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LEARNING FROM ACCIDENTS

THE PIPER ALPHA OIL PLATFORM DISASTER
MESSAGES FOR MANAGING SAFETY

Internal management of safety course transcript

On 6 July 1988 the North Sea oil production platform Piper Alpha exploded killing 167 men. The public inquiry into that accident revealed shortcomings in the management of safety on the platform and there are many messages that managers of oil or chemical facilities need to note. Learning from accidents is a vital part of safety training.

INTRODUCTION (Jim Whiston, ICI group safety manager)

I am pleased to introduce Brian Appleton, who served on the Board of Inquiry, to talk about the Piper Alpha accident and the messages for us in ICI from that sad event in managing safety and improving our safety performance.

Requirements for safe operation (visual aid)

- Hazards recognised and understood
- Equipment "fit for purpose"
- Systems and procedures to maintain integrity
- Competent staff
- Emergency procedures
- Monitor performance

Let us look at the six basic requirements for achieving safe operation: Hazards must be recognised and understood; equipment must be fit for purpose; we must have systems and procedures to maintain plant and process integrity; staff must be trained fully and well competent to do their jobs; we have to plan for foreseeable emergencies; lastly, we must monitor
performance, that is have effective auditing processes. These can be thought of as links in a safety chain but any weakness in that chain will compromise safety. On Piper Alpha there were weaknesses in all of these links, as Brian Appleton will outline.

Brian is a mechanical engineer. He was one of the technical assessors at the Board of Inquiry which began in January 1989. His early career in ICI was in design and in operations, and he was in charge of some of the major start-ups of ICIs petrochemical operations. He did a spell in ICI Australia, came back to the UK and was involved in part of the Oliphant 6 project. He was then Chairman of the agricultural division and finally a director of ICI chemicals and polymers, so he is very well qualified to speak about the safety issues involved in Piper Alpha. So, without further ado, over to you, Brian.

LECTURE (Brian Appleton)

As Jim explained, my aim is to tell you about the Piper Alpha disaster and to draw out of that lessons for us in ICI. The plan I have this evening is in five stages. I would like to start by saying to you what was Piper and what happened to it; then I will tell you a bit about the public inquiry, what its
objectives were and how it works; and then the main part of my talk will be to trace the sequence of events of the disaster itself, and out of those I will draw lessons for us in ICI and then I want to end on the topic which I consider to be the bottom line of safety.

What was Piper Alpha and what happened to it?

Let us start with what was Piper Alpha and what happened to it. Piper Alpha was a very large North Sea oil rig. It was located in the North Sea about 100 miles off the shore of Aberdeen. This is what it looked like. If you think of it roughly as a 75 metre cube, that gives you an idea of the size of it. What it is comprised of - well, at this end the tall tower is the drilling derrick and at the work from the wells at that end came a mixture of oil, gas and condensate,
condensate and mainly propane.

In the middle is the kind of plant that we are used to in ICI processing plant. What it did was to separate that mixture into its constituent parts and then they were exported by pipeline to the shore. Finally, at the north end, the big white structure is the living accommodation because, of course, on an oil rig you don't go home, you stay there. Looking at that, there is some great differences between an
offshore platform and one of our chemical plants. As I said, the first thing is there are many more men on there at any instant because the people not working live there, they do not go home at night.

The second difference arises from what is obvious; it is surrounded by water. If you think of one of our major chemical plants, if we get a fire our instant reaction is to call in the local fire brigade. That local fire brigade comes with first class equipment, well trained crews and experienced
officers. With a fire on an oil rig, you fight it with what exists there at the time, and you do so with the part-time fire fighting crew who may have other jobs as process operators or fitters.

The second difference the water makes is in relation to escape. In our chemical plants, if there is a major incident any of our operators can escape and their means of escape is the surface of the land, and their means of transport is their own legs but on an oil rig it is different. Evacuation from an oil rig has to be organised; you need information from outside that boats are available, whether the helicopter has come, people have to take command and organise the crew to get off it, so there are three radical differences with our chemical plant.

So that was Piper Alpha. What happened to it? Well, on the night of 6 July 1988 at 10 o'clock in the evening there was an explosion and there was a subsequent fire, and three hours later that was all that was left, just part of the southend under the drilling derrick, in three hours. 12,000 tonnes of steel was lying on the bottom of the sea, 474 feet down. But, more importantly, in that three hours 166 men lost their lives, total death toll was 167; one man died of injuries the next day.

Purpose of public inquiry and how it works

In the UK when we have a large loss of life it is our practice to hold a public inquiry. That takes me to the second topic, the public inquiry itself. A public inquiry has only two objectives. Firstly, it has to determine the cause of death and, secondly, it has to make recommendations to prevent a repetition.

What is it like? It is run by a judge, in this case Lord Cullen, a Scottish judge. It is like a court. The parties are represented by counsel and the parties can be survivors represented by counsel; the operator, the Occidental Petroleum Company, was represented by counsel; some of the hardware manufacturers were represented; the trade union was represented; the contractors who had employees there were represented, so it is a court of law with a group of counsel.

But it differs in one major respect from a court of law. You are used to a trial where the police have done the investigation beforehand and they come along to prove their case before the judge and jury. In a public inquiry the inquiry conducts the investigation as it goes along. No-one came along and said, "We have worked out how the disaster happened". We in the inquiry had to do that.

Jim Whiston told you I was an assessor. There were three of us; we had different industrial backgrounds and our sole job was to help the judge, help him investigate, help him decide what recommendations to make and finally help him to write the report. That is the public inquiry.

Events of disaster and how they happened

(visual aid)

1. Initial explosion
- Deficient permit to work system
- Deficient permit to work training

2. Prolonged oil fire
- Deficient hazard analysis
- Deficient emergency training

3. Gas pipe failure
- Deficient hazard analysis

4. Death in accommodation
- Deficient design
- Deficient command
- Deficient training

5. Fire fighting
- Deficient emergency system
- Deficient management of problem

6. Monitoring and auditing
- Deficient quality

Let us turn to the disaster itself and trace the sequence of events. I have told you already that it was an explosion at 10 o'clock on 6 July. We know it was 10 o'clock because one man had just switched on the television news and the announcer had barely said anything, so it was within seconds of 10 o'clock at night. We knew where it was, in part because some of the survivors said "I heard a thump and it came from that direction", another one from different directions. You can eventually home in and it was clear it was in one of the modules in the processing plant.

This was backed up because the control room operator in the minutes prior to the explosion had a series of gas alarms in one module, so we were clear it was 10 o'clock, we were clear where it was in the processing module.

From the sequence of gas alarms, because the ones that came up were on the flooring module, we were confident it was condensate heavy, Propane heavy in there, so in trying to determine what had gone wrong, why had there been an explosion, those facts made us concentrate on what had been happening in the condensate system prior to the explosion.

I have said the platform exported condensate. To do so it pressured it up to about 1,000 PSI. At about quarter to ten that evening, the main export pump pressurizing the condensate tripped out. The process staff tried to start it up and they couldn't get it restarted, so they decided to recommission the spare pump. They knew that the spare pump had been taken out that day for maintenance; in fact, for a major two yearly overhaul. It was going to last a fortnight but they also knew nothing had been done. The pump had been electrically isolated, the suction delivery valves had been shut and the condensate in the pump had been blown down but no work had been done, no slip face had been fitted, the pump had not been opened up. So they decided to recommission that spare pump; a very straightforward job, it would only take minutes to reconnect it electrically.

However, unbeknown to them, a second maintenance job had been done on that pump that day. On the delivery side there was a relief valve and that relief valve had been taken out for overhaul and checking its set pressure. The job had been done by the contractor's people, they didn't get the job finished by 6 o'clock that evening, overtime was restricted so they decided to finish it the next day and the contractor's supervisor took the permit to work back to the control room. When I said permit to work, no doubt you are saying to yourself, well, how could they not know about this second maintenance job? The permit to work system would tell them; that is exactly what it is for.

The reason they didn't know about the permit to work system was that on that Wednesday there were faults in the permit to work system. First of all, the two permits, one for the major overhaul in the pump and the other for the relief valve, were not cross-referenced one to the other. Secondly, when the contractor supervisor took the permit back at 6 o'clock to the control room, he didn't talk to the process supervisor because the process supervisor was busy with his handover - there was a shift change - so the contractor supervisor signed the permit and left it at the desk.

When the inquiry looked at the background we found that this was not an isolated incidence of a failure in the permit to work system. The permit to work system was operated permanently in a different way from that laid down. Permits were never cross-referenced. It was common practice for maintenance supervisors to leave permits on the desk and not talk to the process supervisor. The contractor's supervisor handing the permit to work, it was his first time ever as a supervisor and he had had no training in the permit to work system whatsoever, but that wasn't unusual, neither had the process staff. There was no formal training in the permit to work system at all.

So, when they prepared to start up the spare pump and they opened the suction valve and pressured the pump, condensate leaked out from where the relief valve had been taken off. Yes, blanks should have been fitted on those open ends; they were not. So that was the first event, the initial explosion. Two deficiencies: The permit to work system and training.

I have told you 166 men died. To the best of our knowledge maybe two men died in that explosion, so the explosion was not the major cause of death. What happened with the explosion was that it blew down the fire walls in the module in which it took place and damaged equipment either side and, in particular, it damaged equipment in the module that contained most of the heavy oil.

The management had thought about fires and that is the reason they had fire walls between modules but they had not thought about an explosion, so there were no explosion walls between the modules. Secondly, that oil fire actually persisted for longer than the inventory of oil on Piper would allow it. The reason for that was that Piper was connected not only to the shore by an oil line, but to two other platforms. Those two other platforms exported their oil over to Piper and then to shore.

When the explosion took place and the fire was raging there were a number of ships around, they broadcast Maydays, they tried to inform people what was happening, and the two platforms connected to Piper also picked up those messages, but they went on producing, so in effect they were pumping oil into that fire on Piper, and prolonging it and making it worse.

When we asked them why they kept producing, both managers said, "Well, we assumed that the Piper people would bring the fire under control". The inquiry found that they had no evidence on which to make that assumption. The same thing we noted was that those two managers had had no training in inter-platform emergencies. There had been no practices of one platform in trouble and what happens on the others. The initial explosion unfortunately damaged all the communication equipment on Piper and no-one had envisaged that possibility. So the second sequence of events was the oil fire. No explosion walls, hazard analysis and again emergency training for those managers.

Even that did not actually kill a lot of men. Besides being connected to the other platforms by an oil pipeline, Piper was connected by gas pipelines and to shore by a gas pipeline 16 inch to 20 inch in diameter and ran at 2,000 PSI and they came up on Piper in the middle of that oil fire. That was when they came in. Of course the pipelines were gradually heating up and when they burst, that happened.

I think you might reasonably ask had the possibility of the risers, gas risers, bursting and emptying that large inventory into a platform been recognised? Yes, it had, actually. Just 12 months before this disaster a new engineer had been asked to do a study as to whether it was worthwhile maintaining the stand-by fire fighting ship, a small ship that can pump water onto a platform, and he had done a very thorough study and he had examined the kind of fires that you might get on Piper.

In his report he commented about the gas pipes, the gas risers and what he had said was if a gas riser goes the fire fighting ship will be useless, there will be nothing anybody can do and the loss of life will be enormous. That was in his report. His report was considered at a meeting of senior managers and directors. They were meeting to decide whether they renew the contract for the fire fighting ship. At that meeting that paragraph about the loss of life if a gas riser went was never mentioned, never raised by anyone; it was not discussed at all.

If it had, could something have been done about it? Well, you could have had a water deluge specifically on those risers that would have delayed their rupture. You could fireproof them. Yes, there would be problem of corrosion underneath, it might give difficulties but again you could have bought time. So, the gas risers go, gas fire, you are about hazard analysis, hazard management and in fact analysis had been done but there was no management.

Closer up, looking at Piper and the gas fires, they look like that and like that, but these slides give you a very poor impression of what it was really like and so I want to show you a small piece of video. On the night of the disaster there was a Norwegian

on one of the ships and he had a cinecamera and he was taking film for his child's project and he filmed part of it, and what I am going to show you is the oil fire and then the gas fire coming.
(Video shown)

Incredibly, men still got out after that gas fire and while it was raging but even that did not cause the major loss of life, not directly. When the explosion took place the majority of people were in that white accommodation block. Now, the means of transport to a North Sea oil rig is by helicopter. That is what everybody is used to and that is how the men expected to get off. So those in the accommodation stayed in the accommodation awaiting the helicopter. Other men who were working on the rig, quite a number of them, fought their way through the smoke and the flames into the accommodation. That was where the helicopters would land on the roof and that, of course, was where the management was and the works manager who were taking command.

The majority of men died in that accommodation and they died of carbon monoxide poisoning from smoke because, although the accommodation was designed to withstand some fire, it had not been designed to withstand thick black oil smoke. People kept opening doors, tried to smash windows to get out and every time they did it smoke came in and that is where the majority of people waited and died.

Now, I said waited and died because it was regretfully evident in the inquiry that in that accommodation no command in any shape or form was given. It must have been obvious, looking out through doors and windows, that there was no possibility whatsoever of a helicopter landing on that rig. The only chance anybody had, however dangerous now, however risky, and however many would have lost their lives doing so, was to leave the accommodation, fight their way through this smoke and flames, jump into the sea and hope to be picked up, and there were a lot of vessels around.

In fact, one vessel with all North Sea platforms is the stand-by vessel and its purpose is to pick up people who jump into the sea in an emergency, but unfortunately no such command to leave and take that chance was given. Some men of their own initiative did leave and 28 made it. We do not know how many others tried and died. We know the majority stayed and died because the accommodation module was recovered from the bottom of the sea and the bodies were found inside it.

Why was no command given? No doubt a contributing factor was that the offshore installation manager, in our terms the works manager, had had no major emergency training, he had had no simulation exercises of a disaster on the rig. It was not his fault, it was the people who chose him and failed to provide that training. So, we got death in the accommodation, not designed against smoke, hazard analysis again, lack of command and once again lack of training.

I told you earlier that on a North Sea oil rig when you get fire you have to fight it with what you have got and Piper had quite a lot. The main means of fighting a fire was a deluge system and what that did was to spray a set amount of water on every surface that could contain hydrocarbons and that was in the design of the installation.

On the night of the disaster it didn't work at all. Some men saw dribbles of water coming out. Now, there was no doubt that part of the pipework would have been damaged in the explosion because it ran near it. It is also clear that the explosion killed the main power supply so the main electrically driven water pumps would not work. But of course there were back up pumps for just that case and there were diesel driven emergency firework pumps, but they didn't come into operation.

They were designed for automatic start but on the night of the disaster the automatic start was isolated and the reason for that was that they took their suction sea water from below the rig. The offshore installation manager had been concerned about the risk to divers who might be near that suction below the surface when the pumps started up automatically and he decided that the emergency firewater pumps should be on manual whenever a diver was in the water; note not when he is near the suction, but whenever he is in the water. In the summer months the divers dive 12 hours a day, so for half the time in the summer months the key back up system for fire water was out of commission.

So, for fire fighting, we have an emergency system out of commission. However, even if it had come into operation, it is doubtful whether it would have done the job because there had been a problem with the heads that sprayed the water on Piper. Because it was sea water it corroded all the pipes; the products of corrosion blocked up the heads.

Occidental tackled this first of all by more frequent cleaning. What they did was to flush out the pipework more frequently but of course that just increased the amount of corrosion and they decided if that didn't work they tried larger spray heads and they also blocked. Finally it was decided to replace all the pipework in non-corrosive material and at the time of the disaster one module had had the replacement pipework. Unfortunately it was the one module that didn't catch fire, the drilling module at the south end.

That is, you would agree, a very logical way to tackle the difficult problem but the problem had been picked out four years before the disaster and after four years it was not solved by critical fire fighting system. Again with fire fighting, yes, we have an emergency system out of production and we have got a deficiency in managing a critical safety problem.

This is a catalogue of deficiencies I have told you about. I should tell you they became readily apparent to the inquiry. Why the permit to work deficiencies, things like that, didn't take a lot of probing to find it, so I think you might reasonably ask, well, how is it the management of the platform didn't know about it? Well, they

should have done. There was a lot of monitoring and auditing, certainly much more than I was ever used to in ICI. With the permit to work system every single day there was a safety operator on Piper who did nothing else but monitor the operation of the permit to work system. There were never any reports of faults in the permit to work system from Piper from that daily monitoring.

Six months before the disaster there had been an audit of Piper. One of the chosen topics was the permit to work system. The audit report contained no criticism of the permit to work system whatsoever. The practice of isolating the diesel-driven fire pumps, taking them off automatic start to manual, had been picked up on an in-company audit five years previously and the audit team said, "That's not right, just put them on manual when the divers are near the intake". That recommendation had never been implemented.

When we asked the senior management why they didn't know about the deficiencies that we found so readily, one of them said, "Well, I knew everything was all right because I never got any reports of things being wrong". In my experience that is not the way to be with safety. There is always news on safety and some of it will be bad; continuous good news, you worry. So the final component in this sequence was auditing and it was about quality. So there is a sequence of events on the night of the disaster. With each key step the inquiry found various deficiencies.

Lessons for us in ICI

(visual aid)

- Management responsibility
- Safety depends on systems
- Quality of safety management
- High quality safety auditing

Let's turn now to drawing lessons out of it. The first one is let us go back to what Jim said. Jim said that with all safety, with all major accidents it is like a chain, you can get weak links in it. With Piper all the links in the chain were weak.

When we do accident investigations in ICI, and this was no different, we know from experience that the circumstances of any major accident never repeat themselves. Of course you can make recommendations in detail about permit to work systems or solving the spray head problem or automatic start of diesels but they do not repeat and it is for that reason that with all accident investigations we get to root cause analysis and that is what I want to look at in drawing lessons for us.

The first thing I would note about all those deficiencies I have drawn your attention to is that they were all the responsibility of management. The first lesson in safety is about management and what do I mean by management. Well, I mean you and you and Peter here and me but three things I would say about it is first of all it means every single manager. The second thing to say about it is that specifically it is line

management's responsibility. Safety is the responsibility of line management, it is not the responsibility of safety department. The third thing is above all of the managers your chief executive must be fully and visibly committed. If he is not and he does not show it, nothing you can do can make up for that lack. So, the first lesson is management.

The second lesson I would draw out of it is that it was all about safety systems. Either they existed and they didn't work like the permit to work system or they should have existed and didn't. There was no systematic assessment of major hazards on Piper, ever. There was no hazop of Piper, ever.

The third lesson is that it is about the quality of safety management. The thing about the diesel pumps and the problem with the divers, that manager was right to tackle that problem, it was a real problem, a diver could be killed if he was close to the suction when the pump started up. So he was absolutely right to tackle the problem. What was wrong was the quality of the decision he took. He put the whole platform at hazard for half the time.

That particular manager also gives me another example of quality of safety management. He told us that every single day he walked round the platform for about an hour, an hour and a half, and he did this so that he could check on safety, he could look at permits to work, he could keep his finger on the pulse. I think you would all agree that is right. But later in his evidence he told us he did that at 7 o'clock at night. Nearly all the work finished at 6 o'clock and the reason he did it at 7 o'clock was an offshore installation manager is a very busy man and 7 o'clock was the only time he had. So that third lesson is it is not just management, it is the quality of the management we all put in.

The fourth lesson is about auditing. I have told you about the audits on the permit to work system. I will give you an example of another. There was an annual fire insurance audit on Piper just to influence the amount of money paid for fire insurance. It was conducted by an external firm. We read the reports from the previous four years. Not a single report referred to the problem of the spray heads. It was not a quality audit so that is my fourth lesson which I draw out of this disaster. All the things we found so easily, the inquiry, management should have found by their own auditing. They did sufficient but it was not the right quality so they are my four main lessons.

The bottom line of safety

I told you earlier I wanted to end on the bottom line, safety. I want to do that by telling you two episodes from two of the survivors from Piper. They were both young men, late 20s, early 30s. One of them arrived on Piper just six hours before the explosion. It was his first time ever on Piper. In fact, it was his first ever job offshore; he had never been on an oil installation before.

He had a little introduction course, he had a meal and he was starting work at 6 am the next day, he went to bed early and he was woken up by the explosion. Then he tried to tell us in the inquiry how he escaped but he had an immense problem that at no instant any time did he know where he was. He had never seen the thing before. He kept being asked, "Where were you then?" He said, "I don't know". He eventually found himself on a walkway. He was surrounded by thick black smoke. He could not see, could not even tell us how high up he was and then flames came up through the smoke and he told us that he decided to jump off the walkway and the counsel said to him, "Why did you decide to do that?" and he said "I decided it was better to die hitting the deck than to be burned alive". He did jump and he fell straight in the sea and was rescued and we do not know from where he jumped.

The second episode was a man who worked for a drilling company called Borden. He was at the south end with the drilling derrick so he fought his way along the rig into the accommodation and when he got there he could see barely three feet because of the smoke. He could not see anybody and he said he called out, "Is anybody from Borden here?" and when he was asked why he did that he said, "I didn't want to die alone".

I tell you those two stories because safety is not an intellectual exercise to keep us in work; it is a matter of life and death and it is the sum of our contributions to safety management that determines whether the people we work with live or die and on Piper on 6 July 1988 they died.

EDITORIAL

On July 6, 1988, 167 men died when a series of explosions and fire engulfed the North Sea oil production platform, Piper Alpha, stationed 120 miles north-east of Aberdeen. It was the world's worst off-shore disaster. Lord Cullen, a Scottish High Court judge was asked by the Government to conduct an inquiry. After a 13-month inestigation which included a public inquiry which lasted 180 days, the report (1) was published on November 12 1990.

The report confirmed that the disaster was caused by a massive explosion triggered by a leak of condensate, a light oil (see the schematic opposite).

At about 9.45 p.m. one of the two condensate injection pumps tripped. The investigation concluded that the leak resulted from steps taken by night shift personnel with a view to restarting the other pump which had been shut down for maintenance.

Unknown to them a pressure safety valve had been removed from the relief line of the pump. A blank flange assembly which had been fitted on the site of the valve was not leak-tight.

The explosion was followed immediately by a fire at the west end of module B and a fireball which erupted from the west face. The fire spread rapidly into B module and extended into C module.

Dense black smoke from the fire engulfed the upper parts of the northern end of the platform and the initial explosion was followed by a series of smaller explosions. Most of the emergency systems of the platform, including the fire water system failed to come into operation.

Many of the 226 people on board were trapped in the accommodation area unable to make their way to the survival craft because of the smoke. Twenty minutes into the fire, the pipeline connecting Piper Alpha with the Tartan platform failed. The pipeline was at a pressure of about 120 bar (1740 psi) and contained 450 tonnes of gas. A fireball, in excess of 150 metres diameter, engulfed and rose above the platform.

Lord Cullen says that the lack of awareness concerning the removal of the valve, resulted from a breakdown in communications at shift handover and a failure in the so-called permit to work systems. The operatives did not realise the valve had been removed because the night-shift was not informed during the handover from the day-shift. If the night-shift had known that the relief valve was not in place, no-one would have tried to start condensate injection pump A. This would have been the case if the permit to work system had been implemented properly.

Looking at a number of typical permits to work, revealed a catalogue of errors in regard to who signed them, the work description, the gas tests, electrical isolation and the fixing of isolating tags, and the inertion of dates of times.

Lord Cullen concluded that "the operating staff had no commitment to working to the written procedure and that the procedure was knowingly and flagrantly disregarded". He also considered that "the training required to ensure an effective permit to work system was operated in practice was not provided".

An important message is that the initial explosion may have been fueled by as little as 45 Kg of hydrocarbon in the flammable cloud. The need to prevent gas leaks is, of course, paramount.

Sweeping criticism of Occidental management and the UK Department of Energy over safety procedures and practices was made in the report.

The recommendations fall into three main areas:

- The need for a single offshore regulatory regime under the Health and Safety Executive;
- Formal safety assessments (FSA's)
- The management of safety

The FSA (or safety case) is akin in part to the onshore UK CIMAH Regulations. It also has its roots in the Burgoyne Committee Report, published in 1980, which discussed the need for setting objective, rather than prescriptive, regulations and recommended that a systematic approach to safety

assessments during design and construction should be encouraged.

As a result of the inquiry stringent new safety rules will be implemented in the North Sea oil and gas industry.

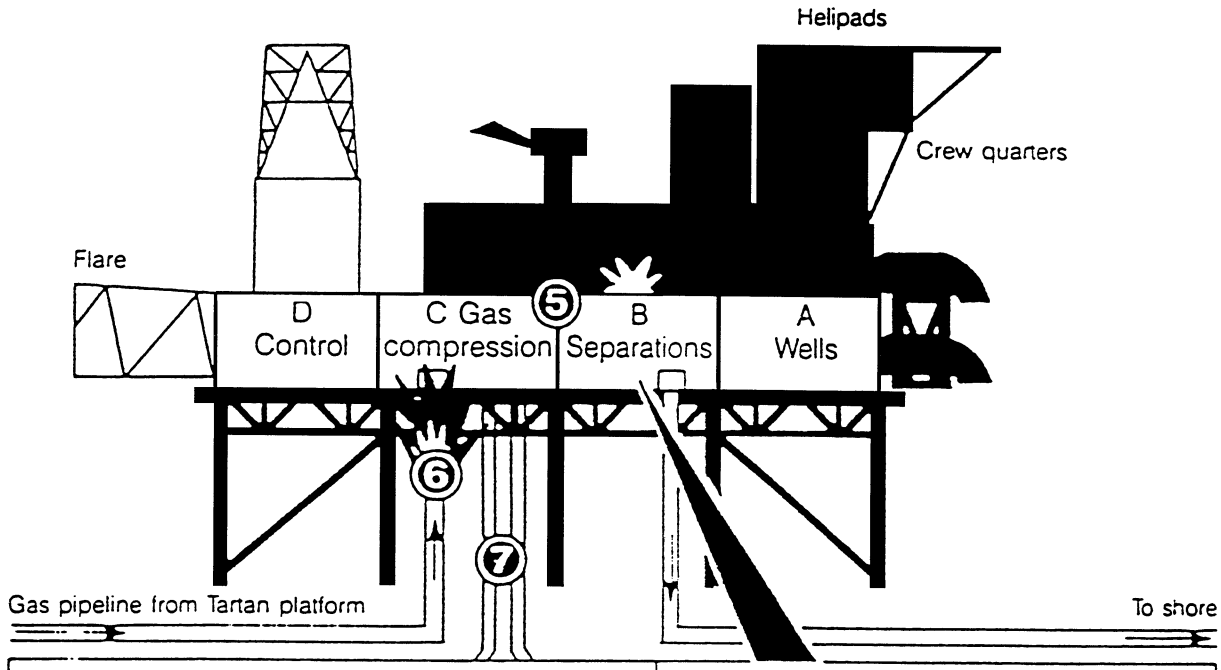
Occidental was criticised for failing to provide adequate safety training. Senior management was too easily satisfied that safety was being maintained and workers and management on the platform were not adequately trained and prepared for a big emergency. The company had failed to protect its workforce. Lord Cullen identified failures in communication and weaknesses in Occidental's management as underlying causes of the disaster.

As families of many of the Piper Alpha victims call for criminal prosecutions against those "responsible" for the disaster, management must realise that commitment to safety must come from top management. Energy Secretary John Wakeman said that if Occidental were to be prosecuted it was now a matter for the Lord Advocate, Lord Fraser of Carmyllie and not for him.

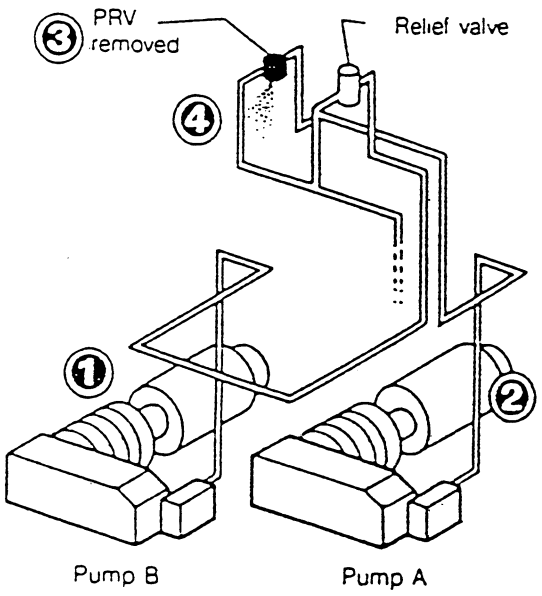
It is essential that the management structure should be organised so that feedback from the bottom to the top should be so effective to ensure not only that instructions are effectively carried out but also that top management are constantly aware of individual responsibilities and problems that arise.

1. The Piper Alpha report is available from HMSO bookshops at £38. The report comprises of two volumes which are not sold separately. ISBN 0 10113102.

   Telephone orders: 071 873 9090
   General enquiries: 071 873 0011



1. Pump B stops working.
2. Pump A started. This had been shut down for maintenance.
3. PRV for Pump A had been removed for maintenance and replaced by cap that was not leakproof
4. Gas escaping from cap ignited probably by spark.
5. Explosion destroys fire control, communication systems and firewall between modules B and C
6. Blazing oil ruptures incoming gas pipeline, fireball engulfs platform as gas acts as 'blowtorch'.
7. Other incoming pipelines rupture, intensifying fires.



Events leading to the Destruction of the Platform