An Analysis of the Piper Alpha Oil Platform Disaster Using Actor-Network Theory

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Introduction

On July 6, 1988, the Piper Alpha oil platform, owned by Occidental Petroleum, experienced a sequence of explosions and fires. This resulted in the death of 167 people, leaving only 61 survivors. This was the worst offshore oil disaster in terms of lives lost and industry impact. This incident has been thoroughly investigated to determine the underlying root cause of this event, and has led to many improvements to the UK oil and gas upstream industry regulations and to offshore platform design requirements. Currently, many scholars have determined the technical root cause to be a gas leak from a condensate pump. Scholars also believe that the permit to work system led to miscommunication between operations workers. However, scholars have yet to adequately consider the effects of the poor safety culture and the economic pressures. With the inherent risks associated with working on an oil platform, it is crucial to maintain a positive safety culture. However, the financial pressure to meet certain oil production demands can lead to unsafe practices. Therefore, if we continue to only focus on the technical and communication flaws then we will miss out on a large contribution to the Piper Alpha disaster. Considering the effects of the safety culture and economic pressures, will provide a better understanding of what led to this catastrophic disaster.

In this paper, I will analyze the Piper Alpha disaster using Actor-Network theory. I argue that a poor safety culture exacerbated by oil production economic pressures led to the destabilization of the Piper Alpha actor-network ultimately resulting in the 1988 disaster. Two rogue actors, safety culture and economic pressure, destabilized Occidental’s goal of producing profitable oil. To support my argument, I will analyze evidence from the Cullen Investigation report (Cullen, 1990).

Background

Piper Alpha was an oil platform located 120 miles north-east off the coast of Aberdeen, Scotland. It was erected in 1976, owned by Occidental Petroleum, and operated for 12 years until it was lost to disaster. Piper Alpha was connected to two other oil platforms, Claymore and Tartan, through both gas and oil pipelines (Figure 1A). Piper Alpha exported 125,000 barrels of oil per day from the Piper Oilfield to the Flotta Terminal on the Orkney Isles (Drysdale & Sylvester-Evans, 1998). To do this, a combination of oil, natural gas, and salt-water brine is extracted from beneath the ocean floor and pumped to the platform. On the platform, water is separated from the oil. Additionally, gas is separated and cooled to remove the gas condensate liquid. The condensate is then pumped back into the oil for export (Lilley, 2013). Piper Alpha had two condensate pumps (only one is needed to maintain production): Pump A and Pump B.

On July 6, 1988, Pump A was down for routine maintenance and for an upcoming 2-week long equipment overhaul. The pressure safety valve was removed, and a blind flange was hand-tightened on to seal off the open pipe. The day shift ended before maintenance work was complete, and it was decided to continue the work in the morning. During the night shift, an alarm indicated that Pump B had tripped, which would cause the rig to go into shutdown without an active condensate pump. The crew was unable to successfully restart the pump, and decided to restart Pump A, unaware that this pump was not fit for operation. Alarms sounded and the first explosion occurred in Module C due to a high-pressure gas leak through the hand-tightened blind flange. This explosion broke the firewall between Module B and C causing the main condensate pipeline to rupture which led to a large fireball in Module B and a pool fire below the modules (Figure 1B). This then caused the gas pipeline to the Tartan platform to rupture, and eventually the pipelines to the Claymore and MCP-01 platforms also failed leading to further explosions. 167 people including two rescue personnel died, and only 61 people survived.

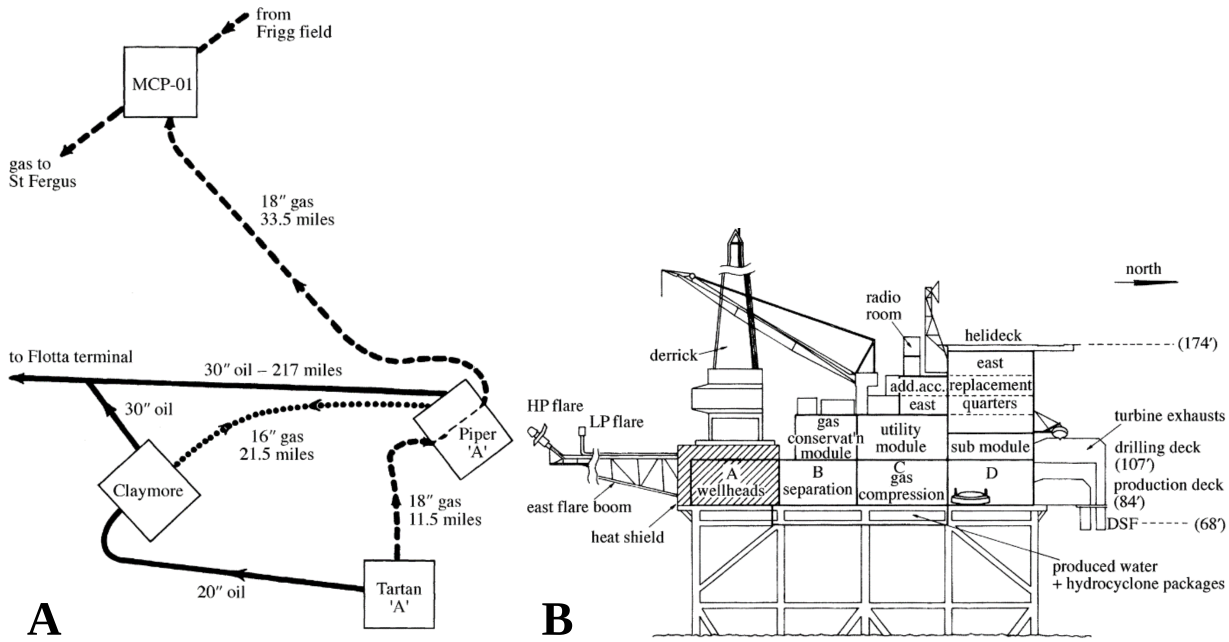

Figure 1. A: Location of Piper Alpha in relation to other platforms and pipelines

B: East projection of Piper Alpha (Drysdale & Sylvester-Evans, 1998)

Literature Review

The Piper Alpha incident was the worst offshore oil disaster in terms of lives lost and industry impact. This incident has been thoroughly investigated to determine underlying root causes of this event. The following analyses focus on the technical causes and miscommunications that led to this disaster; however, they do not adequately consider the effects of the safety culture and economic pressures.

Drysdale and Sylvester-Evans, in their paper “The Explosion and Fire on the Piper Alpha Platform, 6 July 1988: A Case Study”, use a variety of evidence from eyewitness accounts from the survivors, data from nearby platforms, documentation, and recovery of debris and the deceased to analyze the technical causes of the incident (Drysdale & Sylvester-Evans, 1998). In this paper, they analyze the initial explosion and the resulting fires on the Piper Alpha platform. They argue that the major disaster could have been avoided if the initial explosion from module C had been able to be vented freely, without failure to the firewalls, through the east and west face of module C. They recommend that blast walls and additional relief panels should be implemented. Additionally, they point out that access to lifeboats and to the helideck was impossible. Therefore, they recommend that temporary refuge, designed to mitigate the effect of smoke, is needed during an emergency. The analysis in their paper centers around the fires in order to explain the dynamics behind the rapid fire escalation to improve the design of future offshore oil platforms. However, solving the technical design flaws is only one part of the problem, and this analysis is missing the social factors that resulted in the Piper Alpha disaster.

Marc Reid offers a unique perspective to this incident as he is the son of one of the 61 survivors of the Piper Alpha disaster. In his paper, “The Piper Alpha Disaster: A Personal Perspective with Transferrable Lessons on the Long-Term Moral Impact of Safety Failures”, he argues that events from the disaster, such as his father having to jump off the platform into the North Sea, and other process safety events leave a lasting impact (Reid, 2020). Similar to Drysdale and Sylvester-Evans’ report, Reid highlights the technical causes of this event: condensate explosion from a pump in module C. However, Reid also argues that failure of the permit to work system was the root cause of this disaster. While Reid’s argument with the permit to work system does highlight the communication flaws that led to the accident, it fails to take into account the poor safety culture and economic pressure that largely contributed to the significant loss of life.

Both of these arguments find that the condensate pump explosion in module C was the technical root cause that led to this major disaster. Drysdale and Sylvester-Evans focus on changes in the process design that could have eliminated this incident, whereas Reid encourages the need for a better change management and permit to work system. While both of these arguments offer important recommendations to improve process safety, they do not address the safety culture or economic pressure that fueled this disaster.

Conceptual Framework

Actor-Network theory (ANT) provides a framework to characterize the interplay between the people, the technology, the safety culture, and the economic pressures involved in the Piper Alpha disaster. ANT, as defined by sociologist Michael Callon (1986), provides a constructive framework in which the engineer is a network builder that assembles non-human and human actors to form a network. The actors can be heterogeneous factors such as a combination of people, or social, technical, natural, or conceptual factors (Cressman, 2009). Actors can be allies and work to benefit the network, or adversaries that work against the network. Therefore, it is important to be aware of rogue actors that can threaten the stability of the network. Additionally, to maintain a stable network, you can't ignore or privilege some actors over others because all actors have equal power, importance, and influence on the network.

Translation is the process of forming and maintaining an actor-network, and this process occurs in four steps: problematization, interessement, enrollment, and mobilization (Callon, 1986). During problematization, the primary actor (the network builder) defines the problem and identify the relevant actors. The primary actor becomes the "obligatory passage point" (OPP) through which all other actors must pass in order to serve the network. Interessement is when the primary actor actively recruits other actors to the network. During enrolment, the primary actor assigns roles to all other actors who then accept and perform their assigned role within the network. In the final step, mobilization, the primary actor acts as the spokesperson for the actor-network and mobilizes the actors for action. This process of translation is crucial to maintaining a stable network, because the network will fail if one or more actors refuses or is unable to perform their role (Callon, 1986). Additionally, translation is used to understand the relationships, power, and influence between actors.

In the following analysis, ANT will be used to describe how the Piper Alpha network was "translated", using Callon's concept of translation. The Cullen Investigation report will be used to identify the relevant actors and supply evidence for this analysis. Then, ANT will be used to track the actors and their roles in the network in order to identify the rogue actors that resulted in the failure of the Piper Alpha network.

Analysis

Network Formation

Construction of the Piper Alpha actor-network will provide a necessary framework for the following analysis. The human and non-human actors in the network were identified by synthesizing the groups involved with the oil platform on the day of the disaster and recommendations issued following the disaster in the Cullen Investigation (Cullen, 1990). The human actors are as follows: (i) *operations workers* who directly controlled the equipment on the platform, (ii) *Offshore Installation Managers (OIMs)* who are the highest level of control on the platform, (iii) *Occidental Petroleum* which is the corporation responsible for the oil platform, (iv) *Health and Safety Commission (HSC)* who provide regulations that the platform must meet, and (v) *engineers* who design the oil platform. Additionally, the non-human actors are defined as follows: (vi) *equipment and structure* such as firewalls and sprinkler system, (vii) *permit to work system*, (viii) *safety culture*, and (ix) *economic pressure.*

To understand the interplay between these actors, I will track the network's formation during the process of translation. Occidental Petroleum will function as the primary actor, as they owned and operated the refinery; thus, they hired all of the workers, maintained the oil platform, and created the culture present at the time of the disaster in 1988.

The first phase in the translation process is problematization. During this phase, Occidental Petroleum decided to erect the Piper Alpha platform in order to extract oil from the Piper oilfield to provide profit to their company. To do this, Occidental must ensure that the oil platform abides by all regulations outlined by the HSC. Occidental will not be present on the platform, and thus will need to recruit other human actors to execute their problem statement.

During interessement, Occidental recruits all the actors needed to reach their goal of extracting profitable oil. Occidental will require engineers to design the technology needed to extract oil from the Piper oilfield. Occidental's oil platform will need to abide by regulations; thus, the HSC will be recruited to the network. Occidental will not be present on the platform, so, OIMs will be recruited to the network. OIMs are the senior managers on the oil platform and are responsible for overseeing the production of oil. Occidental connects these four human actors by acting as the OPP for the network.

During enrollment, Occidental assigns roles to each of these human actors, and ideally, they will each accept and perform their assigned role within the network. Assuming this ideal situation, the human actors will recruit additional actors into the network. The engineers design the equipment needed to drill and pump the oil, the structure of the oil platform, and the safety systems. In the design and manufacturing of this platform, the engineers must follow any safety regulations issued by the HSC. OIMs recruit operations workers to operate and maintain the equipment on the oil platform in order to carry out the goals of Occidental. The OIMs also recruited a system to manage equipment maintenance: permit to work system.

Mobilization occurs since the OIMs, engineers, and HSC pass through the OPP directly. Additionally, the operations workers, equipment, and permit to work system pass through the OPP indirectly. Occidental instills the goals of the problem statement to the primary actors, and then those actors instill the goals into the subsequent actors that they recruit. Operations workers will report directly to the OIM, and the OIM reports directly to Occidental. The operations workers form direct relationships with the equipment and permit to work system, and will have the most daily direct contact with these actors. Occidental should work closely with the HSC to make sure their oil platform follows all regulations, and they should pass any safety recommendations to the OIMs. The OIMs should make sure that the platform and the operations workers are upholding these safety standards. Together, Occidental, the engineers, the OIMs, and the operation workers must work together to abide by safety regulations issued by the HSC in order to safely produce oil. The structure and translation of this network should not allow for process safety incidents. However, two rogue actors, the safety culture and the economic pressures, ultimately destabilize the Piper Alpha network.

Safety Culture in Design

The safety culture actor destabilized the Piper Alpha network due to lack of inherently safer design and emergency response deficiencies. A critical safety measure that was not maintained was the firefighting system. Piper Alpha had a fire deluge system that was designed to deliver water and foam to seal in the flames and knock down the fire. The diesel fire pumps were switched to manual mode, in accordance with practices during which diving was to take place beneath the platform. In order to start the pumps, someone would have to go to the control panel beside each pump to start it. However, during the night of the disaster, the pumps were in manual mode and they were unable to reach the pumps, and thus no water was supplied to drown the fire.

A recommendation from an audit done on Piper Alpha in 1983 points out that switching the pumps to manual mode was unnecessary by Fire Protection Agency (FPA) standards: "recommendation that a procedure be adopted to ensure that those pumps were set to automatic mode when diving was not being carried out near the intakes of those pumps" (Cullen, 1990). Even if they were able to start the diesel fire pumps, many deluge nozzles were plugged: "A routine test in C Module on 14 May 1988 disclosed that 50% of the deluge nozzles were blocked" (Cullen, 1990). Cullen (1990) also reports that Occidental had been trying to resolve the problem caused by scale plugging the deluge heads for at least four years, but were behind schedule.

As explained above, Occidental experienced ongoing problems with the fire deluge system. The fire deluge is critical to preventing the spread of fire, and should have been given a high priority to replace and maintain the pipes. This lack of inherent safe design suggests that Occidental maintained a poor safety culture. It is important to note that Occidental was informed that they should adjust their practice of switching the pumps to manual; however, the OIM decided to not follow this safety recommendation. Therefore, this suggests that the poor safety culture is an actor that is working against the network. This "safety culture" rogue actor led to instability in the translation phase of mobilization. Occidental and the OIM failed to uphold their role of following safety regulations and maintaining a safe working environment. Due to this instability, the fire deluge system equipment was unable to prevent, or significantly delay, the gas line rupture which resulted in a significant explosion (Macleod & Richardson, 2018).

Safety Culture in Emergency Response

As I have argued above, ongoing problems with the fire deluge system and the failure to follow the FPA's recommendation to switch the fire pumps to automatic were unsafe design choices. The lack of consideration for safety led to failure of the fire deluge system equipment which resulted in significant explosions on Piper Alpha. Some may argue that the practice of switching the pumps to manual mode during diving was actually to maintain the safety of the diver: "The diving superintendent described the difficulties which divers could experience through the effects of disorientation, currents and poor visibility" (Cullen, 1990). Additionally, a few years before the disaster, a diver was injured as a result of being sucked into a pump intake. Evidence suggests that the suction pipes under Piper Alpha were protected with grilles to prevent divers from being sucked in; and only divers within 5 meters of the pump, when the fire pumps were on, would be at risk of serious injury (Macleod & Richardson, 2018). While the personal safety of the diver is important, it should not be prioritized over a potential process safety incident that can endanger the entire personnel on the platform.

This viewpoint about maintaining the safety of the diver implies that Occidental worked to maintain personal safety for its employees. However, further evidence, as outlined below, demonstrates that Occidental has a history of not prioritizing individuals' safety due to significant emergency response deficiencies.

With the inherent risks associated with working on an oil platform, it is critical to have a comprehensive safety training program so that people can carry out their work safely and adequately respond in an emergency situation. However, this was not accomplished by Occidental:

> "26 of the survivors (all contractors' personnel) were asked whether they had received a safety induction. Six of them said that they had never done so. One thought that he had not, and one could not recall. The remaining 18 said that they had received an induction. But 4 said that it had lasted for 5-10 minutes" (Cullen, 1990).

About 30% of the 26 surveyed survivors did not receive any form of safety training. Those that did receive training admitted it was only a cursory training, and some workers had not even been shown the location of their lifeboat. It is important to note that on the night of the disaster, many people were unable to locate their lifeboats and the lifeboats were inaccessible due to smoke; therefore, many people remained in their quarters where they eventually died (Mannan, 2005). Additionally, evacuation drills were not conducted weekly as required:

> "A study of the Monthly Activities Reports for the first half of 1988 showed that 2 lifeboat drills had been held in January, March, and June, 3 in February and April, and one in May, a total of 13" (Cullen, 1990).

During a 6-month timeframe, only 13 drills were performed, and no full-scale shutdown drill had been performed in 3 years (CCPS, 2005). These drills would have taken place unannounced with the purpose of discovering deficiencies in the procedure and communications. The lack of emergency preparedness is extremely concerning since the people work in direct contact with dangerous equipment and hazardous materials such as oil and gas. Additionally, if one human actor on the platform does not follow proper safety protocols than they could harm the entire Piper Alpha network. Without these safety trainings and safety drills, the poor safety culture was not properly addressed. This resulted in a large portion of personnel being ill-equipped to protect themselves and others in an event of an emergency.

The ongoing problems with the fire deluge system resulted in a lack of inherently safer design which ultimately resulted in significant explosions. Without an effective emergency response plan, the safety of individuals on the oil platform was put at risk. This poor safety culture destabilized the Piper Alpha network resulting in the deaths of 167 people.

Economic Pressure

The OIM actor on the Claymore platform failed to fulfill his assigned role due to economic pressures which resulted in the destabilization of the Piper Alpha network. At the time, Piper Alpha produced about 10% of the UK oil production from the UK sector of the North Sea. Occidental Petroleum's large oil production demand led to pressure on the offshore platform to continue to produce oil at all costs. This economic pressure ultimately destabilized the Piper Alpha network due to delays in production shutdown from neighboring platforms. The Claymore production platform needed to shut down in order to prevent back pressure from fueling the fires; however, Claymore was slow to respond:

> "Claymore was informed by Tharos that Piper had a fire on her west side after an explosion. The Operating Superintendent on Claymore told the OIM (his boss) of this report and said that he wanted to shut down the main oil line because of the risk of their oil being released into the fire on Piper, if the heat ruptured the pipework. They knew that Piper's oil had been shutdown. But as the pipeline pressure was stable, the OIM decided to continue production" (Flin, 2001).

The OIMs on other platforms were aware there was a fire on Piper Alpha, but assumed they would be instructed to shut down their operations if needed. However, they were unable to communicate with Piper Alpha due to the explosion damaging the communication, and they continued pumping oil. It is important to note that between the initial mayday from Piper Alpha at 22:05 to the massive explosion at 22:50, the Operating Superintendent requested the OIM to shut down 5 times; however, the OIM refused because he wanted to maintain production. Cullen concludes that the OIM had full authority to shut down oil production, and only delayed because he was reluctant to take responsibility for shutting down oil production (Cullen, 1990). Applying actor-network theory, this suggests that the translation of the Piper Alpha network became unstable in the mobilization phase. Due to the structure of the network, the Operating Superintendent could only indirectly communicate his requests by talking to the OIM. However, the OIM refused one of the main responsibilities of the assigned role by not wanting to accept responsibility for the shutdown. The primary reason of the OIM's hesitations were due to economic pressures. The OIM did not feel compelled to shut down due to the huge associated expense, since it would take several days to restart production with substantial financial consequence (Broadribb, 2014). If the Claymore and Tartan platforms had shut down after the initial explosion, then the rupture of the gas risers responsible for Piper's destruction would likely have been prevented, thus enabling the crew to evacuate (Broadribb, 2014). The economic pressures experienced by Claymore's OIM caused the safety of those on the Piper Alpha oil platform to be compromised.

Conclusion

In this paper, I have used the sociotechnical framework of Actor-Network theory to create and analyze the Piper Alpha actor-network in order to identify the contributing factors to the disaster that killed 167 people. Through an analysis of the fire deluge system and the safety training system, it is clear that Piper Alpha had a lack of inherently safer design and many emergency response deficiencies that both resulted in a poor safety culture. Additionally, Occidental Petroleum's large oil production demand led to pressure on the offshore platform to continue to produce oil at all costs. The poor safety culture exacerbated by oil production economic pressures led to the destabilization of the Piper Alpha actor-network ultimately resulting in the 1988 disaster. This analysis looks beyond the technical and communication flaws that led to the disaster, and considers the effects of safety culture and economic pressures. This will provide a better understanding of what led to the Piper Alpha disaster, in order to effectively balance profit and safety on an offshore oil platform.

Word Count: 3955

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