

**DEVELOPMENT OF A SAFETY FRAMEWORK FOR BULK &
COMMERCIAL LPG SUPPLY SYSTEMS IN COMMERCIAL
BUSINESSES**

Basnayake J.K.

(149378X)

Degree of Master of Science

Department of Building Economics

University of Moratuwa

Sri Lanka

January 2018

**DEVELOPMENT OF A SAFETY FRAMEWORK FOR BULK &
COMMERCIAL LPG SUPPLY SYSTEMS IN COMMERCIAL
BUSINESSES**

Basnayake J.K.

(149378X)

Thesis submitted in partial fulfilment of the requirements for the degree Master of
Science in Safety and Health Management

Department of Building Economics

University of Moratuwa

Sri Lanka

January 2018

Candidate's Declaration

I declare that this is my own work and this thesis does not incorporate without acknowledgement of any material previously submitted for a Degree or Diploma in any other University or the institute of higher learning according to the best of my knowledge. I believe it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

In addition to that I hereby grant to the University of Moratuwa, the non-exclusive right to reproduce and distribute my thesis, in whole or in part, in print, electronic, or other medium. I retain the right to use this content in whole or in part in future works.

.....

.....

Signature:

Date:

Supervisor's Declaration

The above candidate has carried out research for the Master's thesis under my supervision.

Name of the Supervisor: Ch QS. Indunil Seneviratne

.....
Signature of the Supervisor

.....
Date

ABSTRACT

The purpose of this project is to analysis the commercial & bulk LPG supply systems in Sri Lanka and to develop recommendations the safe LPG supply distribution considering market demands in commercial applications. This covers all the LPG supply systems practiced in Sri Lanka by identifying customer's current perception and level of satisfaction with the traditional Gas withdrawal commercial 37.5Kg LPG cylinders and bulk storage LPG bullet tanks.

LP Gas is potentially hazardous from the point of production until it has been safely used and the combustion products have been properly disposed of. The term LP Gas describes a range of products which have much in common on safety concerns during distribution. Safety concerns are the understanding the behavior of LP Gas and keeping it under control during distribution.

The research findings reveal that industry currently follows unsafe practices that limit its ability to take full advantage of market developments and opportunities, particularly compared to bulk LPG supply system. This finding alone justifies the need for the LPG industry to find ways to work with LPG suppliers, distributors and dealers to develop commercially sustainable safe business models for supplying across the country's full consumer market. According to the study new liquid withdrawal cylinders or bulk tanks are to be introduced to the current model to minimize the risk. To enhance the knowledge of users, there is a requirement of comprehensive door to door training progress. Following up available standards, set controls on LPG installations and continuous safety audits can ensure the safety of current commercial and bulk LPG supply systems.

The level of challenges that exist will however likely lead to the commercial industry experiencing growing pains as it wrestles with securing market opportunities and reacting to the increasing competitiveness showed by bulk LPG suppliers. This research has summarized the problems of existing commercial & bulk LPG supply systems and it has shown the opportunity for implementing further safe systems to cater to the demand of industrial LPG requirements like in other many developed countries.

Key Words: LP Gas, Safe, Supply Systems, Risks, Distribution

Table of Contents

	Page
Candidates Declaration	i
Abstract	ii
Table of Content	iii
List of Tables	vii
List of Figures	viii
List of Abbreviations	x
List of Appendices	xi
1. Chapter 1	
Introduction	1
1.1 Background	1
1.2 Problems in current LPG supply system	5
1.3 Research Objectives	5
1.4 Research Methodology	7
1.4.1 Collection Of Primary Data	7
1.4.1.1 Questionnaire	7
1.4.1.2 Interview	7
1.4.1.3 Observation	7
1.4.1.4 Collection of Secondary Data	8
1.5 Data Analysis Techniques	8
1.6 Significance & Limitations of the Study	8
1.7 Chapter breakdown	9
2 Chapter 2	10
Literature synthesis	10
2.1 Status of Commercial LPG Installations	10
2.2 Overview of LPG Consumption in Sri Lankan industries	12

2.3	Practical Problems of Existing Commercial LPG Supply Systems	14
2.3.1	High rate of LPG leak incidents	14
2.3.2	No proper follow up of existing standards.	14
2.3.3	Unplanned increase in number of cylinders proportion to consumption	14
2.3.4	Customer complaints due to drop in efficacy and pressure and temperature	14
2.3.5	Cylinder Handling issues due to high frequency of replacements	15
2.3.6	Non application of correct calculations for cylinder sizing	15
2.4	Possible causes for deviations from standards in LPG installations & Safety Framework to mitigate the Risk.	15
2.4.1	Safety of LPG commercial installations	15
2.4.2	Issues in Siting Of the Tanks	16
2.4.3	Issues in Ventilation and Conditions Around The Tank	19
2.4.4	Tanker Access Issues	19
2.4.5	Security Issues	20
2.4.6	Impact protection	21
2.4.7	Emergency arrangements	21
2.4.8	Service pipework	21
2.4.9	Installation route	22
2.4.10	Materials of construction	22
2.4.11	Pressure	23
2.4.12	Inspection and maintenance	23
2.4.13	Replacement	24
2.4.14	Valves	24
2.5	Safety framework to Mitigate Risks	25
2.5.1	Firefighting measure	25
2.5.2	Training Requirements	26
2.6	Introduction to Bulk LPG Storage Tanks	27
2.6.1	Storage Tank Options	27
2.6.2	Above Ground Tank Option	28
2.6.3	Underground Tank Option	29
2.7	Basic liquid withdrawal LPG systems	30

2.8	Major defects of Commercial Cylinders	34
2.8.1	Regulator related issues	35
2.9	Calculations and Recommendations	36
2.10	Answers from Liquid Withdrawal System	38
2.10.1	Key Elements of Liquid Withdrawal Cylinder System	39
2.11	Research literature synthesis conclusions	41
3	Chapter 3	42
	Research Methodology	42
3.1	Collection of Primary Data	43
3.2	Analyze and selection of the sample population of the study	44
3.2.1	Selecting the Customers for administrating the questionnaire	44
4	Chapter 4	45
	Data Analysis	45
4.1	Standard Follow up issues in the current LPG installations	45
4.1.1	Number of Cylinders in the manifold	45
4.1.2	Answers to the standards follow up during design stage of the installation	46
4.1.3	Cylinder sweating During Operation	46
4.1.4	Pressure Drop in the system	47
4.1.5	Flame fluctuations	47
4.1.6	Separation Distance Constraints	48
4.1.6.1	Area Availability for further expansions	49
4.1.7	Actual and estimated peak LPG consumption	49
4.1.8	Distribution issues of Cylinders	50
4.2.	Advantages raised by the customer	50
4.3	Disadvantages raised by the customer	50
4.4	Data Analysis Conclusion	50

5	Chapter 5	51
5.1	Proposed Safety Framework for LPG installations	52
5.2	Proposed Bulk/Commercial installation procedure	53
5.3	Safety Audit questionnaires for commercial LPG installation system	54
5.4	Development of Risk Assessment	58
	Chapter 6	62
6.1	Conclusion and recommendations	62
5.2	Recommendations	66
5.3	Directions for Future Research	66
5.4	Reference List	68

LIST OF TABLES

Table 1:	Summary of Data Collection	8
Table 2:	Total LPG demand in Sri Lanka	12
Table 3:	Industry Segment wise LPG demand	13
Table 4:	Minimum Safety Distance for Storage Of LPG In Bulk At Customers’ Premises	19
Table 5:	Fire Guidelines for LPG storage system.	26
Table 6:	LPG vaporization Vs. Tank Sizes	28
Table 7:	Evaporation rate in LPG Mixture in different environment conditions	31
Table 8:	Rate of vaporization in cylinders in different environment conditions	32
Table 9:	Pressure drop along the pipeline	32
Table 10:	Number of cylinders Vs. Evaporation capacity	33
Table 11:	Cylinder Defects Analysis	34
Table 12:	Total population of commercial LPG consumers in Sri Lanka	44
Table 13:	Basic questionnaire for bulk/ commercial customers	52
Table 14:	Proposed Safety Audit Checklist	55
Table 15:	Cylinder storage capacity Vs. Safety distance requirement	50
Table 16:	Proposed Safety Audit Checklist	58

LIST OF FIGURES

Figure 1:	Research Methodology	6
Figure 2:	Chapter Breakdown	9
Figure 3 :	Basic commercial LPG manifold	10
Figure 4:	LPG cylinder manifold accessories	12
Figure 5:	Sri Lanka LPG demand breakdown	13
Figure 6:	Basic LPG Liquid Withdrawal System Block Diagram	30
Figure 7:	Drawing of Basic Liquid Withdrawal system	31
Figure 8:	Vapour pressure variation with time	32
Figure 9:	Basic Cylinder manifold install in a building	34
Figure 10:	Commercial customer's Major regulator fixing defects in cylinders	35
Figure 11:	Commercial customer's Major gas leak defects in cylinders	35
Figure 12:	Cross section of a commercial cylinder	36
Figure 13:	Standby & Operation cylinders	37
Figure 14:	Rate of vaporization in peak hours	37
Figure 15:	Basic Liquid Withdrawal LPG system	39
Figure 16:	LOT Valve	40
Figure 17:	Liquid withdrawal manifold with Vaporizer	40
Figure 18:	Pressure Vs LPG flowrate (NFPA 58)	40
Figure 19:	Research Methodology	42
Figure 20:	Cylinders in the manifold	45
Figure 21:	Status of Standard follow up at design stage	46
Figure 22:	Cylinder Sweating During Operation	46
Figure 23:	Pressure Drop in the system	47
Figure 24:	Uncontrolled flame conditions	47
Figure 25:	Space availability for further expansions	48
Figure 26:	Hourly peak LPG consumption	48
Figure 27:	Distance to the nearest LPG distribution hub	49
Figure 28:	Customer distance from Colombo	49
Figure 29:	Proposed Safety Framework Development Stages. Approved by the HSE committee of LPG suppliers	51

LIST OF ABBREVIATIONS

Abbreviation	Description
ASTM	- American Society for Testing and Materials
BLEVE	- Boiling Liquid Expanding Vapor Explosion
CBSL	- Central Bank of Sri Lanka
CPC	- Ceylon Petroleum Corporation
CSC	- Customer Service Center
ECV	- Emergency Control Valve
ESD	- Emergency Shut Down
GDP	- Gross Domestic Product
GSIUR	- Gas Safety Installation and Use Regulations
HEMP	-Hazard & Effect Management Process
HSE	- Health Safety & Environment
ICTAD	- Institute of Construction Training and Development
LGLL	- Litro Gas Lanka Limited
LOT	- Liquid Off Take
LPG	- Liquefied Petroleum Gas
NFPA	- National Fire Protection Agency
NRV	- Non Return Valve
OPSO	- Over-Pressure Shut-Off
OSHA	- Occupational Safety & Health Administration
PRV	- Pressure Relief Valve
QA	- Quality Assurance
SLS	- Sri Lanka Standard
SLTDA	- Sri Lanka Tourism Development Authority
UPSO	- Under-Pressure Shut-Off
WLPGA	- World Liquefied Petroleum Gas Association

LIST OF APPENDICES

Appendix	Description	Page
Appendix –A	Questionnaire for Commercial/ Bulk LPG Users	70
Appendix –B	Questionnaire Development for Safety Framework	72