

Fires and explosions on offshore platforms environmental sciences essay



**ASSIGN
BUSTER**

Introduction

On 20th April 2010, an explosion that was followed with a large fire occurred on an oil rig in the Gulf of Mexico. This fire emitted flames and smoke high into the sky about 40 miles off the coast of Louisiana. This incident has formed the major offshore accident in the recent past. Fire and explosions have therefore constitutes one of the most fatal type of accidents on offshore oil and gas platforms. Synonymous with these platforms are their compact geometry, limited ventilation, constrained escape routes and a high degree of congestions. Towards that end, a minor mishap in operation of these platforms under such conditions is a recipe for a devastating catastrophe. Of all the accidents reported from offshore platforms, fire is reported most frequently. It is therefore crucial to study the behaviour of offshore fire in addition to quantifying the hazards posed by them in order to accomplish a detailed quantitative risk assessment. Typically, offshore oil and gas platforms are divided into an array of modules that support operation functions. Such modules encompass; water injection, high pressure compression, separation and seawater de-aeration. This is in addition to local and main electrical rooms as well as an accommodation block for personnel. A large proportion of these modules are highly congested with the presence of barriers in the form of pipelines and other equipment critical in operational processes. Operating in such conditions poses a very high risk of danger. From the presented scenario, offshore platforms are never completely safe and are thus prone to accidents. Potential risks borne of offshore platforms include fires, explosions, riser and process leaks, structural failures, blowouts, vessel collisions, helicopter

accidents, dropped objects and capsizing. Of these, fires and explosions are the most prevalent.

Characteristics of Fires and Explosions on Offshore Platforms

Virtually all offshore fires and explosions incidents are ignited when fuel (hydrocarbons) are released following offshore system failure. Paramount to this ignition is the combination of oxygen supply and ignition source. An explosion occurs in environments that permit the released hydrocarbons to build up an explosive mixture. The explosion mixture may contain hydrocarbon gases or air and vapour that are enhanced by delayed ignition. A fire on the other hand occurs in situations where the released hydrocarbons ignite immediately after discharge. The severity and characteristics of a subsequent fire and/or explosion depend on a number of factors namely: The mass of the released hydrocarbons The type of released hydrocarbon including its physical state The type of release i. e. high pressure jet or low velocity Dispersion and mixing of the hydrocarbons with the surrounding environment The time when the ignition of released hydrocarbons occur Confinement and ventilation conditions The location of the ignition source. Based on these characteristics, ignition of released hydrocarbons/fuel may result into an explosion only, a fire only, an explosion followed by a fire, or a fire followed by an explosion (Simpson, 1997).

Potential fuels handled offshore include natural gas, crude oil and gas containing condensate and water. These fuels pose a significant amount of risk to personnel, equipment and the environment. Offshore fires differ from those occurring onshore mainly on the basis of level of confinement. Give

the harsh marine environments offshore, there is a need to enclose and shield offshore platforms from adverse weather conditions. It is a known phenomenon that fires in confined environments develop differently from those in open spaces. The confined environment exhibited by offshore platforms restricts free flow of air and this resulting into severely under-ventilated fire environments which in turn affects the size of offshore fires (Chamberlain, 2002). Decomposing hydrocarbons in such confined conditions becomes more intense than in open fires. This is because a mixture of fuel and air is closer to an ideal stoichiometric mixture. Furthermore, the loss of heat to the surrounding environment is limited under confined environments hence resulting into higher flame temperatures. Fires occurring within confined spaces present major hazards similar to those found in open spaces. These hazards include external thermal radiation and direct flame impingement. Fires in confined spaces however have additional hazards due to the effect of confinement. Such additional hazards include impaired visibility due to excess smoke, overpressure impacts from hot combustion gases and toxic carbon monoxide gas resulting from incomplete combustion (Chamberlain, 2002). Let us now divulge into overpressure arising from fires in confined spaces that is an important aspect but often neglected in fire modelling with only a small open in a confined space, highly energized combustion products released from confined fires has the capacity to generate greater pressures than ambient. Under such great pressures, an explosion creating missile effect and blast wave are very likely to occur. This condition may further lead to an explosion creating blast wave and missile effects. Following an ignition of released fuel gas or vapour cloud, there are two possible ways in which a significant blast overpressures can develop.

<https://assignbuster.com/fires-and-explosions-on-offshore-platforms-environmental-sciences-essay/>

Firstly, expanding gases can, in theory, generate overpressures of up to 8bar (800kN/m²) if an explosion is contained within an enclosure. In practice however, parts of the walls in such an enclosure would inevitably collapse hence reducing the confinement thus limiting the capacity of pressure to build up. These events results in an explosion known as " confined vented explosion". Secondly, significant overpressures are still generated where the flame speed is hastened by the combustion process in environments where inflammable mixture is not confined. In such a case, the inertia of the surrounding environment creates sufficient restriction to the explosion process that generates overpressures. In general, the faster the flame travels, the higher is the overpressures generated. Explosions under these conditions are known as " vapour cloud explosions" and are known occur in areas where a large flammable cloud engulfs an area such as a chemical plant (Chamberlain, 2002). On offshore platforms, blast pressures are usually generated by a combination of the two mechanisms described above. As the flammable volumes of released fuels from a point ignition source ignite and burn, the produced flames interacts with the plant and pipework as well as with the boundaries of the module. Offshore fire incidences can range from a minor fire to a major gas rise rupture. The outcome of these scenarios is either a pool of fire or a jet fire that are both preceded by a number of transcend events such as fireballs and/or flash fires. Compared to pool fires, jet fires reach full intensity instantaneousness and can be turned off very swiftly. These characteristics are important when designing control and isolation strategies (Chamberlain, 2002). A pool fire is a turbulent diffusion fire burning above a pool of vaporizing hydrocarbon fuel where the fuel vapour has negligible initial momentum. The continuous handling of heavy

<https://assignbuster.com/fires-and-explosions-on-offshore-platforms-environmental-sciences-essay/>

hydrocarbons onboard increases the probability of occurrence of pool fires on offshore platforms. Liquid fuels accidentally released during the process of overfilling storage tanks in addition to the rupture of tanks and pipes etc. usually forms a fuel pool on the surface of the vessel. The formed fuel pool consequently vaporizes and upon ignition, results into a pool fire. A pool fire is modelled as a sheared elliptical cylinder using a solid frame approach (Chamberlain, 2002). The modeled pool fire is assumed to radiate in two layers; a high emissive power, clean burning zone at the base above which there is a smoky obscured layer as illustrated below: Fig. 1: Flame geometry for a tilted pool fire (Chamberlain, 2002, p. 68). A jet fire is a turbulent diffusion flame resulting from the combustion of a fuel continuously released with some significant momentum in a particular direction. A jet fire represents an important element of risk that is associated with major incidences on offshore platforms. Fuels for jet fires range from light flammable gases to two-phase crude oil releases. Comparing vertical and horizontal jet fires, the former is the most dangerous granted the high probability of impingement on objects downwind. This usually leads to failures to the structure, storage vessel and pipework thus causing further escalation of the event normally referred to as the domino effect. The heat fluxes released from jet fires are very high and range from 200 – 400 kW/m² depending on the type of fuel. Almost all the fuels handled offshore have an inherent capacity to generate jet fires as long as the release occurs in conditions under which the fluid has some initial momentum such as a leak from a pressurized gas line (Chamberlain, 2002). A horizontal jet fire is modelled as the truncated frustum of a cone; emitting thermal radiation from its surface as shown below: Fig. 2: Flame geometry for a horizontal jet fire

<https://assignbuster.com/fires-and-explosions-on-offshore-platforms-environmental-sciences-essay/>

(Chamberlain, 2002, p. 69). For horizontal releases, the buoyancy of the flame dominates over wind momentum thus causing the flame to rise above the horizontal plane. Because objects in the direction of the release receive radiation from emitting paths roughly equal to the flame length (which is much larger than the flame width), a different surface emissive power is assigned to the ends of the solid flame from the SEP used for the sides of the flame (Chamberlain, 2002). A fireball is a rapid turbulent combustion of fuel, usually in the form of a rising and expanding radiant ball of flame. When a fire such as a pool or jet fire impinges on a vessel containing pressure-liquefied gas, the pressure in the vessel rises and the vessel wall weakens. This can eventually lead to catastrophic failure of the vessel with the release of the entire inventory. This phenomenon is known as a boiling liquid expanding vapour explosion (BLEVE). In such releases, the liquefied gas released to the atmosphere flashes due to the sudden pressure drop. If the released material is flammable, it will ignite; in addition to missile and blast hazards, there is thus a thermal radiation hazard from the fireball produced. It is this thermal radiation that dominates in the near field. Although the duration of the heat pulse from a fireball is typically of the order of 10-20 s, the damage potential is high due to the fireball's massive surface emissive power. Due to the high turbulence involved, a fireball can also be expected to cause significant overpressures (Wighus, 1994). A flash fire is a transient fire resulting from the ignition of a gas or vapour cloud, where a delay between the release of flammable material and subsequent ignition has allowed a cloud of flammable material to build up and spread out from its release point. A flash fire is usually characterized by a " wall of flame"

progressing out from the point of ignition at a moderate velocity until the
<https://assignbuster.com/fires-and-explosions-on-offshore-platforms-environmental-sciences-essay/>

entire flammable cloud has burned. Similar to fireballs, flash fires can occur either by ignition of a flammable vapour cloud formed from an instantaneous release, or by delayed ignition of a cloud from a continuous release, provided the turbulence in the cloud is low enough that a fireball does not occur. The instantaneous or continuous releases considered in risk studies would physically correspond to a spreading transient puff or a long steady-state plume (Wighus, 1994). When the cloud ignites, the initial damage will be caused primarily by thermal radiation. However, flash fires may generate more damaging " knock-on" events, especially if they burn back to the source. The knock-on events can be a pool fire, jet fire, BLEVE etc. Further, the presence of obstacles along the pathway and the high degree of congestion on offshore platforms can lead to significant flame acceleration. Such increases in flame speed can in turn lead to significant overpressures and ultimately a partially confined or confined vapour cloud explosion. The effects of these escalation events are likely to be more severe than the flash fire itself (Wighus, 1994).

Causes of Fires and Explosions on Offshore Platforms

Offshore Platforms are operated either by fuel or by electricity; all of which may present inherent danger of a fire hazard. Various scenarios are known to cause fire and /or explosion on offshore platforms such as oil rig, jack-up rig, barge, tanker and other marine vessels. A study by the UK Health and Safety Executive has shown that structural and process failure accounts for approximately 80% of the fire and explosion risks. An evaluation of incidents such as the Piper Alpha in the North Sea and the P-36 off Brazil has revealed that most offshore incidents are process-related (Mansfield, Poulter and

Kletz, 1996). Another important cause of fire and explosion on offshore platforms is blind operations whereby equipment operators have no clue of the actual situation they are operating. Information clarity is very crucial in understanding the situations in which we sometimes find ourselves in. When faced with unexpected occurrences, we are usually susceptible to the natural tendency of interpreting events based on our personal experiences and opinions rather than on known evidence. We therefore possess mindsets that are very difficult to shift and these mindsets are sometimes influenced by stressors. Based on this thinking, personnel operating offshore platforms find themselves in situations that are beyond their control. Due to human weakness and pressure, they end up making that little mistake which results into a major catastrophe (Chamberlain, 2002). Nevertheless, the absence of an inspection and maintenance procedures results into fire and explosion on offshore platforms. The Health and Safety Executive (HSE) has set safety standards that govern the operations of both onshore and offshore facilities. It is the responsibility of the management of these facilities to incorporate HSE regulations in their operations. Unfortunately, personnel on duty fail to correctly carry out or even completely fail to carry out inspection and maintenance procedures hence compromising the integrity of the facilities. It is in situations when the integrity of facilities is compromised that accidents occur unnoticed (Chamberlain, 2002). Moreover, the personnel on duty may lack the adequate knowledge and/or training to operate within confined conditions. There are circumstances where personnel may fail to recognise the exposures within their work environments. For instance, an employee on duty may fail to recognise the presence of leaking gases or fuels as a result of his/her lack of awareness of the tests used to detect such leakages. In this <https://assignbuster.com/fires-and-explosions-on-offshore-platforms-environmental-sciences-essay/>

situation, such an employee fails to take remedial measures to correct the defect hence resulting in a fire incidence. In other cases, personnel are sometimes complacent to learn from past events especially near misses. It is said that nothing is new in safety; whatever happens has happened before. It is therefore vital to take note of previous incidences in order to remain informed on current occurrences (Chamberlain, 2002). Another critical issue is the lack of what is commonly referred to as HAZID (i. e. HAZard IDentification) resulting into scenarios where; there is no formal hazard identification, compromising a safe design, invalidating a safe design and mass production of an output before understanding product behaviour in different situations. Most offshore platforms are found to lack specified hazard assessment procedures through which possible hazards and risks are identified and their effects mitigated. There is a tendency to put in place such risk assessment measures after an accident. This practice is retrospective and achieves nothing in the long-run (Chamberlain, 2002). A build up of hazardous flammable or explosive mixture occurs following an accidental release of gas from offshore platforms. Early detection systems play a crucial role in mitigating risks arising from gas releases. Although gas detection systems in hazardous areas are required to detect all anticipated releases, there are instances where gases reach areas like HVAC inlets without prior detection by the normal detecting systems. Such instances may include large leakages or adverse weather conditions. A research by HSE has revealed that detection systems fail to detect leakages when an HVAC inlet consumes a non-uniform gas distribution. The consumed flammable gas could then penetrate into safe or hazardous areas without detection (HSE, 1996). An explosion hazard occurs from spray releases that

<https://assignbuster.com/fires-and-explosions-on-offshore-platforms-environmental-sciences-essay/>

are caused by atomisation on release of fluids under pressure, re-condensation after release of liquids and impingement of released fluids on nearby equipment. Incidents reported at Flixborough and specifically Buncefield have been linked to such releases. At modest pressures, clouds of small particles e. g. Flammable sprays, aerosols and mists are generated. These particles boil above ambient temperatures and potentially form highly explosive mists. Examples of these particles are found in FPSO pump rooms, well-bergs as well as degassed liquid compression trains notwithstanding any contribution from dissolved gases or light fractions (HSE, 1996).

Fire and Explosion Hazards in Offshore Platforms

There are a number of installations and processes found in offshore platforms that poses a significant risk to ignition of fires and explosions. To begin with, offshore facilities often employ the use of Fibre Reinforced Plastic (FRP) deck gratings based on their apparent advantages compared to steel gratings. In addition to this, FRP gratings are also light-weight, resistant to fire and show improved resistance to environmental exposures. Concerns have however arisen over the exposure of FRP gratings to hydrocarbon pool fires. On the current trajectory, FRP deck gratings are certified based on the US Coast Guard Standards, PFM 2-98 and NVIC 9-97-CH-1. These standards put into consideration combined load tests and a 60-minute fire exposure to a test furnace. The test furnace mimics cellulosic heat profile instead of hydrocarbon fire (HSE, 1996). Cellulosic fires typically have slow development times attaining a temperature of 8800C after 60 minutes compared to hydrocarbons fires that reach a temperature of 11000C in significantly minimal time. Within shorter impingement times, hydrocarbon

jet fires have the capacity to produce significantly high temperatures. Based on these figures, tests have established that some types of glass reinforced FRP deck gratings embedded in either Isophthalic resin or phenolic resin tend to lose their load-bearing capabilities or even fail when exposed to hydrocarbon pool fires. These tests have therefore indicated that a shorter fire duration is required to cause failure or even weakening of FRP deck gratings as compared to the cellulosic fires that were used to certify FRP composite materials. Additionally, tests have also revealed that FRP gratings are not strong enough to support pressure exerted by persons walking or running over them (HSE, 1996). Secondly, offshore gas turbine enclosures are typically fitted with gas detection. However, a significant number of such enclosures are devoid of equipment that detects leakage of flammable liquids. The significant numbers of undetected leaks that consequently ignites into fire incidents points towards poor standards of liquid leak detection within turbine enclosures. The integrity of turbine enclosures is currently able to contain fires or explosions. Conversely, the probability of these enclosures to fail increases significantly as offshore platforms including their equipment degrades with age. It is obvious that an apparent delay in detecting oil mists results into fire outbreaks. An explosion occurring within a turbine enclosure certainly results in the loss of the turbine's integrity hence its fire barrier capability. The loss of enclosure integrity subsequently results in platform threatening escalation (HSE, 1996). Gas turbines are enclosed in sheathes within large areas of hot surfaces. Most of these turbines are dual fuel operating on diesel at least most of the time. Unfortunately, diesel and lubricating oils have significantly lower auto ignition temperatures (AIT) compared to gas. Combining this characteristic with the large hot areas

<https://assignbuster.com/fires-and-explosions-on-offshore-platforms-environmental-sciences-essay/>

within the turbine exposure presents a very high-risk scenario. Diesel and lube oils have an AIT of 2400C while methane has an AIT of 5300C. These temperatures are compared to the external surface of a combustion chamber that can reach 200-4000C. At these temperatures, diesel or lube oils will certainly cause ignition if they come in contact with external hot surfaces (HSE, 1996). The tumble dryer fins found in laundry rooms; though relatively safe appliances, their main danger are fire. Since 2005, three fire incidents reported to HSE are attributed to tumble dryers. Investigations from recent fires have pointed towards an insufficient 'cooling cycle' involving a number of cloths probably contaminated with combustible materials. A series of factors either in isolation or in combination may result in tumble dryer fires. These are: Reduced airflow in the dryer: this results from a build up of lint in the filters/traps but also as a result of poor venting arrangements. This results into overheating by considerably slowing down the drying action. Insufficient cooling cycles: this reduces the temperature of items in the dryer resulting in higher temperatures of the drying items and longer periods for the heat to dissipate from the items. Inappropriate items: such fabrics are normally contaminated with combustible substances such as grease, fats and oils. These contaminated fabrics ignite spontaneously when exposed to higher temperatures generated within the tumble dryer (HSE, 1996). The fourth hazard is HVAC Dampers that are designed to close when responding to a number of initiating conditions for instance confined smoke or gas ingress. Recent inspection conducted by HSE has identified shortcomings in both the testing and inspection regimes of HVAC dampers. These shortcomings have resulted in the inability of the dampers to perform correctly their specified functions. Common deficiencies found include:

<https://assignbuster.com/fires-and-explosions-on-offshore-platforms-environmental-sciences-essay/>

Following an electrical or pneumatic problems, dampers fail to fully close as demanded Failure to close on demand as a result of stuck or badly adjusted linkages The use of remote indicator lights as a sole evidence of successful closure Remote indicators that are not fall-safe e. g. lights go on only when the damper is fully open Failure to carry out full HVAC system test i. e. Dampers is selected and closed individually (HSE, 1996).

Control Measures

An offshore development can never be completely safe, but the degree of inherent safety is increased by selecting the optimum design in terms of the installation/field configuration, layout, and operation. This is done in an attempt to reduce the risk to a level that is As Low As Reasonably Practicable (ALARP) without resorting to costly protective systems. This requires the identification and assessment of major risk contributors, which could be accomplished using Quantitative Risk Assessment (QRA) techniques early in the project life cycle. If a structured approach of identification and assessment is not carried out early in the project, it is possible that the engineering judgment approach will fail to identify all of the major risks, and that loss prevention expenditures will be targeted in areas where there is little benefit. This may result in expensive remedial actions later during the life of the project (HSE, 1996). Owners and operators of offshore platforms must ensure that appropriate systems are put in place for the maintenance, inspection and utilisation of tumble dryers in laundry rooms. Additionally, there is need to identify whether composites are used in areas where they can be exposed to hydrocarbon fuels. Consultation with manufactures and /or suppliers in relation to the duration of time that the integrity of

installations will remain intact for safe use is also very important. To cap it all, managers and operators within offshore facilities must make safety a priority. The HSE has put forth various Occupational Health and Safety regulations which offshore facilities must strive to incorporate in their operations. This will create a safe environment for employees and authorized people visiting the facilities (HSE, 1996).

Conclusion

An offshore platform is typically a complex and expensive engineering structure consisting of numerous systems and is normally unique in terms of design and operational characteristics. Given these complexities, offshore platforms must constantly adopt new approaches, new technologies, and new hazardous cargoes and so on. Each element in this complex system brings forth new hazards in different forms that need mitigation measures. Safety assessments should therefore cover all the possible areas of eminent danger including those where it is quite hard to apply traditional assessment procedures. The lack of reliable safety data coupled with the lack of confidence in safety assessment are the major pitfalls in safety analysis of various engineering activities. To solve such pitfalls, further development is required to that will aid in the development of both a novel and flexible safety assessment techniques. The developed techniques will go a long way in dealing with the uncertainty in a proper manner as well as use decision-making technology on a routine basis. Applications of different approaches are also required at different levels of uncertainty and this will ensure the integrity of offshore platforms.