Safety Science 91 (2017) 33–39

Contents lists available at ScienceDirect

Safety Science

journal homepage: www.elsevier.com/locate/ssci

Development of a monograph for human error likelihood assessment in marine operations

Rabiul Islam [a], Hongyang Yu [a], Rouzbeh Abbassi [a], Vikram Garaniya [a], Faisal Khan [a,b,*]

[a] National Centre for Maritime Engineering and Hydrodynamics, Australian Maritime College (AMC), University of Tasmania, Launceston 7250, Australia
[b] Centre for Risk, Integrity and Safety Engineering (C-RISE), Process Engineering Department, Memorial University of Newfoundland, St. John's, NL A1B3X5, Canada

ARTICLE INFO

Article history:
Received 11 June 2015
Received in revised form 18 May 2016
Accepted 6 July 2016

Keywords:
Monographs
Success likelihood index method
Human error
Maintenance activities
Marine operations

ABSTRACT

Human error is a dominant factor in marine operations, on a daily basis many accidents occur due to human error during maintenance activities of ships. Assessment of the likelihood of human error is essential to minimize accidents and incidents during maintenance operations of marine engines. Most of the current techniques to estimate Human Error Probability (HEP) require significant technical and manpower (expert) resources. The main aim of this study is to develop a monograph for assessing the likelihood of human error in marine operations that can be applied for instant decision making. Due to the lack of human error data for marine operations, the Success Likelihood Index Method (SLIM) is used to estimate HEP. The developed monograph can be helpful for chief engineers or captains in the decision making process for various scheduled and unscheduled maintenance operations. This monograph could also be used as guidance for ship owners, operators, masters and classification societies to better prepare, prioritise and sort maintenance activities for safe and reliable marine operations. It can serve as a helpful tool to reduce the potential of accident occurrence.

1. Introduction

Humans are liable to make errors and this is unavoidable. In operational activities of ships, maintenance is one of the most critical operations. Marine maintenance operations are totally reliant on humans. The literature suggests that many accidents and incidents in the past have occurred due to human error such as in Erika, Costa Concordia and "RALI II" (DMA, 2011; Schröder-Hinrichs et al., 2012; TSB, 2013). Most onboard maintenance is conducted under challenging working conditions. The task plan and design of the equipment being maintained strongly influences the performance of maintenance activities. Incorrectly assembled and difficult to maintain equipment is another contributor to maintenance errors (Pennie et al., 2007). Moreover, broad organisational factors such as poor communication, inadequate system monitoring and failure to learn from previous maintenance errors can result in human error. On the other hand, societal issues such as lack of appreciation from higher management for high quality maintenance operations and extra work pressures can also lead to the occurrence of errors. Lack of adequate training, uncomfortable equipment, failing to follow procedural documentation and adverse working environments in which maintenance activities are performed, are also primary causes of maintenance error. According to Pennie et al. (2007), the human factor in marine operations accounts for 75–96% of maritime casualties. Human factor issues such as poor maintenance, lack of back-up systems and crew fatigue may also lead to a dangerous work environment. Human error could lead to catastrophic accidents as demonstrated in the sinking of the Prestige tanker near the coast of Galicia (Spain). Even if an error does not lead to a catastrophic accident, injuries or loss of life, it can still make notable economic impacts due to delayed operations (Pennie et al., 2007). Shipping is a safety critical industry and there are numerous causes for human error in marine operations. Some of the most common reasons are lack of training, lack of work experience, fatigue, communication and the cultural differences of seafarers. These factors are discussed in more detail in the next few paragraphs.

Training is the expansion of knowledge through instruction. Here, it is associated with an individual's capability to most competently define and accomplish the essential actions required to complete maintenance activities of marine onboard operations. Previous studies by Embrey et al. (1984) and Noroozi et al. (2013) suggest that training is one of the most important performance shaping factors (PSFs) in the maintenance procedures of offshore activities. The International Convention on Standards of

* Corresponding author at: Centre for Risk, Integrity and Safety Engineering (C-RISE), Process Engineering Department, Memorial University of Newfoundland, St. John's, NL A1B3X5, Canada.

E-mail address: fikhan@mun.ca (F. Khan).

http://dx.doi.org/10.1016/j.ssci.2016.07.008
0925-7535/

Training, Certification and Watch keeping (STCW) has set out a mandatory standard for seafarers to accomplish their responsibilities. However, the standards of training set out in STCW are a minimum set (Squire, 2005). Lack of training can be one of the causes for human error in marine operations (Squire, 2005). On the other hand, seafarer training is generally provided on shore (Colleges/Universities) rather than on training ships. This could be a hurdle in providing appropriate knowledge. Training ships play a vital role in seafarers training. Through training on a training-ship, seafarers can comprehend the importance of working on board and witness complete procedures of the ship's operation which in turn can motivate them to work harder and attain more exact knowledge. It is evident in the literature that many fresh theoretically qualified seafarers have a lack of practical skills despite having followed an approved training course, and this is also a factor in human error in marine operations (Phil Deegan, 2011).

Likewise, experience comes from practical contact with, and observation of, procedures. It is defined as the practical knowledge of the maintenance activities of onboard marine operations. One individual may not be as highly trained as other individuals, but may have practical experience about the maintenance activities of marine operations and the stressors that accompany real events. Lack of experience is another reason for human error in marine operations. For example, seafarers working on a container ship when changing to another ship (i.e. bulk carriers) which may not have the same systems, may lack knowledge of the different systems of the new ship. Another issue is technology advancement of the systems and equipment where new requisites need to be understood as seafarers may not be able to utilise their prior experience on new systems. Phil Deegan (2011), a chief engineer suggested that a third engineer with very little experience of machinery operation or maintenance, could become a source of human error in marine operations.

Fatigue is extreme tiredness arising from mental/physical exertion or illness. It is one of the major causes of human error and has contributed to 16% of vessel casualties and 33% of injuries in the maritime industry (Grabowski et al., 2009; Margetts, 1976; Rothblum, 2000). There are various causes of fatigue in marine operations including lack of sleep, stress, boring/repetitive work, noise/vibration, inadequate ventilation, poor lighting, excessive heat/cold, poor air exchange and ship movement. Food (timing, frequency, content and quality), the effects of alcohol, drugs and caffeine, excessive workload, illnesses, poor workspace design and poor shift scheduling are additional causes of fatigue. Fatigue directly affects seafarers' performances by causing inability to concentrate on work, diminished decision making ability, decreased memory, and changed mood and attitude. Likewise, faintness, headaches, heart palpitations, insomnia, loss of appetite, rapid breathing, and inadequate shift scheduling are also causes of fatigue (Squire, 2013). Moreover, seafarers spending long periods of time at sea and performing maintenance work in a challenging environment causes human error in marine operations. The ultimate consequences of fatigue in marine operations are accidents, economic loss, environmental damage, injury, poor health and poorer performance.

Communication is conveying or exchanging information by speaking, writing, or using some other medium. Clear communication (simple language instead of complicated jargon) is essential for safe work in marine operations. It is also a required practice in marine operations to ensure correct understanding of human behaviour at work, but humans rarely follow the practice as it is only an option (Murphy, 2006). The ability to accurately convey information by word of mouth or written communication is important not only for the safety of seafarers, but also for their wellbeing. Some seafarers have a poor language level and hence they face difficulty communicating with colleagues. Communication is not only talking, reading and writing procedures but also the exchange of ideas, information and knowledge between individuals (Murphy, 2006). Poor communication globally among seafarers and the challenge of communication between on-shore and off-shore maintenance operators is another cause of human error in marine operation (Pennie et al., 2007).

Cultural differences are variations in the way of life, beliefs, traditions and laws between different countries, societies and people. Seafarers' background cultures may affect their comprehension and cause human error (Lewis, 2010). Cultural variances are mostly relevant in marine operations due to the engagement of people from many seafaring nations. Cultures tend to diverge in numerous substantial ways. These variances not only sensitise people in different ways, but also affect their understandings of people from other cultures. Some seafarers from Germany, Scandinavia, America, Canada, Australia and Britain tend to pay attention and emphasis on one thing at a time (Lewis, 2010). They like to stick to plans, focus on the facts, and rely on statistical information and reference materials to stay focused. They tackle problems with logic, use nominal body language to communicate with their colleagues. Also some seafarers with different cultural backgrounds such as Japanese, Chinese, Taiwanese, Koreans and Filipinos like to be holistic, subtle and perceive an unfolding schedule of events. They humbly listen to people while paying attention to the whole image in order to agree upon small corrections. They use evidence obtained from reference books and direct contact with people. They avoid conflict, use fine body language (i.e. nods and slight movements) and pay attention to protecting their colleagues from losing face (Murphy, 2006). Seafarers from cultures such as India, Pakistan, Polynesia and Mediterranean populaces however, like to be involved in many things at once. They do not easily lose face simply since failure tends to be attributed to situations rather than to people. These cultural factors are also some reasons for human error in marine operations.

Many of the human factor related issues in maintenance are underlying issues and so can be addressed, but a systematic approach for identifying and addressing them is required. Attention to human factors is a proven way to enhance the performance and reduce the risk of accidents and incidents in marine industries. For quantitative assessments of human error likelihood, it is necessary to estimate HEP. HEPs are estimated based on factors that affect human performance, known as PSFs. A PSF is one aspect of an individual's characteristics, environment, organization, or a task that particularly impacts on human performance and the likelihood of human error. The estimated HEP value indicates the level of human error likelihood in a particular operation.

The Human Error Assessment and Reduction Technique (HEART), the Technique for Human Error Rate Prediction (THERP) and the Success Likelihood Index Method (SLIM) are the most common methods for human error likelihood assessments (Kirwan, 1994; Noroozi et al., 2010; Abbassi et al., 2015). The HEART methodology is easy to comprehend, fast and trustworthy, but it is relatively subjective and heavily dependent on the experience of the analyst (Casamirra et al., 2009; Noroozi et al., 2014). On the other hand, THERP is the most common method for probabilistic human error assessment. However, the effectiveness of this method is restricted to error reduction and it does not offer enough guidance for modelling the impacts of PSFs and scenario development (Jae and Park, 1995). Finally, SLIM is one of the better known methodologies for estimating HEP based on expert judgment. Many other researchers (Deacon et al., 2013; Dhillon, 1987; DiMattia, 2004; Noroozi et al., 2013) have applied this technique in different industries. DiMattia (2004) applied this method to estimate HEP for offshore platform musters, while Noroozi et al. (2013) applied it to pre- and post-maintenance procedures of process facilities and Islam et al. (2016) applied it to maintenance operations of marine engines.