

An Evolution of Risk Assessment Tools in Petrol Station: A Review

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ABSTRACT---- Risk assessment was introduced as a vital tool in decision making to quantify risk in many industries in the world since early 1930s due to disaster or catastrophic accidents that occurred in those days including in World War II. However, the risk methodology has undergone an evolution every day. In the 21st century, the complexity and uncertainty of accidents have become more prominent and repetitive, so the need for research on the complexity and uncertainty of accidents must be closely monitored and studied to identify the root cause of the accident to minimize the magnitude of the risk. There are many researchers on risk assessment on major installations such as chemical plants, nuclear plants, transportation and major hazard installations, but fewer on non-major hazard installations. Early methodology of Probabilistic Safety Assessment (PSA) was introduced to nuclear plants due to the criticality of the plant which involved high chemical substances like uranium. PSA has been manipulated and modified in the chemical industry by adopting Reactor Safety Analysis (RSA) which is actually using the element in the PSA. In the 1980s, the industry adjusted and introduced more integrated methodologies of Risk Management involving three parts: 1. Hazard Identification; 2. Risk Assessment; 3. Risk Mitigation. However, there is no specific methodology that has been used and introduced in non-major hazard installations such as petrol stations because the chemical substances in the station are below the threshold limit according to requirements. Thus, the evolution of risk assessment in the chemical industry must be evaluated and the effectiveness of the methodology in various industries. In this review, the potential to simplify risk assessment for petrol stations, which are categorized as non-major hazards, will be classified as the best model of risk assessment and discussed.

Keywords--- Hazard Identification, Risk Assessment, Risk Mitigation, Petrol Station.

1. INTRODUCTION

Disaster or calamity always refers to the high toll of death in humans such as severe accidents in Bhopal, India, Chernobyl, Russia, Mexico City, Santos, South Brazil and Sungai Buloh, Malaysia (Papazoglou, 1984 & Ibrahim, 2002). The issue of risk disaster is basically related to the consequences of the incident, especially in industry (Zio & Aven, 2013). Meanwhile, in nuclear risk, the earlier indicator category has a major accident, for instance in the case of Fukushima disaster (Aoki & Rothwell, 2013). So, the requirement to study the risk assessment fundamental and evolution of the method must be done parallel with the evolving of industry in the world.

Risk assessment is stated as an overall process of estimating the magnitude of risk and deciding whether or not the risk is tolerable (OHSAS 18001:1999, ISO 14001:1994 dan HSE :2000). Those codes and standards refer to the foundation of risk assessment is a subset of a risk management model which consists of: 1 Hazard identification; 2 Risk Assessment; 3 Risk Control. Risk management is very subjective and can be improved from time to time. The process is a circular process in a one loop. The steps may vary from one researcher to another. Williams and Heins, (1989) introduced 6 steps. In contrast Franks P.J et al, (1995) contains only five steps and (Prichett et al, 1996) 8 steps in the process of suggested to refine risk management paradigm. Thus the risk management framework/model may vary from one

organization to the other because it depends on the goal and target of the organization to achieve, process of the organization also gives a huge influence in determining the model of the risk management

Nowadays, over the 40 years of risk assessment has been used frequently in decision making, and main three industry that involving in is nuclear power plant, space flight, chemical and petroleum process (Garrick & Christie, 2002). Meanwhile, those industries have been evolved for the selective of adopting a risk assessment methods, including heavy industry (A. Bernatik, M. Libisova, 2004), chemical industry such process industry (F. Aqlan, E. Mustafa Ali, 2014), oil and gas industry mainly offshore (S. Andersen, B. Mostue; 2012) and construction industry (A. Pinto, 2014). However, fewer researchers discussed on the vital of using the method or procedure to carry out the risk assessments.

According to (Aven & Krohn, 2014) to justified the method of risk assessment and knowing that it is dependable on the individual characteristic of industry. A risk always regards as an uncertainty which need to quantify by using 2 methods such as the traditional probabilistic reactor safety (PRA) and quantitative risk assessment. However (Apostolakis, 2004) find out that QRA must be given priority in decision making, as the due to the uncertainty of the risk. The probabilistic approach is the earlier approach been introduced for safety analysis (L. Zhang, M. Skibniewski, X. Wu et al, 2014) on the safety risk analysis in metro construction, even though new methods of quantitative risk assessment has been introduced a few years after that. The introduction of Quantitative risk assessment has been introduced widely by the earlier researcher (Papazoglu, et al, 1992, HSE, 1989) whereby this evolving new method and procedural using QRA in risk assessment (Aneziris, Papazoglu, Kostantinidou et al, 2014)

Furthermore, risk assessment has been used rigorously worldwide in estimating of risk chemical storage regards to flammable and toxicity. Those substance include ammonia, fuels and PLG, as discuss by CCPS (2000), ISO 17776 (2000), Papazoglu, Aneziris, Bonanos, and Christou, 1996, Papazoglou, et al, 2000, Papazoglou, I. A., 1992). Those researchers focus study mainly on the chemical plant. However, researchers O. N., Aneziris et al, 2014, Yun, Rogers, and Mannan, 2009, Landucci, et al., 2012 and Tugnoli, et al., 2012) discussed prolong into the risk assessment on the severity effect on LNG installation which is midstream and downstream of petroleum industry. Meanwhile, researcher studied on the risk assessment on transportation of chemicals (CCPS, 1995). Mostly of the risk engulfing in the area of major hazard installation whereby the substance store more than its threshold limit considered as major hazard installation (Occupational Safety & Health, 1994).

Fewer researchers focusing on downstream of petroleum industry such as petrol station. Petrol Station consider as a hazardous and risk area not just onsite but also offsite by (Marta Sigut, S. Alayan, E. Hernandez, 2014, Srivastara, Joseph, More et al, 2015, Walmsley, 2012 and Fabien Cornilier, F. Boctor, J. Renaud, 2012). Mostly of the risk assessment focusing on the risk of the chemical exposure such as Volatile Organic Compound (VOC) which cause death to the humans and environment by (N. Udonwa, E. Uko, B. Ikpeme et al, 2009, S. Bindhya, V. Balachandar, S. Sudha et al, 2010) and S. Singaraju, S. Wanjuri, M. Singaraju et al, 2012). Beside that there is also some pose of hazard due to the leakage of the fuel which effect to the environment (J. Oh, C. Nam, 2014).

Therefore, a new paradigm of research should focusing mainly in downstream of petroleum industry such as petrol station need to be further study and clarify on the severity and impact of fire to humans and environments engulfing the petrol station even though its not consider as major hazard installation under legislation (CIMA 1996; Occupational Safety And Health, 1994). This review paper highlights the best and practicable method of risk assessment of fire explosion at petrol station evolving last 4 decades. Base on this noteworthy research will give a vividly understanding of phenomenology of fire explosion vicinity of petrol station.

2. CHARACTERISTIC OF RISK ASSESSMENT

Risk assessment contains 2 main pillars; 1. Qualitative method which involve of quantify the level of risk in the factor of safety purpose. Such tools are Failure Mode and effect analysis (FMEA), HAZOP and so on. 2. Quantitative method is a process of calculating frequency of accident Such tools are Dow indices, Fault Tree Analysis (FTA) and so on. (Papazoglou, et al 1992).

This QRA is the essential of risk assessment for generic process, so individual risk assessment will depend on the hazards, phenomenon of the physical installation, differ substance engulf.

3. APPLICATION OF RISK ASSESSMENT ON PETROL

Risk assessments basically involve of flammable substances that store in the petrol station such as hazardous chemical typically at petrol station are liquid gas, unleaded petrol, premium unleaded petrol and diesel. Those are category of flammable gas Category (1), (2), (2), (2) dan (4) respectively (HSE, 2000a, Ahmed, Kutty, Shariff, & Khamidi, 2011).

Hazardous substance in the petrol station could be hazardous chemical due to public awareness, the characteristic of petrol is flammable liquid spill while refuelling (Cornillier, Boctor, & Renaud, 2012a), instantaneous release of substance of LPG filling operations, possibility of leaks and spill during tank filling process by a road tanker, explosion hazard when storing and handling and ignition source pose significant risk while fuel dispensing and transferring process. (Zhu, 2014).

4. METHODS IN DECISION MAKING IN THE INDUSTRY (PETROL STATION)

Table 1, showed a recent study have been carried out on the risk assessment in the petrol station whereby showed a significant on the researched. The methodology used in quantify risk engulfing the petrol station.

Mostly studies were conducted on the new framework of risk assessment, monitoring on the realtime of contamination and exposure which could harm to surrounding area, replenishment case study in quantify earlier detection before become disaster. However fewer researcher done one the consequence of the store substance could pose hazard not just onsite but offsite.

Table 1 : List of methods in researched in petrol station.

Year	Summary/ methods	Result/Finding
2007	Remote real-time monitoring and control of contamination in underground storage tank systems of petrol products.	system can diagnose the leakage and start remediation by a specific soil venting process. (Sicile, 2007)
2007	modeling system : COPERT and CALINE4	a consequence, the population living in the vicinity (of the examined urban location) is exposed to an additive concentration ranging from 3 to 6 mgm ³ , increasing the leukemia risk caused by benzene alone from. (Karakitsios, Delis, Kassomenos, & Pilidis, 2007)
2007	Laboratory study case study on the bioremediation of diesel oil contaminated soil.	Bioremediation strategies enhanced the natural of bioremediation of the contaminated soil and treatment nutritional amendment. (Mariano., et al, 2007)
2008	Develop an algorithm for the petrol station replenishment.	Algorithm best usage to distributor to acquire a loading and routing optimization computerized module which has been integrated within their enterprise resource planning system (Cornillier, Boctor, & Renaud, 2008)
2010	Investigation and experimental on One-hundred-and-five Radiello; passive samplers (RAD130. Cartridge Adsorbent and RAD120 Diffusive Bodie, Sigma Aldrich, Inc., St. Louis, Missouri (US)) were used to measure VOCs in the urban are.	the spatial influence of petrol stations on their surroundings based on the fact that the concentration ratio of n-hexane and benzene found in the air of the petrol stations is different from that found in city air (mainly determined by motor vehicle exhaust). (Morales Terrés, Miñarro, Ferradas, Caracena, & Rico, 2010)
2011	develops safety and risk assessment framework by using actual field data related to hazard contributing factors at PFS.	Top most hazard contributing use recorded was carelessness. Risk calculated due to carelessness at PFS is 49.28%. 2nd most significant factor was slips, tips & falls. It achieves risk value of 28.70. 3rd top most risk oriented contributor was miscellaneous cases. (Ahmed et al., 2011)
2014	Investigate and experimental if pressures and flow rates occurring in road- tanker petrol-station systems during the delivery of petrol.	gas displacement pipe will be discharged to the atmosphere when the storage-tank system is opened in order to connect the hoses. extent depends on the flow resistances in the gas displacement system and the resulting excess pressure in the venting system. (Frobese, 1998)

5. OTHERS APPLICATION

5.1 Replenishment of fuel at petrol station

Petrol station basically been constructed with the installation of 2 , 3 or 4 underground storage tank (UL 58 & UL 1746) and the construction of the underground storage must follow the code of construction and legislation(ASME, 2010). However the hazard of the petrol station is while doing the replenishment(Boctor, Renaud, & Cornillier, 2011), (Cornillier et al., 2012)of fuel from the tanker to the underground tank which regards to the leakage(Sacile, 2007) spill and fire.The spillage could cause effect to environment((Rosales, Martínez-Pagán, Faz, & Bech, 2014). In addition (Mariano., et al,2007) laboratory experiment on the soil where the leakage of the diesel from under ground tank could cause a toxicity and pollutants.

Beside that an improvement of the transportation of replenishment process is vital in the multiple period of replenishment and short time window(Boctor et al., 2011). Both give a goods method of enhancing the transportation and replenishment process in petrol station.

5.2 Bussiness unit & Services(Café of Internet/restaurant) in Petrol Station

Petrol station also conctructed with the café of business unit to sell snak foods, oils, and other stuffs while people refuelling their tank. The research found out this unit is best practice in rural area whereby resident could connectec to wolrd out side(Lægran, 2002). In other hand research of the sociological of people interaction in restaurant (D. Norman, 2006) and supermarket as an alternative to local food suppliers (Stefan Neumeier, 2015)indicated a significant of the construted unit business in people gathering and minggle around with the community surrounding.

In other hand, petrol station service also been done to see the dimension of quality of the service provide towards customer(Lehtinen, & Lehtinen, 1991).

5.3 Rainwater reservoir in Petrol Station

Petrol station also coul de a place of getting the water reveoir cause of the such structure of petrol staion in collection rainwater which could be use as daily used(Ghisi, Tavares, & Rocha, 2009).

5.4 Chemical Exposure in Petrol Station

Petrol frequently related to research which Volotice organic Compound(VOCs) and release of chemical substance to atmphoere could harm not just to humans but also to environment. (Majumdar (neé Som), Dutta, Mukherjee, & Sen, 2008) and health risk assesment (Kitwattanavong, Prueksasit, Morknoy, Tunsaringkarn, & Siritwong, 2013) has b, T.,een done to to workers at petrol station which harm to human. Otherwise its vapour exposure cause of cytogenic risk especially benzene, toulene(Bindhya et al., 2010)(Singaraju, Wanjari, Singaraju, & Parwani, 2012)among the workers.According to (Jakobsson, R., et al, 1993)attendants in petrol station have a tendency of getting acute myeloid leukemic(AML) which is a prolong to health risk. Meanwhile,(Celik, A., Cavas. T., & Ergene-Gozukara, S.,2003) researched on the effect of the chemical exposure which could effected of mutagenesis for exposure of attendsnts to fuel.

Furthermore, exposure of chemical such as bezene in petrol, by using sample in urine due to attendants(Weng H.H., et al , 2007). Basically all the researchers focusing on the chemical exposure that caused severity effect not just to worker at petrol station but people surrounding the petrol station such as residents, passerby and enviromnet.

5.5 Hazard fuel in Petrol Station

Petrol station is the hazardous are whereby containoit of chemical of unleaded fuel, diesel and natural gas(Works Health and Safety Act 2012). According to guideline the hazard may pose a risk factor with the existing of the triangle of fire such as 1.ignition 2.oxygen and heat. Therefore, study of risk pose must be to be look into.

5.6 Fuel leakage

Actually, quite a number of researchers investigated on the possibility of fuel leakage which could effect to the environment particulary heavy substance sugc as diesel Mariano.A.P.et al,2007b), release of instanatous gas(Schjolberg,

I., & Ostadahl, A. B., 2008) from the hydrogen station also could harm to humans. Therefore, an analysis of the leakage of VOCs continuously monitoring for 26C and C8 hydrocarbon site to seek the existing of benzene(Derwent et al, 2000). Diesel is among the heavy substances compare to unleaded fuel, leaded fuel and premium. Leakage of diesel to soil will pollute the water environment.

5.7 Type of Fire in Petrol Station

Furthermore, fire is a hazard which could do harm to peoples, damage to property and environments. The electrostatic charge due to plastic pipeline(Walmesly , 2000) sometimes could trigger fire. Meanwhile, fire cum with explosion in LNG storage tank where store a very large quantity of amount of LNG, its an instantaneous release could cause disaster((Dan, Jun, Park, Shin, & Sup, 2014). Jet fire and explosion researched (Zhiyong, Xiangmin, & Jianxin, 2010) from the release of gas hydrogen at gas station will immediately transform to jet fire. However, Boiling Liquid Expanded Vapour Explosion(BLEVE)in the storage in chemical process industry(major hazard industry)(Abbasi & Abbasi, 2007) but rare research on petrol station. In a case of pool fire on the wagon storage tank could occurred(Lautkaski, 2009).

However, rare research done on the consequence analysis of fire hazard specifically in the petrol station as previous researched more keen on the VOCs and Chemical exposure to people onsite and offsite. The consequences risk analysis on chemical process industry is widely used((Han & Weng, 2011, van der Voort et al., 2007 & Di Domenico et al, 2014) this research discuss on the model and effect. But there is a gap on the consequences and severity effect of fire to surrounding area vicinity of petrol station.

6. CONCLUSION

By referring to the previous and latest research on the evolution of risk management ;which focusing in the risk assessment from in the early 1930s until today. The information been gathered and analysis the methods, experiments, observation of case study especially engulf to petrol station.

This paper generally discussed on the terminology of risk management, explanation of risk itself and the range of risk tools has been introduced in the chemical industry (major hazard installations).

According to the literature, the most researched been carried out on the health risk aspect of chemical exposure such as benzene, toluene and other toxic chemical substance to the pump attendants as well as people living surrounding area. Beside that, few research on the community at the business unit such as internet café/restaurant adjacent to petrol station, transportation hazards and fuel leakage.

The new approach of severity effect to the people onsite and offsite vicinity petrol station due to the fire hazards need an immediate attention and care. In addition, fire explosion cases which cause death engulf the aging petrol station become a repetitive incidents. However, until today only severity of chemical exposure as been discussed quite a lot by the previous researchers.

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