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SOME ASPECTS OF THE SAFETY OF NAVIGATION IN POLAR WATERS

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Nowadays, the Arctic zone of Russia is being intensively developed, the cargo turnover of the Northern Sea Route is increasing, oil and gas fields are being developed, fishing and polar tourism are being developed as well. Navigation in polar waters is characterized by many unavoidable adverse factors for the ship crews, such as rotating shift schedule, noise, vibration, electromagnetic fields, etc. Automation of ship navigation, which is aimed at reducing the voyages accident rate, has significantly changed the conditions and nature of work for the seafarers. There appeared to be a problem of discrepancy between functional capabilities of a human operator and requirements of modern sea equipment control systems. The reduction of personnel, the expansion of the functional duties range of crew members leads to significant loads on the whole crew. Frequent and intense disturbances of the geomagnetic field in the Polar regions and the Far North have an adverse effect on the human body functions overall. Crew fatigue becomes one of the main problems of navigation. Irrational light environment can lead to visual fatigue, attention failure, reduced clarity of signals perception, which, in turn, can provoke the accidents. It is highly necessary to develop special organizational and technical measures aimed at optimizing the working conditions of the crew when navigating in polar waters. It is also necessary to develop scientifically based criteria for determining the professional suitability of seafarers based on the results of psychophysiological testing. It is necessary to develop scientifically grounded regimes of work and rest of seafarers.

Keywords: automation of navigation, safety, Polar code, working conditions

The accelerated development of the Arctic zone of Russia and significant increase in cargo turnover of the Northern Sea Route (NSR) are the priorities of economic development of the country. By 2024, it is planned to increase cargo turnover along the Northern Sea Route up to 80 million tons. In the circumpolar regions, oil and gas fields are being developed on the Arctic continental shelf. Fishing and polar tourism are being developed as well. The key condition for achieving the goals of Arctic development is the expansion of the icebreaking, transport and dredging fleets [1,2]. Safety of navigation is one of the most important issues when arranging seafaring on the Northern Sea Route.

In recent years, a number of international and national regulatory documents have been adopted. They address the issues of ensuring the safe operation of ships in polar waters. In order to improve the safety of navigation, the Maritime Safety Committee of the International Maritime Organization (IMO) has adopted an international code for ships operating in polar waters – the Polar Code. IMO makes the Polar Code be mandatory under both the International Convention for the Safety of Life at Sea (SOLAS) and the International Convention for the Prevention of Pollution from Ships (MARPOL). The Polar Code and SOLAS amendments were adopted during the 94th session of IMO's Maritime Safety Committee (MSC), in November 2014. The environmental provisions and MARPOL amendments were adopted during the 68th session of the Marine Environment Protection Committee (MEPC) in May 2015. The Polar Code entered into force on 1 January 2017. The goal of this Code is to provide for safe ship operation and protection of polar environment by addressing risks present in polar waters and not adequately mitigated by other regulatory documents. Every ship to which this Code applies shall have on board a special ship operation document – Polar Water Operational Manual (PWOM), which in its turn is obligatory for issuance of the Polar Ship Certificate together with the list of equipment and provision. The goal of this document is to provide the owner, captain and crew with sufficient information regarding the ship's operational capabilities and limitations in order to support their decision-making process. The Polar Code does not abolish national rules when sailing in the Arctic waters. The document sets out requirements for safety measures, which are provided by the design of ships taking into account icing, mechanical installations for safe ship operation at low temperatures, the strength of the screws and the steering device, etc. There are certain requirements for the means of navigation and communication [3]. The Russian Maritime Register of Shipping, which has leading position in the development of safety standards for ships in ice navigation, in 2017 issued a document on the application of the provisions of the Code for ships operating in polar waters [4].

When considering the safety of navigation as measures aimed at reducing accidents on ships, it is necessary to point out further development of the science of navigation, training programs for marine personnel, improving the design of vessels and shipbuilding. An important factor is the availability of high-quality regulatory documents, providing a high level of safety of navigation when complying with their requirements [5]. Based on the statistics analysis of Maritime accidents, the causes of those at maritime transport are errors of maneuvering; low qualification of crew members; wear and tear of mechanisms and equipment of ships; inattention of shipowners to safety at sea. The human factor

remains one of the main factors affecting the safety of marine vessels [6].

We would like to point out the importance of working conditions of seafarers in ensuring the safety of navigation, including the specific conditions of navigation in polar waters. Working conditions of ship crews are characterized by a number of unavoidable adverse factors (rotating shift schedule, noise, vibration, electromagnetic fields, etc.). In recent years, the most advanced achievements of science and technology have been introduced into the practice of vessel design, shipbuilding and navigation, and the latest technologies have been used as well. These include automation of navigation, which is aimed, among other things, to reduce the ship accident rate due to the human factor. However, the introduction of automation has significantly changed the conditions and nature of the work of seafarers [7]. As a result of the complexity of marine technology, the number of control and monitoring elements has increased, accompanied by an increase in the intensity of the work of boat masters, due to the need for operational analysis of information coming from numerous screens. The technical basis of ship automation is usage of the electronic computing machines (ECM), as well as microprocessors and microcomputers with numerous screens to display operational information about the navigation process. In addition, the bridge has auxiliary means of displaying navigation information on small screens (digital displays, alphanumeric displays, situation plan displays). In the process of work, ship masters perform analysis of graphic and text information, simultaneously using several screens of different sizes, located at different distances from the eyes, having different contrast, color and brightness characteristics. There appear to be a problem of discrepancy of functional capabilities of the human operator to requirements of control system of modern sea equipment. Introduction of modern automated systems of control cause the reduction of crew members. It is a process of combining professions and expanding the range of functional duties of seafarers. In the absence of scientifically based modes of work and rest, under the condition of minimal staffing of automated vessels, the load on the crew increases significantly and, as a consequence, there is a rapid development of fatigue, which negatively affects the safety of navigation. Crew fatigue becomes one of the main problems of navigation [8].

In addition to the above mentioned adverse factors of working conditions and labor process on ships, in the Northern latitudes seafarers are exposed to long-term effects of irreversible natural factors. These include low temperatures, squally winds, difficult ice conditions. In high latitudes (Polar regions and the Far North) there are frequent and intense disturbances of the geomagnetic field (GMF). The effect of geomagnetic disturbances is noticed for the functional state not only of individual organs and systems, but also of the human body as a whole [9]. According to the results of research, in the Arctic and the Far North, the functional state of the organism significantly depends on the variations of GMF. In high latitudes, frequent and intense geomagnetic disturbances can be one of the causes of desynchronization of biological rhythms. And, in the case of chronic and persistent violations of the phase architectonics of rhythms, contribute to the depletion of reserve capabilities and adaptive-regulatory systems of the body. Significant seasonal change in daylight of polar days and nights is one of the extreme climatic factors of the Arctic region, affecting human body [10]. Seasonal changes in daylight in the Arctic region cause changes in the sleep-wake rhythm. These disorders are associated with a high risk of cardiometabolic disease, depression, drowsiness, and decreased working capacity. It becomes obvious that age-related changes in many physiological functions accelerate, which causes premature aging of the body. The results of researches testify the existence of proved interrelation between sleep duration patterns and frequency of the incidents leading to accidents on vessels [11]. Providing optimal environment in marine premises and workplaces of the crew is of special importance for safety of navigation in polar waters in terms of automation of navigation and the specific light climate of the Arctic regions. There are actual issues of energy saving on ships, so an important step is the introduction of modern efficient lighting products on ships and vessels. At the same time, the desire to save energy can lead to deterioration of lighting quality, and new light sources can be perceived by seafarers as less comfortable than the old and familiar ones, especially in the light climate of the Arctic regions [12]. It is necessary to consider possible adverse influence of lamp blinding action on the visual analyzer, as well as its pulsations and color characteristics of light sources.

Conclusion

The specific conditions of navigation in polar waters reveal the need to develop special organizational and technical measures aimed at optimizing the working conditions of the marine crews. Irrational light situation with a high probability can lead to visual fatigue, impaired attention, reduced clarity of signals perception, which, in turn, can provoke the occurrence of ship accidents. It is required to develop scientifically based criteria for determining the professional suitability of crew members based on the results of psychophysiological testing, it is also important to develop work and rest regimes of seafarers.

The most important component of the system of ensuring the navigation safety is the establishment of requirements for the optimal composition of the ship crews. The Ministry of Transport of Russia has announced the beginning of development of Regulations on the minimum composition of ship crews. According to the Federal Portal of Draft Regulations, the relevant draft provides for the formation of a minimum composition for a certain type of vessel, sufficient to meet the requirements

of safety of navigation, environmental, sanitary, fire and transport safety; meeting the requirements for compliance with the working time and rest time of crew members on board. The draft document has not yet been published. It is hoped that the Regulation will be developed on the basis of comprehensive scientific research and taking into account the specific adverse natural factors affecting the ship crew in polar waters.

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