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LEONARD HEMPEL*, JERZY KREFFT*

The analysis of hazardous events during tankers operations

Key words

Hazardous events, safety, vessels, tankers, service, maintenance.

Słowa kluczowe

Zdarzenie niebezpieczne, bezpieczeństwo, statki, zbiornikowce, eksploatacja.

Summary

Shipping companies make use of safety management systems that result in better safety for workers, vessels and cargo. At present, in spite of mandatory use, these systems do not result in the considerable increase of the safety level. One of the reasons can be the lack of feedback between ship designers and the operators who are the crew of the vessel. Results of detailed analysis of hazardous events can be a correct feedback on the way to improve the safety level. Only a systematic analysis of these events enables identification of a safety onboard detection system, the detection of system faults and taking steps to minimise the risk level in the work system. The data concerning hazardous events are kept in many existing safety management systems, but "no systemic" way of presenting the hazardous events allows taking considerable steps to improve safety. To prove the above mentioned condition, the analysis of hazardous events in the BP Shipping company was carried out on the basis of the bulletins delivered to the crews of BP vessels. Only when the data from bulletins are properly processed, is it possible to take steps toward improving the safety level onboard that is, for instance, an improvement of the communication system and the identification of the most dangerous areas on-board the ships that can be different on different types of the ships. Referring to the analysis of the hazardous

* Gdynia Maritime University, Faculty of Marine Engineering, Morska 83 Str., 81-225 Gdynia, tel. 058 690 13 47, fax 058 690 13 99.

events which was carried out, it has been observed that there is a risk of a rise in the number of hazards on the commercial ships in the next few years. That likelihood is based mostly on the regulations in use and the decrease in the number of the crew who must carry out more planned maintenance works (PM's) and more duties. The labour and education situation allows employing the minimum number of crew that is required by regulations, very often with insufficient knowledge, especially for the specialised types of ships. The analysis seems to be a very important study from the point of view of safety of life at sea.

1. Introduction

Safety is a crucial factor when shipping crude oil and its products, liquefied gases such as LPG and LNG, etc. Tankers can becomes a source of energy with a potential likelihood of its rapid release and/or dangerous pollution of the environment. Therefore, the captain and the crew must be aware of the flammable features of the substances carried and must properly assess the requirements of safe work during shipment and handling operations. Figure 1 shows the most frequent hazardous events in relation to the vessel type. It appears that the biggest risk among the other hazardous events is fire. The greatest number of fires occurs on tankers compared to bulk carriers and container vessels.

The rules of safety practices on tanker vessels carrying crude oil have been worked out by J.K.Włodarski [2]. The information presented in his work [2], concerning safe behaviour on tankers, is valuable, because it results from the regulations, theory and service experience. These rules raise awareness and draw attention to the risks that await seamen during handling hydrocarbon compounds.

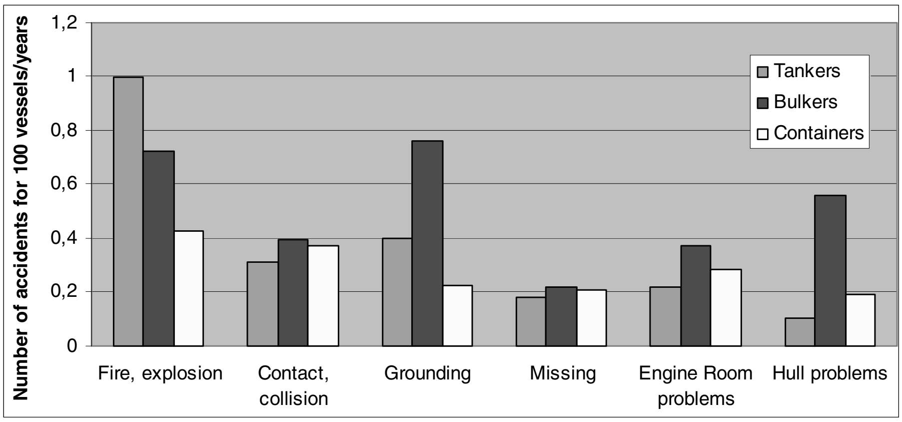

Fig. 1. Types of hazardous events in relation to vessel type [1]
Rys. 1. Rodzaje awarii w zależności od typu statku [1]

The most important premise for safety management can be Mr. A. Brandowki's assumption [3], claiming that the feeling of safety belongs to the most basic human needs.

The formation of conscious human behaviour in the work process, especially as far as work safety and hygiene are concerned, has a considerable influence on working conditions. The results of numerous research studies indicate that, in spite of the improvement of working conditions at sea, the human factor is still the most frequent reason for accidents onboard ships (see Figure 1).

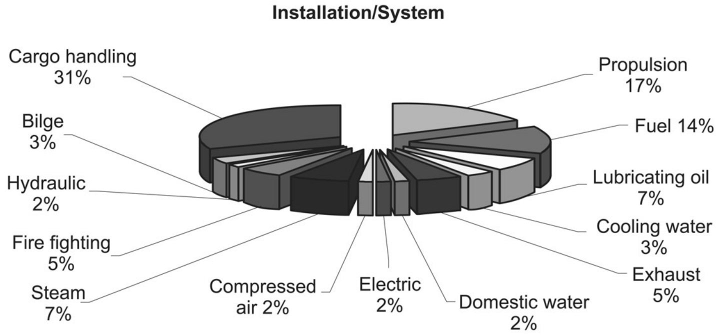

Fig. 2 Main causes of accidents on ships [1]
Rys. 2. Podstawowe przyczyny wypadków na statkach

S. Kristiansen [4] states that in 2000 the human factor was the reason for 70% of the accidents on vessels, where "accident" is understood as each unpleasant event leading to injury, according to R. Studenski [5].

One of the elements limiting the risk and the number of accidents is the application of properly formalised procedures making it possible to minimise the risk and support decision making.

Risk is considered to be a function of the likelihood of adverse results of hazards and their level of severity [6]. In fear of improper management standards and human errors, International Safety Management (ISM) regulations have been introduced in shipping. These regulations are directed to maritime crews and persons handling the ship and not signed onto a vessel. ISM code should be understood as an international code of managing ship operation and preventing sea pollution [7].

The direct reason for creating this code was a series of severe accidents at sea caused by human errors including errors at management level. Therefore, the basic task of the code is to ensure safety at sea, understood as prevention of ill-fated events with the loss of life and maritime environment protection. Procedures required by ISM Code and implemented by ship owners must be kept in writing on every cargo vessel. At present, each ship owner has appropriate procedures required by the code. Many ship owners provide training concerning accidents and hazardous events on their vessels as well as others, as part of a safety management system.

2. Source of study

British Petroleum Shipping distributes bulletins [8] containing information about accidents on vessels to the crews of its tankers. Each case is thoroughly described and sent to all vessels. Apart from the statistical data concerning the events, their causes and effects are worked out. The crews are obliged to put their signatures to this document, to confirm familiarisation with the description. Thanks to this procedure, the following rule is applied: We are learning from others' mistakes, as experiencing hazardous events personally can be the most difficult and the most expensive tuition.

Informative bulletins have been treated by the authors of this article as the source of expertise in hazardous events onboard tankers.

These bulletins contain descriptions of the accidents taking place during over 40 years of maritime activities of BP Shipping. The events mentioned led to injuries and even deaths, damages to the machinery and devices as well as damage to the vessels and consequently the pollution of environment.

The research carried out deals with ships managed by BP Shipping. Their fleet comprises mainly Suezmax tankers, Aframax tankers, VLCC, chemical-product tankers, LNG and LPG carriers. The examined group of vessels, where the incidents of safety regulations violation and body or ship damages occurred, included crud oil tankers and product tankers. 87 events within the years 1967-2006 were analysed. 72 of the events were described in the informative bulletins of BP Shipping, and 15 cases belong to the service experience of the last few years of one of the authors. During some years of working for BP Shipping, the author observed several events and damages to machines and devices which could have been prevented and whose main cause was recklessness or low professional skills of the people employed. These events have not been included in the bulletins.

The analysis of events that took place during such a long period of time may seem pointless, considering the constant technological progress. The reason for choosing this time span was justified by the frequency of the occurrence of accidental events (see Fig. 1) and the availability of case descriptions included in bulletins and current relevance of the events described.

3. Methodology of reports evaluation

The vessel's crews receive the bulletins that contain information about accidents and hazardous events. Anyone who receives the reports must have the suitable experience on the tankers to understand the content. It requires basic knowledge from different scientific fields, such as operation, safety, ergonomics, etc, to analyse the safety conditions of such a complicated human engineering system as ships. The given filter must be used to get the correct information from bulletins. Thus, an appropriate created structure was performed as a given filter, where all the reports about events were moved.

The rows were filled with particular operational events, while the columns, being arranged according to the operating system, were filled with the data analysed. This structure served for multi-criteria assessment of the reports' content and was the basis for the analysis of various safety aspects onboard the examined ships. The structure consisted of 7 sheets, and the content has been presented in Table 1.

Table 1. Sheets content for analysing safety on board
Tabela 1. Zawartość arkuszy analizujących bezpieczeństwo na pokładzie

No.1 Sheet. System: Main-Technical Unit-Close Environment
Sheet consists of data for study system as a whole. These include: study goal, type and name of the vessel, ships age, year of build, manager, operation condition while the hazardous event took place.
No. 2 Sheet. Subsystem: Man
The sheet is used to record the data about people participating directly in the hazardous event. There are following data: age, professional experience, education level, rank, rank certificates, carried out maintenance procedure, type of committed error.
No. 3 Sheet. Subsystem: Technical Unit
Sheet includes data about technical unit that was placed in the area of the hazardous event. Data concern: type of unit, basic unit parameters, type of system/installation where the unit is placed, the given ship area, type of error as a reason for hazardous event, type of excess safety.
No. 4 Sheet. Subsystem: Close Environment (labour environment)
Sheet refers to the most important data about close proximity of hazardous event. It determines: properties such as physical, chemical and biological, workstation spatial features, workstation organisation, team organisation structure and its management, human team intercourse, labour system.
No. 5 Sheet. Main hazardous assessment
It includes data about dangerous factors
No. 6 Sheet. Hazardous event course
Concerns: event model, man as a hazardous event participant, hazards types, direct events causes, events effects, injury type, man participation as part of active safety (prevent), man participation as part of passive safety (protect), man participation as part of after event safety (rescue).
No. 7 Sheet. Conclusions and comments concerning hazardous event
It provides schematic way to reconstruct a sequence of hazardous events, with particular attention to the chain of causation.

Taking into consideration the fact that bulletins are a written description of a hazardous event, not a statistical case study or an accident report, some data was simply unattainable.

In spite of this drawback, it was possible to get a number of relevant data allowing the analysis of the safety system as well as checking the accuracy of the method employed for the research.

4. Analyses results

Only selected results have been presented due to having study bulletins and the data structure.

4.1. Operation condition of the ship

Analysing the general operating condition, when the safety rules and the industrial safety violation occurred, it appears that the largest number of events, that is 78%, took place during sea service of the vessel. 13% of events occurred during planned overhaul activities carried out by the ship crew or shipyard staff. The lowest number of cases, that is 9%, happened during the process of transferring media, machinery or spare parts on board.

4.2. Location of hazardous events occurrence on examined ships

When analysing the vessel as a human engineering system, it is necessary to pay attention not only to the human but to the technical object as well, with its components and parameters. As far as the vessels analysed are concerned, the hazardous events took place on deck (60%), in the engine room (37%), and in the pump room (7%). Most events dealt with the cargo handling installations (31%). The second most frequent hazardous event was ship propulsion system (17%). The frequency of hazardous events in the remaining systems was similar (Fig.3).

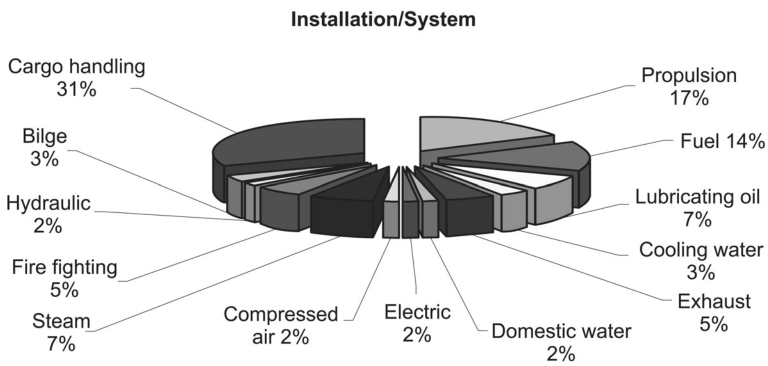

Fig. 3. Frequency of hazardous events occurrence in particular installations
Rys. 3. Częstość występowania zdarzeń niebezpiecznych w poszczególnych instalacjach

It might prove interesting to answer the following question: What system components took part in hazardous events most often? The results obtained are shown in Fig.4. Among the 10 most liable hazards related to machines and technical devices of the engine room and the ship, the hazardous events most often applied to the tanks (30%) and the main engine (19%). Besides, 8 to 12% of events concerning pumps, generator sets, fittings, cranes and winches were also noted.

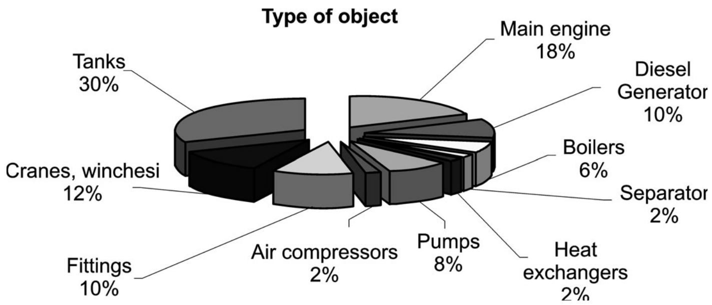

Fig. 4. Technical objects taking part in hazardous events
Rys. 4. Obiekty techniczne uczestniczące w zdarzeniach niebezpiecznych

The data available enabled the assessment of only three parameters of technical objects, which were the direct cause of a hazardous event. These include the following: working medium pressure (60%), increased temperature (37%), and exceeded object efficiency in a given moment of service (3%).

4.3. Human role in hazardous events and accidents

68% of the analysed events happened without the part of a man, during 27% of events – one person was injured, the group accident occurred in 4% of events, whereas fatal consequences happened in 11% of events (Fig. 5).

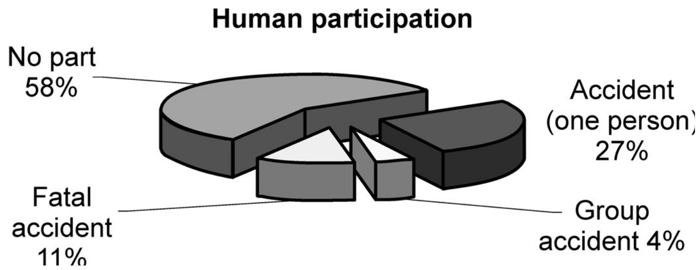

Fig. 5. Participation of man in hazardous events and accidents
Rys. 5. Udział człowieka w zdarzeniach niebezpiecznych i wypadkach

During accidents on board vessels, man was usually hurt by an impact (52%), crushing (18%), cutting (12%), and injured as a result of liquid outflow at high pressure (18%).

As it was mentioned before, the main cause of hazardous events on board ships is the human factor (70%). In the research, various types of human errors were established and presented in Fig. 6. The number of errors made exceeds the number of events due to the fact that many events were caused by a few errors. The following errors were repeating in hazardous events: improper supervision (29%), improper execution of duties (27%), and not fulfilling duties (17%). These statistics prove the opinion mentioned in [4] that the majority of accidents at work are caused by negligence and recklessness of a man. Unfortunately these errors often refer to officers.

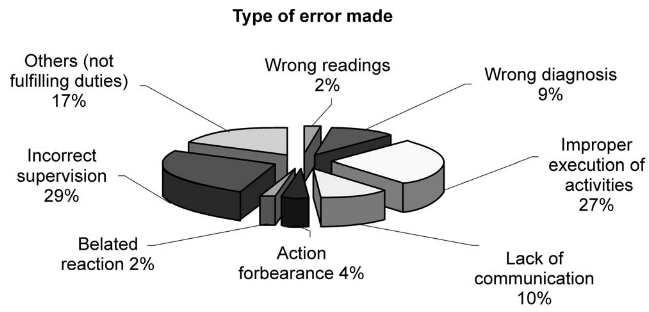

Fig.6. Most frequent errors made by people
Rys. 6. Najczęściej popełniane błędy przez człowieka

4.4. The role of work environment in hazardous events

Another element of the human engineering system, which was the subject of research, is the work environment (close surroundings). Attempts have been made to determine the places on board vessels and the frequency of hazardous events and accident occurrence. 86% of events took place independent of the work system on the ship, that is the watch keeping system or unmanned machinery space (UMS), that is work without supervision. The most frequent reasons of hazardous events were three maintenance activities: supervision (22%), transportation (22%), and inspection (19%) (Fig. 7).

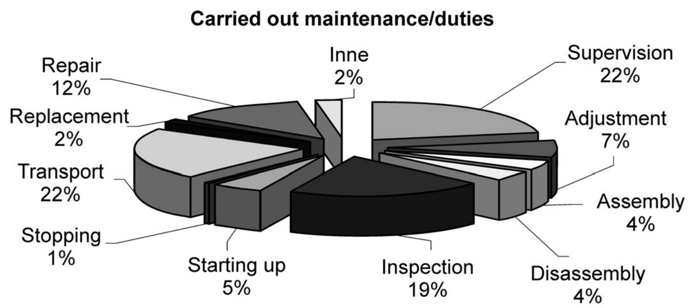

Fig. 7. Maintenance activities during which errors were made
Rys. 7. Operacje eksploatacyjne, podczas których popełniono błędy

A large number of accidents during supervision and inspection are related to the position of the persons who caused the events presented in Fig. 8. Over 65% of the people involved in the hazardous events or accidents or the perpetrators belong to the deck department officers of the management level (20%), of the operation level (25%), and also to the engine room department officers of management level (5%), and operation level (17%).

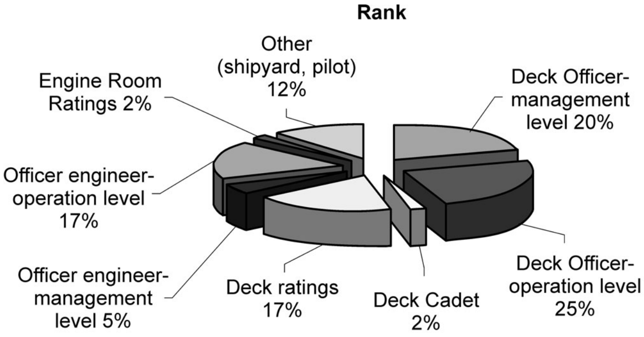

Fig. 8. Position of the people involved in hazardous events
Rys. 8. Pozycja ludzi podczas zdarzeń niebezpiecznych

On the vessels examined, the frequency of hazardous events occurrence reached 55% for the deck department, where 26% happened on the deck, 12% in the hull, and 11% in the superstructure and on the bridge. As far as the engine room space is concerned, the largest number of events was reported on the bottom level (13%), and the middle level (18%), and in the surrounding of the main engine and diesel generators (Fig. 9).

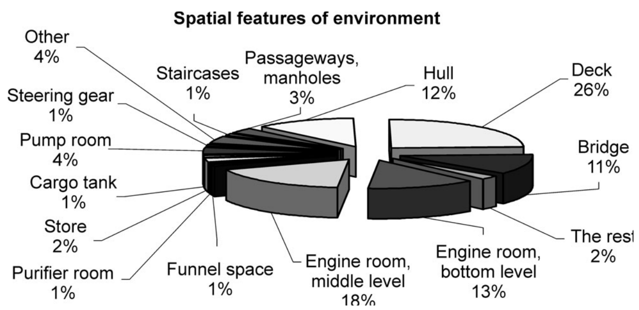

Fig. 9. Frequency of hazardous events occurrence in various places
Rys. 9. Częstość występowania zdarzeń niebezpiecznych w różnych miejscach

Work environment is created by different factors and conditions. The available data enabled the determination of their influence on the events being the subject of the analysis. These events are most often affected by high temperature (56%), gases/vapours (43%), and fuels (33%). The influence of chosen mechanical factors was shown in Figure 4.10. It appears that the greatest risk is created by liquids under pressure (29%) as well as transported parts (20%). Considerable hazard is also created by hot surfaces (15%), moving machine parts (14%), and falling objects (13%).

5. Summary

1. The frequency of hazardous events and accidents must be referred to duration of the analysed ships operations. 13% events took place during manoeuvring, 9% events during supply operations, 13% events, while planned maintenance make a relatively high number of reported events.
2. A relatively high number of events during the process of transferring media, machinery or spare parts, on board require improvement to given procedures, i.e. there ought to be a member of the ships crew for the supplying unit to improve communication and enhance safety.
3. The high frequency of accidents among ratings (17%) can result from the situation on the work market. Seamen with low qualifications and poor experience very often find their jobs on board vessels with considerable risk to safety.
4. The significant number of errors made by people on the vessels examined is said to be due to the following:
   - A high level of fatigue, which results from the constant reduction in the number of crewmembers and the gradual increase of duties arising from international and local regulations. Officers of the management level are more and more burdened with office work (reports, certificates, inspection lists, etc.) neglecting duties of direct supervision of the subordinate department.
   - The lack of the sense of responsibility. Frequent lack of supervision by the officers can serve as a good example.
   - The lack of the predicting ability, which is proved by errors made during repairs of system breakdowns and the reason for alarms. It is common to remove the effects forgetting about the reasons.
   - The lack of proper qualifications and experience. A great number of officers undergo accidents or cause them. The officers instead of initiating and supervising the work of the subordinates, often perform the jobs by themselves. The shortage of officers, observed nowadays, can lead to the limitation of professional requirements for people taking positions at both the operation and management level. There is a severe fear for the increase of hazardous events in the very close future if proper steps are not taken.

The performed study proves the necessity of constant analysis, inspection and introduction of new and more advanced procedures. The authors suggest bringing in obligatorily and simultaneous work-time control systems in the worldwide fleets of ships similar to that already used in road transport.

5. The large number of errors related to communication and the ways of transferring information indicates the disrespect for the important role of the informative load for safety.
6. Many facts observed during the analysis raise the following question: Are the currently binding Conventions concerning work safety at sea well adapted for the needs of safety system and its management? It is important to remember that the safety improvement is an iterative process. Therefore, the existence of feedback is crucial in the methodology of safety improvement. It is characteristic for bulletins to include incomplete descriptions of accidents. We propose to launch the full model account of the hazardous events that occurred.
7. Shipping companies aspire to the improvement of safety conditions onboard vessels in many ways, within the scope of the existing regulations. For example, BP Shipping introduced an additional function for the safety officer in engine room department, which is performed by the third engineer and whose behaviour is to promote a safe approach to work. In Single Buoy Mooring Company (SBM), people who start working for the company, irrespective of their qualifications and experience, have to wear a green helmet that stands out from all the other crewmembers.
8. The analysis presented above can be the proper tool for the identification of hazardous areas, which is the first step in the methodology of Formal Safety Assessment. (FSA) [4].
9 The study that has been carried out in this article confirmed the usefulness of the worked-out methodology (7 sheets). Further study will also concern collecting reports of the hazardous events from different ship companies to develop the authors' method and statistics.

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Analiza zdarzeń niebezpiecznych na obiektach oceanotechnicznych na przykładzie zbiornikowców

S t r e s z c z e n i e

W przedsiębiorstwach żeglugowych istnieją systemy zarządzania bezpieczeństwem, które mają na celu zwiększenie bezpieczeństwa ludzi, statku i przewożonego ładunku. W chwili obecnej, pomimo ich obligatoryjnego wprowadzenia, systemy te nie skutkują znacznym wzrostem poziomu bezpieczeństwa. Jedną z przyczyn tego niekorzystnego stanu może być brak odpowiedniego sprzężenia zwrotnego pomiędzy projektantami a użytkownikami statków. Takie sprzężenie mogą stanowić wyniki szczegółowej analizy zdarzeń niebezpiecznych. Tylko systemowa analiza tych zdarzeń pozwala na identyfikację stanu bezpieczeństwa, wykrywanie błędów w systemie oraz podjęcie działań zmniejszających zagrożenia w systemie pracy. W wielu istniejących systemach zarządzania bezpieczeństwem gromadzi się dane o zdarzeniach wypadkowych i niebezpiecznych, ale ich niesystemowy sposób przedstawiania nie pozwala na podjęcie skutecznych kroków zmierzających do poprawy. Potwierdzeniem tego może być analiza zdarzeń niebezpiecznych w przedsiębiorstwie żeglugowym BP Shipping przeprowadzona na podstawie biuletynów dostarczanych załogom swoich statków. Dopiero odpowiednia obróbka danych zawartych w biuletynach umożliwia uzyskanie informacji pozwalających na podjęcie działań poprawiających stan bezpieczeństwa. Na przykład propozycja zmian niektórych procedur działania, poprawa informacyjności systemu, identyfikacja obszarów niebezpiecznych na statkach. Zwrócono uwagę na duże prawdopodobieństwo wzrostu wypadków w najbliższych latach na statkach floty handlowej. Główną przyczyną może być wzrost liczby zadań eksploatacyjnych wykonywanych przez członków załogi statków oraz sytuacja, jaka wytworzyła się na rynku pracy. Coraz większa liczba statków jest eksploatowana, a coraz mniej osób kształci się w zawodach związanych z morzem. Wydaje się, że poniższe opracowanie jest bardzo istotne z punktu widzenia bezpieczeństwa życia na morzu i ochrony środowiska przed zanieczyszczeniem.