International Journal of Scientific Research in Computer Science, Engineering and Information Technology
 | Volume 3 | Issue 6 | ISSN : 2456-3307

Impact of using Computerised Shigeo Shingo Poka Yoke on Risk Management in Zimbabwe's Petroleum Industry

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ABSTRACT

Petroleum depots and service stations are one of the most dangerous sites due to the existence of the toxic and high volatile petroleum products in the form of liquid and gas. This paper seeks to evaluate the impact of using computerized Poka Yoke by Zimbabwe Petroleum industry from the point of loading, to transportation, to offloading, storage and selling of these products to customers. Companies have employed various ways to eliminate or reduce the risks. A survey of six petroleum companies was conducted. The results revealed that incidents could be reduced by 28.6% if Shigeo Shingo Poka Yoke is employed.

Keywords: Poka Yoke, risk, hazard, petroleum

I. INTRODUCTION

Procedures are one of the core methods that have been used in managing the risks. They show a systematic way to complete a task. Those involved in carrying the tasks are given the procedure and they have to acknowledge that they have read and understood and they shall adhere to the procedure, by signing. Normally Management will carry out spot checks to ensure that the procedures are being followed. Before the product is loaded in the truck usually, a truck inspection sheet has to be completed. The inspection sheet is then used to identify hazards such as worn out tyres, brakes, lights, unlicensed driver, dirty tank among others. Upon completion, the supervisor will then approve the loading of the truck depending on the nature of hazards identified. On the offloading bay, the truck is earthed to discharge static charges, which can be a source of ignition to the surrounding petroleum vapours. Depending on the pump being used the loader will stop the pump once the desired volume has been reached or the pump will automatically stop once the volume set has been reached to avoid spillage. In case of emergency, the loading bay is fitted with an emergency stop switch. When pressed it switches off the electricity to the bay and the alarm rings. Upon hearing the alarm the personnel will immediately move out of the offices and gather at the designated assembly point for further instruction from the Health Safety Environment department. The transport department does route risk assessment. They identify the risks associated with each route and they choose the best route to a certain customer. A map for this route is drawn and notes for risks to take care of are then written down. The driver has to use this route card and can be monitored if he/she goes off route using the computer tracking system. The tracking system will also show the driver's behavior such as over speeding, harsh braking, harsh acceleration, night driving and over revving. At the receiving bay the customer will check if the receiving tank has enough space to avoid spillage. Some tanks have overfilled protection, they cut off the inlet to avoid spillage. The customer will also check the quality of the product in the tank and ensure it is offloaded in the right tank, to avoid mixing different products. Again the truck is earthed then offloaded. Risk assessments for the sites are carried out once or twice per year with a detailed inspection sheet, either by an internal person or independent company. An action plan is drawn from the assessment.

II. METHODS AND MATERIAL

The research was quantitative in nature. It was done through analyzing the risk management techniques used by the petroleum industries in Zimbabwe. A survey was carried out to six (6) petroleum companies in Zimbabwe. Interviews were carried out to the HSEQ manager and each of the operator in the following fields; loading, offloading, transportation, and storage. A detailed questionnaire was used for interviews. Notes were taken, assembled and analysed. The questionnaire was based on the Poka yoke used in the following categories.

0ffloading

- Tank overfill protection: installation of a tank gauging system which can be programmed to activate an alarm once a certain level in the tank has been reached by the petroleum product, thus preventing spillages.
- 1ST stage vapor recovery unit: Installation of a recovery unit inside storage tank. It has a switch, which detects pressure variation inside the tanks and turns on and off the compressor. Vapors are then sucked through a scrubber into the gas line thereby preventing vapor to be released into the atmosphere. Petroleum vapors are hazardous to health and are sources of fire.
- Oil separators with alarm: At the service station forecourt, oil spills are directed into an oil separator, it separates oil and water. Then only water is discharged into the ground or drainage system thereby preventing oil pollution to the environment. However for this system to work efficiently an alarm must be activated once the oil level reaches 90% of the storage tank, then the oil will empted.

Loading

- Pump activated only when tank truck is earthed: loading and offloading of trucks generates static electricity that can cause electrostatic sparks. A combination of sparks and oil vapors may result in fire. Such electrostatic charges can be prevented by earthing the truck. A system can be installed which only activates the loading pump when the truck is earthed.
- Preset function on loading pump: Amount of product to be loaded can be programmed on the pump. Once the volume has been reached the pump automatically switches off, thereby preventing overloading and spillages.

Transportation

- Speedlimiter: Installation of a speed limiter on trucks, which the maximum speed attainable can be set. This prevents drivers from over speeding. Speeding increases the risk of accidents.

Storage

- Tank leak detector: sensors, which detect leaked petroleum product, are installed on the tank.
- Pipe leak detector: A device, which triggers an alarm once there is a leak, is installed on the pipes. Therefore the ground is protected from being contaminated by petroleum products

RESEARCH QUESTIONS

1. What are the Poka Yoke techniques being used by petroleum industry companies?
2. How effective is Poka Yoke?

THEORETICAL FRAME WORK

- Contact Method Darren D (2004)
- Fixed Method Dvorak V (1989)
- Motion step Method Helphyite C (2010)
- Effectiveness of Poka yoke Habloy HG (2001)

III. RESULTS AND DISCUSSION

The results show the distribution of positions for the total number of 59 people who were interviewed. The survey was carried out to (six) 6 petroleum industries in Zimbabwe.

Table 1: Designation of respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	HSE Manager	6	10.2	10.2	10.2
	Depot operators	16	27.1	27.1	37.3
	Driver	13	22.0	22.0	59.3
	Petrol Attendance	14	23.7	23.7	83.1
	Maintenance Technician	10	16.9	16.9	100.0
	Total	**59**	**100.0**	**100.0**	

Table 1 Shows that the Depot operators were the highest respondents with a percentage of 83.1 on the survey carried out and the least being the HSE managers at 10.2%.

Table 2 : Type of Maintenance Technicians

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Electrical	2	20.0	20.0	20.0
	Pump	2	20.0	20.0	40.0
	Tank	2	20.0	20.0	60.0
	Civil	2	20.0	20.0	80.0
	Signage	2	20.0	20.0	100.0
	Total	**10**	**100.0**	**100.0**	

Table 2 shows that 20% of each type of maintenance technician were interviewed.

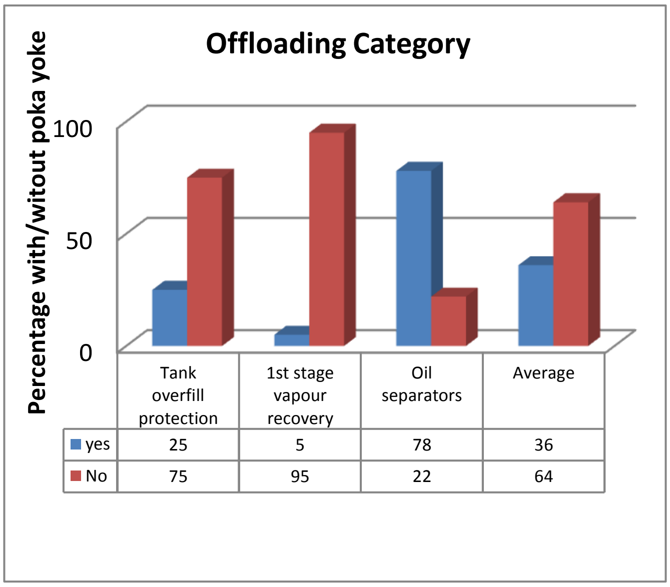

Fig 1: Percentage application of Shigeo Shingo Poka Yoke in offloading category, in Zimbabwe petroleum industries.

The overall number of companies using Poka Yoke in the offloading area is 36% and those not using is 64%.We can deduce from fig 1 that companies are mostly applying Poka Yoke in preventing soil pollution by using separators. This is mainly because of the enforcement by the local regulation from Environmental Management agency (EMA). However, there is very low application of Poka Yoke in eliminating petroleum products vapors, which are the source of fire and respiratory diseases. Five (5) % petroleum companies are only using the first stage vapor recovery technique.

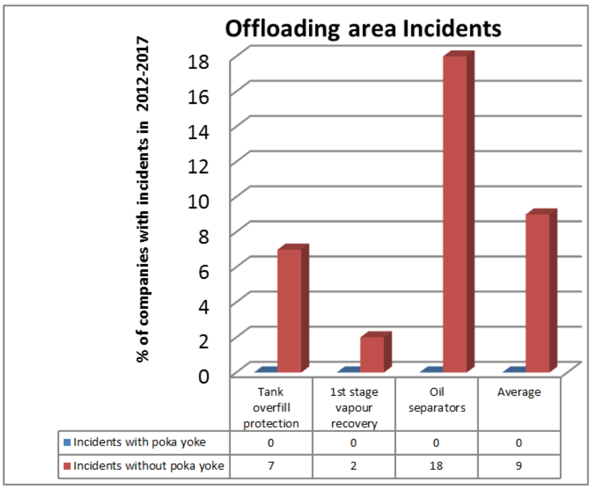

Fig 2: Comparison of incidents for companies with and with no Poka Yoke in the offloading category, for the year 2012 to 2017.

From fig 2, it's clear that use of Poka Yoke is effective. For the companies, which use Poka Yoke, 0% of them had incidents related to the following fields: tank overfills protection, 1st stage vapor recovery and interceptors. . There were incidents for those not using Poka yoke, in all other categories with the highest being linked to lake of alarm systems on interceptors, i.e. 18% of the companies.

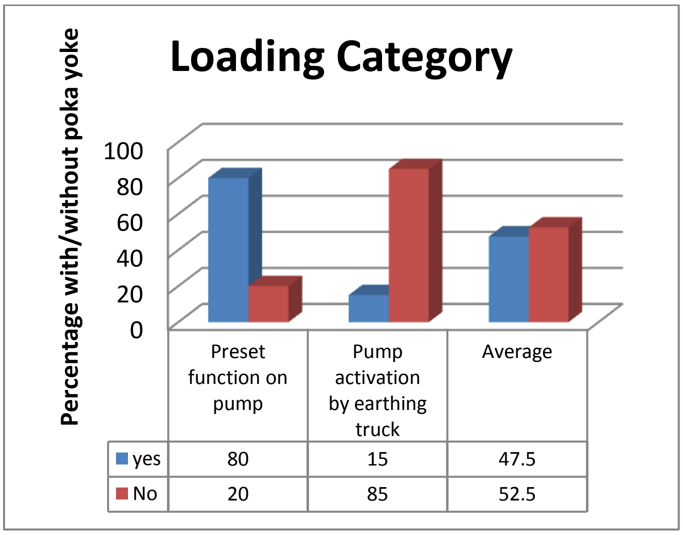

Fig 3: Percentage application of Shigeo Shingo Poka Yoke in loading category, in Zimbabwe petroleum industries.

The results on fig 3, shows that 47.5% companies are using Poka Yoke in the loading category and 52.5% are not using. The most being used are pumps with a function to set the volume to be loaded and the pumps cut when the volume is reached, thus avoiding overfilling which may cause spillages. 80% of the companies are using these pumps. The static charges produced during truck loading can be discharged to the ground by earthing it. Only 15% petroleum companies in Zimbabwe have pumps that start only and if the truck is earthed at their depots.

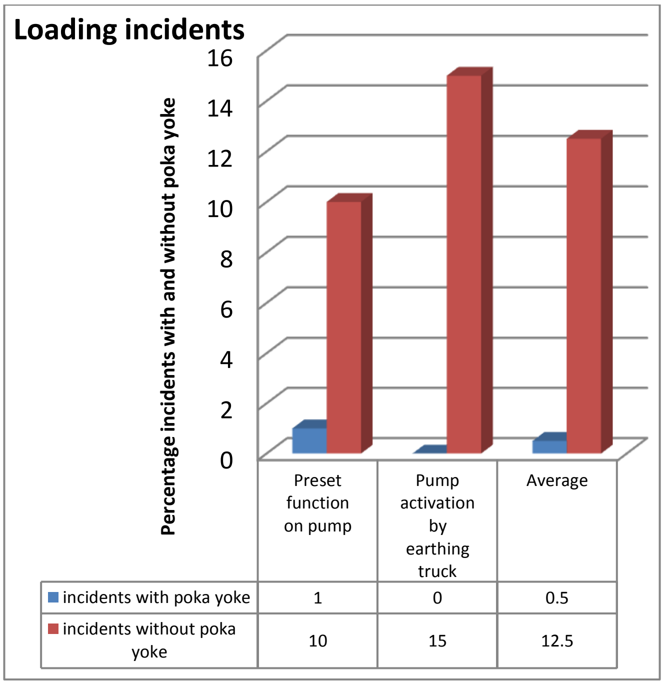

Fig 4 : Comparison of incidents for companies with and with no Poka Yoke in the loading category, year 2012-2017.

As shown on fig 4 when using Poka Yoke companies involved in incidents in the loading category can be reduced from 12.5 to 0.5%. Therefore companies are encouraged to use pumps with preset function and install a device to activate the loading pump only and if the truck is earthed.

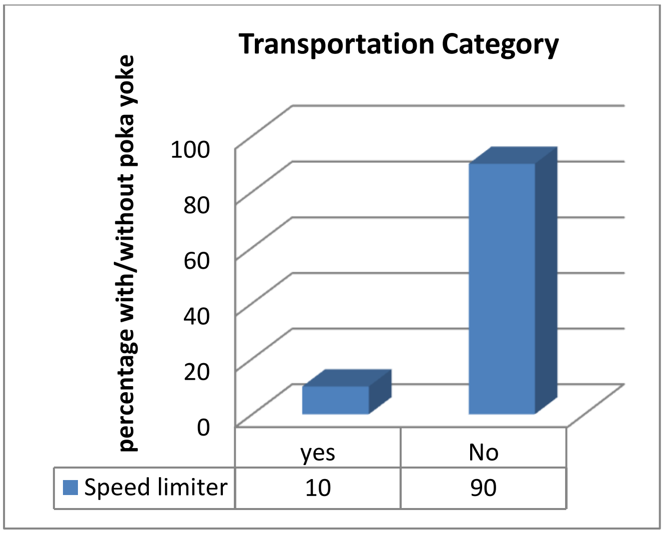

Fig 5: Percentage application of Shigeo Shingo Poka Yoke in the transportation category, in Zimbabwe petroleum industries.

From Fig 5, 10% of the trucks have a speed limiter, which does not allow them to exceed a speed of 80km/hour.

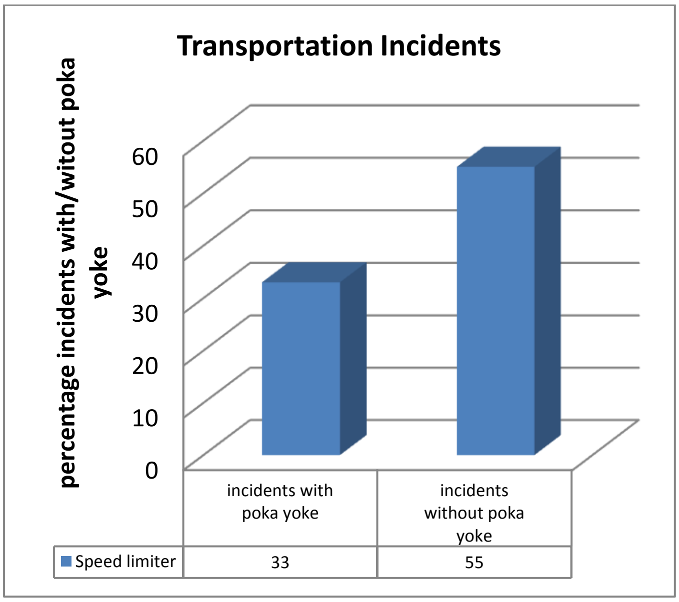

Fig 6 : Comparison of incidents for companies with and with no Poka Yoke in the transportation category, in year 2013 and 2014.

Fig 6 shows that Poka Yoke cannot completely eliminate risk in the petroleum industry. 33% incidents were from trucks installed with a speed limiter.

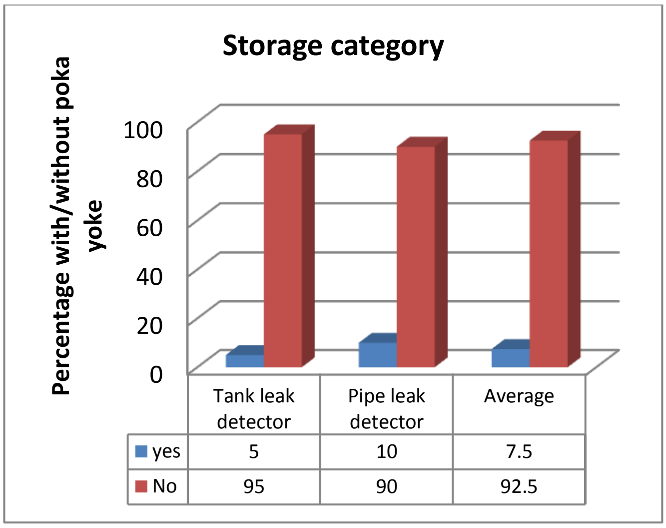

Fig 7 : Percentage application of Shigeo Shingo Poka Yoke in the storage category, in Zimbabwe petroleum industries.

We can deduce from fig7 that companies are reluctant to install leak detectors, which result in huge litres of product being lost and polluting the ground before it could be recognized.

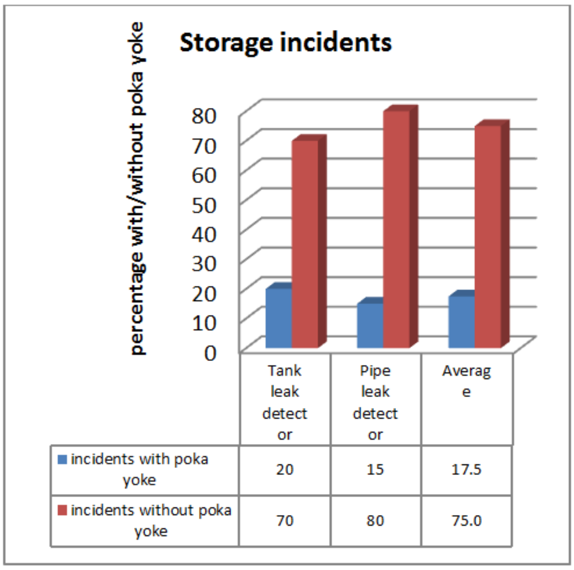

Fig 8 : Comparison of incidents for companies with and with no Poka Yoke in the storage category, year 2012-2017

Fig 8 shows that if companies apply Poka Yoke in the maintenance category the incidents will be reduced to 17.5% from 75%.

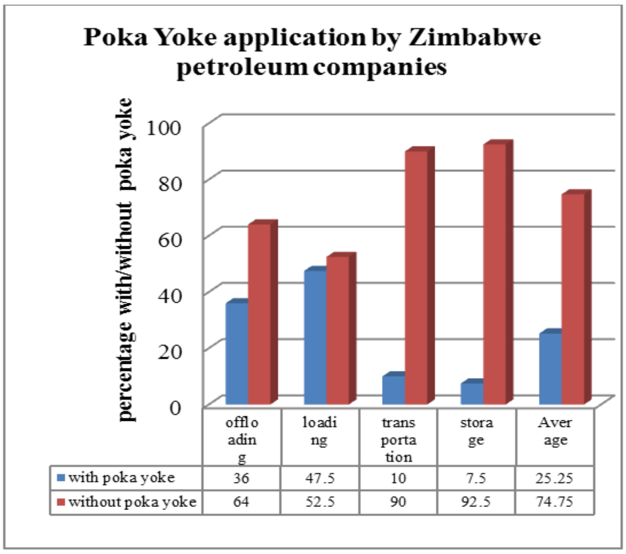

Fig 9 : Summary application of Shigeo Shingo Poka Yoke in 4 operations of petroleum industries in Zimbabwe.

The results in fig 9 show that out of the main Poka Yoke techniques available in petroleum industries of Zimbabwe only 25.25% of them are being applied. Poka Yoke is mostly being applied in the loading category, i.e. 47.5% application. The lowest application of 7.5% of Poka Yoke is in the transportation category.

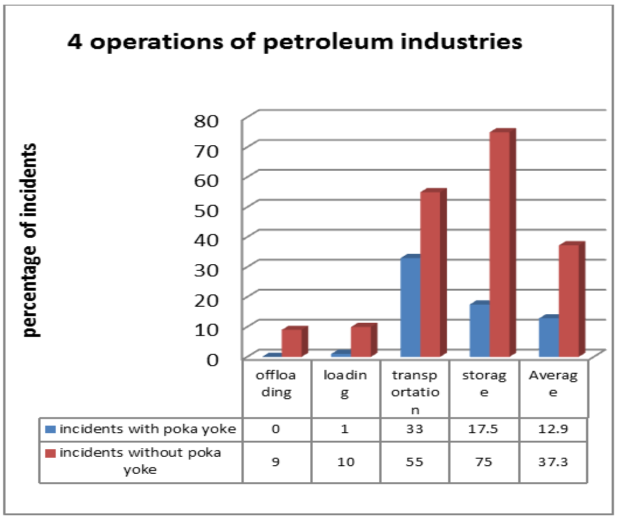

Fig 10 : Summary of comparison of incidents for companies with and with no Poka Yoke in the operations of petroleum industries in Zimbabwe, year 2012-2017.

The results have shown that Poka Yoke is effective, as shown in fig 10. By simply applying Poka Yoke in the petroleum industry operations incidents will be reduced from 37.3% to 12.9%. In some cases, we cannot completely eliminate incidents by using Poka Yoke thus 12.9% incidents were recorded despite of using Poka Yoke. There is a high rate of incidents in storage and transportation therefore companies are encouraged to employ Poka Yoke mainly under these areas.

TABLE: 3 Incidents while using Poka yoke descriptive statistics

N	Mean	Standard Deviation	Range	Minimum	Maximum
6	4.78	3.6	8.2	0.1	8.3

Table 3 shows a mean of 4.78% incidents, a standard deviation of 3.6 and a maximum of 8.3% incidents experienced while using Poka yoke for the major operations under review.

TABLE : 4 Incidents while not using Poka yoke descriptive statistics

N	Mean	Standard Deviation	Range	Minimum	Maximum
6	28.6	13.8	29.4	12.9	42.3

Table 4 shows a high mean number of incidents, 28.6% and a maximum of 42.3% incidents.

IV. CONCLUSION

Even though the computerised Poka Yoke techniques, which were covered by this survey, were not exhaustive, they were the major ones and the results revealed that there is a significant reduction of incidents if petroleum companies in Zimbabwe start using Poka Yoke as a tool for risk management. The reduction to 12.9% (as shown in fig 10) in incidents for techniques, which were under review, means reduction in fatalities, injuries and health problems. The petroleum industry in Zimbabwe is growing considerable. If we are not carefully, the incidents in this sector will also rise proportionally. We can use all other methods for managing risk but Poka Yoke technique is the best. For example, we can train the drivers or write procedures for them not to exceed 80km/hour but this shall not be good enough to enforce them to drive below the set speed. With Poka Yoke, installing a speed limiter ensures and enforces each and everyone to comply with this rule. Therefore, petroleum companies should prioritize in installation of first and second stage recovery system, installation of separators with alarm and leak detectors, truck speed limiters. It should be noted that in some instances Poka Yoke is difficult to apply therefore other methods could be applied. However, in choosing a method for managing risk, choose Poka Yoke first. Poka Yoke can also be used in conjunction with other methods.

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