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Risk Based Assessment of Underground Storage Tanks in Petrol Station

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Abstract: Ageing Underground Storage Tanks (USTs) have come with risks whereby failure due to loss of containments can potentially cause catastrophic damage to humans and environment. The failure due to loss of containments such as oil and gas may triggera domino effect-explosion. This study aims to introduce an alternative method to assess the fitness of the underground storage for operational purposes. Therefore, Risk Based Assessment (RBA) of the underground storage tank at a petrol station has been carried out. RBA consists of three maincomponents: policy, technical factors and maintenance. The result of the RBA provides improved monitoring and supervising of the integrity of the underground storage tank within an acceptable risk range. This RBA can be implemented, replicated and uses by other petrol stations. The results demonstrate that the investigation of the RBAs associated with underground storage tanks, especially those containing polymer material is worthy to be further pursued.

Key words: Petrol station, Risk Based Assessment (RBA), underground storage tank, introduce, petrol station

INTRODUCTION

On a global scale, giant car manufacturers constantly compete to produce more efficient cars, whether conventional, hybrid or future concept models. The increasing number of cars sold is gradually on the rise throughout the time period of 1990-2015. According to Statista, the number of cars is rising on a daily basis, either in manufacturing or in operation on the road. The highest number of cars produced was 72.94 million units; meanwhile, the time period of 1990-1999 has seen the lowest number of cars produced. This attributable to the necessity of reliable transportation in the today's modern, fast-paced world. The numbers of cars is constantly rising every year. Therefore as shown in Fig. 1.

A comparison based on car manufacturers throughout the world gives a significant indicator about the most preferred car brand. Toyota has been the most preferable car brand; followed by Toyota (20.23 million units), Volkswagen (10.14 million units) and GM group (9.9 million units). The least preferable brand is Tata (0.94 million units), mainly because this brand is produced and used in India. Figure 2 shows the number of cars produced according to manufacturer.

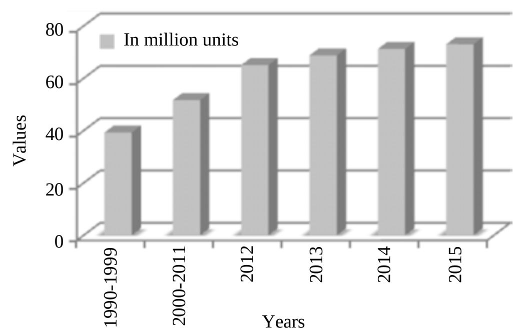

Fig. 1: Number of cars worldwide from 1990-2015

In Malaysia, the combination of transportation vehicles (including passenger cars, commercial vehicles and 4×4 vehicles) make up only around 0.09% of the total number of cars sold worldwide in 2014. The number of registered transportation vehicles in Malaysia is gradually increasing every year (Table 1).

In order for a car to operate, oil consumption is a must. The increase in the demand for oil has triggered the rise in the number of petrol stations installed. Facilities for oil consumption such as petrol stations must be constructed based on the number of cars used. Figure 3

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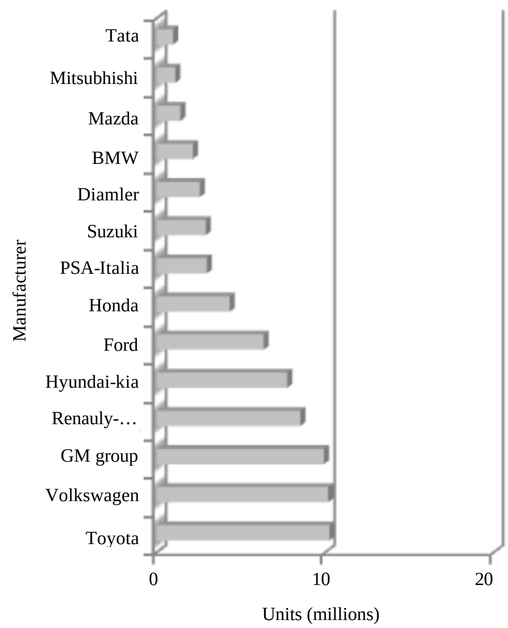

Fig. 2: Number of cars according to the manufacturer (in millions units)

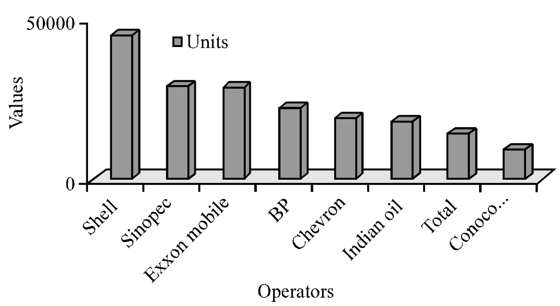

Fig. 3: Number of largest gas and petrol operators until 2009

Table 1: The number of transportation vehicles in Malaysia (1980-2014)

Years	Passenger cars	Commercial vehicles	4×4 vehicles	Total vehicles
1980	80,420	16,842	-	97,262
1985	63,857	26,742	4,400	94,999
1990	106,454	51,420	7,987	165,861
1995	224,991	47,235	13,566	285,792
2000	282,103	33,732	27,338	343,173
2005	416,692	97,820	37,804	552,316
2006	366,738	90,471	33,559	490,768
2007	442,885	44,291	-	487,176
2008	497,459	50,656	-	548,115
2009	486,342	50,563	-	536,905
2010	543,594	61,562	-	605,156
2011	535,113	65,010	-	600,123
2012	552,189	75,564	-	627,753
2013	576,657	79,136	-	655,793
2014	588,341	78,124	-	666,465

shows the largest petrol station operators until the year 2009. On a global scale, there are millions of petrol stations that have been built to meet the increasing number of cars used on the road. Shell (45000 units around the world) is the largest operator in the world, while Conoco Philips is the least (9600 units around the world).

In Malaysia, the petroleum industry, especially the down stream industry has remained untouched due to the Malaysian economy. However, this was suddenly affected due to the Economy Transformation Program (ETP), under the 12 National Key Economic Key Area (NKEA) which is oil and gas. Furthermore, petrol station operators' gross output for retail sales of automotive fuel contributed to about 4.812 million in the country (7.2% out of overall gross output in retail sector).

Generally, a petrol station is not a major hazard facility when the threshold is <100,000 tons of substance. However, special care should be taken into consideration from the early stages 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 (Ramirez-Marengo *et al.*, 2014). Typical, a petrol station is associated with unique features and shapes which consist of three main sections:

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

Underground tank: This area is visible because it contains underground tanks. The indicators are venting pipes and manholes; it is usually a vacant area.

Service store: This is usually located near the dispenser area which contains a small convenience store, storage office, coffee shop, restaurant or motel (Hassanain and Al-Mudhei, 2006).

Petrol stations are considered to have a high potential of fire breakout compared to other non-major hazard installations. This is due to the characteristics of the fuel that such facilities contain. The magnitude of a hazard increases due to the fuel's high flammability and combustibility, quantity store in the station, concentration of vapor within the facility's atmosphere and replenishment processes. Liquid Petroleum Gas (LPG) is categorized as the highest flammable gas (Category 1) compared to diesel (Category 2).

The types of chemical hazards that are involved in petrol stations including their products and Globally Harmonise System (GHS) characteristics are shown in Table 2.

Table 2: Hazardous chemicals in petrol station

Products	Globally Harmonise System (GHS)
Liquid Petroleum Gas (LPG)	Flammable Gas Category 1
Unleaded Petrol (ULP)	Flammable Liquid Category 2
Premium Unleaded Petrol (PULP)	Flammable Liquid Category 2
Diesel	Flammable Liquid Category 2

Therefore, there is a need for an in-depth investigation on underground storage tanks to control and minimize the associated risks by unsafe Underground Storage Tanks (USTs).

According to Kansas Health and Department, the Kansas Health and Department indicated that Above Storage ground Tanks (ASTs)/Underground Storage Tanks (USTs) at service stations have been assessed during 1957-1982 where a total of 11,269 inspections and assessments were made. About 50% of the 11,269 were recorded to be aging tanks (>20 years old). In Montana, USA alone, 1987 steel tanks are over 10 years. A researcher by the name of Leane Hackey; Montana Inspector of Underground Storage Tank Section, found out that: events of leakage could cause:

- Public Health (Benzene, Ethyl benzene and Xylene (BTEX)) (Bare, 2006; Karakitsios *et al.*, 2007)
- Pollute the underground water
- Fire and explosion

A few studies have indicated that a large number of steel tanks leak after a period of 15 years. In fact, a study revealed that 27% of the tanks at Ohio Tank at petrol station operator, USA would leak after 18 years. Leakage was due to the unsafe and loss of integrity of the UST, mainly attributable to corrosion factors such as MIC and water. Conventional methods of solving this problem of the corrosion are:

- Coating: a layer of bitumen is placed on the shell to prevent the water from contacting the surface of the steel (Bogner, 1990)
- Cathodic protection: this is a system that applies anode and cathode by using a wave to avoid the process of the corrosion from taking place

However, in Malaysia, there is a lack of comprehensive data about ageing USTs and thus, the actual number of the aging USTs is unknown by the authorities responsible. Moreover, there are no specific legislations or laws in governing or enforcing this emerging issue of aging USTs. The lack of a formal, standardized legislation also contributes to the loosened enforcement of petrol station premises.

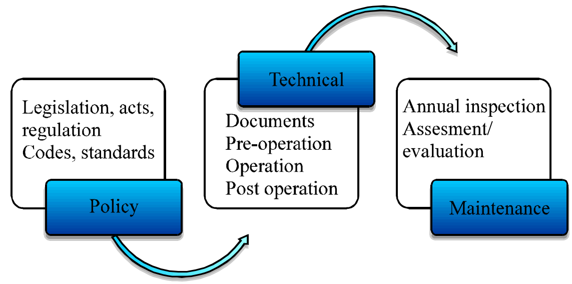

Fig. 4: Risk Based Assessment (RBA) diagram

MATERIALS AND METHODS

An alternative and holistic approach is needed to measure and minimize the issue of aging USTs in Malaysia. Therefore, three elements should be taken into account. Figure 4 shows an RBA diagram and the overall process in monitoring the aging USTs. Constant monitoring should be enforced by implementing cum policies so that technical assessment and maintenance will encounter any unwanted events from taking place and will mitigate corrosion development in old USTs. There are three main elements involved in this RBA process which are as follows:

- Policies
- Technical factors
- Maintenance

Policy: There are many legislations and laws around the world that involve USTs such as in the Dangerous Substance and Explosion Atmospheres Regulation 2002 which stipulates a condition only about how petroleum licenses are issued under the petroleum (Consolidation) Act 1928 (UK). Other related regulations are the Health and Risk at Work Act 1974, Management of Health and Risk at Work Regulation 1990 and Regulation Reform (Fire Risks) Order 2005. Meanwhile, the National Fire Agency Code (NFA Code) is implemented in the USA.

However, the legislation in Malaysia does not mention any organization, creation, manufacturing, maintenance and servicing in prescriptive standards. For instance, the Occupational Safety and Health 1994-OSHA (Act 516), Akta Pembangunan Petroleum 1974 (Act 144), Akta Pembangunan Petroleum 1974 and Akta Kerajaan Tempatan 1971. These acts do not stipulatein detail the documents, manufacturing, installation and maintenance and servicing in prolonged format. Act 516 merely states that any machinery must be registered to the corresponding department. The operators must submit an application to register the UST involved. However, this act does not mention anything about the details of the machinery involved. Meanwhile, Act 144 only stipulates the conditions for the establishment of an organization pertaining to petroleum.

Additionally, Akta Kerajaan Perumahan Tempatan 1971 mentioned and ruled out the licensing procedure on the site to build apetrol station.

On the other hand, codes and regulations should be drawn on the technical section such as fabrication, welding, construction, manufacturing, maintenances andservicing. Therefore, the chains involved in the process are not connected in a sequential manner.

The combination of the legislation and code must be ruled out to for a more comprehensive understanding. An example of this combination is as follows:

Technical: All technical data and documents must be produced and well kept for future reference. The documents involved are:

Pre operation:

- Design drawing and calculation
- Material/mill certificate
- Manufacturer certificate

Operation:

- Fabrication and manufacturing records
- Wielding workmanships
- Carried out by competent wielders, supervisors and

Manufacturers:

- Handheld Ultra Thickness Gauge (UTTG) must be used to measure based line of the thickness
- Using checklist measurement dish end and shell. Check visually the workmanship of wielding

Maintenance/Service:

- Annual assessment: use UTTG to verify the present thickness of UST (Shell and Dish End)
- Any steel UST which is above 5-7 years needs to undergo are qualification process
- A video scope identifier should be used to find any defects and corrosion areas (localized or generalized)

Most importantly, a competent inspector from the oil company or from the governmental party must verify and validate the data by visiting the manufacturer. The usage of XRF 9000s LTi (material identifier) UTTG to verify the thickness of the UST should be considered. Also, a video scope should be used to visualize any corrosion spots, whether localized or generalized.

The comprehensive and alternative RBA assessment above provides a complete and comprehensive system of data documentation and technical support to make better decisions about the fitness of USTs and whether they should continue to operate and are in the allowable age or whether they should be discard and replaced.

The data and process above is predicted to provide beneficial information to oil companies and private operators in making better decisions about the operation of their petrol stations and on UST operation.

RESULTS AND DISCUSSION

The outcome of the RBA will generate early baseline data and records on USTs in terms of:

- Name of the manufacturer
- Name of the material
- Design drawing
- Worksmanship records such as welding, rod filler, name of the welder, etc.
- Record of any alteration from design
- Additional fabrication

A Handheld Ultra Thickness Gauging (UTTG) is a probe that consists of a wave frequency probe and a small digital monitor that are capable of measuring the thickness of the wall of the UST with or without coating. The measurement determines whether the actual thickness differs from the thickness according to the design drawing. If there is a difference, a complete and thorough assessment should be conducted in order to ensure the integrity of the UST. Meanwhile, a video scope identifier that consists of A3M long probe and cum with a video monitor is used to visualize and illustrate the actual conditions in the UST to sort out any internal defects due to corrosion (either localized or generalized).

CONCLUSION

This study explained in detail the RBA process in monitoring closely not just the aging of a UST but also the aging system of the petrol station by keeping early documentation of data and technical reports for the operators to justify the life cycle and integrity of the UST. Furthermore, the records will certainly provide solutions to the operators to prolong the installed USTs. Most importantly, a water management such as proper drainage, proper oil sump and cleanliness should be installed to keep out the rubbish from clogging the water paths.

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LIMITATIONS

The financial budget for this exercise would have been costly for individual operators to reveal whether they have insurance. The UST must be setto a limit of about 7 years of operation and must be open for requalification for fitness to operate according to the code. The site must be closed from operation for about 3 months for the requalification process.

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