JENRM, Vol. 3, No. 1, 15-22, 2016
Research Article

Evaluation of the Operations of Liquefied Petroleum Gas Refilling Plants in Ghana – A Case Study

Broni-Bediako, Eric [1], Amorin,Richard [2]

Abstract
The demand for Liquefied Petroleum Gas (LPG) in Ghana has increased over the years since the Government LPG Promotion Programme in 1990 and has resulted in the rise of the operations of LPG refilling plants in Ghana especially in the urban areas. The operations of these refilling plants have raised a lot of concerns among the general public over the years due to its associated accidents. The study aimed at evaluating the operations of LPG refilling plants in Ghana using Tarkwa as the study area. It adopted survey as its research design and supported with literature review. The main instrument used for data collection was a questionnaire. Data collected from five refilling plants were analysed using statistical methods as well as the grading criteria prescribed by National Petroleum Authority (NPA) of Ghana. None of the LPG refilling plants attained "Grade A". It is recommended that there should be constant monitoring on the operations of LPG refilling plants to ensure total compliance with standards.

Keywords
Liquefied Petroleum Gas (LPG)—National Petroleum Authority (NPA)—Refilling Plant

[1] *bronibediako2005@yahoo.com* Petroleum Engineering Department, University of Mines and Technology
[2] *richard_amorin2006@yahoo.com* Petroleum Engineering Department, University of Mines and Technology

Contents

1. Introduction

Liquefied Petroleum Gas (LPG) is one of the most common and alternative fuels used in the world today [1]. Liquefied Petroleum Gases (LPGs) are by-products of natural gas productions and refineries. LPGs mainly consist of mixtures of hydrocarbons such as propane (C_3H_8), propene (C_3H_6), *n*-butane (C_4H_{10}), isobutene (methyl-propane), and various proportions of other butanes (C_4H_8) [2]. Most commercial applications employ propane or butane [3]. The unique properties of LPG make it a versatile energy source with enormous applications. Some of the applications of LPG are in transportation, domestic activities such as cooking and heating, commercial business, farming, and industrial operations. Amongst these uses, domestic sector is one of the most popular applications for LPG with almost 45% of the global demand coming from domestic cooking and heating [4]. LPG is gaining recognition in Ghana as important fuel source for domestic, commercial, and industrial uses. This could be attributed to its reliability, efficiency, convenience and environmental friendliness. The demand for LPG has attracted investments into the LPG sector which has resulted in the rise of the operations of LPG refilling plants in Ghana especially in the urban areas. The operations of these refilling plants have raised a lot of concerns among the general public over the years due to its associated accidents. To avert LPG related accidents at LPG refilling stations, there is the need to ensure that LPG refilling operators comply with guidelines stipulated by the regulatory body, National Petroleum Authority (NPA). This paper evaluates the operations of LPG refilling plants in Ghana using Tarkwa as the study area.

2. Study Area

Tarkwa, the capital of the Tarkwa-Nsuaem Municipality of the Republic of Ghana is a town in the south-western part of Ghana. Tarkwa is a town which is blessed with gold and manganese and therefore has lots of mining companies like Goldfields Ghana Limited (GGL), Anglogold Ashanti (AGA) and Ghana Manganese Company (GMC). The inhabitants are mainly into mining of these minerals and agriculture. Tarkwa has a 2016 settlement population of about 41,345 people. The municipality is situated between latitudes 4° 0' 0"N and 5° 40' 0"N and longitudes 1° 45' 0"W and 2° 1' 0"W (Fig.1. It is bounded to the north by Wassa Amenfi District, the south by the Ahanta West District, the west by the Nzema East District and the east by Mpohor Wassa East District. Most of the habitants of Tarkwa are migrants from other parts of the country [5, 6, 7].

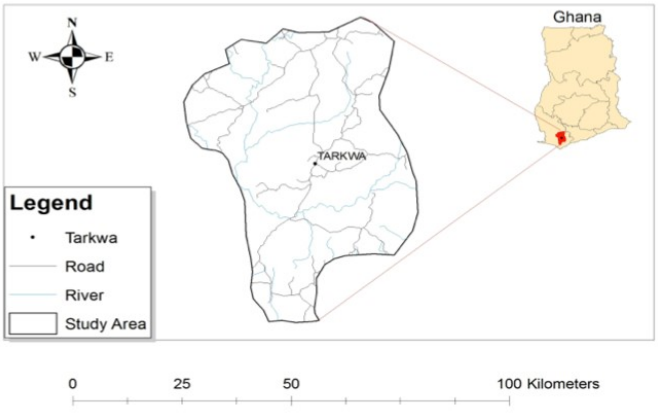

Figure 1. Map Showing the Location of Tarkwa

3. Data Collection and Analysis

3.1 Data Collection Technique

Questionnaire adopted from NPA was the main instrument for collecting data for the research. According to Yin [8], questionnaire is a widely used and important instrument for collecting survey information. It provides structured, often numerical data, being able to be administered without the presence of the researcher, and often being comparatively straightforward to analyse. The questionnaire which required a "yes" or "no" answer and a weighted mark for each answer was used. Responses to the questionnaires were done with the help of the researchers in the form of interactions and interviews. A response to each question whether positive or negative was awarded with the assigned mark(s). In all, five refilling plants were evaluated which currently constitutes the total refilling plants in Tarkwa. The operations of LPG refilling plants were assessed in eight (8) thematic areas as follows:

- Part A: Regulatory Requirements.
- Part B: Occupational Health and Safety.
- Part C: Training Programme.
- Part D: Housekeeping.
- Part E: Maintenance Scheme.
- Part F: Emergency Procedures.
- Part G: Technical Requirements.
- Part H: Infrastructure Requirements.

3.2 Primary and Secondary Data

According to [9], no single source of data has a complete advantage over the others and that the various sources of data collection are highly complementary. In this study, both primary and secondary data were used. Primary data were obtained from operators of LPG refilling plants in Tarkwa through the administration of questionnaires whilst Secondary data were obtained from published literature and government documents.

3.3 Field Visit

The researchers took field visits to five refilling plants to observe the various operations whether the operations conform to the standards of National Petroleum Authority (NPA) of Ghana.

3.4 Data Analysis

Data collected were analysed using simple percentage. Response to a question was assigned the weight stipulated by National Petroleum Authority of Ghana and the individual percentages were obtained from the individual scores and the total weight (score). Refilling plants were graded based on the modified grading system presented in Table 1.

Table 1. Grading System

Category	Score (%)	Remarks
Grade A	80-100	Very Good
Grade B	60-79	Good
Grade C	50-59	Average
Grade D	< 50	Poor

Source: Modified after Anon, 2010

4. Results and Discussion

4.1 Regulatory Requirements

National Petroleum Authority requires all LPG refilling stations to acquire permits and licenses from the approved

institutions in the country. There are about ten (10) regulatory requirements stipulated by NPA [2]. The research revealed that among the five LPG refilling plants in the Tarkwa, Refilling Plant (R. Plant) C and D had almost all regulatory requirements stipulated by NPA except Public Liability Insurance requirement (89%) . Refilling Plant A had a total score of 14 out of 18, indicating 78 % fulfilment of the regulatory requirements. Refilling Plants B and E had 72% (13) and 67% (12) of the regulatory requirements fulfilled respectively. The refilling plants in Tarkwa have complied with 78% of the regulatory requirements. (Table2).

Table 2. Table 2 Regulatory Requirements among Refilling Plants

Regulatory Requirement	**R. Plant A**		**R. Plant B**		**R. Plant C**		**R. Plant D**		**R. Plant E**	
	Y	N	Y	N	Y	N	Y	N	Y	N
EPA Permit Certificate	2	0	2	0	2	0	2	0	2	0
NPA construction Permit	2	0	2	0	2	0	2	0	2	0
Valid Ghana Standard Board Verification Certificates	1	0	0	1	1	0	1	0	1	0
Stickers (Green/Red) devices	1	0	0	1	1	0	1	0	1	0
Non Destructive Test Certificate	2	0	2	0	2	0	2	0	2	0
Ghana National Fire Service Certificate	2	0	2	0	2	0	2	0	2	0
Factories Inspectorate Division Certificate of Examination	0	2	0	2	2	0	2	0	0	2
Development and Building Permits	2	0	2	0	2	0	2	0	2	0
Insurance Certificate for Facility	2	0	2	0	2	0	2	0	0	2
Public Liability Insurance.	0	2	0	2	0	2	0	2	0	0
Percentage (%)	***78***	***22***	***67***	***33***	***89***	***11***	***89***	***11***	***72***	***28***

Y=YES, N=No

4.2 Occupational Health and Safety

Occupational health and safety is the key to the effective operation of any installation to ensure productivity at all stages of operation. LPG refilling plant outlets have a moral, legal duty of care to ensure that employees and any other person who may be affected by their operations remain safe at all times. Table 3 shows the level of occupational health and safety practices among the LPG refilling plants in Tarkwa. Out of the five refilling plant visited, R. Plant B had the best Occupational Health and Safety (OHS) practices followed by R. Plant D. Refilling Plant B had a total score of 5 out of 5 indicating 100% fulfilment of the requirements whilst R. Plant D had a total score of 4 out of 5 indicating 80% fulfilment of the OHS requirements.

About 100% of the respondents had safety shower contributing to good OHS culture. Majority (55%) of the refilling plants did not have uniforms/overalls, steel reinforced safety shoes, hand gloves (canvass/cotton/vinyl coated) and nose masks/breathing filters for the refilling plants attendants (Table 4). The refilling plants in Tarkwa have complied with 56% of the OHS items stipulated by NPA. This depicts that the level of Occupational Health and Safety of refilling plants in Tarkwa is average.

Table 3. Occupational Health and Safety Requirement among LPG Refilling Plants

Occupational Health and Safety Requirements	**R. Plant A**	**R. Plant B**	**R. Plant C**	**R. Plant D**	**R. Plant E**
Uniforms/Overalls for the filling attendants	0	1	0	1	0
Steel reinforced safety shoes	0	1	0	1	0
Hand gloves (canvass/cotton/vinyl coated)	1	1	0	1	0
Nose masks/breathing filters	0	1	0	0	1
Safety shower	1	1	1	1	1
Total	***2***	***5***	***1***	***4***	***2***
Percentage	***40***	***100***	***20***	***80***	***40***

Table 4. Occupational Health and Safety Requirement of LPG Refilling Plants

Occupational Health and Safety Requirements	**Yes**	**%**	**No**	**%**
Uniforms/Overalls for the filling attendants	2	40	3	60
Steel reinforced safety shoes	2	40	3	60
Hand gloves (canvass/cotton/vinyl coated)	3	60	2	40
Nose masks/breathing filters	2	40	3	60
Safety shower	1	100	0	0

Table 5. Training Programme

Refilling Plant	**Training Programme**	**Percentage (%)**
	Yes No	**Availability of Training Programme**
R. Plant A	2 0	100
R. Plant B	0 2	0
R. Plant C	0 2	0
R. Plant D	0 2	0
R. Plant E	0 2	0

4.3 Training Programme

The NPA requires that training be conducted for all personnel working at the LPG refilling plant in Ghana and that the staff involved with handling and refilling LPG cylinders must be trained. The weight for this requirement is two (2). Out of the five LPG refilling plant visited, only one plant station had training programme available for the plant attendant indicating 20% of LPG refilling plants in the catchment area. The rest (80%) did not have training programme available for plant attendants. NPA requires that after initial training, each staff should receive regular training and that refresher training must be provided at least every three years. However, after interviewing the plant attendants, it was revealed that the majority (80%) of the refilling plant stations' attendants had never received any other form of training after their initial training and was therefore depending solely on the day-to-day experience on the job (Table6).

Table 6. Training Programme

Refilling Plant	Training Programme		Percentage (%)
	Yes	No	*Availability of Training Programme*
R. Plant A	2	0	100
R. Plant B	0	2	0
R. Plant C	0	2	0
R. Plant D	0	2	0
R. Plant E	0	2	0
Percentage (%)	***20***	***80***	

4.4 Good Housekeeping

Good housekeeping can help eliminate some workplace hazards and promote safer and proper job handling. As shown in Fig.2, R. Plant B had the highest score of 9 out of the total score of 9 indicating 100% followed by R. Plant C scoring 6 (67%). Refilling Plants A and D had equal weight of 4 (44%) followed by R. Plant E which had the least weight of 1 indicating 11%.

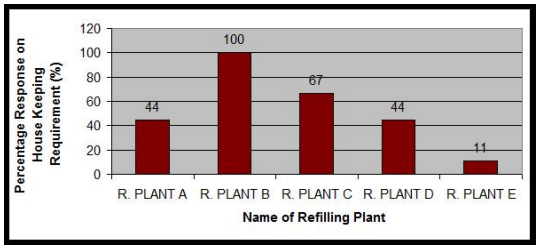

Figure 2. Housekeeping Requirement among LPG Refilling Plants

The refilling plants in Tarkwa have complied with 53% of the basic housekeeping requirements stipulated by NPA (Table 6). In addition, about 60% had washing soap and toilet paper in the washrooms which contribute to some aspect of housekeeping but not enough as categorised by NPA. It was observed that about 80% of the LPG refilling plants had no disposal paper towel/hand dryer in the washroom and poor cleanliness of the washroom (Fig.3). Generally, LPG refilling plants in Tarkwa lack proper house keeping practice. About 53% of the basic house keeping requirements stipulated by NPA is complied by refilling plants in Tarkwa (Fig. 4). This shows that the level of house keeping of refilling plants in Tarkwa is average (50% - 59%).

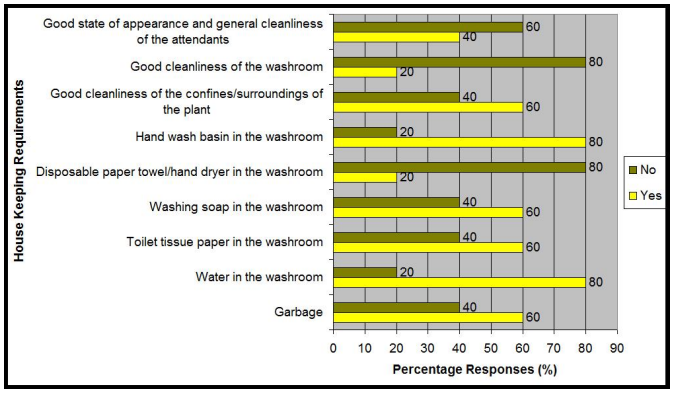

Figure 3. Housekeeping Requirement of LPG Refilling Plants

4.5 Maintenance Scheme

Good maintenance scheme can help eliminate major maintenance work and down times but that is not the case with refilling plants in Tarkwa. Out of the five refilling plants visited, only Plant C had the highest maintenance scheme, scoring 4 out of 7 indicating 57% though far below grade A (80-100) set by NPA. The rest of the Refilling Plants (A, B, D and E) had equal weight of 1 representing 14% as shown in Fig.4.

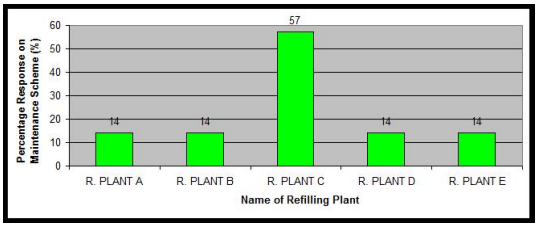

Figure 4. Maintenance Scheme among LPG Refilling Plant

This research work also revealed that none of the LPG refilling plants conducts quarterly maintenance for the LPG installations. However majority (80%) of the refilling plants had monthly maintenance work as the common practice. This indicates the poor maintenance practices among the respondents and therefore in an event of any break down, time and money would be required for major maintenance to be conducted on the LPG refilling plants. Generally, LPG refilling plants are under-maintained (Fig.**??**).

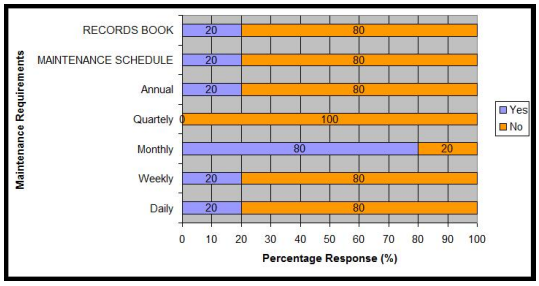

Figure 5. Maintenance Scheme Practices of LPG Refilling Plants

4.6 Emergency Procedures

The safe operation of any LPG refilling plant requires the availability of an emergency plan and an alarm system as set by NPA. The essence of the alarm system is to notify all personnel at the premises of any danger. Out of the five sampled refilling plants, only R. Plant A had both emergency plan and alarm system scoring 3 out of the total weight of 3 (100%). The rest of the refilling plants did not have alarming system installed thus increasing the chance for fire out break and explosion. In terms of the availability of emergency plan and alarm system, the refilling plants in Tarkwa have complied with 60% and 20% respectively. Generally, LPG refilling plants in Tarkwa have poor emergency procedures. Only 40% of the basic emergency requirements stipulated by NPA are complied by refilling plants in Tarkwa (Table 7).

Table 7. Emergency Procedures

Refilling Plant	**Emergency Plant**		**Alarm System**		**Percentage (%)**	
	Y	N	Y	N	*Emergency Plan*	*Alarm System*
R. Plant A	2	0	1	0	100	100
R. Plant B	0	2	0	1	0	0
R. Plant C	0	2	0	1	0	0
R. Plant D	2	0	0	1	100	0
R. Plant E	2	0	0	1	100	0
Percentage (%)	***60***	***40***	***20***	***80***		

4.7 Technical Requirements

As stipulated by the NPA, it is required of all LPG refilling plants to meet all technical requirements for the safe operation of all LPG refilling plants. The availability of dry chemical powder extinguishers, carbon dioxide extinguisher, water reservoir, colour coding for LPG vessels and pipelines and as well as flame arrestors for auto gas dispensing pumps amongst the lot are the technical requirements that have to be fulfilled at every refilling plant. Out of a total weighted score of 45, it was revealed that R. Plant D had complied with 80% (36) of the requirements obtaining Grade A (80-100) followed by R. Plants A (76%), B (71%) and C (67%) with each obtaining Grade B. Surprisingly, R. Plant E had Grade C, scoring 51% (Fig.6). The refilling plants in Tarkwa have complied with 69% of the technical requirements as stipulated by NPA.

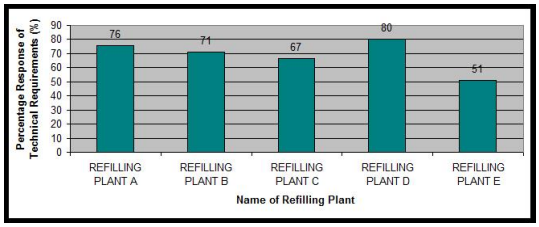

Figure 6. Maintenance Scheme Practices of LPG Refilling Plants

5. Infrastructure Requirements

It is required that all LPG refilling plants in the country meet all infrastructure requirements as stipulated by NPA. Among these requirements are size of plot, state of filling dock and the availability of parking lot for vehicles, changing room, office/salesroom, flame proof lighting system, fire resistant wall, water closet toilet and wooden planks/bitumen on floor. Interestingly, among all the five LPG refilling plants, only R. Refilling plant A had the highest score of 73% (8) representing Grade B. Refilling Plant B and D had Grade B with equal weight of 64% (7) out of 100%(11). Refilling plant C and E failed to meet at least 50% of infrastructure requirements stipulated by NPA and thus obtained Grade D (Fig.7). The refilling plants in Tarkwa have complied with 56% of the infrastructure requirements set by NPA.

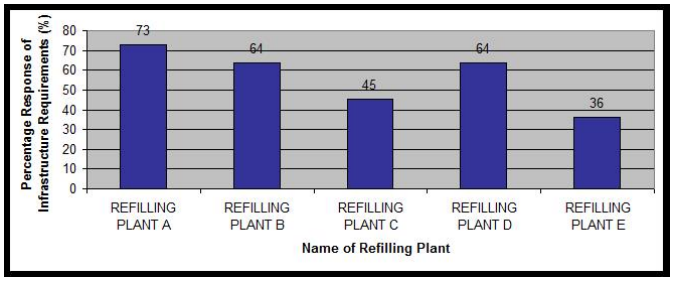

Figure 7. Infrastructure Requirements among LPG Refilling Plant

5.1 Overall Weight

The overall weight of each of the refilling plants under the eight thematic areas of assessments revealed that none of the plants obtained overall Grade A (Very Good). R. Plants A, B, C and D obtained Grade B (Good) each while R. Pant E had grade D (Poor). The grade of all the R. Plants in Tarkwa is B (Table 8).

Table 8. Overall Weights

Assessment Areas	R. Plants				
	A	B	C	D	E
Regulatory Requirements	14	12	16	16	13
Occupational Health & Safety	2	5	1	4	2
Training Programme	0	2	0	0	0
Housekeeping	4	9	6	4	1
Maintenance Scheme	1	1	4	1	1
Emergency Procedures	3	0	0	2	2
Technical Requirements	34	32	30	36	23
Infrastructure Requirements	8	7	5	7	4
Overall Weights (100)	**66**	**68**	**62**	**70**	**46**
Overall Grading	**B**	**B**	**B**	**B**	**D**

6. Conclusions and Recommendation

Based on the analysis from the research, the following conclusions can be drawn:

- LPG refilling plants in Tarkwa have fulfilled 79% of the regulatory requirements of NPA
- Generally, LPG refilling plants in Tarkwa lack good OHS culture. They have complied with 56% of the OHS items stipulated by NPA.
- Majority of the LPG refilling plants in the Tarkwa do not have training programme for the plant attendants.
- The refilling plants in Tarkwa have complied with 53% of the basic housekeeping requirements stipulated by NPA.

- None of the LPG refilling plants conducts quarterly maintenance scheme for the plant. However, 80% of these LPG refilling plants conduct monthly maintenance work.
- LPG refilling plants in Tarkwa have poor emergency procedures. They have complied with 40% of the basic emergency requirements stipulated by NPA.
- The refilling plants in Tarkwa have complied with 69% of the technical requirements stipulated by NPA.
- None of the refilling plants in Tarkwa obtained Grade A in terms of infrastructure requirements. Three of the refilling plants attained Grade B (60 – 79%) whilst two refilling plants had Grade D (<50%).
- None of the refilling plants obtained an overall weight within Grade A. Four (4) of the refilling plants obtained Grade B and one (1) obtained Grade D.

It is therefore recommended that there should be constant monitoring on the operations of LPG refilling plants to ensure total compliance to standards.

7. Acknowledgement

The authors are very grateful to the Mr. Gedzia Korbla Hope, Graduate of University of Mines and Technology for his support during the collection of data.

References

[1] Akabzaa, T and Darimani, A.2001. "Impact of Mining Sector Investment in Ghana: A Study of the Tarkwa Mining Region", http://www.saprin.org. Accessed: March 28, 2014.

[2] Anon.2010. Guidelines for the Establishment of Liquefied Petroleum Gas Filling Plants in Ghana; National Petroleum Authority, pp. 1 – 30.

[3] Anon. 2014. "About LP Gas", www.worldlpgas.com. Accessed: March 28, 2014.

[4] Anon. 2014a. "Tarkwa", http://en.wikipedia.org/wiki/Tarkwa. Accessed: November 25, 2014.

[5] Bhattacherjee, A. 2012. Social Science Research: Principles, Methods and Practice, Creative Commons Attribution, pp. 48 – 87.

[6] Broni-Bediako, E. and Dankwa, K.O .2013. "Assessment of Liquefied Petroleum Gas (LPG) Utilisation in Ghana", A Study at Tarkwa, International Journal of Scientific and Technology Research, Vol. 2. pp. 6 - 10.

[7] Mustafa, K. F. and Gitano-Briggs, H. W. 2008. "Effect of Variation in Liquefied Petroleum Gas (LPG) Proportion in Spark Ignition Engine Emissions",. http://eprints.usm.my/id/eprint/13194. Accessed: March 29, 2014.

[8] Wilson, N. and McLean, S. 1994. Questionnaire Design: A Practical Introduction, University of Ulster Press, Newtown Abbey, Co. Antrim, pp. 211 - 220.

[9] Yin, R. K. 2003. Case Study Research: Design and Methods, Sage, Thousand Oaks, California, 173 pp.