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Automation of emergency response for petroleum oil storage terminals

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ABSTRACT

In the recent decades, several fatal accidents have occurred around the world at petroleum storage sites leading to fire, explosion and toxic release scenarios. Such accidents result in huge loss of lives and property, along with widespread environmental damage due to improper coordination and communication in the emergency response. Therefore, emergency response planning is an integral and essential part of the safety and loss prevention strategy and comprises of the actions taken to manage, control and mitigate the immediate effects of an incident.

An emergency requires a crystal clear hierarchy of command and organizational-procedural guidelines without any ambiguities. This paper highlights the need, structure and development of an automated networking system, called the electronic-Incident Command System (e-ICS), through case study of the Indian Oil Corporation Limited (IOCL) Jaipur storage terminal accident. Based on the previously proposed Incident Command System, e-ICS further strengthens coordination and communication in emergency responses. The response mechanism, through Confirmation, Command, Tactical and Support Nets for vertical and horizontal flow of commands and information has been described. This paper also discusses the importance of the Emergency Operations Center and Emergency Management Computation System in expediting the information flow. Thus, recommendations for improving coordination in crisis management are proposed.

1. Introduction

Petroleum storage terminals normally have large storage tanks containing huge amounts of flammable chemicals. Hence the occurrence of a tank accident is highly probable and usually leads to fire and explosions. Despite highly equipped process plants' and storage sites' considerable efforts towards effective safety measures, it is still possible that an improbable event, or more likely an unforeseen series of events, may lead to a serious incident. In the last four decades, many serious accidents have occurred around the world at petroleum storage sites as a result of control system failure, incompatible reactions, human error, and so on (Lin et al., 2003; Abbasi and Abbasi, 2005; Pasman and Suter, 2005). From the lessons drawn out of root-cause analyses, it is not sufficient to merely depend upon preventive measures but a timely, well-defined emergency response must be implemented when a grave situation actually occurs. The need for effective emergency planning has been reinforced in recent years by major accidents that occurred at Buncefield (UK) in 2005 (MIIB, 2011), Puerto Rico (USA) in 2009 (Chemical Safety Board, USA, 2011) and at Jaipur (India) in 2009 (Sharma et al., 2013). Hence, prudently establishing an adequate ERP to deal with storage industry incidents has become a common concern throughout the world. To prevent an accident from being exacerbated, an emergency system, safety equipment, and manpower should be integrated along with proper evacuation planning. This integration is necessary to increase effectiveness and efficiency of response planning (Fitzgerald, 1996). The main focus in the management of emergencies has been on resources and logistics; in other words, having what and who you need, where and when you need it to meet the crisis within an urgent time frame (Kowalski, 1995).

In the petroleum storage industry, emergency response planners have concentrated on designing better and safer equipment

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and self-contained self-rescuers, decreasing response time, increasing training of rescue teams, and developing escape plans that comply with storage site safety regulations. Immediate and effective response to an accident site is, of course, essential to minimise the severity of accidents, loss of life and the possibility of the loss of the future productivity of the storage site (Kowalski, 1995). ERP is required for various types of accidents to decrease the degree of hazards efficiently by effectively preparing, responding, and restoring normal conditions (Kowalski, 1995). Designing improved equipment along with the application of new technologies and focused training increases the efficiency of rescue operations. Additionally, modified technology has brought more efficient communication, such that personnel in the command center have the opportunity to apprehend real time scenarios as precisely as the front line emergency workers. Thus, an effective communication system almost always curbs the severity of an emergency. Even after the implementation of these action plans, minor incidents may still occur from which lessons can be learnt to further reduce the risk of a major incident, but only if these lessons are widely shared and appropriate actions are taken.

This paper shows that information obtained from post risk assessment carried out on the IOCL Jaipur accident has generated significant data that is essential in emergency response planning. The data generated from the IOCL incident, considered to be crucial in framing on-site emergency plan of storage terminals, is also necessary for an off-site plan. According to the IOCL Jaipur incident analysis, when a leak occurred, staff at the plant site were unable to promptly deal with the critical situation due to unavailability of an effective plan with detail response mechanisms (MoPNG committee, 2010). Therefore, a complete ERP must be effectively developed and distributed on the basis of the real scenario to prevent major incidents in the future. Predictive techniques enable major accident consequences to be assessed, and thus aid in the development and implementation of mitigatory strategies incorporated in an emergency plan. This study outlines a suitable and effective ERP and demonstrates how the response to various emergency levels during an unexpected incident could be readily planned, controlled, and implemented.

2. Learning from the Past

A mysterious variety of accidents occur in process plants and storage terminals of petroleum products. These range from minor leaks to catastrophic releases leading to fire or explosion with the potential to threaten people, structures and surrounding nature. Despite all preventive arrangements, incidents do occur from which lessons can be learnt to further reduce the risk, provided that the lessons are widely shared. Even with high quality safety arrangements and adherence to precautionary procedures, it is still possible that an improbable event, or more likely an unforeseen series of events, could lead to a serious incident. The main purpose of the post-incident assessment is to identify, from the emergency response operation, the weaknesses or strengths in the action plan and to make appropriate corrections in the plan. Therefore an up-to-date emergency response plan is required to tackle emergencies effectively. Predictive techniques enable major accident consequences to be assessed, and thus aid in the development and implementation of mitigatory strategies incorporated in an emergency plan. A list of major petroleum industrial accidents in the last decade with the number of fatalities, injuries and property loss is given in Table 1.

3. IOCL Jaipur accident

During the evening shift of 29th Oct 2009, four employees of the IOCL terminal were carrying out a routine transfer of gasoline from tank 401-A to the neighbouring terminal of BPCL. Around 6:10 pm, a huge leak of gasoline occurred from the 'Hammer Blind Valve'. The liquid gasoline rapidly generated vapours that made the operators lose consciousness. With none of the operating crew being available for initiating control actions, the leak remained uncontrolled and engulfed almost the entire installation. IOCL administration vacated the terminal and cautioned nearby industries. The uncontrolled release of gasoline occurred for over a period of 80 min before igniting the resulting flammable mixture. The total amount of gasoline released was over 2000 tonnes, which resulted in the creation of 81 tonnes of vapour cloud covering an area of 180,000 m^2 (Sharma et al., 2013). An ignition source that triggered the explosion and fire might have been either one of the non-flame proof electrical equipments in the Administrative Block or a vehicle being started in the installation (MoPNG committee, 2010).

At 7:35 p.m. a huge ball of fire with massive explosions broke out engulfing the leaking tank and other nearby tanks. The fire, with flames as high as 30–35 m, was visible from a 30 km radius. Seismological measurements reported that one of the VCEs was equivalent to an earthquake with the intensity of about 2.3 on the Richter scale (MoPNG committee, 2010). As a consequence of this explosion, the entire installation was destroyed and the buildings in the immediate vicinity were heavily damaged. The accident claimed eleven lives and more than 150 were seriously injured.

The fire that followed the explosion spread to all other tanks and burnt for 11 days. The management of IOCL took the decision to allow the petroleum products to burn out in order to avoid further aggravation of the accident in the interest of public safety (MoPNG committee, 2010). The local fire officers were ill-equipped to deal with fire accidents of this magnitude. All the petroleum

Table 1
Major petroleum industrial accidents since 2000.[a]

Date	Plant type	Event type	Location	Property loss (US $ million)	Injuries/fatalities
25/06/2000	Refinery	Vapor cloud explosion	Mina Al-Ahmadi, Kuwait	600	50/5
21/09/2001	Petrochem	Petrochem explosion	Toulouse, France	610	3000/30
19/01/2004	Gas Processing	Fire/explosion	Skikda, Algeria	580	74/27
23/03/2005	Refinery	Fire/explosion	Texas, United States	1500	170/15
11/12/2005	Petroleum	Fire/explosion	Hertfordshire, England	1443	43/0
12/09/2008	Refinery	Hurricane	Texas, United States	750	0
23/10/2009	Refinery	Fire/explosion	Bayamon, Puerto Rico	$\ll$6.4	0
29/10/2009	Petroleum	Explosion/fire	Jaipur, India	32	150/11
02/04/2010	Refinery	Fire/explosion	Washington, United States	–	4
6/01/2011	Refinery	Fire/explosion	Fort Mckay, Albert, Canada	600	–
25/08/2012	Refinery	Explosion/fire	Venezuela	1000	100/50
18/04/2013	Fertilizer plant	Explosion/fire	Texas, USA	–	100/15
23/08/2013	Refinery	Explosion/fire	Visakhapatnam, India	–	14/37

[a] *Sources:* MRCP, 2013; FABIG; Abdolhamidzadeh et al., 2011; Lee's, 2012; Mishra et al., 2014; http://zeenews.india.com/news/andhra-pradesh/ap-govt-to-issue-notice-to-hpcl-over-fire-in-vizag-refinery_874083.html.