BUNCEFIELD AND BEYOND

Important lessons for developing countries

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1.0 Introduction

The morning of 11th December, 2005 saw the birth of the largest inferno in Storage Tank history. The initial explosion could be heard upto 20 miles away, and destroyed property not only within the Depot, but also severly damaged neighbouring industries and structures. The subsequent fire involved 22 Oil storage tanks, containing petroleum products such as Petrol, Kerosene, Diesel and Avtur (Aviation Fuel), and at the peak of the fire fighting operations, 180 fire fighters had been deployed to the incident scene. It took almost 600,000 litres of foam concentrate, about 40,000,000 litres of water and a water supply hose chain almost 30 kilometres long to deal with the incident. The fire fighting operations lasted almost 3 days, but the damping down and recovery operations lasted for around 3 weeks thereafter.

Fig 1. The smoke from the fire was seen from satellite images

Though the scale of the explosion and the subsequent fires was very high, surprisingly there was no fatality (probably because the incident occurred on a holiday i.e. Sunday). Around 43 people were injured in the incident, but none seriously. Commercial and residential structures in the vicinity were extensively damaged, and the fire also engulfed an adjacent building. Areas around the site had to be evacuated, in fact, about 2,000 people had to be given temporary accommodation, and the incident affected almost 25,000 people. Significant damage occurred to both commercial and residential properties in the vicinity and a large area around the site was evacuated on emergency service advice. An important motorway had to be closed.

The emergency services (primarily the Fire and Rescue Services and the police) led the initial response to the incident and its immediate aftermath. As a Category 1 responder under the Civil Contingencies Act of the U.K., the EA (Environmental agency) was also required to co-ordinate with the Emergency services. They worked closely with the Fire and Rescue Services, the Police, the Health Protection Agency (HPA) and the Strategic Health Authority (HSA), and were mainly responsible with the monitoring and advising on water and air pollution aspects of the firefighting activities. HSE (the Health and Safety Executive) is a Category 2 responder, so during the early phase of the incident stood ready to provide advice and expertise on request in support of the emergency services and EA.

2.0 Post incident enquiry

The U.K. Government instituted an enquiry into the incident, with the aim of investigating the causes of the accident, collecting other related information, and preventing such disasters in the future. The Health and Safety Executive (HSE) and the Environmental Agency (EA) were given the task to set up a joint investigation team, under the leadership of HSE. The Buncefield Major Incident Investigation Board is headed by Lord Newton of Braintree and includes Prof. Dougal Drysdale, an authority on fire safety, Dr. Peter Baxter, a medical expert, and representatives of the Environment Agency and HSE (Health and Safety Executive). The Investigation team was tasked with finding out the exact reasons for the accident, and all related factors related to the firefighting and the post accident operations. The team is being assisted by specialists in inspection and investigation from different spheres. The teams shall look at the main areas of mechanical engineering, process engineering, fire and explosion engineering, control and instrumentation, and environmental impact assessment. A striking feature of the enquiry has been the open exchange of views and willingness to share information, something unheard of in developing countries. Already three progress reports have been brought out by the enquiry committee, and in mid-july, 2006, the initial report has also been published. These have been put up for open viewing on their official website : www.buncefieldinvestigation.gov.uk.

3.0 Lessons for Developing countries

This has been reiterated a number of times, but needs to be mentioned here again; that as far as industrial activity is concerned, developing countries have an advantage over developed countries. This is because developing countries are almost always working with proven technologies and systems, handed down by the developed world. In many cases, they also have the knowledge of accidents and disasters concerning industrial processes and products to prepare them for possible accidents and take corrective action. The fact that accidents still do occur in developing countries is because lessons from past accidents are usually forgotten.

The Buncefield incident gives developing countries another opportunity to gain useful knowledge and information on fire prevention and fire fighting aspects concerned with the oil industry. The incident is also one of its kind, in the sense that an accident of this magnitude is experienced rarely. Since it is not possible to take first hand experience of disasters, the analyses/ studies of such incidents are invaluable, as they provide first hand knowledge and inputs from the ‘real’ scene. Some such issues and factors related to the Buncefield incident and specifically the firefighting operations, which can be of specific importance for developing countries are discussed below.

3.1 Cause of the incident

The exact sequence of events leading to the incident, and its causes have still not been conclusively brought out. However, from the information available, some important conclusions can be drawn. That there was a failure of the instrumentation (level gauge) fitted for product level monitoring in the affected Petrol Tank is now accepted. The affected tank (No. 912), a fixed cum floating roof, was being filled with unleaded Petrol by pipeline transfer, starting from 19:00 on the evening of 10 December. After operations closed at midnight, a check was made of the contents of tanks which found everything normal. From approximately 03:00 the level gauge of Tank 912 began indicating an unchanging level reading, despite filling continuing at 550 cubic metres per hour. Calculations show that the tank would have begun to overflow at about 05:20 hours. 40 minutes later, an estimated 300 tonnes of petrol would have spilled down the side of the tank onto the ground inside the bund, a semi-enclosed compound surrounding several tanks. Another important fact is that beside the level gauge, the tank was also fitted with a high level switch, which should have operated once the tank level reached a predetermined level, thus shutting down the inflow. Somehow, even this switch also failed to operate.

The vapour cloud which formed travelled slowly towards the northwest direction, and low wind conditions favoured the accumulation of the vapour rich cloud. In fact, CCTV footage have shown the vapour cloud, 1-2 metres deep flowing away in all directions, from the tank. By 06:01, when the first explosion occurred, the cloud had spread beyond the boundaries of the site. The extent of the damage meant it was not possible to determine the exact source of ignition, but possibilities include an emergency generator and the depot's fire pump system. The investigators did not believe that it was caused either by the driver of a fuel tanker, as had been speculated, or by anyone using a mobile phone.

Quite clearly, the failure of the instrumentation system seems to be the main cause leading to the incident. The exact causes for this are still not known, and are being worked out. However, strengthening the same using regular and periodic preventive maintenance and checks, increasing redundancy, etc, seem to be the solution to the prevention of such occurences. The provision of suitable gas/ vapour detection and alarm systems also needs to be considered for tank farm areas.

3.2 Operational issues

3.2.1 Strategic response

Though the scale of the disaster was unprecedented, the UK has a well documented major response for such incidents (under their COMAH – Control of Major Accident Hazards regulations, 1999), which works on a national level. Under this response, the role of the various responding agencies is clearly documented, and consequently there was little confusion during the whole operations.

The Fire and Emergency Services and other connected agencies in the UK operate a three tier response structure for such major incidents. This consists of a Gold command, which is a strategic centre, usually located away from the incident, a Silver command, which consists of tactical command units at the incident scene, and a Bronze command, which are the frontline firefighting and rescue teams. This set up also envisages the need for external experts on various issues related to the incident, including members of the EA and the HSE, and other external experts, who can be deployed at these three commands depending upon their requirement. This structure was immediately put into place, and by all reports, worked extremely well in controlling the situation and minimising losses.

The co-ordination of a multi-agency response on such a scale had not been experienced before (some fire brigades came to site even without being asked to!) but the operations went off smoothly, and without any major hitches. Though a total of 22 tanks were on fire, that the strategy and tactics worked well can be gauged from the fact that all tank fires had been put out within 48 hours of the operations being started.

A recent comparable disaster in the country was the Vizag Refinery disaster in 1997. Due to the lack of a pre-planned and co-ordinated response, the efforts of the Fire and Emergency services (who worked very gallantly despite all odds) could not bear much fruit. In an earlier incident in a Mumbai Refinery, the Fire services of the Refinery and the Municipal Fire service had an argument over who would lead the response. Such instances are totally undesirable and uncalled for. The need for a well thought out and co-ordinated response for major disasters is a must, and the Fire service fraternity must work toward developing and putting the necessary legislation in place for this.

3.3 Tactical issues

3.3.1 Fire fighting Water arrangement

As the onsite fire water network was damaged in the initial explosions, water had to be transported from the nearest water source, which was a pond 1.8 kms. away. Six high volume pumps were set up at the pond, with six more pumps deployed at various locations to serve as boosters. A hose relay system using high volume hose and booster pumps allowed the movement of required amount of water at adequate pressure to site. Approximately 32,000 liters of water was being used per minute, and a total of 30 kms of hose length had to be laid out for transporting this to site.

Fig. 2. A long hose relay system was used to supply water to the incident site

There have also been similar instances in the country where the fire water network has been damaged during explosions, thus affecting firefighting operations. One such case was the Cochin Refineries fire, where the fire water pump house was damaged due to the explosion. The use of high volume hose (5” to 10” dia) and connected equipment, such as hose laying and making up vehicles, is relatively unheard of in the country. However, strategies for major fires will have to consider and plan for their use during such incidents.

3.3.2 Foam tactics

The initial explosion destroyed the main pump house and fire pumps, rupturing the fire water main, which meant that water could not be provided to the fixed foam systems fitted to many of the tanks on site. Due to this, the foam attack (as also the tank cooling operations), had to be done using mobile and vehicle mounted monitors. For the foam attack, both aspirating as well as non-aspirating foam monitors were used. The required quantity of foam compound was mobilized to site from nearby fire brigades, and later, from a leading foam compound manufacturers’ facility, which was about 300 miles away. On average, 1200 litres of foam compound was used per minute during the operations.

There was a mix of foam compounds available at site, mainly FP (Fluoro Protein) and AFFF-AR (Aqueous Film Forming Foam – Alcohol Resistant) and some quantity of AFFF (Aqueous Film Forming Foam). However, after the initial stages, the foam compound used was primarily FP, and this was found to be both effective and economical. At the same time, and as later tests proved, the environmental impact of the FP foam was almost negligible. The main concerns from foam pollution was because of PFOS (Per Fluoro Octanyl Sulfonate), an ingredient of AFFF, which was actually used in a comparatively small quantity.

Fig. 3. Mobile and Vehicle monitors were used for the foam attack.

As mentioned earlier, the application of foam was over the top using trailer and vehicle mounted monitors. Foam monitors used were of both types i.e. those discharging aspirated (primary aspirated) and non-aspirated (secondary aspirated) foam. FP foam compound was used with both types of monitors and seemed to work effectively with both.

The fact that foam monitors were used, should not in anyway undermine the importance of fixed foam systems provided to the tanks. The intensity of the explosion in the case of the Buncefield incident was so high that it affected the fire water system of the Terminal, thus affecting the fixed systems provided on all tanks, however, this need may not be the case every time. Fixed systems play an important role in fire fighting and fire prevention in case storage tanks, and in recognition of its importance, all international codes (including NFPA 11) recommend the provision of fixed systems to tanks (and do not allow the use of Foam monitors as primary means of protection).

3.3.3 Use of medium expansion foam

Overpressures resulting from vapour cloud explosions are strong enough to cause extensive damage to equipment and structures on industrial sites. The Buncefield incident was no different as there was tremendous damage both within and outside the terminal due to the blast waves of the initial explosions. Such blast waves cause the movement, and in some cases, cracking of pipelines and its joints. This, in turn, leads to leakage of liquids in large quantities, posing the risk of dike fires. Also the leakage of Petrol in the initial stages had led to the liquid spreading throughout the bund, and subsequently, catching fire. Therefore, one of the major factors of the operations, was putting out the fires in the bund area, as they not only complicate the situation, but have the potential to further escalate the incident. For this, the firefighting teams used Medium expansion (MX) foam, as due to its larger volume, it can cover the liquid much faster than low expansion foam. This was achieved using Medium expansion Bund Pourers, and once again the foam compound used was FP. It worked very well for this application, as being protein based, it is more sticky and could hold the foam onto the pipework, valves, etc, resisting the effects of wind and heat longer. This resulted in quick extinction and later, preventing the reignition of spilled fuel. This prevented the escalation and complication of the incident.

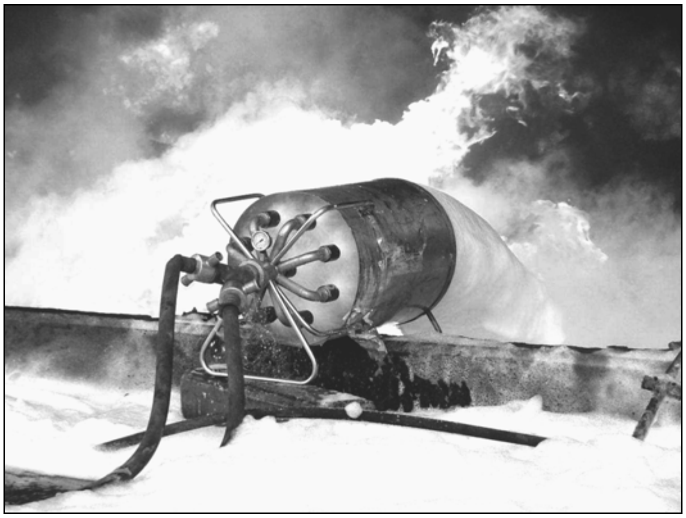

Fig. 4. MX Foam Pourers in action at the Buncefield incident.

In most developed countries, it is accepted that medium expansion (MX) foam (i.e foam having an expansion ratio between 1:21 to 1:200) is an effective and economical means of tackling shallow spill fires with short preburn times, and for covering large spills. It is especially ideal for certain areas such as Tank bund and dike areas, and its effectiveness was amply demonstrated during the Buncefield incident operations. However, the use of MX foam is hardly considered in the country when planning for major storage tank fires and similar scenarios. Besides its use for flammable liquids, it is also finding increasing use in certain Class A situations, as well as for hazardous material (HAZMAT) foams.

3.3.4 Use of foam for post fire security

Post fire security is an important issue in storage tank fires. After the fire has been put out, the fuel and the tank shell still remain hot, and the presence of vapours cannot be ruled out. This poses the risk of reignition of the fuel. In case of the Buncefield incident, the fuel which had leaked out into the bund also added to these concerns. It was therefore, important to keep the surface of the liquid inside the tank covered with a layer of foam, while the liquid was pumped out or transferred, and at the same time, covering the leaked fuel in the bund area to prevent re-ignition risks. Another important point is that foam quality deteriorates with time, due to the drainage of water from the foam layer (more so in case of film forming foams), and it is necessary to replenish the foam layer periodically depending upon conditions.

Both low and medium expansion foam can be used for post fire security, though practically it may not be possible in many cases to apply medium expansion foam over tank shells. However, in this case, MX foam branches and to some extent, pourers were used to apply foam onto the fuel surface from elevated platforms, etc. The salvaged product from the fire damaged tanks was pumped out under a protective layer of foam to prevent any ignition from sparks resulting from scraping of steelwork and floating roofs as the product level reduced.

A very important finding here is that in large incidents such as the Buncefield fire, the amount of foam compound used for post fire security can exceed the quantity used for firefighting. In fact, it was later found that almost 60% of the total foam compound quantity was used in the post fire operations!! What this means is that a sizeable quantity of foam compound is still required after the fire fighting operation is over. Surprisingly, this factor is not considered in most manuals and codes, (including international standards) and needs to be addressed. Some experts suggest the stocking of at least 100% of the stock required for firefighting, for the purpose of post fire security.

3.4 Environmental issues

Nowadays, one of the major concerns globally is the environmental impact of an incident, which includes not the effects of the fire itself, but also the chemicals used for firefighting. The Environmental Agency (EA) was one of the main agencies involved in the Buncefield operations, and worked closely with the Fire service to ensure that the environmental impact of the firefighting operations remained as low as possible. Due to the fact that one of the drinking water sources (aquifer) was very close to the site, the main concern was the containment of liquid on site. Plans were developed to minimise firewater (mainly foam) run-off, and recirculating cooling water. Though some contamination has been reported by the press, tests reveal that the levels are now well below dangerous levels, and that considering the scale of the accident, the environmental management of the incident was fairly successful.

In developing countries, environmental issues have still not attained the same level of importance, and hence, there is little effort to develop specific plans for addressing environmental concerns during major accidents. However, the Fire services can also contribute to this cause by using the appropriate equipment and chemicals, resulting in minimal low environmental impact. Co-ordination and liasion with environmental bodies/ agencies is a must while developing strategies/ tactics for large scale incidents.

4.0 Conclusion

On most occasions, lessons learnt from history are forgotten and inadequate knowledge lead to mistakes, sometimes culminating into major disasters. In some such incidents, inadequate planning for emergencies or incorrect tactics lead to escalation of the incident. It is not always possible to train for such large incidents, hence, analysis and study of such case histories give people who have not had first hand experience, useful inputs derived from both the good and bad experiences. They are a valuable source of information and guidance, which can play an important role in developing confidence in the concerned personnel for tackling such incidents.

The issues discussed above are but a few issues which need further attention and discussion by the Fire service fraternity. Indeed, a number of such issues related to the incident need to be carefully studied and evaluated with the aim of strengthening the hands of the fire fighters.

Images : Courtesy – BP/Angus Fire &
www.eustonfirestation.com/EustonFireStationcom.Shouts.files/Buncefield/Buncefield.htm

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