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Case Study of Engineering Ethics toward Natural Gas Pipeline Leaking: An Analysis through Solving Technique

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Abstract

This paper focuses on the case study of engineering ethics for Gas Pipeline Explosion at Ghislenghien, Belgium. The tragedy happened on 30th of July, 2004 and investigation was conducted to find the root cause. However, the question is remains unsolved. Investigators and experts listed few reasons that may affecting the gas pipeline including safety regulations not being observed due to deadline given is too short, soil erosion and used of mechanical diggers within one meter of the gas pipe. Rescue operation was initiated immediate after the gas explosion. This tragedy causes 24 dead including 5 fire fighters and indicated an amount of 100 million euros lost and lead to multiple reformation. Therefore, a case study of engineering ethics has been done and the analysis has been made in terms of ethical framework and ethical theories respectively. The recommendation of this study is hoped to help the engineers in order to reduce the numbers of accident in their work place.

Keywords: Case study, engineering ethics, ethical framework, ethical theory.

I. 1 INTRODUCTION

This accident happened on July 30, 2004 at Ghislenghien industrial park, near Ath, about 50km south –west of Brussels, Belgium. The trunk gas pipelines at Ghislenghien, Belgium are operated by Fluxys. The structure involved in this accident is an underground pipeline buried 1.10m below the ground surface. Port city of Zeebrugge and France is connected by this gas pipelines to transport high calorific value gas. Two gas pipes were operating at a distance of 7m at the accident sites, one

was built in 1982 and had a diameter of 0.9m, while another (which broke and ignited) was installed in 1991 and had a diameter of 1m. Natural gas flowed at a pressure of 80bar and the steel tubes were 13mm thick[1].

The majority of the network, including the pipeline that exploded, carries "high calorific value" gas, while the second pipeline was not affected by the explosion carries "low caloric value gas".

II. 2THE ACCIDENT

Around 8.15am, fire fighters notified about a "gas leak" in a zone of the Belgian city of Ghislenghien. This leak was evidenced by a loud hissing sound. There are sudden change and tremor in the cavity of ground.

At 8.30am, fire fighters ask for the assistance of the gas utility crew to set up a safety perimeter. However, the leak increases it intensity and forming a whitish sprat shooting about fifteen meters high.

At about 9.00am, an explosion had occurred. The gas cloud ignites and producing a large "fireball" that later transformed into a long flare whole height is approximately at 150m-200m. The temperature in the middle of the fireball is around $3000\,°$. 2 minutes later, the pipe segment between the two sectional valves is successfully isolated to prevent excessive gas leak.

A packaging company occupying $3000\,m^2$ of space and located roughly 60 meters away also caught fire. A number of individuals including fire fighters, officers and workers were thrown tens of meters. The rooftop of building within the area liquefied and tens vehicles caught fire. The long flares keep burning for about 20 minutes. The flame is gradually extinguished after the gas supply had been taken off.

The vibration and the impact on the ground lasting more than 10 minutes was recorded and then propagated downstream of the pipe until a distance of 10kilimoeters from ground zero. These vibrations and impact make the closing of the pipe valves further complicated [1].

III. 3THE CONSEQUENCE AND CAUSES OF THE ACCIDENT

The consequences can be discussed into three categories. The categories are human consequences, property damage and economic consequences [2].

In human consequences, there are total numbers of 24 people dead from the incident. The dead is includes 5 fire fighters, 1 police officer and 5 employees are killed. There are 132 are injured. This tragedy was qualified as Belgium most serious industrial disaster in half a century. Citizens also suffering from moral and psychological damage, they felt risky to stay around that area which explosion may occur again due to the risk will always happened when managing the unknown.

In property damage, an industrial zone of 200m radius is totally destroyed. Besides, a large number of roof and car was damaged and many agricultural fields are burned.The lost caused by the accident is estimated 100 million euros which calculated in October 2004.

Figure. 1.200m radius from the pipeline is totally destroyed [2].

Investigation was conducted in order to find the root cause of the accident. However, the questions remain unanswered. Experts and investigator only found out the gas explosion is caused by pipe leaking. Hence, experts and investigators listed few reasons that cause the pipe leaking. The first cause of the tragedy is safety regulations are not being observed due to the deadlines given by the manager is too short. These lead to some firms on the site do not observe the danger zone designed to prevent heavy machinery being placed over the pipelines. As the heavy machinery placed above the pipelines, there are potential mechanical aggressions that may weakened the pipe wall. Besides, heavy rain and large machinery will cause soil erosion; this explained some pipes are not 1.1m beneath the surface [3].

In addition, the workers work is overload. Ten engineers are responsible for checking 3706km of pipelines. The engineers may not have sufficient time as the deadline given is too short. Therefore, some area is assumed to be safe and ignored by engineer in order to meet the deadline given. The ignored area is where the accident occurred. Furthermore, the workers of the company are not well train in dealing pipe leaking experience. As natural gas has no smell and coulerless, workers must learn the standard of procedure in order to identified pipe leaking and take action as soon as possible to prevent tragedy happened.

Figure. 2.Explosion happened due to pipe leaking [3].

IV. 4THE LESSON LEARNT AND ANALYSIS

Fluxys has reformation the standard of safety and regulation. The security has been tighten especially around construction sites since the explosion to make sure contractor obeying the standard of safety and regulations when construction. Besides, fire fighters union has called for stricter governmental regulations for monitoring gas pipelines. The fire fighters and worker from Fluxys must be trained on the knowledge to identify and method to handle gas leak.

Prediction of possible accident scenarios including other circumstances is analyzed to for the rupture and perforation of a pipeline section over several sensitive zones warrants a very detailed examination to accurately determine the type of difficulties capable of arising. These results enable implementing an effective strategy for handling pipelines valves at the time of an accident.

Moreover, the preventive measures instruments are installed. At the Ghislenghien site, the gas leak more than 45 minutes before igniting, this created a pressure surge. However, there are no automated shutoff mechanism had been triggered and no technician had been sent to the area. Hence, a preventive measures instruments must be installed to shutoff the valves in order to prevent continuous leaking. Besides, cathodic protection systems able to identify the zones of insufficient thickness constitute other technical components vital to structural safety.

In addition, the pipe shutdown system was complicated due to the onset of powerful vibrations propagating along the pipeline trajectory when the presence of a flare extending over 100m high subjected nearby installations to major thermal impacts. The pipe shutdown system must be as easy as possible in order to stop the leaking.

Working to inspect and maintain the gas leak is always a dangerous operation. A wide safety perimeter must be set up around the leak zone. In the event of large leaking. The first action taken must be operating cut-off and control devices located upstream and downstream of the zone so that the gas supply can be stopped and prevent explosion occur at the mainstream and downstream. Besides, both the explosibilty measurement and hot spot prevention steps need to be conducted with considerable attention to detail and precautions, given that a simple cell phone can trigger combustion.

The explosion of a major underground high pressure natural gas pipeline in Belgium was happened due to construction work. However, the causes of this engineering failure could not be investigated whether it is due to unwanted mistake or self-negligence. Therefore, this section focused on the recommendations for actions with analysis of the possible outcomes by taking consideration a pipe leakage problem. The exact cause of the pipe leak is still unclear. Early investigations indicated that the pipeline may have been damaged by of both possibilities and justification based on the ethical frameworks. In this work, the analysis of the case is based on the two code of ethics by Board of Engineer Malaysia, four ethical theories, one solving technique while follows by the knowledge of managing the unknown.

A. 4.1 Code of Ethics

Based on the BEM Code of Professional Conduct, the codes that could be applied in this case are as followed:

Code 1.0.: A Registered Engineer shall at all times hold paramount the safety, health and welfare of the public.

Code 2.0.: A Registered Engineer shall undertake assignments only he is qualified by education and experience in the specific technical fields in which he is involved.
In allowing such disaster happened, the engineers involved in this case have break the BEM code of ethics 1.0 and 2.0 which in turns causes the explosion and numerous loss of life and economic. To avoid such disaster, the engineers should only agree with the construction work (digging task) in pipeline zone if the construction work has fulfilled the requirements of the engineering design and specifications. The engineers should not allowed the used of mechanical diggers or potential mechanical aggression that might cause the leak of pipeline and consequently threaten the life of most people. Besides that, the engineers should only take the task if he has been undergone training and has sufficient experience in dealing with pipe leaking problem. In this case, the engineers should quickly cut off gas supply in the damaged section to prevent such disaster happened.

B. 4.2Ethical Theories

Utilitarianism.Utilitarianism holds that those actions are good that serve to maximize human well-being. The emphasis in utilitarianism is on what will provide the most benefit to the most people and tries to balance the needs of society with the needs of individual [5], [6], [7], [8]. Based on this case, the advantage of the built of underground natural gas pipeline is the natural gas could be transported to everywhere in French for household and industrial usage. In opposite, the built of underground natural gas pipeline would cause the environmental issues. The pipeline might be leak due to the material failure, soil erosion or mechanical aggression and cause the suffering of resident around that particular area. Therefore, engineers have responsibility to ensure that the construction work is conduct in the most environmentally safe manner possible so that to take care the most benefit of most people.

Virtue. Virtue ethics is interested in determining what kind of people we should be. Virtue is often defined as moral distinction and goodness [5]. Based on this case, the company must be more concerned of the maintenance and safety system in order to minimize the possible risk. Regular testing the positive safety system must always be performed and the design system must be easily manipulated by a technician in the event of an extreme emergency or failure of automated controls. Besides that, the government must play the roles of restricting the rules and regulations by forcing the company to conduct yearly maintenance and establishing an organization to conduct irregular spot checks at sites.

Right. Right ethics holds that people have fundamental right that others have duty to protect [5]. Working to repair a gas leak is always a dangerous operation. Therefore, the repair crews have their right to possess appropriate training and equipment from the company. A wide safety perimeter must be set up quickly around the leak zone and ensures the repair crews able to perform their action in the distance as far as possible to the leak. In addition, the residents have their right access to natural gas in order to use the natural gas in a more convenient way and in the most environmentally safe manner possible.

Duty. Duty ethics is defined as people have duties, an important one which is to protect the right of others. A safety system and emergency arrangements must be emphasizing so that to avoid the disaster happened again. It is compulsory to ensure that availability of adequately-trained rescuers, appropriate drilling and testing of emergency arrangements. The company must prepared a permit of work that identifying the roles and responsibilities of employees and the requirements for monitoring the pipeline so that the work of engineers is not overloaded which might divert attention away from safety. Besides that, the government has the duties in controlling the urbanization patterns and potential mechanical aggression in pipeline area. The route of facilities conveying hazardous substances within an urban or industrialized zone, along with the layout of cut-off and control devices might lead to a potential accident.

C. 4.3Solving Technique: Line Drawing

Problem: The early investigation indicated that the pipeline may have been damaged by construction work. The used of mechanical diggers within one meter of a gas pipe and the potential mechanical aggression that would weakened the pipe wall have been contributed to the leakage of pipeline.

Positive paradigm (PP): The construction work is done smoothly and the pipeline is in safe condition.

Negative paradigm (NP): The pipeline is leak.

The other hypothetical examples that can establish for consideration are as followed:

1. There is a legal construction work conducted within the pipeline zone, but it truly is safe and won't affect any damage of underground pipeline.
2. There is an illegal construction work conducted within the pipeline zone, the residents around there are complaint about that, but no action is taken by authorities.
3. Only the employees that have been undergone training and have sufficient related experiences are assigned with the construction work within pipeline zone so that to minimize the risk of the pipeline getting damage.
4. The equipment or tools that are designed specifically for the construction work around pipeline zone are used to ensure the underground pipeline is in safe condition.
5. The construction work should be carried out by following the rules and regulation set by authorities.

6. The construction work is only allowed to carry out within a distance far away from the underground pipeline that is set by authorities.
7. The used of large machinery beneath the surface can caused the damage of the underground pipeline.

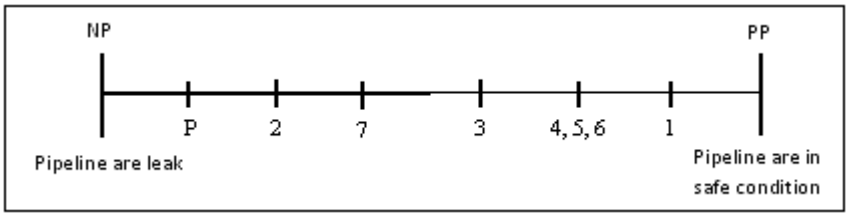

Figure.3. Line-drawing analysis.

As drawn here, it is clear that the construction work that was carried out in this case wasn't the best ethical choice.

D. 4.4Managing the Unknown

Before the tragedy had happened, the pipeline should have been inspected occasionally by maintenance engineer and upon noticing these leaking; they should conduct more testing and investigation to ensure the safety of the pipelines. As a registered engineer, they should always manage the unknown by diligently minimizing the risk since the leaking issue may lead to a huge disaster. Lastly, they should have train their workers to have a standard of safety procedure to deal with pipe leaking, as the gas leak from the pipeline, the worker unable to identify, time is wasted and causes this disaster [9].

5 CONCLUSION

The gas pipeline explosion occurred in Belgium was one of the biggest engineering failure incidents in the world. Following the explosion, possible causes and circumstances surrounding the accident had been investigated to avoid the repetition of such disaster. The safety must be placed in the main priority in the construction of pipeline system. It is necessary to include emergency system such as automated shutoff mechanism so that to minimize the possible risk. With so many uncertainties and issues at hand, the government should take pro-active steps to regulate the construction industry. In this study, it is hoped to help the engineers to predict the right way in practicing the engineering in the work place.

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