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GUIDELINES ON EVACUATION ANALYSIS FOR PERSONNEL OF PASSENGER SHIPS

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Chapter 1 General

1.1 Scope of application

1.1.1 The Guidelines provide two calculation methods, i.e. simplified evacuation analysis and advanced evacuation analysis, to evaluate whether the design of escape routes, evacuation arrangements and evacuation performance of passenger ships comply with the relevant requirements of the International Maritime Organization (IMO) conventions and regulations of the Administration.

1.1.2 The evacuation analysis of other ships and offshore installations may be carried out in accordance with the Guidelines.

1.1.3 Except for the IMO MSC.1/Circ.1533, the application of evacuation analysis in other specific assessments, such as alternative design, fire accidents, and safe return to port, etc., may be carried out in accordance with Chapter 4 of the Guidelines.

1.1.4 The assumptions inherent within the simplified method are by their nature limiting. As the complexity of the ships increases (through the mix of passenger types, accommodation types, number of decks and number of stairways), the use of the advanced method would be preferred. However, in early design iterations of the ship, the simplified method has merit due to its relative ease of use and its ability to provide an approximation to expected evacuation performance.

1.2 Terms and definitions

1.2.1 Advanced evacuation analysis is taken to mean a computer-based simulation that represents each occupant as an individual that has a detailed representation of the layout of a ship and represents the interaction between the occupants and the layout.

1.2.2 Persons load is the number of persons considered in the means of escape calculations contained in Chapter 13 of the International Code for Fire Safety Systems (FSS Code), as amended.

1.2.3 Response duration (R) is the duration it takes for people to react to the situation. This duration 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.

1.2.4 Individual travel duration is the duration incurred by an individual in moving from its starting location to reach the assembly station.

1.2.5 Individual assembly duration is the sum of the individual response and the individual travel duration.

1.2.6 Total assembly duration (t_A) is the maximum individual assembly duration.

1.2.7 Total travel duration (T) is the duration it takes for all persons on board to move from where they are upon notification to the assembly stations.

1.2.8 Embarkation and launching duration ($E+L$) is the duration required to provide for abandonment by the total number of persons on board, starting from the time the abandon ship signal is given after all persons have been assembled, with lifejackets donned.

1.3 Class notations

1.3.1 Upon application, ships for which simplified evacuation analysis is carried out in accordance with Chapter 2 of the Guidelines and which meet the performance criteria specified in 1.6 of the Guidelines may be assigned the class notation "EVA" ; Ships for which advanced evacuation analysis is carried out in accordance with Chapter 3 of the Guidelines and which meet the performance criteria specified in 1.6 of the Guidelines may be assigned the class notation "EVA (Adv)".

1.4 Scenarios to be considered

1.4.1 As a minimum, four benchmark scenarios are to be considered for the evacuation analysis as follows:

(1) Case 1 (primary evacuation case, night) and case 2 (primary evacuation case, day) specified in chapter 13 of the FSS Code.

(2) Case 3 (secondary evacuation cases, night) and case 4 (secondary evacuation cases, day). In these cases only the main vertical zone, which generates the longest individual assembly duration, is further investigated. These cases utilize the same population demographics as the primary evacuation cases. The following are two alternatives that are to be considered for both cases 3 and 4. For ro-ro passenger ships, alternative 1 is to be the preferred option:

- ① Alternative 1: one complete run of the stairways having largest capacity previously used within the identified main vertical zone is considered unavailable for the simulation; or
- ② Alternative 2: 50% of the persons in one of the main vertical zones neighbouring the identified main vertical zone are forced to move into the zone and to proceed to the relevant assembly station. The neighbouring zone with the largest population is to be selected.

1.4.2 The following additional scenarios may be considered as necessary:

(1) Case 5 (Open Deck): If an open deck is outfitted for use by passengers and its gross deck surface area is larger than 400 m² or accommodates more than 200 persons, the additional day case is to be analysed: All persons are to be distributed as defined in the primary day case (case 2) considering the open deck as an additional public space with an initial density of 0.5 persons/m², calculated using the gross deck surface area.

(2) Case 6 (Embarkation): If separate embarkation and assembly stations are employed, an analysis of travel duration from assembly station to the entry point of LSA is to be taken into account in the process of determining embarkation and launching duration ($E+L$). All persons which the ship is certified to carry are initially distributed according to the designated capacities of the assembly stations. The persons will move to the entry point of LSA according to the operator's procedures and designated routes. The time for boarding the LSA is determined during LSA prototype test and thus need not be addressed in detail in the simulation. However, congestion directly in front of the LSA is to be considered as part of the simulation.

1.4.3 If the total number of persons on board calculated, as indicated in the above cases, exceeds the maximum number of persons the ship will be certified to carry, the initial distribution of people is to be scaled down so that the total number of persons is equal to what the ship will be certified to carry.

1.4.4 If detailed data considering the personnel distribution on board is available, evacuation analysis may be carried out based on the data.

1.5 Common assumptions

1.5.1 This method of estimating the evacuation duration in the Guidelines is based on the following assumptions:

- (1) Passengers and crew will evacuate via the main escape route towards their assigned assembly station, as referred to in SOLAS Reg.II-2/13;
- (2) Passenger load and initial distribution are based on chapter 13 of the FSS Code;
- (3) Full availability of escape arrangements is considered, unless otherwise stated;
- (4) Assisting crew will immediately be at the evacuation duty locations ready to assist the passengers;
- (5) Smoke, heat and toxic fire products are not considered to impact passenger and crew performance;
- (6) Family group behaviour is not considered;
- (7) Ship motion, heel, and trim are not considered; and
- (8) Impact of personnel movement and language barriers are not considered.

1.6 Performance standards

1.6.1 The following performance standards, as illustrated in Figure 1.6.1, are to be complied with:

- (1) Calculated total evacuation duration:

$$1.25 (R + T) + 2/3 (E + L) \leq n \quad (1.6.1-1)$$

where: for ro-ro passenger ships, $n = 60$; for passenger ships other than ro-ro passenger ships, $n = 60$ if the ship has no more than three main vertical zones; and 80, if the ship has more than three main vertical zones.

- (2) The embarkation and launching duration:

$$E + L \leq 30 \text{ min} \quad (1.6.1-2)$$

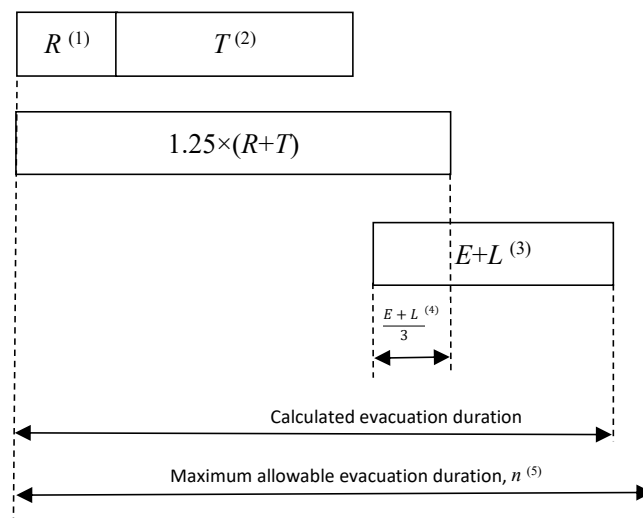


Figure 1.6.1 Schematic diagram of evacuation analysis performance standards

Notes: (1) According to detailed specification of analysis method;

(2) Calculated as per Chapter 2 or Chapter 3 of the Guidelines;

(3) Maximum 30 min in compliance with SOLAS Reg.III/21.1.3;

(4) Overlap duration = $(E+L)/3$;

(5) Values of n (min) provided in (1.6.1-1).

1.6.2 $E + L$ is to be calculated separately based upon:

(1) Results of full scale trials on similar ships and evacuation systems;

(2) Results of a simulation based embarkation analysis; or

(3) Data provided by the manufacturers. However, in this case, the method of calculation is to be documented, including the value of correction factor used.

1.6.3 For cases where neither of the three methods specified in 1.6.2 can be used, $(E+L)$ is to be assumed equal to 30 min.

1.6.4 The embarkation and launching duration $(E+L)$ is to be clearly documented in the relevant shipboard documents, in case of change of LSA in the subsequent operation of ships, e.g. the list of operational limitations required by SOLAS regulation V/30, passenger ship safety certificate or LSA arrangement plan.

1.7 Plans and information

1.7.1 For ships for which evacuation analysis needs to be carried out in accordance with IMO conventions or regulations of the Administration, or which apply for the class notations in 1.3 of this Chapter, the evacuation arrangement plan is to be submitted to CCS for approval and the evacuation analysis calculations are to be submitted to CCS for information.

1.7.2 Plans related to evacuation analysis serve as reference by plan approval, including but not limited to :

(1) Arrangement of escape routes (including calculation of staircase width);

(2) General arrangement;

(3) Layout of steel doors for the global ship;

(4) Layout of fire doors for the global ship;

(5) Layout of lifeboats and rafts;

(6) Layout of outdoor stairs;

(7) Layout of indoor stairs.

1.7.3 The evacuation analysis calculations are to include:

(1) Basic assumptions for the analysis;

(2) Schematic representation of the layout of the zones subjected to the analysis;

(3) Initial distribution of persons for each considered scenario;

(4) Details of the calculations;

(5) Total evacuation duration;

(6) Identified congestion points; and

(7) Identified areas of counter and crossing flows (if any).

Chapter 2 Simplified Evacuation Analysis and Calculation

2.1 Common assumptions

2.1.1 The calculation method for simplified evacuation analysis is generally assumed as follows:

- (1) All passengers and crew will begin evacuation at the same time and will not hinder each other;
- (2) Initial walking speed depends on the density of persons, assuming that the flow is only in the direction of the escape route, and that there is no overtaking;
- (3) People can move unhindered;
- (4) Counterflow is accounted for by a counterflow correction factor; and
- (5) Simplifications are accounted for in a correction factor and a safety factor. The safety factor has a value of 1.25.

2.2 Calculation of the evacuation duration

2.2.1 The following components are to be considered:

- (1) Response duration (R) is to be 10 min for the night time scenarios and 5 min for the day time scenarios;
- (2) Method to calculate the travel duration (T) is given in 2.4 of this Chapter; and
- (3) Embarkation and launching duration ($E+L$) is given in 1.6.2 of the Guidelines.

2.3 Identification of congestion

2.3.1 Congestion is identified by the following criteria:

- (1) Initial density equal to, or greater than, 3.5 persons/m² ; and
- (2) The difference between inlet and outlet of calculated flows (F_C) is larger than 1.5 persons per second.

2.4 Method to calculate the travel duration (T)

2.4.1 Parameters for calculating the travel duration (T):

2.4.1.1 Clear width (W_c) is measured off the handrail(s) for corridors and stairways and the actual passage width of a door in its fully open position.

2.4.1.2 The initial density of persons (D) 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 and expressed in (p/m²).

2.4.1.3 Speed of persons (S): speed (in m/s) of persons along the escape route depends on the specific flow of persons (as defined in 2.4.1.4 of this Chapter) and on the type of escape facility. People speed values are given in Table 2.4.1(1) (initial speed) and Table 2.4.1(3) below (speed after transition point as a function of specific flow).

2.4.1.4 Specific flow of persons (F_s): the specific flow (p/m/s) is the number of escaping persons past a point in the escape route per unit time per unit of clear width W_c of the route involved. Values of F_s are given in Table 2.4.1(1) (initial F_s as a function of initial density) and Table 2.4.1(2) (maximum value) below.

Table 2.4.1(1)¹ Values of initial specific flow and initial speed as a function of density

Type of facility	Initial density D (p/m ²)	Initial specific flow F_s (p/m/s)	Initial speed of persons S (m/s)
Corridors	0	0	1.2
	0.5	0.65	1.2
	1.9	1.3	0.67
	3.2	0.65	0.20
	≥ 3.5	0.32	0.10

Table 2.4.1(2)¹ Values of maximum speed flow

Type of facility	Maximum specific flow F_s (p/m/s)
Stairs (down)	1.1
Stairs (up)	0.88
Corridors	1.3
Doorways	1.3

Table 2.4.1(3)¹ Values of specific flow and speed

Type of facility	Specific flow F_s (p/m/s)	Speed of persons S (m/s)
Stairs (down)	0	1.0
	0.54	1.0
	1.1	0.55
Stairs (up)	0	0.8
	0.43	0.8
	0.88	0.44
Corridors	0	1.2
	0.65	1.2
	1.3	0.67

2.4.1.5 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:

$$F_c = F_s W_c \quad (2.4.1.5)$$

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

$$t_F = N / F_c \quad (2.4.1.6)$$

2.4.1.7 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:

¹ Data derived from land-based stairs, corridors and doors in civil building and extracted from the publication *SFPE Fire Protection Engineering Handbook*, 2nd edition, NFPA 1995.

$$\Sigma F_c(in)i = \Sigma F_c(out)j \quad (2.4.1.7)$$

Where: $\Sigma F_c(in)i$ = calculated flow of route (i) arriving at transition point;

$\Sigma F_c(out)j$ = calculated flow of route (j) departing from transition point.

2.4.1.8 Travel duration T , correction factor and counterflow correction factor

Travel duration T expressed in seconds as given by:

$$T = (\gamma + \delta)t_l \quad (2.4.1.8)$$

Where: γ = the correction factor to be taken equal to 2.0 for cases 1 and 2 and 1.3 for cases 3 and 4;

δ = the counterflow correction factor to be taken equal to 0.3; and

t_l = the highest travel duration resulting from application of the calculation procedure outlined in 2.5 of this Chapter.

2.5 Procedure for calculating the travel duration in ideal conditions

2.5.1 To illustrate the procedure, the following notations are used:

(1) t_{stair} = stairway travel duration (s) of the escape route to the assembly station;

(2) t_{deck} = travel duration (s) to move from the farthest point of the escape route of a deck to the stairway; and

(3) $t_{assembly}$ = travel duration (s) to move from the end of the stairway to the entrance of the assigned assembly station.

2.5.2 For day and night scenarios, the travel duration is to be calculated respectively in accordance with the following basic steps:

2.5.2.1 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.

2.5.2.2 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 clear width. For public spaces, it is assumed that all persons simultaneously begin the evacuation at the exit door (the specific flow to be used in the calculations is the door's maximum specific flow); the number of evacuees using each door may be assumed proportional to the door clear width.

2.5.2.3 Calculation of the initial specific flows F_s , by linear interpolation from Table 2.4.1(1), as a function of the densities.

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

2.5.2.5 Once a transition point is reached; formula (2.4.1.7) 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 clear width. The outlet specific flow(s), F_s , is obtained as the outlet calculated flow(s) divided by the clear width(s); two possibilities exist:

(1) F_s does not exceed the maximum value of Table 2.4.1(2); the corresponding outlet speed (S) is then taken by linear interpolation from Table 2.4.1(3), as a function of the specific flow; or

(2) F_s exceeds the maximum value of Table 2.4.1(2) above; in this case, a queue will form at the transition point, F_s is the maximum of Table 2.4.1(2) and the corresponding outlet speed (S) is taken from Table 2.4.1(3).

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

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

2.5.2.8 Calculation of the travel duration 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 durations are to be summed up if the portions are used in series, otherwise the largest among them is to be adopted. This calculation is to 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} is to be taken as the largest among them. No t_{deck} is calculated for public spaces.

2.5.2.9 Calculation, for each stair flight, of its travel duration as the ratio of inclined stair flight length and speed. For each deck, the total stair travel duration, t_{stair} , is the sum of the travel durations of all stairs flights connecting the deck with the assembly station.

2.5.2.10 Calculation of the travel duration $t_{assembly}$ from the end of the stairway (at the assembly station deck) to the entrance of the assembly station. For each route, the travel duration is to be calculated as the ratio of travel length to speed; For each deck, the total $t_{assembly}$ is to be taken as the maximum value of all routes.

2.5.2.11 The overall duration to travel along an escape route to the assigned assembly station is:

$$t_I = t_F + t_{deck} + t_{stair} + t_{assembly} \quad (2.2.11)$$

2.5.2.12 Based on calculation results, corresponding congestion points are identified in accordance with 2.3.1 of this Chapter

2.5.2.13 Once the calculation is performed for all the escape routes in accordance with the above procedures, the highest t_I is to be selected for calculating the travel duration T using formula (2.4.1.8).

Chapter 3 Advanced Evacuation Analysis and Calculation

3.1 Common assumptions

3.1.1 The calculation method for advanced evacuation analysis is generally assumed as follows:

- (1) The passengers and crew are represented as unique individuals with specified individual abilities and response durations;
- (2) A safety factor having a value of 1.25 is introduced in the calculation to take account of model omissions, assumptions, and the limited number and nature of the benchmark scenarios considered.

3.2 Calculation of the evacuation duration

3.2.1 The following components are to be included in the calculation of the evacuation duration:

- (1) Response duration (R);
- (2) Travel duration (T); and
- (3) Embarkation and launching duration ($E+L$).

3.3 Identification of congestion

3.3.1 Congestion is to be identified in accordance with the following criteria:

- (1) Local population densities exceeding 4 p/m² for significant duration;
- (2) Any identified congestion region persisting for longer than 10% of the simulated total assembly duration (t_A), is considered to be significant.

3.4 Software verification

3.4.1 Advanced evacuation analysis software is to be approved, and the verification process is shown in Figure 3.4.1. For the specific requirements, refer to Appendix 1 of the Guidelines.

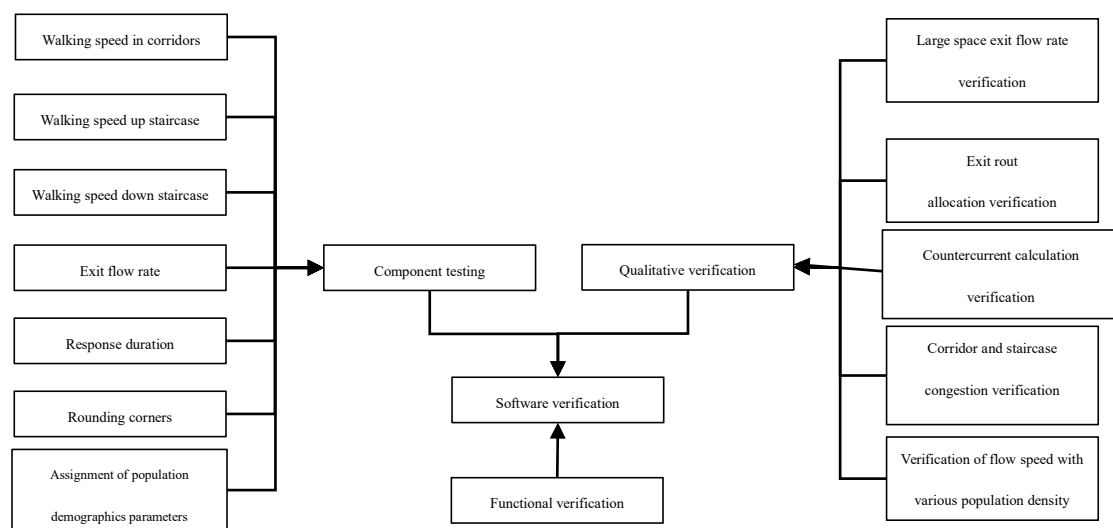


Figure 3.4.1 Advanced evacuation analysis software verification process

3.5 Calculation steps

3.5.1 The basic steps of advanced evacuation analysis are as follows:

- (1) Modeling;
- (2) Scenarios considered;
- (3) Calculation of travel duration;
- (4) Result analysis; and
- (5) Preparation of report.

3.6 Modeling

3.6.1 Modeling means the determination of parameters such as ship geometry modeling, population's composition, response duration, travel speed and exit flow rate through numerical simulation based on advanced evacuation analysis software.

3.6.2 Geometrical modeling

3.6.2.1 Geometrical modeling is to be carried out through advanced evacuation analysis software, using numerical simulation methods to establish personnel operation limits that are in line with the actual layout and size of the spaces and escape routes onboard ships. It provides a geometric model for the calculation scenarios required for advanced evacuation analysis, and endows different scenarios with similar evacuation guidance characteristics related to evacuation speed.

3.6.2.2 Escape routes of primary evacuation scenarios 1 and 2 are to be so arranged to assume that passengers and crew proceed along the primary escape routes to the assembly stations; to this effect, signage, low-location lighting, crew training and other relevant aspects connected with the evacuation system design and operation are to be assumed to be in compliance with the requirements set out in IMO instruments.

3.6.2.3 Secondary evacuation scenarios 3 and 4 are to be assumed that passengers and crew who were previously assigned to the now unavailable primary escape routes in scenarios 1 and 2 proceed along the escape routes determined by the ship designer.

3.6.2.4 In addition to the ship's actual situations, the initial passenger and crew distribution is to meet the provisions in Chapter 13 of the FSS Code.

3.6.3 Population's composition

3.6.3.1 The proportion of passengers with different ages, genders, and physical characteristics is to meet the requirements of Table 3.6.3.1 and remain unchanged in all scenario calculations.

Table 3.6.3.1 Population's composition (age and gender)

Population groups — passengers	Percentage of passengers (%)
Females younger than 30 years	7
Females 30-50 years old	7
Female older than 50 years	16
Female older than 50 — mobility impaired (1)	10
Female older than 50 — mobility impaired (2)	10
Males younger than 30 years	7
Males 30-50 years old	7

Males older than 50 years	16
Male older than 50 — mobility impaired (1)	10
Male older than 50 — mobility impaired (2)	10
Population groups — crew	Percentage of crew (%)
Crew females	50
Crew males	50

Note: All of the attributes associated with this population distribution are to consist of a statistical distribution within a fixed range of values. The range is specified between a minimum and maximum value with a uniform random distribution.

3.6.4 Response duration

3.6.4.1 The response duration for the various scenarios are to be truncated logarithmic normal distributions² as follows:

For Cases 1 and 3 (night cases):

$$y = \frac{1.01875}{\sqrt{2\pi}0.84(x-400)} \exp\left[-\frac{(\ln(x-400)-3.95)^2}{2 \times 0.84^2}\right] \quad (3.6.4.1-1)$$

$$400 < x < 700$$

For Cases 2 and 4 (day cases):

$$y = \frac{1.00808}{\sqrt{2\pi}0.94x} \exp\left[-\frac{(\ln(x)-3.44)^2}{2 \times 0.94^2}\right] \quad (3.6.4.1-2)$$

$$0 < x < 300$$

Where x is the response duration in seconds and y is the probability density at response duration x.

3.6.5 Travel speeds

3.6.5.1 The maximum unhindered travel speeds on flat terrain (e.g. corridors): the male and female walk rates as a function of age³. These are distributed according to Figure 3.6.5.1(1) and represented by approximate piecewise functions shown in Table 3.6.5.1(1).

² "Recommendations on the Nature of the Passenger Response Time Distribution to be used in the MSC.1033 Assembly Time Analysis Based on Data Derived from Sea Trials", Galea, E. R., Deere, S., Sharp, G., Fillips, L., Lawrence, P., and Gwunne, S., The Transaction of The Royal Institution of Naval Architects, Part A – International Journal of Maritime Engineering ISSN 14798751.2007.

³ Ando K, Ota H, and Oki T, *Forecasting The Flow Of People*, Railway Research Review, (45), pp 8-14, 1988.

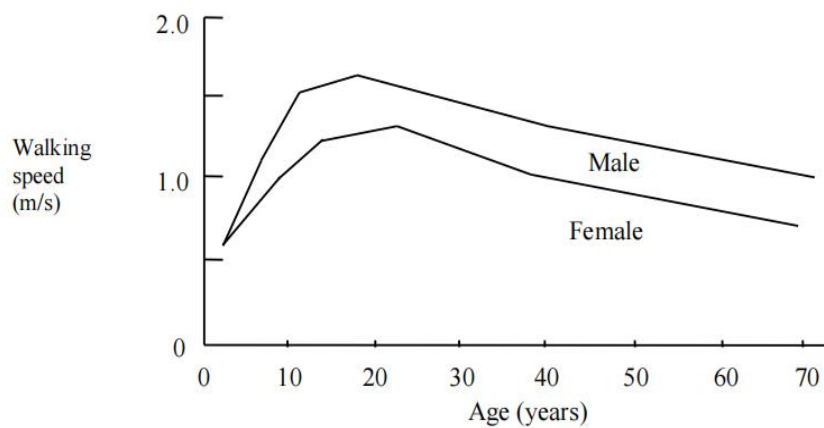


Figure 3.6.5.1 Walking speeds as a function of age and gender

Table 3.6.5.1(1) Regression formulation for mean travel speed values

Gender	Age (years)	Speed
Female	2—8.3	$0.06 \cdot \text{age} + 0.5$
	8.3—13.3	$0.04 \cdot \text{age} + 0.67$
	13.3—22.25	$0.02 \cdot \text{age} + 0.94$
	22.25—37.5	$-0.018 \cdot \text{age} + 1.78$
	37.5—70	$-0.01 \cdot \text{age} + 1.45$
Male	2—5	$0.16 \cdot \text{age} + 0.3$
	5—12.5	$0.06 \cdot \text{age} + 0.8$
	12.5—18.8	$0.008 \cdot \text{age} + 1.45$
	18.8—39.2	$-0.01 \cdot \text{age} + 1.78$
	39.2—70	$-0.009 \cdot \text{age} + 1.75$

For each gender group specified in Table 3.6.3.1, the walking speed is to be modelled as a statistical uniform distribution having minimum and maximum values as follows:

Table 3.6.5.1(2) Walking speed on flat terrain (e.g. corridors)

Population groups—passengers	Walking speed on flat terrain (e.g. corridors)	
	Minimum (m/s)	Maximum (m/s)
Females younger than 30 years	0.93	1.55
Females 30-50 years old	0.71	1.19
Female older than 50 years	0.56	0.94
Female older than 50 — mobility impaired (1)	0.43	0.71

Female older than 50 — mobility impaired (2)	0.37	0.61
Males younger than 30 years	1.11	1.85
Males 30-50 years old	0.97	1.62
Males older than 50 years	0.84	1.4
Male older than 50 — mobility impaired (1)	0.64	1.06
Male older than 50 — mobility impaired (2)	0.55	0.91
Population groups — crew	Walking speed on flat terrain (e.g. corridors)	
	Minimum (m/s)	Maximum (m/s)
Crew females	0.93	1.55
Crew males	1.11	1.85

3.6.5.2 Unhindered stair speeds⁴: speeds given on the base of gender, age and travel direction (up and down) on the unhindered stair are to meet the provisions of Table 3.6.5.2.

Table 3.6.5.2 Walking speed on stairs

Population groups — passengers	Walking speed on stairs (m/s)			
	Stairs down		Stairs up	
	Min.	Max.	Min.	Max.
Females younger than 30 years	0.56	0.94	0.47	0.79
Females 30-50 years old	0.49	0.81	0.44	0.74
Female older than 50 years	0.45	0.75	0.37	0.61
Female older than 50 — mobility impaired (1)	0.34	0.56	0.28	0.46
Female older than 50 — mobility impaired (2)	0.29	0.49	0.23	0.39
Males younger than 30 years	0.76	1.26	0.5	0.84
Males 30-50 years old	0.64	1.07	0.47	0.79

⁴ The maximum unhindered stair speeds are derived from data generated by J. Fruin. Pedestrian planning and design, Metropolitan Association of Urban Designers and Environmental Planners, New York, 1971. The study comprises two staircase configurations.

Males older than 50 years	0.5	0.84	0.38	0.64
Male older than 50 — mobility impaired (1)	0.38	0.64	0.29	0.49
Male older than 50 — mobility impaired (2)	0.33	0.55	0.25	0.41
Population groups — crew	Walking speed on stairs (m/s)			
	Stairs down		Stairs up	
	Min.	Max.	Min.	Max.
Crew females	0.56	0.94	0.47	0.79
Crew males	0.76	1.26	0.5	0.84

3.6.5.3 In the process of advanced evacuation analysis and calculation, the unhindered travel speeds of each evacuee on flat terrain and on stairs (down and up) are consistent within the respective ranges specified in Tables 3.6.5.1(2) and 3.6.5.2.

3.6.6 The exit flow rate (doors) is the number of escaping persons past a point in the escape route per unit time per unit width of the route involved, and is measured in number of persons (p). The exit flow rate⁵ is not to exceed 1.33 p/m/s.

3.7 Scenarios considered

3.7.1 When conducting the evacuation analysis, the initial distributions of passengers and crew are to be set in accordance with Chapter 13 of the FSS Code. The advanced evacuation analysis is to meet the provisions of 3.7.2 and 3.7.3 as below. If more detailed data considering the distribution of crew is available, the actual distribution data is to prevail.

3.7.2 Cases 1 and 3 (night): Passengers in cabins with maximum berthing capacity fully occupied; 2/3 of crew members in their cabins; of the remaining 1/3 of crew members:

- (1) 50% is to be initially located in service spaces;
- (2) 25% is to be located at their emergency stations, including but not limited to the bridge room, central control room, safety center, etc.;
- (3) 25% is to be initially located at the assembly stations and are to proceed towards the most distant passenger cabin assigned to that assembly station in counterflow with evacuees; once this passenger cabin is reached, these crew are no longer considered in the simulation. The ratio between the passenger and counterflow crew is to be the same in each main vertical zone.

3.7.3 Cases 2 and 4 (day): Public spaces, as defined by SOLAS Reg.II-2/3.39, are to be occupied to 75% of maximum capacity of the spaces by passengers. Crew is to be distributed as follows:

- (1) 1/3 of the crew is to be initially distributed in the crew accommodation spaces (cabins and crew day spaces);
- (2) 1/3 of the crew is to be initially distributed in the public spaces;
- (3) The remaining 1/3 is to be distributed as follows:

⁵ Value based on data accepted in civil building applications in Japan, the United Kingdom and the United States; this value is also consistent with the simplified evacuation analysis method.

- ① 50% is to be located in service spaces;
- ② 25% is to be located at their emergency duty locations, including but not limited to bridge room, central control room, safety center, etc.; and
- ③ 25% is to be initially located at the assembly stations and to proceed towards to the most distant passenger cabin assigned to that assembly station in counterflow with evacuees; once this passenger cabin is reached, these crew are no longer considered in the simulation. The ratio between the passenger and counterflow crew is to be the same in each main vertical zone.

3.8 Calculation of travel duration

3.8.1 The travel duration that predicted by models is a random quantity due to the probabilistic nature of the evacuation process.

3.8.2 In total, a minimum of 500 different simulations is to be carried out for each of the benchmark cases in 1.4.1 of the Guidelines. This will yield, for each case, a total of at least 500 values of t_A .

3.8.3 The 500 simulations above are to meet one of the following two conditions:

- (1) Including at least 100 different randomly generated populations (within the range of population demographics specified in 3.6.3.1 of this Chapter). Simulations based on each of these different populations are to be repeated at least 5 times, and these 5 repetitions produce insignificant variations in the results;
- (2) Including at least 500 different randomly generated populations (within the range of population demographics specified in 3.6.3.1 of this Chapter).

3.8.4 The minimum number of 500 different simulations can be reduced when a convergence is determined by an appropriate method, such as the one shown in Appendix 2 of the Guidelines. The total number of different simulations is to be in this case not less than 50.

3.8.5 The value of the travel duration for each of cases 1 to 4: the value t_I is taken which is higher than 95% of all the calculated values (i.e. for each of cases 1 to 4, the durations t_A are ranked from lowest to highest and t_I is selected for which 95% of the ranked values are lower).

3.8.6 The travel duration T is the highest of the four calculated travel durations t_I (one for each of cases 1 to 4).

3.8.7 The procedure for calculating the travel duration for additional scenarios is to be the same as for cases 1 to 4.

3.9 Result analysis

3.9.1 The calculation results are to be compared with the performance standards described in 1.6 of the Guidelines, mainly including:

- (1) Whether the total evacuation duration meet the performance standards specified in 1.6 of the Guidelines;
- (2) Identification of congestion locations as specified in 3.3 of this Chapter.

3.10 Preparation of calculation sheets

3.10.1 In addition to the requirements of 1.7.3, the advanced evacuation analysis calculation sheets are to including the following contents:

- (1) Assumptions other than 1.5 of the Guidelines;

- (2) A necessary explanation of the advanced evacuation analysis algorithm model, including:
- ① The variables used in the model to describe the dynamics, e.g.: walking speed and direction of each person;
 - ② The functional relation between the parameters and the variables;
 - ③ The type of update, e.g.. the order in which the persons move during the simulation (parallel, random sequential, ordered sequential or other);
 - ④ The representation of stairs, doors, assembly stations, embarkation stations, and other special geometrical elements and their influence on the variables during the simulation (if any) and the respective parameters quantifying the influence; and
 - ⑤ A detailed user guide/manual specifying the nature of the model and its assumptions and guidelines for the correct use of the model and interpretations of results are to be readily available.

Chapter 4 Evacuation Analysis in Specific Applications

4.1 General

4.1.1 In the ship design phase, based on benchmark scenarios, congestion points can be identified and confirmed through the evacuation analysis methods described in Chapter 2 or Chapter 3 of the Guidelines, and recommendations on improvement can be proposed to ensure that the design of escape routes and evacuation performance meet the requirements of conventions and codes.

4.1.2 In addition to the evaluation of the design of escape routes for passenger ships as specified in IMO MSC.1/Circ.1533, evacuation analysis is also generally used in other specific applications, such as personnel evacuation in alternative designs, personnel evacuation in emergency, and orderly evacuation during safe return to port. These evacuation analyses are based on specific scenarios, their performance standards, evacuation destinations, personnel distribution, etc. may be different from the relevant provisions of Chapters 1 to 3 of the Guidelines.

4.1.3 If the interested parties need to conduct evacuation analysis as described in 4.1.2 of this Chapter, they can refer to this Chapter for implementation. The relevant performance standards and evacuation plans are to be approved by CCS.

4.2 Evacuation analysis in alternative design

4.2.1 Common ship alternative designs, such as fire safety alternative design and life-saving appliance alternative design, are to require personnel evacuation analysis to evaluate whether the life safety goals of alternative designs can be achieved.

4.2.2 For the analysis of personnel evacuation in fire safety alternative design, its calculation scenario is to be based on the ship design status and risk identification, and the initial personnel distribution, availability of escape routes and availability of assembly stations are to be determined.

4.2.3 To ensure the safety of personnel on board the ship, the personnel evacuation analysis in alternative design of fire safety is intended to maintain an appropriate state of the escape routes, ensure that all personnel have sufficient time to evacuate to a safe area and are not threatened by instantaneous or accumulated fire hazards. In general, the required safe evacuation time (*RSET*) and available safe evacuation time (*ASET*) are used as parameters⁶ for its performance standard. If the equation (4.2.3) is satisfied, personnel evacuation is safe, otherwise it is unsafe:

$$RSET < ASET \quad (4.2.3)$$

RSET means the time required for safe evacuation from a location affected by fire or smoke. The maximum *RSET* for a fully evacuated location is to be calculated and determined by the advanced evacuation analysis method.

⁶ See IMO MSC.1/Circ.1552 “Amendments to the Guidelines on Alternative Design and Arrangements for Fire Safety” (MSC/Circ.1002) for the details.

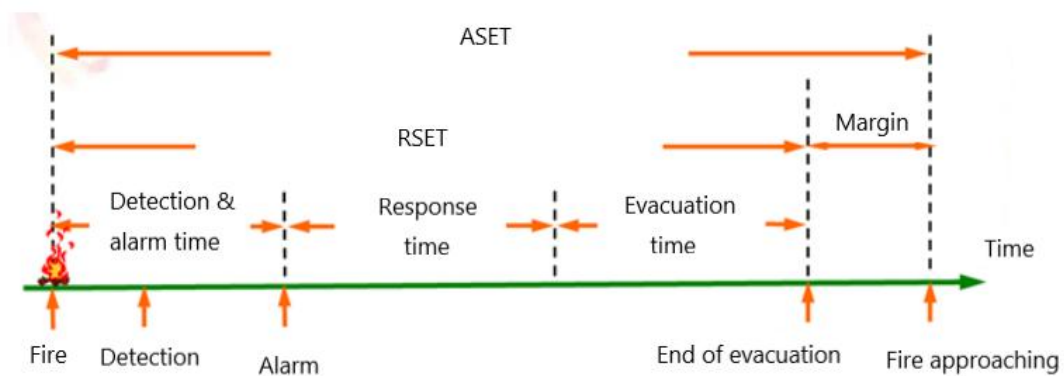


Figure 4.2.3 Schematic diagram of personnel evacuation safety

4.2.4 The personnel evacuation analysis in the alternative design of life-saving appliances is to be based on the ship design status and risk identification, determine the initial distribution of personnel, availability of escape routes, availability of assembly stations, availability of life-saving appliances, etc. If the use of alternative escape route or backup assembly station is involved, it is to be explained.

4.2.5 The personnel evacuation analysis in the alternative design of life-saving appliances is intended to ensure that the design of life-saving appliances, escape routes, assembly stations and evacuation procedures are reasonable, with sufficient safety protection and preventive measures, and to ensure the safe evacuation of personnel on board in emergency. The performance standards may refer to the requirements of 1.6 of the Guidelines.

4.3 Evacuation analysis in fire accidents

4.3.1 The calculation scenario for emergency personnel evacuation in a fire is to be based on the current situation at the time of the fire accident, and the time-domain calculation result of the fire scenario is to be imported, which may include high temperature, low visibility, and toxic gases (e.g. CO). The emergency personnel evacuation under the influence of fire hazard products is to be analysed so as to provide technical support for emergency response to fire accidents and the preparation of personnel evacuation plans.

4.4 Orderly evacuation during safe return to port

4.4.1 When a ship is implementing safe return to port, if the accident exceeds the limits specified in SOLAS Reg.II-1/8-1/2 or Reg.II-2/21/3, personnel on board the ship is to evacuate in order. The calculation scenarios are as follows:

- (1) Analyze the scenarios where each main vertical area, including the escape routes within it cannot be used due to fire/water ingress ;
- (2) Consider the scenarios in day and night separately;
- (3) Assume that the initial distribution of personnel on board the ship is to be concentrated within a safe area.

Chapter 5 Simplified Evacuation Analysis Cases

5.1 General

5.1.1 This Chapter provides a simplified evacuation analysis case only as an example and cannot be viewed as a comprehensive and complete analysis, nor as an indication of the data to be used.

5.2 Ship characteristics

5.2.1 The example is limited to two main vertical zones (MVZ 1 and MVZ 2) of a hypothetical cruise ship. For MVZ 1, a night scenario is considered, hereinafter called case 1 while a day scenario (case 2) is considered for MVZ 2.

5.2.2 In case 1, the initial distribution corresponds to a total of 449 persons located in the crew and passengers cabins as follows: 42 in deck 5; 65 in deck 6 (42 in the fore part and 23 in the aft part); 26 in deck 7; 110 in deck 9; 96 in deck 10; and 110 in deck 11. Deck 8 (assembly station) is empty.

5.2.3 In case 2, the initial distribution corresponds to a total of 1,138 persons located in the public spaces as follows: 469 in deck 6; 469 in deck 7; and 200 in deck 9. Deck 8 (assembly station) is empty.

5.3 Description of the system

5.3.1 Identification of assembly stations: For both MVZ 1 and MVZ 2, the assembly stations are located at deck 8, which is also the embarkation deck.

5.3.2 Identification of escape routes

5.3.2.1 In MVZ 1, the escape routes are as follows, see Figure 5.3.2.1:

(1) Deck 5 is connected with deck 6 (and then deck 7 where assembly stations are located) through one stair (stair A) in the fore part of the zone. Four corridors (corridors 1, 2, 3 and 4) and two doors (respectively door 1 and 2) connect the cabins with stair A. The clear widths and lengths are:

Item	W_c (clear width)(m)	Length (m)	Area (m ²)	Notes
MVZ1—deck 5—corridor 1	0.9	13	11.7	To door 1
MVZ1—deck 5— corridor 2	0.9	20	18	To door 1
MVZ1—deck 5—corridor 3	0.9	9.5	8.55	To door 2
MVZ1—deck 5—corridor 4	0.9	20	18	To door 1
MVZ1—deck 5—door 1	0.9	N.A.	N.A.	To stair A
MVZ1—deck 5—door 2	0.9	N.A.	N.A.	To stair A
MVZ1—deck 5—stair A	1.35	4.67	N.A.	Up to deck 6

(2) Deck 6 is connected with deck 7 (and then deck 8) through two stairs (stairs A and B respectively in the fore and aft part of the zone). Four corridors (corridors 1, 2, 3 and 4) and two doors (doors 1 and 2) connect the fore cabins with stair A; and two corridors (corridors 5 and 6) and two doors (doors 3 and 4) connect the aft cabins with stair B. The clear widths and lengths are:

Item	W_c (clear width)(m)	Length (m)	Area (m ²)	Notes
MVZ1—deck 6—corridor 1	0.9	13	11.7	To door 1
MVZ1—deck 6—corridor 2	0.9	20	18	To door 1
MVZ1—deck 6—corridor 3	0.9	9.5	8.55	To door 2
MVZ1—deck 6—corridor 4	0.9	20	18	To door 1
MVZ1—deck 6—door 1	0.9	N.A.	N.A.	To stair A
MVZ1—deck 6—door 2	0.9	N.A.	N.A.	To stair A
MVZ1—deck 6—stair A	1.35	4.67	N.A.	Up to deck 7
MVZ1—deck 6—corridor 5	0.9	13	11.7	To door 3
MVZ1—deck 6—corridor 6	0.9	20	18	To door 4
MVZ1—deck 6—door 3	0.9	N.A.	N.A.	To stair B
MVZ1—deck 6—door 4	0.9	N.A.	N.A.	To stair B
MVZ1—deck 6—stair B	1.35	4.67	N.A.	Up to deck 7

(3) Deck 7 is connected with deck 8 through stair C (stairs A and B coming from below stop at deck 7). Arrival of stairs A and B and deck 7 cabins are connected to stair C through 8 corridors, doors are neglected here in view of simplifying this example. The clear widths and lengths are:

Item	W_c (clear width)(m)	Length (m)	Area (m ²)	Notes
MVZ1—deck 7—corridor 1	0.9	6	5.4	To stair C
MVZ1—deck 7—corridor 2	0.9	9	8.1	To corridor 7
MVZ1—deck 7—corridor 3	0.9	15	13.5	To corridor 8
MVZ1—deck 7—corridor 4	0.9	6	5.4	To stair C
MVZ1—deck 7—corridor 5	0.9	14	12.6	To corridor 7
MVZ1—deck 7—corridor 6	0.9	15	13.5	To corridor 8
MVZ1—deck 7—corridor 7	2.4	11	26.4	To stair B
MVZ1—deck 7—corridor 8	2.4	9	21.6	From stair A to stair C
MVZ1—deck 7—stair C	1.40	4.67	N.A.	Up to deck 8

(4) Deck 11 is connected with deck 10 through a double stair (stair C) in the aft part of the zone. Two corridors (corridor 1 and 2) connect the cabins with stair C through two doors (respectively doors 1 and 2). The clear widths and lengths are:

Item	W_c (clear width) (m)	Length (m)	Area (m ²)	Notes
MVZ1—deck 11—corridor 1	0.9	36	32.4	To door 1
MVZ1—deck 11—corridor 2	0.9	36	32.4	To door 2
MVZ1—deck 11—door 1	0.9	N.A.	N.A.	To stair C
MVZ1—deck 11—door 2	0.9	N.A.	N.A.	To stair C
MVZ1—deck 11—stair C	2.8	4.67	N.A.	Down to deck 10

(5) Deck 10 has a similar arrangement as deck 11. The clear widths and lengths are:

Item	W_c (clear width) (m)	Length (m)	Area (m ²)	Notes
MVZ1—deck 10—corridor 1	0.9	36	32.4	To door 1
MVZ1—deck 10—corridor 2	0.9	36	32.4	To door 2
MVZ1—deck 10—door 1	0.9	N.A.	N.A.	To stair C
MVZ1—deck 10—door 2	0.9	N.A.	N.A.	To stair C
MVZ1—deck 10—stair C	2.8	4.67	N.A.	Down to deck 9

(6) Deck 9 has a similar arrangement as deck 11. The clear widths and lengths are:

Item	W_c (clear width) (m)	Length (m)	Area (m ²)	Notes
MVZ1—deck 9—corridor 1	0.9	36	32.4	To door 1
MVZ1—deck 9—corridor 2	0.9	36	32.4	To door 2
MVZ1—deck 9—door 1	0.9	N.A.	N.A.	To stair C
MVZ1—deck 9—door 2	0.9	N.A.	N.A.	To stair C
MVZ1—deck 9—stair C	2.8	4.67	N.A.	Down to deck 8

(7) Deck 8, people coming from decks 5, 6 and 7 (stair C) and from decks 11, 10 and 9 (stair C) enters the assembly station through paths 1 and 2. The clear widths and lengths are:

Item	W_c (clear width) (m)	Length (m)	Notes
MVZ1—deck 8—path 1	2.00	9.50	To assembly station
MVZ1—deck 8—path 2	2.50	7.50	To assembly station

5.3.2.2 In MVZ 2, the escape routes are as follows, see Figure 5.3.2.2:

(1) Deck 6 is connected with deck 7 (and then deck 8 where assembly stations are located) through two stairs (stair A and B respectively) in the fore part of the zone and through a double stair (stair C) in the aft part of the zone. Two doors (respectively door A and B) connect the public space with stairs A and B; and two doors (respectively door port side (PS) and door starboard side (SB)) connect the public space with stair C. The clear widths and lengths are:

Item	W_c (clear width) (m)	Length (m)	Notes
MVZ2—deck 6—door A	1	N.A.	
MVZ2—deck 6—door B	1	N.A.	
MVZ2—deck 6—door C PS	1.35	N.A.	
MVZ2—deck 6—door C SB	1.35	N.A.	
MVZ2—deck 6—stair A	1.4	4.67	Up to deck 7
MVZ2—deck 6—stair B	1.4	4.67	Up to deck 7
MVZ2—deck 6—stair C	3.2	4.67	Up to deck 7

(2) Deck 7 is connected with deck 8 through the same arrangements as deck 6 to deck 7. The clear widths and lengths are:

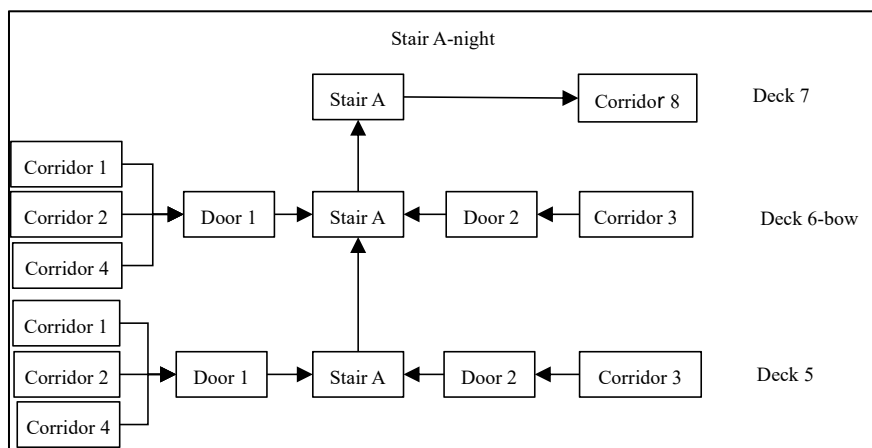
Item	W_c (clear width) (m)	Length (m)	Notes
MVZ2—deck 7—door A	1.7	N.A.	
MVZ2—deck 7—door B	1.7	N.A.	
MVZ2—deck 7—door C PS	0.9	N.A.	
MVZ2—deck 7—door C SB	0.9	N.A.	
MVZ2—deck 7—stair A	2.05	4.67	Up to deck 8
MVZ2—deck 7—stair B	2.05	4.67	Up to deck 8
MVZ2—deck 7—stair C	3.2	4.67	Up to deck 8

(3) Deck 9 is connected with deck 8 through a double stair (stair C) in the aft part of the zone. Two doors (respectively door PS and door SB) connect the public space with stair C. The clear widths and lengths are:

Item	W_c (clear width) (m)	Length (m)	Notes
MVZ2—deck 9—door PS	1	N.A.	
MVZ2—deck 9—door SB	1	N.A.	
MVZ2—deck 9—stair C	3.2	4.67	Down to deck 7

(4) Deck 8, people coming from decks 6 and 7 (stairs A and B) enter directly the embarkation station (open deck) through doors A and B, while people coming from deck 9 (stair C) enter the assembly station through paths 1 and 2. The clear widths and lengths are:

Item	W_c (clear width) (m)	Length (m)	Notes
MVZ2—deck 8—door A	2.05	N.A.	To embarkation station
MVZ2—deck 8—door B	2.05	N.A.	To embarkation station
MVZ2—deck 8—path 1	2	9.5	To assembly station
MVZ2—deck 8—path 2	2.5	7.5	To assembly station



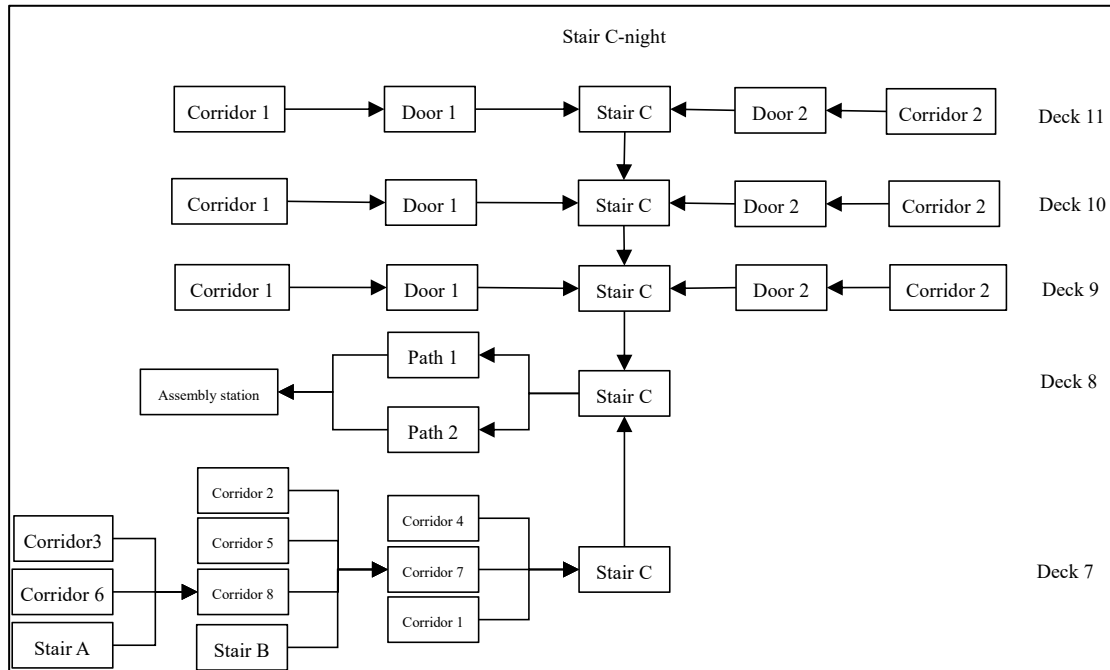
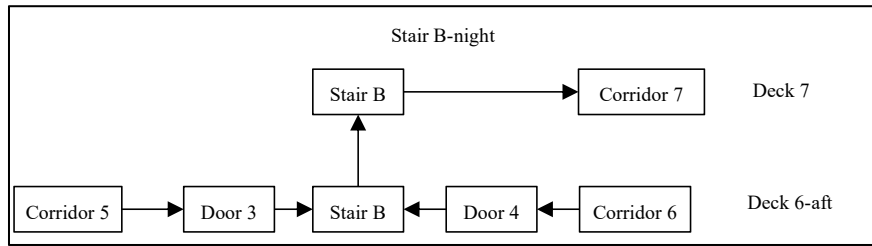
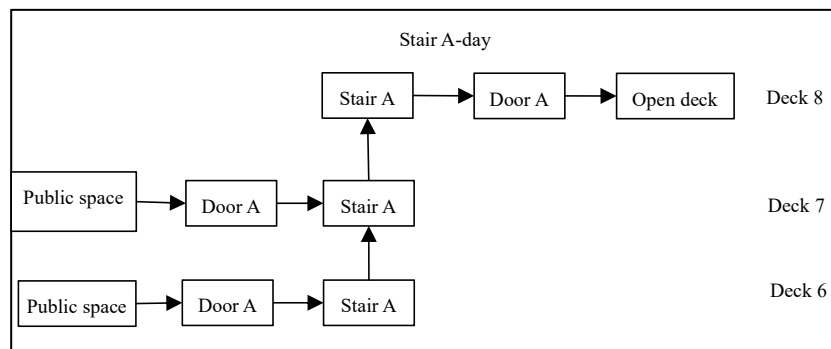


Figure 5.3.2.1 Case 1 (night) - hydraulic network schematisation



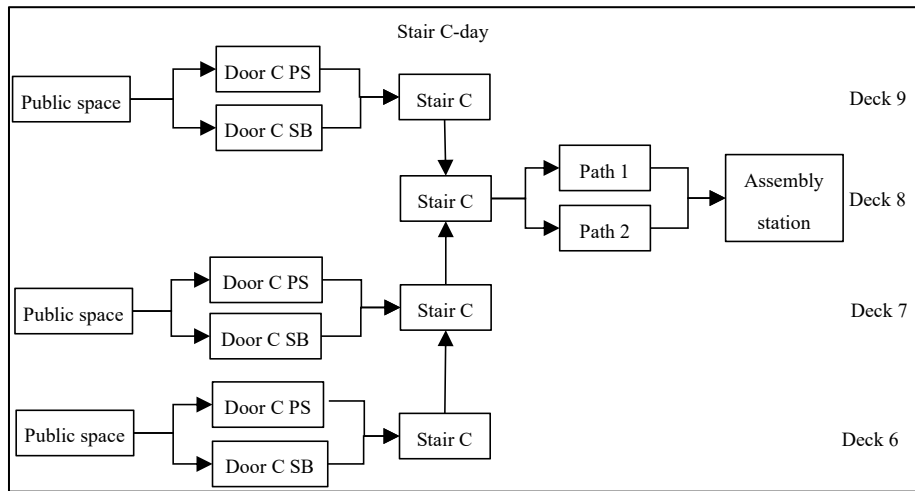
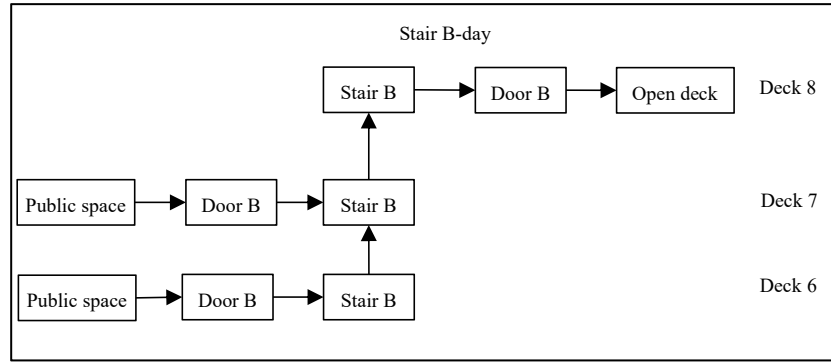


Figure 5.3.2.2 Case 2 (day) - hydraulic network schematisation

5.4 Scenarios considered

5.4.1 Case 1 refers to a day scenario in MVZ 1, according to chapter 13 of the FSS Code, the 449 persons are initially distributed as follows: 42 in deck 5; 65 in deck 6 (42 in the fore part and 23 in the aft part); 26 in deck 7; 110 in deck 9; 96 in deck 10; and 110 in deck 11. Deck 8 (assembly station) is empty. In accordance with 2.5.2, all persons in the cabins are assumed to simultaneously move into the corridors. The corresponding initial conditions are:

MVZ1—corridors	Persons	Initial density D (p/m ²)	Initial specific flow F_s (p/m/s)	Calculated flow F_c (p/s)	Initial speed of persons S (m/s)
Deck 5—corridor 1	11	0.94	0.85	0.77	1.03
Deck 5—corridor 2	12	0.67	0.73	0.65	1.14
Deck 5—corridor 3	8	0.94	0.85	0.77	1.04
Deck 5—corridor 4	11	0.61	0.7	0.63	1.16
Deck 6—corridor 1	11	0.94	0.85	0.77	1.03
Deck 6—corridor 2	12	0.67	0.73	0.65	1.14
Deck 6—corridor 3	8	0.94	0.85	0.77	1.04
Deck 6—corridor 4	11	0.61	0.7	0.63	1.16
Deck 6—corridor 5	11	0.94	0.85	0.77	1.03
Deck 6—corridor 6	12	0.67	0.73	0.65	1.14

Deck 7—corridor 1	4	0.74	0.76	0.69	1.11
Deck 7—corridor 2	4	0.49	0.64	0.58	1.2
Deck 7—corridor 3	6	0.44	0.58	0.52	1.2
Deck 7—corridor 4	4	0.74	0.76	0.69	1.11
Deck 7—corridor 5	6	0.48	0.62	0.56	1.2
Deck 7—corridor 6	2	0.15	0.19	0.17	1.2
Deck 7—corridor 7	0	0	N.A.	N.A.	N.A.
Deck 7—corridor 8	0	0	N.A.	N.A.	N.A.
Deck 11—corridor 1	55	1.7	1.21	1.09	0.75
Deck 11—corridor 2	55	1.7	1.21	1.09	0.75
Deck 10—corridor 1	48	1.48	1.11	1	0.83
Deck 10—corridor 2	48	1.48	1.11	1	0.83
Deck 9—corridor 1	55	1.7	1.21	1.09	0.74
Deck 9—corridor 2	55	1.7	1.21	1.09	0.74

MVZI—stairs, doors and corridors	Persons (N)		Specific flow F_s in (p/m/s)	Max. specific flow F_s (p/m/s)	Specific flow F_s (p/m/s)	Calculated flow F_c (p/s)	Speed of persons S (m/s)	Queue	Comments	Notes
	From current route	Total including those from other routes								
Deck 5—door 1	34	34	2.28	1.3	1.3	1.17	N.A.	Yes	From corridors 1, 2 and 4	1
Deck 5—door 2	8	8	0.85	1.3	0.85	0.77	N.A.		From corridor 3	1
Deck 5—stair A	42	42	1.43	0.88	0.88	1.188	0.44	Yes	From doors 1 and 2	1, 2
Deck 6—door 1	34	34	2.28	1.30	1.3	1.17	N.A.	Yes	From corridors 1, 2 and 4	1
Deck 6—door 2	8	8	0.85	1.30	0.85	0.77	N.A.		From corridor 3	1
Deck 6—stair A	42	84	2.32	0.88	0.88	1.188	0.44	Yes	From doors 1 and 2, From stair A	1, 2
Deck 6—door 3	11	11	0.85	1.30	0.85	0.77	N.A.		From corridor 5	1
Deck 6—door 4	12	12	0.73	1.30	0.73	0.65	N.A.		From corridor 6	1
Deck 6—stair B	23	23	1.05	0.88	0.88	1.188	0.44	Yes	From doors 3 and 4	1, 2
Deck 7—corridor 8	8	92	0.78	1.3	0.78	1.88	1.09		From corridors 3 and 6, From deck 6, stair A	1, 3
Deck 7—corridor 7	10	125	1.75	1.3	1.3	3.12	0.67	Yes	From corridors 2, 5 and 8, From deck 6, stair B	1, 4
Deck 7—stair C	8	133	3.21	0.88	0.88	1.232	0.44	Yes	From corridors 1, 4 and 7; Up to deck 8	1, 2, 5
Deck 11—door 1	55	55	1.21	1.3	1.21	1.09	N.A.		To stair C	1
Deck 11—door 2	55	55	1.21	1.3	1.21	1.09	N.A.		To stair C	1
Deck 11—stair C	110	110	0.78	1.1	0.78	2.17	0.81		Down to deck 10	1, 2
Deck 10—door 1	48	48	1.11	1.3	1.11	1	N.A.		To stair C	1

Deck 10—door 2	48	48	1.11	1.3	1.11	1	N.A.		To stair C	1
Deck 10—stair C	96	206	1.49	1.1	1.10	3.08	0.55	Yes	Down to deck 9	1, 2
Deck 9—door 1	55	55	1.21	1.3	1.21	1.09	N.A.		To stair C	1
Deck 9—door 2	55	55	1.21	1.3	1.21	1.09	N.A.		To stair C	1
Deck 9—stair C	110	316	1.88	1.1	1.10	3.08	0.55	Yes	Down to deck 8	1, 2
Deck 8—path 1	0	200	0.96	1.3	0.96	1.92	0.95		To assembly station	1, 6
Deck 8—path 2	0	249	0.96	1.3	0.96	2.4	0.95		To assembly station	1, 6

Notes:

1 The specific flow "Fs in" is the specific flow entering the element of the escape route; the maximum specific flow is the maximum allowable flow given in Table 2.4.1(2); the specific flow is the one applicable for the calculations i.e. the minimum between "Fs in" and the maximum allowable; when "Fs in" is greater than the maximum allowable, a queue is formed.

2 Some stairs are used by both persons coming from below (or above) and persons coming from the current deck considered; in making the calculation for a stair connecting deck N to deck N+1 (or deck N-1), the persons to be considered are those entering the stairs at deck N plus those coming from all decks below (or above) deck N.

3 At deck 7, 8 persons initially move from the cabins into corridor 8 and 84 persons arrive to corridor 8 from deck 6, stair A; the total is therefore 92 persons.

4 At deck 7, 10 persons initially move from the cabins into corridor 7, 23 persons arrive to corridor 7 from deck 6 stair B and 84 persons arrive to corridor 8 from deck 7, corridor 7; the total is, therefore, 117 persons.

5 At deck 7, 8 persons initially move from the cabins directly to the stair C and 125 persons arrive to stair C from corridor 8; the total is therefore 133 persons.

6 At deck 8 (assembly station), no persons are initially present; therefore, the escape routes on this deck are then used by the total number of persons arriving from above and/or below.

5.4.2 Case 2 refers to a day scenario in MVZ 2, according to chapter 13 of the FSS Code, the 1,138 persons are initially distributed as follows: 469 in deck 6; 469 in deck 7; and 200 in deck 9. Deck 8 (assembly station) is initially empty. In accordance with 2.5.2, all persons are assumed to simultaneously begin the evacuation and use the exit doors at their maximum specific flow. The corresponding initial conditions are:

MVZ2—corridors	Persons	Initial density D (p/m ²)	Initial specific flow F_s (p/m/s)	Calculated flow F_c (p/s)	Initial speed of persons S (m/s)
Deck 6—door A	100	N.A.	1.3	1.3	N.A.
Deck 6—door B	100	N.A.	1.3	1.3	N.A.
Deck 6—door C PS	134	N.A.	1.3	1.76	N.A.
Deck 6—door C SB	135	N.A.	1.3	1.76	N.A.
Deck 7—door A	170	N.A.	1.3	2.21	N.A.
Deck 7—door B	170	N.A.	1.3	2.21	N.A.
Deck 7—door C PS	65	N.A.	1.3	1.17	N.A.
Deck 7—door C SB	64	N.A.	1.3	1.17	N.A.
Deck 9—door C SB	100	N.A.	1.3	1.3	N.A.
Deck 9—door C PS	100	N.A.	1.3	1.3	N.A.

MVZ2—stairs	Persons (N)		Specific flow F_s in (p/m/s)	Max. specific flow F_s (p/m/s)	Specific flow F_s (p/m/s)	Calculated flow F_c (p/s)	Speed of persons S (m/s)	Queue	Comments	Notes
	From current route	Total including those from other routes								
Deck 6—stair A	100	100	0.93	0.88	0.88	1.23	0.44	Yes	Up to deck 7	1
Deck 6—stair B	100	100	0.93	0.88	0.88	1.23	0.44	Yes	Up to deck 7	1
Deck 6—stair C	269	269	1.1	0.88	0.88	2.82	0.44	Yes	Up to deck 7	1
Deck 7—stair A	170	270	1.68	0.88	0.88	1.8	0.44	Yes	Up to deck 8	1, 2
Deck 7—stair B	170	270	1.68	0.88	0.88	1.8	0.44	Yes	Up to deck 8	1, 2
Deck 7—stair C	129	398	1.61	0.88	0.88	2.82	0.44	Yes	Up to deck 8	1, 2
Deck 9—stair C	200	200	0.81	1.1	0.81	2.60	0.78		Up to deck 8	
Deck 8—path 1	0	266	1.2	1.3	1.2	2.41	0.75		From decks 7 and 9	1, 3
Deck 8—path 2	0	332	1.2	1.3	1.2	3.01	0.75		From decks 7 and 9	1, 3
Deck 8—door A	0	270	0.88	1.3	0.88	1.8	N.A.		From deck 7	1, 3
Deck 8—door B	0	270	0.88	1.3	0.88	1-8	N.A.		From 7	1, 3

Notes:

1 The specific flow "Fs in" is the specific flow entering the element of the escape route; the maximum specific flow is the maximum allowable flow given in Table 1.3 of Appendix 1 of the Guidelines; the specific flow is the one applicable for the calculations i.e. the minimum between "Fs in" and the maximum allowable; when "Fs in" is greater than the maximum allowable, a queue is formed.

2 Some stairs are used by both persons coming from below (or above) and persons coming from the current deck considered; in making the calculation for a stair connecting deck N to deck N+1 (or deck N-1), the persons to be considered are those entering the stairs at deck N plus those coming from all decks below (or above) deck N.

3 At deck 8 (assembly station), no persons are initially present; therefore, the escape routes on this deck are then used by the total number of persons arriving from above and/or below.

5.5 Calculation of T_F , t_{deck} and t_{stair}

5.5.1 For case 1:

Item	Persons N	Length L (m)	Calculated flow (p/s)	Speed S (m/s)	Flow duration t_F (s)	Deck or stair Duration t_{deck}, t_{stair}	Entering
					$t_F=N/F_c$	$T=L/S$	
Deck 5—corridor 1	11	13	0.77	1.03	14.3	12.6	Door 1
Deck 5—corridor 2	12	20	0.65	1.14	18.3	17.6	Door 1
Deck 5—corridor 3	8	9.5	0.77	1.04	10.4	9.2	Door 2
Deck 5—corridor 4	11	20	0.63	1.16	17.4	17.3	Door 1
Deck 5—door 1	34	N.A.	1.17	N.A.	29.1	N.A.	Stair A
Deck 5—door 2	8	N.A.	0.77	N.A.	10.4	N.A.	Stair A
Deck 5—stair A	42	4.67	1.188	0.44	35.4	10.6	Deck 6
Deck 6—corridor 1	11	13	0.77	1.03	14.3	12.6	Door 1
Deck 6—corridor 2	12	20	0.65	1.14	18.3	17.6	Door 1
Deck 6—corridor 3	8	9.5	0.77	1.04	10.4	9.2	Door 2
Deck 6—corridor 4	11	20	0.63	1.16	17.4	17.3	Door 1
Deck 6—door 1	34	N.A.	1.17	N.A.	29.1	N.A.	Stair A
Deck 6—door 2	8	N.A.	0.77	N.A.	10.4	N.A.	Stair A

Deck 6—stair A	84	4.67	1.188	0.44	70.7	10.6	Deck 7
Deck 6—corridor 5	11	13	0.77	1.03	14.3	12.6	Door 3
Deck 6—corridor 6	12	20	0.65	1.14	18.3	17.6	Door 4
Deck 6—door 3	11	N.A.	0.77	N.A.	14.3	N.A.	Stair B
Deck 6—door 4	12	N.A.	0.65	N.A.	18.3	N.A.	Stair B
Deck 6—stair B	23	4.67	1.188	0.44	19.4	10.6	Deck 7
Deck 7—corridor 1	4	6	0.69	1.11	5.8	5.4	Stair C
Deck 7—corridor 2	4	9	0.58	1.2	6.9	7.5	Corridor 7
Deck 7—corridor 3	6	15	0.52	1.2	11.5	12.5	Corridor 8
Deck 7—corridor 4	4	6	0.69	1.11	5.8	5.4	Stair C
Deck 7—corridor 5	6	14	0.56	1.2	10.8	11.7	Corridor 7
Deck 7—corridor 6	2	15	0.17	1.2	11.5	12.5	Corridor 8
Deck 7—corridor 8	92	9	1.88	1.09	48.9	8.2	Corridor 7
Deck 7—corridor 7	125	11	3.12	0.67	40.1	16.4	Stair C
Deck 7—stair C	133	4.67	1.232	0.44	108	10.6	Deck 8
Deck 11—corridor 1	55	36	1.09	0.75	50.7	48.2	Door 1
Deck 11—corridor 2	55	36	1.09	0.75	50.7	48.2	Door 2
Deck 11—door 1	55	N.A.	1.09	N.A.	50.7	N.A.	Stair C
Deck 11—door 2	55	N.A.	1.09	N.A.	50.7	N.A.	Stair C
Deck 11—stair C	110	4.67	2.17	0.81	50.7	5.8	Deck 10
Deck 10—corridor 1	48	36	1	0.83	48.2	43.5	Door 1
Deck 10—corridor 2	48	36	1	0.83	48.2	43.5	Door 2
Deck 10—door 1	48	N.A.	1	N.A.	48.2	N.A.	Stair C
Deck 10—door 2	48	N.A.	1	N.A.	48.2	N.A.	Stair C
Deck 10—stair C	206	4.67	3.08	0.55	66.9	8.5	Deck 9
Deck 9—corridor 1	55	36	1.09	0.74	50.7	48.4	Door 1
Deck 9—corridor 2	55	36	1.09	0.74	50.7	48.4	Door 2
Deck 9—door 1	55	N.A.	1.09	N.A.	50.7	N.A.	Stair C
Deck 9—door 2	55	N.A.	1.09	N.A.	50.7	N.A.	Stair C
Deck 9—stair C	316	4.67	3.08	0.55	102.6	8.5	Deck 8

5.5.2 For case 2: since in this particular arrangement there are no corridors, the deck duration is zero.

Item	Persons N	Length L (m)	Calculated flow (p/s)	Speed S (m/s)	Flow duration t_F (s)	Deck or stair Duration $t_{deck},$ t_{stair}	Entering
					$t_F = N / F_c$	$t = L / S$	
Deck 6—door A	100	N.A.	1.3	N.A.	76.9	N.A.	Stair A
Deck 6—door B	100	N.A.	1.3	N.A.	76.9	N.A.	Stair B
Deck 6—door C PS	134	N.A.	1.76	N.A.	76.4	N.A.	Stair C
Deck 6—door C SB	135	N.A.	1.76	N.A.	76.9	N.A.	Stair C
Deck 6—stair A	100	4.67	1.23	0.44	81.2	10.6	Deck 7
Deck 6—stair B	100	4.67	1.23	0.4-4	81.2	10.6	Deck 7
Deck 6—stair C	269	4.67	2.82	0.44	95.5	10.6	Deck 7
Deck 7—door A	170	N.A.	2.21	N.A.	76.9	N.A.	Stair A
Deck 7—door B	170	N.A.	2.21	N.A.	76.9	N.A.	Stair B
Deck 7—door C PS	65	N.A.	1.17	N.A.	55.6	N.A.	Stair C
Deck 7—door C SB	64	N.A.	1.17	N.A.	54.7	N.A.	Stair C
Deck 7—stair A	270	4.67	1.8	0.44	149.7	10.6	Deck 8
Deck 7—stair B	270	4.67	1.8	0.44	149.7	10.6	Deck 8

Deck 7—stair C	398	4.67	2.82	0.44	141.3	10.6	Deck 8
Deck 8—door A	270	N.A.	1.8	N.A.	149.7	N.A.	Embarkation
Deck 8—door B	270	N.A.	1.8	N.A.	149.7	N.A.	Embarkation
Deck 9—door PS	100	N.A.	1.3	N.A.	76.9	N.A.	Stair C
Deck 9—door SB	100	N.A.	1.3	N.A.	76.9	N.A.	Stair C
Deck 9—stair C	200	4.67	2.6	0.78	76.9	6	Deck 8

5.6 Calculation of $t_{assembly}$

5.6.1 Case 1: In this case, all the 429 persons use stair C (316 coming from above deck 8 and 133 from below) and, once arrived at deck 8, need to travel on deck 8 to reach the assembly station using either path 1 or path 2. The corresponding duration is as follows:

Item	Persons N	Length L (m)	Calculated flow (p/s)	Speed S(m/s)	Flow duration t_F (s)	$t_{assembly}$	Entering
					$t_F = N / F_c$	$t = L / S$	
Deck 8—path 1	200	9.5	1.92	0.95	104.4	10	Assembly station
Deck 8—path 2	249	7.5	2.4	0.95	103.9	7.9	Assembly station

5.6.2 Case 2: In this case, all the persons using stair C (totalling 598), once arrived at deck 8, need to travel through on deck 8 to reach the assembly station using either path 1 or path 2. The corresponding duration is as follows:

Item	Persons N	Length L (m)	Calculated flow (p/s)	Speed S(m/s)	Flow duration t_F (s)	$t_{assembly}$	Entering
					$t_F = N / F_c$	$t = L / S$	
Deck 8—path 1	266	9.5	2.41	0.75	110.5	12.7	Assembly station
Deck 8—path 2	332	7.5	3.01	0.75	110.3	10	Assembly station

5.7 Calculation of T

5.7.1 Case 1: According to 2.4, the travel duration $T = \text{maximum } t_I \text{ (equation 2.5.2.11)} \times 2.3$ (sum of correction factor and counterflow correction factor). The maximum values of t_I for each escape route are given in the following:

Escape route on	t_{deck}	t_f	t_{stair}	$t_{assembly}$	t_I	T	Notes
Deck 11	48.2	104.4	22.7	10	185.3	426.2	1
Deck 10	43.5	104.4	17	10	174.8	402	1, 2
Deck 9	48.4	104.4	8.5	10	171.3	394	1, 2
Deck 8	0	104.4	0	10	114.4	286.1	
Deck 7	37.1	108	10.6	10	163.9	377	1
Deck 6—stair A(fore)	42.4	108	21.2	10	179.6	413.1	1, 3
Deck 6—stair B(aft)	34	108	21.2	10	170.2	391.5	1, 3
Deck 5	42.2	108	31.8	10	192	441.6	1, 3

Notes:

1 The flow duration, t_f , is the maximum flow duration recorded on the whole escape route from the deck where persons started evacuating up to the assembly station.

2 The travel duration on the stairways (t_{stair}) is the total duration necessary to travel along all the stairs from the deck where persons originally started evacuating up to the deck where the assembly station is located; in the present case, t_{stair} for persons moving down from deck 11 is, therefore, the sum of t_{stair} from deck 11 to 10 (5.7 s), from deck 10 to 9 (8.5 s) and from deck 9 to 8 (8.5 s), in total 22.7 s; similarly for the other cases.

3 The travel duration on the stairways (t_{stair}) is the total duration necessary to travel along all the stairs from the deck where persons originally started evacuating up to the deck where the assembly station is located; in the present case, t_{stair} for persons moving up from deck 5 is, therefore, the sum of t_{stair} from deck 5 to 6 (10.6 s), from deck 6 to 7 (10.6 s) and from deck 7 to 8 (10.6 s), in total 31.8 s; similarly for the other cases.

Accordingly, the corresponding value of T is 441.6 s.

5.7.2 Case 2: According to 2.4, the travel duration $T = \text{maximum } t_I \text{ (equation 2.5.2.11)} \times 2.3$ (sum of correction factor and counterflow correction factor). The maximum values of t_I for each escape route are given in the following:

Escape route on	t_{deck}	t_f	t_{stair}	$t_{assembly}$	t_I	T	Notes
Deck 9	0	110.4	6	12.7	168.3	387.2	1, 2
Deck 8	0	110.4	0	12.7	162.4	373.4	
Deck 7—stair A	0	149.7	10.6	0	160.3	368.6	
Deck 7—stair B	0	149.7	10.6	0	160.3	368.6	
Deck 7—stair C	0	141.3	10.6	12.7	164.6	378.7	2
Deck 6—stair A	0	149.7	21.2	0	170.9	393	1, 3
Deck 6—stair B	0	149.7	21.2	0	170.9	393	1, 3
Deck 6—stair C	0	141.3	21.2	12.7	175.2	403.1	1, 2, 3

Notes:

1 The flow duration, t_f , is the maximum flow duration recorded on the whole escape route from the deck where persons started evacuating up to the assembly station.

2 In this example, stairs A and B are already leading to the embarkation station; therefore, only those escape routes passing through stair C need additional duration, $t_{assembly}$, to reach the assembly station.

3 The travel duration on the stairways (t_{stair}) is the total duration necessary to travel along all the stairs from the deck where persons originally started evacuating up to the deck where the assembly station is located; in the present case, t_{stair} for persons moving from deck 6 is therefore the sum of t_{stair} from deck 6 to 7 (10.6 s) and from deck 7 to 8 (10.6 s).

Accordingly, the corresponding value of T is 403.1 s

5.8 Identification of congestion

5.8.1 Case 1: Congestion takes place on deck 5 (door 1 and stair A), deck 6 (door 1, stairs A and B), deck 7 (corridor 7 and stair C), deck 10 (stair C) and deck 9 (stair C). However, since the total duration is below the limit (see 5.9.1 of this example), no design modifications are needed.

5.8.2 Case 2: Congestion takes place on deck 6 (stairs A, B and C) and deck 7 (stairs A, B and C). However, since the total duration is below the limit (see 5.9.2 of this example), no design modifications are needed.

5.9 Performance standards

5.9.1 Case 1: The total evacuation duration, according to 1.6.1 is as follows:

$$1.25(R+T) + 2/3 (E+L) = 1.25 \times (10' + 7'22'') + 20' = 41' 43'' \quad (5.9.1)$$

Where: $(E+L)$ is assumed to be 30'

$R = 10'$ (night case)

$T = 7' 22''$.

5.9.2 Case 2: The total evacuation duration, according to 1.6.1 is as follows:

$$1.25(R+T) + 2/3 (E+L) = 1.25 \times (5' + 6' 43'') + 20' = 34' 39'' \quad (5.9.2)$$

Where: $(E+L)$ is assumed to be 30'

$R = 5'$ (day case)

$T = 6' 43''$.

Chapter 6 Advanced Evacuation Analysis Cases

6.1 General

6.1.1 This Chapter provides an advanced evacuation analysis case only as an example and cannot be viewed as a comprehensive and complete analysis, nor as an indication of the data to be used.

6.2 New construction project

6.2.1 Open COMPASS-EVA software to establish a new calculation project for advanced evacuation analysis, set a location for saving the calculation documents, input the general design information of target ship, and select the corresponding calculation scene, as shown in Figures 6.2.1(1) and 6.2.1(2).

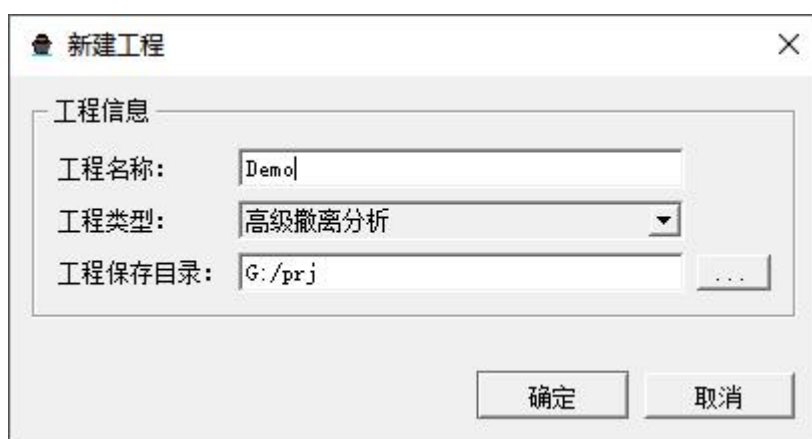


Figure 6.2.1(1) Interface for establishing a new project

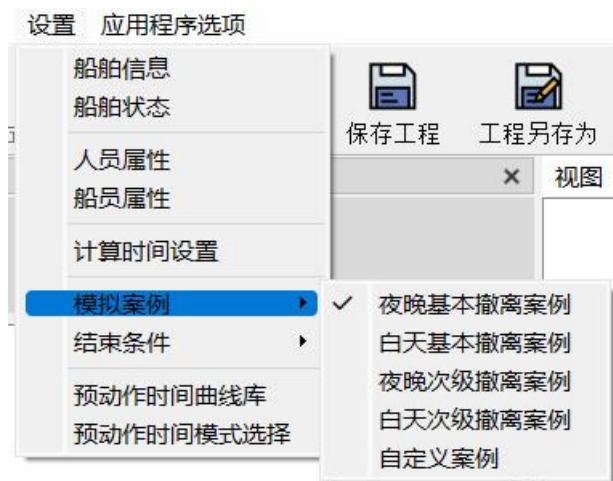


Figure 6.2.1(2) Select the corresponding calculation scene

6.3 Modeling

6.3.1 Geometric model. The layout for compartments on deck is to be created under the geometric model. In this case study, deck.fds document is to be imported to create a geometric model for each deck as shown in Figure 6.3.1.

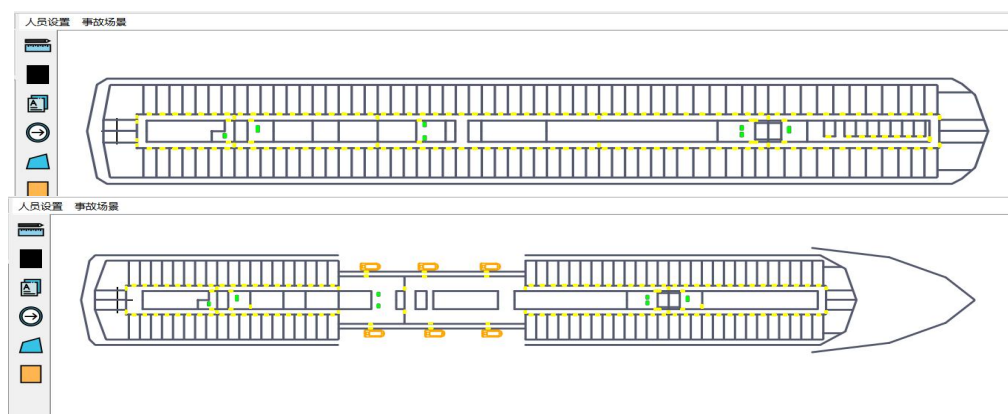


Figure 6.3.1 Geometric model for deck

6.3.2 Planning model. Planning model is the step after completion of geometric modeling for deck.

6.3.2.1 A passenger area and a crew area are to be established on deck 1 and deck 2 separately. The maximum number of people carried in No.7 function area on deck 1 is to be 30 people. Six lifeboats are to be added at both sides of the ship on deck 1. The default setting is to be used. The functional area 11 on deck 2 is to be set as the crew area, with a maximum number of 8 people.

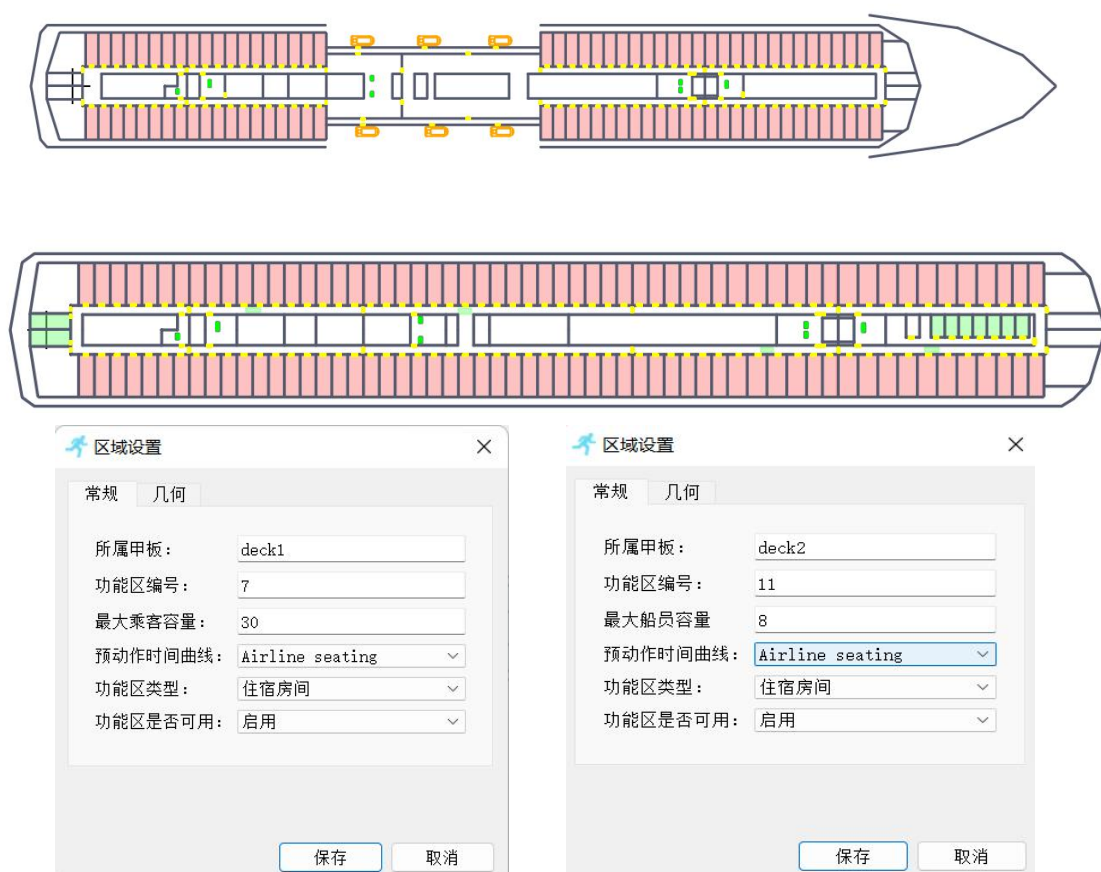


Figure 6.3.2.1 Area setting for deck 1 and deck 2

6.3.2.2 Staircase setting

(1) Select the type of staircase



Figure 6.3.2.2(1) Set the type of staircase

(2) Set the deck layer penetrating the staircase and its location



Figure 6.3.2.2(2) Set the location of staircase

(3) Set the property of staircase



Figure 6.3.2.2(3) Set the property of staircase

6.3.2.3 Set a target area for personnel evacuation.

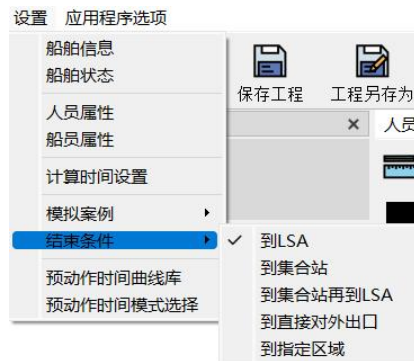


Figure 6.3.2.3 Set a target area for evacuation

6.3.2.4 Planning of evacuation route. The personnel evacuation routes in corresponding areas or spaces are to be set in accordance with the evacuation routes for personnel onboard the ship.

路径编辑

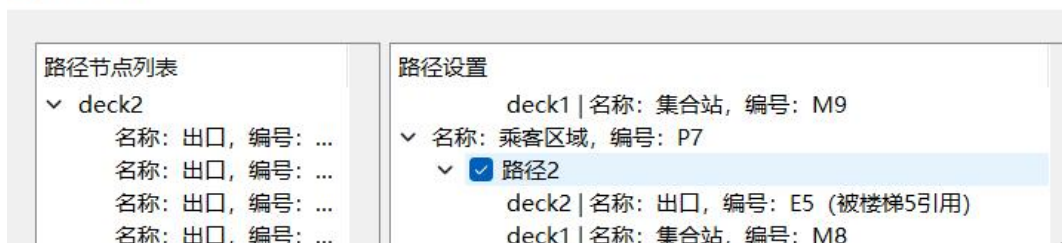


Figure 6.3.2.4 Set the evacuation route

6.3.3 Crowd model. Switch to the crowd model after completing the planning model.

6.3.3.1 Set the initial personnel distribution for corresponding areas on deck 1 and deck 2 to add passengers and crew.

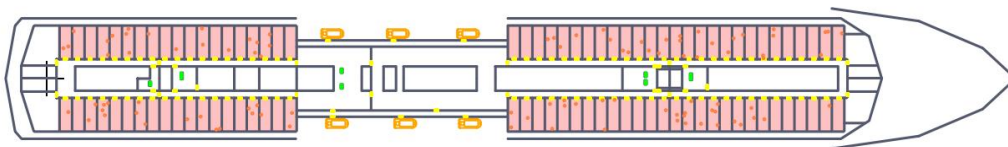


Figure 6.3.3.1(1) Initial personnel distribution on deck 1

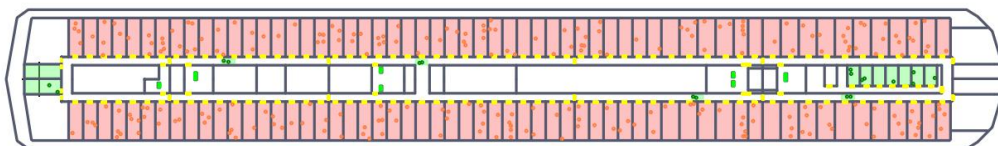


Figure 6.3.3.1(2) Initial personnel distribution on deck 2

6.3.3.2 Set the property of personnel including the response duration and age distribution.

6.3.4 Simulation model. Switch to the simulation model after setting the personnel property. Click the "Start" button to start simulation calculation and then the evacuation time is to change continuously and people are to move in the picture. After the simulation of evacuation, a report is to be generated and the calculation may be checked and saved.

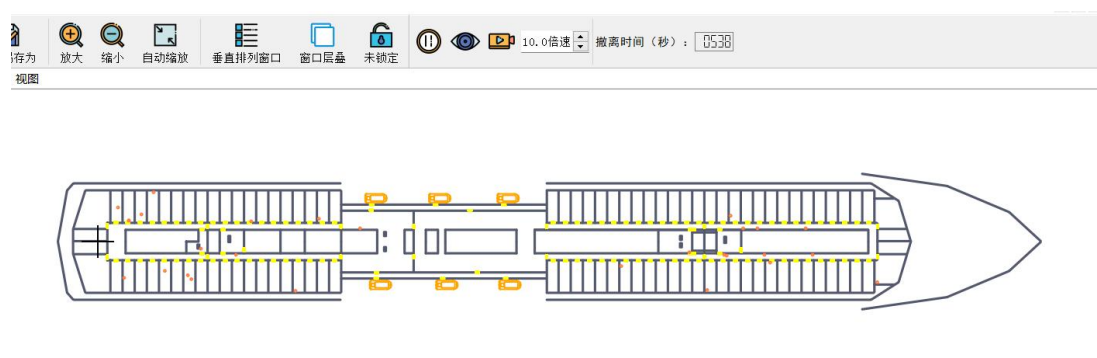


Figure 6.3.4 Process of simulation calculation

6.4 Calculation result output

6.4.1 Detailed calculation information is shown in the evacuation calculation book as shown in Figure 6.4.1.

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Figure 6.4.1 Contents on advanced evacuation analysis calculation sheet

6.4.2 Result analysis

6.4.2.1 Calculation results are to be given on whether the requirements of performance standard are complied with.

5 Calculation results
5.1 Performance standard
The maximum duration for evacuation on foot is 1039.5s.
The entire duration for evacuation is calculated as follows:
$1.25 \times (A+T) + (E+L) \times (2/3) = 1.25 \times 1039.5/60 + 0 \times (2/3) = 21.66(\text{min}) < 60(\text{min})$
This ship complies with the requirement.

Figure 6.4.2.1 Calculation results

6.4.2.2 Calculation results for personnel in specific areas concerned are to be given including pre-action time, evacuation duration and evacuation route.

5.2 Specific area concerned						
Staircase operation data						
Staircase No.	Staircase type	Staircase phase No.	No. of people passing through	Duration for the first person passing through	Duration for the last person passing through	Average rate of passing through (m/s)
Staircase 1	Staircase between layers	2	20	426.50	573.60	0.97
Staircase 1	Staircase between layers	3	48	430.70	661.50	0.90
Staircase 1	Staircase between layers	4	84	426.70	758.90	0.89
Staircase 1	Staircase between layers	5	106	430.50	810.30	0.90
Staircase 1	Staircase between layers	2	20	426.50	573.60	0.97
Staircase 1	Staircase between layers	3	48	430.70	661.50	0.90
Staircase 1	Staircase between layers	4	84	426.70	758.90	0.89

Figure 6.4.2.2 Calculation results for specific areas

6.4.2.3 Confirm the congestion point

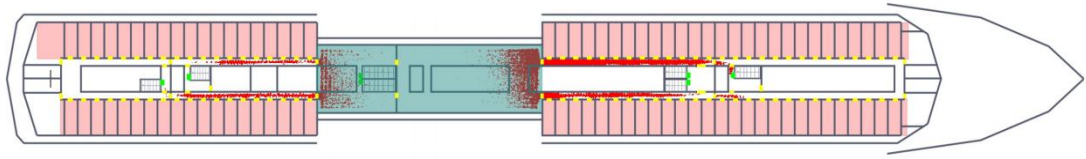


Figure 6.4.2.3 Diagram of congestion points

6.4.2.4 Other calculation results. Evacuation statistical charts for assembly stations and lifeboats concerned may be exported and the following figure is the evacuation statistical chart for one assembly station.

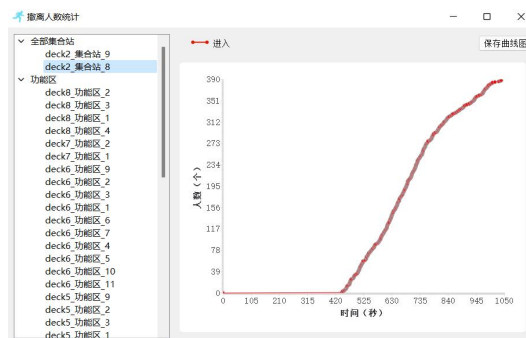


Figure 6.4.2.4 Number of personnel entering assembly station 8 measured by time

Appendix 1 Advanced Evacuation Analysis Software

Verification Requirements

1.1 Component testing

Component testing involves checking that the various components of the software perform as intended. This involves running the software through a battery of elementary test scenarios to ensure that the major sub-components of the model are functioning as intended. The following scenarios are mainly included:

- (1) Test 1- Maintaining set walking speed in corridor. One person in a corridor 2 m wide and 40 m long with a walking speed of 1 m/s is to be demonstrated to cover this distance in 40 s.
- (2) Test 2- Maintaining set walking speed up staircase. One person on a stair 2 m wide and a length of 10 m measured along the incline with a walking speed of 1 m/s is to be demonstrated to cover this distance in 10 s.
- (3) Test 3- Maintaining set walking speed down staircase. One person on a stair 2 m wide and a length of 10 m measured along the incline with a walking speed of 1 m/s is to be demonstrated to cover this distance in 10 s.
- (4) Test 4- Exit flow rate. 100 persons (p) in a room of size 8 m by 5 m with a 1 m exit located centrally on the 5 m wall. The flow rate over the entire period is not to exceed 1.33 p/s.
- (5) Test 5- Response duration. Ten persons in a room of size 8 m by 5 m with a 1 m exit located centrally on the 5 m wall. Impose response durations as follows uniformly distributed in the range between 10 s and 100 s. Verify that each occupant starts moving at the appropriate time.
- (6) Test 6- Rounding corners. Twenty persons approaching a left-hand corner (see figure 1.1.6) will successfully navigate around the corner without penetrating the boundaries.

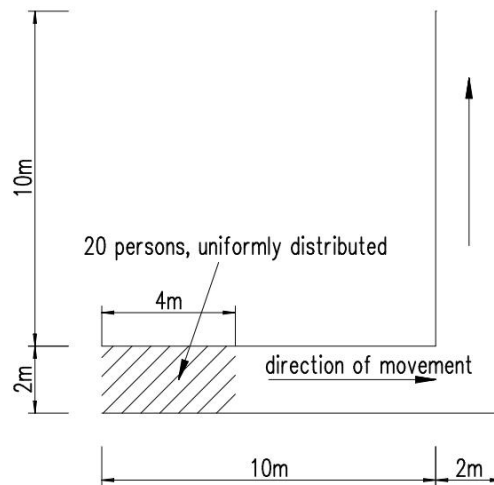


Figure 1.1.6 Transverse corridor

- (7) Test 7- Assignment of population demographics parameters. Choose a panel consisting of males 30-50 years old from table 3.6.5.1(2) and distribute the walking speeds over a population of 50 people. Show that the distributed walking speeds are consistent with the distribution specified in the table.

1.2 Qualitative verification

This form of model validation concerns the nature of predicted human behaviour with informed expectations and demonstrates that the behavioural capabilities built into the model are able to produce realistic behaviours. The following scenarios are mainly included:

- 1.2.1 Test 8: Counterflow – two rooms connected via a corridor. Two rooms 10 m wide and long connected via a corridor 10 m long and 2 m wide starting and ending at the centre of one side of each room. Choose a panel consisting of males 30-50 years old from table 3.6.5.1(2) with instant response time and distribute the walking speeds over a population of 100 persons.

(1) Step 1: One hundred persons move from room 1 to room 2, where the initial distribution is such that the space of room 1 is filled from the left with maximum possible density (see figure 1.2.1). The time the last person enters room 2 is recorded.

(2) Step 2: Step one is repeated with an additional ten, fifty, and one hundred persons in room 2. These persons are to have identical characteristics to those in room 1. Both rooms move off simultaneously and the duration for the last persons in room 1 to enter room 2 is recorded. The expected result is that the recorded duration increases with the number of persons in counterflow increases.

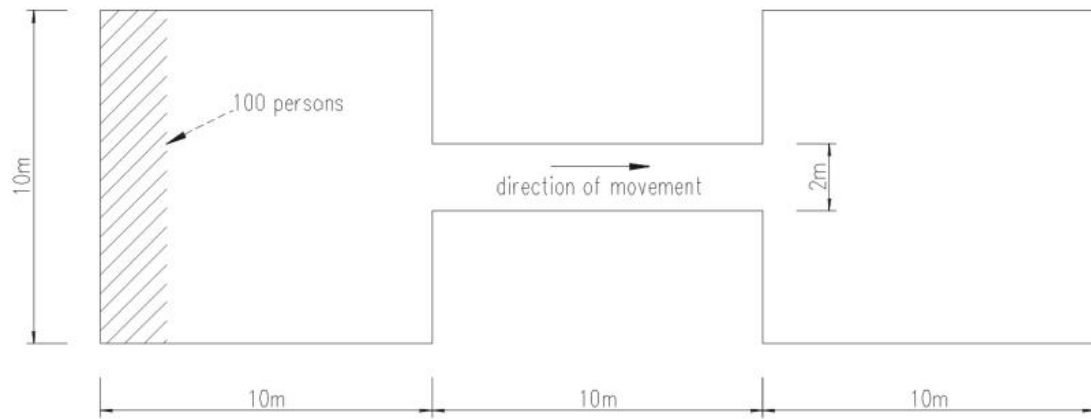


Figure 1.2.1 Two rooms connected via a corridor

1.2.2 Test 9- Exit flow: crowd dissipation from a large public room. Public room with four exits and 1,000 persons (see figure 1.2.2) uniformly distributed in the room. Persons leave via the nearest exits. Choose a panel consisting of males 30-50 years old from table 3.6.5.1(2) with instant response time and distribute the walking speeds over a population of 1,000 persons.

(1) Step 1: Record the amount of time the last person needs to leave the room.

(2) Step 2: Close doors 1 and 2 and repeat step 1.

The expected result is an approximate doubling of the duration to empty the room.

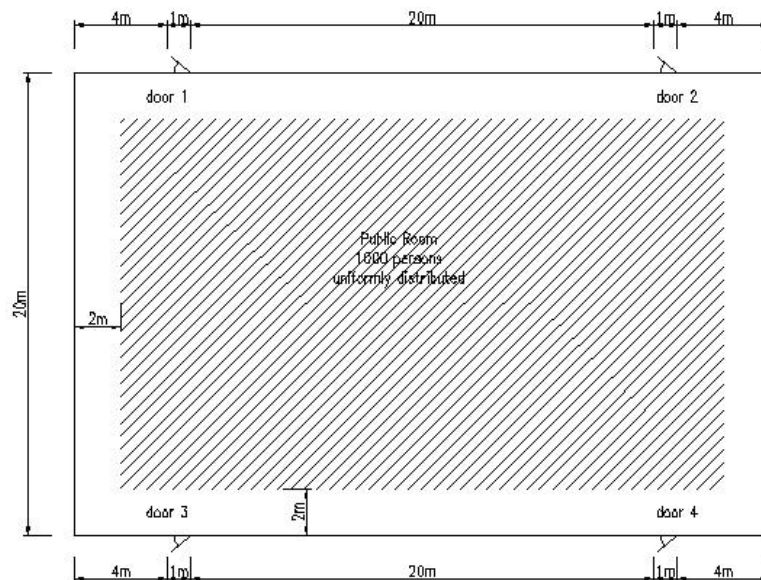


Figure 1.2.2 Exit flow from a large public room

1.2.3 Test 10: Exit route allocation. Construct a cabin corridor section as shown in figure 1.2.3 populated as indicated with a panel consisting of males 30-50 years old from table 3.6.5.1(2) with

instant response time and distribute the walking speeds over a population of 23 persons. The people in cabins 1, 2, 3, 4, 7, 8, 9, and 10 are allocated the main exit. All the remaining passengers are allocated the secondary exit. The expected result is that the allocated passengers move to the appropriate exits.

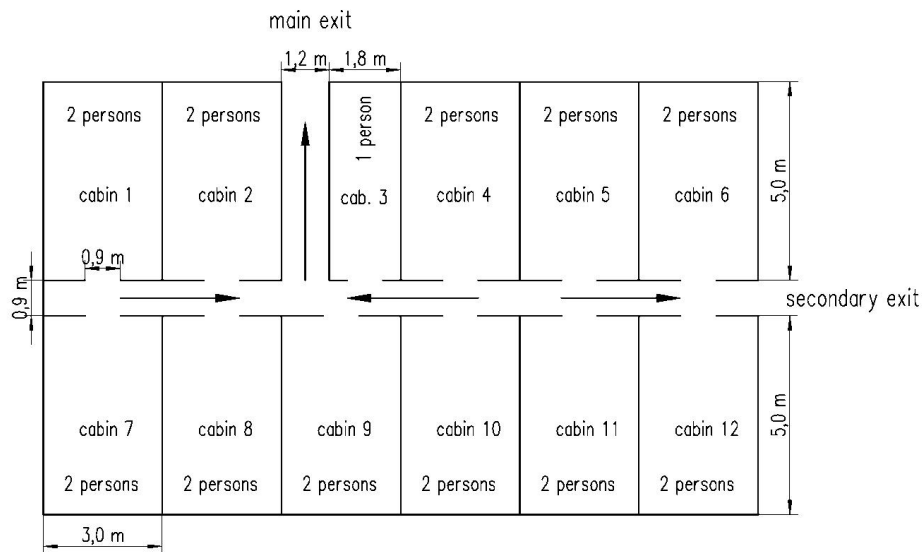


Figure 1.2.3 Cabin area

1.2.4 Test 11: Staircase. Construct a room connected to a stair via a corridor as shown in figure 1.2.4 populated as indicated with a panel consisting of males 30-50 years old from table 3.6.5.1(2) with instant response time and distribute the walking speeds over a population of 150 persons. The expected result is that congestion appears at the exit from the room, which produces a steady flow in the corridor with the formation of congestion at the base of the stairs.

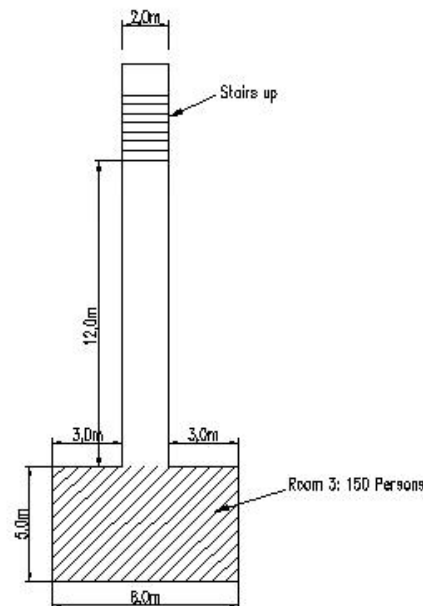


Figure 1.2.4 Escape route via stairs

1.2.5 Test 12: Flow density relation. The software is to be tested for a corridor without any obstructions. It is to be demonstrated that the flow of persons in the corridor is generally smaller at very high population densities compared with that at moderate densities.

1.3 Functional verification

Functional verification involves checking that the model possesses the ability to exhibit the range of capabilities required to perform the intended simulations. This requirement is task specific. To satisfy functional verification the model developers must set out in a comprehensible manner the complete range of model capabilities and inherent assumptions and give a guide to the correct use of these capabilities. This information is to be readily available in technical documentation that accompanies the software.

Appendix 2 Example of Convergence Criterion

The following process is given as an example of a convergence criterion mentioned in paragraph 3.8.4 of the Guidelines.

2.1 In total, a minimum of 50 different simulations are to be carried out for each of the benchmark cases. This will yield, for each case, a total of at least 50 values of tA . More than 50 simulations may be required according to the outcome of the convergence test (2.3 and 2.4 of this Appendix), which requires to increment the number of simulations one by one (see 2.3 of this Appendix) and to test the criterion every batch of 50 simulation runs (see 2.4 of this Appendix).

2.2 These simulations are to be made up of at least 10 different randomly generated populations (within the range of population demographics specified in paragraph 3.6.3.1 of the Guidelines). Simulations based on each of these different populations are to be repeated at least 5 times. If these 5 repetitions produce insignificant variations in the results, the total number of populations analysed is to be 50 rather than 10, with only a single simulation performed for each population.

2.3 Observed 95th centile of tA :

2.3.1 For each case, the evaluation of the 95th centile is an incremental evaluation which is performed every simulation run using all available tA previously calculated from the first to the last simulation run of the case studied.

2.3.2 The value of the 95th centile of all calculated total assembly times (noted $T_{0.95}$) is taken which is higher than 95% of all the previous calculated values (i.e. for each of the four cases, for each simulation run increment, indexed on letter "i" below, all available values of assembly times tA of the case are ranked from lowest to highest and $T_{0.95}^i$ is selected for which 95% of the ranked values are lower. Consequently, at the simulation number i, there is a series of i values of $T_{0.95}^i$).

2.4 Convergence criterion:

2.4.1 For each case, the convergence test is an evaluation of the following criterion which is performed every batch of 50 simulation runs. N denotes the number of simulations that have been run every time the criterion is tested (i.e. $N = 50$ for the first batch, $N = 100$ for the second batch etc.)

2.4.2 The distance between the maximum to the minimum of $T_{0.95}^i$ obtained over the 50 last simulation increments is not to exceed the distance (in absolute value) of the mean of $T_{0.95}^i$ over the 50 last simulation increments, to the maximum allowable assembly time (T_{lim}):

$$|T_{lim} - T_{0.95}^{mean50}| \geq T_{0.95}^{max50} - T_{0.95}^{min50}$$

Where:

$$T_{lim} = \frac{n - \frac{2}{3}(E+L)}{1.25} \text{ with } n, E, \text{ and } L, \text{ as defined in 1.6.1,}$$

$$T_{0.95}^{mean50} = mean(T_{0.95}^i), \text{ with } i \text{ between } (N - 49) \text{ and } N,$$

$$T_{0.95}^{max50} = maximum(T_{0.95}^i), \text{ with } i \text{ between } (N - 49) \text{ and } N, \text{ and}$$

$$T_{0.95}^{min50} = minimum(T_{0.95}^i), \text{ with } i \text{ between } (N - 49) \text{ and } N.$$

2.4.3 For each of the four cases, the following iterative method is to be followed to determine the travel Time T_{case} :

-- If the criterion is not met, another batch of 50 simulations is to be run;

-- If the criterion is met, sufficient number of simulations has been run for the case.

T_{95}^{mean50} (for the first N which satisfies the criterion) is selected as the travel time T_{case} ;

and

-- If a total of 500 simulations have been run for the case, the process is to be stopped and

T_{95}^{mean50} is selected as the travel time T_{case} .

2.5 The value of the travel time to comply with the performance standard T is the highest of the four calculated travel times T_{case} (one for each of the four cases).

2.6 The same procedure for a convergence criterion for case 5 and the travel duration in case 6 (travel duration from assembly stations to the LSA entry points) can be based on the same principle (paragraph 2.1 to 2.5 of this Appendix). For case 6, the procedure requires to adapt the notations (tA) and to take into account $(E+L) \leq 30'$ (see formula 1.6.1-2 of the Guidelines for the definition of T_{lim}).

Appendix 3 Introduction to COMPASS-EVA Software

3.1 Introduction of software

COMPASS-EVA is a passenger ship personnel evacuation analysis software developed by China Classification Society for various types of passenger ships (such as cruise ships and ro-ro passenger ships), maritime tourism and leisure platforms, special purpose ships carrying more than 240 persons, and other novel and complex vessels in compliance with the requirements of IMO MSC.1/Circ.1533 and involves two calculation functions: advanced evacuation analysis and simplified evacuation analysis. The calculation function and process of this software are shown in the following figure:

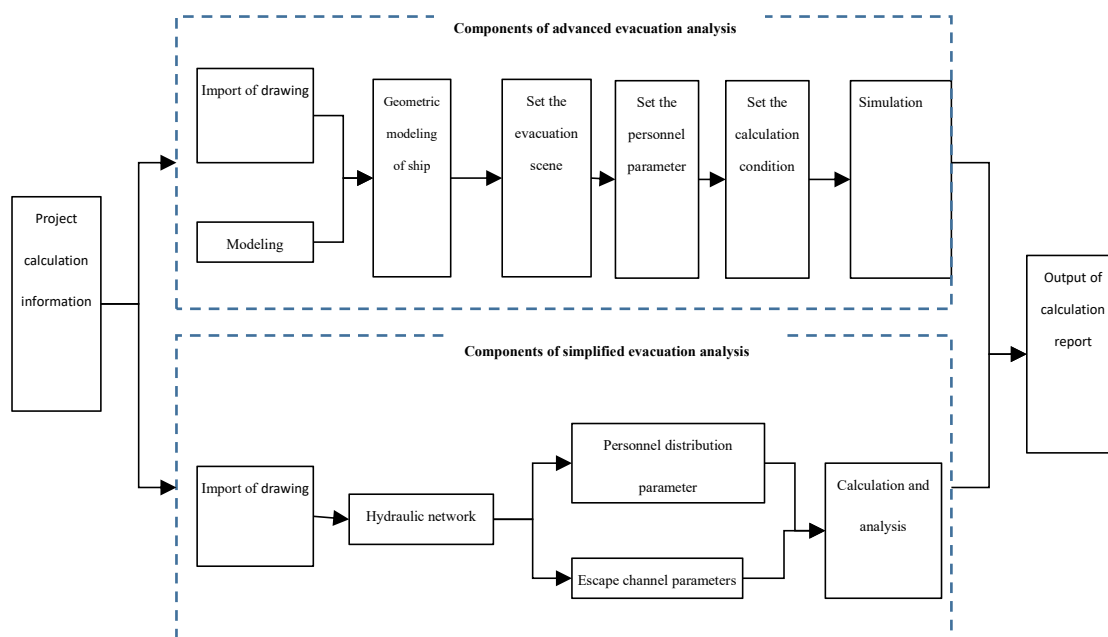


Figure 3.1 Diagram of COMPASS-EVA calculation function

This software may simulate the personnel evacuation in different evacuation scenarios of ships, so as to help designers obtain evacuation data, analyse data to identify inappropriate escape arrangements and congestion points, optimize evacuation routes, improve the design and layout of evacuation devices and enhance the safety of ship evacuation.

In addition, with expanded calculation functions, the software is capable to carry out evacuation analysis calculation for complex ship scenarios including the heel/trim condition under flooding accidents and fire accidents. For personnel evacuation analysis under fire accidents, the time domain calculation results under fire accident scene are imported, including high temperature, low visibility and toxic gas (e.g. CO) to analyze the impacts on personnel evacuation.

3.2 Advanced evacuation analysis

In the advanced evacuation analysis calculation module, software calculation operations mainly include the following parts:

(1) Geometric model: Modeling for ship compartment and escape route is to be carried out under

this model. The following modeling methods are provided by the software:

- ① Interactive drawing tools, including bulkhead, exit and gateway, are capable of drawing arrangements of compartments on each deck;
- ② .dxf document generated by importing CAD software;
- ③ .fds document generated by importing fire accident modeling software;
- ④ .deck document generated by importing this software.

(2) Planning model: This model applies to details in arranging personnel evacuation, including the arrangement of personnel area, assembly station, space, passage, staircase, life-saving equipment, key node and personnel escape route.

(3) Crowd model: Based on macro settings such as the age ratio and range of movement speed of the trapped individuals, this model randomly generates the age, initial position and movement speed of the trapped individuals, which are used as initial conditions for evacuation analysis and calculation. At the same time, simulation details may n be set, such as fire hazards.

(4) Simulation model: This model simulates the evacuation scene of passenger ships, providing a visual display of the evacuation process, including the movement of trapped individuals, display of temperature changes caused by fires, and ultimately output evacuation calculation reports and operation files for future reference.

3.3 Simplified evacuation analysis

In the simplified evacuation analysis calculation module, the following parts are mainly included:

(1) Drawing import: Import the deck model, the purpose of importing the model is to assist in establishing a hydraulic network model and generating reports, without directly participating in simplified calculations. Provide the following three drawing import methods:

- ① .dxf document generated by importing CAD software;
- ② .fds document generated by importing fire modeling software;
- ③ .deck document generated by importing this software.

(2) Create a hydraulic network diagram: used to establish a simplified model and set relevant parameters.

- ① Modeling: Simplify the four node types of starting point (corridor, door and staircase), conversion point (door and staircase), end point (assembly station) and connection used for evacuation calculation;
- ② Parameter setting: Modeling area setting (deck scope and main vertical zone), benchmark scenario settings (basic evacuation at night, secondary evacuation at night, basic evacuation in the daytime and secondary evacuation in the daytime) and node attribute settings.

(3) Calculation and simulation: including error detection and simplified calculation.

- ① Error detection:
 - (a) Check whether the initial values of all node settings are reasonable;
 - (b) Check whether there is any starting node;
 - (c) Check whether there is any error starting node and only corridor, staircase and door can be set as the starting node;
 - (d) Check whether there is any end node;
 - (e) Check whether the conversion node is reasonable;
 - (f) Check whether all nodes are connected to the end node;

- (g) Check whether the allocation of testing personnel is reasonable.
- ② Simplified calculation:
 - (a) Calculation of initial item;
 - (b) Calculation of transition item;
 - (c) Evacuation route and duration.
- (4) Output of calculation sheet: The calculation sheet covers ship's particulars, hydraulic network diagram, initial item, transition item, evacuation route, evacuation duration and congestion point to determine whether the target ship complies with the requirements of performance standards.