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Preliminary study on the Interim Guidelines for evacuation analyses for new and existing passenger ships

Submitted by Japan

SUMMARY

Executive summary: This document provides the results of a preliminary study on the Interim Guidelines for evacuation analyses for new and existing passenger ships (MSC/Circ.1033)

Action to be taken: Paragraph 8

Related documents: MSC/Circ.1033, FP 46/16, MSC 75/24 and FP 47/7

Background

1 The Interim Guidelines for evacuation analyses for new and existing passenger ships was adopted by the Maritime Safety Committee, at its seventy-fifth session, and circulated as MSC/Circ.1033. The Sub-Committee, at its forty-sixth session, decided to review the Interim Guidelines in the near future. Therefore, the Sub-Committee was of the view that the work programme item on "Recommendation on evacuation analysis for new and existing passenger ships" should be kept on the work programme of the Sub-Committee (FP 46/16, paragraph 13.1.3) and the Committee agreed with this view (MSC 75/24, paragraph 22.22 and annex 29).

2 The Committee, at its seventy-fifth session, developed the updated work plan for large passenger ship safety matters and the Sub-Committee has been instructed to consider whether an evacuation analysis should be made mandatory for large passenger ships (FP 47/7, annex 3).

3 Taking into account the above issues, it may be helpful to submit information on the interim guidelines for evacuation analyses for new and existing passenger ships.

Results of preliminary study on interim guidelines

4 The National Maritime Research Institute (NMRI) has been conducting the research on evacuation analyses in passenger ships. Some results of the research were already reviewed in the correspondence group on the evacuation analysis established under the Sub-Committee at FP 45 and FP 46.
5 The NMRI has been studying the interim guidelines and pointed out some problems. The results of the preliminary study are set out in the annex of this document.

6 The major problems, pointed out by the NMRI, of the guidelines for the advanced evacuation analysis are as follows:

.1 The calculated evacuation time (total evacuation time) is introduced, in the guidelines, as the unique index for evaluating escape route arrangement. However, there is no index for directly evaluating local congestion.

.2 The response time (i.e. the time specified for individual evacuee on starting) for benchmark scenarios has wide range (i.e. 6 minutes for cases 1 and 3 and 3 minutes for cases 2 and 4). The variety in time for starting eliminates the congestion at places near initial positions of evacuees in the analysis based on benchmark scenarios.

.3 Regarding the scenarios representing reduced escape route availability (i.e. scenarios other than primary evacuation cases) the number of scenarios is only two and the scenarios have not been fully discussed.

7 Some comments by the NMRI on the interim guidelines are also described in the annex.

Action requested of the Sub-Committee

8 The Sub-Committee is invited to note the information.
ANNEX

RESULTS OF THE PRELIMINARY STUDY ON INTERIM GUIDELINES FOR EVACUATION ANALYSES FOR NEW AND EXISTING PASSENGER SHIPS

1 Introduction

The interim guidelines were developed by the Sub-Committee on Fire Protection and circulated as MSC/Circ.1033 for the purpose of unified implementation of the requirement on evacuation analysis which is required by regulation II-2/13.7.4 in the International Convention for the Safety of Life at Sea (SOLAS). We would like to pay our respect to all persons involved in the development of the guidelines, especially for the great effort of Dr. Mario Dogliani, who has contributed as the coordinator of the correspondence group and the chairman of the working group on evacuation analysis.

We have recognized the effectiveness of evacuation analyses on the evaluation of escape route arrangements of passenger ships (2), (3). We consider that the evacuation analyses are more effective for evaluating escape route arrangements of large ships or of ships with large number of evacuees rather than for evaluating escape route arrangements of small ships or of ships with small number of evacuees. In view of this, it is rational to consider the application of the requirement on evacuation analysis to large passenger ships, as the Fire Protection Sub-Committee has been instructed by the Maritime Safety Committee (c.f. FP 47/7 ANNEX 3).

For the discussion on the mandatory application of the requirement on evacuation analysis, it is necessary, prior to discussion, to review MSC/Circ.1033, i.e., the Interim Guidelines for Evacuation Analysis for New and Existing Passenger Ships, in regard to the effectiveness of evacuation analysis based on the guidelines.

The primary purpose of the evacuation analysis is to identify congestion points for improvement of escape route arrangement. In this paper, we review the guidelines mainly for the advanced evacuation analysis in regard to the identification of congestion.

2 Major problems of guidelines for advanced evacuation analysis

2.1 Evaluation of local congestion

The biggest defect of the guidelines is the lack of concrete index for evaluating local congestion. Microscopic evacuation simulations (advanced evacuation analysis) are tools for identifying congestion points in escape routes (2) and the guidelines for microscopic evacuation simulations should specify the index for local congestion, which may occur at certain points on escape routes, and the criteria for judgment based on the index.

In the revised SOLAS Convention, it is required for passenger ships that the width of escape route should, basically, not be less than one cm for one person who is expected to use the route. The basic requirement on the width of escape route can be interpreted as that the maximum time for waiting on a local queue due to congestion should be within a certain time, e.g., 75 seconds, taking into account the value of specific unit flow rate referred to in the guidelines, i.e., 1.33 (80/60) persons/m·sec. Hereafter, congestion time means maximum time for waiting on a local queue, which depends on positions on escape routes.
We cannot recommend the allowable congestion time at this stage of the research, because the allowable congestion time should be determined through the exhaustive discussion on various evacuation scenarios and other issues related to the allowable safe time (local survival time) such as smoke movement. The above-mentioned value, 75 seconds, however, can be used as a reference for starting discussion.

### 2.2 Response time

We roughly investigated the effect of variety of walking speed and response time on congestion time, considering some cases of evacuation from one room containing 48 persons. The results of the investigation are given in APPENDIX 1. Based on the results of investigation, it can be said that range of response time should be much shorter than total evacuation time for identifying points of congestion on escape routes. In view of this, the response times for the benchmark cases in the interim guidelines on the advanced evacuation analysis should be reviewed.

### 2.3 Accident scenarios

In the guidelines for advanced evacuation analysis, two scenarios on reduced escape route availability, i.e., "Case 3" and "Case 4", are included. These scenarios were developed to reflect the following requirement in SOLAS Convention:

"In addition, the analysis shall be used to demonstrate that escape arrangements are sufficiently flexible to provide for the possibility that certain escape routes, assembly stations, embarkation stations or survival craft may not be available as a result of a casualty."

Taking into account the basic required function for evacuation analysis, i.e., demonstration for flexibility of escape route arrangement, we consider that these two scenarios (case 3 and case 4) in the guidelines are not sufficient.

Furthermore, alternative 1 and alternative 2 for case 3 and case 4 are not independent each other; i.e., when 50 % of stairways capacity in a main vertical zone (MVZ) can not be available, a part of persons within the MVZ (maximum 50 % of total of them) would escape to the adjacent MVZ. This case is a combination of alternative 1 and alternative 2.

When alternative 2 for case 3 and case 4 is used (or in the case mentioned above), the population in the adjacent MVZ should increase by the persons coming from the MVZ in consideration, and may cause additional congestion in the adjacent MVZ. The degree of such congestion may depend on the number of persons who come from the original MVZ. MVZ, which has the largest capacity but does not generate longest travel time, will give biggest impact to the adjacent MVZs. Therefore, even in case 3 and 4, it may be necessary to consider all the MVZ.

To facilitate the future discussion on the issue of unavailability of escape route, we set out the draft accident scenarios for evacuation simulation in Appendix 2 (4).

### 2.4 Large encountered flow

In the case 2 (day time), large number of persons enjoying restaurant area should go back to cabins in order to take their lifejackets. These persons may go through the boundaries of MVZ, and may encounter, in corridors and stairways, flow of persons who come from their cabin. This scenario is not considered in the guidelines.
It is usual that every ship has emergency procedures taken by crew to guide passengers in order to avoid such encountered flow or congestion caused by such flow.

3 Other problems of the interim guidelines

Regarding the text in the guidelines for advanced analysis, care should be taken to express that the results of advanced analysis are probabilistic. In view of this, the following editorial correction of the guidelines can be made, without changing the substances of the existing one:

ANNEX 2, Appendix, paragraph 4.3

In these cases only the main vertical zone, which provides the highest possibility of generation of longest assembly time generates the longest assembly time, is further investigated. These cases utilize the same population demographics as in case 1 (for case 3) and as in case 2 (for case 4). One of the following two alternatives is to be considered for both case 3 and case 4:

4 Concluding remarks

We pointed out some problems in the Interim Guidelines for Evacuation Analyses for New and Existing Passenger Ships. The major subjects for further consideration in the amendment to the guidelines for advanced analysis can be summarized as follows:

.1 Developments of index and criterion for evaluating local congestion;

.2 The range of response time should be shortened or eliminated for identifying congestion points; and

.3 Scenarios on reduced escape route availability should be reviewed.

The results of study were reviewed by the members of committee for regulation research S402, "Fire Safety of Large Passenger Ships", in Shipbuilding Research Association of Japan. We appreciate all members of the committee and secretariats of the association.

5 Reference

(This study was conducted by Susumu OTA, Koichi YOSHIDA, Keiko MIYAZAKI and Mitujiro KATUHARA, National Maritime Research Institute)

.1 MSC/Circ.1033, "Interim Guidelines for Evacuation Analyses for New and Existing Passenger Ships"

.2 M. Katuhara, et al., "Escape Analysis of Ship by Multi-Agent Simulation Using Model of Group Psychology", Traffic and Granular Flow '01, October 15-17, 2001, Symposion, Nagoya University, Japan


.4 Shipbuilding Research Association of Japan, Regulation Research Committee No. 48, "Study on Safety Analysis of Escape Route Arrangements", March 2001 (in Japanese)
APPENDIX 1

Investigation on the Effect of Variety of Walking Speed and Response Time on Congestion Time

1 Conditions for calculation

We investigated evacuation from a half of a room such as restaurant. The room and initial distribution of persons were assumed as illustrated in figure 1. We investigated the situation of evacuation at which 48 persons went out the room through one exit. The times for evacuation including time for waiting at the exit were calculated under some conditions. For simplification of calculation, the length of path (distance) for all persons were represented by 16 values, which were 2 to 17 m at 1 m interval, and each value represented the distance to exit from three persons. Thus the distances to exit from all persons (48) were assumed to be 2 to 17 m. In the calculation, at first, the time of arrival of each person was calculated based on the distance, walking speed and response time. The formation of queue was evaluated based on the times of arrival of persons and the flow rate at the exit.

The width of exit was assumed at 75 cm and 90 cm. The specific unit flow rate was assumed at 1.33 persons/m·sec, taking into account the guidelines. Therefore, when queue take place at the exit, each person go out every one second through exit having 75 cm width and every 0.835 second through exit having 90 cm width, respectively. The following conditions were calculated:

Condition 1: All persons started walking simultaneously and walked at the same speed, 0.912 m/s, i.e., the average speed on "flat terrain" in Table 3.4 in ANNEX 2 of the guidelines taking into account "population's composition" in Table 3.1;

Condition 2: All persons started walking simultaneously and walked in various speed as specified in Table 3.4 and Table 3.1; and

Condition 3: All persons started walking at individual response time as specified for Case 2 & 4 (day case) in Table 3.2 and walked in various speed as specified in Table 3.4 and Table 3.1.
Calculation under "condition 2" were repeated 100 times, varying the walking speed of individual person, and calculation under "condition 3" were also repeated 100 times, varying the walking speed and response time of individual person.

2 Results of calculation

Figure 2 shows the relation between time of arrival to the exit of each person and time for waiting at exit of the person under "condition 1". Each triangle indicates the time of arrival of each person to the exit and the time for waiting of each person at the exit under the conditions that the width of exit was 75 cm. Similarly, each circle indicates these values under the conditions that the width of exit was 90 cm. The persons who came to the exit at the last waited 30.5 sec and 22.8 sec in cases that the widths of exit were 75 and 90 cm, respectively.

Figure 3 shows the relation between time of arrival to the exit and time for waiting at exit under "condition 2". These calculations indicated that the maximum times for waiting were 26.0 and 19.3 sec for 75 and 90 cm width of the exit, respectively.

Figure 4 shows the relation between time of arrival to exit and time for waiting at exit under "condition 3". The maximum times for waiting were 3.7 and 2.9 sec for 75 and 90 cm width of the exit, respectively. These results of calculation indicate that significant queues were not formed at the exit due to wide variety of response time.

Figure 5 shows the evacuation time, i.e., the time to go through the exit of each person, under "condition 2", sorted by the evacuation time. The effect of exit width can easily be observed from the figure.

Figure 6 shows the evacuation time of under "condition 3". Under "condition 3", the effect of width of the exit on evacuation time was insignificant because significant queue at the exit did not take place due to the wide range of response time.

3 Discussion

Based on the results of calculations, it can be said that wide variety of response time eliminate the significant queue at points to which the walking distances of persons are short. In other words, range of response time should be much shorter than total evacuation time, for the purpose of identification of points of congestion on escape routes, because the wide range of response
time eliminates congestion in calculation at places near the initial positions of evacuees. In view of this, the response times for the benchmark cases in the interim guidelines on the advanced analysis should be reviewed. The simplest way of the amendment to the guidelines is to assume that all evacuees start moving simultaneously.
APPENDIX 2

DRAFT ACCIDENT SCENARIOS FOR EVACUATION SIMULATION

This appendix provides the draft accident scenarios to facilitate the discussion on revision of the guidelines for advanced evacuation analysis.

1 Types of scenario for evacuation simulation

The scenarios of the following four types should be considered in the evacuation simulation to evaluate escape route arrangements of passenger ships:

.1 basic scenarios (all escape routes are available);
.2 scenarios for unavailability of each series of stairways;
.3 scenarios for obstruction of escape route in front of each fire room; and
.4 scenarios for inclined situations.

All scenarios should have both, day case and night case.

2 Outline of scenarios

2.1 Basic scenarios

Basic scenarios correspond to "Case 1" and "Case 2" in the guidelines.

2.2 Scenarios for unavailability of each series of stairways

These scenarios are considered for the evaluation of flexibility/redundancy of escape route arrangements. These scenarios are determined through the following procedures:

.1 to identify all stairways used as escape route, separating each stairway between two decks;
.2 to identify all series of stairways from all decks to decks for assembly stations; and
.3 to determine the scenario for unavailability of each series of stairways.

One stairway can be included in plural series of stairways. Number of scenarios to be considered equals to the number of series of stairways and depends on escape route arrangement. Inclination of ship is not considered.

2.3 Scenarios for obstruction of escape route in front of each fire room

These scenarios are considered for the evaluation of flexibility/redundancy against, basically but not restricted for, fire casualties. These scenarios are determined through the following procedures:
to identify all fictitious fire rooms, i.e., the rooms facing to a escape route categorized into "service spaces of high fire risk (galleys, pantries containing cooking appliances, etc.)" and rooms having door facing to a escape route categorized into "machinery spaces of category A" (c.f. paragraph (6) and (9) in regulation II-2/9.2.2.4.2.2 in SOLAS Convention);

2 to identify all doors facing to a escape route; and

3 to determine the scenario for obstruction of escape route at each door.

In each scenario, one obstruction of escape route is considered as illustrated in figure 7. In this figure, rooms "A" and "B" are the fictitious fire rooms. This figure indicates the method for determining obstructions and four scenarios are determined based on this figure. Inclination of ship is not considered.

2.4 Scenarios for inclined situations

These scenarios are considered for the evaluation of dimension of escape route against basically but not restricted for, flooding casualties. In these scenarios, inclination of ship is considered and all escape routes are assumed to be available.

Static heel at 20 degrees to starboard side and port side are considered.

The results of experiments on walking speed and unit flow rate under inclined conditions are given in Reference (3). Proposed coefficients for considering the scenarios are summarized in the tables below, based on the results of experiments. Table 1 shows the ratios of walking speeds under the condition of 20 degree heel to those under upright condition. Table 2 shows the ratios of unit flow rates under the condition of 20 degree heel to those under upright condition.

| Table 1  Proposed coefficient for correction of walking speed for 20 degree heel |
|---------------------------------|---------------------------------|
| Corridors                        | Direction                      |
| Longitudinal                    | Coefficient for correction of walking speed |
| Transverse                      | Ascending : 0.7                | Descending : 1.1               |
| Longitudinal                    | Ascending : 0.8                | Descending : 0.8               |
| Stairways                       | Transverse                     |
| Steepened                       | Ascending : 0.7                | Descending : 0.7               |
| Gentled                         | Ascending : 1.2                | Descending : 0.8               |

| Table 2  Proposed coefficient for correction of unit flow rate for 20 degree heel |
|---------------------------------|---------------------------------|
| In corridors                    | Direction                      |
| Longitudinal                   | Coefficient for correction of walking speed |
| Transverse                      | Ascending : 0.8                | Descending : 1.0               |
| Longitudinal                   | Ascending : 1.0                | Descending : 0.7               |
| To stairways                    | Transverse                     |
| Steepened                       | Ascending : 0.6                | Descending : 0.5               |
| Gentled                         | Ascending : 1.1                | Descending : 0.9               |