RULES

PUBLICATION 26/P

EVACUATION ANALYSIS ON PASSENGER SHIPS

March
2025

Publications P (Additional Rule Requirements) issued by Polski Rejestr Statków complete or extend the Rules and are mandatory where applicable.

GDAŃSK

Publication 26/P – Evacuation analysis on passenger ships – March 2025 is an extension of the requirements contained in *Part I – Classification Regulations of the Rules for the Classification and Construction of Sea-Going Ships*.

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This Publication also applies to other PRS regulations if it is mentioned there.

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Introduction

This *Publication* has been developed based on the information given in MSC.1/Circ.1533 and provides guidance on evacuation analysis.

The *Publication* is intended for the development of evacuation analysis for both new and existing passenger ships.

In the case of new ships, it is recommended that this guidance be used when conducting evacuation analysis at an early stage of the design process, in accordance with SOLAS regulation II-2/13.7.4.

The layout of the *Publication* corresponds to that of MSC.1/Circ.1533, which is treated as the source document.

PART 1

GUIDELINES ON EVACUATION ANALYSIS FOR NEW AND EXISTING PASSENGER SHIPS

Preamble

1 The following information is provided for consideration by, and guidance to, the users of these guidelines:

- **.1** To ensure uniformity of application, typical benchmark scenarios and relevant data are specified in the guidelines. Therefore, the aim of the analysis is to assess the performance of the ship with regard to the benchmark scenarios rather than simulating an actual emergency.
- **.2** Although the approach is, from a theoretical and mathematical point of view, sufficiently developed to deal with realistic simulations of evacuation on board ships, there is still a shortfall in the amount of verification data and practical experience on its application. As information becomes available from actual ship evacuation incidents, the figures, parameters, comparative scenarios and performance standards can be re-evaluated and used to improve the guidelines in the future.
- **.3** Almost all the data and parameters given in the guidelines are based on well-documented data coming from civil building experience. The data and results from ongoing research and development show the importance of such data for improving the interim guidelines. Nevertheless, the simulation of these benchmark scenarios are expected to improve ship design by identifying inadequate escape arrangements, congestion points and optimizing evacuation arrangements, thereby significantly enhancing safety.

2 For the above considerations, it is recommended that:

- **.1** the evacuation analysis be carried out as indicated in the guidelines, in particular using the scenarios and parameters provided;
- **.2** the objective should be to assess the evacuation process through benchmark cases rather than trying to model the evacuation in real emergency conditions;
- **.3** application of the guidelines to analyse actual events to the greatest extent possible, where passengers were called to assembly stations during a drill or where a passenger ship was actually evacuated under emergency conditions, would be beneficial in validating the guidelines;
- **.4** the aim of the evacuation analysis for existing passenger ships should be to identify congestion points and/or critical areas and to provide recommendations as to where these points and critical areas are located on board; and
- **.5** keeping in mind that it is the company's responsibility to ensure passenger and crew safety by means of operational measures, if the result of an analysis, conducted on an existing passenger ship shows that the maximum allowable evacuation duration has been

exceeded, then the company should ensure that suitable operational measures (e.g. updates of the onboard emergency procedures, improved signage, emergency preparedness of the crew, etc.) are implemented.

1 GENERAL

The purpose of this part of the guidelines is to present the methodology for conducting an evacuation analysis and, in particular, to:

.1 confirm that the performance standards set out in these guidelines can be met;
.2 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;
.3 demonstrate that escape arrangements are sufficiently flexible to provide for the possibility that certain escape routes, assembly stations, embarkation stations or survival craft may be unavailable as a result of a casualty;
.4 identify areas of intense counter and cross flows; and
.5 provide information gained by the evacuation analysis to the operators.

2 DEFINITIONS

For the purposes of this *Publication*, the following definitions apply:

2.1 ***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) (resolution MSC.98(73)).

2.2 ***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.

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

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

2.5 ***Total assembly duration (t_A)*** is the maximum individual assembly duration.

2.6 ***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.

2.7 ***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.

3 METHOD OF EVALUATION

The steps in the evacuation analysis are specified as below.

3.1 Description of the system

The description of the evacuation system should include:

.1 identification of passenger and crew assembly stations;
.2 identification of escape routes.

3.2 Common assumptions

This method of estimating the evacuation duration is based on several idealized benchmark scenarios and the following assumptions are made:

.1 passengers and crew will evacuate via the main escape route towards their assigned assembly station, as referred to in SOLAS regulation 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/crew performance;
.6 family group behaviour is not considered; and
.7 ship motion, heel, and trim are not considered.

4 SCENARIOS TO BE CONSIDERED

4.1 As a minimum, four scenarios (cases 1 to 4) should be considered for the analysis as follows. If more detailed data considering the crew distribution is available, it may be used.

.1 **case 1** (primary evacuation case, night) and **case 2** (primary evacuation case, day) in accordance with 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 should be considered for both cases 3 and 4. For ro-ro passenger ships, alternative 1 should 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 should be selected.

4.2 The following additional scenarios may be considered as appropriate:

.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 m^2 or accommodates more than 200 persons, the following, additional day case should 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/m^2, 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 should 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 should be considered as part of the simulation. These congestions need to be considered as blockage or obstacle for passenger and crew passing, i.e. generated with a LSA entry flow rate equal to the one observed during the LSA test.

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 should be scaled down so that the total number of persons is equal to what the ship will be certified to carry.

5 PERFORMANCE STANDARDS

5.1 The following performance standards, as illustrated in figure 5.1, should be complied with:

Calculated total evacuation duration:

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

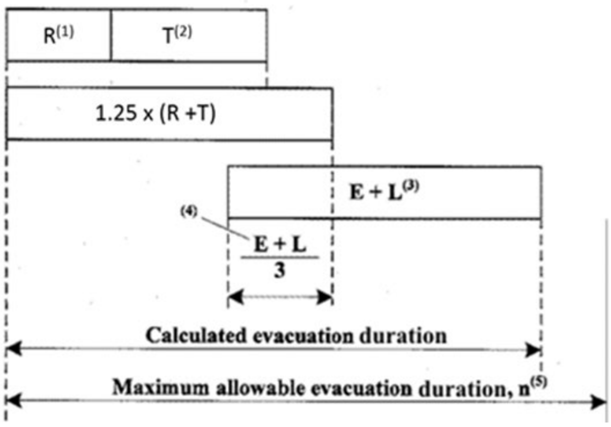
$$(E+L) \leq 30 \text{ min} \qquad (2)$$

5.2 In performance standard (1):

.1 for ro-ro passenger ships, n = 60; and

.2 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.

5.3 Performance standard (2) complies with SOLAS regulation III/21.1.3.



(1) according to detailed specification of analysis method
(2) calculated as in the annexes to these guidelines
(3) maximum 30 min in compliance with SOLAS regulation III/21.1.3
(4) overlap duration = 1/3 ($E+L$)
(5) values of n (min) provided in paragraph 5.2

Figure 5.1

5.4 $E + L$ should 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 should be documented, including the value of correction factor used.

The embarkation and launching duration ($E+L$) should be clearly documented to be available in case of change of LSA.

5.5 For cases where neither of the three above methods can be used, ($E+L$) should be assumed equal to 30 min.

6 DOCUMENTATION

The documentation of the analysis should report on the following items:

.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 methodology used for the analysis if different from these guidelines;
.5 details of the calculations;
.6 total evacuation duration;
.7 identified congestion points; and
.8 identified areas of counter and crossing flows.

7 CORRECTIVE ACTIONS

7.1 For new ships, if the total evacuation duration calculated is in excess of the allowed total evacuation duration, corrective actions should be considered at the design stage by suitably modifying the arrangements affecting the evacuation system in order to reach an acceptable total evacuation duration.

7.2 For existing ships, if the total evacuation duration calculated is in excess of the allowed total evacuation duration, onboard evacuation procedures should be reviewed with a view toward taking appropriate actions which would reduce congestion which may be experienced in locations as indicated by the analysis.

PART 2

GUIDELINES FOR A SIMPLIFIED EVACUATION ANALYSIS FOR NEW AND EXISTING PASSENGER SHIPS

1 SPECIFIC ASSUMPTIONS

This method of estimating evacuation duration 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 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 CALCULATION OF THE EVACUATION DURATION

The following components should be considered:

.1 response duration (R) should 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 appendix 1; and
.3 embarkation and launching duration (E+L).

3 IDENTIFICATION OF CONGESTION

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.

APPENDIX 1

METHOD TO CALCULATE THE TRAVEL DURATION (T)

1 PARAMETERS TO BE CONSIDERED

1.1 *Clear width (Wc)*

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

1.2 *Initial density of persons (D)*

The initial 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 and expressed in (p/m²).

1.3 *Speed of persons (S)*

The speed (m/s) of persons along the escape route depends on the specific flow of persons (as defined in paragraph 1.4) and on the type of escape facility. People speed values are given in tables 1.1 (initial speed) and 1.3 below (speed after transition point as a function of specific flow).

1.4 *Specific flow of persons (Fs)*

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 *Wc* of the route involved. Values of *Fs* are given, in tables 1.1 (initial *Fs* as a function of initial density) and 1.2 (maximum value) below.

Table 1.1[2)]
Values of initial specific flow and initial speed as a function of density

	Initial density *D* (p/m²)	(p/m/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 1.2[2)]
Value of maximum specific flow

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

Table 1.3[2)]
Values of specific flow and speed

Type of facility	Specific flow *Fs* (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) 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.

1.5 *Calculated flow of persons (Fc)*

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:

$$Fc = Fs\ Wc \tag{1.5}$$

1.6 *Flow duration (t_F)*

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

$$t_F = N/Fc \tag{1.6}$$

1.7 *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:

$$\Sigma\ Fc(in)i = \Sigma\ Fc(out)j \tag{1.7}$$

where:

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

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

1.8 *Travel duration T, correction factor and counterflow correction factor*

Travel duration *T* expressed in seconds as given by:

$$T = (\gamma + \delta\ )\ t_I \tag{1.8}$$

where:
γ = is the correction factor to be taken equal to 2 for cases 1 and 2 and 1.3 for cases 3 and 4;
δ = is the counterflow correction factor to be taken equal to 0.3; and
t_I = is the highest travel duration expressed in seconds in ideal conditions resulting from application of the calculation procedure outlined in paragraph 2 of this appendix.

2 PROCEDURE FOR CALCULATING THE TRAVEL DURATION IN IDEAL CONDITIONS

2.1 Symbols

To illustrate the procedure, the following notation is used:

t_{stair} = stairway travel duration(s) of the escape route to the assembly station
t_{deck} = travel duration (s) to move from the farthest point of the escape route of a deck to the stairway
$t_{assembly}$ = travel duration (s) to move from the end of the stairway to the entrance of the assigned assembly station

2.2 Quantification of flow duration

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 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.

.3 Calculation of the initial specific flows *Fs*, by linear interpolation from table 1.1, as a function of the densities.

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

.5 Once a transition point is reached; formula (1.7) is used to obtain the outlet calculated flow(s) *Fc*. In cases where two or more routes leave the transition point, it is assumed that the flow *Fc* of each route is proportional to its clear width. The outlet specific flow(s), *Fs*, is obtained as the outlet calculated flow(s) divided by the clear width(s); two possibilities exist:

  .1 *Fs* does not exceed the maximum value of table 1.2; the corresponding outlet speed (*S*) is then taken by linear interpolation from table 1.3, as a function of the specific flow; or

  .2 *Fs* exceeds the maximum value of table 1.2 above; in this case, a queue will form at the transition point, *Fs* is the maximum of table 1.2 and the corresponding outlet speed (*S*) is taken from table 1.3.

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

.7 Calculation, from *N* (number of persons entering a flight or corridor) and from the relevant Fc, 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.

.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 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. No t_{deck} is calculated for public spaces.

.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.

.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.

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

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

.12 The procedure should be repeated for both the day and night cases. This will result in two values (one for each case) of t_I for each main escape route leading to the assigned assembly station.

.13 Congestion points are identified as follows:

- **.1** in those spaces where the initial density is equal, or greater than, 3.5 persons/m^2; and
- **.2** in those locations where the difference between inlet and outlet calculated flows (Fc) is in more than 1.5 persons per second.

.14 Once the calculation is performed for all the escape routes, the highest t_I should be selected for calculating the travel duration T using formula (1.8).

APPENDIX 2

EXAMPLE OF GUIDELINES APPLICATION

An example illustrating the application of the guidelines for Case 1 (basic evacuation, night time) and Case 2 (basic evacuation, day time), for an evacuation analysis at an early stage of the design of a hypothetical new cruise ship, is given in Appendix 2 of MSC.1/Circ.1533.

It should be noted that at the time of development of this example, such requirements were not applicable to passenger ships other than ro-ro passenger ships. Therefore, this example should be considered as an illustration of the application of the guidelines only.

Description, evacuation scenarios, tables and figures, see Appendix 2 of Annex 2 of MSC.1/ Circ.1533.

PART 3

GUIDELINES FOR AN ADVANCED EVACUATION ANALYSIS OF NEW AND EXISTING PASSENGER SHIPS

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.

The principles for developing an advanced evacuation analysis are given in Appendices 1, 2 and 3 of Annex 3 of MSC.1/Circ.1533.
