

Maintenance-related Disaster Cases in the Oil and Gas Industry

By: Z. Ismail, S.Z. Md. Dawal and R. Karim, F.I.E.M., P.Eng.

INTRODUCTION

The oil and gas industry is reputed to be one of the most concerned on the issues of maintenance and safety, and is one of the best in terms of having an effective maintenance and safety culture. However, whenever an accident happens, the impact is so devastating and involves enormous losses of property and life that the memory lingers for decades and the event becomes a classic example cited time and again.

If we trace the chain of activities of the industry from Exploration and Production, Crude Transportation and Storage; Processing and Refining; and Product Transportation and Storage, we can find a trail of unforgettable disasters like the Piper Alpha offshore platform explosions and fire; the crude oil spill of the Esso Valdez; the explosion and fire at the Gas Processing Plant in Longford, Australia; the explosion and fire at the Liquefied Natural Gas (LNG) plant in Badak, Indonesia; the fire at the BP Refinery in Grangemouth, Scotland, and Texaco and Gulf Refinery at Milford Haven; and the explosion and fire at the Liquefied Petroleum Gas (LPG) storage terminal facility in San Juan Ixhuatepec near Mexico City. Some of these were directly or indirectly the result of a poor state of maintenance and repair of equipment and systems. This article identifies commonalities in selected disasters along the chain of activities of the oil and gas industry and highlights the lessons to be learnt from these disasters.

BACKGROUND

There are two main types of disasters – routine disasters and surprises. A disaster could be of a routine nature or it could be a unique event; a precursor event; or a superlative event. While we can learn from the experience of routine disasters since the impact is somewhat similar, a once-off disaster or a surprise event is more difficult to manage. Sensible responses to routine

disasters can be developed, reviewed every now and again, and further improved like disaster warning systems; emergency management schemes; and disaster recovery programmes. For a surprise event, there is not much experience to draw from and the preparation to face such an occurrence is usually lacking. There are not many lessons to be learnt and there are no references to be made on similar previous events [1].

MAINTENANCE AND SAFETY CULTURE

Each industry and each player in the industry has, associated with it, what can be termed as a maintenance and safety culture for that industry or organisation. A good culture results in a good safety record while a bad culture results in a poor safety record. The key to a good culture lies in a demonstrated management commitment that treats maintenance and safety as having equal priority to other organisational goals. The statement of 'Safety First' is the truth and nothing but the truth. Employees are involved in and know that they have ownership of the safety process. Realistic and achievable targets are set for all work groups to achieve. Employees are adequately trained in the necessary skills. Incident investigations are carried out not so much as to apportion blame but to minimise and prevent future occurrences. Positive steps are taken to improve employee behaviours, attitudes and values, and this includes employee involvement and ownership of the process; developing teamwork and supporting leadership within workgroups; recognising and valuing individual contributions to general safety; and fostering an environment where employees genuinely care about the welfare of their co-workers [2].

Through the establishment of a good maintenance and safety culture, a high degree of safety performance can be achieved. The maintenance and safety management system has to be aware of

the business hazards, and therefore be proactive to it. The attitude throughout the organisation on the application of the management systems must be honest and sincere as shown by the commitment of senior managers, and that the actions taken are not just because of the threat of legal sanctions. The handling of commercial pressure must demonstrate the knowledge of what is the overall business priority, which is safety. The state of information and readiness 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 [3].

EXAMPLES AND DISCUSSION

Production Platform

On July 6, 1988, at about 2200 hours, an explosion occurred on the Piper Alpha platform facility in the North Sea. Within seconds, a major unstabilised crude-oil fire developed and all but the well-head area and the lower parts of the platform were engulfed in smoke. The subsequent fire escalation was swift and dramatic with the first of three gas risers failing catastrophically after 20 minutes. In that disaster, 167 out of 229 people lost their lives in what was the world's worst offshore accident. The background to the investigation and the sources of evidence has been reviewed. The available evidence has been examined to explain the rapid escalation of fire following the initial explosion. There followed a commentary on the way fire and fire dynamics are now being considered in the design and operation of UK offshore installations [4].

At the height of the blaze on the platform, flames could be seen 100km away. The first survivors to reach the mainland said they slid down pipes and jumped into the icy sea to escape the flames. A full inquiry by Lord Cullen was held and six platforms nearby were

closed as a precaution. The UK Offshore Operators' Association stated that accidents have fallen by 50% since the Piper Alpha disaster, and workers and unions are consulted on matters of safety. Others contend that they have been unable to find evidence that offshore safety has improved significantly since 1988. They accuse oil companies of ignoring one of the key points of Lord Cullen's inquiry into the disaster – that the offshore workforce be fully involved in safety procedures. They also accused the industry of being anti-union and hostile to regulations laid down by the state authorities. Workers are afraid to whistle-blow for fear of losing their jobs. Cullen stated that the company operating the rig was not prepared for a major emergency and adopted a superficial attitude to the assessment of the risks of a major hazard [5].

Crude Oil Transportation

The Exxon Valdez departed from the Trans Alaska Pipeline Terminal at 9.12pm on March 21, 1989. On its way, the tanker encountered icebergs and it detoured from the normal shipping lanes to get past the icebergs. The ship failed to turn back to the shipping lanes and ran aground on Bligh Reef at 12.04am on March 24. The failure to maintain its structural integrity caused the carrier to break and resulted in 257,000 barrels out of a cargo of 1,264,155 barrels being spilled. The spill stretched on for 460 miles and affected a beach line of 1300 miles. Damage to the ecosystem, birds and animals were enormous [6].

Gas Processing Plant

Built in 1969, the plant at Longford is the onshore receiving point from platforms in the Bass Strait.

The plant consists of three gas processing plants (GPPs) and one crude oil stabilisation plant. It was the primary provider of natural gas to Victoria, and provided some supply to New South Wales.

The primary cause of the incident is, again, a failure to maintain structural integrity from the brittle rupture of a heat-exchanger due to abnormally high temperature difference. About 10 metric tonnes of hydrocarbon vapour were immediately released due to the rupture. It

formed a vapour cloud which drifted downwind, and got ignited some 170 metres away when it reached a set of heaters. The flame front flashed back through the vapour cloud, and when it reached the rupture in the heat exchanger, a fierce jet fire developed which lasted for a few days. As a result of the disaster, two workers died and eight others were injured.

The company initially blamed the accident on a worker's negligence. The Royal Commission, however, cleared the worker of any negligence, and instead found that:

'The causes of the accident on September 25, 1998 amounted to a failure to provide and maintain so far as practicable a working environment that was safe and without risks to health. This constituted a breach or breaches of Section 21 of the Occupational Health and Safety Act 1985.' Other findings included:

- a) The Longford plant was poorly designed, and made isolation of dangerous vapours and materials very difficult.
- b) There was inadequate training of personnel in normal operating procedures of a hazardous process.
- c) There were excessive alarms and the warning systems had caused workers to become desensitised to possible hazardous occurrences.
- d) The relocation of plant engineers to Melbourne had reduced the quality of supervision at the plant.
- e) Poor communication between shifts meant that the pump shutdowns were not communicated to the following shift.

Other managerial shortcomings highlighted were:

- a) The company had neglected to commission a hazard and operability (HAZOP) analysis of the heat exchanger system, which would almost certainly have highlighted the risk of tank rupture caused by a sudden temperature change.
- b) The company's two-tiered reporting system (operator to supervisor to management) meant that certain warning signs such as a previous similar incident (on August 28) were not reported to the appropriate parties.

- c) The company's maintenance and safety culture was more oriented towards preventing lost time due to accidents or injuries, rather than protection of the workers and their health [7].

LNG Processing Plant

An LNG gas cloud explosion at the Badak LNG plant made it necessary for the CEO to make a public apology to the president at an LNG conference in Jakarta. For a long-term trade in LNG, the first priority is the security of supply. The confidence of buyers in this respect was definitely and permanently dented by a disruption of product shipments due to the explosion and fire. There was also national embarrassment and loss of goodwill.

LPG Storage

The Mexico City LPG storage explosion and fire was another classic case of operational failure due to several technical factors. The explosion, fire and boiling liquid expanding vapour explosions (BLEVEs) at the Pemex LPG Terminal in San Juan Ixhuatepec, near Mexico City on November 18, 1984 caused about 500 deaths. A drop in pressure was noticed in the control room but the cause was not identified or determined. The rupture of an 8" pipeline connecting a sphere and a series of vessels was not detected. The release of LPG continued between 5 and 10 minutes resulting in a 2-metre high cloud covering an area of 200 metres by 150 metres. When the cloud reached a flare tower, the first explosion occurred and emergency shutdown procedures were too late to arrest the catastrophe. BLEVEs continued for one and a half hours as vessels exploded and projected fiery rockets over great distances. The terminal was completely destroyed and the activity was powerful enough to be registered on a seismograph at the University of Mexico. The probable cause is overpressure from the pipeline to the storage facility; and inadequate pressure relief and control. The state of maintenance and repair was found to be very poor. Several pressure gauges were not calibrated and gave erroneous readings.

Management was found not to fully understand the implications of differing regulations concerning the transfer of hazardous materials inter-state and intra-state. The regulatory requirements at federal and state levels were different and had caused confusion and a misunderstanding in procedures. Fire fighters were ignorant of the behaviour of BLEVEs and several were killed in their attempt to fight the fire.

Refinery Fire and Explosion

The Shell Newhaven fire, the BP Grangemouth's series of fires, and the devastating Texaco and Gulf Refinery fires at Milford Haven injured scores of workers. It was found that there were weaknesses and failures in management, equipment, state of maintenance and control systems. This means that the fires could have been avoided.

LINGERING QUESTIONS

From the examples mentioned, it can be concluded that almost all the disasters cited were routine disasters. Similar accidents had happened elsewhere sometime in the past. The question is whether people do really learn from history or not. Is there anything to learn from past disasters, or it may be that even a routine disaster is so unique that there is nothing much to learn from it.

Common Weakness

Basically, the failure at all the accidents mentioned is, in one way or another, related to maintenance failure. In the case of the Piper Alpha disaster, the compressor header pipe gave way during maintenance because of overpressure, giving rise to a rupture and the release of flammable and explosive contents. The Exxon Valdez failed to maintain its structural integrity to contain the crude as it broke into two due to too much stresses subjected to its structure. In the case of the Longford GPP facilities disaster, the LPG failed to be contained because of the rupture of a heat-exchanger. A cryogenic vessel rupture caused the vapour cloud explosion at the LNG facilities; and pipeline overpressure and loss of structural integrity caused a rupture which caused the fire, explosion and

BLEVE at the New Mexico storage facility disaster.

As in all accidents, there was no single factor that solely contributed to the disaster, but a combination of other contributory failures that caused the disaster to happen. In the Piper Alpha case, it was really a comedy of errors. First, one out of two vital compressors producing power for the entire complex was down for overhaul. A single safety valve on the header was taken out for repair and a blind plate fixed in its place, thus rendering the system unsafe to operate. Repair work was simultaneously carried out on the deluge pump for automatic fire-fighting system and the procedure on Piper Alpha required that the pump be put on manual control whenever there were divers in the water. It can only be started from a different location. Shutdown procedures on neighbouring platforms which fed gas to Piper Alpha required high-level intervention.

System overpressure caused by the failure of safety valves due to poor maintenance, or not removing blind plates, and the continuous feeding of fuel into a fire zone are very common; systems and an idiot-proof design must be adopted. Communication failure is another contributory cause of accidents. A break in the chain-of-command e.g. waiting for instructions which never came because the ones to issue the command were dead and replacements were not appointed. There were also interface problems like shift changeover duty and missing vital safety documents. Language problems among workers from different nationalities have also been known to contribute to disasters. Inadequate training on procedures not only for on-site workers but also for casual contract workers, and for new recruits combined with inadequate supervision due sometimes to secondment of experienced supervisors and replacement by fresh ones are other contributory causes of accidents.

Another observation that can be made is that, in many cases, victims are placed in a situation that can be described with the phrase 'jump out of the frying pan into the fire'. In the Piper Alpha disaster, there were people who

perished after jumping 200 feet into the icy waters of the North Sea in order to escape the raging fire on the platform. In the case of the Mexico City disaster, there were ambulances with victims driving through gas clouds en route to the hospital; and in other cases, there were people seeking shelter in gas-filled confined spaces, akin to waiting for disaster to strike.

There are several cases of breakdown in support infrastructure, inadequate logistics and supplies of essentials. We also encounter several cases of human errors in judgement, systems weaknesses, management failings, lack of worker training and involvement in safety matters, and unanticipated hindrances during rescue operations.

Lessons Learnt

Some of the lessons that could be learnt from the examples mentioned are:

- a) There could be a complete disruption of supplies affecting all economic activities with enormous damage and financial losses. There is a need to offer an alternative supply system.
- b) Frequently, inadequate and far-from-satisfactory settlements and compensations were given to the victims.
- c) There is a need to re-examine the Limits of Operational and Financial Authority especially during emergencies.
- d) There is a need to re-examine the design standards on redundancy, maintenance and other policies on equipment related to safety such as safety valves and the use of blind plates.
- e) There may be a need for an idiot-proof system for maintenance and safety.
- f) There is a need to conduct regular technical audits, HAZOP studies and hazard analysis.
- g) Failure in communication must be minimised by taking extra care at the interfaces.
- h) There must be continuous training on maintenance and safety.
- i) Special care must be taken in handling contractual workers in matters of site maintenance and safety procedures which could be very different from what they are used to.

- j) There must be drills and exercises to debug and pre-empt potential problems.
- k) There must be an arrangement for adequate infrastructure and logistic support in case of an emergency.
- l) The blame could be on human error, equipment failure or control system failure; but ultimately, the management is responsible.

CONCLUSIONS AND RECOMMENDATIONS

In the preparation of guidelines related to industrial maintenance and safety, there is a need to maintain good coordination and understanding between the federal and state agencies and the private sector in order to avoid discrepancies in implementation. Good communication across all levels must be maintained with special emphasis at the interfaces. Drills and full scale exercises must be conducted regularly to assess the requirements for logistics and supplies of essentials; and generally debug potential problems in the systems. Maintenance and safety training and refresher courses must be carried out regularly. In cases of shared common facilities, there should be more cooperation across company lines to maintain and repair these facilities. ■

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Success

There are two kinds of success. One is the very rare kind that comes to the man who has the power to do what no one else has the power to do. That is genius. But the average man who wins what we call success is not a genius. He is a man who has merely the ordinary qualities that he shares with his fellows, but who has developed those ordinary qualities to a more than ordinary degree.

-Theodore Roosevelt