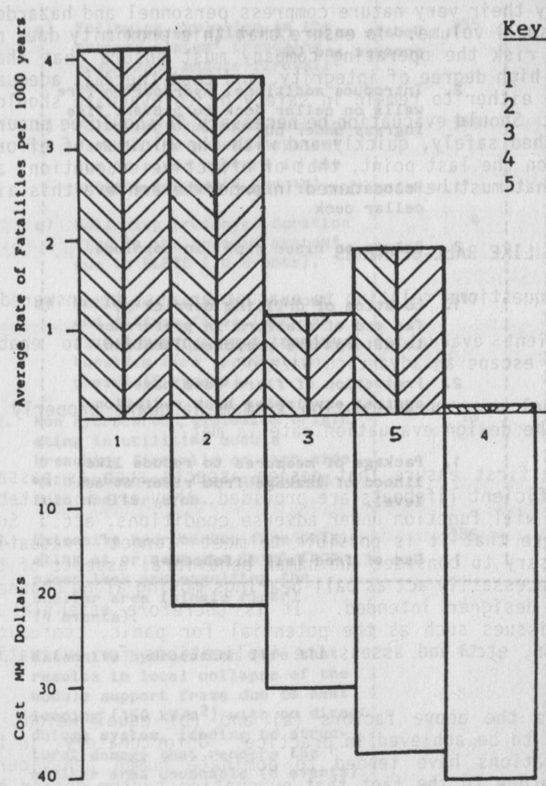
FIGURE 3 RISK-COST DIAGRAM

EXAMPLE RISK COST DIAGRAM

Comparison of Risk and Cost for a number of risk reducing measures for an oil pipeline.



A HUMAN FACTORS APPROACH TO THE EFFECTIVE DESIGN OF EVACUATION SYSTEMS

by
B.P. Fitzgerald, M.D. Green, J. Penington & A.J. Smith
WS Atkins Engineering Sciences Ltd.

1.0 INTRODUCTION

Offshore installations by their very nature compress personnel and hazardous plant into a relatively small volume. To ensure that this proximity does not present an unacceptable risk the operating company must ensure that their plant is reliable with a high degree of integrity, and that there is adequate protection for personnel either to remain in safety or to evacuate should a hazardous incident occur. Should evacuation be necessary it should be ensured that it can be accomplished safely, quickly and with the minimum of effort. This paper concentrates on the last point, that of effective evacuation, and discusses the elements that must be considered in order to achieve this aim.

2.0 PEOPLE DO NOT BEHAVE LIKE BALL-BEARINGS

In general two critical questions relating to evacuation must be answered:

a. Have sufficient evacuation systems been provided to enable personnel to escape an advancing hazard?

b. Will personnel use the evacuation system hardware properly in order that the design evacuation rate is met?

Thus it is necessary to first ensure that design aspects such as passage widths are adequate, sufficient lifeboats are provided, they are in suitable locations, the lifeboats will function under adverse conditions, etc.. Such considerations will ensure that it is possible to meet "target" evacuation rates. It is then necessary to consider the human behavioral aspects of the problem: people do not necessarily act as ball-bearings moving along channels as required and as the designer intended. It is therefore essential to consider human factors issues such as the potential for panic, confusion, ignorance, disorientation, etc. and assess the implications for evacuation system design.

It is important to give the above factors (a) and (b) equal weight if successful evacuation is to be achieved in practice. Unfortunately, in the past, hardware considerations have tended to dominate human behavioural considerations. This is due to the fact that evacuation system design has been considered as a purely engineering problem with engineering solutions. Ample evidence is now available to show that this approach is misguided.

2.1 Theory and Practice

System designers should not be distracted by what we shall call the airline evacuation test syndrome. When attempting to establish evacuation rates one must guard against basing tests on drills carried out by fit young people, all very familiar with the layout and the emergency drills, dressed in tracksuits and trainers, in nice warm, well-lit surroundings. It is necessary to be aware of the fact that they may have been recently trained and specially briefed. The Manchester air disaster in August 1985, where 55 people lost their lives through failure to evacuate in a fire situation, demonstrates what can happen in reality.

The International Civil Aviation Organisation base their aircraft design accreditation upon the ability to evacuate an aircraft in 90 seconds through half the available exits. In this incident, the time available should have been sufficient for all the people to have escaped if the performance of the actual evacuation had matched that of the accreditation test. In the words of the Air Accident Investigation Branch inquiry report [1] "*as soon as smoke invades the cabin this 90 seconds criteria ceases to have any relevance, i.e. because this type of certification does not, by intent, address itself to the effects of smoke and toxic/irritant gases upon breathing difficulties, loss of vision, induced panic and therefore 'irrational' behaviour e.g. egress over seat-backs*".

In the wake of the Manchester incident various tests have been carried out to attempt to simulate these conditions in order to understand why evacuation was not successfully achieved. One of the most noteworthy [2] was a series of tests conducted by researchers at Cranfield on behalf of the Civil Aviation Authority. In half of these tests, the volunteers carrying out the test were offered an extra reward of £5.00 if they were among the first half of their number to leave the aircraft.

In each of these tests, after an initial period of relative order, the situation rapidly deteriorated. The designated evacuation routes were bypassed, the aisles and exit doors became jammed, tempers were lost and near chaos resulted:

* Some volunteers walked over others, while some searched for family and friends before trying to escape.
* Significantly, a "notable number" of volunteers were behaviourally inactive, ie. were unable to move.
* A number of tests were abandoned as the Safety Officer considered it to be too dangerous to continue.
* Two evacuations were terminated when a volunteer fell and would otherwise have been trampled.

The Cranfield paper notes that many of the volunteers felt that they had learnt a great deal about how to get out of an aircraft in an emergency, but that they had found the competitive rush of people a frightening experience. Overall the competitive tests gave far slower times for total evacuation than the ordinary drills. Interestingly though, among their conclusions the researchers observed that with a wider passageway through a bulkhead exit door of 30 inches or more, a higher rate of evacuation was achieved in the

competitive tests than in the non-competitive drills. It would however be wrong to draw too many conclusions from this series of tests. It is by no means certain that this competitive urge exists in real emergencies and panic should not be mistaken for competitiveness in this form. Furthermore tests cannot determine what many researchers believe is the critical issue, that of getting personnel to recognise that evacuation is required. It does however demonstrate that the implications of human behaviour in stress situations are by no means straightforward.

2.2 What is Panic?

The subject of panic behaviour is one which is widely misunderstood, due in no small part to popular misconceptions fuelled by the media. Almost invariably in newspaper reports the word 'panic' is used when describing the behaviour of people running away from danger, such as a building on fire. The essential point that this definition misses is that running away is usually the most sensible course of action. There is thus a need for a precise definition of panic so that is it possible to develop a model which will explain why and when such behaviour is likely to occur.

A number of attempts have been made to provide a robust definition of panic behaviour. A useful working definition is provided by Smith[3] as;

> *A fear-induced behaviour which is non-rational, non-adaptive and non-social, which serves to reduce the escape possibilities of an individual or group as a whole.*

This definition shows that panic is not exclusively a group phenomenon but can also occur with individuals. It also demonstrates that panic can lead not only to flight behaviour but also to an inability to move.

Models of human behaviour are usually developed from the results of psychological experiments and from conducting interviews with subjects who have experienced a behaviour pattern of interest. However there are difficulties with this approach for panic behaviour. There are obvious ethical difficulties in conducting experiments into panic behaviour on human subjects, although some have been conducted (eg. Schultz[4], Mintz[5], and Kelley[6]). In addition unfortunately most subjects who experience panic in real-life situations do not survive the ordeal.

The only other major source of information consists of analysis of past events. However, there is an unfortunate tendency with such analysis to attribute panic behaviour as the cause of a disaster rather than a consequence. An example of this is given in Sime [7] with an incident that occurred on 2 April 1973 at the Lowenbraukeller in Munich. In this accident around 3000 people were attending a concert in a hall filled considerably in excess of its recommended capacity. At the end of the concert two girls were crushed to death and a number of other people were injured as they made their way out of the main exit.

In subsequent reports it was stated that panic had led to the incident in view of the fact that no objective threat to the crowd was apparent and that eight other exits were hardly used. Sime however found that the cause was in fact the overfilling of the hall which meant that any crowd movement resulted in crushing a number of people. This served to provide a threatening situation.

In addition Sime points out that no account had been taken of the crowds' lack of knowledge of other exits available and that people at the back of the crowd may well have been unaware of the pressure building up at the front.

Notwithstanding these difficulties, several authors have attempted to produce models of human behaviour under extreme threat stress, most in the context of human behaviour during fires. Notable examples are given by Mawson [8], Wood [9], Canter [10] and Quarantelli [11].

The model proposed by Wood (ref. 9) consists of the following four stages:

1. **Threat appraisal.** This is the stage of detection of symptoms of an incident, and the fact that they represent a threatening situation. Human beings, particularly in groups, are decidedly reluctant to accept symptoms of a potential hazard as threatening. Social inhibitions are very strong at this stage, and individuals do not want to stand out from the crowd or leave themselves open to a loss of face. This can cause a slow initial response to a hazard, which has obvious implications for the design of evacuation systems.

2. **Validation of symptoms.** Initial symptoms may well be ambiguous to the extent that the exact nature of the threat is unknown, even though it is apparent that something is wrong. This uncertainty leads to an attempt to verify the nature of the hazard. If an individual is alone, some attempt may be made to discover the origins of a symptom, for example from where a smell of smoke originates. Whereas the first attempts of a group to validate the symptoms are likely to be a group discussion of them and their implications.

3. **Definition of the situation.** Having appraised and validated the symptoms, the individual or group will attempt to structure the situation based not only on the symptoms but also on personality, training and experience. If those involved have no experience of a hazard, as is often the case, attempts to structure the situation may be frustrated. This inability will lead to a failure to initiate appropriate behavioural reaction. This lack of action in a situation that clearly requires it further increases the level of threat, which makes it more difficult to structure the situation, and so on. This spiralling dilemma can lead to an individual failing to take any action at all, known popularly as "frozen with fear".

4. **Evaluation of a response.** Having defined the situation there then occurs a decision-making process concerned with the evaluation of available responses. If the response chosen does not lead to a lowering of the level of threat then the stress on an individual or group will increase due to the failure to adapt. Greater effort will then be invested in the adaption responses and as each is exhausted so the choice of further action will become less selective. It is in this situation that rational behaviour may deteriorate into non-rational, and an adaptive response become non-adaptive - in other words what may be described as panic behaviour may be experienced.

Other authors have proposed models that differ in varying ways from the one described above but most are agreed on the two necessary conditions to occur (eg. Reference (5), Reference (11), Janis [12], and Turner and Killan [13].

These are:

(i) A major hazard is either present or perceived to be present, and,

(ii) The opportunities for escape diminish rapidly.

Dr Jonathon Sime, an environmental psychologist whose interest lies in the field of human behaviour and building safety, has focused on people's behaviour under threat of fire. Sime believes panic to occur in the conditions described above. This behaviour is characterised by self preservation at all costs through non-social, and non-adaptive behaviour. He believes that the tendency to limit information to individuals is a misguided one which increases the likelihood of panic and the time taken to initiate escape behaviour.

Sime's research resulted in the development of an affiliative model which predicts that in a situation of potential entrapment people move towards familiar persons and places. This contradicts the engineering approach which models human beings as non-thinking objects or "ball-bearings" enabling recommendations on minimum exit widths to be determined. The model assumes that when people are threatened by a fire they will try to escape by moving away from the fire towards the nearest route. Sime's research supports the affiliative model and has revealed that the most important factors influencing direction of movement during escape are a combination of a person's role, affiliative ties and consequent proximity to one exit or another.

This is illustrated by Canter [15] in his examination of the Kings Cross Fire of November 1987. People in the Kings Cross Underground station at the time of the fire were about to continue their journey, ie. by leaving the station on a train, thereby displaying conventional and affiliative behaviour. In this instance it would have saved their lives if they had been permitted to continue this action. However, the police officers present asked them to leave the station by the platform exits, and so unwittingly led a number of people to their deaths. Examination of the position of the bodies showed people were overcome by flames and fumes in positions directly relating to their customary journeys.

This raises the issue of the part played by leadership and authority in emergency situations. Although it seems that London Underground staff appeared to have made attempts to instruct people, the evidence was that no one took any notice. In contrast everyone followed the instructions given to them by police officers who were tragically uninformed. This is demonstrated too in the video of the fire at Bradford City Football Club where people were reluctant to climb on to the pitch until police officers gave the direct order.

3.0 EMERGENCY DRILLS OFFSHORE - WHAT THEY TELL US

In order to appreciate how these aspects of human behaviour can be taken into account in the design of improved offshore evacuation systems, we must also recognise how current systems actually operate. The evaluation of performance in actual incidents will provide us with some data. Also of interest, although of less direct relevance, is the wealth of experience gained from emergency drills offshore.

3.1 Typical experiences

Statutory Instrument SI 1976 No. 1542 states that each installation must conduct a muster drill at least every 28 days. These drills can highlight potential shortcomings in an installation's procedures and systems.

From the time the alarm sounds it can take anything up to ten minutes or more for personnel to muster. A further period must then be allowed for a head count, which may or may not present the desired outcome. Response times depend on the number of personnel on the installation, the size of the installation (perhaps an accommodation barge is attached), and so on. Though difficult for the authors to substantiate, it is interesting to note that there are numerous tales of muster drills running on for an hour or more before account has been taken of all personnel.

It must be remembered that emergency drills stop short of total evacuation, even if all personnel are assembled at the lifeboats. Typical factors affecting muster times are:

A helicopter crew change involving key personnel can give rise to great confusion should it coincide with an evacuation alarm. These personnel may not be fully aware of what is expected of them. They are also likely to be slower to react, having possibly been off the installation for a number of weeks.

The early hours of the morning is known to be the time when personnel are likely to be slowest in responding to an alarm. Many personnel will be asleep, and generally this will include some key personnel. There is the obvious delay of personnel dressing as well as the reduction in ability to react effectively.

A high frequency of false or spurious alarms reduces the urgency of action of personnel. This is particulary prevalent during hook-up and commissioning phases, when several false alarms may sound during the course of a day. Frequency and anticipation of drills also encourages complacent response. Some personnel, particulary those off shift, are far more likely to await confirmation of the alarm or further information in the hope that it is all clear, so that they can stand down.

Mustering at an inappropriate location - Experience has shown that some people will muster or attempt to muster at their designated point, even if circumstances indicate that alternative action is required. Personnel less familiar with the installation may well be unsure of alternative muster points and procedures, even if they are confident in their knowledge of their designated point.

Lack of information and/or poor quality information through a disruption in communications or through unavailability or ill-informed/unfamiliar key personnel in many instances leads to inappropriate actions or incorrect instructions. Such a situation in a real emergency could prove to be disastrous.

Location of personnel can adversely affect muster response times. Obvious examples of these would be personnel working down the legs of a ConDeep platform or in the lower pontoon spaces of a semi-submersible.

Injured personnel and procedures for dealing with them - The degree to which personnel anticipate dealing with injured personnel in an emergency situation can affect total evacuation time almost as much as the level of preparedness of procedures and hardware for dealing with injuries.

Possible actions to be taken in order to overcome, at least partially, some of these problems will be addressed later. As indicated above, evacuation drills often do not test the actual method of evacuation. Only the mustering to evacuation points is carried out. Hence problems liable to be encountered in the act of evacuation by a chosen method are not highlighted, and so personnel are unprepared for overcoming them. Among many points, this must be one of the important lessons from the Piper Alpha disaster.

4.0 PIPER ALPHA - THE WORST CASE HAPPENED

It is worth recalling the consequences of the primary event on Piper Alpha at 10.00 pm on 6 July 1988. The escalation of the event leading to the massive fireball that engulfed the platform some twenty two minutes later has one terrible parallel with the Manchester air disaster: The time available should have been sufficient for all the personnel to have escaped if the performance of the actual evacuation had matched the standard generally expected by the offshore industry.

The main consequences of the primary event were:

* Fire prevention systems were knocked out
* All alarm and Public Address systems failed
* Emergency power systems were only partially effective
* Control Room was effectively destroyed
* Command structure was disrupted - key personnel unavailable
* Emergency shutdown may not have been fully effective (Not proven)
* Some muster points / lifeboat stations were rendered untenable (Not one lifeboat was launched)
* Life raft launch systems failed or were operated ineffectively
* Helicopter evacuation was made impossible due to fire and smoke
* Evacuation routes from primary muster points in accommodation were impassable
* Communications were lost to other nearby installations and the shore.

Secondary consequences included:

o Great difficulty was experienced in evacuating from such heights (i.e. main platform levels)

- o Haphazard collection and pick-up of survivors at sea level was experienced. ie. no plan existed, no pre-designated points were established - hence no equipment such as lifejackets, rescue lights/beacons were available. (This is not a criticism of the efforts of the rescuers)
- o Most rescue craft were there only by co-incidence

4.1 Survivors' Evidence

Analysis of the evidence of the survivors who took the stand at the Public Inquiry before Lord Cullen [16], serves to illustrate these points only too graphically. From days 26 to 53 of the Inquiry, 58 survivors felt able to give evidence; of whom

A number jumped into the sea:

15 from about 150 feet (pipe deck)
4 from 174 foot level(Helidecks)
1 from 84 foot level
3 from 68 foot level
and 5 or so from about 20 feet (from hoses and a navigation platform).

Most descended as follows:

- 25 went down a knotted rope from 68 foot level to a navigation platform at 20 foot level.
- 4 slid down a hose from a small navigation platform just below the 68 foot level and dropped the last 20 feet into the sea
- 1 slid down a second rope
- 1 climbed down cables attached to a platform leg
- 4 climbed down the structure during at least part of their route.

Many commented on the dilemma they faced:

Some 30 or so reported being in the galley and/or the accommodation block at some point following the first explosion. At least six specifically reported that no-one was in charge in the galley. At least ten reported trying every door out of the accommodation. Confusion, lack of information and a growing sense of "panic" was reported by many. At least three instances of personnel being "frozen by fear" were reported, of whom two were persuaded into action by others.

Of 20 who reported sheltering in the "Whitehouse", 15 jumped from the pipedeck and 4 slid down a hose as mentioned above.

Their eventual rescue was reported as follows:

21 were picked up by fast rescue craft (FRC) from the platform without going into the sea
About 9 were picked up by FRC while in the sea holding onto platform legs
17 were picked up by FRC from open water
6 were picked up from the sea by the support vessel, *Maersk Logger*
5 were picked up from the sea by the standby boat, *Silver Pit*.

Their reported use of life saving equipment was:

Half a dozen or more did not have on life jackets
Most did not have on survival suits
Two who did have on survival suits reported difficulty in the water due to hoods filling with water and pulling them down
Only one survivor who gave evidence actually managed to get into a life raft launched from the platform, and that was after jumping into the sea and coming across it by chance.

Also with regard to evacuation planning, in addition to their considered comments, some evidence by survivors is particularly worthy of note:

Day 26, P61D	"What seemed to be little things made a big difference that night."
Day 27, P98F	The diving supervisor had no communications following initial explosion, so he had no instructions as to best route to muster stations. (He decided on his own initiative).
Day 28, P113A	One man tied the Knotted Rope (the single most successful item used for evacuation that night) to a handrail. The witness thought this was not necessary, but had no time to argue. The witness also observed that difficulty was encountered in persuading people to go down the rope.
Day 28, P117D	Divers tried to use a second unused FRC on the *Silver Pit* but it failed to start.
Day 31, P24C	"I was caught up in all the confusion" (He was near the knotted rope). Evacuation down the knotted rope was however carried out in an orderly manner.
Day 32, P76C	"They were really new to the platform, and they did not have a clue where to go, and so I told them to follow me; I did not know where we were going to go."
Day 33, P75D	"I do not actually know where I was, ...we were trying to find ways to get outside of the accommodation. .....For some reason, we decided to have a rest, to get our thoughts together, I think...."
Day 35, P10A	"There was [a queue of people waiting to get out of that door]. I do not know how many, but there were people there on their hands and knees......because of the smoke."
Day 35, P40C	"...but to muster everybody in the Whitehouse at that particular time, not knowing what the emergency was, just did not seem feasible."
Day 36, P28B	(On helideck, just before the mushroom cloud of flames erupted) "We were just sort of walking about. We all did it. There was nothing else left."
Day 37, P7B	(In the cinema when the first explosion happened) "There was a bit of a panic. People started making to the door to get out. I got out, went to my cabin, put on some warm clothes and a life jacket."
Day 37, P31B	"After the initial explosion most people were concerned about their friends and what was happening to them."
Day 37, P78F	People were moving in a crowd within the accommodation, and trying the exit doors.

Day 37, P79G "You normally wait for information from whoever is in charge, ...nobody told us anything."

Day 40, P118G (In the galley area) "Everyone was pushing....wanted to know what to do."

This evidence demonstrates a number of the concepts of human behaviour identified in previous research. Everyone was aware of the existence of a life-threatening situation and, due to the rapid escalation of the incident, the opportunities to escape were rapidly diminishing. It has been illustrated by the survivors statements that confusion resulted and indeed panic behaviour was experienced (a number of people were frozen with fear, for example). In some cases people adopted normal behaviour i.e. they queued to get out of a door and people were moving towards the exit doors with which they were familiar. Also many reported looking for their "group" of friends and workmates. In this respect it can be said that non-adaptive and affiliative behaviour was experienced. It is clear that this behaviour was due to lack of information available about the incident and a lack of any instructions or indications regarding safe evacuation routes, coupled with the rapidly growing need to evacuate. These are the very conditions under which the research discussed in Section 2 above suggests that non-adaptive behaviour will start to occur.

Furthermore, it was demonstrated that people needed and sought leadership and guidance and did not receive it. The order to abandon the platform was never given.

It is also worthy of note that several of the divers observed that they were able to contribute significantly to the pick-up and handling of injured personnel on the *Silver Pit*. They felt that their more rigid command structure, arranged almost on military lines, stood up better in the highly stressed situation than the less formal company emergency response structure.

4.2 Post-Piper evacuation proposals

A number of hardware solutions to the evacuation problems encountered on Piper Alpha have been proposed since the disaster, some of which were suggested by the survivors themselves. The main proposals are listed here; some of which were already available on the market, if not in use elsewhere.

The use of the following has been widely discussed:-

- Smoke hoods / Personal emergency respirators
- Safe havens
- Protected walkways to lifeboats
- Escape chutes
- Personal lifelines / controlled descent devices
- Scramble nets, ropes etc.
- Free-fall lifeboats (40 to 60 seater)
- Personal survival packs

These items have been suggested in addition to the other measures being discussed and implemented with a view to fire mitigation and hydrocarbon release reduction. Measures such as sub-sea isolation systems, platform edge and splash-zone emergency shutdown valves, increased fire wall protection, etc. are bound to influence both the potential scale of any incident and the opportunity for personnel to escape.

But these are only the hardware solutions. How can we relate the human factors issues identified above to their effective implementation?

5.0 HUMAN FACTORS ISSUES THAT MUST BE CONSIDERED

As discussed in Section 4.1 above, the experiences of the survivors amply demonstrate the need for information discussed by Sime [7,14]. The importance of the provision of information during emergencies cannot, in the opinion of the authors, be stressed too highly. The urgency of the response of personnel, and the effectiveness of their response is directly related to the quality and amount of information with which they are supplied. Hence great effort should be expended to ensure that information systems will continue to function throughout any potential incident.

There is also a clear need in any threat stress situation for a familiar and authoritative command structure. The case of the Policemen in the Kings Cross fire, and the experience of the divers on the *Silver Pit* again are ample demonstration of this.

Experience has shown that training of personnel to deal with emergency situations, and the various permutations that can occur, dramatically improves their capability to respond effectively. This is particularly important for key personnel but is also required for all those involved. As previously mentioned, the shock of seeing and having to deal with injured personnel can have an adverse affect on the response capability of individuals. Emergency drills therefore must take account of this.

The suggestions below are based upon these needs for information and command. The former includes direct vocal systems and also pictorial, visual and written guidance systems. However the suggestions for means of command are necessarily general in nature. This listing is not intended to give a complete solution and may seem rather pat. These are simply some of the key points that should be taken into account in any human behavioural and ergonomic assessment of a design.

Human Behaviour Issues

* Provision of information about the incident upon which escape actions can be based.

* Clear definition of command structure so that no matter who is removed it is always clear who will step into the breach.

* Strong leadership and guidance.

* Clear definitions of actions in event of alarms and of alternative actions if no alarms. (Simple summary cards to be included in survival packs.)

* Fear of use / reticence to use will influence the effectiveness of chutes, controlled descent devices etc. The number of chutes provided must consider this. Strong leadership will ease the situation, as has been shown people tend to do exactly what they are told under emergencies.

* Adequate emergency training.

* Drills to be at non-fixed times and with variation of incident, evacuation methods etc. Key personnel training to include table top exercises. If practicable carry out annual full test of evacuation to completion.

* The inclusion of "injured" personnel, blocked routes, unavailable muster points, communication disruptions etc. in the drill. Possibly with donning of smoke hoods.

Other physical or ergonomic issues need to be considered in the hardware design. These obviously include the avoidance of smoke ingress to safe havens, accommodation, main muster points and protected evacuation walkways. Other items that should be noted are:

<u>Ergonomics Issues</u>

* Information provision - blast protected PA systems and/or telephone systems, greater availability of two-way radios, perhaps individual radio receivers in personal survival packs.

* Emergency lighting of proven effectiveness, perhaps with illuminated arrows on evacuation routes.

* Width of walkways, lifeboat entrance doors etc to be adequate to ensure desired flow rates.

* The ease of use of evacuation methods, the number of actions required for implementation must be minimised and simplified. Instructions must be clear and concise, preferably of pictorial type. (Remember the painter line length and the life raft drifting under the platform on Piper Alpha.)

* The use of simple diagrammatic instructions. Visual (and perhaps audible) attraction to chutes and lifeboats etc when PAPA given.

* Testing of all alarms and evacuation system design to meet ergonomic considerations.

The Piper Alpha disaster has demonstrated several issues that need consideration. There are two in particular that must be remembered. The first is that an incident can escalate very quickly. In such circumstances it must be asked whether 60 people can really get into a free-fall lifeboat in good order, and ready for an effective launch. It is quite probable that the perceived threat will be too great for rational behaviour. Information provision, relating to the progress of the incident, and fire wall protection can obviously play their part in reducing the perceived level of that threat. It might not be possible however for a practical design to maintain a sufficiently low level of threat for 60 individuals to muster, receive the order to evacuate, board a lifeboat and then launch it. This is one area where the authors feel that more research is needed to ensure that this expectation is not unrealistic. It may be that smaller lifeboats seating fewer people are required.

The other point that is raised by Piper Alpha is a less precise one, and is an extension of the first. Perhaps it is simplistic to put it in these terms, but the disaster showed that if the firewater pumps etc fail you might only have about twenty minutes before a further significant failure occurs. As this is only one data point, it is difficult to draw any conclusion from it. Yet it would seem prudent in such a situation, the worst case admittedly, to expect little more than ten minutes to be available for evacuation.

It is also worth remembering that on Piper Alpha the worst case happened.

6.0 CONCLUSION

This paper has shown that human behaviour patterns play an important role in the effectiveness of evacuation systems. Reference has been made to recent research into human behaviour under threat stress, and findings related to a number of recent disasters have been used to illustrate these concepts. Analysis of the Piper Alpha disaster has demonstrated the need for such human behavioural considerations to be taken into account in the design of evacuation systems offshore.

The engineering approach to design of these systems will go some way to ensuring the safe operation and evacuation of offshore platforms. However it is evident that human beings do not always behave in a logical or appropriate manner. It is not always possible to predict human behaviour but this paper gives some valuable insights. It is the belief of the authors that if these issues are incorporated into the design of evacuation systems, they will improve evacuation strategies and ultimately SAVE LIVES.

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AUTHOR/TITLE/KEYWORD