Assessment of Implementation of Fire Risk Reduction Rules at Petroleum Dispensing Stations in Kisumu County, Kenya

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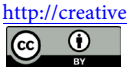

Abstract

Fire safety is an essential aspect in each workplace; its efforts are geared to the preservation of life and protection of property. Petroleum dispensing stations handle highly flammable and combustible materials that ignite at any given time at a conducive condition. The government of Kenya has instituted various laws and legislation to alleviate the fire safety status of such workplaces which should be adhered to. The study aimed to assess the implementation of Fire Risk Reduction Rules in Kisumu County which will provide bases for the improvement of the available fire risk reduction rules and gauge the Fire safety status in petroleum dispensing stations. Research methods employed involved physical observation, interviews, and measurements. The study established that 27 (90.3%) Branded petroleum dispensing stations and 11 (68.8%) of independent petroleum stations had implemented safe storage and handling of highly flammable petroleum products, none of the stations had fully implemented the provisions in the Fire risk reduction rules, however, branded petroleum dispensing had better performance in the implementation than the Independent Petroleum dispensing stations. In view of the findings, the study recommends beef up of capacity in the directorate of occupation safety and health personnel to enable workplace inspections and awareness creation and enforcement on implementation of the Fire risk reduction rules as well as improvement of the available rules to be more specific on nature of works in petroleum dispensing stations.

Keywords

Fire Safety, Fire Risk Reduction, Petroleum Dispensing Stations

1. Introduction

Background to the Study

Petroleum dispensing stations are categorized as hazardous workplaces where flammable substances, including gasoline, diesel, and illuminating kerosene are stored either underground or above ground. Implementation of established fire risk reduction rules at any workplace is key to the attainment of a safe workplace, petroleum dispensing stations handle highly flammable substances which categorize the workplace as highly hazardous, posing the potential risk to personnel, public, property, and the environment, hence the need to have stringent rules regarding fire safety in place. Mismanaging safety matters in such workplaces could cause catastrophic disasters. Zhou Y. *et al*., [1] the flammability hazard of fuel is quantified by its flash point, that is the lowest temperature at which the fuel can vaporize to form an ignitable mixture with air. Gasoline has a flashpoint around −43˚C whereas Diesel fuel flash points vary between 52˚C and 96˚C (126˚F to 204˚F) depending on the standard method used in the measurement.

Fire risk reduction rules, 2007 is subsidiary legislation derived from the Factories and other places of work Act (Cap 514), The main objective of the provision is to give guidelines on prevention of fire incidents at the workplace and means of protection of property and injury to persons at the workplace and its surroundings in case of any eventuality. According to [2] Ragil, M. *et al*., fire is a dominant hazard in the workplace, and despite the technological advancement in fire safety, it remains the leading cause of lives and property loss at commercial and industrial facilities worldwide.

2. Materials and Methods

A cross sectional study was employed in the research. The target population for this research study comprised petroleum dispensing stations distributed in the seven Sub Counties of Kisumu County. The target population was divided into two groups: which was categorized into independent petroleum dispensing stations (IPDS) and branded petroleum dispensing stations (BPDS) as defined by the energy regulatory commission as illustrated in **Table 1** below.

A multi-stagesampling method was employed in the study, whereby from the seven sub-counties that form Kisumu County Four Sub Counties were purposefully selected as the sample. All petroleum dispensing stations in the four selected sub-counties formed the target population. The selected counties were Kisumu East, West, Central, and Muhoronibased on their high number of PDS that amounted to 57% of the total and all the petroleum dispensing stations formed the sample.

3. Results and Discussion

An observational checklist and structured interview were used to collect data on the extent of the implementation of the Fire Risk Reduction Rules with the

Table 1. Target population.

Sub County	Independent petroleum Dispensing stations	Branded petroleum Dispensing stations	Total
Kisumu Central	3	16	19
Kisumu East	4	8	12
Kisumu West	6	2	8
Nyando	3	3	6
Muhoroni	3	5	8
Seme	2	2	4
Nyakach	3	2	5
TOTAL	24	38	62

Source: author-physical count (2016).

results as indicated in Table 2.

The study established that 90.3% of the BPDS and 68.8% of the IPDS had fixed storage tanks in a safe position while 9.7% of the BPDS and 31.2% of the IPDS had not implemented this requirement. This was attributed to the keenness on safe storage of petroleum products in underground tanks and ensuring implementation by the occupiers especially the branded petroleum dispensing stations who operate with standard procedures since they are owned by multinational companies as compared to the independently owned petroleum dispensing stations.

The study also established that 83.9% of the BPDS and 56.2% of the IPDS had installed fire resistant storage structures while 31.1% of the BPDS and 43.8% of the IPDS had not implemented the requirement. Fire resistant storage structures are key priorities to any petroleum dispensing station as they will determine the fire safety of the workplace and its neighborhood, most branded petroleum dispensing stations had implemented this requirement as compared to the independently owned stations who had some of their petroleum products stored in temporary drums which are not fire resistant due to minimal storage spaces provided for storage and ignorance on its consequences.

Only 32.3% of the BPDS and 25% of the IPDS had installed vent pipes on the storage tanks, this was as a result of lack of awareness on the importance of the provision of the vents as had been established during awareness interview done in the study and ignorance the occupiers had, as most of the occupiers had prioritized the security of the petroleum products hence safety being secondary with regard to the provision of the vents

Data on the implementation of installation of firefighting equipment and detection systems in the petroleum dispensing stations was sought as tabulated in Table 3 below.

Fire risk reduction rules section 29(1,2) require every occupier to provide means of extinguishing fire at the workplace and ensure that the position is distinctively and conspicuously marked. Most petroleum dispensing stations had

Table 2. Implementation of safe storage and handling of highly flammable substances.

VARIABLE	Branded petroleum dispensing stations				Independent petroleum dispensing stations			
	YES		NO		YES		NO	
	Freq	%	Freq	%	Freq	%	Freq	%
Fixed Storage tanks in safe position away from direct sunlight	27	90.3	4	9.7	11	68.8	5	31.2
Fire resistant storage structure	26	83.9	5	31.1	9	56.2	7	43.8
Availability of vent pipes on storage tanks.	10	32.3	21	67.7	4	25	12	75

Table 3. Firefighting equipment and detection systems installation.

Variable	BPDS				IPDS			
	YES		NO		YES		NO	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%
fire detectors	9	29	22	71	2	12.5	14	87.5
Fire alarm system	12	38.7	19	61.3	1	6.2	15	93.8
Dry powder extinguishers	20	64.5	11	35.5	6	37.5	10	62.5
Water type extinguishers	19	61.3	12	38.7	7	43.7	9	56.3
Carbondioxide type extinguishers	15	48.4	16	51.6	2	12.5	14	87.5
Automated foam sprinkler system	0	0	31	100	0	0	16	100

installed portable fire extinguishers though not adequate according to the hazards within the workplace, none had fixed firefighting installation which could be more appropriate for the fires involved in such workplaces. It was established that most of the petroleum dispensing stations had installed portable extinguishers as the main firefighting equipment, most being dry powder type of fire extinguisher at 64.5% in BPDS AND 37.5% of IPDS this was contrary to a study carried out by [3] Muindi on assessment of workplace fire safety preparedness in KMTC in Eastern Kenya region which established that the availability of fire extinguishers in the workplaces was less than half (35.5%).

Formation and training of fire fighting teams in any workplace is key to attainment of quick and effective response in any fire incident, interviews were carried out to establish the implementation of this requirement in the petroleum dispensing stations, as indicated in **Table 4** below.

The study established that 48.4% of branded petroleum dispensing stations and 25% of independent petroleum dispensing stations had trained staff on fire safety, this was attributed to the fact that most of these workplaces rely on county

Table 4. Formation and training of firefighting teams.

Variable	BPDS				IPDS			
	Implemented		Not implemented		Implemented		Not implemented	
	Freq	%	Freq	%	Freq	%	Freq	%
Formation of firefighting teams	12	38.7	19	61.3	2	12.5	14	87.5
Training of firefighting teams	15	48.4	16	51.6	4	25	12	75

fire brigade on response to fire incidents. This was contrary to a study carried out by [4] Kulkarni *et al.* on Knowledge and practices regarding fire safety amongst health care workers in tertiary care teaching hospital in Marathwada region of Maharashtra, India, indicating that 53.96% received training of fire safety, 96.4% health care worker knew that what action to be taken in the case on fire accident and DCP fire extinguisher can be used for A, B, C, type of fire while concurring with the study by Muindi indicated 84% of the respondents had never been trained on fire safety preparedness, knowledge of the staff on fire safety preparedness was low. It was also established that 38.7% of BPDS and 12.5% of IPDS had formed firefighting teams while 61.3% of the BPDS and 87.5% of the IPDS had not implemented this requirement.

An observation checklist and records of proof on the installation of spark proof electrical equipment and bonding systems during offloading of the flammable products were sought as indicated in **Table 5** below.

According to the FRRR, section 13 any workplace dealing with highly flammable and combustible substances should install spark proof electrical equipment especially in the sites where flammable vapors are likely to be concentrated, in the case of petroleum dispensing stations, all fittings on the fueling pumps and offloading areas should comply with this requirement, it was established that 64.5% of BPDS and 43.8% of IPDS had installed spark proof electrical equipment. Spark proof electrical fittings curb causes of fire and explosion due to exposure of electrical fittings and equipment to flammable vapors in the right proportions.

It was also established that 48.4% of BPDS and 31.2% of IPDS had provided bonding facilities at offloading and loading points while 51.6% of BPDS and 68.8% of IPDS had not implemented the requirement, the importance of bonding of loading and offloading trucks was overlooked at most of this workplace, this could be because of lack of awareness on the consequences from such work.

Data on the Implementation of the requirement to have relevant signage conspicuously displayed in the petroleum dispensing stations was collected and established as indicated in **Table 6** below.

The study established that 83.9% of BPDS and 56.3% of IPDS had implemented the requirement to display restriction on the use of mobile phone at the workplace while 16.1% of BPDS and 37.5% of IPDS had not implemented this

Table 5. Installation of spark proof electrical equipment and bonding.

Variable	BPDS				IPDS			
	Implemented		Not implemented		implemented		Not implemented	
	Freq	%	Freq	%	Freq	%	Freq	%
Bonding provision on pumps and offloading site	15	48.4	16	51.6	5	31.2	11	68.8
Spark proof electrical equipment	20	64.5	11	35.5	7	43.8	9	56.2

Table 6. Availability and display of relevant signage.

Variable	BPDS				IPDS			
	YES		NO		YES		NO	
	Freq	%	Freq	%	Freq	%	Freq	%
Restriction of use of mobile phone at pump site	26	83.9	5	16.1	9	56.3	7	43.7
NO smoking signage	28	90.3	3	9.7	10	62.5	6	37.5
Switch off engine while fueling	17	54.9	14	45.1	4	25	12	75
Fire assembly point	18	58.1	13	41.9	6	37.5	10	62.5

requirement, contrary to the availability of the signage within the station, most of the personnel and customers, noted, visiting these workplaces were not adhering to the signages, most of the dispensing stations had provided the use of mobile pay at the pump site, hence, the petroleum dispensing station occupiers need to provide a pay point away from the pump sites, which is deemed safe for electronic payment, this can be identified in liaison with the occupation safety and health officers. Rectification on violations of stipulated FRRR should be noted during inspections carried out by stipulated directorate of occupation health and safety officers which do not seem to be the case as observed during the study. Lack of adequate audits on Fire safety creates room for violations. It was also established that 90% BPDS and 62.3% IPDS had implemented the NO smoking signage. This was attributed to awareness and enforcement of the [5] Tobacco Control Act (2012) on prohibition of smoking at any public area except at designated points and occurrence of fire due to source of ignition resulting in keenness on enforcing this requirement.

It was also established that 54.9% of BPDS and 25% of IPDS had implemented the display of signage on switching off of engine while fueling, while 45.1% of BPDS and 75% of IPDS had not implemented the requirement, from observation and interview carried out established that most of the customers do not adhere to this requirement probably due to the culture and lack of adequate enforcement from the dispensing station personnel. Fire assembly points are established

for persons at the workplace to gather for further instructions during the occurrence of fire incidents at the work place, from the study it was established that only 58.1% of BPDS and 37.5% of IPDS had implemented this requirement, this could have been attributed to the importance attached to setting aside such spaces by the occupiers, this concurred with a study carried out by [6] Kironji where 28.57% had adequate fire assembly point, 21.43% were not while 50% had no fire assembly point and concluded that the key challenge with the provision of assembly point was lack of adequate space in the city to locate the assembly point due to priority on car wash, car park, storage of waste and other items.

Measurements were carried out to further establish the implementation of mounting portable fire extinguishers on the height of not less than 60 cm from the floor at the petroleum dispensing stations.

Measurements to establish the implementation of mounting of portable firefighting in the petroleum dispensing stations were carried out as indicated in Table 7 below.

According to the [7] fire risk reduction rules LN59 29(3), it is required of every occupier to ensure that any portable fire extinguisher is mounted at an easily accessible height of not less than 60 cm from the floor. It was established that most of the fire extinguishers found were not mounted at all being 55 number while 29 were mounted at a height which was not easily accessible being above one metre from the floor. Though the requirement does not specify the maximum height, extinguishers should be easily accessible for quick response in the event of an incident. Accessibility of firefighting equipment is key to fast containment of any fire incident at a given workplace, the reaction during the first few minutes of the inception stage of any fire will determine the magnitude of the incident.

Further analysis on the association on duration of operation of petroleum dispensing station and implementation of the fire risk reduction rules was done to establish the significance present as indicated in Table 8 below.

It was established that there was no statistical significance between the number of years a station had been in operation and implementation of storage of Petroleum tanks in fixed tanks in a safe position away from direct sunlight where $\chi^2 = 2.62$, df = 4, p = 0.062 whereas availability of adequate firefighting equipment and detection systems indicated a strong relationship between the

Table 7. Height of mounted portable fire extinguishers.

Height in cm	Number of extinguishers	
	BPDS	IPDS
Not mounted	35	20
60 cm	35	10
61 - 100 cm	23	17
Above 100 cm	19	10

Table 8. Association between duration PDS has been in operation and extent of implementation of relevant sections of the fire risk reduction rules.

FRRR	Duration PDS has been in operation	Number of stations	Status of implementation	
			Implemented	Chi-square
Fixed Storage tanks in safe position away from direct sunlight	0 - 1 year	7	5 (10.6%)	$\chi^2 = 2.62$, df = 4, p = 0.062
	1 - 5 years	24	20 (42.5%)	
	5 years and above	16	12 (25.5%)	
Availability of adequate Dry powder type of extinguishers	0 - 1 year		4 (8.5%)	$\chi^2 = 2.35$, df = 6, p = 0.025
	1 - 5 years		10 (21.3%	
	5 years and above		12 (25.5%)	
Carrying out of fire safety Audits	0 - 1 year		1 (2.1%)	$\chi^2 = 0.327$, df = 1, p = 0.002
	1 - 5 years		4 (8.5%)	
	5 years and above		6 (12.8%)	
Training of firefighting teams	0 - 1 year		2 (4.3%)	$\chi^2 = 1.602$, df = 2, p = 0.003
	1 - 5 years		3 (6.4%)	
	5 years and above		14 (29.8%)	
Installation of spark proof electrical equipment and fittings	0 - 1 year		4 (8.5%)	$\chi^2 = 1.957$, df = 4, p = 0.524
	1 - 5 years		15 (31.9%)	
	5 years and above		8 (17%)	

number of years a station had been in operation and implementation where $\chi^2 = 2.35$, $p = 0.025$. This indicated the inconsistency in statistical significance between the number of years a petroleum dispensing station has been in operation, there was no guarantee of full compliance on those stations who had been in operation above five years compared to those which had been in operation for less than a year.

Explosive vapor presence in petroleum dispensing stations are rampant due to the nature of work carried out at in these workplaces, The study sought to establish the measurements at the different points within the petroleum dispensing stations. An explosimeter was used to measure the presence of Explosive vapor within different points within the station to determine its safety status as indicated in Figure 1 below.

The measures obtained from the fueling pump site indicated presence of explosive concentrations during fueling time at readings of 2.4% during daytime and 2.2% during the nighttime indicating that the introduction of ignition source guaranteed explosion could occur. This was attributed to increased workload during the day and increased temperatures which lead to high expansion rate of fuel and increased fume generation. Readings recorded when the pump site was

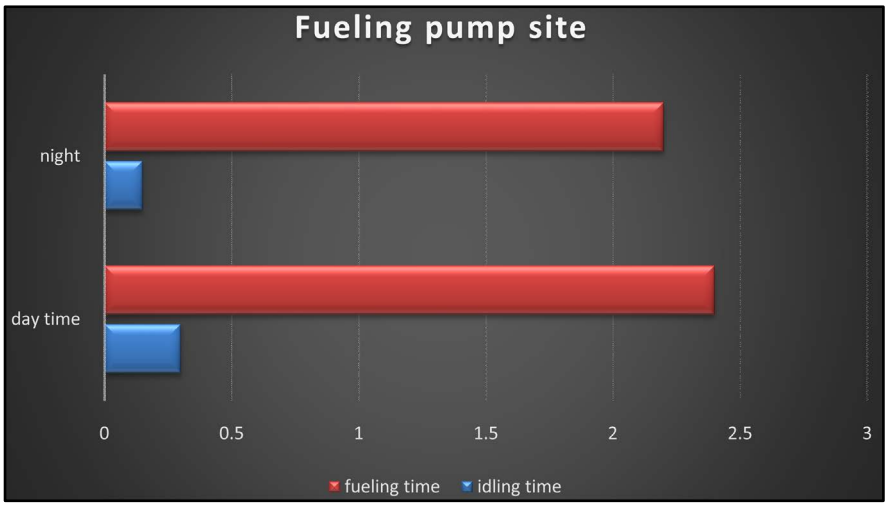

Figure 1. Explosive limit measurements at the fueling pump site.

idle or not fueling established it was below the lower explosive limit, which indicated being too lean to burn. Indicating that in the event of fuel dispensing he is fume generation while during idling time the less risk of fire occurring as explosive readings are noted to be low.

Further measurements were carried out to find out the concentration of explosive vapor at the fuel offloading sites during the active offloading time and the non-offloading time as indicated in **Figure 2**.

The fuel storage site also had varied or readings during the offloading of gasoline, the concentration of the explosive vapor was 3.0% during daytime and 2.4% at night, this indicated the danger of explosion at introduction of an ignition source during both periods. The idle time indicating flammable vapor concentration is too lean to support combustion. The reading indicated the need to barricade offloading sites when the process is going on and placing firefighting equipment on standby to be used in the event of fire occurring.

The service bays at petroleum dispensing stations are key areas where maintenance of vehicles and other works take place apart from fueling, measurements on the concentration of explosive vapour presence were done to establish its safety, the results are as indicated in **Figure 3** below.

The service bay could be considered the safe place in the petroleum dispensing stations as the readings during both night and day are below the lower explosive limits. This could be attributed to the sense that the works carried out in these sites does not entail direct handling of gasoline. Though due to wind direction changes, the bays could receive the flammable vapor concentration from either the pump dispensing site or the fuel storage area.

4. Conclusion and Recommendations

Implementation of fire risk reduction rules was not fully done by the petroleum dispensing stations as required by the regulation. None of the stations had fully complied with the implementation.

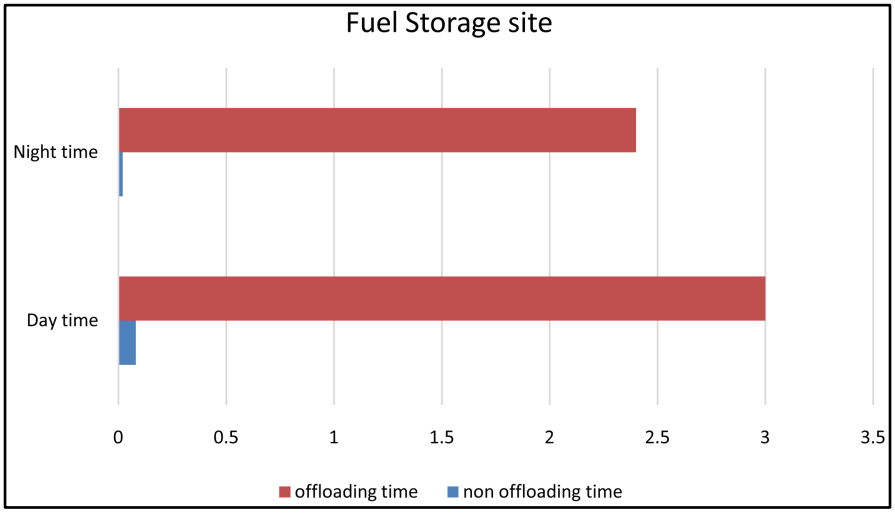

Figure 2. Explosive limit measurements at the fuel storage site.

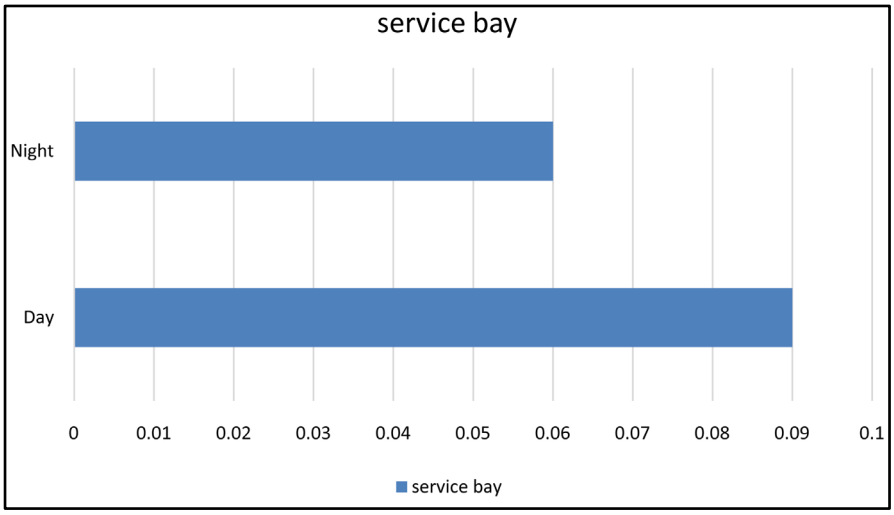

Figure 3. Explosive limit measurements at the service bay.

There was no significant statistical relationship between the number of years a station has been in operation and the full implementation of the fire risk reduction rules. Some of the implemented regulations were not enforced hence rendering the general purpose of the requirements lose its meaning and jeopardizing the fire safety status of the petroleum dispensing stations.

The study recommends:

1) The directorate of occupation safety and health should beef up capacity to enable attainment of inspection of workplaces to ensure implementation of the set-up rules within the law.

2) Zoning should be carried out to determine the safe areas where works deemed to cause ignition can be carried out for example mobile phone payments.

3) Improvement of the existing regulation regarding the handling of highly flammable petroleum products to be specific.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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