Accident Investigation

Piper Alpha Disaster

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Executive Summary

Accidents are usually caused by a combination of factors like human error, management failings, omissions and neglect. They serve to take the industry out of their comfort zones and improve their processes. The purpose of this report is to investigate the causes of Piper Alpha accident within the framework of Events and Causal Factors Analysis, Barrier analysis and Risk Tree analysis. It was observed that poor engineering design, management failings and improper training of the employees contributed as the root causes of the accident. The impact of the accident on the industry and regulatory bodies has also been analysed. It was found that major changes have been made to cover the short comings identified. However, several challenges still remain which have prevented the offshore workplaces from becoming safer places and caused further accidents. These include management greed and neglect of onsite workers. A short analysis of the investigation techniques has also been included in the report.

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Introduction

The incident covered in this study is *Piper Alpha disaster* which took place in 1988. Piper Alpha was an oil production platform on North Sea, approximately 110 miles from Aberdeen, which was operated by Occidental Petroleum (Caledonia) Ltd. It started as an oil platform in 1976 which was later converted to a gas conversion facility in 1980. It acted as a hub of a network of platforms interconnected by oil and gas pipelines (CCPS, 2005). It accounted for roughly 10% of total oil and gas production in North Sea at the time (Duff, 2008).

On July 6, 1988, Piper Alpha experienced a series of cataclysmic blasts and explosions which resulted in fireballs up to 120 m high. The massive flames of fires prevented any rescue operations from sea or air for several days. It destroyed the platform completely and claimed the lives of 167 out of 226 people on board (Duff, 2008). The death toll included two emergency response personnel who died during a rescue attempt. Many survivors were horrifically injured when they tried to escape fire by jumping into the open sea from heights of up to 30 m. The total insured loss of the disaster was over $ 3.45 bn. Piper Alpha disaster is considered the world's worst offshore disaster in terms of magnitude of losses and its impact on industry and safety regulatory bodies worldwide. It served to raise the awareness of critical health and safety issues in offshore operations.

Analysis of Evidence

In 1988, an official public enquiry was launched under the chairmanship of Lord Cullen with the following objectives

- To investigate the causes of the incident, and
- To prepare a roadmap for reforms in organizational health and safety (OHS) to prevent future accidents.

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Since most of the platform was completely destroyed due to the fire, the evidence was based upon the accounts given by survivors and eyewitnesses. The sequence of events (facts) as per Cullen enquiry report is as follows

1. Two separate work permits had been issued for condensate Pump A without any reference to each other. One was for general pump repair and the other was for testing of relief valve (RV). During RV testing, RV was replaced by a blind flange (flat metal disc). As the work could not be completed by the end of the shift, the flange remained in place which meant it was not ready for operation. However, the supervisor did not inform the staff of the next shift about the status of the permit. There was no mention of the status of this permit in the control room and maintenance logs.
2. During the night shift, the condensate Pump B suddenly stopped and could not be restarted. It was important to restore one of the pumps as the entire power supply of the oil platform depended on these pumps. The on field manager looked through the documents and did not find any status of permit of RV testing. The manager assumed it was safe to start Pump A. The missing valve was not noticeable as the metal disc was several metres above ground level and it was hidden by other machinery.
3. When Pump A was switched on, gas flowed through it and created very high pressure which the loosely fitted blind flange could not withstand. There was a gas leak at very high pressure which was noticed by the crew. However, before anyone could react, the gas found an ignition source and there was a heavy explosion which broke the firewall and dislodged the panels around the module in control room. One of the panels ruptured a nearby condensate pipe which created another fire.
4. The crew members left the control room and retreated to their accommodation module and waited for evacuation instructions, as they had been trained. However, the heavy fires disintegrated the platforms emergency organization and there was no attempt to

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use loudspeakers to order an evacuation. At the same time, the fire due to the ruptured pipe continued as it was continuously being fed with gas from the Claymore and Tartan pipelines. This resulted in loss of 81 personnel in the crew quarters due to smoke inhalation.

5. A series of explosions and heavy fire took place. This prevented any rescue operations either from helicopters or other ships for several hours. This resulted in complete destruction of the oil platform. At the height of the event, natural gas was being burned on Piper Alpha at a rate equivalent to the entire United Kingdom natural gas consumption rate (CCPS, 2005).

Events and Causal Factors Analysis

The Events and Causal Factors (ECF) Chart depicts the necessary and sufficient events and causal conditions for accidental occurrence in a logical sequence (TRAC, 1995). It is based on the premise that accidents happen due to multiple causes and it is necessary to identify the chain of events that led to the accident to identify the main causes, contributing causes and the root causes.

To prepare ECF, it is necessary to answer the question: what happened and why did it happen. It will help in finding the direct causes, contributing causes and root causes of the accident.

Barrier Analysis

Barrier analysis is based on the premise that hazards are associated with every accident. It is a technique used to perform the root cause analysis during an accident investigation. It is based on the concept of tracing energy flows, with a focus on identifying barriers to those flows i.e. to identify how and why the barriers did not prevent the energy flows from causing harm (Kingston et al., 2005).

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Barrier Analysis Worksheet			
What were the barriers?	**How did each barrier perform?**	**Why did the barrier fail?**	**How did the barrier affect the accident?**
Improper Work permit systems	Two separate work permits issued without cross-referencing	Manager did not inform the status of work permit during change of shifts	Pump A was started without the knowledge that it contained metal disc in place of RV
Height of relief valve	The metal disc was placed at a height from ground level	The metal disc was not visible when Pump A was started	The metal disc could not withstand the overpressure and caused gas leak
Irresponsible management	RV was not replaced as the shift had ended	Management did not consider it essential to complete testing by taking overtime	The pump A was started without replacing the essential RV which caused gas leak
Design of control room	The control room was designed for fire but not for explosions.	The explosion damaged the walls of the control room.	The damage in walls and nearby pipe resulted in greater fires which prevented rescue operations.
Lack of emergency training	Employees were not regularly trained in emergency evacuation and response	The employees retreated to crew cabin and waited for further instructions which never came.	Loss of 81 lives in crew cabin as no one took the initiative to start rescue operations
Inadequate authority of	Off shore managers in	The managers did not	Continuous supply of

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offshore managers	Claymore and Tartan were not authorized to stop production	stop the production of gas even when they could see the fire from Piper Alpha	fuel caused huge fireballs which prevented rescue efforts

Table 1: Barrier Analysis Worksheet

Risk Tree Analysis

Risk tree analysis is a technique used in probabilistic risk assessment (PRA) to evaluate risks associated with a complex engineered technological entity (e.g. offshore oil platforms, nuclear plants etc.). This is a quantitative technique where the risk is characterized by

1. The magnitude of possible adverse consequence
2. The probability of occurrence of each consequence

The hazards identified in the barrier analysis have been given the rating on a scale of 1-10 (1= min, 10= max) to determine their probabilistic risk rating. The ratings are on the basis of author's assessment

Hazard	Magnitude	Probability	Risk Rating
Improper Work permit systems	5	6	30
Height of relief valve	3	6	18
Irresponsible management	7	7	49
Design of control room	9	3	27
Lack of emergency training	8	3	24
Inadequate authority of offshore managers	6	2	12

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Table 2: Risk Matrix assessment

The risk assessment matrix helps in developing the risk tree.

Summary Report

This section contains the root causes of the disaster as derived from the above analysis and recommendations for future course of action

Conclusions

From the above analysis, the root causes of the Piper Alpha accident were as follows:

1. **Improper Work permit system:** The work did not have references to each other which resulted in two separate work permits on the condensate pumps to be issued. Moreover, there was no communication between the workers of two shifts about the status of work permits. This resulted in starting Pump A when it was not ready for operation.
2. **Poor plant design:** The walls of the platform were originally designed for oil and were capable of withstanding fire and not an explosion. Even after the installation of gas conversion equipment in 1980 in the platform, the design of the blast walls remained the same. This was the major reason for the initial explosions.

There were several secondary causes which added to the severity of the accident. Most important among them were

1. **Inadequate training of employees:** The employees were not adequately trained in emergency evacuation procedures which resulted in the chaos and loss of lives of many workers in the crew accommodation.
2. **Management failings:** The management at nearby platforms like Claymore and Tartan did not stop their production even when they could see the fire at Piper

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platform. The management assumed that they would be informed of the situation if any action was necessary. The reason given for inaction was that it was very expensive to stop and restart the production. Thus, corporate greed and management inaction added to the severity of the accident.

Recommendations

The recommendations for the industry are as follows

1. **Assessment of engineering design of structures:** The industry players must carry out the assessment of the design of their structures for their ability to withstand explosions and fires. There is a need to carry out research in this direction.
2. **Improvement in record keeping:** Records must be maintained with high integrity and the details of work permits must be clearly mentioned. There must be proper communication between the supervisors about status of work permits when there is a change in shifts.
3. **Training of employees:** The employees must be trained in emergency evacuation and other emergency response. Regular drills and simulation exercises must be carried out so that casualties can be minimized in case of an accident.

Impact on Industry

The magnitude of losses in Piper Alpha ensured that it acted as a catalyst for changes to health and safety regime in offshore operations. Most offshore operators voluntarily carried out self-assessment of their installations and management systems (Warne, 2008). The Cullen report, published in 1990, made 106 further recommendations to the industry and the regulatory bodies all of which were accepted. Most of the legislations were offshore operations specific but they had implications across the processing and manufacturing

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industry. The Health and Safety at Work Act, 1974 remained in place but it was supplemented by new offshore-specific regulations recommended by Cullen enquiry. The major changes to the legislation were as follows:

1. **Change from prescriptive to goal-setting approach to legislation:** Before Piper Alpha disaster, the health and safety was thought of as a matter of compliance rather than a responsibility. It was attributed to a 'prescriptive' approach to legislation. For example, the effects of explosions on offshore structures were not factored in and the safety ratings were based on carbonaceous fires, rather than hydrocarbon fires or explosions. Post 1990, there was a stress on goal-setting approach to legislation which intended to encourage continuous self-monitoring and self-assessment which would create safer environment for offshore operations. For example, the use of safety case regime demonstrated the stress on goal-setting approach to legislation. Post Piper Alpha disaster, a safety case approved by Health and Safety Executive (HSE) was made mandatory for offshore operations. According to Warne, the safety case should demonstrate that the operator and duty holders have an adequate safety management system in place (2008). Moreover, they should identify major accident hazards, assess the risks from those hazards, establish adequate audit and reporting arrangements and take the measures necessary to reduce the risks to people to as low as reasonably practicable. This safety case has to be approved by HSE at least six months in advance before the installation.

   Another major recommendation of the Cullen enquiry was that the responsibility of the safe operation now rested with the operator of the installation. This was intended to create a sense of responsibility in the offshore supervisors.
2. **Changes to industrial structures:** Post Piper, research was conducted to demonstrate the results of explosions in confined spaces as observed in offshore locations. From

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the Piper experience, it was realized that cutting off fuel supply is essential to minimize damages to the structure. The major changes in structures were as follows

a. The structures of oil platforms were redesigned to withstand worst case overpressures and temperatures.
b. The location of pipeline isolation valves was shifted to the seabed rather than at a height, which was the case earlier.
c. The emergency shutdown valve was relocated to a protected place rather than near the control room, which was the case earlier.
d. Changes in deluge systems and fire pumps were made to make them more effective during an accident.

3. **Stress on post-event safety:** Many of Cullen recommendations centred around the evacuation exercises with a stress on training the employees and conducting regular trials. Some of the changes were as follows
    a. All the employees had to undergo safety training at least once in six months irrespective of their previous experience.
    b. Evacuation drills were to be mandatorily conducted and the plant supervisor was made responsible for this.
4. **Changes to management system:** Cullen report understood the necessity of people, processes and good management to bring about the above changes. So, there were recommendations to promote good management practices, some of them are as follows
    a. Changes in permit to work system where creation of logs was made necessary and cross-referencing was essential
    b. Formalized handovers between shifts so that there is communication between the workers in different shifts.

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The changes meant that the organizations had to invest massively in their present systems. Some large organizations like Shell had to invest up to $ 1 bn to implement the changes in its offshore operations. The recommendations have been mostly successful as there is a visible dip in the number of major offshore accidents around the world. However, a survey conducted on 100 offshore locations around the world by HSE revealed that the key issues identified by Cullen enquiry have not been completely dealt with. The findings indicated that more than 60% of the plants were below acceptable level of safety and 16% of plants did not comply with legislative requirements. This shows that the broader lessons of the incident have not been learned by the industry. There are several challenges which have resulted in other accidents

1. **Neglect of onsite workers by Management:** Neglect of onsite workers is still prevalent as the management prefers to use contract workers and shows little respect for workforce dissent (IOSH, 2008). The Brent Bravo incident of 2003 (where a huge gas release resulted in two casualties and almost 150 were put at risk of smoke inhalation) shows that the management still does not take into account the safety and recommendations of onsite workers when planning for safety standards.
2. **Asset integrity:** The challenge for senior management is to consistently measure their performance against industry safety standards. This will facilitate a continuous improvement program. A zero accident record makes the management adopt a relaxed attitude towards safety and the asset integrity is compromised.
3. **Training of new workers:** Due to cost cutting measures of organizations, training of new workers for emergency preparedness has been neglected. Lack of training of workers in emergency evacuation was a major reason for high casualties during the incident of Buncefield fire in 2005 (IOSH, 2008).

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These challenges are still present which have prevented the lessons from Piper Alpha disaster to be learnt completely by the industry. They have resulted in some future incidents as shown.

Critique of analysis methods

It is acknowledged that accidents rarely occur due to a single reason. Most accidents are caused due to a combination of performance errors, management oversight, omissions etc. This leads to a sequence of events which results in the final accident. The aim of the investigators is to analyse this sequence so as to identify the potential hazards which were neglected.

During the present investigation, the construction of ECF chart required gathering of factual evidence which can help in constructing the chain of events which led to the accident. Thus, the initial ECF was very incomplete as it contained many informational deficiencies. As new information was unearthed by the author from different sources, there was a change in ECF and it was constantly upgraded. This made it a very time consuming affair. However, in author's opinion, the construction of ECF is very important as it helps in identifying direct causes, contributing causes and the root causes of the accident. It helps the investigators to

- Organise the accident data,
- Guide further investigation,
- Validate and confirm the true accident sequence from other sources,
- Identify and validate factual findings, probable causes, and contributing factors,
- Simplify organisation of the investigation report,
- Illustrate the accident sequence in the investigation report.

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Thus, ECF acts as a framework into which the results of other investigative techniques like Barrier analysis, risk tree analysis can be integrated which provides the core for a good investigation.

The barrier analysis worksheet helps in identifying the barriers which were overlooked by the supervisors during safety audits. It follows the principle that it is important to treat the root causes rather than treating the symptoms. As there can be multiple, root causes, the process can be iterative and time consuming, but it lays the ground work for future continuous improvement.

During the investigation, the barrier analysis worksheet helped in identifying the root causes from the several causes identified by the ECF. Since the information was readily available, it did not result in an iterative process which made it easier to work with. Barrier analysis provided clarity of insight into the investigation due to the use of energy flow techniques. However, it resulted in some loss of flexibility during investigation as Energy Trace method cannot be applied to every situation. Thus, some compromises are necessary to use barrier analysis during a major investigation. However, it provides a useful platform for identifying the important hazards which can help in implementing the process of continuous improvement for improving the industry health and safety standards.

Use of Management Oversight and Risk Tree (MORT) framework for the investigation revealed that it can be extremely time consuming and tedious when learning about and first using the MORT chart. As MORT charts can only be prepared and understood by trained professionals, in most cases, this approach can be classified as overkill. However, in a complex investigation like Piper Alpha where the evidence is based on the account of eye witnesses, the MORT approach is useful. According to the experts, MORT charts provide a systematic method of evaluating the specific control and management factors that may have caused or contributed to the accident. Thus, it not only aids the accident investigator by

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identifying root causes of the accident, but also serves as a planning and organizational tool for the collection of evidence and other relevant information. However, in author's opinion, MORT chart do not add much value to the investigation process.

The use of barrier analysis and ECF chart is recommended for accidents where direct evidence is not readily available (as was in case of Piper Alpha disaster). The use of MORT can be avoided in smaller accidents as it can be time consuming and does not add much value to the investigation process. Moreover, the barrier analysis must be used in conjunction with ECF charts to provide a proper framework for accident investigation and achieving maximum benefit.

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References

CCPS. (2005). *Building Process Safety Culture: Tools to enhance process safety performance.* New York: Center for Chemical Process Safety of the American Institute of Chemical Engineers.

Duff, S. (2008, June 6). *Remembering Piper Alpha disaster*. Retrieved June 10, 2010, from BBC News Web site: http://news.bbc.co.uk/2/hi/uk_news/scotland/7438774.stm

IOSH. (2008, August 20). *Piper Alpha: 20 years on*. Retrieved June 10, 2010, from IOSH Offshore Group Web site: http://www.iosh.co.uk/groups/offshore_group/group_articles/piper_alpha_20_years_on.aspx

Kingston, J., Nertney, R., Frei, R., Schallier, P., & Koornneef, F. (2005). *Barrier Analysis Analysed in MORT Perspective.* Delft, Netherlands: Noordwijk Risk Initiative Foundation.

Sklet, S. (2004). Comparison of some selected methods for accident investigation. *Journal of Hazardous Materials, Vol. 111, Issue 1-3* , 29-37.

TRAC. (1995). *Events and Causal Factors Analysis.* Idaho: Technical Research and Analysis Center.

Warne, P. (2008, July 7). *Piper Alpha: 20 years on and the laws on safety keep evolving*. Retrieved June 10, 2010, from The Press and Journal: Energy: http://energy.pressandjournal.co.uk/Article.aspx/710854/

Woolfson, C., & Beck, M. (2000). The British Offshore Oil Industry After Piper Alpha. *New Solutions: A Journal of Environmental and Occupational Health Policy, Vol. 10, No. 1-2* , 11-65.

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