TRANSNAV International Journal on Marine Navigation and Safety of Sea Transportation
Volume 2
Number 2
June 2008

Analysis of Factors Affecting the Evacuation of People from Vessels in Life-Endangering Situations

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ABSTRACT: The trends to build ever larger passenger vessels enforce the necessity of continuous improvement of safety systems on such ships. Sea voyages constitute nowadays an attractive form of spending one's leisure, which is why people aboard vessels should also have their safety ensured in the case of a necessity to evacuate them. Paper presents the methods of lengthening of the time available for conducting evacuation, shortening the time of becoming aware of the necessity of evacuation and shortening the time of evacuation itself. An interesting concept of signalling the direction of evacuation by means of sound, bound strictly with the way man's instrument of hearing functions and the way of locating the source of sound is also presented at the paper. A new approach to designing evacuation systems is discussed at the paper. The concept of a "safe haven" is presented.

1 INTRODUCTION

The trends to build ever larger passenger vessels enforce the necessity of continuous improvement of safety systems on such ships. Sea voyages constitute nowadays an attractive form of spending one's leisure, which is why people aboard vessels should also have their safety ensured in the case of a necessity to evacuate them. The analysis of factors affecting the evacuation process should take place already at the stage of designing the vessel, which permits the partial elimination of hazards during the vessel's operation.

The time of potential evacuation of the people should not exceed the time available for its conduct. It should be remembered that the time at our disposal is reduced by the time necessary for becoming aware of the need for evacuation (Fig. 1).

For buildings on land the real evacuation time is counted up to the moment of leaving the building. For vessels, this process has to be divided into the following stages: relocation from the place of being alerted to the assembly place, abandoning the vessel (boarding the life-saving means and their launching on water, or lowering the life-saving means and skating).

Estimating evacuation time can be performed by various methods; the most convenient and currently ever wider applied form is computer simulation of the evacuation process.

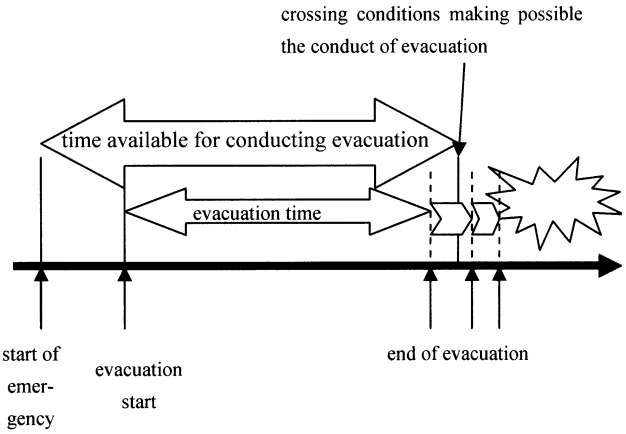

Fig. 1. Diagrammatic image of the dependence between real time of evacuation and the time available for its conduct

2 MEANS OF ENSURING SAFETY DURING A SEA VOYAGE

In order to create a system permitting to avoid the necessity of evacuation, it would be necessary to eliminate human errors leading to the emergence of life-threatening situations at the stage of designing, constructing and operating the vessel. Yet this is not always possible, which is evidenced by occasionally happening sea disasters, sometimes causing fatalities. Therefore, efforts should be concentrated on a possibly safe evacuation from the vessel, seeing that situations threatening human life at sea, cannot be totally eliminated (Fig. 2).

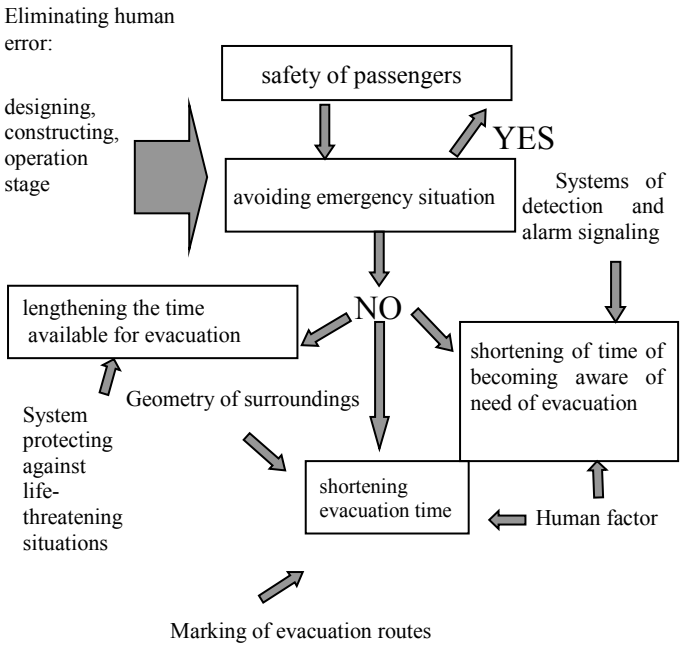

Fig. 2. Diagram presenting means of ensuring safety during a vessel voyage

In the case when it is impossible to avoid a situation enforcing evacuation (eg. fire, collision), it should be attempted to lengthen the time available for evacuation, to shorten evacuation time, and also to shorten the time of becoming aware of the necessity of abandoning the vessel.

Lengthening of the time available for conducting evacuation can be attained by improving security systems before crossing the life-threatening conditions. First of all, one should bear in mind the difficult conditions for movement and the vessel's list. The presence of fire affects man through smoke, thermal radiation, or shortage of oxygen. These factors endanger man's safety, and may make evacuation difficult or downright impossible, and constitute direct threat to human health and life. Particular attention should be paid to the application of appropriate equipment materials. In staircases and corridors it is necessary to make shorings and insulations from non-flammable materials. Uncovered surfaces in staircases and corridors should be made of materials which spread flames slowly (SOLAS). When putting finishing touches to interiors, particularly in corridors and staircases, they should be selected in such a way that they do not emit excessive amounts of toxic gases and smoke.

Shortening the time of becoming aware of the necessity of evacuation is significantly affected by the human factor. The randomness of population among the passengers should be taken into consideration (eg. the appearance of drunks) and concentrate first of all on improving the systems of detection and alarm signalling. Early detection of menace and starting evacuation gives better chances of conducting it in the time at our disposal, up to the moment when conditions on the vessel exceed the values safe for human health and life.

Shortening the time of evacuation itself is affected, among other things, by the geometry of evacuation routes and their appropriate marking (Łozowicka, 2006). Proper information plays an essential role in conditions of threat, enabling man to make the right decision concerning the direction of evacuation. In a labyrinth of routes, frequently in conditions of restricted visibility, man faces the necessity of choosing the direction of further route at each encountered bifurcation. The decision is made in a state of strong nervousness caused by the existing menace. Man finds himself in a situation unusual for him and even a simple layout of corridors does not warrant his avoiding straying and wandering around the same paths. An appropriate combination of lighting and evacuation marking permits a fast and safe evacuation of people from the place of threat.

An interesting concept is the suggestion of signalling the direction of evacuation by means of sound, bound strictly with the way man's instrument of hearing functions and the way of locating the source of sound. Man's instrument of hearing is essentially a mechanical system very sensitive to small changes in the surrounding sound waves. A sound wave emitted from a certain source first reaches the ear situated closer. On the basis of various pressures in each of the ear channels, man is able to locate the source of sound (O'Connor, 2005). During experimental evacuation of ferries (Withington, 2001) evacuation time was in many cases shortened by 30%.

The individual course of evacuation is also affected by knowledge of the layout of corridors, sex and age of participants of the evacuation, as well as their physical condition. The efficiency of evacuation is also strongly influenced by people's extra-evacuation activities, like awaiting further information, fire-fighting, alerting others, awaiting

help, attempts at rescuing belongings etc. (Łozowicka, 2003).

3 A NEW APPROACH TO DESIGNING EVACUATION SYSTEMS

Work aimed at improving the safety of life at sea has been conducted by International Maritime Organisation experts for many years. In future it is planned to depart from the necessity of evacuating passengers from a vessel in the case of the emergence of a crisis situation. The concept of a "safe haven" is arising, according to which it is just the vessel herself that is to constitute the best "lifeboat". In the case of emergency the vessel should reach the port using her own propulsion. It is assumed that passengers and crew will get evacuated to safe regions on board the vessel, where they will have adequate conditions for survival (not necessarily luxurious ones) until the vessel makes the port (IMO, 2004). For the designers of modern passenger vessels this means in practice the striving to fulfil the following requirements:

1 Attaining of a vessel's suitable resistance to damage.
2 Retaining a proper operational level by the vessel in the case of emergency.
3 Ensuring safe conditions for people's health and life in the case of emergency.

In the case of emergency it is assumed for people to stay on board for a few hours; this is to be prolonged in future to a few days, which is connected with the necessity of providing people with living standards (food, toilets etc.). As long as dangers attendant on sea voyages cannot be eliminated, however, and until the time of implementing the "safe haven" concept, efforts should be made to minimise casualties among people in case of emergency, by ensuring for them safe and efficient evacuation from the vessel.

4 RESUMÉ

Disasters at sea happening for years and human casualties connected with them, have enforced the necessity of performing evacuation analyses and designing safe evacuation systems. Methods of constructing, equipping and marking evacuation routes are continuously improved. Even at the stage of designing the vessel numerous models arise, which simulate the evacuation process. An important role is played by methods of informing passengers and securing evacuation routes. The application of the smallest number of simplifications and taking into account of the largest number of parameters affecting the evacuation process will permit predicting its course in the case of real menace and may minimise the number of fatalities in future. Perfecting methods of analysing evacuation time is indispensable to ensure the passengers of safety during sea voyages, the more so, since they have been becoming in recent times not only a means of moving, but they are also a way of spending one's leisure in an attractive way.

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