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Relevance of international legal and national standards of safety of navigation and the role of classification societies in the context of modern challenges and innovations in shipbuilding

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■ **Abstract.** The relevance of international legal and national safety standards for shipping is growing due to modern challenges, such as innovations in shipbuilding, climate change and growing requirements for environmental safety, which underlines the important role of classification societies in this process. The purpose of the study was to analyse the impact of international and national safety standards on modern shipbuilding and to assess the role of classification societies in ensuring the safe operation of ships. The study applied the methods of system analysis, comparative law and empirical modelling. The main results of the study were the identification of the need for further harmonisation of international legal standards with national requirements, improvement of the role of classification societies in monitoring innovations in shipbuilding, and formulation of proposals for improving the environmental safety of shipping. In addition, the paper identified the prospects for using the latest technologies to improve safety standards in maritime transport. In particular, the article focused on the role of classification societies in ensuring that ships comply with these standards, as well as their contribution to the introduction of innovations in shipbuilding. The study contained an analysis of current regulations and standards governing shipping safety, as well as cases of their implementation in practice. The key changes in ship safety requirements in view of current risks, including environmental challenges and increased quality requirements, were identified. The practical value of the work lies in the possibility of using the results obtained by both regulatory authorities and shipbuilding companies to improve internal safety standards and support international certification

■ **Keywords**: technological innovation; autonomous shipping; environmental regulations; integration; standards

■ Introduction

Shipping safety is one of the key conditions for the efficient functioning of the global economy. In the context of globalisation and rapid technological development, the maritime industry is facing a number of new challenges that require constant adaptation and improvement of shipping safety standards. Modern shipping is facing new challenges such as piracy, terrorism, cyber-attacks on navigation systems and environmental risks associated with climate change. This requires a review of existing safety standards and the creation of new legal mechanisms to ensure the protection of sea lanes and ships.

Innovations in shipbuilding, including the use of alternative fuels, new materials and technologies (e.g. autonomous ships), create new opportunities but also raise questions about the safety of such vessels. Traditional safety standards do not always adequately address these innovations, and new international

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and national regulations are needed. Increasing attention to environmental protection, in particular in connection with the International Convention for the Prevention of Pollution from Ships (MARPOL)[1], creates additional challenges for the shipbuilding industry. The introduction of environmentally friendly technologies on ships should be accompanied by the adaptation of international and national safety standards. Classification societies (CS) play a pivotal role in ensuring the safety of shipping, as they carry out certification, technical control and inspection of ships. In the context of innovation in shipbuilding, their role becomes even more important as they act as intermediaries between government regulators, shipbuilders, and ship operators. In the context of globalisation and active integration into the international economy, it is relevant for Ukraine to comply with international shipping safety standards. This not only helps to improve the country's image, but also opens up new opportunities for international trade. Thus, the study of international and national shipping safety standards, as well as the role of classification societies in the context of modern challenges and innovations, is extremely important for improving maritime safety and maintaining the stable development of the global maritime industry.

The issue of international legal and national standards of shipping safety has been the subject of research by many scholars. According to a study by O. Aneziris *et al.* (2021), achieving the International Maritime Organisation's (IMO) greenhouse gas emission reduction targets requires significant efforts, especially in the introduction of new technologies and alternative fuels. The main challenge is the high cost and technological uncertainty that affects global decision-making.

The study by M. Issa *et al.* (2022) highlights the challenges of introducing autonomous vessels, especially in the context of safety and compliance with international regulations. The main challenge is legal uncertainty, as current legislation does not always take into account the specifics of such technologies, which can complicate their integration into global shipping. T.C. Nwokedi *et al.* (2023) focus on the role of classification societies in maintaining maritime security under the Abuja Memorandum of Understanding. The authors emphasize the effectiveness of cooperation between international and local regulatory bodies in ensuring safety standards. A. Joseph & D. Dalaklis (2021) highlight the importance of the International Convention "On the Safety of Life at Sea"[2] in reducing risks in shipping, noting that the instrument continues to play a key role in ensuring maritime safety, in particular in response to new challenges posed by innovation and environmental threats. R. Baumler *et al.* (2021) focus on the human factor in the context of IMO's maritime safety measures. They conclude that, despite significant technical improvements, the human factor remains the main issue affecting shipping safety.

The review shows that there are several unexplored aspects in the existing research on the integration of new technologies and innovations in shipping safety. These shortcomings open up opportunities for further research in these areas. The purpose of the article was to study international and national shipping safety standards, and to determine the role of classification societies in ensuring compliance with these standards, as well as to assess the impact of innovations in shipbuilding on the development and adaptation of safety standards in the face of modern challenges. The objectives of the study were to analyse international shipping safety standards and assess national regulations governing the activities of classification societies.

Materials and Methods

To study the role of classification societies in ensuring compliance with safety standards in shipping and shipbuilding, several methodological approaches were used to provide a comprehensive view of the topic. This approach provided a deeper understanding of how classification societies influence maritime safety through the supervision of ship construction, maintenance, and certification of compliance with international standards.

A systematic analysis of Ukrainian and international regulations, such as conventions, was carried out. This method helped to clarify the legal framework governing the activities of classification societies and to identify the main requirements for shipping safety. This made it possible to determine how national legislation implements international standards. International regulations were analysed, in particular conventions governing maritime safety, such as International Convention "On the Safety of Life at Sea"[3], The International Safety Management (ISM) Code[4], International Convention on Standards of

[1] International Convention for the Prevention of Pollution from Ships (MARPOL). (1973, November). Retrieved from https://www.imo.org/en/about/Conventions/Pages/International-Convention-for-the-Prevention-of-Pollution-from-Ships-(MARPOL).aspx.
[2] International Convention "On the Safety of Life at Sea". (1974, November). Retrieved from https://ips.ligazakon.net/document/MU74K04U.
[3] Ibidem, 1974.
[4] International Safety Management (ISM) Code. (1998, July). Retrieved from https://www.imo.org/en/ourwork/humanelement/pages/ISMCode.aspx.

Training, Certification and Watchkeeping for Fishing Vessel Personnel (STCW-F)[1], Maritime Labour Convention (MLC)[2], MARPOL[3], Basel Convention "On the Control of Transboundary Movements of Hazardous Wastes and Their Disposal"[4], BWM Convention[5], Directive of the European Parliament and of the Council No. 2009/16/EU[6], Directive of the European Parliament and of the Council No. 2014/90/EU[7].

The article also analysed national legislation on shipping safety, such as the Merchant Shipping Code of Ukraine[8], the Law of Ukraine No. 1054-IX "On Inland Water Transport"[9], the Resolution of the Cabinet of Ministers of Ukraine No. 240 "On Amendments to the Regulation on the State Service of Maritime and Inland Water Transport and Shipping of Ukraine"[10], as well as laws on the ratification of international standards[11,12,13].

International and national shipping safety standards were analysed, including the legislation of EU countries such as Greece[14], Norway (Norway to build the world's…, 2024), France[15] and Germany[16,17]. The case study method was used to investigate specific cases of innovation in shipbuilding and its impact on safety standards, such as autonomous ships, the introduction of alternative fuels and the use of composite materials. The study examined situations where new technologies or innovations have led to changes or improvements in safety standards. At the same time, examples of the implementation of shipping safety standards were analysed using classification societies such as Lloyd's Register and DNV GL (Chu *et al.*, 2023).

The methods of scientific cognition used provided a comprehensive approach to the study of the role of classification societies, allowing to collect and analyse information from various sources. This contributed to the formation of a comprehensive understanding of their role in ensuring compliance with safety standards for shipping and shipbuilding, as well as the identification of the main challenges and opportunities for further development in this area.

Results

Modern challenges and innovations in shipbuilding. Modern challenges in shipbuilding have a significant impact on the industry, particularly in the context of global environmental requirements, new technologies and safety of navigation. International regulations, in particular from the IMO, are aimed at reducing greenhouse gas emissions and pollutants such as sulphur and nitrogen oxides. IMO 2020 has significantly reduced the permissible level of sulphur emissions, which has become a major challenge for the shipbuilding industry. Shipbuilding companies are looking for ways to reduce their carbon footprint,

[1] International Convention on Standards of Training, Certification and Watchkeeping for Fishing Vessel Personnel (STCW-F). (1995, July). Retrieved from https://www.imo.org/en/ourwork/humanelement/pages/stcw-f-convention.aspx.
[2] Maritime Labour Convention. (2006, February). Retrieved from https://www.ilo.org/international-labour-standards/maritime-labour-convention-2006.
[3] International Convention for the Prevention of Pollution from Ships (MARPOL). (1973, November). Retrieved from https://www.imo.org/en/about/Conventions/Pages/International-Convention-for-the-Prevention-of-Pollution-from-Ships-(MARPOL).aspx.
[4] Basel Convention "On the Control of Transboundary Movements of Hazardous Wastes and Their Disposal". (1999, July). Retrieved from https://zakon.rada.gov.ua/laws/show/995_022#Text.
[5] International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWM). (2004, February). Retrieved from https://www.imo.org/en/About/Conventions/Pages/International-Convention-for-the-Control-and-Management-of-Ships'-Ballast-Water-and-Sediments-(BWM).aspx.
[6] Directive of the European Parliament and of the Council No. 2009/16/EU "On State Control of Ports". (2009, April). Retrieved from https://zakon.rada.gov.ua/laws/show/984_005-09#Text.
[7] Directive of the European Parliament and of the Council No. 2014/90/EU "On Shipboard Equipment and Repealing Council Directive 96/98/EU". (2014, August). Retrieved from https://zakon.rada.gov.ua/laws/show/984_008-14#Text.
[8] Merchant Shipping Code of Ukraine. (1995, May). Retrieved from https://zakon.rada.gov.ua/laws/show/176/95-вр#Text.
[9] Law of Ukraine No. 1054-IX "On Inland Water Transport". (2020, December). Retrieved from https://zakon.rada.gov.ua/laws/show/1054-20#Text.
[10] Resolution of the Cabinet of Ministers of Ukraine No. 240 "On Amendments to the Regulation on the State Service of Maritime and Inland Water Transport and Shipping of Ukraine". (2023, March). Retrieved from https://zakon.rada.gov.ua/laws/show/240-2023-п#Text.
[11] Resolution of the Cabinet of Ministers of Ukraine No. 350 "On the Acceptance by Ukraine of the 1981, 1989 and 1990 Amendments and the 1988 Protocol to the International Convention for the Safety of Life at Sea, 1974". (1992, June). Retrieved from https://zakon.rada.gov.ua/laws/show/350-92-п#Text.
[12] Resolution of the Verkhovna Rada of Ukraine No. 3939-XII "On Ratification of the Convention on the protection of the Black Sea from pollution". (1994, Febraury). Retrieved from https://zakon.rada.gov.ua/laws/show/3939-12#Text.
[13] Law of Ukraine No. 464/96-VR "On Ukraine's Accession to the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978". (1996, November). Retrieved from https://zakon.rada.gov.ua/laws/show/464/96-вр#Text.
[14] Law of the Geece No. 743 "On the Protection of the Marine Environment and Arrangement of Other Matters Related Thereto". (1977, October). Retrived from https://leap.unep.org/en/countries/gr/national-legislation/law-no-743-protection-marine-environment-and-arrangement-other.
[15] French Transport Code. (2024, October). Retrieved from https://www.legifrance.gouv.fr/codes/texte_lc/LEGITEXT000023086525/.
[16] Federal Maritime Responsibility Act of the Germany. (2002, July). Retrieved from https://www.gesetze-im-internet.de/.
[17] Shipbuilding and Maritime Infrastructure Act of Germany. (2016, June). Retrieved from https://www.gesetze-im-internet.de/englisch_bseeschg/englisch_bseeschg.pdf.

including through the use of new energy sources. The shipping industry needs more energy-efficient solutions to reduce fuel consumption and environmental impact. Shipbuilding companies are required to integrate innovative approaches to ship and engine design, including the use of AI-based solutions to optimize routes and reduce energy consumption.

One of the main challenges is the introduction of alternative energy sources, such as liquefied natural gas (LNG), hydrogen energy, ammonia, or battery-powered electric ships. These technologies help to reduce carbon dioxide emissions, but their implementation requires infrastructure upgrades and significant investments. The industry is moving towards ship automation, including autonomous ships that can operate without a crew. This not only increases efficiency, but also reduces safety risks. However, the introduction of autonomous systems requires the development of new legal frameworks and safety standards.

The introduction of new technologies, including green solutions, is an expensive process. Shipbuilding companies are forced to balance environmental requirements with financial costs, which affects their ability to adapt to change. Overall, the shipbuilding industry is actively transforming under the influence of global challenges. Integration of environmental requirements, the latest technologies and enhanced safety measures are crucial for its sustainable development. For Ukraine, the development of shipbuilding is strategically important, as the country has access to the Black Sea. The integration of innovations such as the use of alternative energy sources and digital technologies can help modernize Ukraine's shipbuilding industry and increase its competitiveness in the global market.

Modern shipbuilding uses lighter and stronger materials, such as composites, to reduce the weight of ships and improve their fuel efficiency. The introduction of new technologies such as rotor sails and solar panels allows the use of renewable energy sources to propel ships, which reduces fuel consumption. The use of artificial intelligence, the Internet of Things (IoT) and big data to monitor the status of ships in real-time, optimise routes and predict technical failures can significantly improve the efficiency of ship management. Fully autonomous or partially autonomous ships are already being tested. They are able to carry out maritime operations with minimal human intervention, potentially reducing human error and improving safety of navigation. The use of modular technologies in ship construction can significantly reduce the time and cost of ship assembly. Modular structures are easier to repair and modernize (Melnyk *et al.*, 2023). Thus, shipbuilding faces a number of challenges, but innovations open up new opportunities for efficient, environmentally friendly and safe development of the industry, which, in turn, requires improving the regulatory framework in this area.

International and national legislation in the field of shipping and shipbuilding. The IMO is a specialised UN agency that coordinates activities in the field of maritime safety and pollution prevention. Since its foundation in 1948, the IMO has been implementing and maintaining international safety standards, including International Convention "On the Safety of Life at Sea"[1] (1974) and MARPOL[2] (1973). In addition, the IMO is actively involved in the creation of new regulations and policies to respond to modern environmental and technological challenges. The organisation develops new protocols and amendments to conventions to ensure that regulations remain relevant and effective in the face of climate change and technological developments. One of the most important modern environmental standards is the implementation of IMO 2020, which significantly limits sulphur emissions from ships. Since 1 January 2020, the maximum sulphur content in marine fuels has been reduced from 3.5% to 0.5%. This is forcing shipping companies to switch to more environmentally friendly fuels, install exhaust gas cleaning systems (scrubbers) or use alternative energy sources such as LNG. These changes are part of IMO's broader strategy to reduce greenhouse gas emissions from shipping by 50% by 2050.

At the same time, international standards are aimed at ensuring the safety of human life, protecting the environment, and improving the quality of ship construction and operation. Thus, the International Convention "On the Safety of Life at Sea"[3] is one of the most crucial international treaties governing the safety of navigation. It was adopted in 1914 after the Titanic disaster, and the current version was adopted in 1974. Convention sets minimum standards for ship design, equipment, and operation to ensure the safety of human life at sea. The International Convention "focuses on safety of navigation, including requirements for ship design, equipment, and operation. The main goal is to ensure the safety of life at sea, but it does not contain direct environmental standards. Although Convention requires compliance with technical standards that may indirectly affect environmental performance (e.g., carbon emission

[1] International Convention "On the Safety of Life at Sea". (1974, November). Retrieved from https://ips.ligazakon.net/document/MU74K04U.
[2] International Convention for the Prevention of Pollution from Ships (MARPOL). (1973, November). Retrieved from https://www.imo.org/en/about/Conventions/Pages/International-Convention-for-the-Prevention-of-Pollution-from-Ships-(MARPOL).aspx.
[3] International Convention "On the Safety of Life at Sea". (1974, November). Retrieved from https://ips.ligazakon.net/document/MU74K04U.

requirements), the main focus is on ship safety rather than environmental performance. Updates to the convention do not always respond promptly to new environmental challenges, such as ship pollution or climate change.

The International Safety Management[1] is part of the International Convention "On the Safety of Life at Sea"[2] and regulates safety management on ships and in shipping companies. Its goal is to reduce the risk of accidents through systematic safety management. The STCW-F[3] defines international standards for seafarers' training, certification, and watchkeeping. The MLC[4] was adopted by the International Labour Organisation (ILO) and sets standards for working conditions for seafarers. It ensures the rights of seafarers to decent working conditions, medical care and rest, which is important for maintaining safe navigation through improved working conditions. The MARPOL[5] aims to prevent pollution of the marine environment from ships, including operational and accidental emissions. It was adopted in 1973 and subsequently supplemented by the 1978 Protocol. The Basel Convention[6] regulates the transport of hazardous wastes and their disposal, in particular from ships. It provides control over the transport of such substances to avoid environmental disasters in the event of ship accidents. The BWM Convention[7] regulates the management of ballast water on ships to prevent the invasion of alien species into ecosystems. Requirements include the treatment of ballast water before it is discharged into the sea.

Thus, the international legal standards developed by the IMO are critical to ensuring safe navigation and protecting the environment. They are constantly evolving in response to new technological and environmental challenges, helping the industry to adapt to modern requirements and standards. International shipping and shipbuilding safety standards are key to ensuring crew safety and environmental protection. They are constantly being updated to meet modern technological and environmental challenges, such as decarbonisation and the use of new types of energy. The IMO plays a key role in this process, developing global standards and promoting their implementation in global shipping practices.

National shipping safety standards in the European Union (EU) have several common features, which are determined by EU legislation, but each country also implements its own specific requirements depending on local needs and geographical conditions. Major international standards, such as International Convention "On the Safety of Life at Sea"[8], MARPOL[9] and others, are binding on all EU member states, but additional regulations are being developed at the EU level to implement higher safety and environmental requirements than the global standards.

The European Maritime Safety Agency (EMSA) is responsible for monitoring the implementation of safety and environmental standards. It helps EU member states implement safety standards, provides technical assistance and audits maritime administrations. Each EU country is obliged to implement EU directives into its national legislation. For example, Directive No. 2009/16/EU[10] obliges countries to carry out a thorough inspection of foreign vessels entering EU ports to verify their compliance with international safety standards. Directive of the European Parliament and of the Council No. 2014/90/EU[11] regulates the standards of marine equipment in the EU. It obliges national shipping control authorities to ensure that equipment on ships meets safety requirements and has an EU certificate of conformity. In some EU countries with large coastal areas and ports, national standards may be more stringent or adapted to local conditions (Table 1).

[1] International Safety Management (ISM) Code. (1998, July). Retrieved from https://www.imo.org/en/ourwork/humanelement/pages/ISMCode.aspx.
[2] International Convention "On the Safety of Life at Sea". (1974, November). Retrieved from https://ips.ligazakon.net/document/MU74K04U.
[3] International Convention on Standards of Training, Certification and Watchkeeping for Fishing Vessel Personnel (STCW-F). (1995, July). Retrieved from https://www.imo.org/en/ourwork/humanelement/pages/stcw-f-convention.aspx.
[4] Maritime Labour Convention. (2006, February). Retrieved from https://www.ilo.org/international-labour-standards/maritime-labour-convention-2006.
[5] Ibidem, 2006.
[6] International Convention for the Prevention of Pollution from Ships (MARPOL). (1973, November). Retrieved from https://www.imo.org/en/about/Conventions/Pages/International-Convention-for-the-Prevention-of-Pollution-from-Ships-(MARPOL).aspx.
[7] International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWM). (2004, February). Retrieved from https://www.imo.org/en/About/Conventions/Pages/International-Convention-for-the-Control-and-Management-of-Ships'-Ballast-Water-and-Sediments-(BWM).aspx.
[8] International Convention "On the Safety of Life at Sea". (1974, November). Retrieved from https://ips.ligazakon.net/document/MU74K04U.
[9] International Convention for the Prevention of Pollution from Ships (MARPOL). (1973, November). Retrieved from https://www.imo.org/en/about/Conventions/Pages/International-Convention-for-the-Prevention-of-Pollution-from-Ships-(MARPOL).aspx.
[10] Directive of the European Parliament and of the Council No. 2009/16/EU "On State Control of Ports". (2009, April). Retrieved from https://zakon.rada.gov.ua/laws/show/984_005-09#Text.
[11] Directive of the European Parliament and of the Council No. 2014/90/EU "On Shipboard Equipment and Repealing Council Directive 96/98/EU". (2014, August). Retrieved from https://zakon.rada.gov.ua/laws/show/984_008-14#Text.

Table 1. Peculiarities of standards in the EU coastal states

Greece	Greece has one of the largest ferry systems in Europe, with numerous islands. National standards include specific requirements for the design and operation of ferries, as well as for passenger safety systems. Particular attention is paid to fire-fighting systems on ships due to high temperatures in summer1.
Norway (associated with the EU through the European Economic Area)	Norway, a world leader in the use of electric and hybrid ships, has introduced additional standards to reduce CO2 emissions (Norway to build the world's…, 2024). Oslo became the first port in the world to offer infrastructure for charging electric ships. Due to the harsh weather conditions and the Arctic zone, Norway has additional safety requirements for ships operating in polar waters.
France	France, as a country with major ports, including Marseille and Le Havre, pays special attention to the transport of dangerous goods. Standards for tankers require additional safety measures and monitoring of vessels to prevent accidents and oil spills2 (French Transport Code, 2024).
Germany	Germany, as one of the leading countries in shipbuilding, has strict requirements for cargo ships, in particular, in terms of their design and navigation equipment3,4. Hamburg, as one of the largest European ports, is actively implementing innovative technologies to improve safety. The German shipping industry is focusing on the development of low-emission ships and the introduction of hybrid engines.

Source: compiled by the author

In general, national shipping safety standards in the EU are closely linked to European legislation, which sets the basic regulatory framework. At the same time, member states adapt these standards to their specific needs and geographical conditions. The EU is a global leader in the implementation of environmental standards and the latest technologies in shipbuilding and shipping, which helps ensure high safety and environmental protection.

In Ukraine, national shipping safety standards are developed in line with international norms and requirements set by the IMO and are gradually being harmonised with European legislation. The main Ukrainian regulations and standards are aimed at regulating maritime safety, shipbuilding, environmental protection, and seafarers' working conditions. In particular, the Merchant Shipping Code of Ukraine[5] is the main document regulating all aspects of maritime shipping, including ship safety, navigation, shipping and environmental protection. The Code is aligned with international requirements, but continues to be improved to integrate the latest international standards. The Law of Ukraine No. 1054-IX[6] stipulates that classification and technical supervision of inland waterway vessels is carried out by a classification society chosen by the shipowner. In accordance with the Resolution of the Cabinet of Ministers of Ukraine No. 240[7], approved by the Resolution of the Cabinet of Ministers of Ukraine No. 212[8], the State Service of Maritime and Inland Water Transport and Shipping of Ukraine (Shipping Administration) is a central executive body that implements state policy in the areas of maritime and inland water transport and shipping.

The Shipping Administration is responsible for implementing international ship safety standards and ensuring their compliance with IMO requirements. It supervises vessels operating under the Ukrainian flag, conducts inspections of vessels in ports and certifies crews, ensures compliance with and fulfillment of obligations undertaken under international agreements in the spheres of sea and inland water transport and shipping. As part of its efforts to integrate

[1] Law of the Geece No. 743 "On the Protection of the Marine Environment and Arrangement of Other Matters Related Thereto". (1977, October). Retrived from https://leap.unep.org/en/countries/gr/national-legislation/law-no-743-protection-marine-environment-and-arrangement-other.
[2] French Transport Code. (2024, October). Retrieved from https://www.legifrance.gouv.fr/codes/texte_lc/LEGITEXT000023086525/.
[3] Federal Maritime Responsibility Act of the Germany. (2002, July). Retrieved from https://www.gesetze-im-internet.de/.
[4] Shipbuilding and Maritime Infrastructure Act of Germany. (2016, June). Retrieved from https://www.gesetze-im-internet.de/englisch_bseeschg/englisch_bseeschg.pdf.
[5] Merchant Shipping Code of Ukraine. (1995, May). Retrieved from https://zakon.rada.gov.ua/laws/show/176/95-вр#Text.
[6] Law of Ukraine No. 1054-IX "On Inland Water Transport". (2020, December). Retrieved from https://zakon.rada.gov.ua/laws/show/1054-20#Text.
[7] Resolution of the Cabinet of Ministers of Ukraine No. 240 "On Amendments to the Regulation on the State Service of Maritime and Inland Water Transport and Shipping of Ukraine". (2023, March). Retrieved from https://zakon.rada.gov.ua/laws/show/240-2023-п#Text.
[8] Resolution of the Cabinet of Ministers of Ukraine No. 212 "Some Issues of Optimising the Functioning of Central Executive Authorities in the Areas of Maritime and Inland Water Transport and Shipping". (2022, March). Retrieved from https://zakon.rada.gov.ua/laws/show/212-2022-%D0%BF#Text.

into the EU, Ukraine is actively harmonizing its national shipping safety standards with EU requirements. Ukraine has already ratified most of the major IMO conventions, including International Convention "On the Safety of Life at Sea"[1], MARPOL[2] and STCW-F[3]. Following the signing of the Association Agreement[4], Ukraine has committed itself to harmonising its legislation with EU directives and regulations in the field of maritime transport. This includes the implementation of EU directives on port state control of ships, environmental protection and maritime safety. Ukraine is gradually introducing requirements to reduce sulphur emissions in line with international environmental standards and EU directives.

Ukraine has significant potential in shipbuilding due to its geographical location, access to the Black and Azov Seas, a developed network of inland waterways and a rich history of shipbuilding. Ukraine's main shipyards are located in Mykolaiv, Kherson, Kyiv and Odesa, which provides access to waterways and convenient transport links. Successful harmonisation with European standards, modernisation of port and shipbuilding infrastructure, and the development of skilled personnel will help Ukraine to take an important place in the global shipping market. National shipping safety standards in Ukraine are based on international and European standards and continue to evolve in response to new challenges and technological innovations. Harmonisation with European requirements, modernisation of infrastructure and improvement of safety management systems will contribute to the improvement of the level of safety of shipping in Ukraine and the country's integration into the global transport network.

International standards developed by the IMO have a significant impact on the reform of Ukraine's shipbuilding and shipping industry. The International Convention "On the Safety of Life at Sea"[5], the MARPOL[6] and the STCW-F[7] define the basic requirements for ship safety and environmental standards that must be implemented in Ukrainian national legislation. This forces Ukrainian shipbuilding companies to update their processes and equipment to meet global requirements. Ukraine has ratified international agreements to reduce greenhouse gas emissions and other harmful substances (IMO, 2020). The implementation of these standards affects the reform of the shipbuilding industry, as it forces companies to look for more environmentally friendly solutions, such as the use of energy-efficient technologies in ships and the transition to cleaner fuels (LNG, hydrogen). International standards require modernisation of ships and maritime infrastructure to improve safety and environmental performance (Baumler *et al.*, 2021). For example, the requirements for life-saving equipment, firefighting systems and modern navigation aids are constantly changing and require Ukrainian shipbuilders and shipowners to comply with new regulations. The gradual adaptation to the emission requirements in the SECA zones is influencing changes in shipbuilding processes in Ukraine. This requires switching to more environmentally friendly fuels and modernising existing vessels to reduce emissions.

Cooperation with international classification societies plays an important role in raising the quality and safety standards of the Ukrainian shipbuilding industry. Classification societies, such as Lloyd's Register, Bureau Veritas, DNV GL, and others, certify ships for compliance with international standards and check their technical condition (Chu *et al.*, 2023). Classification societies certify ships and infrastructure for compliance with international safety and environmental requirements. Cooperation with these organisations provides Ukrainian shipbuilding companies with access to the global market, as certified vessels can operate in international waters. International classification societies are actively implementing the latest technologies in shipbuilding and shipping. Cooperation with them will allow Ukrainian companies to introduce modern technologies (e.g., electric or hydrogen-fuelled vessels), increasing their competitiveness. Classification societies provide technical support and expertise to Ukrainian companies. This applies not only to new ship designs, but also to the modernisation of the existing fleet in accordance with standards. Cooperation with well-known

[1] Resolution of the Cabinet of Ministers of Ukraine No. 350 "On the Acceptance by Ukraine of the 1981, 1989 and 1990 Amendments and the 1988 Protocol to the International Convention for the Safety of Life at Sea, 1974". (1992, June). Retrieved from https://zakon.rada.gov.ua/laws/show/350-92-п#Text.

[2] Resolution of the Verkhovna Rada of Ukraine No. 3939-XII "On Ratification of the Convention on the Protection of the Black Sea from Pollution". (1994, Febraury). Retrieved from https://zakon.rada.gov.ua/laws/show/3939-12#Text.

[3] Law of Ukraine No. 464/96-VR "On Ukraine's Accession to the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978". (1996, November). Retrieved from https://zakon.rada.gov.ua/laws/show/464/96-вр#Text.

[4] Association Agreement Between Ukraine, of the One Part, and the European Union, the European Atomic Energy Community and their Member States, of the Other Part. (2014, March). Retrieved from https://zakon.rada.gov.ua/laws/show/984_011#Text.

[5] International Convention "On the Safety of Life at Sea". (1974, November). Retrieved from https://ips.ligazakon.net/document/MU74K04U.

[6] International Convention for the Prevention of Pollution from Ships (MARPOL). (1973, November). Retrieved from https://www.imo.org/en/about/Conventions/Pages/International-Convention-for-the-Prevention-of-Pollution-from-Ships-(MARPOL).aspx.

[7] International Convention on Standards of Training, Certification and Watchkeeping for Fishing Vessel Personnel (STCW-F). (1995, July). Retrieved from https://www.imo.org/en/ourwork/humanelement/pages/stcw-f-convention.aspx.

classification societies increases the confidence of international partners in Ukrainian shipbuilders and shipowners, promoting ship exports and attracting investment in the industry.

One of the key functions of classification societies is to assess the latest technologies in shipbuilding, including the use of alternative energy sources to reduce emissions and improve the energy efficiency of ships (Nwokedi *et al.*, 2023). Classification societies are working on the certification and implementation of such technologies. Classification societies such as DNV GL and Bureau Veritas are actively certifying LNG ships and developing standards for the safe operation of LNG ships. The use of hydrogen as a fuel for ships requires new safety standards, in particular for the storage and transportation of hydrogen on ships. Lloyd's Register is working to develop rules for the certification of hydrogen fuel cell ships.Classification societies certify hybrid ships that use both conventional engines and battery systems. Such projects support environmental standards by reducing CO_2 emissions.

Autonomous ships are a new stage in the development of shipping, and classification societies play a key role in setting standards and certifying such vessels. DNV GL and Lloyd's Register are leading the way in creating rules for the certification of autonomous vessels that can operate without a crew or with minimal personnel. This includes remote control, automation and safety systems. As autonomous vessels depend on digital systems, cybersecurity becomes critical. Classification societies are assessing the resilience of such systems to cyberattacks and introducing new standards to ensure their safe operation (Aslam *et al.*, 2020). The introduction of autonomous vessels poses new challenges for classification societies, as these vessels require new approaches to safety assessment and technical surveillance. Classification societies are developing new standards for such vessels (Maritime autonomous surface ships, 2024), including requirements for navigation systems, cybersecurity, and control systems. Autonomous vessel technology is developing rapidly, leading to changes in approaches to maritime safety. Autonomous vessels can significantly improve the efficiency of shipping, but they also pose new threats, such as cybersecurity and the reliability of artificial intelligence systems.

Adapting standards for autonomous vessels is challenging, as these technologies significantly change traditional approaches to safety, navigation, and ship management. For the effective introduction of autonomous vessels into global shipping, classification societies, government agencies, and international organisations need to develop new standards that take into account the specific risks and challenges associated with autonomy (Shahbakhsh *et al.*, 2022). Autonomous vessels rely heavily on sophisticated navigation systems that include sensors, radar, Automatic Identification Systems (AIS), Global Positioning System (GPS), and artificial intelligence. These systems must operate without crew intervention and provide accurate and safe navigation. Standards should include requirements for redundancy of navigation systems so that if the primary system fails, the backup system can operate. Install systems to remotely monitor navigation data from shore-based control centres to support the autonomous vessel. Ensuring that mapping systems meet the highest standards of accuracy, including regular updates of navigation charts databases. One of the biggest risks to autonomous vessels is the threat of cyber hacking or cyberattacks that could disrupt control systems or affect navigation (Serra & Fancello, 2020). Autonomous vessels rely on connected systems that can be vulnerable to attacks. Introduce mandatory cybersecurity standards for autonomous vessels, including permanent data encryption, intrusion detection systems, and regular audits. Autonomous vessels should have redundant control systems isolated from external connections to maintain essential functions in the event of cyberattacks (Wiśnicki *et al.*, 2021). It is important to ensure that crew at shore-based centres and responsible professionals receive cybersecurity training to manage autonomous systems. Autonomous vessels use artificial intelligence (AI)-based control systems to make real-time decisions. These systems analyse information from navigation and sensor systems to ensure the safe movement of the vessel. Standards need to be established for testing AI systems to ensure their reliability and accuracy in different marine environments. This includes scenario modelling and stress tests to determine how AI systems react in challenging situations. For autonomous vessels, standards need to be in place for remote monitoring and intervention in the event of AI issues. This may include the ability to return control of the vessel to a shore-based centre in the event of an autonomous system failure. The standards should require transparency in the AI decision-making process to understand how the vessel will react to different situations. Adapting standards for autonomous vessels requires a comprehensive approach covering technical, legal, and cybersecurity aspects. Classification societies need to rethink traditional approaches to safety and technical surveillance, developing new standards that will ensure the safe and efficient operation of autonomous vessels in international waters.

These organisations actively cooperate with government agencies, international organizations and private companies to ensure that vessels meet modern safety requirements. Government authorities often involve classification societies in the process of developing and updating national standards and regulations for shipping safety. This applies

especially to new requirements related to innovative technologies and alternative energy sources. Classification societies carry out regular inspections and audits of ships in accordance with established state procedures. This ensures that ships meet safety requirements during their operation. Classification societies work closely with the IMO, and other international bodies that set global standards in shipbuilding and shipping. Classification societies are involved in the development of new standards and regulations within the IMO, such as the International Convention "On the Safety of Life at Sea"[1] and MARPOL[2]. Their expertise is important for the implementation of realistic and effective safety standards. The classification societies are members of working groups of the IMO and other international organisations that develop recommendations and practices for shipbuilding. For example, their involvement is essential in the development of standards for new types of ships, such as autonomous or electric ships. Classification societies work closely with shipbuilders, shipowners, and other commercial entities to implement safety standards, technical innovations and environmental requirements. Classification societies work with shipbuilding companies at the design and construction stage to ensure that projects meet international standards. They check technical specifications, structural safety and the correct installation of equipment. Private companies cooperate with classification societies in the development and certification of new technologies, such as hydrogen or LNG fuel systems, electric ships and autonomous control systems. The societies provide technical guidance and conduct tests to verify the reliability and safety of new technologies. Companies order certification of new vessels and equipment from classification societies to ensure that they meet international requirements. Such certification allows private companies to successfully operate their vessels on the global market.

Thus, classification societies play an important role in ensuring safety, certification, and innovation in shipbuilding and shipping. Their activities include assessing compliance with international standards and developing rules for the latest technologies, such as autonomous ships. Classification societies play a crucial role in ensuring that ships meet international safety standards and promote the introduction of the latest technologies in shipbuilding through cooperation with government agencies, international organisations and private companies. Through their certification, technical supervision and advisory mechanisms, they help to maintain a high level of safety globally and stimulate innovation in the shipbuilding industry.

The international maritime industry, including shipping and shipbuilding, is facing new challenges that require further development of existing standards. Current challenges include the introduction of autonomous vessels, increased environmental safety requirements, combating cyber threats and the integration of the latest technologies. International standards developed by the IMO and other regulators need to evolve to meet these new realities. The development of autonomous vessels will require updated standards that address safety, monitoring, cybersecurity, and liability in emergency situations. Existing standards are designed for crewed vessels, so new rules are needed for risk assessment and testing of autonomous systems. With the proliferation of digital technologies in shipping, cybersecurity is becoming a critical issue. Standards should provide comprehensive protection against possible attacks on navigation and control systems, including backup solutions to ensure the reliability of ships.

The IMO is already implementing emission reduction requirements including IMO (2020), but further standards should focus on promoting the use of renewable energy sources, the development of hydrogen, electric and other environmentally friendly technologies. Global efforts to decarbonize shipping will require the creation of new regulations to control emissions and promote environmental innovation (Hasanspahić *et al.*, 2020). Further development of international standards and innovations is critical for improving shipping safety and modernizing shipbuilding in Ukraine. Stimulating investment in the latest technologies, modernising infrastructure and working closely with international partners will allow Ukraine to achieve quality results in the global shipbuilding industry, meeting current challenges and trends.

Discussion

The present study allows us to trace trends in the development of shipping safety standards and their impact on the efficiency of shipping operations. It is important to note that international organisations, such as the IMO, are constantly updating safety regulations to reflect new challenges and technological advances. The article analyses the key aspects of interaction between national and international standards that ensure the safety of navigation. This includes a study of national legislative initiatives

[1] International Convention "On the Safety of Life at Sea". (1974, November). Retrieved from https://ips.ligazakon.net/document/MU74K04U.

[2] International Convention for the Prevention of Pollution from Ships (MARPOL). (1973, November). Retrieved from https://www.imo.org/en/about/Conventions/Pages/International-Convention-for-the-Prevention-of-Pollution-from-Ships-(MARPOL).aspx.

that adapt international standards to the specifics of local conditions, as well as the role of classification societies in monitoring compliance with these standards. This is important for understanding how innovative technologies, such as shipping automation and the use of artificial intelligence, can improve safety and efficiency. The study demonstrates how the latest technologies, including sensors and monitoring systems, can reduce accident risks and improve ship management. Studying these changes allows us to understand how the adaptation of international standards to new conditions can contribute not only to improving safety, but also to the development of the competitiveness of shipping companies in the global market. This is critical in the context of globalisation and economic integration.

In today's environment, shipping is undergoing significant changes under the influence of Digitalisation 4.0 technologies and new environmental requirements. Y. Ichimura *et al.* (2022) and A. Sepehri *et al.* (2022) highlight the need to adapt standards to support the industry in the face of digital transformation. These authors point out the importance of developing new criteria for risk assessment and integrating automated monitoring systems, which are essential elements of modern ship management. Countries should not only adapt their internal processes, but also actively cooperate with other market participants – shipowners, technology providers and government regulators. This may include joint research and development of new standards that take into account technological innovations and their impact on the safety and efficiency of shipping.

A study by S. Fu *et al.* (2022) supports this view by proposing a quantitative approach to accident cause analysis. This approach allows for better identification of the risks that accompany the introduction of new technologies and offers models for improving crew training and risk management. At the same time, studies by M. Kim *et al.* (2020) and S. Qazi *et al.* (2023) highlight the need to introduce new business models that consider the growing impact of autonomous technologies and electrification on shipping. Despite numerous studies, there are different approaches to addressing the challenges, which are not always consistent. A. Sepehri *et al.* (2022) highlight the importance of integrating automated systems for accident monitoring and prevention, but this model may be limited in the face of unpredictable weather events or technical failures. Classification societies should be prepared not only to implement new technologies, but also to ensure their smooth operation in the face of real risks, which are not always taken into account in theoretical models.

A study by Z. Tan *et al.* (2021) highlights the importance of emission control policies (ECA) in China, but demonstrates the challenges of enforcement as some ships try to avoid the requirements by using routes or less environmentally friendly fuels. This example highlights the need to integrate innovative monitoring technologies to help reduce non-compliance. This calls into question the general standards for environmental control, which may not be effective enough without proper support from technology. The findings, including the development of new standards for automated monitoring and control systems, are consistent with K. Liu *et al.* (2021) and S. Xu *et al.* (2021). These studies highlight the importance of introducing new risk assessment methods that take into account the impact of new environmental regulations. This will allow for better identification of potential risks associated with the electrification of ships and the introduction of new fuels such as LNG or hydrogen.

The innovations contribute to the integration of environmental standards into modern shipping, which is also supported by J.A. Felício *et al.* (2021), who highlight the impact of environmental practices on the sustainability of the industry. However, it should be recognised that technology cannot be a one-size-fits-all solution to all problems. For example, S. Yildiz *et al.* (2021) showed that the human factor remains a key element in cases of accidents. This means that even with the most advanced technologies, such as autonomous systems or automated control systems, human error is still a major source of risk. This requires not only technical innovations, but also improved training and staff development, as outlined by Y. Ichimura *et al.* (2022) and A. Sepehri (2022). S. Fu *et al.* (2022) also point out certain limitations of quantitative models describing accidents. Such models may not fully account for all external factors, such as changes in weather conditions, human factors or technical failures that are difficult to predict using statistical methods.

Classification societies need to take into account technological innovations and changes in global environmental policy. The introduction of standards for autonomous vessels, as noted by M. Kim *et al.* (2020) and S. Qazi *et al.* (2023), is an important step in the development of the industry. However, CSs should focus not only on standards, but also on staff training to support these technologies, as highlighted in many studies. In addition, it is necessary to intensify cooperation with other market participants – government regulators, shipowners, and technology providers – to develop standards that cover all aspects of shipping safety and efficiency. The findings are in line with those of M. Issa *et al.* (2019), who show that ship electrification can be an important factor in reducing emissions. In this context, classification societies should develop new standards not only to ensure the safe operation of such ships, but also to integrate automated monitoring and control systems

that can track environmental indicators, including greenhouse gas emissions.

Comparing different approaches to the adaptation of standards in the current environment, it can be concluded that the successful development of shipping requires the flexibility of classification societies to introduce new methods of risk assessment and technological innovations. Although technology plays a crucial role in improving safety, it cannot replace the human factor, which remains a key element in accident prevention. The results complement the research of other authors, demonstrating that the successful integration of new technologies in shipping depends on the ability of classification societies to adapt to change and create new standards for ships with alternative energy sources, emission monitoring systems and automated control systems. In addition, it is important to improve the skills of personnel and cooperate with other market participants to develop new technologies that will make the industry more sustainable and environmentally friendly.

Conclusions

The study analysed the main international and national safety standards, their impact on shipbuilding, and the role of classification societies in ensuring these standards. It also examines how modern technologies, including automation and digitalisation, are changing approaches to safety in shipping. The results show that the integration of the latest technologies into shipbuilding and operation processes significantly increases the level of safety and efficiency of maritime transport. International standards, such as the International Convention "On the Safety of Life at Sea" and MARPOL conventions and the rules developed by the IMO, are the basis of the global shipping safety system. Their alignment with national standards ensures an adequate level of protection of human life, property, and the environment.

The findings confirm that international and national safety standards are critical to ensuring the safety of shipping, especially in the context of globalisation and rapid technological development. The importance of these standards lies in the fact that they not only help to reduce the risks associated with accidents, but also ensure the competitiveness of shipping companies in the global market. Classification societies are important entities that provide an independent assessment of the condition of ships and their compliance with international safety standards. The main functions of classification societies include inspection and certification of ships, and providing technical advice on the latest technologies and innovations in shipbuilding, such as alternative fuels and autonomous vessels. Their contribution to maintaining a high level of safety is critical in the face of rapid technological change. International Convention "On the Safety of Life at Sea" standards are not sufficient to ensure environmental sustainability in the construction of new ships, while EU standards are more focused on reducing negative environmental impact. To achieve greater environmental friendliness in shipbuilding, it is necessary to integrate these two approaches, updating and adapting international standards to modern environmental challenges.

In the near future, shipping safety standards will be adapted to new challenges such as climate change, cyber threats and new types of cargo. Innovations in shipbuilding, such as the development of autonomous ships and green technologies, will require updating both international and national standards. International organisations, such as IMO, together with classification societies, should be actively involved in the development of these new standards, ensuring that innovations are aligned with safety requirements to maintain a high level of shipping safety worldwide. Promising areas for further research in this area may include a deeper study of the impact of environmental standards on shipbuilding, as well as the development of new approaches to safety that would take into account changes in the global environment. In particular, researchers should pay attention to the integration of artificial intelligence into ship safety monitoring systems and their potential impact on shipping safety.

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Conflict of Interest

None.

References

[1] Aneziris, O., Gerbec, M., Koromila, I., Nivolianitou, Z., Pilo, F., & Salzano, E. (2021). Safety guidelines and a training framework for LNG storage and bunkering at ports. *Safety Science*, 138, article number 105212. doi: 10.1016/j.ssci.2021.105212.

[2] Aslam, S., Michaelides, M.P., & Herodotou, H. (2020). Internet of ships: A survey on architectures, emerging applications, and challenges. *IEEE Internet of Things Journal*, 7(10), 9714-9727. doi: 10.1109/jiot.2020.2993411.

[3] Baumler, R., Arce, M.C., & Pazaver, A. (2021). Quantification of influence and interest at IMO in maritime safety and human element matters. *Marine Policy,* 133, article number 104746. doi: 10.1016/j.marpol.2021.104746.

[4] Chu, K.H., Papaioannou, M.G., Chen, Y., Gong, X., & Ibrahim, I.H. (2023). Techno-regulatory challenges for remote inspection techniques (RIT): The role of classification societies. In *Smart ports and robotic systems* (pp. 305-326). New-York: Springer International Publishing. doi: 10.1007/978-3-031-25296-9_16.
[5] Felício, J.A., Rodrigues, R., & Caldeirinha, V. (2021). Green shipping effect on sustainable economy and environmental performance. *Sustainability*, 13(8), article number 4256. doi: 10.3390/su13084256.
[6] Fu, S., Yu, Y., Chen, J., Xi, Y., & Zhang, M. (2022). A framework for quantitative analysis of the causation of grounding accidents in arctic shipping. *Reliability Engineering & System Safety*, article number 108706. doi: 10.1016/j.ress.2022.108706.
[7] Hasanspahić, N., Vujičić, S., Čampara, L., & Piekarska, K. (2020). Sustainability and environmental challenges of modern shipping industry. *Journal of Applied Engineering Science*, 19(2), 369-374. doi: 10.5937/jaes0-28681.
[8] Ichimura, Y., Dalaklis, D., Kitada, M., & Christodoulou, A. (2022). Shipping in the era of digitalization: Mapping the future strategic plans of major maritime commercial actors. *Digital Business*, 2(1), article number 100022. doi: 10.1016/j.digbus.2022.100022.
[9] IMO. (2020). *Global limit on sulphur in ships' fuel oil reduced from 01 January 2020*. Retrieved from https://www.imo.org/en/MediaCentre/PressBriefings/pages/34-IMO-2020-sulphur-limit-.aspx.
[10] Issa, M., Ibrahim, H., Ilinca, A., & Hayyani, M.Y. (2019). A review and economic analysis of different emission reduction techniques for marine diesel engines. *Open Journal of Marine Science*, 9(3), 148-171. doi: 10.4236/ojms.2019.93012.
[11] Issa, M., Ilinca, A., Ibrahim, H., & Rizk, P. (2022). Maritime autonomous surface ships: Problems and challenges facing the regulatory process. *Sustainability*, 14(23), article number 15630. doi: 10.3390/su142315630.
[12] Joseph, A., & Dalaklis, D. (2021). The international convention for the safety of life at sea: Highlighting interrelations of measures towards effective risk mitigation. *Journal of International Maritime Safety, Environmental Affairs, and Shipping,* 5(1). doi: 10.1080/25725084.2021.1880766.
[13] Kim, M., Joung, T.-H., Jeong, B., & Park, H.-S. (2020). Autonomous shipping and its impact on regulations, technologies, and industries. *Journal of International Maritime Safety, Environmental Affairs, and Shipping*, 4(2), 17-25. doi: 10.1080/25725084.2020.1779427.
[14] Liu, K., Yu, Q., Yuan, Z., Yang, Z., & Shu, Y. (2021). A systematic analysis for maritime accidents causation in Chinese coastal waters using machine learning approaches. *Ocean & Coastal Management*, 213, article number 105859. doi: 10.1016/j.ocecoaman.2021.105859.
[15] Maritime autonomous surface ships. (2024). Retrieved from https://britanniapandi.com/2024/07/maritime-autonomous-surface-ship-trials/.
[16] Melnyk, O.M., Shcherbina, O.V., Mykhailova, I.V., Obnyavko, T.S., & Korobko, T.O. (2023). Focused research on technological innovations in shipping industry: Review and prospects. *Transport Development*, 1(16), 164-174. doi: 10.33082/td.2023.1-16.13.
[17] Norway to build the world's first ships to transport CO2 captured from the atmosphere. (2024). Retrieved from https://mind.ua/news/20232173-norvegiya-pobudue-pershi-v-sviti-sudna-yaki-perevozitimut-vilovlenij-z-atmosferi-co2.
[18] Nwokedi, T.C., Akpufu, I.D., Ndikom, O.B., Mbachu, J.C., Anyanwu, C.E., & Daniel, B.O. (2023). Periscoping performance of classification societies in maritime safety from the prism of the Abuja MoU on port states control. *Maritime Technology and Research*, 5(2), article number 260788. doi: 10.33175/mtr.2023.260788.
[19] Qazi, S., Venugopal, P., Rietveld, G., Soeiro, T. B., Shipurkar, U., Grasman, A., Watson, A.J., & Wheeler, P. (2023). Powering maritime: Challenges and prospects in ship electrification. *IEEE Electrification Magazine*, 11(2), 74-87. doi: 10.1109/mele.2023.3264926.
[20] Sepehri, A., Vandchali, H.R., Siddiqui, A.W., & Montewka, J. (2022). The impact of shipping 4.0 on controlling shipping accidents: A systematic literature review. *Ocean Engineering*, 243, article number 110162. doi: 10.1016/j.oceaneng.2021.110162.
[21] Serra, P., & Fancello, G. (2020). Towards the IMO's GHG goals: A critical overview of the perspectives and challenges of the main options for decarbonizing international shipping. *Sustainability*, 12(8).
[22] Shahbakhsh, M., Emad, G.R., & Cahoon, S. (2022). Industrial revolutions and transition of the maritime industry: The case of Seafarer's role in autonomous shipping. *The Asian Journal of Shipping and Logistics*, 38(1), 10-18. doi: 10.1016/j.ajsl.2021.11.004.

[23] Tan, Z., Liu, H., Shao, S., Liu, J., & Chen, J. (2021). Efficiency of Chinese ECA policy on the coastal emission with evasion behavior of ships. *Ocean & Coastal Management*, 208, article number 105635. doi: 10.1016/j.ocecoaman.2021.105635.
[24] Wiśnicki, B., Wagner, N., & Wołejsza, P. (2021). Critical areas for successful adoption of technological innovations in sea shipping – the autonomous ship case study. *Innovation: The European Journal of Social Science Research*, 37(2), 582-608. doi: 10.1080/13511610.2021.1937071.
[25] Xu, S., Kim, E., & Haugen, S. (2021). Review and comparison of existing risk analysis models applied within shipping in ice-covered waters. *Safety Science*, 141, article number 105335. doi: 10.1016/j.ssci.2021.105335.
[26] Yildiz, S., Uğurlu, Ö., Wang, J., & Loughney, S. (2021). Application of the HFACS-PV approach for identification of human and organizational factors (HOFs) influencing marine accidents. *Reliability Engineering & System Safety*, 208, article number 107395. doi: 10.1016/j.ress.2020.107395.

Актуальність міжнародно-правових і національних стандартів безпеки судноплавства та роль класифікаційних товариств у контексті сучасних викликів та інновацій у суднобудуванні

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■ **Анотація.** Актуальність міжнародно-правових і національних стандартів безпеки судноплавства зростає у зв'язку із сучасними викликами, такими як інновації в суднобудуванні, зміни клімату та підвищення вимог до екологічної безпеки, що підтверджує важливу роль класифікаційних товариств у цьому процесі. Метою роботи був аналіз впливу міжнародних і національних стандартів безпеки на сучасне суднобудування та оцінка ролі класифікаційних товариств у забезпеченні безпечної експлуатації суден. У дослідженні застосовано методи системного аналізу, порівняльного правознавства та емпіричного моделювання. Основними результатами роботи стало встановлення необхідності подальшої гармонізації міжнародно-правових стандартів з національними вимогами, удосконалення ролі класифікаційних товариств у моніторингу інновацій у суднобудуванні, а також формулювання пропозицій щодо підвищення екологічної безпеки судноплавства. Крім того, у роботі виявлено перспективи використання новітніх технологій для покращення стандартів безпеки в морському транспорті. Зокрема, акцентовано увагу на ролі класифікаційних товариств у забезпеченні відповідності суден цим стандартам, а також на їхньому внеску у впровадження інновацій у суднобудуванні. Дослідження містить аналіз сучасних нормативних актів і стандартів, що регулюють безпеку судноплавства, а також випадків їх реалізації на практиці. Визначено ключові зміни у вимогах до безпеки суден з огляду на сучасні ризики, зокрема екологічні виклики та підвищені вимоги до якості. Практична цінність роботи полягає в можливості використання отриманих результатів як нормативно-правовими органами, так і суднобудівними підприємствами для вдосконалення внутрішніх стандартів безпеки та підтримки міжнародної сертифікації

■ **Ключові слова:** технологічні інновації; автономне судноплавство; екологічні норми; інтеграція; стандарти