The Use of Mandatory Equipment On-board – A New Study

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Abstract

In contrast to the ships of yesteryear, modern merchant vessels are complex structures incorporating a variety of mechanical and electrical systems. The twentieth and twenty-first centuries have seen a steady increase in the regulation of international shipping by national, regional, and global bodies. One aspect of such regulation has been to determine the essential equipment that all vessels should carry on a mandatory basis. Mandatory equipment specified by the SOLAS and MARPOL conventions of the IMO includes for example, fire fighting equipment; lifesaving equipment and environmental protection equipment.

On-board a vessel it is vital that such mandatory equipment is understood and that, when operated, it is used appropriately and maintained correctly. However there is evidence to suggest that in some cases such equipment is either poorly operated and/or poorly maintained resulting in both a threat to life and to the environment. The reasons for this may be complex and in 2012/3 a new study was initiated at SIRC with a view to exploring the complex factors which may underpin the periodic misuse and neglect of such equipment.

This paper introduces the new study and outlines its aims, objectives, and methods. It then considers the issues raised in the relevant literature which creates a starting point for the research.

Introduction

Modern merchant vessels are complex structures which incorporate a variety of mechanical and electrical components and systems. Some of the equipment carried on-board international ocean going vessels is mandatory under international law. Although such mandatory equipment varies in function, generally speaking, the aim of mandatory equipment is to protect life at sea, and/or the marine environment.

Mandatory equipment can be divided into three categories: emergency response equipment, navigational aids/ bridge equipment, and equipment designed to protect the environment. Emergency response equipment includes life-saving apparatus, fire-detecting and fire-fighting equipment, and emergency communications equipment. The carriage of emergency response equipment is required under SOLAS. The carriage of navigational aids and bridge equipment including RADAR/ARPA, ECDIS, AIS, Compass, etc, is also mandatory under SOLAS. However, the carriage and use of equipment designed to protect the environment is generally covered by the IMO MARPOL convention. Equipment includes items such as oily water separators and ballast water treatment systems. Table 1 summarises examples of the types of equipment in each of these categories[1]. In this paper we will focus on just three pieces of mandatory equipment: lifeboats; watchkeeping alarms (BNWAS); and oily water separators.

Table 1: Examples of Mandatory Equipment

Emergency Response Equipment
Fire fighting equipment Hoses (*SOLAS Chapter II-2, Part A, Regulation 4*) BA Sets (*SOLAS Chapter II-2, Part A, Regulation 17*) Extinguishers (*SOLAS Chapter II-2, Part A, Regulation 6*) CO2 Systems (*SOLAS Chapter II-2, Part A, Regulation 5*) Lifesaving equipment Lifeboats (*SOLAS Chapter III, Part B)* Life Rafts (*SOLAS Chapter III, Part B)* Life Jackets/ Buoys (*SOLAS Chapter III, Part B, Regulation 7*) GMDSS (*SOLAS Chapter IV)* Emergency Alarms Fire Alarms (*SOLAS Chapter II-2, Part A, Regulation 12-14*) Water Ingress Alarm (*SOLAS Chapter XII, Regulation 12*)
Navigational Aids/ Bridge equipment
Navigational Aids AIS (*SOLAS Chapter V, Regulation 19*) GPS (*SOLAS Chapter V, Regulation 19*) ARPA Radar (*SOLAS Chapter V, Regulation 12*) ECDIS (*SOLAS Chapter V, Regulation 19*) Compass (*SOLAS Chapter V, Regulation 12*) Bridge Equipment VDR *(IMO Resolution A.861 (20))* Bridge Watch Alarm *(IMO Resolution MSC 282(86))*
Environmental Protection Equipment
Oil Water Separators (MARPOL Annex I**)** Ballast Water Treatment (MARPOL Annex I**)**

[1] Please note the list is not extensive, and only provides examples of some of the common types of mandatory equipment.

Shipboard mandatory equipment has been introduced gradually over a period of roughly a century. Notwithstanding the extended period of this introduction, over time some of this mandatory equipment has been recognised as being characterised by recurrent problems. In 2001, for example, the UK Marine Accident Investigation Branch (MAIB) reported that since 1989 it had received reports of seafarers being killed or injured in accidents relating to the launch of lifeboats. These problems have yet to be resolved as the recent, much publicised, case of the accident aboard the cruise vessel *Thomson Majesty* demonstrates. In this case five seafarers were killed in the course of a lifeboat drill and a further three were injured. Similarly, Oily Water Separators which have been mandatory since the 1970's have performed poorly resulting in the discharge of oily wastes into the marine environment sometimes resulting in fines and the prosecution of seafarers and shipping companies (Grey, 2006).

Common problems with such equipment are frequently technical in nature however there may be other issues which impede the proper use of mandatory equipment. These may include poor maintenance, ineffective training, poor design from an ergonomic standpoint, and so on. In a SIRC study of accident investigation reports, for example, in addition to 'poor design' the following factors were found to have been identified by accident investigators (in four countries over a ten year period) as being associated with lifeboat accidents: 'inappropriate/ineffective maintenance'; 'inadequate training/ experience'; 'poor judgement/operation'; 'third party deficiencies' (Tang et al, 2013). With such a persistent history of poor performance, in so many cases, it remains unclear why many of these problems endure. This paper provides the background to a new study at SIRC which aims to delve more deeply into the issues underlying the problems associated with the operation of mandatory equipment in order to try to answer some of the longstanding questions that remain about its performance and use.

The new research is being jointly funded by the Lloyd's Register Foundation (LRF), The TK Foundation and Cardiff University. The intention of the research is to produce a detailed and nuanced picture allowing for the possibility that companies can direct their future efforts with regard to documentation of procedures and the provision of training far more effectively. This should help reduce future accidents as well as mitigating seafarer stress.

In this paper, prior to the initiation of fieldwork, we will focus on three pieces of equipment (lifeboats, watchkeeping alarms, and oily water separators) in order to consider some of the 'known factors' which relate to the use of mandatory equipment by reviewing available published materials which are already in the public domain. This may provide us with an early indication of some of the issues that the fieldwork should consider in relation to a broader range of equipment and it will outline the broad context within which the research will be conducted.

Methods

The literature used in this article was identified via a combination of library and internet search. Academic and industry journals and popular magazines were incorporated in the review and, where these were unknown to us, these were identified using Google, Google Scholar, and academic search engines such as Scopus[2]. In undertaking keyword searches the key terms used were 'maritime industry', 'maritime accidents', 'seafarers', and 'mandatory equipment'. Supplementary searches of related topics in academic journals were also undertaken to contextualise the review and relate the issues connected to the use of mandatory equipment to a broader context.

Emergency Response Equipment

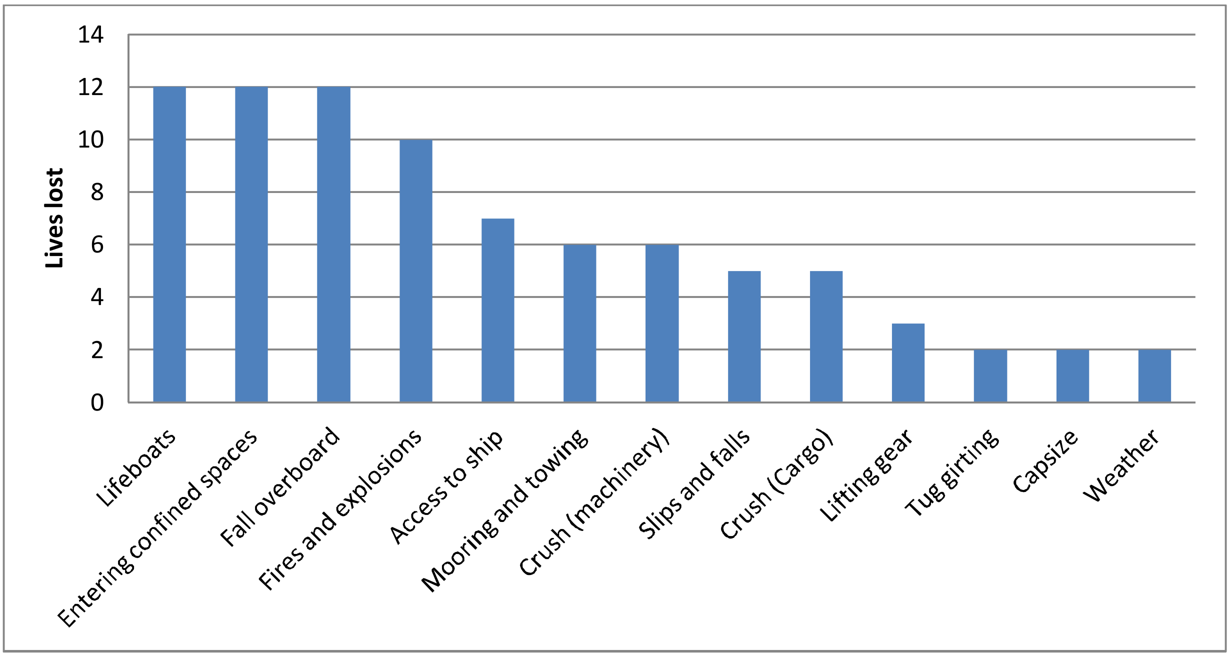
Emergency situations on-board ships present seafarers with considerable personal risk as seafarers are generally confined to the vessel and there is frequently nobody else in the vicinity to help them to deal with emergency situations. To cope with emergencies, ships are required to carry their own fire fighting and life saving appliances, fire detectors and alarms (SOLAS Chapter II-2 and Chapter III). It is also mandatory that fire fighting and lifeboat drills are carried out regularly according to emergency drill plans (Chapter III, Regulation 19). These drills not only involve the use of, and practice with, emergency equipment such as fire fighting equipment and lifeboats, but also teamwork. Such

[2] Scopus is a large abstract and citation database of peer-reviewed research literature relating to a variety of disciplines including the social sciences. The database includes details from over 20,500 titles from more than 5,000 international publishers.

teamwork involves communication and coordination between team members and interaction between people and equipment.

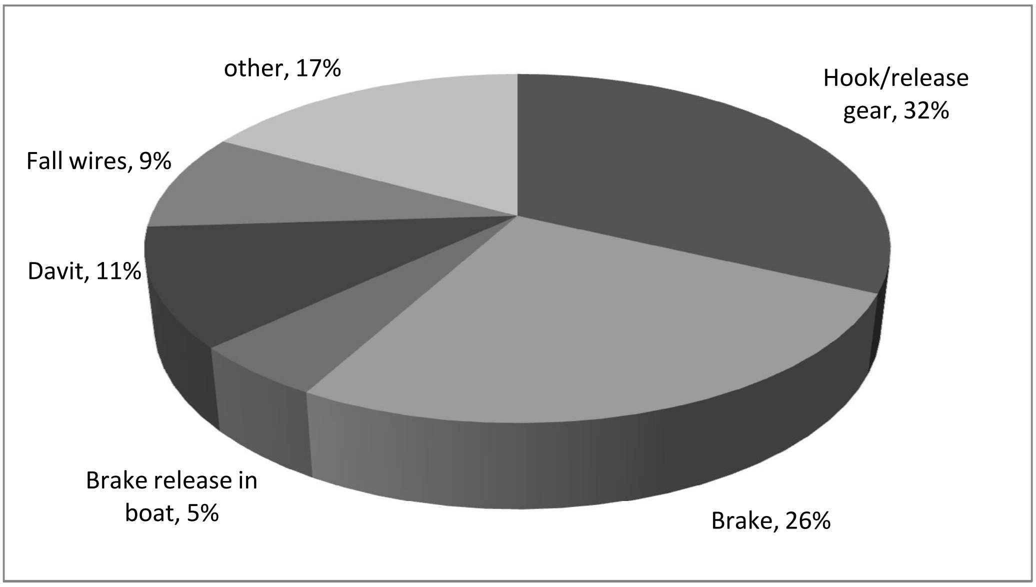
To maximise the effectiveness of drills SOLAS requires that 'drills shall, as far as practicable, be conducted as if there were an actual emergency' (Chapter III, Regulation 19: 3.1). This suggests that drills should simulate real emergency situations as closely as possible. One part of this is a requirement that lifeboats should be lowered regularly as part of drills (Chapter III, Regulation 19: 3.3). However, lifeboat drills have come to be recognised as a serious hazard and have resulted in many fatalities (OCIMF, 1994). Indeed some commentators have observed that in some circumstances lifeboats have caused more fatalities than they have saved lives (Barber, 2005). In 2001, the *Review of Lifeboat and Launching Systems' Accidents* carried out by the MAIB suggested that lifeboat drills were a common source of accidents, and that lifeboat accidents were one of the most frequent causes of fatalities (see Figure 1).

Figure 1: Fatal accidents 1989-1999 (as collected by the MAIB)



The *Lifeboat Incident Survey – 2000* conducted jointly by OCIMF, Intertanko and SIGTTO (2000) further suggested that the majority of accidents (75 out of 89) involved davit-launched totally enclosed lifeboats with on-load release hooks. The on-load release hook has emerged as a particular problem, as it may open when unanticipated by seafarers and drop a lifeboat into the water from a considerable height. The OCIMF 1994 survey revealed that release system failure and brake failure were two major contributory causes of davit-launched totally enclosed lifeboat accidents (see Figure 2). The subsequent *MCA Research Project 555* (MCA 2006) suggested that while lifeboat accidents also arose from problems associated with other elements of lifeboat launching systems, such as winches, and falls, most serious accidents, especially those leading to fatalities, occurred because of on-load release hook problems.

Figure 2: Component failure in lifeboat accidents (from OCIMF survey 1994)



Not only do lifeboat accidents cause injuries and fatalities, but they may also have less obvious effects on seafarers, such as reducing seafarer confidence in their use (MCA, 2006; OMICF, 1994) and undermining the efficacy of drills. Captain Dennis Barber (2006, p. 22), a ship inspector, has noted for example, that ‘masters [on vessels with totally enclosed boats, on-load release gear and remote lowering] will often provide plausible excuses as to why they have not done the exercise, citing restrictions in ports by harbour masters as the most commonly encountered reason.’ It is also reported that some Captains resort to falsifying their records of lifeboat drills due to fear of accidents (Maritime Accident Casebook, 2011). The MAIB (2001: 32) review point out:

> "Shipmasters report that to raise their crew's confidence in the systems, they regularly take an active part in launching a lifeboat. Privately they express a feeling of unease, both at taking part in the operation and the need for them to do so."

Even where they are carried out it may be that lack of confidence in lifeboat safety serves to undermine the training benefits associated with drills. The available literature on training, and the importance of motivation in effective training, (see for example Noe and Wilk, 1993; Facteau et al., 1995; Mathieu et al., 1992 4 XLQRQHV, 1997, Wei-Tao 2006) suggests that it is reasonable to posit that lack of confidence in lifeboat safety, and the fear that this is likely to promote, will undermine the efficacy of lifeboat drills. Webster and Martocchio (1993) have specifically linked anxiety to reduced training motivation (Cloquitt et al, 2000). That such anxiety amongst seafarers remains prevalent in relation to lifeboats seems evident. In 2013 a 'discussion' of lifeboat safety was promoted by the industry association *Intermanager*. In a summary of the findings *Intermanager* reported that one seafarer 'likened his onboard training to 'Russian Roulette'' (http://www.intermanager.org/2013/05/intermanager-discussion-reveals-lifeboat-hook-concerns/).

There is also a body of evidence which suggests that the degree of commitment from supervisors/managers to training markedly influences worker motivation with regard to training (Gist, 1987). In this context it seems reasonable to assume that where shipmasters and seafarers themselves are uneasy about holding, and taking part in drills, (as reported by the MAIB in 2001 op cit) this is likely to undermine both seafarer motivation and, as a consequence, the usefulness of drills as training scenarios.

These observations may help to explain why training in relation to lifeboat operation has sometimes been identified as flawed. A recent survey, in which 62 accident investigators responded to an on-line questionnaire about the lifeboat accidents they had investigated, found that respondents were likely to see on-board training and maintenance as 'not fit for purpose' (Maritime Accident Casebook, 2011). There are also a number of specific accident investigation reports which identify poor training as contributing to, or causing, lifeboat-related accidents (see for example the case of the tanker *Port Arthur* ATSB 2004 and the bulk carrier *Sea Urchin* TSB 2006). It has been observed that unstable crewing practices (crew not regularly returning to the vessels with which they are familiar) and the variety of different lifeboat designs compound training problems and increase the likelihood that accidents will occur. The Canadian report into the accident involving the lifeboat of the vessel *Sea Urchin* highlights for example that:

> The large number of often complex designs, combined with the fact that crew members rarely return to the same vessel, creates a lack of familiarity with an essential piece of lifesaving equipment, thereby continuing to put seafarers at risk. (TSB 2006:13)

As well as design and training problems, there have also been problems associated with poor maintenance and resultant 'equipment failure' identified in some reports about lifeboat accidents. An OCIMF (1994) survey collected data on 92 lifeboat incidents by distributing a questionnaire to ship operators and national authorities. It found that 'equipment failures and design shortcomings were responsible for approximately two thirds of all reported lifeboat incidents' (p.3). The Lifeboat Incident Survey (2000) conducted jointly by OCIMF, Intertanko and SIGTTO, which collected data on 89 lifeboat incidents, using the same questionnaire, depicted a similar situation. In a later study Ross (2006) analysed 266 lifeboat accident reports gathered from seven countries. He noted that in terms of frequency design, training, and maintenance were almost equally identified as underlying causes of lifeboat accidents. Importantly, Ross observed that accident investigations were always subjective and that in most cases design, training, and maintenance were interrelated, for example, poor design might make maintenance difficult and thus lead to poor maintenance.

The aforementioned *MCA Research Project 555* (MCA, 2006) also considered these issues and sought views from manufacturers, ship owners/managers, seafarer trade unions, and seafarers. Their survey suggested that:

- Though many existing on-load release hooks satisfy legal requirements, they are inherently unstable, unsafe, and not fit for purpose. Some hook designs are sensitive to wear and can become dangerous after repeated disengagement. Further, under SOLAS requirements, lifeboats and launching equipment are primarily designed for one-off use in emergency. They are not designed with a particular view to their being launched and recovered in the course of drills. There is a suggestion that it is technically possible to design safer and more reliable systems, but there is little commercial incentive to go beyond minimum legal requirements.

- Lifeboat safety problems are rarely reported to the manufacturers.

- Work pressure leads to the lack of time for training and drills.

- There is no standardisation in hook designs and manufacturers (for obvious reasons) are unwilling to collaborate with each other. According to one manufacturer, there are around 70 different on-load release systems (LSM 2007). As a result, seafarers may face different designs of hooks on different ships, but may not be aware of different operational procedures and maintenance requirements.

- The marine environment does not allow a maintenance or service free design. Seafarers, however, do not have the knowledge to do adequate maintenance/service. IMO has set out guidelines in MSC Circular 1206 that lifeboats should be serviced by the manufacturer-approved engineers. It has not been adopted into SOLAS, however.

On the issue of maintenance, it is believed that one reason for poor lifeboat maintenance may be that lifeboats are considered to be complex by seafarers, who are particularly wary of the on-load release systems (Gale, 2008). The matter is compounded by the fact that the quality of 'operation, maintenance and training manuals' is often poor, as the MAIB (2001: 30) review points out:

> "[These manuals] frequently lack clear and accurate descriptions of the equipment and operating principles. Superfluous information, particularly where one instruction manual is intended to serve several types of system, leads to confusion. Inaccurate translations between languages can compound these problems.
>
> These shortcomings result in crews ignoring them on the grounds that they are not only unreliable, but also contain too much extraneous material. They become time consuming to read, and the end result is incorrect maintenance and operation of equipment."

The consideration of the published literature associated with lifeboats thus raises a number of issues which need to be considered when exploring the use and misuse of a range of mandatory items of equipment. These include the possibilities of design failings, poor training and motivation, poor maintenance regimes, the impact of crewing practices, and the impact of workloads. It is now worth considering the literature published around the use of a rather different piece of equipment (the Bridge Navigational Watch Alarm

System) in order to see if there are other issues which emerge as potentially relevant to the broader study of mandatory equipment.

Bridge Navigational Watch Alarm System

In 2009, IMO Resolution MSC 282(86) was adopted making it mandatory to phase in the Bridge Navigational Watch Alarm System (BNWAS) on cargo and passenger ships between 2011 and 2014. A major factor behind the adoption of this resolution was the large number of groundings and collisions attributed to watch keepers falling asleep. For example, the Nautical Institute suggested that, of human factor related marine accidents between 1996 and 2006, watch keepers falling asleep explained three per cent of collisions and eight per cent of groundings (Gale and Patraiko, 2007). Similarly, the Marine Accident Inquiry Agency (MAIA) in Japan found that watch keepers dozing off caused 28 per cent of groundings around its coasts in 2004 (Gale and Patraiko, 2007).

In order to try to stop watch keepers falling asleep the BNWAS requires the bridge watch keeping officer to periodically (every 3 to 12 minutes depending on the setup) push a button, to prevent an alarm being triggered in the cabins of deck officers and/or of the captain. Other more advanced systems use motion sensors to detect whether the watch keeper is awake, or monitor how bridge navigational equipment is being used to see if seafarers are mentally alert. If these systems detect a lack of motion or a lack of alertness over a certain period of time, the alarm will be triggered. A typical example of a BMWAS panel is shown in Figure 3.

Figure 3: Example of a BNWAS bridge panel

Source: http://gcaptain.com/bnwas-bridge-navigational-watch-alarm/?25555)

As it requires regular attention (generally every ten or so minutes) BNWAS can be irritating, especially as they serve no function in relation to navigational tasks. A short report from Chalmers University of Technology on the use of alarms (and also on the need for display dimmers) on-board modern vessels, highlights the extent to which alarms should 'alert the officer of the watch to a problem, not be an annoying distraction of little informational value that constantly needs to be silenced' (Lutzhoft and Jacobson no date). The problem for seafarers is that for those who are alert and functioning a BNWAS may be precisely described as an 'annoying distraction' which offers no navigational assistance but requires 'silencing'. In this context the temptation to silence the alarm permanently may be great. In the wider literature on alarm systems BNWAS may be regarded as akin to 'low-urgency' alarms. These are alarms which do not usually require urgent attention, or indicate imminent danger. BNWAS are curious in respect of the fact that seafarers are required to prevent activation of the alarms on a regular basis and that this is a necessary but not an 'urgent' task. Once an alarm is activated there may of course be a need for immediate action. Bliss, *et al.*, (1995) in a study of responses to alarms of different urgency found that low-urgency alarms were responded to less frequently and more slowly than urgent alarms. In the medical setting, Edworthy and Hellier (2005) suggest that such alarms are regarded as irritating and may actually interfere with the conduct of a task. Block, *et al.*, (1999) found that, as a result, anaesthetists often switched off such low-urgency alarms.

The irritating nature, and low importance of such alarms, may explain why there have been a number of reports of the watch alarm being disabled on ships in transit. In 2008, for example, the general cargo ship *Antari* went aground off the coast of Larne in Northern Ireland. The officer of the watch had been asleep for over three hours on the bridge when the vessel grounded and the accident investigation report notes that the 'watch alarm was not switched on' (MAIB 2009). In a similar but rather more complex incident the Captain of the vessel *Karin Schepers* fell asleep on 3rd August 2011 resulting in his vessel grounding off the Cornish coast two hours later. Like the *Antari* the vessel was equipped with a bridge watch alarm but this was switched off. The report notes that 'A BNWAS was fitted on *Karin Schepers* but it was not turned on at the time of the accident, and evidence indicates that it had not been used for several months' (MAIB 2012: 12). The report continues:

> The requirement to carry a BNWAS was confirmed by the International Maritime Organization (IMO) in amendments to SOLAS Chapter V, Regulation 19, effective 1 January 2011. The amendment gives dates by which various vessels must have fitted a BNWAS, and states that it shall be in operation whenever the ship is underway at sea. (ibid: 13)

However, in spite the evidence arising from cases where BNWAS might have prevented the occurrence of an incident BNWAS are not universally welcomed by seafarers who assert that not only may they be irritating they might even serve to distract watch keepers from their duties, especially in traffic-dense areas.

When they are used as intended, although such systems clearly deal with the problem of watch officers falling asleep they do not address the issue of why watch keepers might fall asleep. As such, these systems are identified as addressing the symptoms of the problem but not the problem itself (*Lloyd's List*, 2007). Drawing on research evidence, Michael Grey (2011) suggests that boredom and fatigue are two factors which may make watch keepers sleepy. In addition, it is argued that the increasing level of automation on-board de-skills seafarers and changes their role from active navigators to passive monitors (Grey, 2011; 2012). This can make watch keeping boring, especially in open sea, where 'traffic' is sparse. Automation can also be seen to have allowed for the reduction of crewing levels. Smaller crews mean that in periods of intense activity there may be overload experienced by some crew members. In an ethnographic study of seafarers, for example, Sampson notes that chief officers often work very long hours in port (Sampson, 2013). This means that periodically, seafarers may not have enough time for rest, which ultimately may cause fatigue. Furthermore, smaller crews may make it less likely that an AB is posted on the bridge as a watchman during the hours of darkness (a practice advocated by some maritime administrations). Several accident investigation reports have noted that the presence of a watchman would have served to dramatically reduce the chances of a watch keeper falling asleep in the first place and would certainly have reduced the possibilities of such an event passing unnoticed.

The example of the BNWAS thus provides us with further information about problems that can arise in relation to the use of mandatory equipment. Here mandatory equipment may be characterised as being used in an attempt to address a problem once it arises when more effective strategies could be employed to prevent the problem arising in the first place. This may undermine the commitment of operators to the effective use of the equipment. Furthermore the literature, relating to both BNWAS systems and other low-urgency alarms, demonstrates that where operators find equipment an irritating and unwelcome distraction, and where they regard it as being of little functional assistance to them in their jobs, they may choose to disable the equipment (in this case to switch it off).

Oily Water Separators

Oily water separators allow cargo vessels to segregate oil from waste bilge water and in line with MARPOL regulations to discharge water with an oil content of less that 15ppm (parts per million) directly into the ocean. Remaining oil residues are required to be stored on-board until such time as they can be transferred to reception facilities ashore, or incinerated. The MARPOL convention requires ships to keep an Oil Record Book (ORB) in which OWS usage and oily waste disposal are recorded.

Although the installation and operation of OWS has been mandatory since the 1970s, there are enduring problems with the use (and abuse) of oily water separators. It is an open secret within the industry that some seafarers continue to discharge bilge waste directly to the sea through a so-called 'magic pipe' bypassing the OWS that has been installed on-board. In 2012, for example, the operators of the vessel *M/V Susan K* were ordered to pay a substantial US$1.2 fine having been found guilty of using a 'magic pipe' to discharge oily bilge waste water over-side. According to an on-line report:

> The chief engineer and other crew members on-board the vessel repeatedly discharged oily bilge waste water from the vessel into the ocean from before Aug. 1, 2011, to March 4, 2012, by using a hose that bypassed the vessel's OWS, aka a "Magic Pipe". The chief engineer then falsified the vessel's oil record book to conceal the dumping from Coast Guard inspectors when the vessel entered the U.S. ports in Alaska on Jan. 24, 2012, and then in Houston on March 4, 2012. (http://gcaptain.com/german-shipowners-plead-guilty-in-magic-pipe-case/ accessed June 17th 2013)

As a result, of the continuation of such violations, port states have tightened up their surveillance and prosecution of such MARPOL infringements. As early as 2006, US Department of Justice statistics showed that shipping companies had been fined $145m, and that seafaring staff had been sentenced to a total of 18 years' incarceration for falsifying ORB records and using 'magic pipes' (Joshi, 2006). Similarly, European and Canadian courts also levied high fines on shipping companies whose ships illegally discharged oily waste overboard (Gale, 2007). However, as the case of the *Susan K* demonstrates infringements of the MARPOL regulations continue.

It is important to recognise that seafarers face prosecution as a result of the discharge of illegal waste overboard. They may also face long periods of time detained in the USA, or other prosecuting nations, whilst awaiting trial when accused of utilising magic pipes. This can certainly be understood to have a deterrent effect on seafarers. For example, it has been reported that some senior seafaring staff are increasingly reluctant to sail to the US at all for fear of criminal charges. Michael Grey (2010) recounted one ship manager's complaint:

> "A ship manager, who had come from marine engineering at sea not long before, told me that so much attention was now being given to the operation of the oily water separator by the engineering staff that the condition and performance of the engine had become almost secondary. Engineers, he said, were worrying themselves sick about whether a scrutiny of the oil record book

> would reveal some deficiency and see them subjected to an interrogation not far short of torture by the US authorities. There were chief engineers who had gone sick rather than return to a ship bound for the US."

This raises the interesting question of why infringements of MARPOL regulations concerning the discharge of oily bilge water continue to persist. As implied in the quote above there may be reasons that are not associated with the mandatory OWS itself but are associated with record keeping. However there may also be reasons why the operation of the OWS itself raises problems for seafarers. Like the lifeboat designs discussed hitherto there are many different makes of OWS on the market and not all of these are regarded as 'fit for purpose'. OWS have been described as 'crude' technology, and one ship manager commented (LSM, 2007: 28):

> "OWS, and incinerators, are still a 'grey' area. They are not governed by class rules with regard to capacity and quality … they are often the last item on the ship's specification. So often we are confronted with absolutely minimal equipment, which needs constant attention and a lot of man hours of a minimal crew to work the thing. It is basically not technology that should be on-board a ship, certainly not after a few years of use"

It is argued by many that some OWS only work 'in theory' i.e. in laboratory conditions where oil 'sits nicely on top of fresh water'. It has been suggested that OWS may be less effective when required to filter bilge waste which contains thick sludge, emulsions, fuel oil, and detergent (Grey, 2006; *Lloyd's List*, 2006). In these circumstances it may become impossible to discharge any water via the OWS when the system cannot effectively filter out impurities. Alternatively some OWS have been said to allow for the discharge of oily wastes that have combined with other substances and are no longer recognised by the system as 'oil discharge'. It would seem that performance issues have dogged this particular example of mandatory equipment such that ship managers have complained that:

> "Nobody condones the alteration of oil record books, nor do we excuse dumping of slops at sea, but … when will we accept responsibility for requiring an OWS design with filters that do not require replacement every fourth day? How can we countenance continued and repeated OWS prosecutions by the US Department of Justice when the industry can't get its act together on a technically effective, user-friendly design?" (Maitland, 2010)

Thus without the capacity to filter oily bilge water, and perhaps in the absence of management support ashore, the last resort left to a seafarer may be to dump it at sea illegally. A variety of issues may contribute to such decisions such as the provision of insufficient waste holding capacity on-board (Gale 2007), and the unavailability or expense of waste reception facilities ashore (Abou-Elkawam, 2011; Gale, 2007; Grey 2006; Maitland, 2010).

Reasons for OWS violations not only relate to 'hardware', however, and it has also been suggested that 'human factors' contribute to continued MARPOL violations. For example, poor training may be being provided relating to both the operation and maintenance of OWS. There may also be poor supporting literature provided by OWS manufacturers to operators (operator manuals on-board). Furthermore, such problems might be combining with an increased complexity associated with the equipment (*Lloyd's List*, 2006). Additionally, and as with the operation of lifeboats, fear may be a factor here. If seafarers are sufficiently afraid of making a mistake with the operation of OWS they may be resistant to training and fearful of operating the equipment at all – perhaps resorting to magic pipes. Finally, some authors have suggested that the occupational culture associated with shipping is to blame. Features of such a culture are considered to include: an ethos of not reporting problems or 'making a fuss' but instead 'making do' with whatever is available at sea (Grey, 2006; *Lloyd's List*, 2008; Olney, 2007); not challenging senior people (Gale, 2007; Olney, 2007); and perhaps an attitude that 'dumping is OK' so long as you don't get caught (Gale, 2007; Joshi, 2006).

Thus the example of the OWS offers us more threads to pursue in our understanding of the variety of reasons why mandatory equipment may be poorly used on-board. Here we can add the occupational culture of shipping to the aforementioned issues which included poor design, maintenance, and training.

Conclusions

In this paper we have highlighted some of the issues that may impede the effective use of mandatory equipment by seafarers. These include: technical design; training; maintenance; motivation; fear; the perceived usefulness of equipment; occupational culture; and crewing practices. There will undoubtedly be an opportunity to develop our understanding of some of these issues in the course of our forthcoming fieldwork as well as to consider other, new and emergent, ideas.

This paper is exploratory and will aid researchers in their future fieldwork. Nonetheless, though partial and preliminary, it serves to highlight a variety of challenges that the maritime industry faces with regard to the use of mandatory equipment. Once the research is completed we hope the findings will allow companies to make changes (as required) to a variety of practices and procedures pertaining, both directly and indirectly, to the use of mandatory equipment in order to maximise its effectiveness on-board.

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