Journal of Engineering and Applied Sciences 12 (9): 2347-2351, 2017
ISSN: 1816-949X

An Alternative Approach of Leakage Detection in Underground Storage Tank

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Abstract: Ageing of Underground Storage Tanks (USTs) have come with risks whereby failure due to loss of containment can potentially cause catastrophic damage to humans and environment. The failure due to the loss of containments such as fuel and gas may trigger a domino effect of fire. This study aims to introduce an alternative approach of risk assessment by adopting Risk Based Assessment (RBA), Structural Health Monitoring (SHM) and Area Location of Hazards Atmospheric (ALOHA) Loss of Containment (LOC) to assess the fitness of the underground storage tank for operational purposes and the possibility of the risk engulfing petrol station. The RBA is a process that involves in collecting all the primary and secondary data such as policy, technical and maintenance data. These data will be the input to the SHM. SHM is a process of using unique acoustic emission and guided wave gadget Long Range Ultra Thickness (LRUTG) in capturing the thickness of the wall of UST, type material, temperature, level of pressure of the material, stress and strain. Both data from RBA and SHM will be the input to the Area Location of Hazards Atmospheric (ALOHA) by adopting the consequences model such as Loss of Containment (LOC). This tool will simulate and predict the magnitude and severity effect of the fire risk to the on-set and off-set of the petrol station. The result of the combination and holistic of the above approach will provide a novel way of monitoring and supervising the underground storage tank's integrity and prediction of an early information of the fire risk at petrol station. This approach can be implement and replicate to other petrol stations.

Key words: Underground Storage Tank (UST), Risk Based Assessment (RBA), Structural Health Monitoring (SHM), area location of hazards atmospheric, loss of containment

INTRODUCTION

The rapid growth of emerging down stream petroleum industries such as petrol stations has become a huge challenge in managing hazards created of its operation and maintenance. This is supported by the advancement of technology in exploration, operation, drilling, pipelines, oil tankers and state the art of machinery in a collaboration between multi-government organizations of oil production under the Organisation of Petroleum Exporting Countries (OPEC) and Arab Organisation of Petroleum Exporting Countries (AOPEC) (Khan *et al*., 2002). On the other hand, Malaysia itself witnessed output gross retail sales of automotive fuel that contributed to about 4.812 mln. Malaysian Ringgits (7.2% out of the overall gross out in the retail sector). This represents the rapid growth of the industry, especially in petrol station operations and traders.

Due to the increasing demand of fuel there is always a tendency of creating a new hazard of fire. Cases of accidents involving petrol stations in Malaysia are quite low in number. In addition, based on previous statistics, a case of pool fire is very rare. A petrol station is not a major hazard facility when the threshold is <100,000 tonnes of substance. However, special intention should be taken into consideration from the early stage of design, construction, installation and maintenance of its components in order to maintain safety and security throughout the life cycle of the petrol station in terms of uncertainty and complexity of risk (Pekalski, 1997). Furthermore, a petrol station has it unique features and shape which consists of 3 study.

Dispensing area: Dispensers are located and covered by a steel or concrete canopy. Numbers of dispensers are depending to the individual petrol station.

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Underground tank: This area is visible because it contains underground tanks. The indicators are venting pipe, manhole and it is usually vacant area.

Service store: Usually nearby the dispenser area that contain small convenience store, storage office, coffee shop, restaurant or motel (Hassanain and Al-Mudhei, 2006).

Generally, the integrity of the petrol station and aging facilities such permanent structure of buildings, piping, underground storage tank are of concern, especially in aging USTs which need immediate action during the early stages of the design of the petrol station. Once the USTs buried underground no inspection or maintenance could be done. In Malaysia, the period of inspection of unfired pressure vessels was stipulated in the factory machinery Act 1976 and was set at a 15 months of fixed interval. However, USTs do not fall under the requirements of the pressure vessels. According to factory machinery Act 1976, pressure vessels under clause 3: "any enclosed vessel under a pressure vessel greater than atmospheric pressure by any gas or mixture or combination of gases and includes any vessel under pressure of steam external to the seam boiler and any vessel which is under pressure of a liquid or gas or both and any vessel subjected internally to a pressure less than atmospheric pressure" will need to abide to this requirement.

However, under the same act in the same clause: underground storage tanks do not need certification for fitness but they at least must be constructed following safe engineering. As such there are no specific laws, legislations or guidelines pertaining to the UST's risk especially in Malaysia. Furthermore, UST is considered as an open system since there is a venting pipe to the atmosphere hence UST is not under a pressure vessel's requirements. However, the integrity of the tank system remains unclear, especially if it has been operating for >15 years (10, 11). Since, USTs are buried underground, the lack of periodic inspection may cause accidents. Argument by Chang and Lin (2006), pointed out that about one third of these accidents are caused by lightning and 72% are caused by human errors such as equipment malfunction, defects on the shells, leak and rupture, static electricity, open flames, etc. Irony, prevailing data on the tank accidents reports 242 cases between 1960-2003, gathered from published reports (Persson and Lonnermark, 2004), books (CPC, 1983, 2002; Pekalski, 1997) CSB incident news (USCSB, 2003) and databases (University of Queensland, 2001; CHSIB, 2004; ICHemE, 2002; PAJ, 2004; NOAO, 1999). Hence, a comprehensive risk assessment on fires and explosions at petrol stations with regards to USTs must be taken into consideration in curbing any calamity/disaster from occurring and affecting the people living around the premises.

MATERIALS AND METHODS

Many previous researchers carry out deep researches either using quantitative or qualitative methods that have been commonly discussed in their respective research methods. However, as an engineer always seeks for answers in precisely manner by using digits or numbers. Conducting research is about the philosophy behind the research (Holden and Lynch, 2004). Finding answers which is sufficient and holistic is vital in finding the truth. A paradigm is defined as the basic belief system that guides the investigator not only in choice of method but also in ontologically and epistemologically fundamental ways. This paradigm will help the researcher to guide and conduct the research thoroughly. Therefore, in explaining of paradigm of risk (ontology) and fires in underground storage tanks at petrol stations (epistemology) are needed. The reality of the risk in petrol stations such as aging underground storage tanks does not involve any standardized information due to disclosure or improper dissemination of risk information to the workers onsite. Workers are not given any information in terms of the management of the risk. In conjunction, they do not have sufficient knowledge to deal with the consequences of the risk when they arise. In the real world, petrol fuel stations pose are considered hazardous premises. Hence, the risk of fire at petrol stations is due to the aging structures and other hazards such as housekeeping, unsafe acts and unsafe conditions. Risk is a very subjective word and a method of qualitative study of extensive methodological literature must be carried out (Denzin and Lincoln, 2003). The findings will address the risk and fire in underground storage tanks at petrol stations and this must clearly transform the findings as an input to authorities in giving licenses to petrol fuel stations in Malaysia. Fire has been the main problem faced by operators of petrol stations and they tried to formulate the best methods in curbing the problems from becoming worse. The factors that contribute to the calamity are risks. However, the researcher is keen to investigate the risk of fire in underground storage tanks at petrol stations in the context of Malaysia.

The risk of fire in underground storage tanks has been chosen due to the containment of the hazardous substances inside the underground storage tanks. Therefore, if the hazardous substances manage to become released this could cause disaster such as fire,

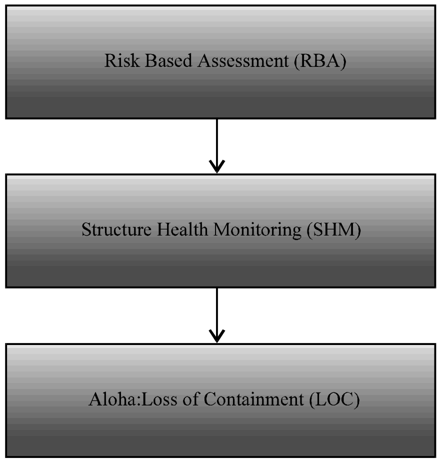

Fig. 1: New combination process between Risk Based Assessment (RBA) and of Structural Health Monitoring (SHM) cum Loss of Containment (LOC)

explosion. Consequently, this would affect workers, damage properties and negatively affect the vicinity of the petrol station. Therefore, underground storage tanks need to be explained in detail. To carry out the research, a qualitative method has been adopted which uses a combination of the Risk Based Assessment (RBA), Structural Health Monitoring (SHM) and Loss of Containment (LOC). This comprehensive and holistic approach uses the RBA, SHM and LOC and gives a vivid ontology and epistemology of the research on the risk of fire in underground storage tanks in petrol stations.

Combination process between Risk Based Assessment (RBA), Structural Health Monitoring (SHM) and ALOHA (Loss of Containment (LOC)): This combination of processes will be adopted in a case study approach using old (>15 years) and aging underground storage tanks (Fig. 1). The new process will provide a good and comprehensive approach in quantifying the aging underground storage tank which are >15 years and could pose fire hazards if mitigation is not applied in the petrol station. Details of the process are explained.

Risk Based Assessment (RBA): Risk based assessment (API, 2000) is the early stage of process in collecting and gathering data such as primary data (technical drawings, manufacturing data reports and inspection testing plan) and secondary data (authority's inspection report, 3rd party report). The data will be delivery as a preliminary input of information of the UST's status. Early information is ready for the next process that is SHM.

Structural Health Monitoring (SHM): Structural Health Monitoring is a process or a system to monitor damage in structures, especially in industries of aviation, civil and mechanical (Boller and Buderath, 2007). Basically, the elements that are involved in the process are:

- Structure's observation process in monitoring the propagating process of the structure from the early stages until it faces the process of failure and damages the integrity of the structure
- Statistical analysis is the second process whereby data will be input and measurements need to be carried out to find the starting point of corrosion to prepare for mitigation
- Screening process to visualize the overall structure in ensuring whether the structure is in good condition

The above case study is a sample of underground storage tanks which use a unique gadget LRUTG (Long Range Ultra Thickness Gauging) to measure of justification in the range of thickness of the wall (ranging from 4-9 mm). The thickness that gives enough proof that the integrity of the wall of the UST starts to give away will be recorded. The gathering and compilation of data will be the raw input such as measurement of thickness, type of material, temperature, level of pressure of the material, stress and strain. This data will be computed in computer software such as ALOHA, safetrend and SAFETI to predict the range of thickness.

ALOHA (Loss of Containment (LOC)): LOC is a process of predicting and justifying the magnitude of the hazard posed by the event (fire in this case) that could affect the vicinity of the area (petrol station in this case). This simulation software involves all data such as temperature, pressure, nominal thickness, weather, chemical substance character and so on. Data from the RBA's process and SHM's process also been added to strengthen the reliability of the datacollections.The process will be justified as.

Substance classification: In this stage from the data input to the system, classification of the chemical substance is a priority in the system (fuel, gas or diesel); type of chemical characteristics are very different from each other such as liquid, gaseous or a combination of both. Incidents are predict, whether fires, explosions or toxic releases.

Quantity release: In this stage the total quantity of the substance must be justified in number such as 30000, 60000 and 90000 L. The quantity is a very important input to the system so that it can predict the intensity and severity magnitude of an incident.

Operation mode: This stage involves a simulation that will give a range of predictions of sequences of the substance release such as plume fire, pool fire, explosion, Boiling Liquid Expanding Vapour Explosion (BLEVE) and so on. The mode operation of the release of the substances occurred such as leakage due to hairline crack, instantaneous outcome burst and so on.

Release rate: In this stage, the simulation will list a specific type of release of the accident. There are a range of releases such as pinhole, wielding crack, sipping process and type of diameter of the release activity. This method will calculate the rate of the outcome of the substance from the containment either mode of instantaneous vapour, gradual leakage, overfills of the substance, etc.

Incident cause: In this stage the simulation will give one or multiple prediction(s) in terms of the incident caused based on the data computed by the system. Fire, explosion, BLEVE, Blast or a combination of the above are a few hazards that could be generated by the system. The intensity of the severity could appear after the data has been computed and be visualized in pictures in the form of contours of severity against the distance. Furthermore, the magnitude of affect onset, offset, vicinity of the premise, individual and society are all factors taken into consideration. The cause of the incident could be established during the fieldwork. Sometimes either a single factor of incidents or a combination of fires and explosions take place.

Mitigation: The outcome of the result positively ensures the researcher to rule out some measurements and judgments and draw a clear boundary of the installation of the petrol station away from heavy populations of people such as shopping malls, crowded residential houses and community areas. The outcome of the simulation will give a contour of hazard and severity zone to the vicinity of the petrol station. This baseline data will provide authorities to make proper decisions, justifications and judgment in issuing licenses to operate petrol stations in Malaysia

RESULTS AND DISCUSSION

Hence, the combination of the approach by adopting Risk Based Assessment (RBA) and then justify the data into Structural Health Monitoring (SHM) for USTs. Finally, input to the Software ALOHA, Loss of Containment (LOC) will give a vivid and crystal prediction of the fire risk of a form of risk contour in regards to UST's leakage at petrol station. This approach will help the operators and people living the vicinity of the petrol station to take up some measure or mitigation if the fire broke out.

CONCLUSION

Therefore, the approach of leakage detection in this study is to give an alternative tool in a form of simulation and prediction of magnitude and severity effect of the fire risk to the on-set and off-set of the petrol station. The result of the combination and holistic of the above approach will provide a novel way of monitoring and supervising the underground storage tank's integrity and prediction of an early information of the fire risk at petrol station. This approach can be implement and replicate to other petrol stations and adopted by oil companies.

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