A HUMAN FACTORS ANALYSIS OF A ROAD TANKER TRANSFER INCIDENT

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A large quantity of flammable liquefied gas was released from a terminal. The release occurred during a road tanker off-loading operation. The site was a top tier CIMAH site and had prepared an emergency plan for such an event but the site operators failed to implement it. Fortunately the gas did not ignite and there were no serious injuries from this potentially catastrophic event.
The underlying causes of the errors occurring just before or during the incident show a fundamental weakness in the training culture of the company. There was a failure to adequately train plant supervisors and workforce. In addition there was a latent organisational problem leading to the belief by senior management that emergency response is solely a management responsibility.
There is some evidence of a blame culture and tendency to look to technological fixes that may inhibit the company's ability to learn from this incident. Changes need to be made in the structure and organisation of the emergency response if the mistakes made during this incident are to be avoided.

Keywords: Human factors, Incident, tanker transfer.

INTRODUCTION

A recent incident at a CIMAH top tier distribution centre, led to an uncontrolled release of gas. Whilst emergency plans have been drawn up for this site, initial information indicated that there were some deficiencies in their operation. The Risk Assessment Section (RAS) at The Health and Safety Laboratory in Sheffield was asked to carry out a human factors analysis of the incident. The study formed an expert view on the contribution of human factors to the incident, which identifies any deficiencies in the company's safety management systems focusing on emergency planning and emergency management training.

THEORY OF ORGANISATIONAL ACCIDENT CAUSATION

Previous human factors research on major incidents in high technology systems has shown that there are often underlying organisational problems that lead to poor performance by the operators of a system. For example, human factors analyses of the Piper Alpha, Chernobyl, and Kings Cross disasters have identified the organisational precursors of these incidents.

Several theories of organisational accident causation have also been put forward. Reason (1990) has made a distinction between active and latent errors. Latent failures are those errors which result from fallible management decisions at the higher levels of an organisation. Active errors are those unsafe acts which are committed by those at the immediate task interface. Latent failures lead to weaknesses in the organisation's defences and thus increase the likelihood that when active failures do occur, they will combine with existing preconditions to breach the systems defences and result in adverse events (see Figure 1). Thus, to properly understand the genesis of accidents, one must understand both the latent and active errors that led to an accident. This theory of organisational accident causation has been chosen as the most suitable explanatory framework to summarise the data that were collected in this study.

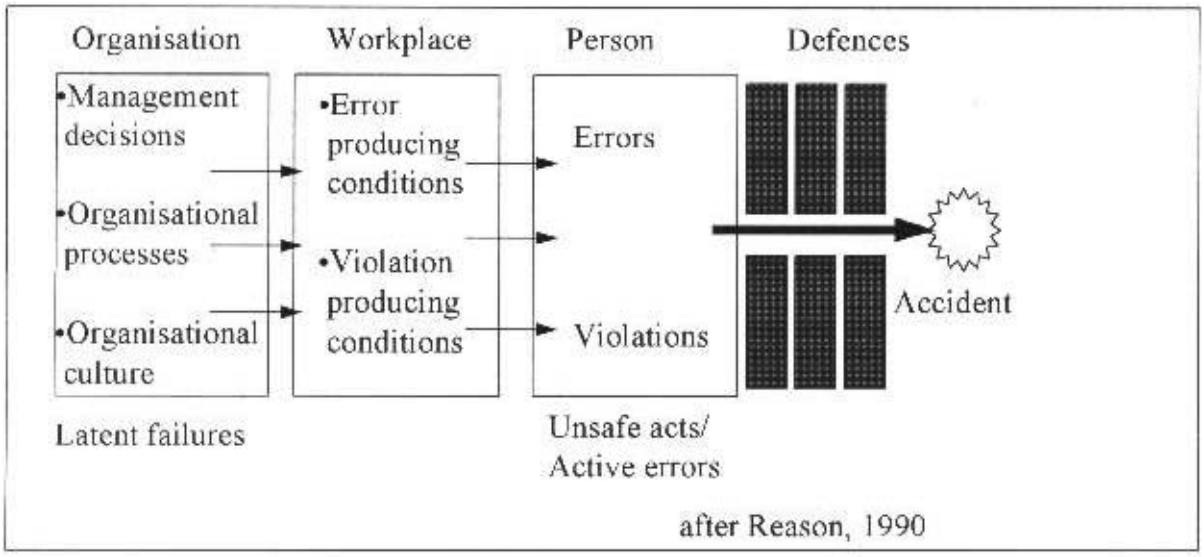

Figure 1, Modelling organisational accidents

INCIDENT SUMMARY

Approximately 1.7 tonnes of gas were released during a road tanker unloading operation at about 6:15am. The road tanker was prepared for discharge with both the liquid and vapour return hoses connected. After opening the valves, the driver noticed a small leak from the flexible hose collar where he has connected it to the installation's fixed pipework. The breakaway coupling failed when the driver attempted to cure the small leak by tightening hose collar with a plastic hammer. The blow caused the breakaway coupling to partially fail. The valves within the coupling could not close and gas was released at about 2 $kg.s^{-1}$. Figure 2 shows the liquid discharge line arrangement.

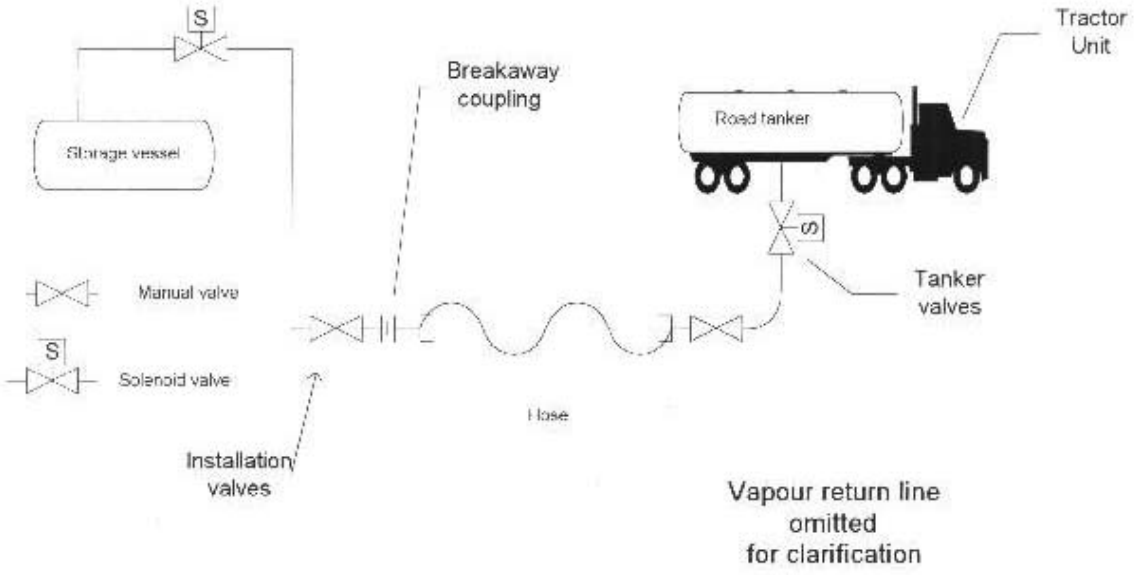

Figure 2, Line diagram of tanker liquid discharge line arrangement.

After the coupling had failed the driver closed the two nearest valves (liquid filling and vapour return) on the installation. Engulfed in a gas cloud, he went to the road tanker to close the manual valves. Unknowingly, the driver failed to fully close the liquid valve and the release continued. He then switched off the master electrical isolation switch on the tractor unit but he did not operate the tanker's emergency stop which would have closed the solenoid valves on the tanker.

The site emergency shut down system was initiated but the release of gas continued. The driver decided that the release must be coming from the storage tank, informed the supervisor and, mistaking the noise of the fire water pumps for the liquefied gas discharge pumps, re-entered the cloud to access the pump controls in the adjacent compressor house. There he switched off all the pumps including the firewater pumps that fed the sprinkler system which he immediately put back on when he realised his error .

The site supervisor called the depot manager but did not initiate the emergency plans. The supervisor, assisted by some other drivers, started to look for the tanker driver who was now missing. The supervisor entered the gas cloud to attempt to close the already closed valves on the installation. Two drivers acting on their own initiative, decided to check and evacuate some of the nearby premises.

After the fire brigade and police had arrived, but before they could take any action, the driver on his own initiative re-entered the gas cloud and closed the tanker valve. The release then quickly stopped. On arrival at the site, the depot manager initiated the emergency plans.

ERRORS LEADING UP TO AND IMMEDIATELY FOLLOWING THE GAS RELEASE

The first seven errors in the incident are concerned with the tanker driver's actions before or during the incident.

ERROR 1: INCORRECT ACTION/PROCEDURAL VIOLATION[1]

The first active error occurred when the tanker driver tried to stop the initial leak by using a plastic mallet to tap the hose collar which led to the breakaway coupling failing, releasing gas. The performance shaping factor that may have led to this error was the tanker drivers poor risk perception of the potential implications of his actions. The interview data and eye-witness statements showed that two latent organisational problems also contributed:

(1) There was poor organisation of tool availability in the tanker loading bay area in that the mallet was not needed for any other task in the area and should not have been available.

(2) It was accepted practice for tanker drivers to tap the collar with a mallet rather than using the custom designed spanner. This procedural violation had not been identified nor controlled in the three month safety reviews. Interview respondents commented using the plastic mallet in this way was accepted practice. Typical statements were as follows; *'everyone uses the mallet,'* and *'it was not unusual to use the mallet in this way.'*

ERROR 2: ACTION TOO LITTLE

The tanker driver did not close the liquid filling valve on the tanker completely. The poor visibility of the tanker valves in the gas cloud may have influenced the tanker driver's

[1] 'Procedural safety violation' - a violation of a safety procedure

performance in this task. The interview data shows that the tanker driver felt under stress and time pressure at this time. These factors may also have influenced his performance. During the interview the tanker driver also reported that he felt torn between staying in the affected area and evacuating it to ensure his own personal safety. The gas cloud could have ignited at some distance (HSE 1987) and it is generally assumed that any personnel with the confines of an ignited gas cloud would become a fatality (Rew et al 1996) This conflict `kept recurring and interfered with his ability to diagnose the incident correctly. The consequences of the tanker driver's failure to completely close the tanker valves were that the gas continued to escape from the tanker. There was also a deterioration in the tanker driver's physical condition possibly due to the anaesthetic properties of the gas (HSE 1987).

ERROR 3: INCORRECT SITUATIONAL AWARENESS OF THE STATUS OF THE TANKER VALVE.

The tanker driver had an incorrect situational awareness (Endsley, 1995) of the status of the tanker valve. He believed it was closed properly when it was still partially open. This error had the same performance shaping factors as Error 2; poor environmental conditions and decision making under stressful and time pressured conditions. The poor emergency response training culture was found to be an important latent organisational problem that contributed to this error. Tanker drivers and plant supervisors are not involved in emergency exercises, and are therefore denied the opportunity to learn about emergency management under simulated conditions.

ERROR 4: MISDIAGNOSIS OF THE CONTINUING SOURCE OF THE RELEASE.

The tanker driver believed that the source of the gas leak was from the tanks and not from the tanker. Previous research has shown that in emergency situations, people become ‘anchored’ to their initial diagnosis (Tversky and Kahneman, 1974) and seek confirming evidence to support this diagnosis (Nesbitt and Ross, 1986). These cognitive biases (i.e. anchoring and confirmation bias) may have affected the tanker driver's ability to consider other sources of the leak. His performance may also have been affected by stress and time pressure, and also the confusing signals that he received from the noisy environment.

ERROR 5: COMMUNICATE INCORRECT INFORMATION

The tanker driver ‘communicated incorrect information’ about the source of the gas leak to the plant supervisor. The tanker driver informed the plant supervisor that the gas leak originated at the tank and not at the tanker. This error was influenced by stress, time pressure and his incorrect belief that the source of the leak was the tanks and not the tanker.
This communication error led to the Plant Supervisor having an incorrect understanding of the source of the problem.

ERROR 6: PROCEDURAL SAFETY VIOLATION

The tanker driver committed a procedural safety violation by re-entering the affected area. The emergency plan states that staff should remain at their muster stations during an incident. The tanker driver stated that he re-entered the affected area to switch off the gas pumps which he incorrectly believed were still running. He had confused the sound of the fire water sprinkler pumps running with the liquefied gas compressor and thought that it was still running. During the interviews the tanker driver also reported that his behaviour was strongly influenced by ‘..a need to sort the problem out’ and that it was this that led him to re-enter the gas cloud. The other two factors which may have influenced the tanker driver's behaviour at this point were poor perception of the risks to his personal safety and the failure to organise a

muster of site staff by the Plant Supervisor (cf Error 10). The lack of a formal muster left a window of opportunity for the driver to re-enter the affected area.

The poor emergency response training culture meant that people at the workforce and supervisory levels did not know how to deal with an incident. The workforce did not understand the importance of mustering and staying at muster points. There was no organisational policy to ensure that new employees were trained in emergency response soon after arriving at the company or after being promoted to positions with more responsibility (i.e. to the role of plant supervisor).

ERROR 7: INCORRECT ACTION CARRIED OUT

On re-entering the affected area, the tanker driver made his way to the compressor house to switch off the gas pumps. Whilst attempting to carry out this task, he inadvertently switched off the sprinkler system. The performance shaping factors which may have influenced the drivers actions were poor visibility in the compressor house (as reported by the tanker driver during the interviews) and the driver's lack of knowledge that the switches in the compressor house could have ignited the release. This points to an organisational communication problem, where the potential risks from the switches in the compressor house were not communicated to the workforce. Interview data showed that senior management knew that the switches in the compressor house were not suitable for use in a flammable atmosphere. However, this information was not communicated to the tanker driver until after the incident.

ERRORS IN THE IMPLEMENTATION OF THE EMERGENCY PLANS

The remaining active errors relate to the failure to implement the emergency plans following the incident.

ERROR 8: DECISIONS AND ACTIONS NOT CARRIED OUT

The Plant Supervisor failed to set the emergency plans into operation. The key influencing factor that led to this failure was Error 7, i.e. the procedural safety violation where the tanker driver re-entered the affected area. The tanker driver's disappearance caused a ‘situational distractor’ at a critical point in the management of the incident. The Plant Supervisor became preoccupied with finding the tanker driver when he should have been implementing the emergency plans. The Plant Supervisor's focus on finding the missing tanker driver precluded attention being paid to the potential on and off-site implications of the gas leak. The knock on effects of the supervisor's preoccupation with finding the tanker driver were errors 10,11, 12, and 13.

ERRORS 9: FAILURE TO ORGANISE AN EMERGENCY MUSTER

The Plant Supervisor did not organise an immediate muster of site staff. This is contrary to the emergency procedures that state a muster should be organised to account for site staff. The unfamiliarity of the workforce and the Plant Supervisor with the emergency plans, stress, time pressure and the missing tanker driver all contributed to this error. The lack of an organised muster meant that some of the workforce entered areas affected by the gas cloud. They also carried out unauthorised communications and actions, for example, the unauthorised evacuation of people from neighbouring sites (cf Error 14). Once again this error was related to the poor emergency response training culture. Interview data showed that the Plant supervisor had not been involved in any mustering practices at the site prior to the incident and that many of the people on-site were relatively new to the company.

ERROR 10: FAILURE TO COMMUNICATE
The Plant Supervisor failed to make the notification calls during this incident. This error was influenced by his being focused on trying to find the missing tanker driver. The consequences of this communication failure were that the neighbouring sites did not receive formal notification of the incident. Potential ignition sources for the gas leak were not removed. The poor emergency response training culture contributed to this error. The organisation's training policy denied the supervisor the opportunity to practice making the formal notifications to neighbouring sites which are specified in the emergency procedures.

ERROR 11: DECISIONS NOT MADE
The next active error made by the Plant Supervisor was that he did not consider the off-site implications of the incident and put the off-site emergency plan into operation. Again this error was judged to be a consequence of the poor emergency response training culture. In addition, the assessment of the emergency plans showed that the criteria for upgrading from the on-site to the (CIMAH) off-site emergency plan are not clearly specified. This error may be partially attributed to the design and content of the emergency plans themselves.

ERROR 12: PROCEDURAL SAFETY VIOLATION
The Plant Supervisor entered the gas cloud to try to find the missing tanker driver. The performance shaping factors that influenced this error were the poor risk perception by the Plant Supervisor and the situational distractor of the missing tanker driver. The Plant Supervisor's actions led to a further delay in implementing the emergency plans. Organisational problems, including the poor emergency response training culture and poor communication of mustering procedures from senior management, were the latent factors responsible for this error.

ERROR 13: COMMUNICATE INCORRECT INFORMATION
Two workers informed the people in some of the neighbouring plants to evacuate. This is contrary to local authority advice which states that people should close all windows and shelter indoors. A lack of knowledge about the evacuation procedures amongst the workforce led to this error. On an organisational level, the poor emergency response training culture meant that the workforce did not know the correct procedure for responding to an incident.

ERROR 14: ACTION TOO LATE
There was a delay in setting off the off-site emergency siren. The siren was set off when the manager arrived at the site after the release. The Plant Supervisor's lack of knowledge about the emergency procedures, together with the situational distractor of the tanker driver going missing may have caused this error. At an organisational level the poor emergency response culture contributed to this error.

ERROR 15: PROCEDURAL SAFETY VIOLATION
The Tanker Driver re-entered the gas cloud to close the tanker valve after he had realised that it must have been left open. He did this in the presence of the Senior Fire Brigade Officer. There was a lack of command and control during the incident due to the failure to initiate the on-site emergency plan, that allowed the driver the opportunity to make this second re-entry. Also, his lack of knowledge about the emergency procedures meant that he did not perceive the risks involved in making this second re-entry. Once again the poor emergency response training culture was an important contributor to this error.

ASSESSMENT OF THE EMERGENCY PLANS

There are two types of emergency plans. The on-site emergency plan is produced by the company and describes the actions that have to be taken during an on-site incident. The off-site emergency plan is produced by the Local Emergency Planning Authority and describes the actions that have to be taken if the incident has off-site implications. That is to say, if there is a danger that the gas leak will affect the surrounding area.

Overall the on-site and off-site emergency plans were judged to be satisfactory. Some problems were identified with both plans and these are discussed below, starting with the on-site emergency plan.

PROBLEMS IDENTIFIED WITH THE ON-SITE EMERGENCY PLAN

- There is no dedicated section in the emergency plan that describes the criteria for setting the plan into action.

- There are very few key roles and responsibilities specified in the on-site emergency plan. It is just assumed that the most senior manager will be contacted and will take control. This may pose a problem for out of hours incidents or where there are likely to be time delays before the Terminal or other Senior Manager arrives on-site.

- The authority dynamics of the system in the absence of a key manager in 'an out of hours' incident are not well specified. That is to say, the point at which the plant supervisor should take control of an incident is not clear.

- Parts of the emergency plan are very general. There is not enough guidance in some areas, e.g. dealing with the media and contacting relatives to let them know of injuries to people who work on site. Also, these actions are typically carried out by the police, not the company.

- The appendices of the on-site emergency plan refer to the incident controller and various other roles. However, when these roles will be assigned and by whom is not clear from the plan.

PROBLEMS IDENTIFIED WITH THE OFF-SITE EMERGENCY PLAN

The off-site emergency plan is very good at outlining the risks and the core responsibilities of the emergency services and other interested parties. It is not so good at giving detailed advice on how to carry out individual roles. There are also some structural problems with how the plan is presented meaning that it is not very user friendly. There is also no consideration of out of hours incidents in the emergency plan. There are particular problems associated with out of hours' incidents which are not recognised in the emergency plan.

While these problems with the emergency plans are easily resolved a cultural change has to be effected if a poor response to an incident is to be avoided in the future.

ASSESSMENT OF EMERGENCY RESPONSE TRAINING

The interviews were also used to gain insights into the type of emergency response training.

EMERGENCY RESPONSE TRAINING PRIOR TO THE INCIDENT

One copy of the on-site emergency plan is kept outside the Terminal Manager's office. Prior to the incident there were annual updates of the emergency plans. There is also a three month

safety review where emergency response issues are considered. This safety review covers general safety issues in the organisation and is a forum where problems with the emergency arrangements are discussed along with other types of problems. There is no dedicated auditing of the emergency plans. The annual updates usually consist of changes of addresses and telephone numbers of people who have key roles to play during an incident.

An annual table top emergency exercise takes place. Only terminal managers and senior management take part. Plant supervisors and operatives are not involved in these. Plant supervisors are trained by the Terminal Manager. Plant supervisors receive no instruction about the emergency arrangements beyond having the plans shown to them by the Terminal Manager who reads through the plans with them. The workforce (below supervisory level) do not have a familiarisation session with the emergency plans. Plant supervisors and the workforce attend a one day training day. During this training day, they are taught how to use different types of fire extinguishers and how to control cylinder and flange fires. A mustering practice also takes place.

Off-site emergency exercises are written and organised by the Local Authority who decide how often the off-site arrangements are practised. One of the senior managers interviewed thought that the site had been involved in two off-site exercises, but he was unsure about this.

In addition, everyone receives a general health and safety induction when they start working. During this induction they are shown the location of emergency exits and muster points on site and where the emergency shut off buttons are located. Tanker drivers are also shown the tanker manual and attend a training day.

The site have also tested the communication system for warning neighbouring sites that there is an incident. An on-site training session with the Fire Brigade has also been carried out.

PROBLEMS WITH THE EMERGENCY RESPONSE TRAINING

The interview data identified three areas where there are problems with emergency response training. These are:

(1) the provision of training for plant supervisors and the workforce;

(2) communication of emergency response information; and

(3) the knowledge and skills of people in the emergency response system.

Provision of Emergency Response Training for Plant Supervisors and the Workforce.

Emergency response training for supervisors comprised a talk through of the emergency plans by the Terminal Manager. After he has been '..brought up to speed by the Terminal Manager..' the Plant Supervisor's knowledge of his responsibilities during an incident is not tested. Rather, there is an assumption in the company that this run through will equip the supervisor with the skills and knowledge that he needs to react appropriately to an incident. Secondly, there is no specific organisational policy on retraining times. The frequency that the Terminal Manager should go through the emergency plans with the Plant Supervisor is not formally stated. The company director interviewed stated that he expected that the Terminal Manager and Plant Supervisor would run through the emergency plans approximately once every three months, but this was not a formal requirement.

This problem is symptomatic of a general failure of the senior management to strategically plan emergency response training for plant supervisors and the workforce. The interview data showed that supervisors and the workforce are not involved in the table top

emergency exercises. Only Terminal Managers and above participate in these exercises. The workforce (e.g. tanker drivers) did not have a familiarisation session with the emergency plans from the Terminal Manager. During the interviews the Plant Supervisor reported that he had not taken part in any practices of the notification communications to neighbouring sites prior to the incident. He had not had the opportunity to practice the notification calls that he was supposed to make during an incident and which he failed to make during the incident.

At the workforce level there were several gaps in emergency response training. For example, when interviewed the tanker driver reported that he had received no training about what parts of the plant the emergency shut off buttons close down. He also stated that he had not been taken around the site and shown the emergency muster points:

'*I knew where they were but I had never been shown them.*' (Tanker driver).

Other interviewees reported that they had never seen the emergency plans and that they had not been told where the muster points were. The problems with the emergency response training for the workforce and supervisors were best summed up by one of the interview respondents who stated that:

"It was a 'pass on your knowledge' type of training." (Manager -)

Communication of Emergency Response Information

There was poor communication of emergency response information between senior managers and from senior management to lower levels of the workforce. For example, the problems identified during tabletop emergency exercises were not communicated throughout the organisation. Senior and terminal managers who had not participated in an exercise received no feedback about what had happened in emergency exercises. Management did not consider that feedback from emergency exercises may have been useful to plant supervisors and the workforce. The lack of feedback from table top emergency exercises impeded organisational learning at all levels, from senior management down to the workforce. There was also no written record kept of the types of errors that people made during tabletop exercises. This information could have been used to heighten awareness of the main types of decision making and communication failures that people make under simulated emergency conditions.

There was only one copy of each emergency plan per site, which ware kept in the Terminal Managers office. There was not a copy of the emergency plans available for the workforce to read (for example in the canteen). There were also no copies in the tanker bay area. This denied the workforce the opportunity to learn about the emergency arrangements through incidental learning. Finally, prior to the incident the workforce had not been issued with key cards summarising the main points of what to do in an emergency.

Knowledge and Skills in the Emergency Response System.

The structure of emergency response training meant that there was an over-reliance on the Terminal Manager being on-site for an incident to be managed properly. There was a general failure in the company to plan for the contingency of the Terminal Manager not being on-site when an incident occurred. The interview data shows a faulty belief at senior management level that if Terminal Managers and Plant Supervisors had received training in the emergency arrangements it could be assumed that the rest of the workforce would react appropriately. This belief was indicative of an organisational failure to strategically plan emergency response. The organisation also failed to consider the various contingencies that may be involved in an incident, for example, the Terminal Manager not being present on-site. This strategic planning failure meant that there was a lack of redundancy in the emergency response system. If the Terminal Manager was not present and the Plant Supervisor did not

respond properly, no-one at the workforce level had received any training about setting the plans into operation.

The interview data also suggested that there was a degree of apathy amongst senior management about training the workforce, for example,

> *'You can do all the training in the world but you still do not know how people will react on the day.'* (Senior manager).

The prevailing management attitude was to exclude the workforce as far as possible from emergency response training. Given this safety culture problem, it is not surprising that people responded inappropriately on the day of the incident.

DISCUSSION

The data analysis showed that the majority of the active errors committed during the gas leak were related to a poor emergency response training culture in the company. 80% (12/15) of the active errors were related to this latent organisational problem. The main problems can be summarised as follows:

(1) There was a failure to train plant supervisors and the workforce so that they fully understood the emergency arrangements. This was caused by a poor management understanding of the importance of training all levels of the organisation in emergency response (see point 2 below).

(2) There was a faulty belief at senior management level that emergency response is solely a management responsibility. This led to a failure to consider the contingency of what happens if the Terminal Manager is not present on-site when an incident happens.

In addition to the main problems described above, there were also some limitations with the emergency plans. However, these problems were not so serious and can be easily rectified. Problems were identified with both the on-site and off-site emergency plans, but overall they were satisfactory. The poor response to the incident was related more to a lack of knowledge about the emergency procedures by the plant supervisor and the workforce than to problems with the content

and structure of the plans themselves. Following from these findings the main recommendations suggest ways to improve the emergency response training. By making improvements in emergency response training, Plant Supervisors and operators will improve their knowledge about the emergency arrangements. This in turn should lead to a better organised emergency response if an incident occurs in the future.

It is very important that the senior management learn the right lessons from this incident. During the interviews two findings emerged that may influence the lessons that are learnt at a management level of the organisation.

- There is evidence of a blame culture with a tendency for senior management to blame the operators involved in the incident.
- There is a drive towards identifying a technological cause and solution to the coupling failure. These problems and their implications are discussed below:

BLAME CULTURE

The senior management who were interviewed repeatedly expressed the view that the incident would have been managed better if a different plant supervisor had been in charge. The plant supervisor was described as 'the weak link' and 'not up to scratch.' When asked whether he thought that there were problems with the way the foreman had been trained one of the senior

managers interviewed admitted that *'... it did not specifically say that this was what you should do… if there had been someone else in charge they would have known what to do.'* Also, when asked why he thought that the notification system did not work during the incident the senior manager replied that it did not work because of the foreman. This attitude shows a lack of understanding of the organisation's contribution to the incident. Similar opinions were expressed by other managers who were interviewed:

'The foreman was the weak link. Even though he was new he should have known the basics - he would have been told.' (Director)

'Human error caused the incident.' (Senior manager)

This attitude of blaming the person at the sharp end of the system means that the company may have problems learning the organisational lessons from this incident. Senior management have to make changes in the structure and organisation of emergency response training to prevent a similar scenario happening again. There also needs to be a major shift in management attitudes involving a move away from blaming people at the sharp end of the system and focusing on the organisational weakness.

LOOKING FOR A TECHNOLOGICAL FIX TO THE INCIDENT

Following the incident, the company have removed all of the breakaway couplings from their sites and have paid a third party to carry out an assessment of the couplings.

During the interviews with senior management it became apparent that there is a focus on identifying the technological causes of the incident rather than trying to understand the human and organisational problems. A commonly held view amongst management at the time was that the design of the coupling was to blame for the incident.

CONCLUSION

The main underlying cause of the poor emergency response to the gas leak was the poor emergency response training culture in the organisation. There has to be a major cultural change in management attitudes to emergency response training and in the provision of training to supervisors and the workforce.

RECOMMENDATIONS

The company need to recognise the underlying organisational problems that led to the errors highlighted in this incident. There needs to be a major shift in management attitudes away from a blame culture:

Recommendation 1, Managers need to openly accept the deficiencies in the safety management system that led to the procedural errors in this incident.

Recommendation 2, A system of error reporting needs introducing that does not involve apportioning blame so that future problems recognised by the workforce can be reported and action taken.

There is a need for a cultural shift in senior management thinking about the provision and type of emergency response training that Plant Supervisors and the workforce receive. Talking through incident scenarios with colleagues at each site will facilitate discussion of the emergency arrangements amongst the workforce and raise the profile of the emergency plans at a local level.

Recommendation 3, Emergency response training for Plant Supervisors and the workforce should be revised. Plant Supervisors and the workforce should be included in tabletop emergency exercises and receive instructional training on the emergency arrangements.

Recommendation 4, Focus groups should be set up at each site to carry out walk-throughs and talk-throughs of incident scenarios in the tanker loading bay area. These focus groups should comprise of the Terminal Manager, tanker drivers and plant supervisors and repeated on a regular basis.

Recommendation 5, Mustering practice should be carried out once per month. A written record of the types of errors and problems that occur in exercises and during mustering practices should be made.

Recommendation 6, Feedback from tabletop emergency exercises should be disseminated to all levels of the organisation, from senior management to the workforce.

Changes need to be made to the emergency plans to make its communication effective.

Recommendation 7. The authority dynamics of the on-site emergency plan should be clarified; particularly the responsibilities of the Plant Supervisor and workforce when key staff are absent.

Recommendation 8, Copies of the on-site emergency plan should be readily available on-site. It is recommended that copies are placed in the staff canteen to allow the workforce to read through it.

Recommendation 9, Pocket sized key cards that summarise the main points of responding to an incident should be issued to all staff and visitors to the site.

There are two main lessons to be learned from this incident that can be applied to similar companies:

Recommendation 10, The communication of an emergency plan is an essential part of the emergency preparation. All staff need to be trained on the actions they must take and the activities of others, that take place during in an emergency. The communication of the emergency plan needs to be in a form that is appropriate to the individual, and have a feed back-loop to check that the communication is effective.

Recommendation 11, It is important to include all the workforce in emergency exercises and ensure that any feedback from such exercises is disseminated to all relevant people.

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