$p(x1,x2) = \frac{1}{2}(p_1 + J)$$
$$J > J_k:$$
$$p(x1,x2) = \frac{1}{2}(p_2 + J)$$

404. Where the compartment or groups of compartments considered extends over the entire subdivision length (Ls):
p(x1, x2) = 1

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

$$r(x1,x2,b) = 1-(1-C)\cdot\left[1-\frac{G}{p(x1,x2)}\right]$$

where

$$C = 12\cdot J_b\cdot(-45\cdot J_b + 4)$$

where

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

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

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

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

408. Where neither limits 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

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

409. 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:

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

500. Calculation of factor si

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

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

ϕv 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 ϕv;¨

Range is the range of positive righting levers, in degrees, measured from the angle ϕe. The positive range is to be taken up to the angle ϕv;

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

502. The factor si, for any damage case at any initial loading condition, di, shall be obtained from the formula:

si = minimum {sintermediate,i or sfinal,i· smom,i}

where:

sintermediate,i is the probability to survive all intermediate flooding stages until the final equilibrium stage, and is calculated in accordance with H6.503;

sfinal,i is the probability to survive in the final equilibrium stage of flooding. It is calculated in accordance with H6.504

smom,i is the probability to survive heeling moments, and is calculated in accordance with paragraph H6.505.

503. **Calculation of s intermediate**

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

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

where GZmax is not to be taken as more than 0.05 m and Range as not more than 7°. sintermediate = 0, if the intermediate heel angle exceeds 15°. Where cross-flooding fittings are required, the time for equalization shall not exceed 10 min.

504. **Calculation of s final**
The factor sfinal,i shall be obtained from the formula:

$$S_{final,i} = K \cdot \left[\frac{GZ_{max}}{0.12} \cdot \frac{Range}{16}\right]^{\frac{1}{4}}$$

where:

$K = 1$ if $\phi_e \leq \phi_{min}$
$K = 0$ if $\phi_e \geq \phi_{max}$

$$K = \sqrt{\frac{\theta_{max} - \theta_e}{\theta_{max} - \theta_{min}}}$$

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

505. **Calculation of s moment**
The factor $s_{mom,i}$ is applicable only to passenger ships (for cargo ships $s_{mom,i}$ shall be taken as unity) and shall be calculated at the final equilibrium from the formula:

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

where:

Displacement is the intact displacement at the subdivision draught;

M_{heel} is the maximum assumed heeling moment as calculated in accordance with subparagraph H6.505.a; and $s_{mom,i} \leq 1$

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

M_{heel} = maximum {$M_{passenger}$ or M_{wind} or $M_{Survivalcraft}$}

a. **Calculation of Mpassenger**: $M_{passenger}$ is the maximum assumed heeling moment resulting from movement of passengers, and is to be obtained as follows:

$M_{passenger} = (0.075 \times N_p) \times (0.45 \times B)$ (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 beam of the ship.

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.

b. **Calculation of Mwind**: M_{wind} is the maximum assumed **wind** force acting in a damage situation:

$M_{wind} = (P \times A \times Z) / 9,806$ (tm)

where:

$P = 120$ N/m^2;

A = projected lateral area above waterline;

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

T = ship's draught, d_i.

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

c.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;

c.2. for lifeboats which are arranged to be launched fully loaded from the stowed position, the maximum heeling moment during launching shall be taken;

c.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;

c.4. persons not in the life-saving appliances which are swung out shall not provide either additional heeling or righting moment; and

c.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.

506. **Equalization arrangements**

a. 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. These fittings together with their controls shall be acceptable to the RBNA. Suitable information concerning the use of equalization devices shall be supplied to the master of the ship

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

c. 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.

507. **Cases where si is equal to zero**

a. In all cases, si is to be taken as zero in those cases where the final waterline, taking into account sinkage, heel and trim, immerses:

a.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 si. Such openings shall include air-pipes, ventilators and openings which are closed by means of weathertight doors or hatch covers; and

a.2. any part of the bulkhead deck in passenger ships considered a horizontal evacuation route for compliance with chapter II-2.

b. The factor si 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:

b.1. immersion of any vertical escape hatch in the bulkhead deck intended for compliance with the SOLAS chapter II-2;

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

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

508. However, where compartments assumed flooded due to progressive flooding are taken into account in the damage stability calculations multiple values of sintermediate may be calculated assuming equalization in additional flooding phases.

509. Except as provided in H6.507.b.i, openings closed by means of watertight manhole covers and flush scuttles, small watertight hatch covers, remotely operated sliding watertight doors, side scuttles of the non-opening type as well as watertight access doors and hatch covers required to be kept closed at sea need not be considered.

600. Calculation of the factor v_i

601. The factor vm shall be obtained from the formula:

vm = v(Hj, n, m, d) - v(Hj, n, m-1, d)

where:
Hj, n, m is the least height above the baseline, in metres, within the longitudinal range of x1(j)...x2(j+n-1) of the m_{th} horizontal boundary which is assumed to limit the vertical extent of flooding for the damaged compartments under consideration;

Hj, n, m-1 is the least height above the baseline, in metres, within the longitudinal range of x1(j)...x2(j+n-1) of the (m-1)th horizontal boundary which is assumed to limit the vertical extent of flooding for the damaged compartments under consideration;

j 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 H6.301; and

x1 and x2 represent the terminals of the compartment or group of compartments considered in H6.400.

a. The factors v(Hj, n, m,d) and v(Hj, n, m-1,d) shall be obtained from the formulae:

$$v(H,d) = 0.8\frac{(H-d)}{7.8}$$

if (H_m-d) is less than, or equal to, 7.8 m;

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

in all other cases

where:

v(Hj, n, m, d) is to be taken as 1, if Hm coincides with the uppermost watertight boundary of the ship within the range (x1(j)...x2(j+n-1)), and

v(Hj, n, 0, d) is to be taken as 0.

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

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

dA = pi [v1 Smin 1 + (v2 - v1)Smin 2 + ..+ (1-vm-1)Smin m]

where:

vm= the v-value calculated in accordance with H6.601;

smin = the least s-factor for all combinations of damages obtained when the assumed damage extends from the assumed damage height Hm downwards.

700. Permeability

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

TABLE T.H6.701.1 PEREMABILITY OF A GENERAL COMPARTMENT

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.

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

TABLE T.H6.702.1 PERMEABILITY OF A CARGO COMPARTMENT

Spaces	Permeability at draught ds	Permeability at draught dp	Permeability at draught dl
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

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

800. Special requirements concerning passenger ship stability
[Rule 8 of Chapter II-1 Part A of the SOLAS Convention]

801. A passenger ship intended to carry 400 or more persons shall have watertight subdivision abaft the collision bulkhead so that si = 1 for the three loading conditions on which is based the calculation of the subdivision index and for a damage involving all the compartments within 0.08L measured from the forward perpendicular.

802. 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 below. Compliance with this regulation is to be achieved by demonstrating that si, as defined in H6.500, is not less than 0.9 for the three loading conditions on which is based the calculation of the subdivision index.

803. The damage extent to be assumed when demonstrating compliance with the deepest subdivision draught (d_s)

(see A2.104.a), is to be dependent on both N as defined in H6.200, and Ls as defined in A2.118, such that:

a. 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 A2.104.a, unless a lesser vertical extent of damage were to give a lower value of si, in which case this reduced extent is to be used;

b. where 400 or more persons are to be carried, a damage length of 0.03Ls 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 angle to the centerline at the level of the deepest subdivision draught;

c. where less 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 H6.802;

d. where 36 persons are carried, a damage length of 0.015Ls 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

e. 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 H6.802.d and H6.802.b.

H7. INTEGRITY OF THE HULL, HULL OPENINGS AND MEANS OF CLOSURE

100. Openings in watertight bulkheads below the bulkhead deck in passenger ships [SOLAS II-1/B2/13]

101. The number of openings in watertight bulkheads is to be reduced to the minimum compatible with the design and proper operation of the ship, satisfactory means of closure are to be provided for these openings.

102. Pipes, scuppers, electric cables, etc. carried through watertight bulkheads

a. Where pipes, scuppers, electric cables, etc., are carried through watertight bulkheads, arrangements are to be made to ensure the watertight integrity of the bulkheads.

b. Valves not forming part of a piping system shall not be permitted in watertight bulkheads.

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

103. No doors, manholes, or access openings are permitted in watertight transverse bulkheads dividing a cargo space from an adjoining cargo space.

104. Not more than one door, apart from the doors to shaft tunnels, may be fitted in each watertight bulkhead within spaces containing the main and auxiliary propulsion machinery including boilers serving the needs of propulsion. Where two or more shafts are fitted, the tunnels are to be connected by an intercommunicating passage. There is to be only one door between the machinery space and the tunnel spaces where two shafts are fitted and only two doors where there are more than two shafts. All these doors are to be of the sliding type and are to be so located as to have their sills as high as practicable. The hand gear for operating these doors from above the bulkhead deck is to be situated outside the spaces containing the machinery.

105. Watertight doors, except as provided in Part II, Title 26 (passenger ships designed or adapted for the carriage of goods vehicles and accompanying personnel), are to be power-operated sliding doors capable of being closed simultaneously from the central operating console at the navigation bridge in not more than 60 s with the ship in the upright position.

106. The means of operation whether by power or by hand of any power-operated sliding watertight door shall be capable of closing the door with the ship listed to 15° either way. Consideration shall also be given to the forces which may act on either side of the door as may be experienced when water is flowing through the opening applying a static head equivalent to a water height of at least 1 m above the sill on the centreline of the door.

107. Watertight door controls, including hydraulic piping and electric cables, are to be kept as close as practicable to the bulkhead in which the doors are fitted, in order to minimize the likelihood of being affected by any damage which the ship may sustain. The positioning of watertight doors and their controls is to be such that if the ship sustains damage within one fifth of the breadth of the ship, such distance being measured at right angles to the centreline at the level of the deepest subdivision draught, the operation of the watertight doors clear of the damaged portion of the ship is not impaired.

108. **Power operated sliding watertight doors**: all power-operated sliding watertight doors are to be provided with means of indication which will indicate at all remote operating positions whether the doors are open or closed. Remote operating positions shall only be at the navigation bridge and at the location where hand operation above the bulkhead deck is required by paragraph H6.507.

109. Each power-operated sliding watertight door:

a. shall have a vertical or horizontal motion;

b. is to be normally limited to a maximum clear opening width of 1.2 m. The RBNA may permit larger doors only to the extent considered necessary for the effective operation of the ship provided that other safety measures, including the following, are taken into consideration:

b.1. special consideration is to be given to the strength of the door and its closing appliances in order to prevent leakages; and

b.2. the door is to be located inboard the damage zone B/5;

b.3. is to be fitted with the necessary equipment to open and close the door using electric power, hydraulic power, or any other form of power that is acceptable to the RBNA;

b.4. is to be provided with an individual hand-operated mechanism. It is to be possible to open and close the door by hand at the door itself from either side, and in addition, close the door from an accessible position above the bulkhead deck with an all-round crank motion or some other movement providing the same degree of safety acceptable to the RBNA. Direction of rotation or other movement is to be clearly indicated at all operating positions. The time necessary for the complete closure of the door, when operating by hand gear, shall not exceed 90 s with the ship in the upright position;

b.5. is to be provided with controls for opening and closing the door by power from both sides of the door and also for closing the door by power from the central operating console at the navigation bridge;

b.6. is to be provided with an audible alarm, distinct from any other alarm in the area, which will sound whenever the door is closed remotely by power and which shall sound for at least 5 s but no more than 10 s before the door begins to move and shall continue sounding until the door is completely closed. In the case of remote hand operation it is sufficient for the audible alarm to sound only when the door is moving. Additionally, in passenger areas and areas of high ambient noise the RBNA may require the audible alarm to be supplemented by an intermittent visual signal at the door; and

b.7. is to have an approximately uniform rate of closure under power. The closure time, from the time the door begins to move to the time it reaches the completely closed position shall in no case be less than 20 s or more than 40 s with the ship in the upright position.

110. The electrical power required for power-operated sliding watertight doors is to be supplied from the emergency switchboard either directly or by a dedicated distribution board situated above the bulkhead deck. The associated control, indication and alarm circuits is to be supplied from the emergency switchboard either directly or by a dedicated distribution board situated above the bulkhead deck and be capable of being automatically supplied by the transitional source of emergency electrical power in the event of failure of either the main or emergency source of electrical power.

111. Power-operated sliding watertight doors shall have either:

a. a centralized hydraulic system with two independent power sources each consisting of a motor and pump capable of simultaneously closing all doors. In addition, there is to be for the whole installation hydraulic accumulators of sufficient capacity to operate all the doors at least three times, i.e. closed-open-closed, against an adverse list of 15°. This operating cycle is to be capable of being carried out when the accumulator is at the pump cut-in pressure. The fluid used is to be chosen considering the temperatures liable to be encountered by the installation during its service. The power operating system is to be designed to minimize the possibility of having a single failure in the hydraulic piping adversely affect the operation of more than one door. The hydraulic system is to be provided with a low-level alarm for hydraulic fluid reservoirs serving the power-operated system and a low gas pressure alarm or other effective means of monitoring loss of stored energy in hydraulic accumulators. These alarms are to be audible and visual and is to be situated on the central operating console at the navigation bridge; or

b. an independent hydraulic system for each door with each power source consisting of a motor and pump capable of opening and closing the door. In addition, there is to be a hydraulic accumulator of sufficient capacity to operate the door at least three times, i.e. closed-open-closed, against an adverse list of 15°. This operating cycle is to be capable of being carried out when the accumulator is at the pump cut-in pressure. The fluid used is to be chosen considering the temperatures liable to be encountered by the installation during its service. A low gas pressure group alarm or other effective means of monitoring loss of stored energy in hydraulic accumulators is to be provided at the central operating console on the navigation bridge. Loss of stored energy indication at each local operating position shall also be provided; or

c. an independent electrical system and motor for each door with each power source consisting of a motor capable of opening and closing the door. The power source is to be capable of being automatically supplied by the transitional source of emergency electrical power in the event of failure of either the main or emergency source of electrical power and with sufficient capacity to operate the door at least three times, i.e. closed-open-closed, against an adverse list of 15°.

112. For the systems specified above, provision should be made as follows:

a. Power systems for power-operated watertight sliding doors is to be separate from any other power system.

b. A single failure in the electric or hydraulic power-operated systems excluding the hydraulic actuator shall not prevent the hand operation of any door.

113. Control handles is to be provided at each side of the bulkhead at a minimum height of 1.6 m above the floor and is to be so arranged as to enable persons passing through the doorway to hold both handles in the open position without being able to set the power closing mechanism in operation accidentally. The direction of movement of the handles in opening and closing the door is to be in the direction of door movement and is to be clearly indicated.

114. As far as practicable, electrical equipment and components for watertight doors is to be situated above the bulkhead deck and outside hazardous areas and spaces.

115. The enclosures of electrical components necessarily situated below the bulkhead deck shall provide suitable protection against the ingress of water.

Guidance

Refer to the publication IEC 60529(1976):

i. electrical motors, associated circuits and control components; protected to IPX 7 standard;

ii. door position indicators and associated circuit components; protected to IPX 8 standard; and

iii. door movement warning signals; protected to IPX 6 standard.

iv. Other arrangements for the enclosures of electrical components may be fitted provided the RBNA is satisfied that an equivalent protection is achieved. The water pressure IPX 8 is to be based on the pressure that may occur at the location of the component during flooding for a period of 36 h.

End of guidance

116. Electric power, control, indication and alarm circuits is to be protected against fault in such a way that a failure in one door circuit will not cause a failure in any other door circuit. Short circuits or other faults in the alarm or indicator circuits of a door shall not result in a loss of power operation of that door. Arrangements is to be such that leakage of water into the electrical equipment located below the bulkhead deck will not cause the door to open.

117. A single electrical failure in the power operating or control system of a power-operated sliding watertight door shall not result in a closed door opening. Availability of the power supply should be continuously monitored at a point in the electrical circuit as near as practicable to each of the motors. Loss of any such power supply should activate an audible and visual alarm at the central operating console at the navigation bridge.

118. Central operating console at the navigation bridge

a. The central operating console at the navigation bridge shall have a "master mode" switch with two modes of control:

a.1. a "local control" mode which shall allow any door to be locally opened and locally closed after use without automatic closure, and

a.2. a "doors closed" mode which shall automatically close any door that is open. The "doors closed" mode shall automatically close any door that is open. The "doors closed" mode shall permit doors to be opened locally and shall automatically re-close the doors upon release of the local control mechanism.

a.3. The "master mode" switch shall normally be in the "local control" mode. The "doors closed" mode shall only be used in an emergency or for testing purposes. Special consideration is to be given to the reliability of the "master mode" switch.

b. The central operating console at the navigation bridge is to be provided with a diagram showing the location of each door, with visual indicators to show whether each door is open or closed. A red light shall indicate a door is fully open and a green light shall indicate a door is fully closed. When the door is closed remotely the red light shall indicate the intermediate position by flashing. The indicating circuit is to be independent of the control circuit for each door.

c. It shall not be possible to remotely open any door from the central operating console.

119. If the RBNA is satisfied that such doors are essential, watertight doors of satisfactory construction may be fitted in watertight bulkheads dividing cargo between deck spaces. Such doors may be hinged, rolling or sliding doors but shall not be remotely controlled. They shall be fitted at the highest level and as far from the shell plating as practicable, but in no case shall the outboard vertical edges be situated at a distance from the shell plating which is less than one fifth of the breadth of the ship, such distance being measured at right angles to the centreline at the level of the deepest subdivision draught.

120. Should any such doors be accessible during the voyage, they shall be fitted with a device which prevents unauthorized opening. When it is proposed to fit such doors, the number and arrangements shall receive the special consideration of the RBNA

121. Portable plates on bulkheads shall not be permitted except in machinery spaces. The RBNA may permit not more than one power-operated sliding watertight door in each watertight bulkhead larger than those specified in H7.109 above to be substituted for these portable plates, provided these doors are intended to remain closed during navigation except in case of urgent necessity at the discretion of the master. These doors need not meet the requirements of H7.109.b.iv above regarding complete closure by hand-operated gear in 90 s.

122. Trunks and tunnels

a. Where trunk ways or tunnels for access from crew accommodation to the stokehold, for piping, or for any other purpose are carried through watertight bulkheads, they is to be watertight and in accordance with the requirements of SOLAS regulation 16-1.. The access to at least one end of each such tunnel or trunk way, if used as a passage at sea, is to be through a trunk extending watertight to a height sufficient to permit access above the bulkhead deck. The access to the other end of the trunk way or tunnel may be through a watertight door of the type required by its location in the ship. Such trunk ways or tunnels shall not extend through the first subdivision bulkhead abaft the collision bulkhead.

b. Where it is proposed to fit tunnels piercing watertight bulkheads, these shall receive the special consideration of the RBNA.

c. Where trunk ways in connection with refrigerated cargo and ventilation or forced draught trunks are carried through more than one watertight bulkhead, the means of closure at such openings is to be operated by power and be capable of being closed from a central position situated above the bulkhead deck.

200. Internal watertight integrity of passenger ships above the bulkhead deck
[**SOLAS II-1/B-2/17**]

201. 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, electric 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.

202. 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 weather tight. Freeing ports, open rails and scuppers shall be fitted as necessary for rapidly clearing the weather deck of water under all weather conditions.

203. The open end of air pipes terminating within a superstructure shall be at least 1 m above the waterline when the ship heels to an angle of 15°, or the maximum angle of heel during intermediate stages of flooding, as determined by direct calculation, whichever is the greater. Alternatively, air pipes from tanks other than oil tanks may discharge through the side of the superstructure. The provisions of this paragraph are without prejudice to the provisions of the International Convention on Load Lines in force.

204. 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.

205. Doors are to be opened and closed locally on both sides with the ship heeled 15 ˚ to each side. If the ship is allowed to heel up to 20 ˚, during the intermediate stages of flooding, so the doors are to be capable of operating by hand with the ship heeled 20 ˚.

206. Position indicators is to be provided in the bridge as well as locally on both sides of the doors to indicate whether the doors are open or closed and fasteners are fully fitted.

300. Doors in watertight bulkheads of cargo ships and passenger ships
[IACS Unified Interpretation SC156]

301. This Chapter covers doors located in way of the internal watertight subdivision boundaries and the external

watertight boundaries necessary to ensure compliance with the relevant subdivision and damage stability regulations.

302. Doors in watertight bulkheads of small cargo ships not subject to any statutory subdivision and damage stability requirements may be hinged quick acting doors arranged to open out of the major space protected. They shall be constructed in accordance with the requirements of the RBNA and have notices affixed to each side stating "To be kept closed at sea". This Chapter shall not apply to HSCs pending completion of revision of the HSC Code by IMO and consideration of same by the applicable IACS WPs.
This Chapter does not apply to doors located in external boundaries above equilibrium or intermediate waterplanes.

303. The design and testing requirements for watertight doors vary according to their location relative to the equilibrium waterplane or intermediate waterplane at any stage of assumed flooding.

304. This context shall not be limited to watertight doors covered by SOLAS. Watertight doors required by other statutory damage stability requirements, e.g. MARPOL, the IBC and IGC Codes are covered as well. Small cargo vessels not subject to damage stability requirements are not required to comply with the full scheme.

305. Definitions: See A2.101

306. **Structural Design**: doors shall be of approved design and substantial construction in accordance with the requirements of RBNA and shall be of a strength equivalent to that of the subdivision bulkheads in which they are fitted.

307. **Operation Mode, Location and Outfitting** : doors shall be fitted in accordance with all requirements regarding their operation mode, location and outfitting, i.e. provision of controls, means of indication, etc., as shown in Table T.H6.307.1 below. This table is to be read in conjunction with the following general notes:

a. For passenger ships the watertight doors and their controls are to be located in compliance with H7.107 and H7.109.b.ii above.

b. Frequency of Use whilst at sea

b.1. *Normally Closed*: Kept closed at sea but may be used if authorised. To be closed again after use.

b.2. *Permanently Closed*: The time of opening such doors in port and of closing them before the ship leaves port shall be entered in the log-book. Should such doors be accessible during the voyage, they shall be fitted with a device to prevent unauthorised opening.

b.3. *Normally Open:* May be left open provided it is always ready to be immediately closed.

b.4. *Used:* In regular use, may be left open provided it is ready to be immediately closed.

c. Type:

Power operated, sliding or rolling *	**POS**
Power operated,hinged	POH
Sliding or Rolling	S
Hinged	H

(*) Roll
ing doors are technically identical to sliding doors.

d. Control

d.1. Local: All doors, except those which are to be permanently closed at sea, are to be capable of being opened and closed by hand, (and by power, where applicable) locally, from both sides of the doors, with the ship listed to either side. Arrangements for passenger ships shall be in accordance with H7.109.b.iv above.

d.2. For passenger ships, the angle of list at which operation by hand is to be possible is 15° or 20° if the ship is allowed to heel up to 20° during intermediate stages of flooding.

d.3. For cargo ships, the angle of list at which operation by hand is to be possible is 30°.

e. **Remote**: Where indicated in Table T.H6.307.1 below, doors are to be capable of being remotely closed by power from the bridge Where it is necessary to start the power unit for operation of the watertight door, means to start the power unit is also to be provided at remote control stations. The operation of such remote control is to be in accordance with H7.119. Arrangements for passenger ships shall be in accordance with H7.118.b. above.

f. **Indication**: where shown in Table T.H6.307.1 below,

g. position indicators are to be provided at all remote operating positions as well as locally, on both sides of the door, to show whether the doors are open or closed and, if applicable, with all dogs/cleats fully and properly engaged. Indication at all remote control positions .

g.1. The door position indicating system is to be of self-monitoring type and the means for testing of the indicating system are to be provided at the position where the indicators are fitted.

g.2. An indication (i.e. red light) should be placed locally showing that the door is in remote control mode ("doors closed mode"). Special care should be taken in order to avoid potential danger when passing through the door. Signboard/instructions should be placed in way of the door advising how to act when the door is in "doors closed" mode.

h. **Alarms**: doors which are to be capable of being remotely closed are to be provided with an audible alarm, distinct from any other alarm in the area, which will sound whenever such a door is remotely closed. For passenger ships the alarm shall sound for at least 5 s but not more than 10 s before the door begins to move and shall continue sounding until the door is completely closed. In the case of remote closure by hand operation, an alarm is required to sound only while the door is actually moving. In passenger areas and areas of high ambient noise, the audible alarms are to be supplemented by visual signals at both sides of the doors.

i. **Notices**: as shown in Table T.H6.307.1., doors which are normally closed at sea but not provided with means of remote closure, are to have notices fixed to both sides of the doors stating, "To be kept closed at sea". Doors which are to be permanently closed at sea are to have notices fixed to both sides stating, "Not to be opened at sea".

308. **Fire Doors**: watertight doors may also serve as fire doors but need not be fire-tested when intended for use below the bulkhead deck.

a. Where such doors are used at locations above the bulkhead deck they shall, in addition to complying with the provisions applicable to fire doors at the same locations, also comply with means of escape provisions of Part II, Title 11, Section 3, E.12.

b. Where a watertight door is located adjacent to a fire door, both doors shall be capable of independent operation, remotely if required by H7.119 and from both sides of the each door.

TABLE T.H6.307.1. INTERNAL DOORS IN WATERTIGHT BULKHEADS IN CARGO SHIPS AND PASSENGER SHIPS

Position relative to equilibrium or intermediate waterplane	**1. Frequency of use whilst at sea**	**2. Type**	**3. Remote Control*6**	**4. Indication locally and on Bridge *6**	**5. Audible Alarm *6**
I. Passenger Ships					
A. At or below	Norm. Closed	POS	Yes	Yes	Yes
	Perm. Closed	S, H	No	No	No
B. Above	Norm.Open	POS, POH	Yes	Yes	Yes
	Norm. Closed	S, H	No	Yes	No
		S, H	No	Yes	No
II. Cargo Ships					
A. At or below	Used	POS	Yes	Yes	Yes
	Norm. Closed	S, H	No	Yes	No
	Perm. Closed	S, H	No	No	No
B. Above	Used	POS	Yes	Yes	Yes
	Norm. Closed	S, H	No	Yes	No

Position relative to equilibrium or intermediate waterplane	6. Notice	7. Comments	8. Regulation
I. Passenger Ships			
A. At or below	No	Certain doors may be left open, see SOLAS II-1/15.9.3	SOLAS II-1/15.9.1, 2 & 3
	Yes	See Notes 1 + 4	SOLAS II-1/15.10.1 & 2
B. Above	No		SOLAS II-1/15.9.3 SOLAS II-1/20.1 MSC/Circ.541 B. Above
	Yes	See Note 2	
	Yes	Doors giving access to Ro-Ro Deck	SOLAS II-1/20-2
II. Cargo Ships			
A. At or below	No		SOLAS II-1/25-9.2
	Yes	See Notes 2 + 3 + 5	SOLAS II-1/25-9.3
	Yes	See Notes 1 + 4	SOLAS II-1/25-9.4 SOLAS II-1/25-10
B. Above	No		SOLAS II-1/25-9.2
	Yes	See Notes 2 + 5	SOLAS II-1/25-9.3 SOLAS II-1/25-10

Notes:
1. Doors in watertight bulkheads subdividing cargo spaces.

2. If hinged, this door shall be of quick acting or single action type
3. "ICLL66 + A.320" or "1988 Protocol to ICLL66", MARPOL, IGC and IBC-Codes require remotely operated watertight doors to be sliding doors
4. The time of opening such doors in port and closing them before the ship leaves port shall be entered in the logbook.
5. The use of such doors shall be authorised by the officer of the watch.
6.Cables for control and power systems to power operated watertight doors and their status indication should comply with the requirements of Part II, Title 11, Section 7, Chapter E, E5.600.

308. **Normally closed doors at sea**: the doors that are not necessary for frequent access at sea are to be kept normally closed and may be of any type. Hinged or sliding doors normally kept closed are to be operated locally from both sides and are to be fitted with plates on both sides with the sign: "Keep this door closed while at sea."

309. **Doors normally open at sea**: Where there are public spaces for the passage of passengers and crew, the doors may usually be kept at sea, both sliding and/or hinged. In addition:

a. Doors maintained normally open at sea are to be provided with motor operation from the both sides of the door and remote closing from the bridge. The operation of these ports should be similar to the following:

a.1. Doors must be of the self-closing type and can be closed with a tilt angle opposite to lock of up to 3.5 s

a.2. The approximate time of closing of hinged doors shall not be greater than 40 seconds and not less than 10 seconds.

a.3. The ports except these of emergency, are to be provided with remote release from the control station manned permanently, individually or in groups, and individual release from both sides of the door. The release keys are to be provided with a function to prevent automatic re-setting of the system.

a.4. Retaining hooks not subjected to the control of the central station are prohibited.

a.5. A door remotely closed from the control station are to be provided with means for re-opening from both sides by local control. After the activation of this local control, the door are to be self closed automatically.

a.6. There must be an indication of closed door in the control station.

a.7. The automatic shutdown system must be designed so that in case of failure of the system the doors are closed automatically.

a.8. Local accumulators for doors provided with energized system of opening and closing are to be able to open and close the doors for 10 minutes after the fall of power of the control system.

a.9. The failure of a local or central system of a door shall not impair the operating of other doors.

a.10. Sliding doors or with the energized system of opening is to be provided with alarm that sounds at least 5 seconds before, but not more than 10 seconds, after the door is been released from the control station and before the door starts its movement, and continue to sound until the total closing of the door.

a.11. Double-leaf doors equipped with latch necessary for their fire shall have a latch that is automatically activated by the operation of the doors when released by the control system.

a.12. The doors with energized opening and closing mechanism are to be provided with approved system that should be able to operate in case of fire and that complies with the FTC (Fire Testing Code) of the IMO.

b. doors usually kept open at sea should be equipped with audible alarms, distinct from any other alarm in the area, which should trigger whenever the doors are closed remotely. The alarms are to sound for at least 5 s, but not more than 10 seconds before the doors start to move up and keep ringing until the doors are fully closed. In passenger areas and areas of high ambient noise, alarms are to be supplemented by visual signals on both sides of the doors.

[SOLAS CHAPTER II-1/B-2/9 Regulation 9]

400. Double bottoms in passenger ships and cargo ships other than tankers

401. 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.

402. 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

a. However, in no case is the value of h to be less than 760 mm, and need not be taken as more than 2 000 mm.

403. Small wells constructed in the double bottom in connection with drainage arrangements of holds, etc., shall not extend downward more than necessary. A well extending to the outer bottom is, however, permitted at the after end of the shaft tunnel. Other wells (e.g., for lubricating oil under main engines) may be permitted by the RBNA if satisfied that the arrangements give protection equivalent to that afforded by a double bottom complying with this regulation. In no case shall the vertical distance from the bottom of such a well to a plane coinciding with the keel line be less than 500 mm.

404. 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.

405. In the case of passenger ships which are employed in special trades for the carriage of large numbers of special trade passengers, such as the pilgrim trade, the Administration of the State whose flag such ships are entitled to fly, if satisfied that it is impracticable to enforce compliance with the requirements of this chapter, may exempt such ships from those requirements, provided that they comply fully with the provisions of:

a. the rules annexed to the Special Trade Passenger Ships Agreement, 1971; and

b. the rules annexed to the Protocol on Space Requirements for Special Trade Passenger Ships, 1973.

and which are engaged on regular service within the limits of a short international voyage, the RBNA may permit a double bottom to be dispensed with if satisfied that the fitting of a double bottom in that part would not be compatible with the design and proper working of the ship.

406. Any part of a passenger ship or a cargo ship that is not fitted with a double bottom in accordance with H7.401, H7404 or H7.405 shall be capable of withstanding bottom damages in that part of the ship.

407. In the case of unusual bottom arrangements in a passenger ship or a cargo ship, it shall be demonstrated that the ship is capable of withstanding bottom damages as specified in H7.408.

408. Compliance with H7.406 or H7.407 is to be achieved by demonstrating that s_i, when calculated in accordance with H6.500 above, is not less than 1 for all service conditions when subject to a bottom damage assumed at any position along the ship's bottom and with an extent specified in item b below for the affected part of the ship:

a. 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.

b. Assumed extent of damage shall be as follows:

TABLE T.H7.408.1 – ASSUMED EXTENT OF DAMAGE

	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 14.5m, whichever is less
Transverse extent	B/6 or 10 m, whichever is less	B/6 or 5 m, whichever is less
Vertical extent, measured from the keel line	B/20 or 2 m, whichever is less	B/20 or 2 m, whichever is less

c. If any damage of a lesser extent than the maximum damage specified in H7.408.b would result in a more severe condition, such damage should be considered.

409. In case of large lower holds in passenger ships, the RBNA 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 H7, but assuming an increased vertical extent.

500. Prevention and control of water ingress, etc [**SOLAS II-1/B4/22**]

501. All watertight doors is to be kept closed during navigation except that they may be opened during navigation as H7.503 and H7.504. Watertight doors of a width of more than 1.2 m in machinery spaces may only be opened in the circumstances detailed in that regulation. Any door which is opened in accordance with this paragraph is to be ready to be immediately closed.

502. Watertight doors located below the bulkhead deck having a maximum clear opening width of more than 1.2 m is to be kept closed when the ship is at sea, except for limited periods when absolutely necessary as determined by the RBNA.

503. 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.

504. Certain watertight doors may be permitted to remain open during navigation only if considered absolutely necessary; that is, being open is determined essential to the safe and effective operation of the ship's machinery or to permit passengers normally unrestricted access throughout the passenger area. Such determination is to be made by the RBNA only after careful consideration of the impact on ship operations and survivability. A watertight door permitted to remain thus open is to be clearly indicated in the ship's stability information and shall always be ready to be immediately closed.

505. Portable plates on bulkheads shall always be in place before the ship leaves port, and shall not be removed during navigation except in case of urgent necessity at the discretion of the master. The necessary precautions is to be taken in replacing them to ensure that the joints are watertight. Power-operated sliding watertight doors permitted in machinery spaces in accordance with SOLAS regulation SOLAS II-1/B2/13 is to be closed before the ship leaves port and shall remain closed during navigation except in case of urgent necessity at the discretion of the master.

506. Watertight doors fitted in watertight bulkheads dividing cargo between deck spaces is to be closed before the voyage commences and is to be kept closed during navigation; the time of opening such doors in port and of closing them before the ship leaves port is to be entered in the log-book.

507. Gangway, cargo and fuelling ports fitted below the bulkhead deck is to be effectively closed and secured watertight before the ship leaves port, and is to be kept closed during navigation.

508. The following doors, located above the bulkhead deck, is to be closed and locked before the ship proceeds on any voyage and shall remain closed and locked until the ship is at its next berth:

a. cargo loading doors in the shell or the boundaries of enclosed superstructures;

b. bow visors fitted in positions as indicated in paragraph H7.508.a;

c. cargo loading doors in the collision bulkhead; and

d. ramps forming an alternative closure to those defined in paragraphs H7.508.a to H7.508.c inclusive.

509. 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.

510. Notwithstanding the requirements of paragraphs 8.1 and 8.4, the RBNA 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 disembark-

ing of passengers when the ship is at safe anchorage and provided that the safety of the ship is not impaired.

511. The master shall ensure that an effective system of supervision and reporting of the closing and opening of the doors referred to in H7.508 is implemented.

512. The master shall ensure, before the ship proceeds on any voyage, that an entry in the log-book is made of the time of the last closing of the doors specified in H7.513 and the time of any opening of particular doors in accordance with H7.514 below.

513. Hinged doors, portable plates, sidescuttles, gangway, cargo and bunkering ports and other openings, which are required by these regulations to be kept closed during navigation, is to be closed before the ship leaves port. The time of closing and the time of opening (if permissible under these regulations) is to be recorded in such log-book as may be prescribed by the RBNA.

514. Where in a between-decks, the sills of any of the sidescuttles parallel to the bulkhead deck at side and having its lowest point 1.4 m plus 2.5% of the breadth of the ship above the water when the ship departs from any port, is to be closed watertight and locked before the ship leaves port, and they shall not be opened before the ship arrives at the next port. In the application of this paragraph the appropriate allowance for fresh water may be made when applicable.

a. The time of opening such sidescuttles in port and of closing and locking them before the ship leaves port is to be entered in such log-book as may be prescribed by the RBNA.

b. For any ship that has one or more sidescuttles so placed that the requirements of paragraph 14 would apply when it was floating at its deepest subdivision draught, the RBNA 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, and having its lowest point 1.4 m plus 2.5% of the breadth of the ship above the waterline corresponding to the limiting mean draught, and at which it will therefore be permissible to depart from port without previously closing and locking them and to open them at sea on the responsibility of the master during the voyage to the next port. In tropical zones as defined in the International Convention on Load Lines in force, this limiting draught may be increased by 0.3 m.

515. Sidescuttles and their deadlights which will not be accessible during navigation is to be closed and secured before the ship leaves port.

517. When a rubbish-chute, etc., is not in use, if the inboard opening is situated below the bulkhead deck of passenger ships and the freeboard deck of cargo ships, the cover shall be watertight and, in addition, an automatic non-return valve shall be fitted in the chute in an easily accessible position above the deepest subdivision draught. Such cover is to be kept closed and secured.

600. Angle of flooding
- See Part II, Title 11, Section 1

700. Flooding detection system for passenger ships [SOLAS II-1/B-4/22-1 AND MSC.1/Circ.1291]

701. Passenger ships carrying 36 or more persons constructed on or after 1 July 2010 to be provided with flooding detection systems for watertight spaces below the bulkhead deck based on guidelines developed by the Organization.

702. These guidelines are intended to provide detailed requirements for flooding detection systems to provide information in the case of flooding in order to assess the actual flooding situation and support the decision-making process.

703. **Definitions**

a. **Flooding detection system** means a system of sensors and alarms that detect and warn of water ingress into watertight spaces. Continuous flood level monitoring may be provided, but is not required.

b. **Sensor** means a device fitted at the location being monitored that activates a signal to identify the presence of water at the location.

c. **Alarm** means an audible and visual signal which announces a flooding condition requiring attention.

704. **System installation**

a. A flooding detection system should be fitted in all watertight spaces below the bulkhead deck that:

a.1. have a volume, in cubic metres (m^3), that is more than the ship's moulded displacement per centimetre (cm) immersion at deepest subdivision draught; or

a.2. have a volume more than 30 m^3, whichever is the greater.

b. Any watertight spaces that are separately equipped with a liquid level monitoring system (such as fresh water, ballast water, fuel, etc.), with an indicator panel or other means of monitoring at the navigation bridge (and the safety centre if located in a separate space from the navigation bridge), are excluded from these requirements.

705. **Sensor installation**

a. The number and location of flooding detection sensors should be sufficient to ensure that any substantial water ingress into a watertight space requiring a flooding detection system is detected under reasonable angles of trim and heel. To accomplish this, flooding detection sensors required in accordance with paragraph 6 should generally be installed as indicated below:

a.1. **Vertical** location – sensors should be installed as low as practical in the watertight space.

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

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

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

706. **Unusual arrangements**: For watertight spaces with unusual arrangements or in other cases where these guidelines would not achieve the intended purpose, the number and location of flooding detection sensors should be subject to special consideration.

707. **Alarm installation**

a. Each flooding detection system should give an audible and visual alarm at the navigation bridge and the safety centre, if located in a separate space from the navigation bridge. These alarms should indicate which watertight space is flooded.

b. Visual and audible alarms should conform to the Code on Alarms and Indicators, 1995, as may be amended, as applicable to a *primary alarm* for the preservation or safety of the ship.

708. **Design requirements**

a. The flooding detection system and equipment should be suitably designed to withstand supply voltage variation and transients, ambient temperature changes, vibration, humidity, shock, impact and corrosion normally encountered in ships. Sensor cabling and junction boxes should be suitably rated to ensure operability of the detection system in a flooded condition. In addition, the detection system should be designed on the fail-to-safety principle, where an open sensor circuit should result in an alarm condition. *

b. The flooding detection system should be continuously powered and should have an automatic change-over to a stand-by power supply in case of loss of the normal power supply. Failure of the normal power supply should be indicated by an alarm.

709. **Detector maintenance, accessibility and testing**

a. Documented operating, maintenance and testing procedures for the flooding detection system should be kept on board and be readily accessible.

b. Flooding detection system sensors and equipment should be installed where they are accessible for testing, maintenance and repair.

c. The flooding detection system should be capable of being functionally tested using either direct or indirect methods. Records of testing should be retained on board.

CHAPTER J
METHOD FOR THE CALCULATION OF TRANSVERSAL FLOODING (CROSS-FLOODING)

J1. PRINCIPLES OF CALCULATION OF THE CROSS-FLOODING [RESOLUTION MSC.362(92) (Adopted on 14 June 2013)]

100. Definitions

101. The following definitions are used by this Chapter J.

102. Σk: Sum of friction coefficients in the considered cross-flooding arrangement..

103. **S (m^2)** Cross-section area of the cross-flooding pipe or duct. If the cross-section area is not circular, then:

$$S_{equiv} = \frac{\pi \cdot D_{equiv}^2}{4}$$

where:

$$D_{equiv} = \frac{4 \cdot A}{p}$$

A = actual cross-section area

p = actual cross-section perimeter

104. θ_0 **(°)**Angle before commencement of cross-flooding. The cross-flooding device may be assumed to be full or empty dependent on its arrangement and internal volume (see Part II, Title 21, Section 2 of Chapter K).

105. θf_0 **(°):**Heel angle at final equilibrium ($\phi_f \leq \phi$).

106. θ **(°):** any angle of heel between the commencement of cross-flooding and the final equilibrium at a given time.

107. W_f (m3): Volume of water which is used to bring the ship from commencement of cross-flooding ϕ_0 to final equilibrium ϕ_f.

108. **W θ (m ^{3}):** Volume of water which is used to bring the ship from any angle of heel ϕ to the final equilibrium ϕ_f.

109. **H_0 (m):** ead of water before commencement of cross-flooding, with the same assumption as for ϕ_0.

110. **H θ (m):** Head of water when any angle of heel ϕ is achieved..

111. **h_f(m)**: Final head of water after cross-flooding (h_f=0, when the level inside the equalizing compartment is equal to the free level of the sea).

112. **g (m/s^2)**: The acceleration due to gravity (9.81 m/s^2).

200. Formulas

201. Time required from commencement of cross-flooding ϕ_0 to the final equilibrium ϕ_f:

$$T_f = \frac{2W_f}{S \cdot F} \cdot \frac{1}{\sqrt{2gH_0}} \cdot \frac{1}{\left(1 + \sqrt{\frac{h_f}{H_0}}\right)}$$

202. Time required to bring the ship from any angle of heel ϕ to the final equilibrium ϕ_f:

$$T_\theta = \frac{2W_\theta}{S \cdot F} \cdot \frac{1}{\sqrt{2gH_\theta}} \cdot \frac{1}{\left(1 + \sqrt{\frac{h_f}{H_\theta}}\right)}$$

203. Time required from commencement of cross-flooding ϕ_0 until any angle of heel ϕ is achieved:

$T = T_f - T_\theta$

204. Dimensionless factor of reduction of speed through an equalization device, being a function of bends, valves, etc. in the cross-flooding system:

$$F = \frac{1}{\sqrt{(\sum k_i) + 1}}$$

Values for k can be obtained from appendix 2 of the Resolution MSC.362(92) or other appropriate sources such as computational fluid dynamics (CFD) or model testing. If other appropriate sources are used, then the +1 factor in the formulae may not be appropriate. CFD can also be used to evaluate the discharge coefficient for the whole cross-flooding duct.

205. Cross-flooding through successive devices of different cross-section:

a. If the same flow crosses successive flooding devices of cross-section S_1, S_2, S_3… having corresponding friction coefficients k_1, k_2, k_3…, then the total k coefficient referred to S_1 is:

$$\Sigma k = k_1 + k_2 \cdot S_1^2 / S_2^2 + k_3 \cdot S_1^2 / S_3^2 \ldots$$

206. If different flooding devices are not crossed by the same volume, each k coefficient should be multiplied by the square of the ratio of the volume crossing the device and the volume crossing the reference section (which will be used for the time calculation):

$$\sum k = k_1 + k_2 \cdot \frac{S_1^2}{S_2^2} \cdot \frac{W_2^2}{W_1^2} + k_3 \cdot \frac{S_1^2}{S_3^2} \cdot \frac{W_3^2}{W_1^2} \ \ldots$$

207. For cross-flooding through devices in parallel that lead to the same space, equalization time should be calculated assuming that:

$$S \cdot F = S_1 \cdot F_1 + S_2 \cdot F_2 + \ldots$$

With

$$F = \frac{1}{\sqrt{(\sum k_i) + 1}}$$

for each device of cross-section S_i

300. Air pipe venting criteria

301. In arrangements where the total air pipe sectional area is 10 per cent or more of the cross-flooding sectional area, the restrictive effect of any air back pressure may be neglected in the cross-flooding calculations.

302. The air pipe sectional area should be taken as the minimum or the net sectional area of any automatic closing devices, if that is less.

303. The k coefficient used in the calculation of cross-flooding time should take into account the drop of head in the air pipe. This can be done using an equivalent coefficient k_e, which is calculated according to the following formula:

$$K_e = k_w + k_a \cdot (\rho_a/\rho_w) \cdot (S_w / S_a)^2$$

onde:

k_w = k coefficient for the cross-flooding arrangement (water)
k_a = k coefficient for the air pipe
ρ_a = air density
ρ_w = water density
S_w = cross-section area of the cross-flooding device (water)
S_a = cross-section of air pipe

400. Alternative Methods

401. As an alternative to the provisions in sections 2 and 3, and for arrangements other than those shown in Figure F.J3.101.2 direct calculation using computational fluid dynamics (CFD), time-domain simulations or model testing may also be used.

J2. EXAMPLE FOR THE TREATMENT OF LATERAL INCLINATION ANGLES AND OF MANOMETRIC HEIGHTS IN DIFFERENT STAGES OF CROSS-FLOODING (ILLUSTRATED)

FIGURE F.J2.101.1a to 1.d – EXAMPLES FOR TREATMENT OF HEEL ANGLES AND WATER HEADS AT DIFFERENT STAGES OF CROSS-FLOODING

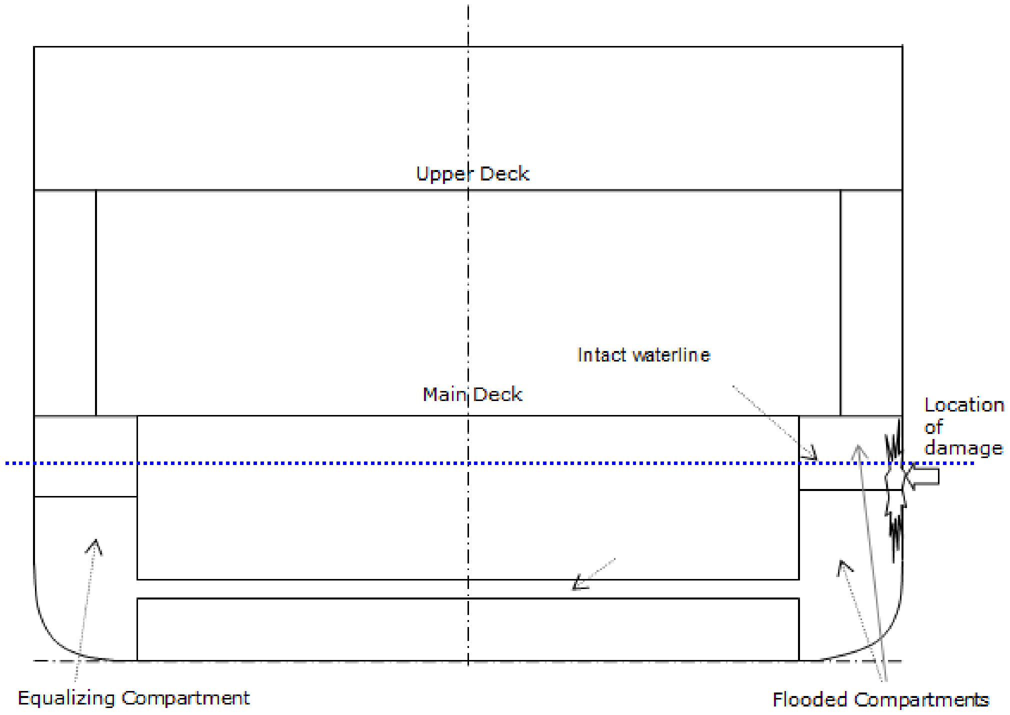


Figure 1(a) – Section showing cross-flooding pipe and compartments

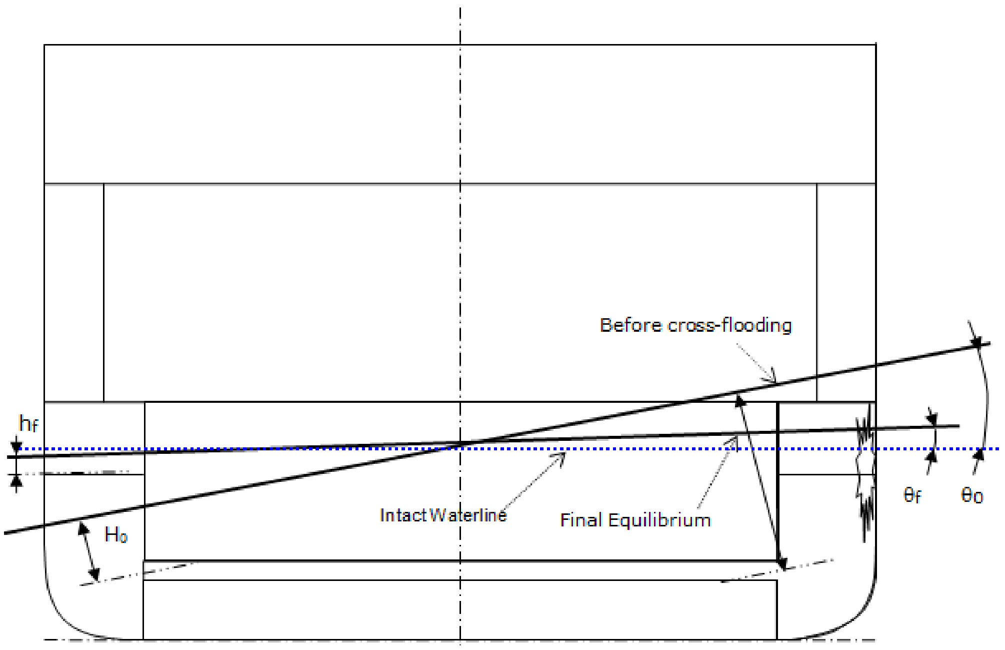


Figure 1(b) – Initial and Final stages of cross-flooding

Note: H_0 on the left side of figure 1(b) depicts the head of water if the cross-flooding device was assumed full whereas H_0 on the right side of figure 1(b) shows the head of water if the cross-flooding device was assumed empty.

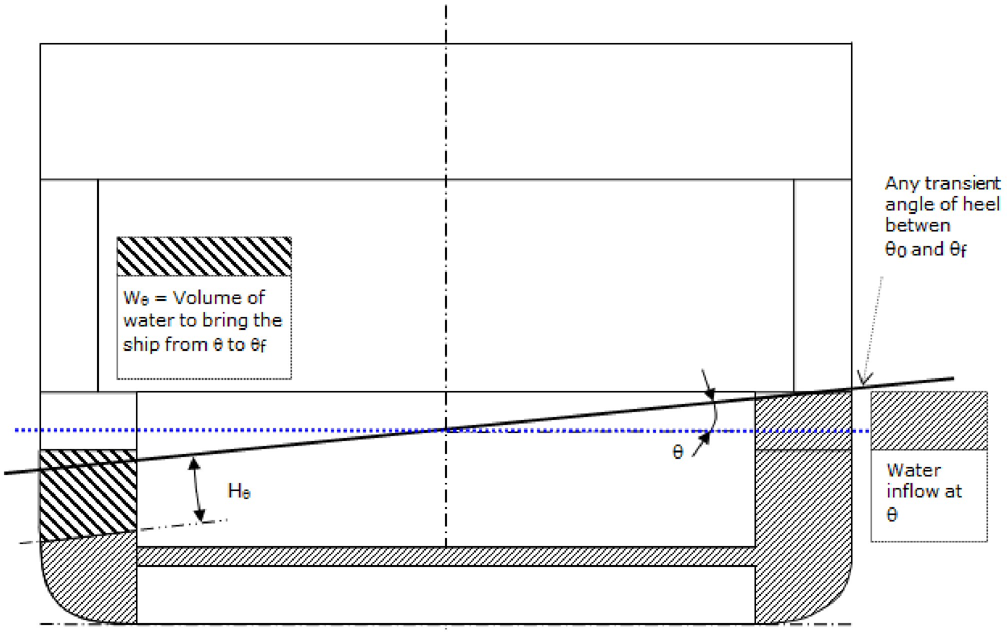


Figure 1(c) – Situation at any transient angle of heel, θ

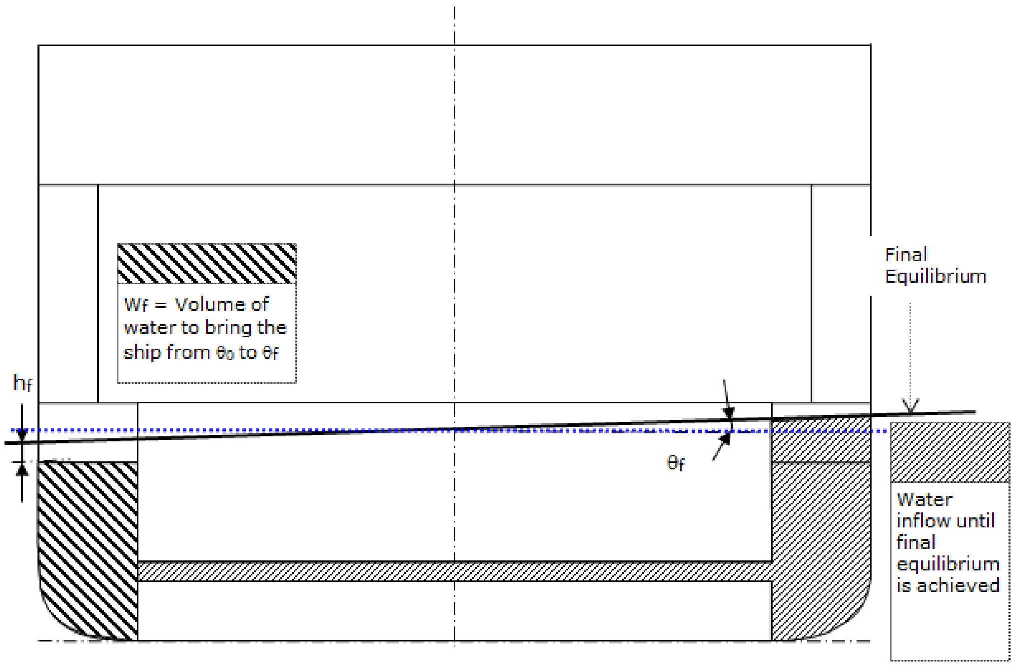


Figure 1(d) – Situation at final equilibrium

J3. FRICTION COEFFICIENTS IN CROSS-FLOODING ARRANGEMENTS (ILLUSTRATED)

FIGURE F.J3.101.1 – Figures 1 to 6–COEFFICIENTS OF FRICTION

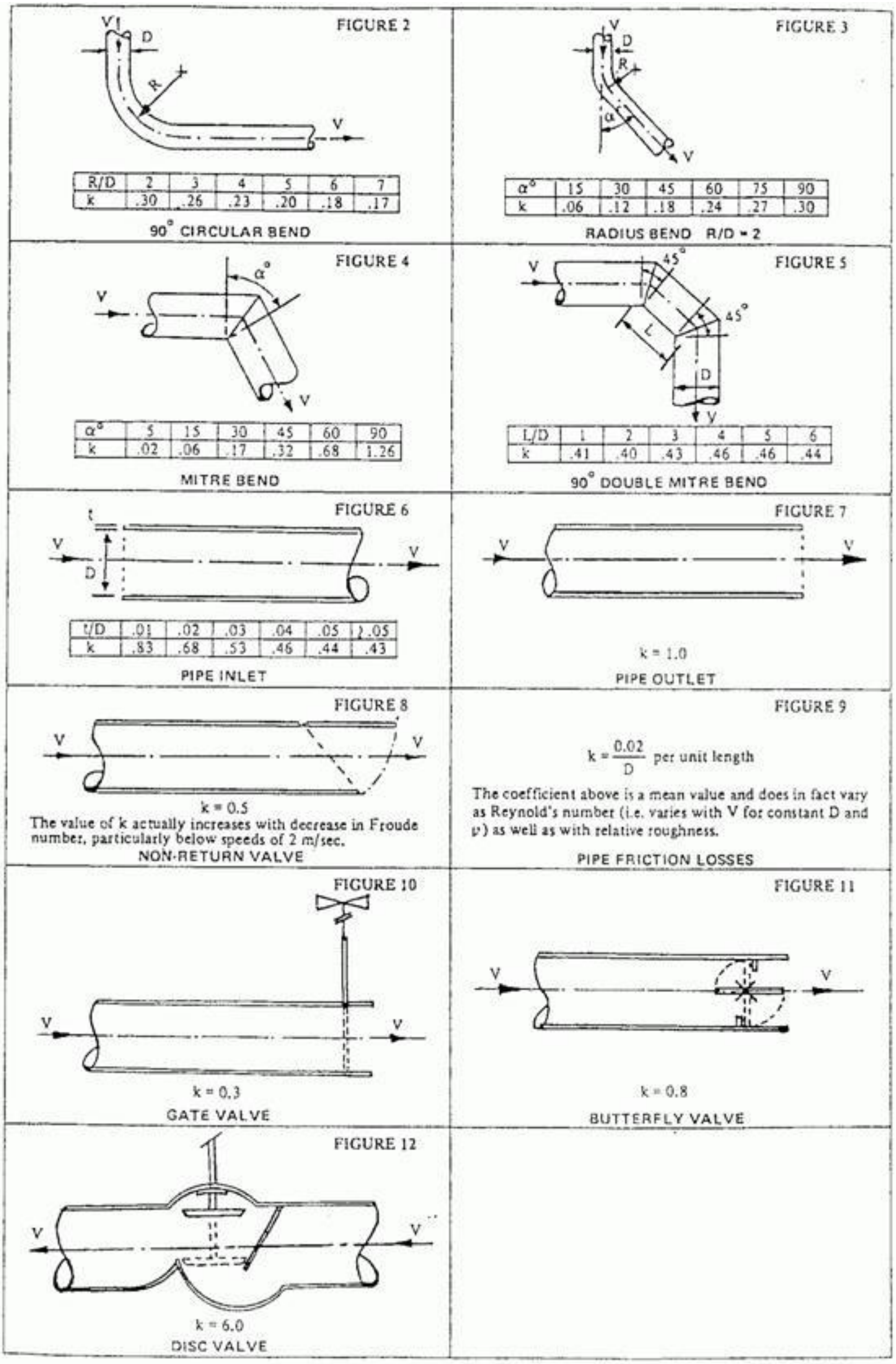
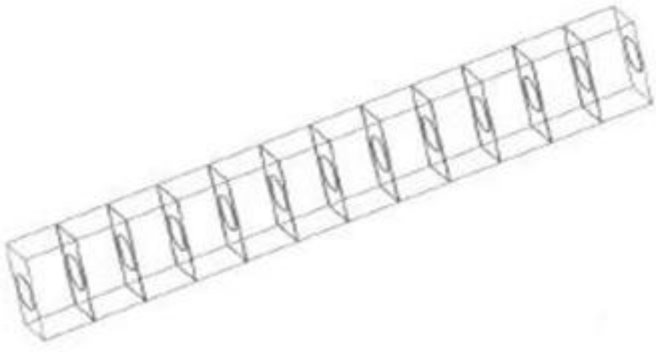


FIGURE F.J3.101.2 – CROSS FLOODING THROUGH A SERIE OF STRUCTURAL DUCTS WITH OPENINGS FOR PASSAGE

1 - Cross flooding through a series of structural ducts with one manhole

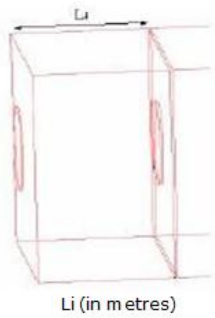


$$k = 0.6718 \times L_i^{0.119} \qquad (0 < L_i < 12)$$
$$k = 0.903 \qquad (12 \le L_i)$$

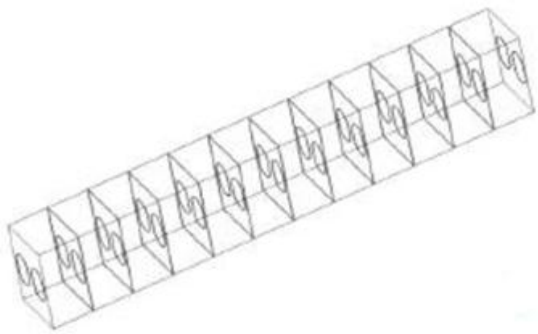
where:
k = friction coefficient related to each space between two adjacent girders
L_i = Length of the duct in meters

Note: k is evaluated with effective cross-section area therefore in calculations use the real cross-section area A and not S_{equiv}. The pressure loss for entrance in the first manhole is already computed in the calculation.

2 – Li (in metres)



3 – Cross flooding through a series of structural ducts with two manholes



$$k = 1.7968 \times L_i^{-0.026} \quad (0 < L_i < 12)$$
$$k = 1.684 \quad (12 \le L_i)$$

Where:

K = friction coefficient related to each space between two adjacent girders

L_i.= Length of the duct in meters

Note: k is evaluated with effective cross-section area therefore in calculations use the real cross-section area A and not S_{equiv}. The pressure loss for entrance in the first manhole is already computed in the calculation.

J4. EXAMPLE USING VALUES OF A PASSENGER SHIP

100. Example of calculation for a passenger ship

EXAMPLE USING FIGURES FOR A PASSENGER SHIP

Dimension of the considered cross-flooding pipe:

Diameter	D = 0.39 m
Length	l = 21.0 m
Cross-section area	S = 0.12 m^2
Wall thickness	t = 17.5 mm

k-values for the considered cross-flooding system:

Inlet	0.45
Pipe friction (0.02 l/D)	1.08
2 radius bends (α = 45°)	0.36
Non-return valve	0.50

Sufficient air venting is assumed to be in place.

From this follows:

$$F = \frac{1}{\sqrt{(\sum k_i) + 1}} \qquad F = \frac{1}{\sqrt{3.39}} = 0.54$$

105. Time required from commencement of cross-flooding ϕ_0 to the final equilibrium condition ϕ_f:

$$T_f = \frac{2W_f}{S \cdot F} \cdot \frac{1}{\sqrt{2gH_0}} \frac{1}{\left(1 + \sqrt{\frac{h_f}{H_0}}\right)}$$

106. Head of water before commencement the cross-flooding:

$$H_0 = 5.3\text{m}$$

107. Volume of water which is used to bring the ship from commencement of cross-flooding to the final equilibrium condition:

$$W_f = 365\text{m}^3$$

108. Final head of water after cross-flooding:

$$h_f = 1.5m$$

$$T_f = \frac{2 \cdot 365m^3}{0.12m^2 \cdot 0.54} \cdot \frac{1}{\sqrt{2 \cdot 9.81 m/s^2 \cdot 5.3m}} \cdot \frac{1}{\left(1 + \sqrt{\frac{1.5m}{5.3m}}\right)}$$

$$T_f = 721s$$

109. Calculation of any transient situation of cross-flooding:

The purpose is to find the situation after 600s.

Assumed transient situation:

Cross-flooded volume: 265 m^3

Volume of water which is used to bring the vessel from the transient situation to the final equilibrium :

W_0 = 365 m3 – 265 m3 = 100 m^3

Corresponding head of water:

H_0 = 2.8 m

Time required to bring the vessel from any transient situation to the final equilibrium condition:

$$T_{\theta} = \frac{2W_{\theta}}{S \cdot F} \cdot \frac{1}{\sqrt{2gH_{\theta}}} \cdot \frac{1}{\left(1 + \sqrt{\frac{h_f}{H_{\theta}}}\right)}$$

$$T_{\theta} = \frac{2 \cdot 100m^3}{0.12m^2 \cdot 0.54} \cdot \frac{1}{\sqrt{2 \cdot 9.81m/s^2 * 2.8m}} \cdot \frac{1}{\left(1 + \sqrt{\frac{1.5 \approx m}{2.8 \approx m}}\right)}$$

$T_{\phi} = 240$ s

Time between commencement of cross-flooding and assumed transient situation:

$T = T_f - T_{\phi} = 721$ s $- 240$ s $= 481$ s

As T is less than 600 s, further transient situations with larger cross-flooded volume may be calculated in the same way.

On the reverse, if T was of more than 600 s, further transient situation with smaller cross-flooded volume may be calculated. Situation after 600 s may be found by successive iterations.

CHAPTER T
INSPECTIONS AND TESTS

CHAPTER CONTENTS

T2. AT THE END OF CONSTRUCTION

100. to 300. - See Part II, Title 11, Section 1,

400. Testing of doors

401. Doors which become immersed by an equilibrium or intermediate waterplane, are to be subjected to a hydrostatic pressure test.

402. For large doors intended for use in the watertight subdivision boundaries of cargo spaces, structural analysis may be accepted in lieu of pressure testing. Where such doors utilise gasket seals, a prototype pressure test to confirm that the compression of the gasket material is capable of accommodating any deflection, revealed by the structural analysis, is to be carried out.

403. Doors which are not immersed by an equilibrium or intermediate waterplane but become intermittently immersed at angles of heel in the required range of positive stability beyond the equilibrium position are to be hose tested. Additionally, such doors may need to be pressure tested to a head as specified by a National standard or regional agreement

404. For clarification purposes it shall be noted that even though these doors are covered by the text in this Subchapter T2 ,in accordance with the practice of LL, SOLAS and MARPOL Conventions such hose testing usually is related to weathertight doors rather than to watertight doors.

405. **Pressure Testing**: the head of water used for the pressure test shall correspond at least to the head measured from the lower edge of the door opening, at the location in which the door is to be fitted in the vessel, to the bulkhead deck or freeboard deck, as applicable, or to the most unfavourable damage waterplane, if that be greater. Testing may be carried out at the factory or other shore based testing facility prior to installation in the ship.

406. **Leakage Criteria:** The following acceptable leakage criteria should apply to:

a. Doors with gaskets — No leakage

b. Doors with metallic sealing — Max leakage 1 liter/min.

407. Limited leakage may be accepted for pressure tests on large doors located in cargo spaces employing gasket seals or guillotine doors located in conveyor tunnels, in accordance with the following

$$Leakage\ rate\ \left(\frac{litre}{\min}\right) = \frac{1}{6568} * (P + 4.572) * h$$

Where:

P = perimeter of door opening (metres)

h = test head of water (metres)

408. However, in the case of doors where the water head taken for the determination of the scantling does not exceed 6.10 m, the leakage rate may be taken equal to 0.375 liter/min if this value is greater than that calculated by the above-mentioned formula.

409. For doors on passenger ships which are normally open and used at sea or which become submerged by the equilibrium or intermediate waterplane, a prototype test shall be conducted, on each side of the door, to check the satisfactory closing of the door against a force equivalent to a water height of at least 1m above the sill on the centre line of the door Arrangements for passenger ships shall be in accordance with H7.106 above

500. Hose Testing

501. All watertight doors shall be subject to a hose test (see note below) after installation in a ship. Hose testing is to be carried out from each side of a door unless, for a specific application, exposure to floodwater is anticipated only from one side. Where a hose test is not practicable because of possible damage to machinery, electrical equipment insulation or outfitting items, it may be replaced by means such as an ultrasonic leak test or an equivalent test.

Note: Part II, Title 11, Section 2, T.6[IACS UR S14.2.3]
Hose testing: when hose testing is required to verify the tightness of the structures the minimum pressure in the hose, at least equal to 2 × 105 Pa, is to be applied at a maximum distance of 1.5 m. The nozzle diameter is not to be less than 12 mm.

Rgmm14en-PIIT21S1-abdeghj-00