RESOLUTION A.266 (VIII) adopted on 20 November 1973

RECOMMENDATION ON A STANDARD METHOD FOR ESTABLISHING COMPLIANCE WITH THE REQUIREMENTS FOR CROSS-FLOODING ARRANGEMENTS IN PASSENGER SHIPS

INTER-GOVERNMENTAL MARITIME CONSULTATIVE ORGANIZATION

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RECOMMENDATION ON A STANDARD METHOD FOR ESTABLISHING COMPLIANCE WITH THE REQUIREMENTS FOR CROSS-FLOODING ARRANGEMENTS IN PASSENGER SHIPS

THE ASSEMBLY,

NOTING Article 16(i) of the Convention on the Inter-Governmental Maritime Consultative Organization concerning the functions of the Assembly,

NOTING ALSO Regulation 7(e) of Chapter II of the International Convention for the Safety of Life at Sea, 1960 and Regulation 5(c) of the Regulations on Subdivision and Stability of Passenger Ships (Resolution A.265(VIII)),

DESIRING application of a uniform method of calculation for cross-flooding arrangements in passenger ships,

HAVING CONSIDERED the Recommendation by the Maritime Safety Committee at its twenty-sixth session,

ADOPTS the Recommendation on a Standard Method for Establishing Compliance with the Requirements for Cross-Flooding Arrangements in Passenger Ships, the text of which is set out in the Annex to this Resolution,

INVITES all governments concerned to take appropriate steps to give effect to the Recommendations as soon as possible.

ANNEX

RECOMMENDATION ON A STANDARD METHOD FOR ESTABLISHING COMPLIANCE WITH THE REQUIREMENTS FOR CROSS-FLOODING ARRANGEMENTS IN PASSENGER SHIPS

In order to ensure uniform application of Regulation 7(e) of Chapter II of the International Convention for the Safety of Life at Sea and/or Regulation 5(c) of the Regulations on Subdivision and Stability of Passenger Ships (Resolution A.265(VIII)), Administrations are recommended to apply the following cross-flooding formulae:

Time required for complete cross-flooding (seconds)

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

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

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

Hence:

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

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

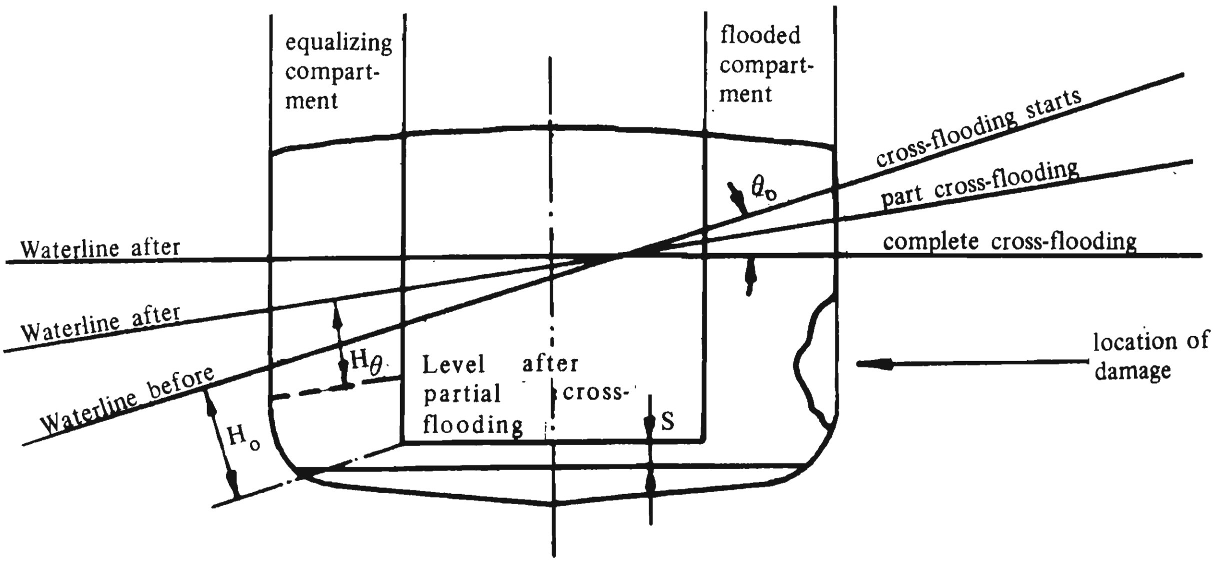


FIGURE 1

The following parameters, in feet or metric units, are used in formulae (I) – (III):

W = volume of water entering the equalizing compartments during the considered period,

S = cross-section area through the cross-flooding duct,

H_o = head of water before commencement of cross-flooding,

H_θ = head of water at the time of cross-flooding where the vessel is heeled $\theta°$, (or at the angle of margin line immersion),

h_f = 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),

$$F = \frac{1}{\sqrt{1 + \Sigma k}}$$

= dimensionless factor of reduction of speed through the duct, being a function of bends, valves, etc., in the cross-flooding system.

For guidance some typical values for k are given in Figures 2 – 12.

EXAMPLE

Cross-flooding pipe, diameter (D) 0.39 m, length (ℓ) 21.0 m
cross-section area (S) 0.12 m²

'k' values for the cross-flooding system:

Inlet	0.45
Pipe friction $\frac{0.02\ \ell}{D}$	1.08
2 Radius bends ($\alpha = 45°$)	0.36
Non-return valve	0.50
Outlet	1.00
	Σk = 3.39

$$\therefore F = \frac{1}{\sqrt{1 + \Sigma k}} = \frac{1}{\sqrt{1 + 3.39}} = 0.48$$

Initial angle of heel = θ_o = 11.9°
Head before cross-flooding commences = H_o = 5.3 m
Head after complete cross-flooding = h_f = 1.5 m

$$\text{Time to complete cross-flooding} = T_o = \frac{2W}{SF} \cdot \frac{\left(1 - \sqrt{\frac{h_f}{H_o}}\right)}{\sqrt{2g \cdot H_o}} \cdot \frac{1}{\left(1 - \frac{h_f}{H_o}\right)}$$

In this case:

W = final volume of water entering the equalizing compartment
= 365 m³

$$\therefore T_o = \frac{2 \cdot 365}{0.12 \cdot 0.48} \cdot \frac{\left(1 - \sqrt{\frac{1.5}{5.3}}\right)}{\sqrt{2g \cdot 5.3}} \cdot \frac{1}{\left(1 - \frac{1.5}{5.3}\right)}$$

= <u>815 seconds</u> (13.6 minutes)

The vessel is balanced at 7° using the stability curve and H_θ measured to the equilibrium waterplane. W is now the volume added to reduce the heel angle from 7° (or θ) to zero.

$$\text{Time from 7° heel to upright} = T_\theta = \frac{2W}{SF} \cdot \frac{\left(1 - \sqrt{\frac{h_f}{H_\theta}}\right)}{\sqrt{2g \cdot H_\theta}} \cdot \frac{1}{\left(1 - \frac{h_f}{H_\theta}\right)}$$

Head after partial cross-flooding to 7° heel = H_θ = 3.7 m
and W = 160 m³

$$\therefore T_\theta = \frac{2 \cdot 160}{0.12 \cdot 0.48} \cdot \frac{\left(1 - \sqrt{\frac{1.5}{3.7}}\right)}{\sqrt{2g \cdot 3.7}} \cdot \frac{1}{\left(1 - \frac{1.5}{3.7}\right)}$$

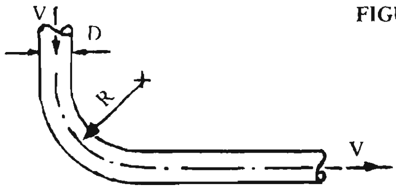
= <u>400 seconds</u> (6.7 minutes)

∴ Time from start of cross-flooding to 7° heel = $T_o - T_\theta$

= <u>415 seconds</u> (6.9 minutes)

FRICTION COEFFICIENTS IN CROSS-FLOODING ARRANGEMENT

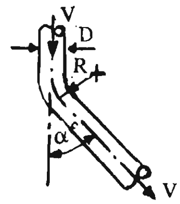
FIGURE 2



R/D	2	3	4	5	6	7
k	.30	.26	.23	.20	.18	.17

90° CIRCULAR BEND

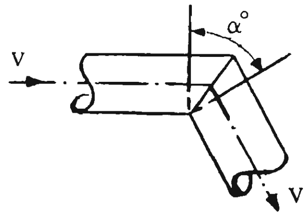
FIGURE 3



α°	15	30	45	60	75	90
k	.06	.12	.18	.24	.27	.30

RADIUS BEND R/D = 2

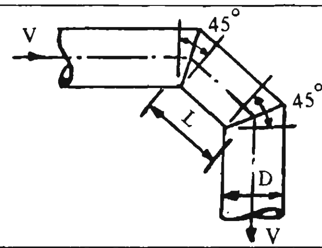
FIGURE 4



α°	5	15	30	45	60	90
k	.02	.06	.17	.32	.68	1.26

MITRE BEND

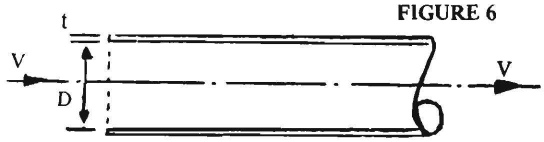
FIGURE 5



L/D	1	2	3	4	5	6
k	.41	.40	.43	.46	.46	.44

90° DOUBLE MITRE BEND

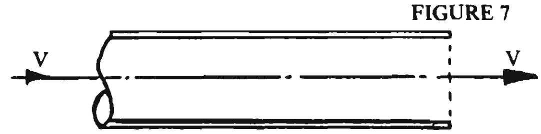
FIGURE 6



t/D	.01	.02	.03	.04	.05	>.05
k	.83	.68	.53	.46	.44	.43

PIPE INLET

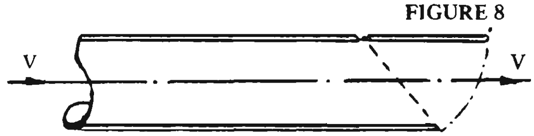
FIGURE 7



k = 1.0

PIPE OUTLET

FIGURE 8



k = 0.5

The value of k actually increases with decrease in Froude number, particularly below speeds of 2 m/sec.

NON-RETURN VALVE

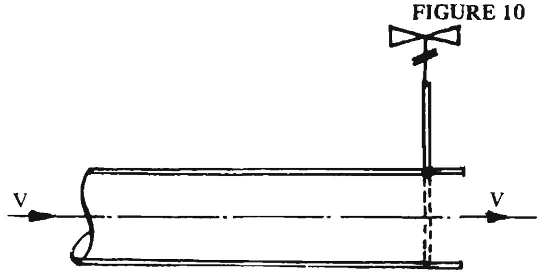
FIGURE 9

$$k = \frac{0.02}{D} \text{ per unit length}$$

The coefficient above is a mean value and does in fact vary as Reynold's number (i.e. varies with V for constant D and ν) as well as with relative roughness.

PIPE FRICTION LOSSES

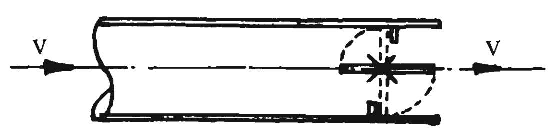
FIGURE 10



k = 0.3

GATE VALVE

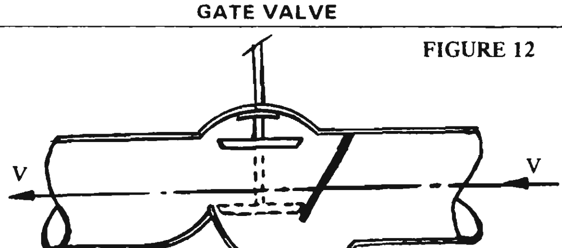
FIGURE 11



k = 0.8

BUTTERFLY VALVE

FIGURE 12



k = 6.0

DISC VALVE