ClassIBS

ISTHMUS BUREAU OF SHIPPING

PART 3
SUBDIVISIONS

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PRINCIPLES FOR THE CLASSIFICATION AND CONSTRUCTION OF STEEL SHIPS 2012

PART 3 SUBDIVISIONS

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PRINCIPLES FOR THE CLASSIFICATION AND CONSTRUCTION OF STEEL SHIPS

PART 3 SUBDIVISIONS

Chapter 1 GENERAL

1.1 General

1.1.1 Application

The requirements in this Chapter apply to cargo ships of not less than 500 *gross tonnage* engaged in international voyages and 80 *m* in length for freeboard (L_f) and upwards. However, tankers specified in Chapter 26, Part 2 of the Rules.

1.1.2 Definitions

For the purpose of this chapter, the following definitions apply.

(1) "Compartment" is a part of the hull formed by shells, decks and bulkheads which are to be watertight as a rule.

(2) "Group of compartments" is a part of the hull formed by two or more compartments which are adjacent with each other.

(3) "Deepest subdivision draught" (d_s) is the draught which corresponds to the summer draught assigned to the ship in accordance with the requirements of International Load line Convention (*ILLC)*.

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

(5) "Partial subdivision draught" (d_p) is the draught which corresponds to the summation of light service draught specified in **(4)** above and 60% of the difference between light service draught and the deepest subdivision draught.

(6) "Subdivision length of the ship" ($\boldsymbol{L_s}$) is the greatest projected moulded length in metres of the ship at or below deck or decks limiting the vertical extent of flooding with the ship at the deepest subdivision draught.

(7) "Mid-length" is the midpoint of $\boldsymbol{L_s}$.

(8) "Aft terminal" is the aft limit of $\boldsymbol{L_s}$**.**

(9) "Forward terminal" is the forward limit of $\boldsymbol{L_s}$.

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

(11) "Breadth of ship" (B') is the greatest moulded breadth in metres of the ship at or below the deepest subdivision draught.

(12) "Draught" (***d*** ') is the vertical distance in metres from the keel line to the water line in question at the midpoint of L_s.

(13) "Permeability of a space" (μ) is the proportion of the immersed volume of that space (a compartment or group of compartments) which can be occupied by water. The value μ is shown in **Table 1.1-1** and **Table 1.1-2** according to the purpose of the space. However, in spaces intended for the carriage of liquid, the more stringent value of μ is to be taken when calculating the subdivision index in **1.2**. Where substantiated by calculations and specifically accepted by the Society, other figures for permeability specified in **Table 1.1-1** and **Table 1.1-2** may be used notwithstanding the provision above.

(14) "Internal opening" is the opening provided in decks or bulkheads forming a compartment excluding those that are completely exposed.

(15) "External opening" is the opening provided in shells, exposed decks or bulkheads forming a compartment.

(16) "Timber deck cargo" means a cargo of timber carried on an uncovered part of a freeboard or superstructure deck. The term does not include wood pulp or similar cargo.

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

Table 1.1-1 Permeability of general compartment

Space for	Locker	Accomodation	Machinery	Void	Liquid
Permeability	0.60	0.95	0.85	0.95	0 or 0.95

Table 1.1-2 Permeability of cargo compartment

Space for	Permeability at draught d_S	Permeability at draught d_p	Permeability at draught d_l
Dry cargo spaces	0.70	0.80	0.95
Container spaces	0.70	0.80	0.95
Ro-ro spaces	0.90	0.90	0.95
Cargo liquids	0.70	0.80	0.95

1.2 Subdivision Index

1.2.1 Subdivision Index

1. The value of the Required Subdivision Index (R) is to be given by the following formula:

(1) In case L_S>100m

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

(2) In case $100m \geq L_S \geq 80m$

$$R=1-\left[1/\left(1+\frac{L_S}{100}\cdot\frac{R_0}{1-R_0}\right)\right]$$

R_0: The value R as calculated in accordance with the formula in **(1)** above.

2. The Attained Subdivision Index (A) for the ship is to be not less than the Required Subdivision Index (R), calculated in accordance with **-1** above. A is obtained by the summation of the partial indices A_S, A_P and A_l (weighted as shown) calculated for the draughts d_{S1}, d_P, d_l specified in **1.1.2(3)** to (**5**) in accordance with the following formula:

$$A=0.4A_S+0.4A_P+0.2A_l$$

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

$$A_x=\Sigma p_i \cdot S_i$$

Where, each partial index is not less than 0.5R**.**

A_x : Each partial index corresponds to draughts, d_S, d_P and d_l specified in **1.1.2(3)** to (**5**).

p_i: Probability that a compartment or a group of compartments in question may be flooded (hereinafter referred to as compartment flooding probability), which is to be in accordance with the requirements in **1.2.2.**

S_i: Probability of survival after flooding a compartment or a group of compartments in question (hereinafter referred to as "survival probability"), which is to be in accordance with the requirements in **1.2.3.**

i: Indication of each compartment or group of compartments in question.

3. Partial index (A_x) is to be calculated under the following conditions:

(1) Level trim is to be used for the deepest subdivision draught and the partial subdivision draught. The actual service trim is to be used for the light service draught. Where any service condition, the trim variation in comparison with the calculated trim is greater than $0.005L_S$**,** one or more additional calculations of A are to be submitted for the same draughts but different trims so that, for all service conditions, the difference in trim in comparison with the reference trim used for one calculation will be less than $0.005L_S$

(2) All flooding in compartments and groups of compartments over the entire ship's length is to be taken into account.

(3) Assumed extent of hull damage is the following:

(a) Vertical extent is to be up to d' + 12.5 (m) from the baseline. However, if a lesser extent will give a more severe result, then such an extent is to be assumed.

(b) Horizontal extent of damage is measured inboard from Ship's side, at a right angle to the centreline at the level of the deepest subdivision draught and damage of the transverse extent greater than half breadth (B'/2) of the ship may be exempted. Where the ship has a compartment formed by longitudinal watertight bulkheads which are not on the ship's centreline, all damage which extend from the outmost compartment (hereinafter referred to as wing compartment) to the ship's centreline are to be assumed.

(4) In the flooding calculations carried, only one breach of the hull damage need to be assumed and only one free surface need to be considered.

(5) In the case of unsymmetrical arrangements, the calculated *A* value is to the mean value obtained from calculations involving both sides. Alternatively, it is to be taken as that corresponding to the side which evidently gives the least favourable result.

(6) When determining the positive righting lever (*GZ*) of the residual stability curve, the displacement for the intact condition is to be used.

1.2.2 Compartment Flooding Probability (p_i)

1. The Compartment Flooding Probability (p_i) for a compartment or group of compartments is to be determined by the following **(1)**, **(2)** or **(3)** according to the number of damaged compartment.

(1) Where the damage involves a single zone only:

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

Where:

$x1$: The distance (m) from the aft terminal of L_s to the aft end of the zone in question

$x2$: The distance (m) from the aft terminal of L_s to the forward end of the zone in question

b: The mean transverse distance (m) measured at right angles to the centreline at the deepest subdivision loadline between the shell and an assumed vertical plane extended between the longitudinal limits used in calculating the factor p_i and which is a tangent to, or common with, all or part of the outermost portion of the longitudinal bulkhead under consideration. This vertical plane is to 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 $B'/2$.

j: The aftmost damage zone number involved in the damage starting with no.1 at the stern

k: The number of a particular longitudinal bulkhead as barrier for transverse penetration in a damage zone counted from shell towards the centre line. However, value of k according to side shell is to be taken as zero.

$p(x1, x2)$: It is specified in **-2**.

$r(x1, x2, b)$: It is specified in **-3**. However, $r(x1, x2, b_0)$ is to be taken as zero.

(2) Where the damage involves two adjacent zones:

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

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

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

(3) Where the damage involves three or more adjacent zones:

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

n: The number of adjacent damage zones involved in the damage

2. The Compartment Flooding Probability (p_i) is to be determined by the following **(1)**, **(2)** or **(3)** according to longitudinal position of compartment under consideration.

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

In case $J \le J_K$:

$$p(x1,x2)=p_1=\frac{1}{6}J^2(b_{11}J+3b_{12})$$

In case $J>J_K$

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

J: Non-dimensional damage length given below:

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

$x1$ and $x2$ are specified in **-1** above.

J_k: As given by the following formula:

In case $L_S \le 260m$

$$J_k=\frac{J_m}{2}+\frac{1-\sqrt{1-\frac{55}{6}J_m+\frac{121}{4}J_m^2}}{11}$$

$$J_m=\min\left\{\frac{10}{33},\frac{60}{L_s}\right\}$$

In case $L_S>260m$

$$J_k=J_k^*\cdot\frac{260}{L_S}$$

$$J_k^*=\frac{J_m^*}{2}+\frac{1-\sqrt{1-\frac{55}{6}J_m^*+\frac{121}{4}J_m^{*2}}}{11}$$

Where: $J_m^*=3/13$

$$J_m=\frac{60}{L_s}$$

b_{11}, b_{12}, b_{21} and b_{22}: Coefficient given by the following:

$$b_{11}=\frac{1}{6}\left(\frac{2}{(J_m-J_k)J_k}-\frac{11}{J_k^2}\right)$$

$$b_{12}=11 \qquad \text{If} \quad L_S\leq 260(m)$$

$$=\frac{1}{6}\left(\frac{11}{J_k}-\frac{1}{J_m-J_k}\right) \qquad \text{If} \quad L_S>260(m)$$

$$b_{21}=-\frac{1}{6}\frac{1}{(J_m-J_k)^2}$$

$$b_{22}=\frac{1}{6}\frac{J_m}{(J_m-J_k)^2}$$

J_n: Normalized length of a compartment or group of compartments is to be taken as the lesser of $\boldsymbol{J}$ and $\boldsymbol{J_m}$.

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

In case $J\leq J_k$

$$p(x1,x2)=\frac{1}{2}(p_1+J)$$

In case $J>J_k$

$$p(x1,x2)=\frac{1}{2}(p_2+J)$$

$x1$, $x2$, p_1, p_2, J and J_k are specified in **(1)** above.

(3) Where the compartment or groups of compartments considered extends over the entire subdivision length ($\boldsymbol{L_s}$):

$$p(x1,x2)=1$$

$x1$ and $x2$ are specified in **(1)** above**.**

3. The factor $r(x1, x2, b)$ is to be determined by the following formulae:

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

$x1$, $x2$ and b are specified in **-1** above.

C: Coefficient given by the following:

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

J_b: Coefficient given by the following:

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

G: As given by the following formula:

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

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

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 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:

$$G=\frac{1}{2}\cdot(G_2+G_1\cdot J)$$

b_{11}, b_{12} and J are specified in **-2** above.

J_0: Coefficient given by the following:

$J_0=\min(J, J_b)$

1.2.3 Probability of Survival (S_i)

1. The Probability of Survival (S_i) for any damage case at any initial loading condition is to be obtained from the formula:

$S_i=\min\{S_{final,i}\}$

$S_{final,i}$: It is the probability to survive in the final equilibrium stage of flooding.

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

K: Coefficient given by the following:

$K=1.0$ if $\theta_e\leq\theta_{min}$

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

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

Where, θ_{min} is 25° and θ_{max} is 30° for cargo ships.

θ_e: It is the final equilibrium heel angle (°).

GZ_{max}: It is the maximum positive righting lever (m) up to the angle θ_v. However, in the calculation s of $S_{final,i}$, It is not to be taken as more than $0.12m$.

θ_v: It is the angle (°), where the righting lever becomes negative, or the angle (°) at which an opening incapable of being closed weathertight becomes submerged.

Range: It is the range (°) of positive righting levers measured from the angle θ_e. However, the positive range is to be taken up to the angle θ_v and, in the calculations of $S_{final,i}$, it is not to be taken as more than 16°.

2. Where horizontal watertight boundaries are fitted above the waterline under consideration, the factor (s) calculated for the lower compartment or group of compartments is to be obtained by multiplying the value as determined in **-1** above by the factor v_m given by following formula.

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

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

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

j, n, $x1$ and $x2$ are specified in **1.2.2-1**.

m: It is each horizontal boundary counted upwards from the waterline under consideration;

$v(H_{j,\,n,\,m}, d')$ and $v(H_{j.n.m\text{-}1}, d')$: Coefficient given by the following:

$$v(H,d')=0.8\frac{(H\text{-}d')}{7.8} \qquad \text{if} \quad H_m\text{-}d'\leq 7.8m$$

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

$v(H_{j,\,n,\,m}, d')$ is to be taken as 1, if H_m coincides with the uppermost watertight boundary of the ship within the range $x1_{(j)}......Kx2_{(j+n-1)}$, and $v(H_{j,\,n,\,0}, d')$ is to be taken as 0.

v_m is to be taken as 0, if v_m determined by above formula is taken as less than 0, and v_m is to be taken as 1,if v_m determined by above formula is taken as more than 1.

3. Where the requirement in **-2** above is applied, in general, each contribution dA to the Attained Subdivision Index A is obtained from the formula:

$$dA=p_i\cdot[v_1\cdot S_{min1}+(v_2\text{-}v_1)\cdot S_{min2}+\cdots+(1\text{-}v_{m\text{-}1})\cdot S_{min\,m}]$$

v_m: The value calculated in accordance with **-2** above;

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

4. In all cases, probability of survival (s_i) is to be taken as 0 in those cases where, taking into account sinkage, heel and trim, the openings in accordance with following **(1)** and **(2)** immerse at the final waterline:

(1) The openings through which progressive flooding may take place and such flooding is not accounted for in the calculation of probability of survival **(**s_i)

(2) Air-pipes, ventilators and the openings which are closed by means of weathertight doors or hatch covers

5. The probability of survival (s_i) is to be taken as 0 if, taking into account sinkage, heel and trim, any of the following **(1)** to **(3)** occur in any intermediate stage or in the final stage of flooding:

(1) Immersion of any vertical escape hatch in the bulkhead deck

(2) Any controls intended for the operation of watertight doors, valves on piping or on ventilation ducts intended to maintain the integrity of watertight bulkheads from above the bulkhead deck become inaccessible or inoperable

(3) Immersion of piping or ventilation ducts maintained a watertight and located within any compartment

6. Where the ship carries timber deck cargo, the calculation of s_i may be modified as deemed appropriate by the Society.

1.3 Openings

1.3.1 Internal Openings

1. Internal openings below the final damage waterline or the intermediate waterline and considered to prevent progressive flooding in the calculation of the subdivision index are to be watertight.

2. The number of internal openings required to be watertight under the requirement of **-1** above is to be minimized, and their closing appliances are to comply with the following **(1)** to **(5)**. Relaxation of the requirements regarding watertight openings above the freeboard deck may be considered, where deemed by the Society that the safety of the ship is not impaired.

(1) Closing appliances are to be of ample strength and watertightness for water pressure to the equilibrium/intermediate waterplane.

(2) Closing appliances for internal openings which are used while at sea are to be sliding watertight doors complying with the following conditions.

- (a) Capable of being remotely closed from the bridge
- (b) Capable of being opened and closed by hand locally, from both sides of the opening with the ship listed 30 *degrees* to either side
- (c) Provided with position indicators showing whether the doors are open or closed at all operating positions
- (d) Provided with an audible alarm which will sound at the door position whenever such a door is remotely closed
- (e) Power, control and indicators for which are to be operable in the event of main power failure

Particular attention is to be paid to minimizing the effect of control system failure.

(3) Closing appliances normally closed at sea, are to be watertight closing appliances complying with the following conditions.

- (a) Capable of being opened and closed by hand locally, from both sides of the opening with the ship listed 30 *degrees* to either side. If hinged, it is to be of a quick acting or single action type.
- (b) Provided with position indicators showing whether the doors are open or closed on the bridge and at all operating positions

Such indicators are to be operable in the event of main power failure.

- (c) Provided with notices affixed to both sides of the closing devices stating To be kept closed at sea unless provided with means of remote closure
- (d) Be in accordance with **(2)(d)** and **(e)** above, if operable remotely

(4) Watertight doors or ramps fitted to internally subdivided cargo spaces are to be permanently closed at sea, and are to comply with the following conditions.

- (a) Not to be remotely controlled
- (b) Provided with notices affixed to both sides of the doors stating Not to be opened at sea
- (c) Fitted with a device which prevents unauthorized opening where accessible during the voyage

(5) Other closing appliances which are kept permanently closed at sea are to comply with **(4)(a)** and **(b)** above

3. Bolted watertight manholes kept permanently closed at sea, need not apply to the provisions of **-2** above.

4. Closing appliances for internal openings required to be watertight under the requirement of **-1** above are to comply with the provisions of **12.3, Part 2**, unless otherwise provided in **-2** above.

1.3.2 External Openings

1. All external openings below the final damage waterline in the calculation of the subdivision index are to be watertight.

2. The closing appliances for external openings required to be watertight under the requirements of **-1** above are to be permanently closed at sea, and are to comply with the following **(1)** to **(4)**.

(1) Closing appliances are to be of ample strength and watertightness for water pressure to the equilibrium/ intermediate waterplane.

(2) Indicators showing whether the doors are open or closed are to be provided on the bridge. Such indicators are to be operable in the event of main power failure. However, such indicators are not required for cargo hatch covers,fixed side scuttles and bolted manholes.

(3) Closing appliances are to be provided with a notice affixed at their operating positions stating
To be kept closed at sea. However, such notice is not required for cargo hatch covers, fixed side scuttles and bolted manholes.

(4) Closing appliances for openings in the shell plating below the bulkhead deck accessible during the voyage are to be fitted with a device which prevents unauthorized opening, except where specially approved by the Society.

3. Closing appliances for external openings above the equilibrium/intermediate waterplane but below the bulkhead deck are to be normally closed at sea, and are to comply with the following **(1)** to **(4)**.

(1) Closing appliances other than those permanently closed at sea are to be capable of being opened and closed by hand locally, from both sides of the opening with the ship listed 30 *degrees* to either side. If hinged, it is to be of a quick acting or single action type.

(2) Indicators showing whether the doors are open or closed are to be provided on the bridge. Such indicators are to be operable in the event of main power failure. However, such indicators are not required for fixed side scuttles.

(3) Closing appliances are to be provided with a notice affixed at their operating positions stating "To be kept closed at sea". Closing appliances permanently closed at sea are to be provided with a notice stating not to be opened at sea. However, such notices are not required for fixed side scuttles.

(4) Closing appliances for openings in the shell plating accessible during the voyage are to be fitted with a device which prevents unauthorized opening, except where specially approved by the Society.