Consideration on Limiting the Elements of Human Factor Influence on Breakdowns of Ship's Machinery Illustrated by Some Case Studies

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Abstract

The paper in the first part introduces the reader into general issues contributing to the complex role of the human factor in safe ship operation. Further the capacity which the International Maritime Organization (IMO) attaches to the human element in shipping is discussed. Next the International Safety Management (ISM) role towards safer ship operation and the economic viability of a ship-owner is highlighted. The last part of the paper contains two case studies the first illustrating the need for training expertise and certification for shipboard electrical officers and the second case giving an example how not observing simple procedures and checklists by the crew can lead to fatal and costly accident.

1. Underpinning background of the human factor element issue

Merchant seafaring is rated as the second most hazardous occupation with seafarers 260 times more likely to have fatal accidents as compared to those employed in any other industry (Roberts vol.360, p.543)7. Maritime accidents involving ships in collisions, foundering, groundings, fires, explosions etc. in the period 1999-2004 are presented in Fig. 1, these are responsible for heavy loss of property and long-term environmental damages, they on the other hand account for large number of valuable lives.

Large floating population of passengers at sea along with over a million seafarers, inevitably on board for operation of some 88 000 ships at any given time continues to be at risk exposed to the vagaries of seas and operational hazards.

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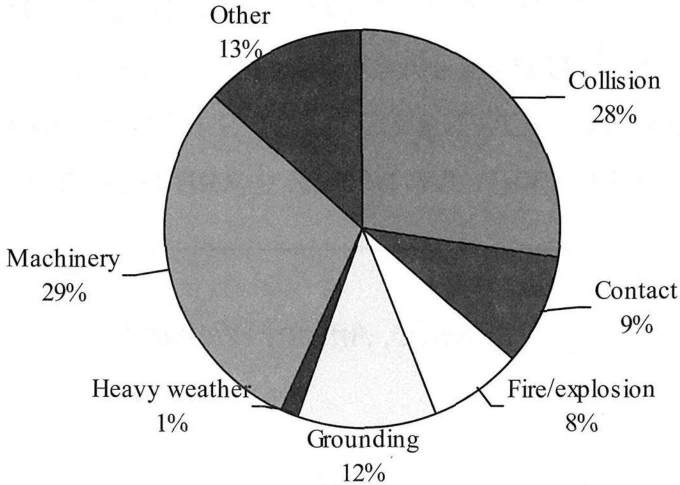


Fig. 1. Hull & Machinery. Claims 1999-2004. Costs in per cent

In the aftermath of the oil crises of the seventies and trade slump of early eighties the ship owners, to survive in this highly competitive shipping business, were left with no other option but to drastically cut down their costs of operations. Crew expenses, accounting for 25 to 35% of total operational costs (Stopford 2000)[8] were the primary targets. The strategy adopted was, firstly to replace a portion of human element by technology. Such partial replacement had also became unavoidable from the standpoint of higher surveillance of operational parameters that became necessary for monitoring and control of contemporary shipboard propulsion and power plants, which for the same reasons of economy needed to be more efficient and consequently demanded operations within tighter tolerances.

Safe and efficient operation of shipboard propulsion plants and their auxiliary equipment within narrow limits of operational parameters is not possible without certain degree of automatic controls. Second course of action to support this strategy was to target cheaper workforce. This necessitated many traditional ship owners to flag out their vessels for necessary freedom to employ seafarers ready to work at lower wages, wherever they could get them from. This change in ship operating pattern however has not been without repercussions. In many cases the 'flags of convenience' became associated with the term 'crew of convinience' (Alderton 2001)[1], because of seafarers with lower levels of knowledge and skills from nations where maritime education and training systems could not keep up with the standards dictated by changing technology, obviously for the same reasons that produced cheaper workforce. In contrast though, these seafarers needed higher knowledge and skills commensurate with contemporary advancing technology. Present pattern of crewing is generally characterized by multinational seafarers in short-term employment contracts, normally provided by crewing agencies (Couper 2000)[4]. While according to a research conducted by the Cardiff University (Kahvechi 2002)[6] which states that approximately 65% of the world fleet have adopted multinational crewing strategies with about 10% of the fleet staffed with crew composed of five or more different nationalities, there are reports that there may be as many as 15 or 16 nationalities on a single ship.

This global diversity is also indicative of widely differing training and skills levels among other attributes of such seafarers. The process of globalization has introduced a broad social and ethnic diversity as a result of multinational crew (IMO News 2002)[5]. Globalization of crew dictates not only a higher level of knowledge of common language and skills to apply it, but also a compatible technical knowledge commensurate with levels and structures of shipboard management for effective teamwork. The physical barriers to communications get exacerbated due to language and cultural diversities of the personnel involved. Outcome of these changes in the ship management pattern and in shipboard technology have had adverse influences on personal safety, ship and environment safety as well as on the efficiency of operations.

These concerns have been prompting the maritime community to direct its concerted efforts towards enhancement of maritime safety for protection of life, property and the environment.

2. The Human Element in the Work of the IMO

The lone figure standing atop the international memorial to seafarers outside the London headquarters of the International Maritime Organization (IMO) is symbolic of the importance that IMO attaches to the human element in shipping – the complex multi-dimensional issue that involves the entire spectrum of human activities performed by ships' crews, shore based management, regulatory bodies and others.

An analysis of 187 instances of groundings and collisions carried out by IMO's Sub-Committee on Flag State Implementation (FSI) indicates that, in 150 cases, or some 80 per cent, the human element was a contributory factor. Broadly equivalent results have emerged from similar analyses and fatigue has emerged as a significant factor in maritime accidents – along with others such as communication, competence, culture, experience, health, situational awareness, loneliness, isolation, stress and working conditions.

IMO has to date accomplished a significant amount of work in addressing the human element in shipping, at sea and ashore. In 1991, a Working Group was established on the role of the Human Element in Maritime Casualties and since then Assembly resolutions have set forth the human element vision, principles and goals for the Organization (resolution A.850(20) updated by A.947(23)) and requested the IMO Committees to focus their attention on "shifting emphasis onto people" (A.900(21)).

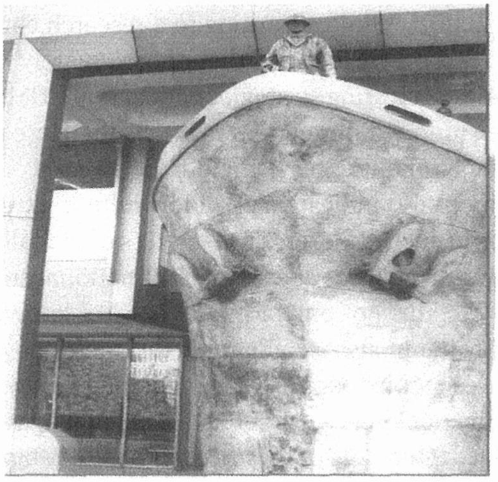


Fig. 2. International memorial to seafarers

Key human element regulations include the STCW Convention – particularly the revision of the Convention in 1995 – and the ISM Code – mandatory for most ships since 2002. IMO has also developed Guidelines for the Investigation of Human Factors in Marine Casualties and Incidents, included in the IMO Code for the Investigation of Marine Casualties and Incidents, and comprehensive Guidance on fatigue mitigation and management has been published.

There is also the STCW-F Convention for fishing vessel personnel, which unfortunately is not yet in force due to lack of sufficient ratifications – but this has not stopped IMO from holding a series of regional familiarization seminars around the world and developing a number of model courses for fishing vessel personnel, which are nearing completion.

Meanwhile, IMO's Maritime Safety Committee (MSC) agreed at its 81st session in May 2006 that a comprehensive review of the STCW Convention and STCW Code is needed, in order to ensure that the Convention meets the new challenges facing the shipping industry including, but not limited to, rapid technological advances today and in the future. The MSC instructed the Sub-Committee on Standards of Training and Watch keeping (STW) to define, as a first step, the issues to be reviewed and advise the MSC accordingly, before embarking on the actual work. The target completion date is 2008.

In the light of analyses of accidents indicating that fatigue was a main contributing factor, a new work program item on review of the principles for establishing the safe manning levels of ships has also been included in the work program of the STW Sub-Committee.

IMO's Joint MSC/Marine Environment Protection Committee (MEPC) Working Group on Human Element continues to meet annually and MSC 81 approved MSC/MEPC circulars on: checklist for considering human element issues by IMO bodies; strengthening of human element input to the work of IMO; framework for IMO consideration of ergonomics and work environment; and the Organization's strategy to address the human element, which includes a related action plan.

Amongst other items, the next session of the Joint Working Group on the Human Element, meeting during MSC 82 in November-December 2006, will analyze the report of a study into the impact and effectiveness of the ISM Code which was carried out by a Group of Independent Experts selected from administrations, organizations, academia and the shipping industry. Based on the data collected, the report concludes that where the ISM Code had been embraced as a positive step toward efficiency through a safety culture, tangible positive benefits were evident; and ISM Code compliance could be made easier through a reduction in the administrative process.

From the above, it can be seen that work on the human factor continues to evolve – while it remains at the heart of IMO's work. Effective implementation of the STCW Convention and the ISM Code through appropriate education and training will continue to have a significant impact on the quality of seafarers and the operational safety of ships. By focusing on the human element in general IMO is strengthening the link between management ashore and performance afloat to sustain a safety culture. The achievement of safer, more secure and efficient shipping on clean oceans will always be dependent on human factors.

The various Conventions and Resolutions mentioned in this article can be downloaded from the IMO website: www.imo.org.

3. Towards safer ship operations and the economic viability of a ship-owner

The International Safety Management (ISM) guidelines were developed to provide a framework for the proper development, implementation and assessment of safety and pollution prevention management.

When ISM was rolled out, many companies produced large volumes of manuals, which clouded or failed to address key issues. They hoped to raise the safety culture through the use of lengthy procedures and checklists, which did not bode well with those who were supposed to use them. Some companies then changed their strategy by first soliciting feedback and participation from those using the manuals and then writing concise, user friendly procedures. Checklists which did not serve any purpose were removed; data flow was better managed through the intelligent use of information technology; and improved transparency between the vessel and the office removed the blame culture.

Ship vetting, the needs of the ISPS Code and reduced turn-around times in port presented an added administrative burden for ships' staff, particularly where numbers had remained the same or had reduced, resulting in increased fatigue. Some ship managers have recognized this imbalance and have taken action to redress it by:

- Placing additional deck officers and/or ratings on board for vessels on short trading patterns or difficult routes or difficult cargo handling processes.
- Recruiting Administrative Assistants to manage the shipboard administration (a role previously undertaken by the Radio Officer).
- Providing shore assistance for maintenance routines and increased dry-dock budgeting.
- Reducing the duration of crew contracts.
- Increasing onboard recreational facilities.

Although this resulted in increased operating costs, there have also been huge indirect cost savings through a reduction in accidents and incidents.

With the shortage of properly qualified seafarers, the burden of providing additional training is becoming more evident. Training is not about just providing what is available in the market or meeting regulatory requirements. Some companies are providing training to understand company systems and internal workings. These programs are internally developed using feedback from ships' staff and applying lessons learnt from incidents, coupled with management business objectives.

Almost all shipboard systems and operations are heavily dependent on human intervention and the human link will constantly remain a weak link in this equation. Therefore the human element needs to be continuously managed and improved. In the final analysis, continued 1earning processes, renewed strategies in managing human capital, and improvement of work practices will form the basis for safer ship operations and for the economic viability of a company.

For a fuller version of Captain Sivasundram's article go to: www.he-alert.org/displayArticle.aspx/articleID=HE00565

4. Some accidents case studies

A. Passenger vessel switchboard fire (Alert - The International Maritime Human Element Bulletin. Issue 2005)[2].

This report of a switchboard fire in a 55,451gt 'state of the art' passenger vessel, built in 1992, demonstrates that some regulatory, design/construction and training deficiencies only manifest themselves after an emergency has occurred – in this case some 10 years after the ship first entered service. The report, from the Transportation Safety Board of Canada, highlights a number of important Human Element issues.

Following the catastrophic failure of the main circuit breaker for one of the diesel generators, fires were started in the main switchboard room (MSR) and the adjacent engine control room (ECR). During the events leading up to the failure of the circuit breaker, none of the senior engineering or electrical officers demonstrated sufficient knowledge or expertise in troubleshooting problems with medium-voltage propulsion plants.

It was company policy for senior engineer officers who were standing by the construction of a new ship to be trained in the vessel's 6.6 kV electrical systems by the equipment manufacturers, with these officers then training the incoming generation of ship's crew, who in turn would train the ones who followed them. However, this system of succession training had fallen into disuse such that, at the time of the accident, neither the engineers nor the electricians had been trained in the ship's electrical generation, distribution, and application systems.

Because the MSR did not have an independent smothering system, the crew extinguished the fires using portable carbon dioxide (CO_2) extinguishers. The lack of an independent connection to the ship's CO_2 smothering system in the MSR deprived the vessel of an effective and safer means to fight fires in this compartment. Furthermore, as the fire was being fought, one of the diesel generators continued to supply 6.6 kV power to the switchboard, located approximately one meter from the firefighting activities. This exposed the crew to undue risk, albeit there were no injuries.

The report recommends a review of the requirements for structural fire protection and fire-extinguishing systems to ensure that the fire risks associated with compartments containing high levels of electrical energy are adequately assessed; and that the provisions of the International Convention for the Safety of Life at Sea (SOLAS) dealing with structural fire protection and fixed fire-extinguishing systems are addressed.

Furthermore, the report highlights the need for internationally accepted minimum standards for training, expertise, and certification for shipboard electrical officers.

This comprehensive and very technical investigation report is essential reading for all those involved in the regulation, design, construction and operation of ships with medium-voltage generation and distribution systems.

The full report can be downloaded from: http://www.tsb.gc.ca/en/reports/ marine/2002/m02w0135/m02w0135.pdf.

B. CASE STUDY 2 (GL FLENSBURG PRESENTATION, MAY 2002)[3]

A container ship built in 1995 of 2480 TEU capacity and a MAN-B&W 6S70MC main engine of 16860 kW, 91 rpm suffered a very serious main engine crankshaft breakdown two crank webs on cylinders No. 3 & 4 have slipped. Crank web on cylinder No. 3 has been turned by 10° in astern direction and cylinder No. 4 crank web was shifted by 315° in the ahead direction (see Fig. 3). Following sequence of events took place: Automatic ME safety system triggered an engine slow down due to "Piston Cooling Flow on cylinder No.

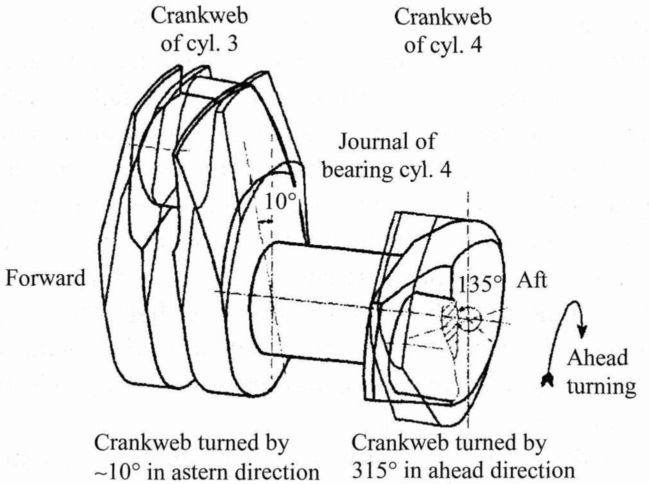
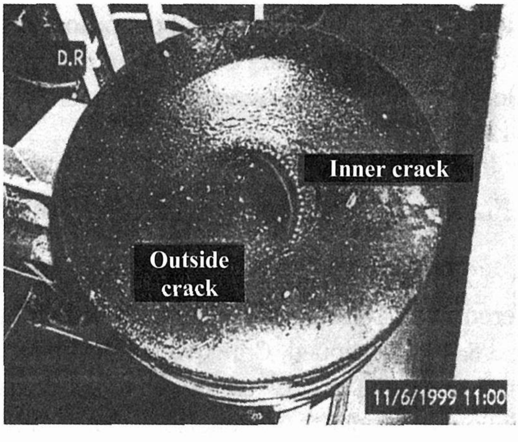


Fig. 3. Detailed picture of damage to crank webs cylinders No. 3 and No. 4

3" announcement. The engine was stopped manually by the engineer on watch. The ship was in ballast condition, stormy weather caused the ship to roll up to 45° both sides.

The engineers checked the piston cooling oil flow-found o.k. Drain pipe from under piston space of cylinder No. 3 was checked and no flow present – o.k. (but later it was stated that the drain pipe was clogged). After 5 min. M.E. stoppage, the engine was started again in ahead rotation. Immediately after that an enormous thump was heard (like an internal explosion), and the engine brought to a stop. Cause stated: hydraulic impact in combustion chamber of cylinder No. 3 what has caused the slippage of crank webs cylinder No. 3 and cylinder No. 4. During later inspection it was discovered that the piston crown of cylinder No. 3 had two cracks (an inner crack and an outer) during



Damage
Craks in piston crown
Cause:
- Hydraulic thump in combustion chamber of cyl. No. 3
- Slippage of crankwebs on cyl. 3 & 4

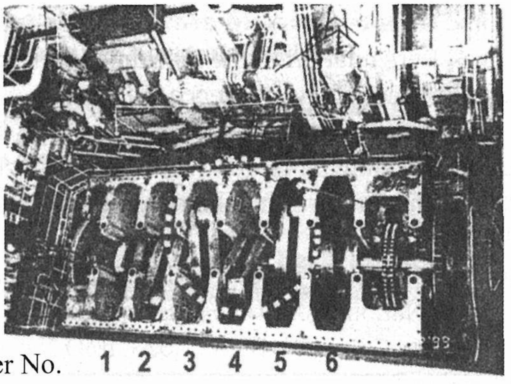
Fig. 4. Damage details on piston crown of cylinder No. 3

the 5 min engine stoppage the cooling oil seeped through into the combustion chamber of cylinder No. 3 (see Fig. 4).

The final picture of the damage (see Fig. 5), crank webs of cylinders No. 1, 2, 3 turned by about 35° i relation to crank webs of cylinders No. 4, 5, 6. The aft crank web of cylinder No.3 and forward crank web of cylinder No. 4 have shifted outwards by about 2 mm. Undertaken temporary repair to bring the ship from Azores area to Hamburg; piston of cylinder No. 3 pulled out. Cylinder No. 1 and No. 2 cut off. Permanent repair – first it was intended to bring back the slipped crank webs into original position but was given up due to the excessive turning of the crank webs, second proposal was to built in new crank webs but this turned out to be too expensive compared with fitting a new crankshaft.

The question arises if this damage could be avoided. The straightforward answer is yes. It could be avoided if routine procedures were observed. It means that the turning gear was clutched in and the engine rotated with open indicator cocks to observe eventual emission from the indicator cocks. If this procedure would be carried out the engineers could notice the oil being ejected from cylinder No. 3 but this was not done, the normal procedure has been violated with fatal results. The only excuse concerning the engineers action can be the state in which the ship was sailing (heavy rolling) and the clogged drain pipe from the under piston space of cylinder No. 3, but if this drain valve has been regularly opened it would not be chocked so again some negligence on the engine crew side.

Forward



Aft

Cylinder No.

Damage Picture

- Crabkwebs of cyl. 1, 2, 3 turned by about 35° relative to crankwebs 4, 5, 6
- Aft crankweb of cyl. 3 and forward crankweb of cyl. 4 projecting about 2 mm outwards

Firing:
1 – 5 – 3 – 4 – 2 – 6

Fig. 5. Picture of turned crank webs seen from top of the engine bedplate

CONCLUSIONS

It makes sense of continuing projects to improve the awareness of the Human Element in the maritime industry. In the time to come we should be focusing on the application of the body of knowledge that has already been accumulated to address the specific Human Element issues of: fatigue, effective communication, automation and alarm management, strict observation of procedures, complacency and routine slips, trips and falls, health, safety and wellbeing, recruitment, retention, education, training and competence, and information management. There is also an urgent need to review the STCW convention with respect to introduce the electrical engineer diploma as more and more electrical systems are introduced on today's ships (diesel-electric propulsion), case study A is an obvious evidence of having on board electrical engineers familiar with the vessels 6.6 kV electrical systems. Thus there is a need for internationally accepted minimum standards for training, expertise and certification for shipboard electrical officers.

Finally there should be a decisive reverse in financial outlays for technology development and crew training, i.e. 80% of finances should be devoted for in depth training and less for a continuous development of technology with which the crew cannot catch up.

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