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INTERIM GUIDELINES FOR A SIMPLIFIED EVACUATION ANALYSIS ON RO-RO PASSENGER SHIPS

1 The Maritime Safety Committee, at its seventy-first session (19 to 28 May 1999), noted that under SOLAS regulation II-2/28-1.3, ro-ro passenger ships constructed on or after 1 July 1999 are required to undergo an evacuation analysis at an early stage of design.

2 The Committee, noting that computerized simulation systems are still under development, decided that a simplified interim evacuation analysis method was needed and approved the Interim Guidelines for a simplified evacuation analysis on ro-ro passenger ships, as set out in the annex.

3 Member Governments are invited to bring the annexed Interim Guidelines to the attention of those concerned and use the provisions contained therein, as appropriate, in conjunction with the relevant requirements of SOLAS regulation II-2/28-1.3.

4 Member Governments are invited to:

.1 collect and submit to the Sub-Committee on Fire Protection for further consideration any information and data resulting from research and development activities, full-scale tests and findings on human behaviour which may be relevant for the necessary future upgrading of the present interim guidelines; and

.2 submit to the Sub-Committee on Fire Protection information on experience gained in the implementation of the Interim Guidelines, as well as in trial applications of the Interim Guidelines to high-speed passenger craft.

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ANNEX

INTERIM GUIDELINES FOR A SIMPLIFIED EVACUATION ANALYSIS OF RO-RO PASSENGER SHIPS

1 GENERAL

1.1 In addition to the relevant requirements applicable, ro-ro passenger ships' escape routes are required to be evaluated by an evacuation analysis early in the design process, under SOLAS regulation II-2/28-1.3.

1.2 The purpose of the guidelines is to provide information indications on how to execute a simplified evacuation analysis and use its results to:

.1 identify and eliminate, as far as practicable, congestion which may develop during an abandonment, due to normal movement of passengers and crew along escape routes, taking into account the possibility that crew may need to move along these routes in a direction opposite the movement of passengers; and

.2 demonstrate that escape arrangements are sufficiently flexible to provide for the possibility that certain escape routes, assembly stations, embarkation stations or life-saving appliances and arrangements may be unavailable as a result of a casualty.

2 DEFINITIONS

2.1 *Passenger load* is the maximum number of passengers on board.

2.2 *Crush conditions* is the maximum allowable density in escape routes or spaces, fixed at 3.5 pers./m².

2.3 *Awareness time (A)* is the time it takes for passengers to process and react to the situation. This time begins upon initial notification (e.g. alarm) of an emergency and ends when the passenger has accepted the situation and begins to move towards an assembly station.

2.4 *Travel time (T)* is defined as the time it takes for all persons on board to move from where they are upon notification to the assembly stations and then on to the embarkation stations.

2.5 *Embarkation time (E) and launching time (L)* is the sum of which defines the time required to provide for abandonment by the total number of persons on board.

3 METHOD OF EVACUATION

The steps in the evacuation analysis are:

3.1 Description of the system

.1 Identification of assembly stations.

.2 Identification of embarkation stations.

.3 Identification of escape routes.

.4 Identification of life-saving appliances.

3.2 Assumptions

This method of estimating evacuation time is basic in nature and, therefore, common evacuation analysis assumptions should be made as follows:

.1 all passengers and crew will begin evacuation at the same time, and will not hinder each other;

.2 passengers and crew will evacuate via the primary escape route;

.3 walking speed depends on the density of persons and the type of escape facility, assuming that the flow is only in the direction of the escape route, and that there is no overtaking;

.4 no passengers or crew have disabilities or medical conditions that will severely hamper their ability to keep up with the flow;

.5 counterflow is accounted for by a counterflow factor;

.6 passenger load is assumed to be 100% (full load);

.7 full availability of escape arrangements is considered;

.8 people can move unhindered; and

.9 effects of the ship's motions, passengers' age and disability, restricted visibility due to smoke, etc., are accounted for in a safety factor.

3.3 Scenarios to be considered

3.3.1 As a minimum, two scenarios should be considered for the analysis, namely night time (Case 1) and day time (Case 2), as per resolution A.757(18).

3.3.2 The initial distribution of persons on board for these two scenarios should be based upon paragraph 3.2 (Cases 1 and 2) of resolution A.757(18).

3.3.3 Additional relevant scenarios can be considered, as appropriate.

3.4 Calculation of the evacuation time

The following components should be considered:

.1 The Awareness time (A) should be assumed to be 10 min in night scenarios and 5 min in daylight scenarios.

.2 The method to calculate the Travel time (T) is given in the appendix.

.3 Embarkation time (E) and launching time (L).

3.5 Performance standard

The following performance standards, as illustrated in figure 3.5, should be complied with:

Calculated evacuation time: $A + T + \mathbf{b}\ (E + L) \le 60'$ (1)

$E + L \le 30'$ (2)

Performance standard (1) is derived from resolution 4 of the 1995 SOLAS Conference.
Performance standard (2) complies with SOLAS regulation III/21.1.4.

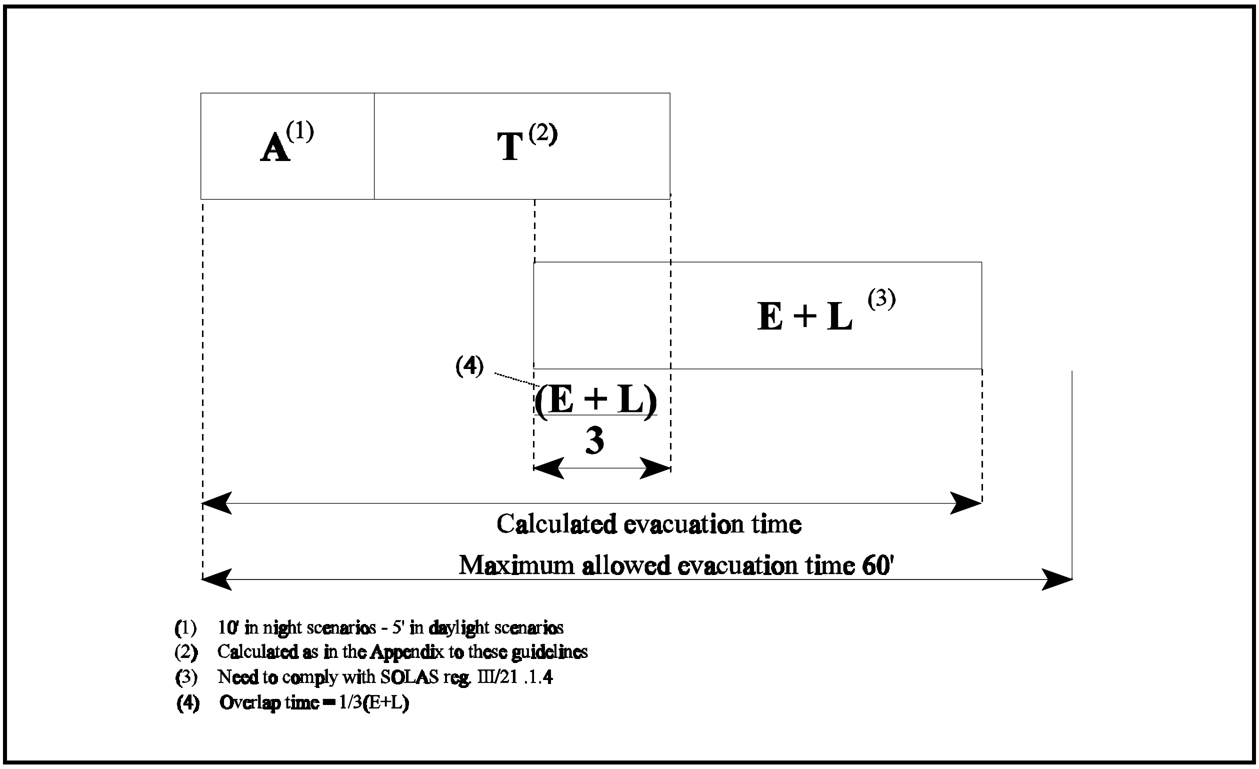

Figure 3.5

3.6 Calculation of E + L

.1 E + L should be calculated based on:

.1.1 the results of full scale trials on similar ships and evacuation systems; or

.1.2 data provided by the manufacturers, however, in this case, the method of calculation should be documented including the value of particular safety factor used.

.2 In case neither of the two methods can be used, E + L is assumed to be 30 min.

3.7 Identification of congestions

3.7.1 The presence of congestion should be verified on the basis of the following criteria:

.1 crush conditions; and

.2 significant queues (accumulation of more than 1.5 persons per second between ingress and exit from a point).

3.7.2 Details on identification of congestion are provided in the appendix to these guidelines.

3.8 Flexibility of arrangements

3.8.1 The unavailability of a single embarkation station or any life-saving appliances and arrangements should be fully compensated by the capacity of the other embarkation stations or life-saving appliances and arrangements on the same embarkation deck.

3.8.2 Unavailability of corridors, stairways, doors, etc., is accounted for in the safety factor.

4 CORRECTIVE ACTIONS

If the total evacuation time calculated as described in paragraph 3.5 is in excess of 60 min, corrective actions should be considered at the design stage by suitably modifying one or more components in the evacuation system (e.g., escape routes, life-saving appliances, etc.) In this case, the evacuation time should be recalculated.

5 DOCUMENTATION

The documentation of the analysis should report the following items:

.1 the basic assumptions for the analysis;

.2 a schematization of the layout of the zones subjected to the analysis;

.3 the initial distribution and density of persons immediately before the evacuation at least in two cases (daytime and night-time);

.4 the parameters of the initial movement of the persons;

.5 the method for the analysis, if different from these interim guidelines;

.6 the overall time; and

.7 the congestion points and the significant queues.

APPENDIX

METHOD TO CALCULATE THE TRAVEL TIME (T)

1 PARAMETERS TO BE CONSIDERED

1.1 Effective width (W_e)

In order to accommodate lateral body sway and assure balance, persons moving through the escape routes maintain a clearance from walls and/or other fixed items (e.g. handrails, fixed seats, etc.). The effective width of any portion of an escape route is the clear width of that portion reduced by the sum of the clearances. Recommended values for clearances are given table 1.1.

Table 1.1

Derive from "SFPE of Fire Protection Engineering handbook, 2nd edition NFPA 1995"

Escape route element	Clearance (m)
Stairways	0.15
Handrails	0.05
Public space fixed seats	0
Walls	0.20
Doors	0.15

1.2 Clear width

Clear width is:

.1 measured off the handrail(s) for corridors and stairways;

.2 the actual passage width of a door in its fully open position;

.3 the space between the fixed seats for aisles in public spaces; and

.4 the space between the most intruding portions of the seats (when unoccupied) in a row of seats in public spaces.

1.3 Density of persons (D)

Density of persons in an escape route is the number of persons (p) divided by the available escape route area pertinent to the space where the persons are originally located expressed in (p/m^2).

The available escape route area should be calculated using the effective width W_e.

1.4 Speed of persons (S)

The speed (m/s) of persons along the escape route depends on the density of persons and on the type of escape facility. Values for speed of persons are given in table 1.5.

1.5 Specific flow of persons (F_s)

Specific flow (persons/ms) is the number of evacuating persons past a point in the exit route per unit time per unit of effective width W_e of the route involved. Values for F_s are given in table 1.5 for various values of density and route characteristics.

Table 1.5

Derive from "SFPE of Fire Protection Engineering Handbook, 2nd edition NFPA 1995"

Type of Facility	Condition	Density D (p/m^2)	Speed of persons S (m/s)	Specific Flow Fs (p/(ms))
Stairs (down)	Low	< 1.9	1.0	0.54
	Optimum	1.9 to 2.7	0.50	0.94
	Moderate	2.7 to 3.2	0.28	0.77
	Crush	> 3.2	0.13	0.42
Stairs (up)	Low	< 1.9	0.8	0.43
	Optimum	1.9 to 2.7	0.40	0.75
	Moderate	2.7 to 3.2	0.22	0.62
	Crush	> 3.2	0.10	0.32
Corridors, doorways	Low	< 1.9	1.4	0.76
	Optimum	1.9 to 2.7	0.70	1.30
	Moderate	2.7 to 3.2	0.39	1.10
	Crush	> 3.2	0.18	0.55

1.6 Calculated flow of persons (F_c)

The calculated flow of persons (p/s) is the predicted number of persons passing a particular point in an escape route per unit time. It is obtained from:

$$F_c = F_s \bullet W_e \qquad (1.6)$$

1.7 Flow time (t_F)

Flow time (s) is the total time needed for N persons to move past a point in the egress system, and is calculated as:

$$t_F = N / F_c \qquad (1.7)$$

1.8 Transitions

Transitions are those points in the egress system where the type (e.g. from a corridor to a stairway) or dimension of a route changes or where routes merge or ramify.

In a transition, the sum of all the outlet calculated flow is equal to the sum of all the inlet calculated flow:

$$\Sigma F_c(in)_i = \Sigma F_c(out)_j \qquad (1.8)$$

where:

$F_c(in)_i$ = calculated flow of route (i) arriving at transition point

$F_c(out)_j$ = calculated flow of route (j) departing from transition point

1.9 Crush conditions

Maximum allowable density, in escape routes or spaces, is 3.5 persons/m^2 .

1.10 Safety factor and counterflow factor

Travel time T expressed in seconds as given by:

T = (* + ( )t_I (1.10)

where:

(is the safety factor to be taken equal to 2.0
* is the counterflow factor to be taken equal to 0.30
t_I is the highest travel time in ideal conditions resulting from application of the calculation procedure outlined in paragraph 2 of this appendix.

2 PROCEDURE FOR CALCULATING THE TRAVEL TIME IN IDEAL CONDITIONS

2.1 Symbols

To illustrate the procedure, the following notation is used:

t_{stair} = travel time(s) from the uppermost (or lowermost) deck to the closest embarkation station.

t_{deck} = travel time(s) to move from the farthest point of the escape route of a deck to the stairway.

2.2 Quantification of flow time

The basic steps of the calculation are the following:

.1 Schematization of the escape routes as a hydraulic network, where the pipes are the corridors and stairways, the valves are the doors and restrictions in general, and the tanks are the public spaces.

.2 Calculation of the density D in the main escape routes of each deck. In the case of cabin rows facing a corridor, it is assumed that the people in the cabins simultaneously move into the corridor; the corridor density is therefore the number of cabin occupants per corridor unit area calculated considering the effective width (see paragraph 1.3). For large public spaces, it is assumed that all persons simultaneously begin evacuation and use the exit doors at their maximum specific flow; the number of evacuees using each door can be assumed proportional to the door effective width. Other assumptions can be made on the basis of layout considerations. In any case, the check of non occurrence of crush condition should be made, by verifying that $D < 3.5$ p/m^2.

.3 Calculation of the specific flows F_s from the initial densities, which represent the initial flows along corridors or through doors.

.4 Calculation of the flow F_c for corridors and doors, in the direction of the correspondent assigned escape stairway.

.5 Once a transition point is reached, formula (1.8) is used to obtain the outlet calculated flow(s) F_c. In cases where two or more routes leave the transition point, it is assumed that the flow F_c of each route is proportional to its effective width.

In regard to the inlet flows, two possibilities exist:

- the value of specific flow F_s does not exceed the value defined as "optimum" in table 1.5, and the value of the speed (S) is then taken by interpolation from table 1.5; and

- the value of specific flow F_s exceeds the value defined as "optimum" in table 1.5; in this case, a queue will form at the transition point, and the outlet flow should be assumed equal to the "crush" value defined in table 1.5, and the outlet speed (S) of persons is taken as the 'optimum' one in table 1.5. This is due to the fact that, once past a congestion point, the density of persons decreases and the speed increases. The queue at the transition point is characterized by a growing rate equal to the difference between the inlet outlet values of the calculated flows F_c.

.6 The above procedure is repeated for each deck, resulting in a set of initial values of calculated flow F_c and speed S, each entering the assigned escape stairway.

.7 Using formula (1.8) and considering the landing of each stairway as a transition point having inlet flows coming from stairs and deck, the flow F_c resulting from the passage from landing to stairway is calculated. The procedure will be the same as described in .5 above.

.8 The calculation of .7 should be repeated for each stairway flight until the embarkation stations are reached.

.9 Estimation, from N (number of persons entering a flight or corridor) and from the relevant F_c, of the flow time t_F of each stairway and corridor. The flow time t_F of each escape route is the longest among those corresponding to each portion of the escape route.

.10 Assessment of the travel time t_{deck} from the farthest point of each escape route to the stairway, is defined as the ratio of length/speed. For the various portions of the escape route, the travel times should be summed up if the portions are used in series, otherwise the largest among them should be adopted. This calculation should be performed for each deck; as the people are assumed to move in parallel on each deck to the assigned stairway, the dominant value t_{deck} should be taken as the largest among them.

.11 Estimation of the travel time along each stairway, t_{stair}, from the uppermost (or lowermost, depending on whether the route is ascending or descending) deck to the assembly station, is defined as the ratio of stairway length/speed.

.12 The overall time to travel along an escape route to the assigned assembly station is:

$$t_I = t_F + t_{deck} + t_{stair} \qquad (2.2.12)$$

.13 If the assembly station of a main vertical zone can be reached both from lower and upper decks, the overall t_I will not be the sum of the travel times from the lowerdecks and from upperdecks to the assembly station, but the greatest of the two.

.14 The procedure should be repeated for both the daytime and night-time case, unless the disposition of people is such that either case is obviously overlapping (this is usually true for the night-time case, but it should be verified). A different value of t_I will result for each main escape route leading to the assigned assembly station.

.15 The potential congestion points stemming from the analysis should be highlighted.

.16 Once the calculation is performed for all the escape routes, the highest t_I should be selected for calculating the travel time T using formula (1.10).

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