Available online at www.elixirpublishers.com (Elixir International Journal)

Social Science

Elixir Soc. Sci. 67 (2014) 21194-21197

ISSN: 2229-712X

Identification and classification of commonly prevalent errors in operational shipping practices: A study based on literature review

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ARTICLE INFO

Article history:

Received: 3 December 2013;
Received in revised form:
20 January 2014;
Accepted: 31 January 2014;

Keywords

Shipping,
Safety,
Prevention,
Procedures.

ABSTRACT

Modern shipping, with increased number of vessels, faster, more sophisticated, expensive, specialized, complex operation, governed by comprehensive rules and regulations as per national and international authorities, is a vital industry carrying 90% of world trade. Although modern technology and modern navigation equipments contributed more efficient marine transportation than before but injury and fatality statics indicate that shipping remains a high risk industry. This study outlines the classification, types and commonly prevalent errors in shipping operations. Study concludes that qualification, training and development of crew members as one of the key concerns in the effort to achieve higher safety standards aboard ship.

Introduction

An error is an action or lack of action that violates some tolerance limits of the system and can be defined as deviation from accuracy or correctness. Human errors are the basic cause of failure in many engineered systems (such as Bhopal and Chernobyl systems). Every human error is a determining condition for the intensity of accident. In maritime business, the human errors add to the chain of events for occurrence of disasters. Therefore, to achieve greater marine safety such human errors need to be noticed and corrected.

According to sources, 80% of maritime accidents are due to human error. In a study by the UK P&I Club, out of the total claims 62% were attributable to human error. The ISM Code and STCW 95 are the result of IMO's commitment to addressing the human element in all aspects of maritime industry. Over the past years, the shipping industry, around the world, focused on improving ship structure and the reliability of ships systems in order to reduce casualties and increase efficiency and productivity with significant improvements in hull design, propulsions and navigational equipments. Ship system, today, is technologically advanced and highly reliable.

Classification of errors

Human errors

Human error is defined as "an action or omission as the immediate cause of the event from which liability arises" (UK P&I Club). It can also be defined as "a departure from acceptable or desirable practice on the part of an individual that result in an unacceptable or undesirable results" (ABS). The UK P&I Club's previous studies show that only 12% of their marine casualty claims were the result of structural failure. Though mechanical and equipment failures account for another 16% of claims, many of these can be attributed to failures in maintenance and upkeep, which are rooted in human and organizational errors. Human errors may range from violations to lack of adequate experience, training and knowledge. These errors are magnified and compounded on times of stress and panic. Human performance levels vary among individuals depending on training, variability among individuals, organizational pressure, and system complexity. Performance deteriorates when pressure levels are either too low or too high. In addition, errors are influenced by cultural and moral values, management responsibilities, individual training and integrity.

Organizational errors

Analysis of past decisions regarding marine system operations provide numerous examples of organizational deficiencies which resulted in marine system failures (e.g. Exxon Valdez, the Braer, Ocean Ranger, etc). In ships, various components of organizational errors may occur because of the incompatibility at the level of collections of individuals at organization and society, individuals in unilateral actions, organizational or individual willingness to take calculated risks, organizational goal setting etc. Similarly other sources of errors can be at the level of corporate management who may not provide resources required to promote safe operations because of under pressure to reduce costs and maintain schedules. Failure can also occur as a result of errors or bad decisions, most of which can be traced back to problems at the management level. The structure, procedure and culture of an organization also contribute to the safety of ship operations and economic efficiency and risk management practices.

Categories of human errors

Human errors may occur due to execution failures and are commonly termed as slips, lapses, trips, or fumbles. The basic error types are:

Slip

Slips are errors in execution or actual behavior, fails to conform to the intention or plan. This problem may occur at stage of the processes. Slips or lapses occur during the execution of routine, well-practiced tasks in familiar surroundings in which the individual actions are controlled in a largely automatic fashion. In other words, the execution failures typically occur at the skill or rule based level of performance.

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Skill-based slips

The skill-based level of performance is related to actions that have been done many times, typically on a daily basis over a period of many years. Skill-based performance is usually related to manual manipulation. Typing is a good example of skill-based behavior where skill-based mistake is to type an incorrect letter. This is an example of "fat-fingering" with computer professionals.

Rule-based slips

The rule-based level of performance is characterized by tasks for which training, experience or procedures have provided ready-made solutions or 'rules'. Rule-based slips are typically the result of failing to properly follow the established rules.

Various types of errors, under skill based and rule based, can be identified as follows:

Skill based error - Improper checking of instrument reading.

Decision error - Wrong response on an emergency fire alarm.

Routine violation - Failing to adhere to safety maneuvering procedures.

Exceptional violation - Unauthorized anchoring during voyage.

Error of commission -hitting thumb with hammer.

Extraneous act -reading a different class's assignment in class.

Sequential error -by casual, light the fire before opening the damper.

Time error -running a red light.

Lapses -actual behavior fails to conform to the intention/plan (omitted action, memory failure).

Mistakes -Mistakes are errors in planning an action.

Rule based mistake- Wrong rule selected for action.

Knowledge based mistake- Error in generating a novel plan for novel situation.

Unintentional versus intentional- Mistake on test vs over speed while driving.

Unrecovered versus recovered

Recovered: error with possibility for damage but no damage actually occurred. Ex: driving home drunk and reach safely. The recovered error of one day could be the next day's unrecovered error.

Classification based on where error originates:

Operational Errors - Situations where the machine or process was operated beyond the normal or accepted design boundaries. Examples: The machine frame was not cleaned properly and the resultant microbiological corrosion resulted in structural perforation.

Design Errors - Design of machine or system that did not meet operational requirements. Machine performance requirements were changed without a sound design review, often by maintenance planner or vendor sales represented and installed without competent oversight review or with tacit engineering approval. An example of this error is dryer felt roll failed from fatigue originating where a stiffener was welded into the roll and resulted in a fatigue crack and failed catastrophically. Another example can be increase of machine operating speed by 5% without serious engineering review, which may result in reduced production capability because of failure of some components.

Maintenance Errors- Maintenance mechanics did not repair a machine or properly install the machine or component after a repair. Examples: Pump shaft had loose bearings because of poor fitting practice that may result in corrosion that reduced the fatigue strength of the shaft and the shaft fractured from corrosion fatigue.

Manufacturing errors- Components improperly manufactured resulting in premature failure.

Original installation errors - At the time of the installation a properly designed and manufactured piece of equipment was installed incorrectly and, as a result, failed prematurely.

Supervisory errors- A situation where there is general recognition that a potentially serious problem exists but no action is taken and the result is a significant failure. Example: A super-calendar drive failure occurred when the reducer ran out of oil. The 2000 hp reducer had been leaking for over a year but no corrective action had been taken.

Judgment - Good judgment is usually the result of experience. An experience is frequently the result of bad judgment. But to learn from the experience of others requires those who have the experience to share the knowledge with those who follow.

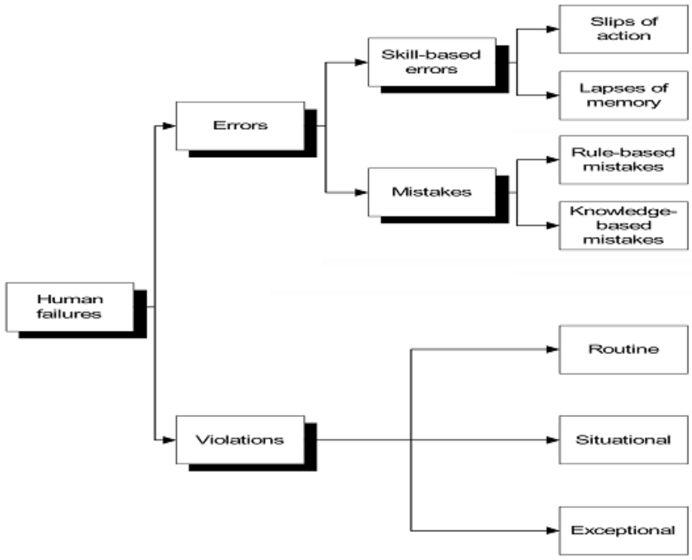

Figure: Components of Human errors (Source: unknown)

Classification of error in shipping industry

Classification based on human error

Communications errors - Errors of transmission of information
Slips- Accident lapses
Violations - Infringement, transgression
Ignorance- Low awareness, Poor learning
Planning and preparation- Program, Procedure, readiness
Selection and Training- Interviews/Meeting
Limitations and Impairment- Boundaries of applications
Mistakes- Cognitive error
Culture- Errors pertaining to goal setting, incentives administration, value system and trust

Violations

Ignorance- Low awareness, Poor learning
Planning and preparation- Program, procedure, readiness
Structure and organization- Connectivity, interdependence
Monitoring and Controlling- Awareness, corrections
Mistakes- Cognitive error

Classification based on system error

Serviceability- Inability to satisfy purpose and conditions
Compatibility- Unacceptable impacts and costs
Durability- Unexpected maintenance and less than expected usefulness
Capacity- Demand exceed design capability

Classification based on procedural error

Incorrect- Faulty
Incomplete- Lacking parts
Inaccurate- Untrue
Excessive complexity- Unnecessary intricacy
Poor organization- Dysfunctional structure or transmission
Poor documentation- Ineffective information arrangement

Environmental factors

Realty regarding human error

- Errors are consequences, rather than causes
- People cannot easily avoid these actions as they did not intend to commit
- You cannot change the human conditions but you can change the conditions in which humans work.
- Error management is all about managing the manageable.

Identification of human error

The maritime system is a people system and human errors figure prominently in casualty situations. As per statistics available, about 75-96% of marine casualties are caused, at least in part, by some form of human error. Studies have shown that 84-88% of tanker accidents, 79% of towing vessel accidents, 89-96% of collisions, 75% allissions, and 75% of fires and explosions are caused by human errors.

However, accidents do not happen by a single failure or mistake, but by the confluence of a whole series or chain of errors. In looking at how accidents happen, it is usually possible to take the development of an accident through a number of discrete events. Based on one study, there are three major elements that can help prediction of errors:

a) Nature of the task and its environmental circumstances,
b) Mechanism governing the performance, and
c) Nature of the individual.

Different methods of error identification

The following methods can help identifying the errors:

- Human factors analysis and classification system (HFACS)
- Technique for the retrospective and predictive analysis of cognitive errors. (TRACE)
- Human error assessment and reduction technique (HEART).
- Task analysis for error identification (TAFEI)
- Predictive human error analysis (PHEA)
- Action based detection
- Outcome based detection
- Awareness based detection
- Planning based detection

Prevention of human errors

Addressing the human side of shipping must be the most effective approach for increasing safety. Human has been expected to adapt to the system but this does not work, instead, what needs to be done is to adapt the system to the human. This kind of human centered approach has many benefits, including increased efficiency and effectiveness, decreased errors and accidents, decreased training costs, decreased personnel injuries and lost time and increased morale. It is relatively cheap compared to other costs in this business to select mariners carefully, to train and develop them and to build strong professional and safety minded human resources.

Many areas are there where the industry can improve Safety and Performance, through the application of basic principles of human factors. The three largest problems were fatigue, inadequate communication and coordination between people onboard, and inadequate technical knowledge. Below are summary of some components of human factors that need to be improved in order to prevent casualties.

Fatigue

Fatigue has been cited as the 'number one' concern of mariners in different surveys and studies. A new study has objectively substantiated these anecdotal fears: in a study of critical vessel casualties and personnel injuries, it was found that fatigue contributed to 16% of the vessel casualties and 33% of the injuries.

Inadequate communications

Another area concern for error management is communication practices between shipmates, between masters and pilots, ship-to-ship, and ship-to-VTS. Better procedures and training can be designed to promote better communications and coordination on and between vessels.

Inadequate general technical knowledge

In one study, this problem was responsible for 35% of casualties. The main contributor to this category was a lack of knowledge of the proper use of technology. Because of limited training and development practices extended, mariners often do not understand how the automation works or under what set of operating conditions it was designed to work effectively, such as radar.

Inadequate knowledge of own ship systems

A frequent contributing factor to marine casualties is inadequate knowledge of own ship operations and equipment. Several studies and casualty reports have warned of the difficulties encountered by crews and pilots who are constantly working on ships of different sizes, with different equipment, and carrying different cargoes. The lack of ship-specific knowledge was cited as a problem by 78% of the mariners surveyed. A combination of better training, standardized equipment design, and an overhaul of the present method of assigning crew to ships can help solve this problem. Standard familiarization procedures should be used for the new joining crews.

Poor Design of Automation

Poor design pervades almost all shipboard automation, leading to collisions from misinterpretation of radar displays, oil spills from poorly designed overfill devices, and allisions due to poor design of bow thrusters. Poor equipment design was cited as a causal factor in one-third of major marine casualties. The 'fix' is relatively simple: equipment designers need to consider how a given piece of equipment will support the mariner's task and how that piece of equipment will fit into the entire equipment 'suite' used by the mariner. Human factors engineering methods and principles are in routine use in other industries to ensure human-centered equipment design and evaluation. The maritime industry needs to follow suit.

Lack of situation awareness and complacency

Situation awareness is dependent on capacities such as attention, perception, memory, anticipation and decision making and therefore subject to individual differences.

Tests of suitability

Habitually attentive individuals with undistorted, objective perception with effective working memory and decision making capacity constitute the best choice as operators of ship. The methods for accomplishing such a selection exist in the form of psychological tests or a combination of tests and ship simulators for those who are already trained. Using such methods makes it possible to rule out those individuals who have difficulties in maintaining a reliable level of situation awareness.

Decisions Based on Inadequate Information

Mariners, too often, have a tendency to rely on either a favored piece of equipment or on memory. Many casualties result from the failure to consult available information, such as, from radar or an echo-sounder. In other cases, critical information may be lacking or incorrect, leading to navigation errors, for example, bridge supports often are not marked, or buoys may be off-station.

Faulty standards, policies, or practices

This includes lack of available, precise, written, and comprehensible operational procedures aboard ship. Other problems in this category include management policies which encourage risk-taking, such as, pressure to meet schedules at all costs, and the lack of consistent traffic rules from port to port.

Poor maintenance

Published reports and survey results expressed concern regarding the poor maintenance of ships. Poor maintenance can result in a dangerous work environment, lack of working backup systems, and crew fatigue due to make emergency repairs. Poor maintenance is also a leading cause of fires and explosions.

Hazardous natural environment

The marine environment is not a forgiving one. Currents, winds, and fog make for treacherous working conditions. When we fail to incorporate these factors into the design of our ships and equipment, and when we fail to adjust our operations based on hazardous environmental conditions, we are at greater risk for casualties.

Complacency – a state of mind

Completing numerous uneventful watches might bring the illusion that there is not a great presence of risk in shipping and psychological conclusion is therefore that it is safe. An illusionary feeling, called, 'complacency' might build up. Complacency is an unconcerned attitude, where individuals behave and think in a routine like mode, anticipating an ordinary development of the present situation. There are means to counteract complacency, one of which is to become aware of it. Select appropriate personalities for sensitive tasks and organize so that errors stand a chance to be detected before they materialize into accidents.

Apart from the above the following factors to be considered for the error rectification:

- Man machine interface (ergonomics) procedures
- Safety management (control, awareness) training
- Dissemination of experience
- Exchange of information
- Improvements in training
- Selection of personnel
- Motivation
- Promotion of a safety culture and co-operation of workers
- Improved understanding of error mechanisms
- Improved modeling
- Validation of methods
- Hours of work and rest
- Installation of safety warning devices, such as sensors and alarms, to detect problems and signal that corrective action is needed.

Conclusion

An error that is corrected before it can cause damage is an error nonetheless. The trend shows that over the last several years, the world's ship casualties have gradually declining, as a result of advancement of marine technology and establishment and implementation of international conventions and regulations. The scope of study was to identify different types of errors and its characteristics. The study finds that continual training is mandatory for safe operations. While this training should cover technical fundamentals, it also needs to be concerned with issues of human interaction. It is evident that human error contributes to the vast majority (75-96%) of marine casualties, making the prevention of human error of paramount importance to reduce the number and severity of maritime accidents. Out of identified errors, as it is evident, the majority of errors occur as a result of technologies, work environments, and organizational factors which do not sufficiently consider the abilities and limitations of the people who must interact with them, thus, 'setting up' the human operator for failure. Therefore, it is necessary to design technologies, work environments, and organizational factors by keeping the human operator in mind which supports the human operator and foster improved performance and fewer accidents. Other applications which are significant is to develop programs to improve management of human and organizational error, careful consideration need to be given to information (collection, communications and learning) and incentives particularly as they affect the balance of several objectives, such as costs and safety under uncertainty in operations. Bridge Resource Management (BRM) may be the first step towards improvement of communication onboard. Crew fatigue is also one of the issues onboard which can be reduced by manning with sufficient numbers of crew and giving sufficient rest hours. Also, proper training pertaining to different types of equipments and technologies used should be given to crew members before joining a vessel to avoid errors.

Acknowledgement

Deep gratitude is bestowed to Mr Madhu Sankara Pillai, a course participant of MEO Class 1 (February 2010 batch) for his significant contribution for preparing a literature base.

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