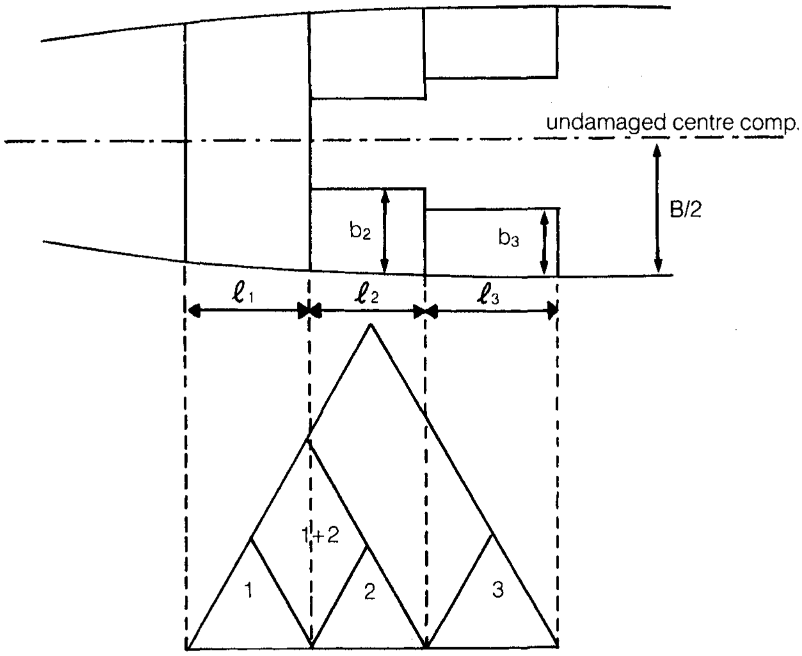
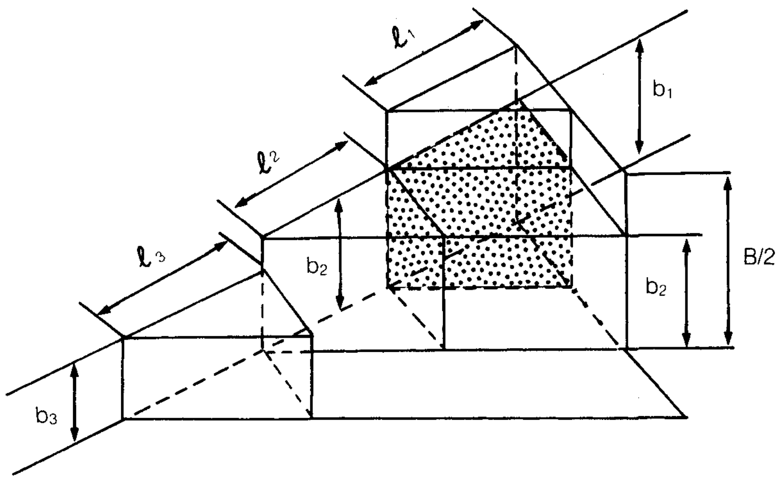
When determining the factor "p" for simultaneous flooding of space 1, (in figures A-4 and A-5), and adjacent side compartment(s) the values "r_1", "r_{12}", etc. should be calculated according to regulation 25-5.2, taking "b" for space 1 equal to the breadth of the adjacent side compartment(s).





shaded portion represents $p_1 * r_1$

The p - factor for comp. 1 + 2 : $p = p_{12} * r_{12} - p_1 * r_1 - p_2 * r_2$

where r_1 is function of ℓ_1 and b_2
r_2 is function of ℓ_2 and b_2
r_{12} is function of $\ell_1 = \ell_2$ and b_2

FIGURE A-3 ILLUSTRATION OF COMBINED DAMAGE AT THE END OF UNDAMAGED CENTRE COMPARTMENT

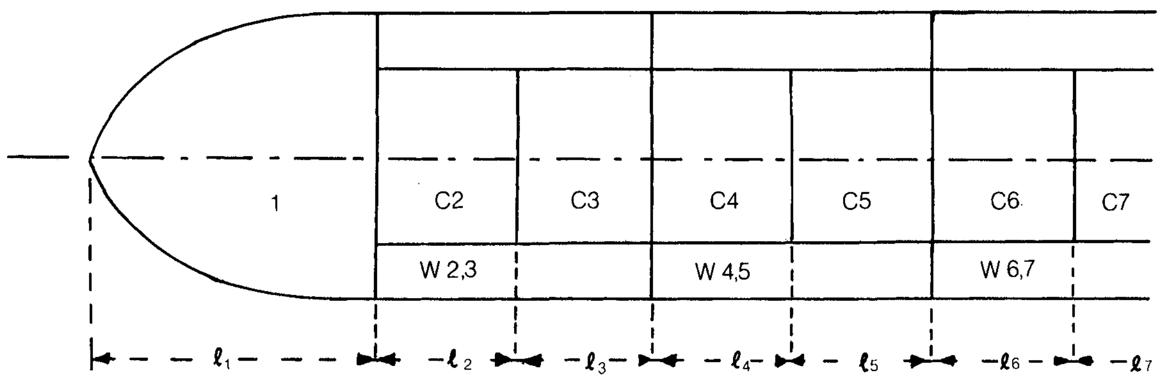


FIGURE A-4

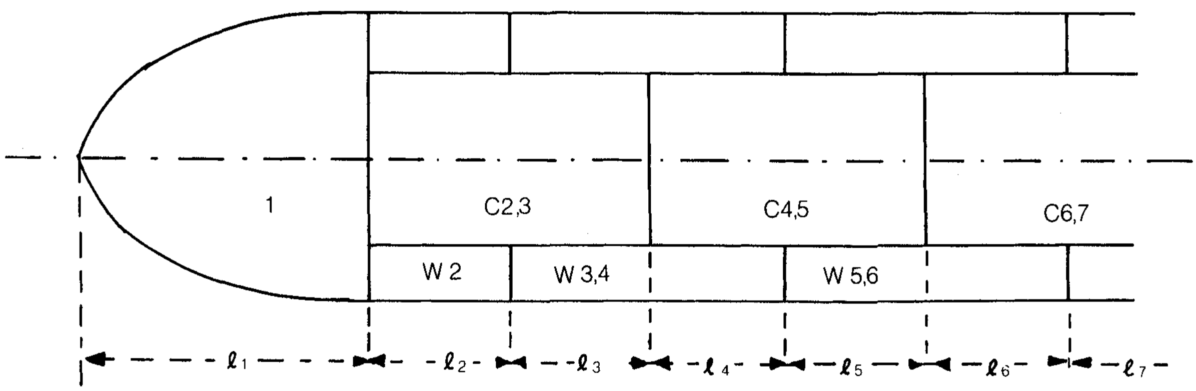


FIGURE A-5

TABLE A-3

Application of regulation 25-5* to subdivision arrangement shown in figure A-4

damage zone(s) as compartment or group of compartments**	p-factor	Distances XI and X2 for determination of factor P
1	$p = p_1$	$x_1 = 0$ $x_2 = \ell_1$
W2,3	$p = p_{23}.r_{23}$	$x_1 = \ell_1$ $x_2 = \ell_{1-3}$
W4,5	$p = p_{45}.r_{45}$	$x_1 = \ell_{1-3}$ $x_2 = \ell_{1-5}$
1 and W 2,3	$p = p_{1-3}.r_{1-3} – p_1.r_1 - p_{23}.r_{23}$	$x_1 = 0$ $x_2 = \ell_{1-3}$
W 2,3 and W 4,5	$p = p_{2-5}.r_{2-5} - p_{23}.r_{23} - p_{45} - r_{45}$	$x_1 = \ell_1$ $x_2 = \ell_{1-5}$
1 and W 2,3 and W 4,5	$p = p_{1-5}.r_{1-5} – p_{1-3}.r_{1-3} - p_{2-5}.r_{2-5} + p_{23}.r_{23}$	$x_1 = 0$ $x_2 = \ell_{1-5}$
W 2,3 and W 4,5 and W 6,7	$p = p_{2-7}.r_{2-7} - p_{2-s}.r_{2-5} - p_{4-7}.r_{4-7} + p_{45}.r_{45}$	$x_1 = \ell_1$ $x_2 = \ell_{1-7}$

r_{1-5} is function of ℓ_{1-5} & b_{2-5}
r_{45} is function of ℓ_{45} & b_{2-7}

TABLE A-4

Application of regulation 25-5* to subdivision arrangement shown in figure A-4

damage zone(s) as compartment or group of compartments**	p-factor	Distances X_1 and X_2 for determination of factor P
C2 and W 2,3	$p = p_2 (1-r_2)$	$x_1 = \ell$ $x_2 = \ell_{12}$
C3 and W 2,3	$p = p_3 (1-r_3)$	$x_1 = \ell_{12}$ $x_2 = \ell_{1-3}$
C4 and W 4,5	$p = p_4 (1-r_4)$	$x_1 = \ell_{1-3}$ $x_2 = \ell_{1-4}$
1 and C2 and W 2,3	$p = p_{12} (1-r_{12}) – p_1 (1-r_1) - p_2 (1-r_2)$	$x_1 = 0$ $x_2 = \ell_{12}$
C2 and C3 and W 2,3	$p = p_{23} (1-r_{23}) - p_2 (1-r_2) - p_3 (1-r_3)$	$x_1 = PI$ $x_2 = \ell_{1-3}$
C3 and C4 and W 2,3 and W 4,5	$p = p_{34} (1-r_{34}) - p_3 (1-r_3) - p_4 (1-r_4)$	$x_1 = A2$ $x_2 = \ell_{1-4}$
1 and C2 and C3 and W 2,3	$P = p_{1-3}(1-r_{1-3})-p_{12}(1-r_{12})-p_{23}(1-r_{23})+p_2(1-r_2)$	$x_1 = 0$ $x_2 = \ell_{1-3}$
C2 and C3 and C4 and W 2,3 and W 4,5	$p = p_{2-4}(1-r_{2-4})-p_{23}(1-r_{23})-p_{34}(1-r_{34})+p_3(1-r_3)$	$x_1 = \ell_1$ $x_2 = \ell_{1-4}$

* **With particular reference to 25-5.1 and 25-5.2.1**
** **To be considered flooded for s-calculation.**

TABLE A-5

Application of regulation 25-5* to subdivision arrangement shown in figureA-5

damage zone(s) as compartment or group of compartments**	p-factor	Distances XI and X2 for determination of factor P	
1	$p = p_1$	$x_1 = 0$	$x_2 = \ell_1$
W2	$p = p_2.r_3$	$x_1 = \ell_1$	$x_2 = \ell_{12}$
W3,4	$p = p_{34}.r_{34}$	$x_1 = \ell_{12}$	$x_2 = \ell_{1-4}$
1 and W 2	$p = p_{12}.r_{12} – p_1.r_1 - p_2.r_2$	$x_1 = 0$	$x_2 = \ell_{12}$
W2andW3,4	$p = p_{24}.r_{24} - p_2.r_2 - p_{34}.r_{34}$	$x_1 = \ell_1$	$x_2 = \ell_{1-4}$
1 and W 2 and W 3,4	$P = p_{1-4}.r_{1-4} - p_{12}.r_{12} - p_{2-4}.r_{2-4} + p_2.r_2$	$x_1 = 0$	$x_2 = \ell_{1-4}$
W 2 and W 3,4 and W 5,6	$p = p_{2-6}.r_{2-6} - p_{24}.r_{24} - p_{3-6}.r_{3-6} + p_{34}.r_{34}$	$x_1 = \ell_1$	$x_2 = \ell_{1-6}$

TABLE A-6

Application of regulation 25-5* to subdivision arrangement shown in figure A-5

damage zone(s) as compartment or group of compartments**	p-factor	Distances Xl and X2 for determination of factor P	
C2,3 and W 2	$p = p_2\ (1-r_2)$	$x_1 = \ell_1$	$x_2 = \ell_{12}$
C2,3 and W 3,4	$p = p_3\ (1-r_3)$	$x_1 = \ell_{12}$	$x_2 = \ell_{1-3}$
C4,5 and W 3,4	$p = p_4\ (1-r_4)$	$x_1 = \ell_{1-3}$	$x_2 = \ell_{1-4}$
1 and C2,3 and W 2	$P = p_{12}\ (1-r_{12}) – p_1\ (1-r_1) - p_2\ (1-r_2)$	$x_1 = 0$	$x_2 = \ell_{12}$
1 and C2,3 and W 2 and W 3,4	$P = p_{1-3}(1-r_{1-3})-p_{12}(1-r_{12})-p_{23}(1-r_{23})+p2(1-r_2)$	$x_1 = 0$	$x_2 = \ell_{1-3}$
C2,3 and C4,5 and W 3,4	$P = p_{34}\ (1-r_{34})$	$x_2 = \ell_{12}$	$x_2 = \ell_{1-4}$
C2,3 and C4,5 and W 2 and W 3,4	$P = p_{2-4}(1-r_{2-4})-p_2(1-r_2)-p_{34}(1-r_{34})$	$x_1 = \ell_1$	$x_2 = \ell_{1-4}$
C2,3 and C4,5 and W 3,4 and W 5,6	$P = p_{3-5}(1-r_{3-5})-p_{34}(1-r_{34})-p3\ (1-r_3)$	$x_2 = \ell_{12}$	$x_2 = \ell_{1-5}$
C2,3 and C4,5 and W 2 and W 3,4 and W 5,6	$P = p_{2-5}(1-r_{2-5})-p_{24}(1-r_{24})-p_{3-5}(1-r_{3-5})+p_{34}(1-r_{34})$	$x_1 = \ell_1$	$x_2 = \ell_{1-5}$

* **With particular reference to 25-5.1 and 25-5.2.1**

** **To be considered flooded for s-calculation.**

II RECESSES

1. Recesses may be treated as actual or fictitious compartments using the example in Figure A-6.

2. The following nomenclature is used in this section:

ℓ_1, ℓ_2, ℓ_3 length of damage zones as shown in figure A-6;

p_1, p_2, p_3 are "p" calculated according to regulation 25-5.1, using ℓ_1, ℓ_2, ℓ_3 as "ℓ";

p_{12}, p_{23} are "p" calculated according to regulation 25-5.1, using $\ell_1 + \ell_2$ and $\ell_2 + \ell_3$ as "ℓ";

p_{123} is "p" calculated according to regulation 25-5.1, using $\ell_1 + \ell_2 + \ell_3$ as "ℓ";

r_1 is "r" calculated according to regulation 25-5.2, using ℓ_1 as "ℓ" and "b" as shown in Figure A-6; Z

r_2 is "r" calculated according to regulation 25-5.2, using ℓ_2 as "ℓ" and "b" as shown in Figure A-6;

r_{12}, r_{23} is "r" calculated according to regulation 25-5.2, using $\ell_1 + \ell_2$ as "ℓ" and "b" as shown in Figure A-6;

r_{123} are "r" calculated according to regulation 25-5.2, using $\ell_1 + \ell_2 + \ell_3$ as "ℓ" and "b" as shown in Figure A-6;

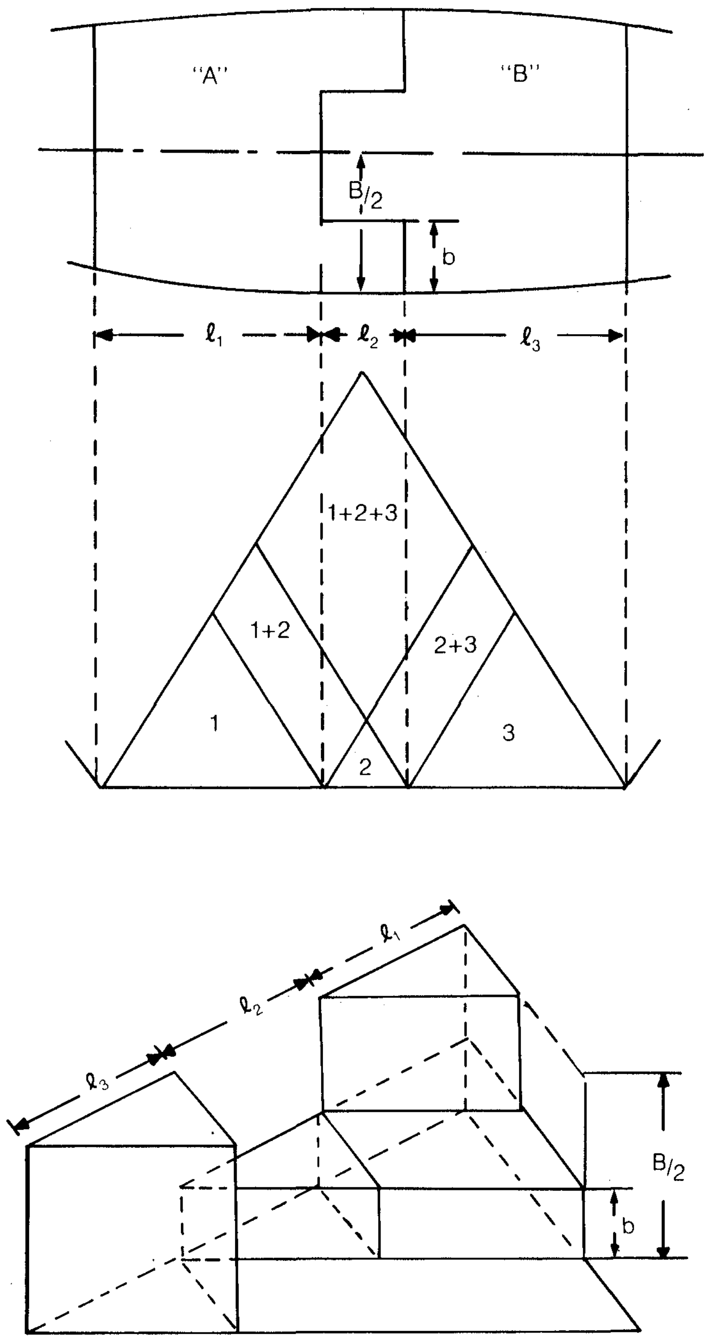


FIGURE A-6

3. Application to actual compartments:

Spaces to be considered flooded for s-calculation	p-factor to be used for calculating contribution to attained subdivision index
A	$p=p_{12}.r_{12}$
B	$p=p_3$
A and B	$p=p_{123} – p_{12}.r_{12} -_3$
alternatively:	
A	$p=p_1$
B	$p=p_3$
A and B	$p=p_{123} – p_1 –p_3$

4. Application to fictitious compartments

A	$p=p_{12}.r_{12} + p_1 (1-r_1)$
B	$p=p_3$
A and B	$p=p_{12} – p_{12}.r_{12} –p_1.(1-r_1) –p_3$

III DAMAGE PENETRATION

For uniform application of these regulations the depth of penetration "b" should be determined using the following guidelines:

The mean transverse distance "b" shall be measured between the shell at the deepest subdivision load line and a vertical plane tangent to, or common with, all or a part of the longitudinal bulkhead but elsewhere outside thereof, and orientated so that this mean transverse distance to the shell is a maximum, except that in no case shall the maximum distance between this plane and the shell exceed twice the least distance between the plane and the shell.

When the longitudinal bulkhead terminates below the deepest subdivision load line the vertical plane referred to above is assumed to extend upwards to the deepest subdivision load line.

The following Figures A-7 and A-8 illustrates the application of this definition.

A damage zone containing abrupt changes of breadth may also be dealt with by subdividing into smaller zones, each having constant "b" values.

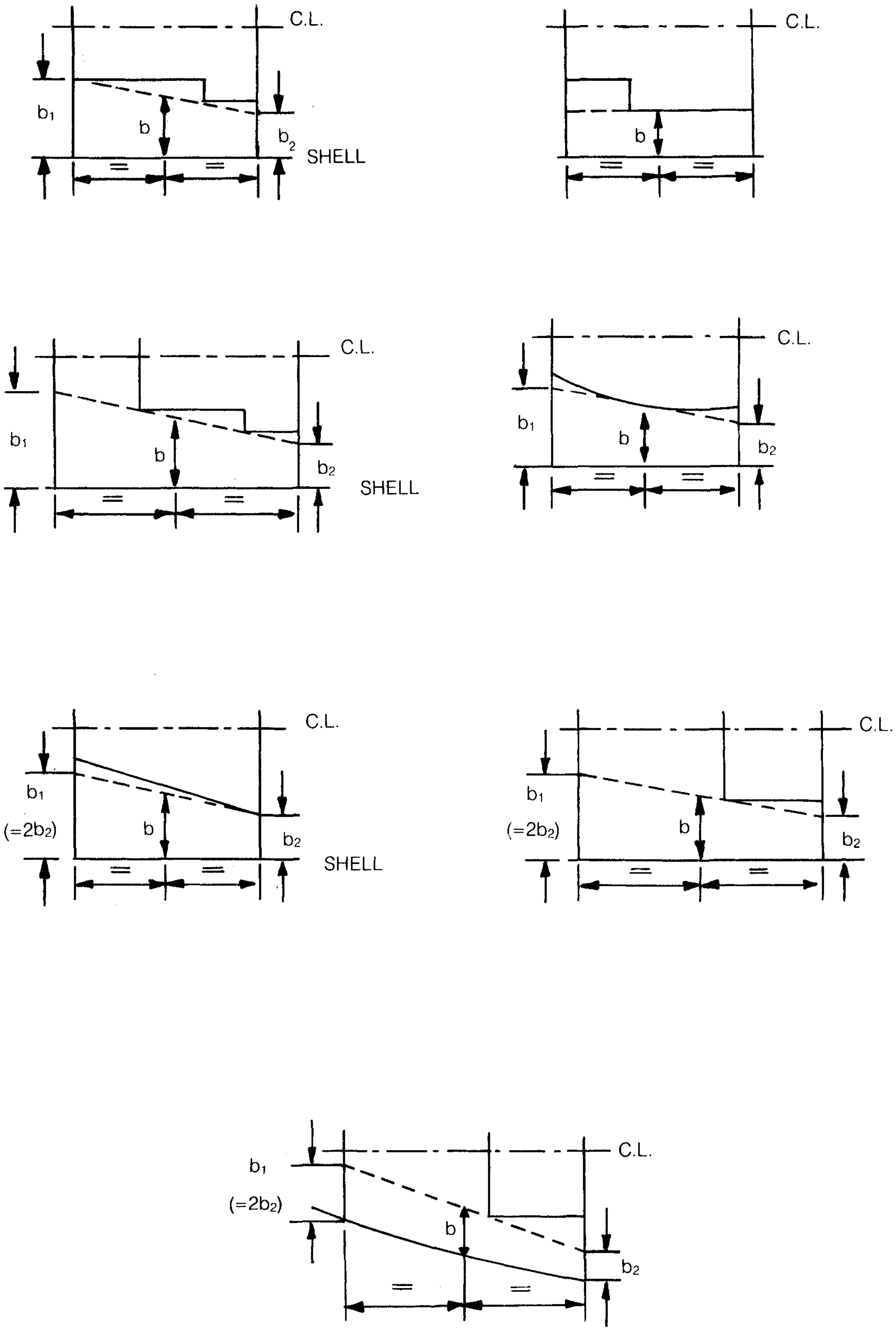
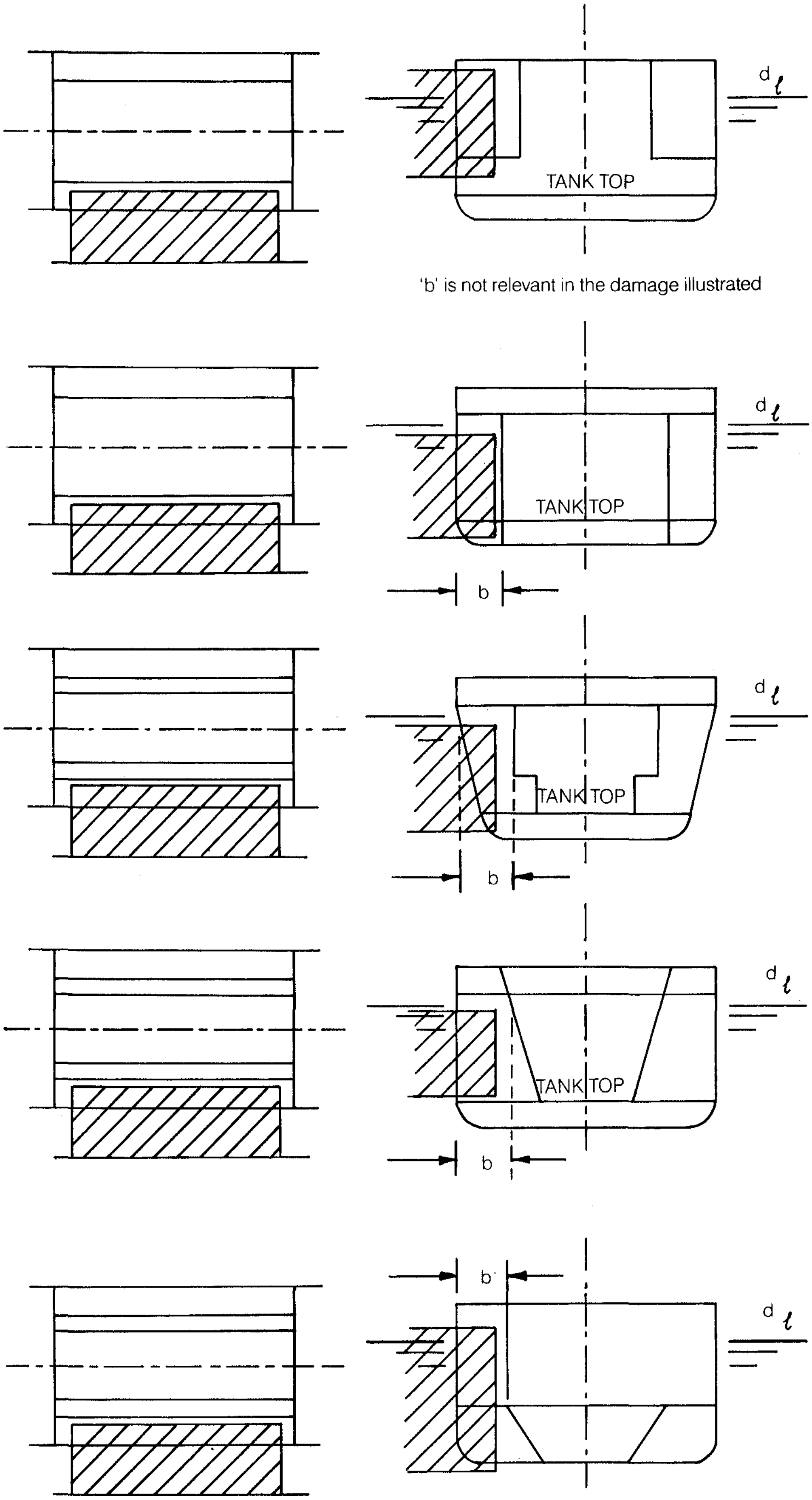

C.L.
b1
b
b2
SHELL
=
=
C.L.
b
=
=
C.L.
b1
b
b2
SHELL
=
=
C.L.
b1
b
b2
=
=
C.L.
b1
(=2b2)
b
b2
SHELL
=
=
C.L.
b1
(=2b2)
b
b2
=
=
b1
(=2b2)
C.L.
b
b2
=
=

FIG A-7



d l
TANK TOP
'b' is not relevant in the damage illustrated
d l
TANK TOP
b
d l
TANK TOP
b
d l
TANK TOP
b
b
d l

FIG A-8

APPENDIX 3

1. Introduction

This appendix describes various possible watertight subdivision arrangements, the consequent flooding scenarios and the method of determining the relevant contribution "dA" to the attained index "A".

2. Definition of the Terms and Symbols used

Note: subscripts 1,2,3 etc below relate to the appropriate spaces in Figures A-9 *to* A-12.

eg. C_{123} is a space comprising compartments Cl, C2, C3
C_{345} is a space comprising compartments C3, C4, C5

S_{67} is the factor which accounts for the probability of survival after flooding compartments C6, C7 (etc).

---------> indicates the direction of assumed side damage.

dA gives the contribution *to* the attained index of the damage case being considered.

d is the draught being considered and is either "dℓ" or "dp" (ie deepest subdivision load line or partial load line).

H_1, H_2 are the first and second horizontal subdivisions respectively viewed from the waterline upwards.

HU is the uppermost boundary which limits the vertical extent of flooding.

V_1, V_2 are the first and second longitudinal subdivisions respectively viewed from the side where damage is assumed.

C indicates a compartment bounded on all sides by watertight boundaries.

C_{123} indicates a space which for the purpose of assumed flooding is treated as a single space comprising compartments Cl, C2 and C3.

• indicates a compartment which lies outside the limits prescribed for all the damage scenarios (ie the compartment remains intact for all assumed damage cases) except for possible cross-flooding.

P_ℓ (reg 25.5.1) is the factor which accounts for the probability that the longitudinal extent of damage does not exceed the length of the damage zone (length "l") being considered.

3. Contribution *to* the attained index "A" applying various forms of watertight subdivision.

This section details the contribution to the attained index "A" of various combinations of longitudinal and horizontal watertight subdivision and is included to illustrate the concepts of multiple horizontal and longitudinal subdivision.

For multiple longitudinal subdivisions with no horizontal subdivisions, the general formula is;

$dA=p_1 *[r_1 *s_1 + (r_2-r_1)*s_2 +.......+ (1-r_{m-1})*s_m]$

where

m = the number of longitudinal subdivisions, plus 1
ri = the "r" value as function of "bi"
si = the "s" factor for compartment n_i"

For multiple horizontal subdivisions, with no longitudinal subdivisions the general formula is;

dA = $p_1*[v_1 *Smin_1 + (V_2-V_1) *Smin_2 +......+ (1 -v_{n-1}) Smin_n]$

where

n = the number of horizontal subdivisions between the subdivision water line and Hmax, plus 1;

V_j = the "v" value as function of assumed damage height "H_j"

$Smin_j$ = the least "s" factor for all combinations of damages obtained when the assumed damage extends from the assumed damage height "H_j" downwards.

Generally, when there are combinations of longitudinal and horizontal subdivisions:

$$\begin{aligned}
dA \quad = \quad & p_1*\{r_1*[V_1*Smin_{11} + (v_2-v_1)*Smin_{12} +......+ (1 - v_{n-1}) Smin_{1n}] \\
+ \quad & (r_2-r_1)*[V_1 *Smin_{21} + (v2-vI)*Smin_{22} +......+ (1 - v_{n-1}) Smin_{2n}] \\
. \\
. \\
. \\
+ \quad & (1-r_{m-1})*[V_1*Smin_{m1} + (v_2-v_1)*Smin_{m2} +......+ (1 - v_{n-1}) Smin_{mn}]
\end{aligned}$$

where

m = the number of longitudinal subdivisions, plus 1

n = the number of horizontal subdivisions (within each longitudinal subdivision) between the subdivision waterline and Hmax, plus 1;

r_i = the "r" factor as function of "b_i";

V_j = the "v" value as function of assumed damage height "H_j";

$Smin_{ij}$ = the least "s" factor for all combinations of damages obtained when the assumed damage extends from the shell to bi and from the assumed damage height "H_j" downwards.

The following examples illustrate how to deal with situations where there are combinations of longitudinal and horizontal subdivision, assuming the damage to occur between two consecutive watertight bulkheads only.

If however the damage extends beyond one or more transverse bulkheads then all terms p_i r_i for i = 1, 2.......m are calculated for a group *of* wing compartments as a function of "b_i".

3.1 Examples of longitudinal subdivision

Examples of longitudinal subdivision only are given in Figure A-9.

Each part of the figure illustrates the damage cases which would need to be evaluated for a particular arrangement of watertight boundaries.

The formulae for calculating the contribution to the attained index – "dA" - are given in each case.

3.2 Examples of horizontal subdivision

Examples of horizontal subdivision only are given in Figure A-10.

This illustrates the principles described in the previous section as applied to horizontal subdivision.

Regulation 25-4.7 specifies that in the event that a lesser vertical extent of damage means a lesser contribution to the "A" value, then this lesser extent is to be assumed in obtaining the requisite damage stability results.

3.3 Examples of longitudinal/horizontal subdivision

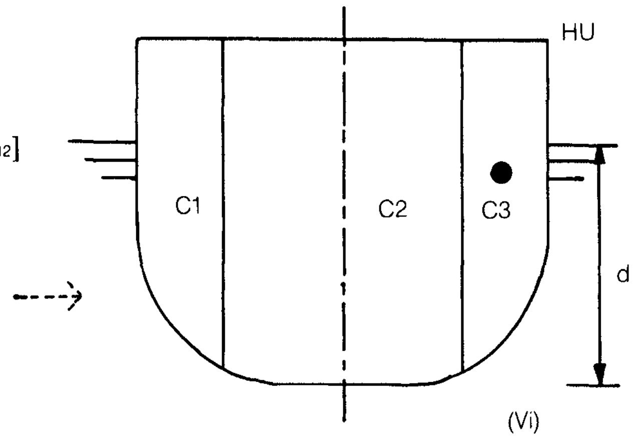
This section illustrates the principles used when combining the longitudinal and horizontal watertight subdivision described in the previous two sections. Examples are given in Figures A-11 and A-12.

To determine the contribution to the attained subdivision index ‘A’ –say dA - for various damage scenarios

Examples of Multiple Longitudinal Subdivision

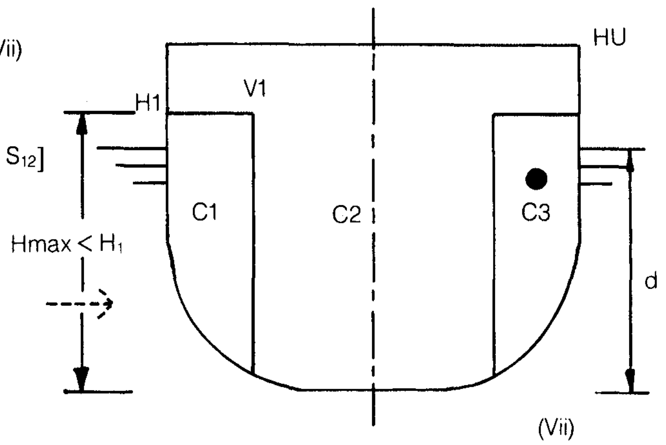
Referring to Figure (Vi)

$$dA = p_l{}^* [\, r_1 * s_1 + (1 - r_1) * s_{12}]$$



Referring to Figure (Vii)

$$dA = p_l{}^* [\, r_1 * s_1 + (1 - r_1) * S_{12}]$$



Referring to Figure (Viii)

$$dA = p_l{}^* [\, r_1 * s_1 + (r_2 - r_1) * s_{12}) + (1 - r_2) * s_{123}]$$

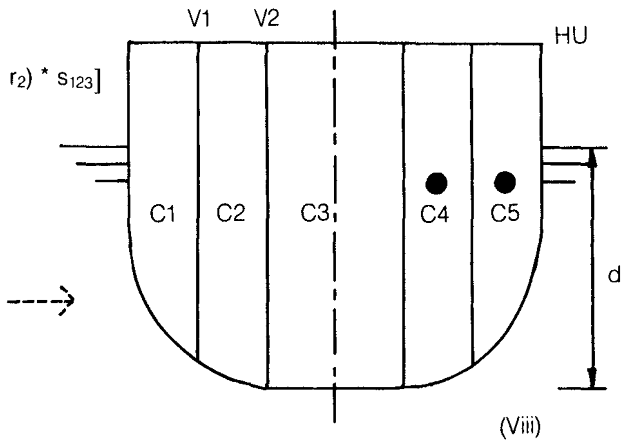


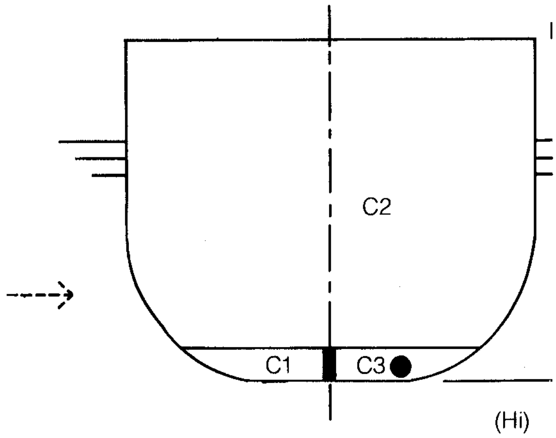
FIG A-9 INTERPRETATION OF LONGITUDINAL SUBDIVISION
(In all instances, v = 1**)**

To determine the contribution to the attained subdivision index 'A' - say dA - for various damage scenarios.

Examples of Multiple Horizontal Subdivision.

Referring to Figure (Hi)

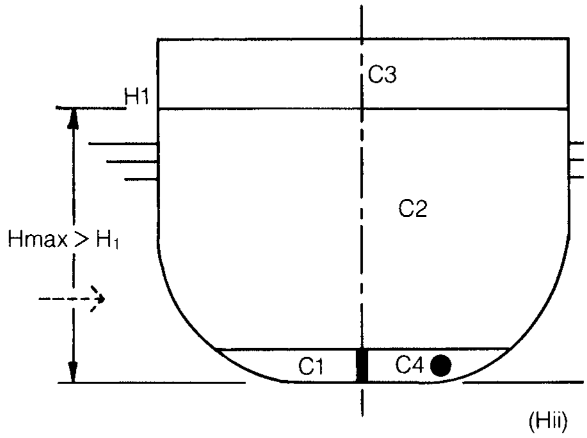
$dA = p_{\ell} * smin$
where
Smin= the lesser of s_{12} and s_2



(Hi)

Referring to Figure (Hii)

$dA = p_{\ell} * [\ v_1 * Smin_1 + (1 - V_1) * Smin_2]$
where
$Smin_1$ = the lesser of s_{12} and s_2
$Smin_2$ = the lesser of s_{123} and s_{23}

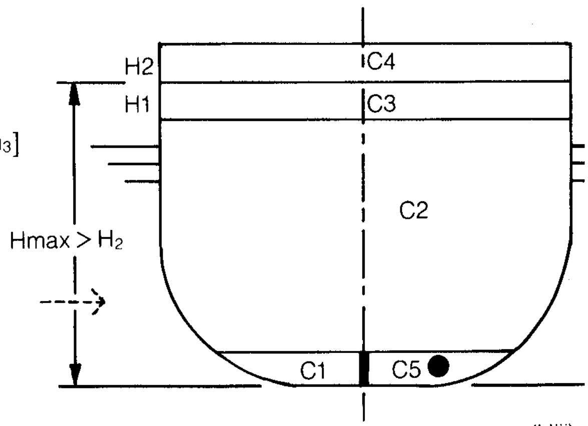


(Hii)

Referring to Figure (Hiii)

$dA = p_{\ell} * [\ v_1 * Smin_1 + (v_2 - v_1) * Smin_2 + (1 - v_2) * Smin_3]$

where
$Smin_1$ = the lesser of s_{12} and s_2
$Smin_2$ = the lesser of s_{123} and s_{23}
$Smin_3$ = the lesser of s_{1234} and s_{234}



(Hiii)

FIG A-10 INTERPRETATION OF MULTIPLE HORIZONTAL SUBDIVISION
(In all instances, r = 1)

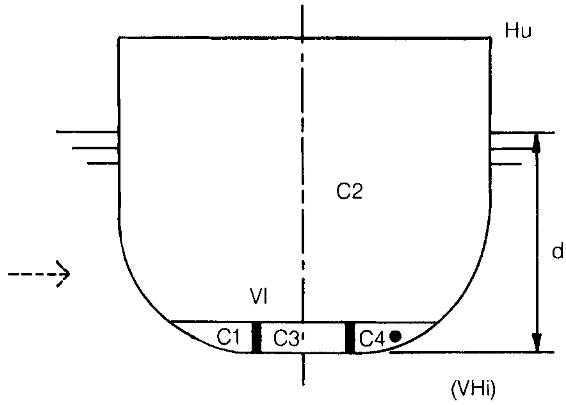
To determine the contribution to the attained subdivision index 'A' - say dA - for various damage scenarios.

Examples of Multiple Longitudinal/Horizontal Subdivision

Referring to Figure (VHi)

$$dA = p_\ell * [\, r_1 * Smin_1 + (1 - r_1) * Smin_2]$$

where
$Smin_1$ = the lesser of s_{12} and s_2
$Smin_2$ = the lesser of s_{123} and s_2

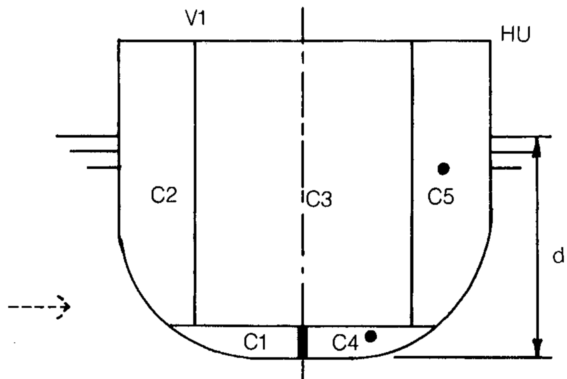


(VHi)

Referring to Figure (VHii)

$$dA = p_\ell * [\, r_1 * Smin_1 + (1 - r_1) * Smin_2]$$

where
$Smin_1$ = the lesser of s_{12} and s_2
$Smin_2$ = the lesser of s_{123} and s_{23}

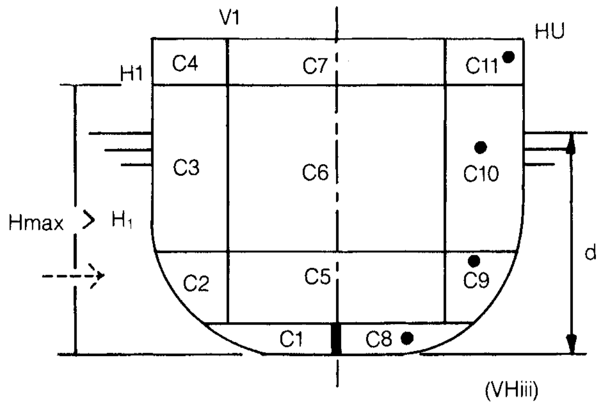


(VHii)

Referring to Figure (VHiii)

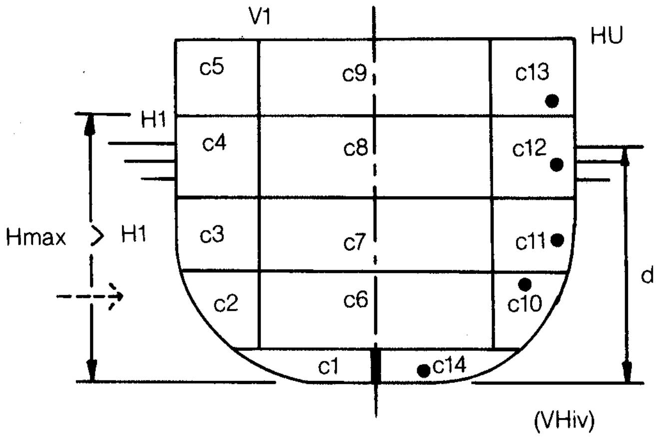
$$dA = p_\ell * \{ r_1 * [\, v_1 Smin_{11} + (1 - V_1) * Smin_{12}] + (1 - r_1) * [\, v_1 * Smin_{21} + (1 - v_1) * Smin_{22}] \}$$

where
$Smin_{11}$ = the least of s_{123} and s_{23} and s_3
$Smin_{12}$ = the least of s_{1234} and s_{234} and s_{34}
$Smin_{21}$ = the least of s_{12356} and s_{2356} and s_{36}
$Smin_{22}$ = the least of $s_{1234567}$ and s_{234567} and s_{3467}



(VHiii)

FIG A-11 INTERPRETATION OF COMBINED LONGITUDINAL & HORIZONTAL SUBDIVISION



Referring to Figure (VHiv)

$$dA = p_\ell * \{ r_1 * [v_1 \, Smin_{11} + (1 - v_1) * Smin_{12}] + (1 - r_1) * [v_1 * Smin_{21} + (1 - v_1) * Smin_{22}]\}$$

where

$Smin_{11}$ = the least of s_{1234} and s_{234} and s_{34} and s_4
$Smin_{12}$ = the least of s_{12345} and s_{2345} and s_{345} and s_{45}
$Smin_{21}$ = the least of $s_{1234678}$ and s_{234678} and s_{3478} and s_{48}
$Smin_{22}$ = the least of $s_{123456789}$ and $s_{23456789}$ and s_{345789} and s_{4589}

FIG A-12 INTERPRETATION OF COMBINED LONGITUDINAL & HORIZONTAL SUBDIVISION

EXPLANATORY NOTES TO THE SOLAS REGULATIONS ON SUBDIVISION AND DAMAGE STABILITY OF CARGO SHIPS OF 100 METRES IN LENGTH AND OVER

PART B

This part of the explanatory notes is intended to give some guidance on how to apply the individual regulations.

<u>Regulation 25-1</u>

The purpose of item 6 of the footnote to regulation 25-1 is to exclude from the application of the regulations on subdivision and damage stability of cargo ships (part B-1) only those ships which must comply with the damage stability requirements of the 1966 LL Convention in order to obtain a Type A or Type B-60 through to Type B-100 freeboard assignment.

Part B-1 regulations were developed and intended as a separate required standard for all cargo ships. Equivalency between the part B-1 and Load Line damage stability requirements is neither implied nor suggested.

Paragraph 3

The circumstances where this paragraph of the regulations might apply for example could be:

.1 ships constructed to a standard of damage stability with a set of damage criteria, agreed by the Administration;

.2 ships where the side-shell has been significantly strengthened by the provision of a "double-skin" where it may be agreed to use enhanced values of the reduction factor "r", regulation 25-5.2. In such a case supporting calculations indicating the superior energy-absorbing characteristics of the structural arrangement are to be provided;

.3 vessels of a multi-hull design, where the subdivision arrangements would need to be evaluated against the basic principles of the probabilistic method since the regulations have been written specifically for mono-hulls.

<u>Regulation 25-2</u>

Paragraph 1.2

This definition does not preclude loading the ship to deeper draughts permissible under load line assignments such as tropical, timber, etc.

Paragraph 1.3

The light ship draught is the draught, assuming level trim, corresponding to the ship lightweight. Lightweight is the displacement of a ship in tonnes without cargo, fuel, lubricating oil, ballast water, fresh water and feed water in tanks, consumable stores, plus crew I passenger and their effects.

The draught corresponding to the partial load line is given by the formula

$$d_p = d_{\ell s} + 0.6\,(d_{\ell} - d_{\ell s})$$

Where

d_p	=	draught corresponding to the partial load line, (m);
$d\ell$	=	draught corresponding to the deepest subdivision load line, (m);
$d\ell_s$		lightship draught (m);

Paragraph 2.1

The illustration of the definition of "L_s" according to paragraph 2.1 of regulation 25.2 is given in figure B-1.

For the forward deck limiting the vertical extent of flooding "H_{max}" is to be calculated in accordance with the draught ("dl") at the deepest subdivision load line, based on the corresponding formula in regulation 25-6, paragraph 3.3. The forward terminal position at the deepest subdivision load line is to be taken as indicated in figure B-2 and the after one in a similar manner.

<u>Regulation 25-4</u>

Paragraph 1

The regulations do not specify at which side of the ship damage should be assumed. Where there is 100% symmetry about the ship centreline of:

- the main hull,
- erections which are given credit for buoyancy in the damage stability calculations,
- the internal subdivision restricting the extent of flooding for the damage stability calculations,

it is clear that damage may be assumed on either the port or starboard sides, each producing the same value of "A".

It is rare for complete symmetry to exist and therefore, in theory, two calculations for "A" should be made, one assuming port damage and the other starboard damage.

However, the calculated "A" value may be taken as that which evidently gives the less favourable result. Otherwise the mean value obtained from calculations involving both sides is to be used.

Paragraph 2

$$A = \sum p_i S_i$$

Where

p_i	is independent of the draught, but includes the factor "r";
s_i	is dependent on the draught and includes the factor "v";

and is a weighted average of s-factors calculated at draughts of $d\ell$ and d_p.

It is recommended that the product "$p_i s_i$" should be calculated using five decimal places, whilst the final results, ie the indices "A" and "R" should be to at least three decimal places.

Paragraph 3

For any ship, including those with a raked keel, the design waterline shall be used as a reference for level trim.

Paragraph 6

See figures in Appendix 2, Part A

When there is more than one longitudinal subdivision to consider, penetration need not extend to the ship's centreline if such penetration does not provide any contribution to the attained subdivision index.

For example, when a pipe tunnel in the centre of a ship is fitted, damage to this tunnel may cause heavy progressive flooding leading to loss of the vessel. In this instance the penetration may be stopped outside the pipe tunnel, and the "p" factor multiplied by the factor "r", as calculated for a penetration in a wing compartment only. If a wing compartment is fitted in addition, it is possible to take account of two different penetrations, and applying the factor (r_2-r_1) rather than (1-r), as obtained when the damage is extended to the centreline.

"r_2" is then the "r" value for penetration to the pipe tunnel only, and "r_1" is the "r" value for penetration to the longitudinal bulkhead only. See figure A-11 (VHi).

Regulation 25-5

See figures and explanations in Part A, Appendices 2 and 3.

In particular, note when calculating "r" values for a group of two or more adjacent compartments (or zones) the "b" value must be the same for all compartments (or zones) in that group.

Regulation 25-6

Paragraph 1.2

If the final waterline immerses the lower edge of any opening through which progressive flooding takes place, the factor "s" may be re-calculated taking such flooding into account.
If the resulting "s" is greater than zero, the "dA" of the compartment or group of compartments may contribute to the index "A".

Paragraph 3.3

Where the height of the horizontal subdivision above the baseline is not constant, the height of the lowest point of the horizontal subdivision above the baseline be used in calculating "H".

The permeability value for cargo spaces is given in regulation 25-7.

Where a ship is fitted with significant quantities of cargo insulation, the permeabilities of the relevant cargo spaces and/or the void spaces surrounding such cargo spaces may be calculated, whilst giving consideration to the volume of insulation material in those spaces, provided that the insulating material is shown to comply with the following conditions:

.1 it is impermeable to water under hydrostatic pressure at least corresponding to the pressure caused by the assumed flooding;

.2 it will not crush or break up due to hydrostatic pressure at least corresponding to the pressure caused by the assumed flooding;

.3 it will not deteriorate or change its properties over the long term in the environment anticipated in the space it which it is installed;

.4 it is highly resistant to the action of hydrocarbons; and

.5 it will be adequately secured so that it will remain in position if subjected to collision damage and consequent displacement, distortion of its supporting and retaining structure, repeated rapid ingress and outflow of seawater and the buoyant forces caused by immersion following flooding.

Regulation 25-8

Paragraph 1.1

It is straightforward to obtain minimum GM (or maximum KG) values which comply with the relevant intact stability requirements, and can be expressed by a unique curve against ship draught.

However, it is not possible to obtain a unique set of minimum GM values for deepest load draught ("dl") and for partially loaded draught ("dp") which ensure compliance with regulation 25-1 to 25-6, because there are an infinite number of sets of GMs to meet the regulations.

Therefore, one approach might be to choose a GM value for the deepest loaded draught as close as possible to the minimum GM value relevant to the intact stability requirements based on a realistic loading condition, then vary the GM value for partial loaded draught whilst retaining a realistic loading condition and obtain a limiting value of GM to comply with the regulations 25-1 to 25-6.

Of course, other practical approaches may also be taken.

Paragraph 1.2

Where cross-flooding arrangements are fitted, calculations are to be carried out in accordance with IMO resolution A.266 (VIII).

The time for equalization shall not exceed ten minutes.

Paragraph 3

Curves of limiting GMs should be drawn as indicated in figures B-3 and B-4.

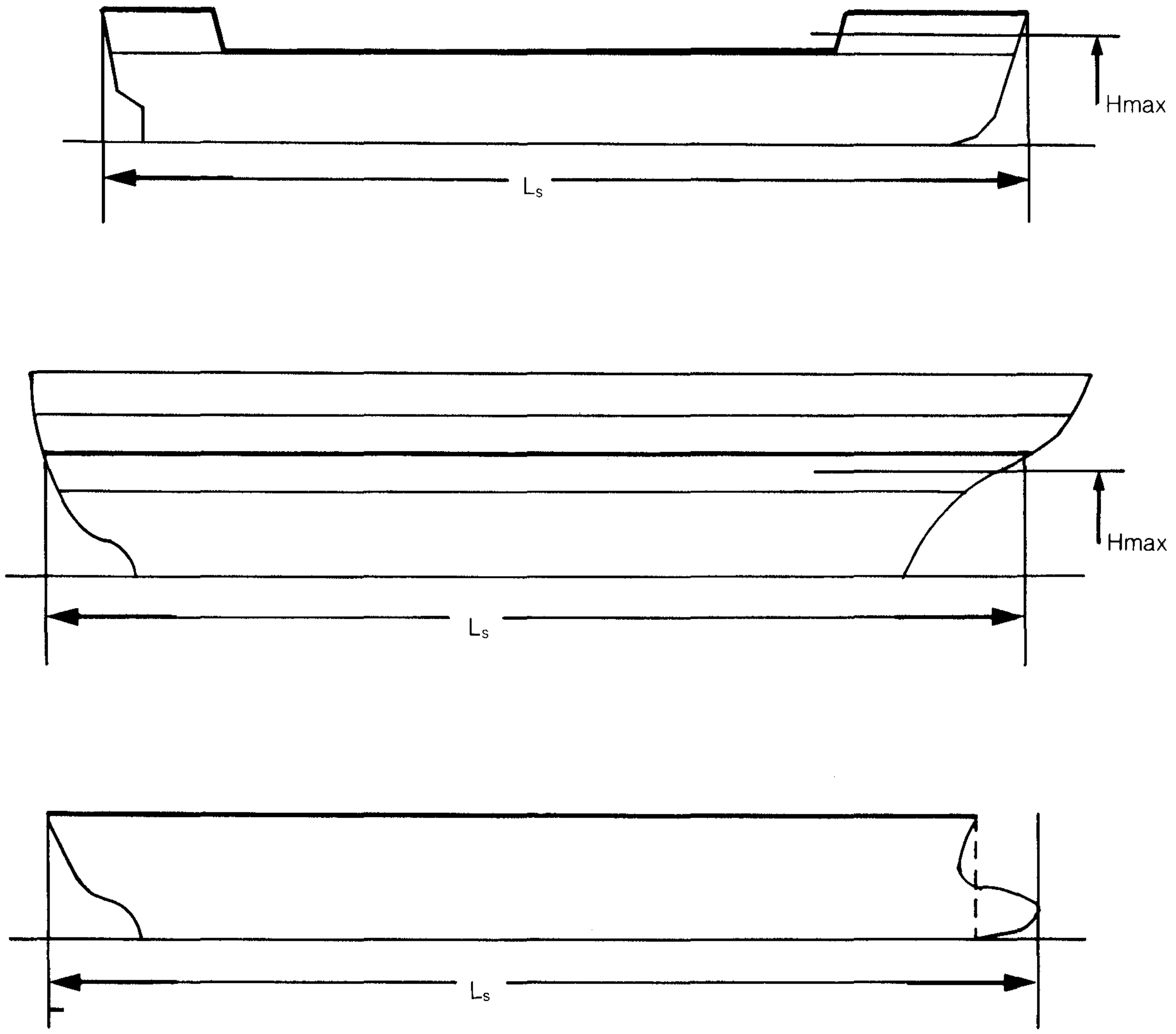
Linear interpolation should be applied to the GM values only between the deepest subdivision load line and the partial load line, when developing the curve of minimum operational Gms or corresponding maximum allowable KGs.

Regulation 25-9

Paragraph 4

The words "Satisfactory and essential" mean that scantlings and sealing requirements for those doors or ramps should be sufficient to withstand the maximum head of the water at the flooded waterline.

Illustration of the definition of "L_s" according to paragraph 2.1 of Regulation 25-2



a deck, or decks, which limit the highest vertical extent of flooding

Hmax as specified in Regulation 25-6 should be used for the definition of the vertical extent of flooding.

FIG B-1

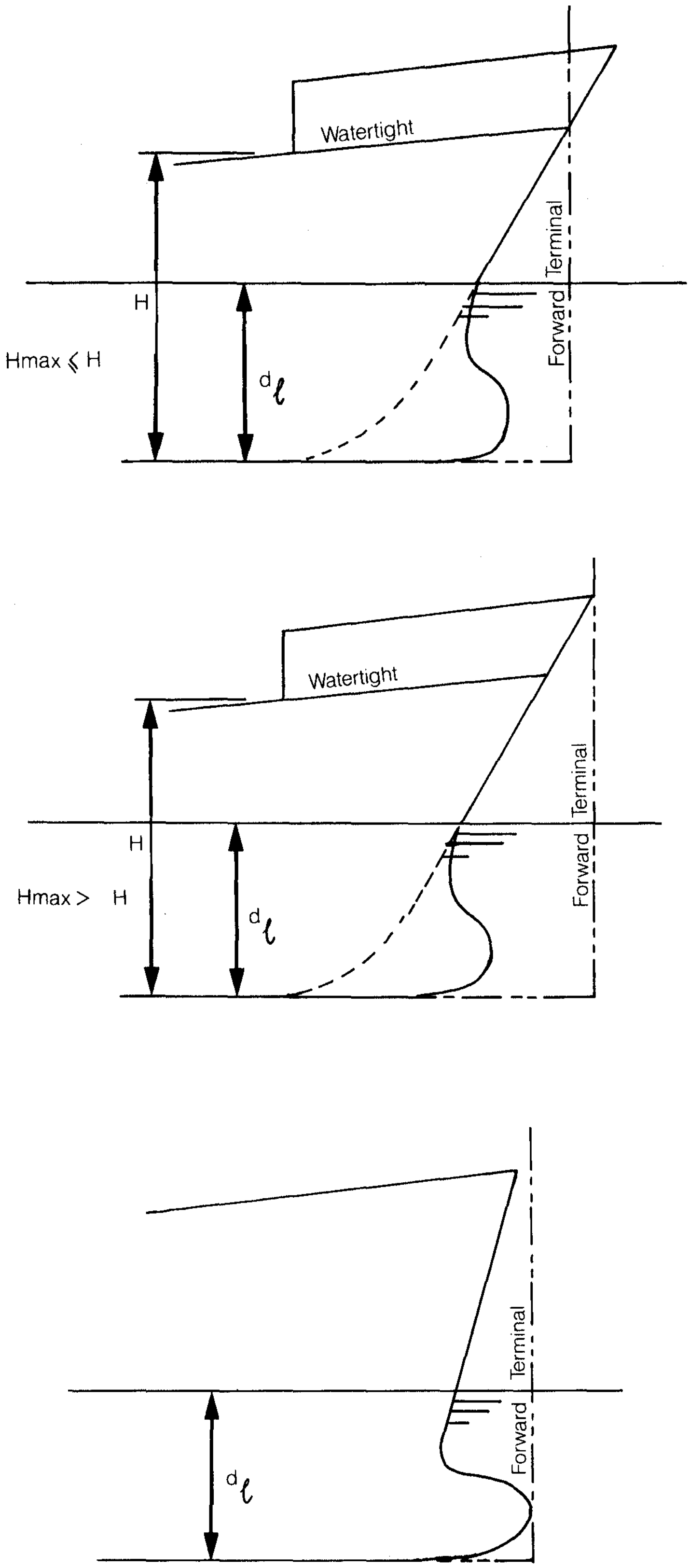
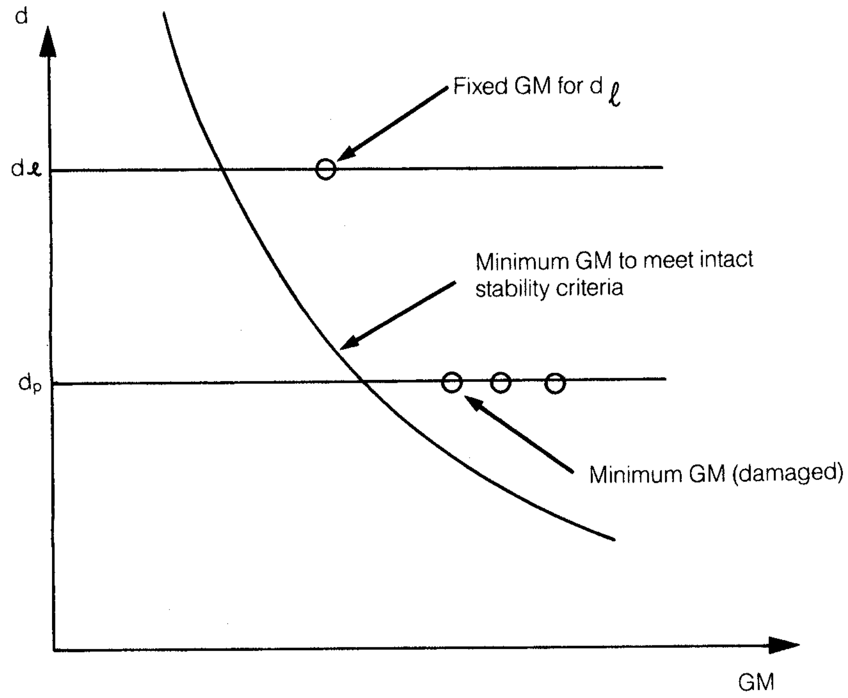
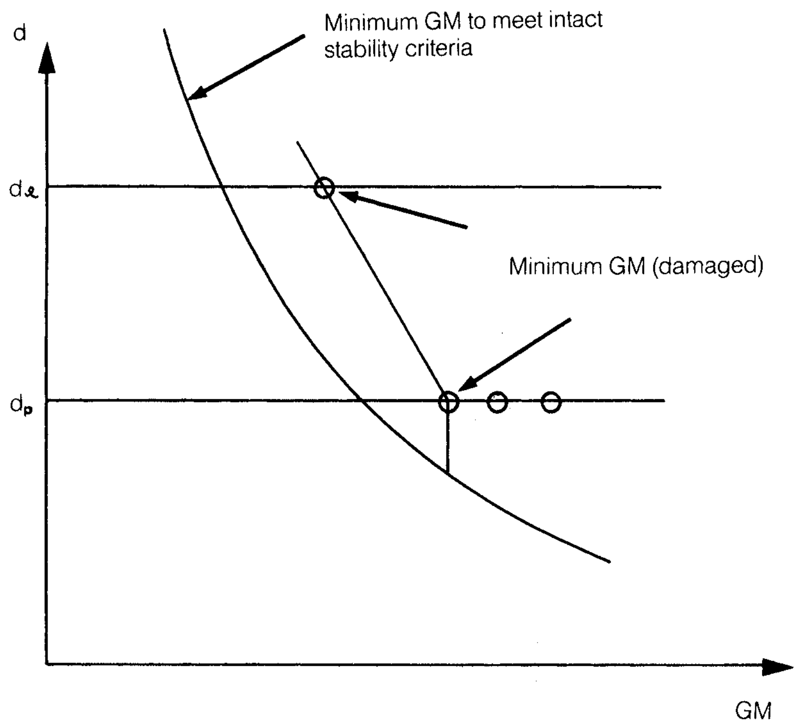

Watertight
H
Hmax ⩽ H
d_ℓ
Forward Terminal
Watertight
H
Hmax > H
d_ℓ
Forward Terminal
Terminal
Forward
d_ℓ

FIG B-2



d
Fixed GM for d ℓ
dℓ
Minimum GM to meet intact stability criteria
dp
Minimum GM (damaged)
GM

FIG B-3



d
Minimum GM to meet intact stability criteria
dℓ
Minimum GM (damaged)
dp
GM

FIG B-4

ANNEX III

TEXT OF AMENDMENTS TO CHAPTER II-1 OF THE INTERNATIONAL CONVENTION FOR THE SAFETY OF LIFE AT SEA, 1974

Chapter II-1

CONSTRUCTION -SUBDIVISION AND STABILITY, MACHINERY AND ELECTRICAL INST ALLA TIONS

Insert the following new part B-1, comprising regulations 25-1 to 25-10, after existing part B:

PART B-1 -SUBDIVISION AND DAMAGE STABILITY OF CARGO SHIPS[2]

(This part applies to cargo ships constructed on or after 1 February 1992).

Regulation 25-1

Application

1. The requirements in this part shall apply to cargo ships over 100m in length (“Ls”) but shall exclude those ships which are shown to comply with subdivision and damage stability regulations in other instruments[3] developed by the Organization. The requirements in this part shall apply to cargo ships of 80m in length (“Ls”) and upwards but not exceeding 100m in length, if constructed on or after 1st July 1998.

2. Any reference hereinafter to regulations refers to the set of regulations contained in this part.

3. The Administration may for a particular ship or group of ships accept alternative arrangements, if it is satisfied that at least the same degree of safety as represented by these regulations is achieved. Any Administration which allows such alternative arrangements shall communicate to the Organization particulars thereof.

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[2] The Maritime Safety Committee, in adopting the regulations contained in part B-1, invited Administrations to note that the regulations should be applied in conjunction with the explanatory notes developed by the Organization in order to ensure their uniform application. (See Annex 11 of this Notice).

[3] Such as Annex I to MARPOL 73/78, IBC, IGC, BCH and GC Codes, Guidelines for the Design and Construction of Offshore Supply Vessels (resolution A. 469(XII), Code of Safety for Special Purpose Ships (resolution A.534(13» and regulation 27 of the 1966 LL Convention for bulk carriers assigned B-60 or B-100 freeboards.

Regulation 25-2

Definitions

For the purpose of these regulations, unless expressly provided otherwise:

1.1 Subdivision Load Line is a waterline used in determining the subdivision of the ship.

1.2 Deepest subdivision load line is the subdivision load line which corresponds to the summer draught to be assigned to the ship.

1.3 Partial load line is the light ship draught plus 60% of the difference between the light ship draught and deepest subdivision load line.

2.1 Subdivision length of the ship ("L_s") is the greatest projected moulded length of that part of the ship at or below deck or decks limiting the vertical extent of flooding with the ship at the deepest subdivision load line.

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

2.3 Aft terminal is the aft limit of the subdivision length.

2.4 Forward terminal is the forward limit of the subdivision length.

3. Breadth ("B") is the greatest moulded breadth of the ship at or below the deepest subdivision load line.

4. Draught ("d") is the vertical distance from the moulded baseline at mid-length to the waterline in question.

5. Permeability ("μ") of the space is the proportion of the immersed volume of that space which can be occupied by water.

Regulation 25-3

ReQuired subdivision index "R"

1. These regulations are intended to provide ships with a minimum standard of subdivision.

2. The degree of subdivision to be provided shall be determined by the required subdivision index "R", as follows:

.1.1 for ships over 100m in length;

$R = (0.002 + 0.0009L_s)^{1/3}$; and

.1.2 for ships of 80m in length and upwards, but not exceeding 100m in length;

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

where R_0 is the value R as calculated in accordance with the formula in subparagraph 1.1.1, and "L_s" is the length of the ship in metres.

Regulation 25-4

Attained subdivision index "A"

1. The attained subdivision index "A" calculated in accordance with this regulation, shall not be less than the required subdivision index "R", calculated in accordance with paragraph 2 of regulation 25-3.

2. The attained subdivision index "A" shall be calculated for the ship by the following formula:

$$A = \Sigma p_i s_i$$

where:

"i" represents each compartment or group of compartments under consideration,

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

"s_i" accounts for the probability of survival after flooding the compartment or group of compartments under consideration, including the effects of any horizontal subdivision.

3. In calculating "A", level trim shall be used.

4. This summation covers only those cases of flooding which contribute to the value of the attained subdivision index "A".

5. The summation indicated by the above formula shall be taken over the ship's length for all cases of flooding in which a single compartment or two or more adjacent compartments are involved.

6. 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; and additionally, for all cases of simultaneous flooding of a wing compartment or compartments and the adjacent inboard compartment or compartments, assuming a rectangular penetration which extends to the ship's centreline, but excludes damage to any centreline bulkhead.

7. 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 will give a more severe result, such extent is to be assumed.

8. If pipes, ducts or tunnels are situated within assumed flooded compartments, arrangements are to be made to ensure that progressive flooding cannot thereby extend to compartments other than those assumed flooded. However, the Administration 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.

9. In the flooding calculations carried out according to the regulations, only one breach of the hull need be assumed.

Regulation 25-5

Calculation of the factor "p_i"

1. The factor "p_i" shall be calculated according to paragraph 1.1 as appropriate, using the following notations:

x_1 = the distance from the aft terminal of "L_s" to the foremost portion of the aft end of the compartment being considered;

x_2 = the distance from the aft terminal of "L_s" to the aftermost portion of the forward end of the compartment being considered;

E_1 = x/L_s

E_2 = x_2/L_s

E = $E_1 + E_2 - 1$

J = $E_2 - E_1$

J^1 = $J - E$, if $E \geq 0$

J^1 = $J + E$, if $E < 0$

The maximum nondimensional damage length, $J_{max} = 48/L_s$, but not more than 0.24

The assumed distribution density of damage location along the ship's length

a = $1.2 + 0.8E$, but not more than 1.2

The assumed distribution function of damage location along the ship's length

F = $0.4 + 0.25\,E\,(1.2 + a)$

y = J/J_{max}

p = $F_1\,J_{max}$

q = $0.4\,F_2\,(J_{max})^2$

F_1 = $y^2 - \frac{y^3}{3}$, if $y < 1$,

F_1 = $y - \frac{1}{3}$ otherwise;

F_2 = $\frac{y^3}{3} - \frac{y^4}{12}$, if $y < 1$,

F_2 = $\frac{y^3}{2} - \frac{y}{3} + \frac{1}{12}$ otherwise.

1.1 The factor "pi" is determined for each single compartment:

1.1.1 Where the compartment considered extends over the entire ship length, "L_s":

$$p_i = 1$$

1.1.2 Where the aft limit of the compartment considered coincides with the aft terminal:

$$p_i = F + 0.5\,ap + q$$

1.1.3 Where the forward limit of the compartment considered coincides with the forward terminal:

$$p_i = 1 - F + 0.5\,ap$$

1.1.4 When both ends of the compartment considered are inside the aft and forward terminals of the ship length, "L_s":

$$p_i = ap$$

1.1.5 In applying the formulae of paragraphs 1.1.2, 1.1.3 and 1.1.4, where the compartment considered extends over the "mid-length", these formulae values shall be reduced by an amount determined according to the formula for "q", in which "F_2" is calculated taking "y" to be J^1/J_{max}.

2. Wherever wing compartments are fitted, the "p_i" - value for a wing compartment shall be obtained by multiplying the value, as determined in paragraph 3, by the reduction factor "r" according to subparagraph 2.2, which represents the probability that the inboard spaces will not be flooded.

2.1 The "p_i"- value for the case of simultaneous flooding of a wing and adjacent inboard compartment shall be obtained by using the formulae of paragraph 3, multiplied by the factor (1 -r).

2.2 The reduction factor "r" shall be determined by the following formulae:

For J < 0.2 b/B:

$$r = \frac{b}{B}\left(2.3 + \frac{0.08}{J + 0.02}\right) + 0.1, \qquad \text{if } \frac{b}{B} \leq 0.2$$

$$r = \left(\frac{0.016}{J + 0.02} + \frac{b}{B} + 0.36\right), \qquad \text{if } \frac{b}{B} \leq 0.2$$

For J < 0.2 b/B the reduction factor "r" shall be determined by linear interpolation between

$$r = 1, \text{ for } J = 0$$

and

r = as, for the case where $J \geq 0.2b/B$, for J = 0.2 b/B,

Where:

b = the mean transverse distance in metres measured at right angles to the centreline at the deepest subdivision load line between the shell and a plane through the outermost portion of and parallel to that part of the longitudinal bulkhead which extends between the longitudinal limits used in calculating the factor "p_i".

3. To evaluate "p_i" for compartments taken singly the formulae in paragraphs 1 and 2 shall be applied directly.

3.1 To evaluate the "p_i"-values attributable to groups of compartments the following applies:

for compartments taken by pairs:

$p_i = p_{12} – p_1 – p_2$
$p_i = p_{23} – p_2 – p_3$, etc.

for compartments taken by groups of three:

$p_i = p_{123} – p_{12} – p_{12} + p_2$
$p_i = p_{234} – p_{23} – p_{34} + p_3$, etc.

for compartments taken by groups of four:

$p_i = p_{1234} – p_{123} - p_{234} + p_{23}$
$p_i = p_{2345} - p_{234} - p_{345} + p_{34}$, etc

where:

p_{12}, p_{23}, p_{34}, etc.,
p_{123}, p_{234}, p_{345}, etc and
p_{1234}, p_{2345}, p_{3456}, etc

shall be calculated according to the formulae in paragraphs 1 and 2 for a single compartment whose non dimensional length "J" corresponds to that of a group consisting of the compartments indicated by the indices assigned to "p".

3.2 The factor "p_i" for a group of three or more adjacent compartments equals zero if the nondimensionallength of such a group minus the non dimensional length of the aftermost and foremost compartments in the group is greater than "J_{max}".

Regulation 25-6

Calculation of factor "s_i"

1. The factor "s_i" shall be determined for each compartment or group of compartments according to the following:

1.1 in general for any condition of flooding from any initial loading condition "s" shall be

$$S = C \sqrt{0.5\,(GZ_{max})(range)}$$

with $C = 1$, if $\varnothing e \leqslant 25°$

$C = 0$, if $\varnothing e > 30°$

$C = \sqrt{\dfrac{30 - \varnothing e}{5}}$ otherwise

GZ_{max} = maximum positive righting lever (in metres) within the range given below but not more than 0.1m;

range = range of positive righting levers beyond the angle of equilibrium (in degrees) but not more than 20°; however, the range shall be terminated at the angle where openings not capable of being closed weathertight are immersed;

$\varnothing e$ = final equilibrium angle of heel (in degrees);

1.2 s = 0 where the final waterline taking into account sinkage, heel and trim, immerses the lower edge of openings through which progressive flooding may take place. Such opening shall include air-pipes, ventilators and openings which are closed by means of weathertight doors or hatch covers, and may exclude those openings closed by means of watertight manhole covers and flush scuttles, small watertight hatch covers which maintain the high integrity of the deck, remotely operated sliding watertight doors, access doors and access hatch covers, of watertight integrity, normally closed at sea and sidescuttles of the non-opening type. However, if the compartments so flooded are taken into account in the calculations the requirements of this regulation shall be applied.

1.3 For each compartment or group of compartments "s_i" shall be weighted according to draught considerations as follows:

$s_i = 0.5\, S_\ell + 0.5\, s_p$

where

"s_ℓ" is the "s"-factor at the deepest subdivision load line
"s_p" is the "s"-factor at the partial load line.

2. For all compartments forward of the collision bulkhead, the "s"-value, calculated assuming the ship to be at its deepest subdivision load line and with assumed unlimited vertical extent of damage is to be equal to 1.

3. Wherever a horizontal subdivision is fitted above the waterline in question the following applies.

3.1 The "s"-value for the lower compartment or group of compartments shall be obtained by multiplying the value as determined in subparagraph 1.1 by the reduction factor "v" according to subparagraph 3.3, which represents the probability that the spaces above the horizontal subdivision will not be flooded.

3.2 In cases of positive contribution to index "A" due to simultaneous flooding *of* the spaces above the horizontal subdivision, the resulting "s"-value for such a compartment or group of compartments shall be obtained by an increase of the value as determined by subparagraph 3.1 by the "s"-value for simultaneous flooding according to sub paragraph 1.1, multiplied by the factor (1-v).

3.3 The probability factor "vi" shall be calculated according to:

$v_i = \frac{H-d}{H_{max} - d}$ for the assumed flooding up to the horizontal subdivision above the subdivision load line, where "H" is to be restricted to a height of "H_{max}",

$v_i = 1$, if the uppermost horizontal subdivision in way of the assumed damaged region is below "H_{max}", where:

"H" is the height of the horizontal subdivision above the baseline (in metres) which is assumed to limit the vertical extent of damage,

"Hmax" is the maximum possible vertical extent of damage above the baseline (in metres), or

$H_{max} = d + 0.056\ L_s\ (1 - \frac{L_s}{500})$, if $L_s \leq 250m$;

$H_{max} = d + 7$, if $L_s > 250m$

whichever is less.

Regulation 25-7

Permeability

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

Spaces	Permeability
Appropriated to stores	0.60
Occupied by accommodation	0.95
Occupied by machinery	0.85
Void spaces	0.95
Dry cargo spaces	0.70
Intended for liquid	0 or 0.95[4]

Regulation 25-8

Stability information

1. The master of the ship shall be supplied with such reliable information as is necessary to enable him by rapid and simple means to obtain accurate guidance as to the stability of the ship under varying conditions of service. The information shall include:

.1 a curve of minimum operational metacentric height (GM) versus draught which assures compliance with the relevant intact stability requirements and the requirements of regulations 25-1 to 25-6, alternatively a corresponding curve of the maximum allowable vertical centre of gravity (KG) versus draught, or with the equivalents of either of these curves;

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

.3 all other data and aids which might be necessary to maintain stability after damage.

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

'Whichever results in the more severe requirements.

3. In order to provide the information referred to in 1.1, the limiting GM (or KG) values to be used, if they have been determined from considerations related to the subdivision index, the limiting GM shall be varied linearly between the deepest subdivision load line and the partial load line. In such cases, for draughts below the partial load line if the minimum GM requirement at this draught results from the

calculation of the subdivision index, then this GM value shall be assumed for lesser draughts, unless the intact stability requirements apply.

Regulation 25-9

Openings in watertight bulkheads and internal decks in cargo ships

1. The number of openings in watertight subdivisions is to be kept to a minimum compatible with the design and proper working of the ship. Where penetrations of watertight bulkheads and internal decks are necessary for access, piping, ventilation, electrical cables, etc., arrangements are to be made to maintain the watertight integrity. The Administration may permit relaxation in the watertightness of openings above the freeboard deck, provided that it is demonstrated that any progressive flooding can be easily controlled and that the safety of the ship is not impaired.

2. Doors provided to ensure the watertight integrity of internal openings which are used while at sea are to be sliding watertight doors capable of being remotely closed from the bridge and are also to be operable locally from each side of the bulkhead. Indicators are to be provided at the control position showing whether the doors are open or closed, and an audible alarm is to be provided at the door closure. The power, control and indicators are to be operable in the event of main power failure. Particular attention is to be paid to minimize the effect of control system failure. Each power-operated sliding watertight door shall be provided with an individual hand-operated mechanism. It shall be possible to open and close the door by hand at the door itself from both sides.

3. Access doors and access hatch covers normally closed at sea, intended to ensure the watertight integrity of internal openings, shall be provided with means of indication locally and on the bridge showing whether these doors or hatch covers are open or closed. A notice is to be affixed to each such door or hatch cover to the effect that it is not to be left open. The use of such doors and hatch covers shall be authorized by the officer of the watch.

4. Watertight doors or ramps of satisfactory construction may be fitted to internally subdivide large cargo spaces, provided that the Administration is satisfied that such doors or ramps are essential. These doors or ramps may be hinged, rolling or sliding doors or ramps, but shall not be remotely controlled. Such doors or ramps shall be closed before the voyage commences and shall be kept closed during navigation; the time of opening such doors or ramps in port and of closing them before the ship leaves port shall be entered in the log book. Should any of the doors or ramps be accessible during the voyage, they shall be fitted with a device which prevents unauthorised opening.

5. Other closing appliances which are kept permanently closed at sea to ensure the watertight integrity of internal openings shall be provided with a notice which is to be affixed to each such closing appliance to the effect that it is to be kept closed. Manholes fitted with closely bolted covers need not be so marked.

Regulation 25-10

External openings in cargo ships

1. All external openings leading to compartments assumed intact in the damage analysis, which are below the final damage waterline, are required to be watertight.

2. External openings required to be watertight in accordance with paragraph 1 shall be of sufficient strength and, except for cargo hatch covers, shall be fitted with indicators on the bridge.

3. Openings in the shell plating below the deck limiting the vertical extent of damage shall be kept permanently closed while at sea. Should any of these openings be accessible during the voyage, they shall be fitted with a device which prevents unauthorized opening.

4. Notwithstanding the requirements of paragraph 3, the Administration may authorize that particular doors may be opened at the discretion of the master, if necessary for the operation of the ship and provided that the safety of the ship is not impaired.

5. Other closing appliances which are kept permanently closed at sea to ensure the watertight integrity of external openings shall be provided with a notice affixed to each appliance to the effect that it is to be kept closed. Manholes fitted with closely bolted covers need not be so marked.