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Some technical aspects of spills in the transportation of petroleum materials by tankers

Zubaidah Ismail [a,*], Ramlee Karim [b]

[a] University of Malaya, Lembah Pantai, 50603 Kuala Lumpur, Malaysia
[b] Petmel Resources Private Limited, 53 Persiaran Zaaba, Taman Tun Dr Ismail, 60000 Kuala Lumpur, Malaysia

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ABSTRACT

The petroleum industry is most concerned about safety and one which has an effective safety culture. This study analyzed the accident cycle in the sea transportation activities of the industry. The analysis was based on published data over the past 44 years involving spills of 1000 tonnes and above. Total spill volume was 4.27 mil tonnes with a mean of 64,000 tonnes and a standard deviation of 86,6000 tonnes. Total cleanup cost was estimated to be 17.8546 bil Int$, with a mean of 955.075 mil Int$, a standard deviation of 698.376 mil Int$. It was observed over the study period there seemed to be a cycle of about 10 years. There was a decreasing trend of spill volume. Crude represented 99% and the rest involved final products. About 65% of the tankers finally broke up and about 35% was associated with fire and explosion. Navigation error caused 42.5% of the accidents, storms and hurricanes caused 31.8% of the accidents, mechanical and maintenance related factors caused 18.2% of the accidents, engine failure represented 4.5% and other causes with about 3%. The highest number of deaths was recorded from the Independenta with 43.

1. Introduction

There are two main types of accidents – routine accidents and surprises. An accident could be of a routine nature or it could be a unique event; a precursor event; or a superlative event. While there are lessons to learn from the experience of routine accidents since the impacts are somewhat similar, a once-off accident or a surprise event is more difficult to manage. Sensible responses to routine accidents can be developed, reviewed every now and again and further improved. These could include accident warning systems, emergency management schemes, and accident recovery programs. For a surprise event there is not much to draw from experience and the preparedness to face such an occurrence is usually lacking. There are not many references to be made on similar previous events as pointed out by Michell (1996). Each industry and each stakeholder in the industry has, associated with it, what can be termed as a safety culture and an SMS for that industry or that particular organization. A good safety culture results in a good safety record and a bad safety culture results in a poor safety record. The key to a good safety culture lies from a demonstrated management commitment that treats safety as having equal priority to other organizational goals. Some are guided by the statement of 'Safety First'. Employees are involved in, and know that they have the ownership of, the safety process. Realistic and achievable safety targets are set for all work groups to achieve. Employees are adequately trained in safety skills. Incident investigations are carried out not so much as to apportion blame but to minimize and prevent future occurrences. Positive steps are taken to improve employee behaviors, attitudes and values. These include employee involvement and ownership of the safety process. It involves developing teamwork and supporting leadership within workgroups. It recognizes and values individual contributions to safety. It fosters an environment where employees genuinely care about the safety of their co-workers (Ahern, 2007). Monitoring techniques could be introduced to assist in assessing the general safety conditions of the organization. In order to reduce risks associated with operational activities, one approach is to provide real time and risk-based accident forecasting mechanisms and tools that could enable the early understanding of any deviations and link with possible accident scenarios. A forecasting algorithm could be developed to identify and estimate safety measures for each operation step and process model element and validated with process conditions as proposed by Gabbar (2010).

A high degree of safety performance can be achieved through the establishment of a good safety culture. The safety management system has to be aware and know the business hazard, and therefore be proactive to it. The attitudes throughout the organization on the application of the safety management systems must be honest and sincere as shown by the commitment of senior managers

* Corresponding author. Address: Department of Civil Engineering, University of Malaya, 50603 Kuala Lumpur, Malaysia. Tel.: +60 379675284; fax: +60 379675318.
E-mail addresses: zubaidahjka@gmail.com (Z. Ismail), ramleekarim@gmail.com (R. Karim).

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(Ismail et al., 2011), and that the actions taken are not just because of the threats of legal action but also to achieve an overall satisfied workforce (Dawal et al., 2009). The handling of commercial pressure must demonstrate knowledge of what is the overall business priority, which is safety. The state of being informed and ready is also important to ensure that incidents do not escalate into worse accidents; and accident investigation and analysis do uncover the underlying factors and any managerial failings that might have led to the accidents as commented by Hudson (2003). Human factors play an important role in the completion of emergency procedures. Human factors analysis is rooted in the concept that humans make errors, and the frequency and consequences of these errors are related to work environment, work culture, and procedures as observed by Deacon et al. (2010).

The petroleum industry involves activities like exploration, production, transportation, processing and refining, storage and product distribution. Each activity is different from another with different general degree of risks involved (Ismail et al., 2012a,b). There are distinct differences even within one type of activity like transportation between land and water transportation or between use of tankers or pipelines. In the current study focus is put on transportation using tankers. The main concern of transportation using tankers is the possibility of spills which will cause environmental disasters. An environmental disaster is a disaster to the natural environment due to human activity. It can include the deaths of animals and plants, or severe disruption of human life. Environmental disasters can have an effect on agriculture, biodiversity, the economy and human health. The causes include pollution, depletion of natural resources, industrial activity or agriculture. Some scientists argue that the ecosystem has recovered when all parts are functioning again while others argue that the impacts will last for decades (Pierce, 2002).

Coinciding with the collapse of the government in Somalia there have since been escalating incidents of hijackings of petroleum tankers in the waters offshore of the country. Although there have been alleged threats of blowing-up the tankers there have so far been no such incidents which would cause massive spills. The agenda seems to be ransom money which the owners and insurance companies have this far paid amounting to billions of dollars per year. The current concern is the expanding area of operation which has reached much further south into the Indian Ocean then just offshore Somalia. This has been possible by the support of ‘motherships’ (Bright, 2011; Saul and Maltezou, 2011). Will there come a time when idle threats become real environmental disasters.

DeCola and Fletcher (2006) stated that human factors – either individual errors or organizational failures – have been reported to cause as much as 80% of oil spills and marine accidents. Impact of spills is difficult to quantify due viscosities, specific gravity, light, medium or heavy crudes or finished products which behave differently upon exposure to the open sea. Ambient conditions of atmospheric pressure, temperature, wind conditions, waves and currents all have an effect of the spread of the oil on the water surface. Training and emergency preparedness, safety equipment, evacuation procedures, availability and effectiveness of rescue parties all have an influence on the overall impact of spills. O’Brien (2003) proposed a strategy in the approach to cleaning-up of spills.

Attempt have been made to assess the direct and indirect, immediate and long-term casualty of spills including the economic and environmental aspects but this kind of study is difficult to conduct due to the above-mentioned complexity of parameters involved. Damage to the ecosystem, birds and animals as a result of the Exxon Valdez accident, for instance, were enormous (Leacock, 2005). This massive 987-foot tanker has left a lingering, long-term effect on the natural habitat that surrounds these pristine waters, along with an enormous socio-economic effect that has left many people wondering when and where the next oil spill will be (Wells et al., 1995). Etkin (2000) gave a comprehensive worldwide analysis of the factors affecting the cost of spill cleanup. Liu and Wirtz (2009) proposed the relationship between direct and indirect impact of oil spills as a function of spill size. White (2003) and White and Molloy (2003) analyzed the factors affecting the cost of oil spills including type of oil, size and rate of spillage, characteristics of the spill location including physical, biological and economic conditions, sea and weather conditions, time of the year and effectiveness of clean-up operation. Hooke (1997) gave a comprehensive account of maritime casualties for the period 1963–1996. The long-term health effects of oil spills (Walsh, 2010) and the impact on the environment (Kingston, 2002; Guarino and Spotts, 2010) and wildlife habitat (USFWS, 2004) including salt marshes and mangrove swamps have been discussed.

The objectives of this study are:

- To analyze the details of spills in accidents involving the transportation of crude oil and products by tankers.
- To determine the most critical basic cause of the accidents.
- To get a general feel of the consequences of cleanup cost and general impact based on the parameters involved in the accident.
- To help reduce the impact by proposing appropriate steps and procedures to mitigate the anticipated problems.

2. Materials and methods

Details on spills were retrieved mainly from the Internet and reports dating back to 1964 involving 66 spills of about 1000 tonnes and above. Loss of human life or economic and environmental impact or spill volume may be used as a measure of the severity of the accident and an indication of its overall impact. What is certain is that not one factor like size or frequency could completely assess the impact on its own. This study is limited by the analysis of chronology of events, spill quantum distribution, cumulative amounts, location of spills, return period and some other relevant statistics of each accident including a crude risk analysis of the accident. The values for the mean, standard deviation, percentage probability and coefficient of variability were calculated and the probable causes were also recorded and analyzed. Then spills were grouped into five categories: 50 K tonnes and less, 5–100 K tonnes, 101–150 K tonnes, 151–200 K tonnes, and 201 K tonnes and above. The basic events were categorized under navigation error, storm, mechanical and maintenance related, engine failure and others. These could result in collision, running aground or fire and collision. The top events were categorized under structural damage (broke) and fire and explosion. An application program was used to calculate the probability for each scenario. The probability figures were ranked to determine the relative criticality of each scenario. An estimate of total cost of cleanup per spill in Int$ was also developed relating to each country’s GDP.

3. Results and discussion

3.1. Details of spills

Table 1 gives a summary of the 66 spills observed giving dates, tanker names, spill sizes, location, overall relative probabilities and pertinent remarks about each incident.

Fig. 1a shows the occurrence of events through the study period. Steep slopes indicate a longer time lapse before the next event. There appeared to be a cycle of about 10 years. The lapse of time between two neighboring events had a maximum of 154 weeks between the Nakhodka which happened on 2 January 1997 and the Erika accident which happened on 12 December 1999. This was followed with