Appendix
CNG cylinder burst in a bus during gas filling – Lesson learned

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ABSTRACT

An accident leading to bursting of a compressed natural gas (CNG) cylinder fitted to a passenger bus in India resulted one person died and four persons injured. This paper presents the incident, the human factor involved, safety issues and lesson learned.

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1. Introduction

Compressed natural gas, CNG, is the natural gas compressed into very high pressure of usually 3000–3600 psi (Ahmad, 2004). Natural gas is lighter than air, and mixtures of air and natural gas are inflammable only in a fairly narrow range of gas concentrations between 3.7% and 17% by volume (http://www.equivalentsparsmsds.com/getsinglePtsds.asp?ID=185971 dated 20.7.09). Natural gas is an environmentally clean, plentiful, low-cost fuel for motor vehicles. Chemically, it normally consists of over 90% methane with smaller amounts of ethane, propane, butane, carbon dioxide and other trace gases. The high methane content gives natural gas its high octane rating (120–130) and clean-burning characteristics, allowing high engine efficiency and low emissions. CNG has the following safety features that make it an inherently safer than petrol, diesel or LPG (Ahmad, 2004),

(1) It is lighter than air so if it leaks, it just rises up and dissipates into the atmosphere.
(2) It has a self-ignition temperature of 700 °C as against 455 °C for petrol.
(3) CNG has to mix with air within a small range of 3.7–17% by volume for combustion to take place. This is a far narrower range than for petrol.
(4) CNG cylinders are designed and built of special materials to withstand high pressures, therefore, are far safer than ordinary petrol tanks.

It is being used for many years in vehicles in countries like Argentina, Italy, Pakistan, Brazil, USA and New Zealand. CNG used as fuel for vehicles in only late 1990s in India. In Delhi (May 2001), the number of CNG buses rapidly increased from 900 to 7000, which represented perhaps the largest city CNG bus fleet in the world (Erlandsson and Weaver, 2002). In general, the major problem of the CNG bus in India is it is not suitable for travel at least 200 miles at a time due to non-availability of the CNG filling station all over the country. The danger of fire in case of leakage CNG would be greatest near the ceiling and for the liquid fuel it is always near the floor. The strength of the natural gas cylinders and fuel system generally avoids any leakage or fire. The accidental data are available in diesel powered vehicles but fatal accident data and experience are limited for CNG buses as it started recently in India. The major causes for CNG bus accident are due to the gas pipe disconnection, accident due to driver’s errors, related to filling operation and structural failures. Time has proven that natural gas vehicles safe in actual operation all over the world. This paper deals with incident that leads to burst one cylinder and killed one person and injured four persons is based on data collection, examination of material of construction of burst cylinder, scientific analysis, interviewed the eye witness and the role of human factor for the incident.

1.1. Human factor

The human factor defined by Health and Safety Executive as “Human factors refer to environmental, organizational and job factors, and human and individual characteristics which influence behavior at work in a way which can affect health and safety” (http://www.hse.gov.uk/humanfactors/majorhazard/index.htm dated 0925-7535/S - see front matter © 2010 Elsevier Ltd. All rights reserved.
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6.7.09). Human errors generally categorized into several types as operating errors, design errors, maintenance errors, fabrication errors, inspection errors and contributory errors (Meister, 1962). Lincon (1960) classifies five distinct types of errors in operating equipment and are as follows:

1. **Attention errors** – operator fails to pay attention to things when require attention.
2. **Memory errors** – operator’s memory fails to perform a required task as specified in the operating procedure.
3. **Interpretation errors** – misunderstands the meaning of given information and takes action accordingly by the operator.
4. **Operation errors** – incorrect action by the operator to achieve the desired effect.
5. **Identification errors** – incorrect identification of an item and so the subsequent decision is incorrect.

The operating errors are highlighted in Fig. 1. Human errors are also categorized as

1.2. **Unintentional**

- **Slips** – are failures during the actual execution of actions, speech, etc. (i.e. ‘actions-not-as-planned’). The plan itself may or may not be acceptable.
- **Lapses** – are failures at the storage or recall stage (i.e. forgotten information, planned actions, etc.). Again, the plan may or may not be acceptable.
- **Mistakes** – are errors in the selection of objectives (or faulty intentions) or the means to achieve them (the plan). So intended actions may proceed as planned, but fail to achieve their intended outcome. Not understanding properly how something works or an error of diagnosis or planning.

1.3. **Intentional**

- **Violations** – are situations where operators deliberately carry-out actions that are contrary to organizational rules, operating procedures, etc.

2. **The gas cylinders**

The bus originally has 12 nos. of cylinders and was conforming IS: 15480:2004 specifications (Indian Standard Code). These 12 cylinders were cascaded and had a single filling point. These cylinders were adopting sound engineering practice. The valve was of IS: 3224:2002 standard. Among 12 cylinders, six cylinders have 80 L water capacity and other six have 50 L water capacity. The owner had also installed three additional gas cylinders of 80 L water capacity which two were conforming the IS: 15480:2004 specifications and the others were not. The two cylinders (confirming IS specification) were installed by local vender, had one filling point and the valve is satisfying the IS: 3224:2002 standard. The other cylinder, not confirming IS specification, had separate filling point. This cylinder and its fittings were not confirm the IS specifications.

The automobile fuel station was granted the licence in Form G of Gas Cylinder Rules 2004 by the Chief Controller of Explosives, Nagpur. The licensee had to use only one filling point for CNG bus. But unfortunately, the owner of the bus and the filling station operator always used portable filling assembly with multivalve arrangement for the additional three cylinders.

3. **The incident**

At around 14 = 20 h, first week of July, 2007, the bus reached the authorized filling station for refuelling. The chassis fitted originally with 12 nos. of cylinders were filled by the CNG gas. The bus had one portable type of filling assembly and was used to fill other three cylinders. The two cylinders (confirming the IS specification) were also filled by the CNG gas. During the gas filling in the last cylinder, a burst took place at around 14 = 40 h. Due to the burst, this cylinder was unable to withstand high pressure. Due to the burst, this cylinder was totally dislodged from its grouting and found lying in pieces in the ground. Seats and windowpanes of the bus were also badly damaged. Clamp for holding this additional cylinder fitted to the bus was found at the scene of occurrence. The CNG intake line from these cylinders (three additional cylinders) to the engine was found damaged. Twelve nos. CNG cylinders with valves and piping of original CNG cylinders cascade fitted to the bus were found totally intact. The pressure of CNG in the cascade fitted to the bus
was found to be 170 kg/cm² (g). All the tyres and tubes of the bus were found intact. The facilities in the dispensing station with CNG cascade, CNG compressor and two numbers of CNG dispensers, canopy, sales room, electric transformer room, CNG pipelines and boundary wall of the premises were found intact.

3.1. Damage to the property

The CNG cylinder, not confirming IS specification, is damaged into pieces, and the windows and rear seats of one passenger bus received substantial damage due to bursting. Portable filling assembly with multi valve system was made also found to be damaged.

A. Injured: four persons.
B. Died: one person (on the spot due to head injury).

4. Research of technical failures

4.1. Analysis of the burst cylinder

The sample piece of burst cylinder was examined – a comparative statement showing the test result of the burst cylinder and standard quality as required under CNG cylinder specifications are shown in Table 1.

4.2. Examination of the burst cylinder

Twelve cylinders were installed in the bus by manufacturer adopting sound engineering practice and cylinders were of IS: 15490:2004 standard. These 12 cylinder cascade has one filling point. Two cylinders of IS: 15490:2004 standard were installed by the bus owner through local vender. This cylinder had one filling point and was filled by one portable filling assembly using multivalve and it violates all the engineering practice.

One cylinder fitted by local vender of unknown standard with one additional filling point had been fitted to the bus and it violates all the engineering practice. From the test result, it is evident that Tensile Strength and Yield Strength, Carbon, Chromium, Molybdenum and Manganese content are low compared with the standard cylinder. This cylinder is not fit for CNG service. Thus, it can be emphatically that the burst cylinder of unknown origin was totally unfit for CNG service.

5. Research of human failures

5.1. Provision of additional (2 nos.) filling point in the bus

The bus operator with the intention of running the bus for more distances has decided to install additional cylinder with portable filling facility. The bus operator got additional cylinders fitted without obtaining the technical approval of bus manufacturer and also it violates of Rule 45 of Gas Cylinders Rules 2004. Human errors have been generally recognized as the unsafe acts performed by the bus operator.

5.2. Unsafe human activities

The automobile fuel station licensee has failed to use only one approved filling point in the bus. Instead, they used additional two portable filling assembly to fill additional three cylinders.

1. Portable filling assembly with multivalve was used by operator of the fuel station. This is against the design of CNG refuelling system.
2. Owner of the bus should not have additional fuel cylinders without the prior technical approval of bus manufacturer.
4. Before filling CNG, no inspection was carried out by the fuel station operator.
5. The filling operator does not have proper training and committed the unsafe activity of refuelling with two portable filling points to fill three additional cylinders in the bus which is against the commitment by the licensee of the fuel station. It is the violation of Rule 16 of Gas Cylinder Rules 2004 committed by the filling station owner.

6. Probable cause of the accident

On the examination of the physical and chemical analysis of material of burst cylinder, it may be concluded that physical and chemical property of the material do not meet the requirement of the material for CNG cylinder including the cylinders of IS: 15490:2004 standard. The ill-fated cylinder was unable to withstand high pressure and the bus operator had no knowledge about CNG cylinder specification. Thus, the failure of material of the cylinder operating error is the cause of this accident.

<table>
<thead>
<tr>
<th>Sl. no.</th>
<th>Name of the test</th>
<th>Burst cylinder specification</th>
<th>Standard CNG cylinders specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Micro structure</td>
<td>Uniform distributed fine grained, ferrite and pearlite structure are normalized</td>
<td>Uniform distributed fine grained ferrite and pearlite structure are normalized</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.101</td>
<td>0.34-0.37</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.226</td>
<td>0.15-0.35</td>
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<td></td>
<td></td>
<td>0.393</td>
<td>0.05-0.85</td>
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<tr>
<td></td>
<td></td>
<td>0.016</td>
<td>0.020 (MAX)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.015</td>
<td>0.020 (MAX)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.112</td>
<td>0.15 (MAX)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.116</td>
<td>1.00-1.20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.019</td>
<td>0.15-0.69</td>
</tr>
<tr>
<td>1</td>
<td>Yield strength (MPa)</td>
<td>349</td>
<td>785</td>
</tr>
<tr>
<td>2</td>
<td>Tensile strength (MPa)</td>
<td>448.7</td>
<td>928</td>
</tr>
<tr>
<td>3</td>
<td>% Elongation</td>
<td>22</td>
<td>14</td>
</tr>
<tr>
<td>4</td>
<td>Hardness (HBR)</td>
<td>83-84</td>
<td>106-109</td>
</tr>
<tr>
<td>5</td>
<td>Bend test</td>
<td>Satisfactory</td>
<td>Satisfactory</td>
</tr>
</tbody>
</table>
7. Human errors

Analysis is shown that an operating error was the main cause of this accident. The nature of the error can range from unintentional ways where mistakes occurred by the bus owner and subsequently by the bus operator. Twelve cylinders were installed in the bus by the bus manufacturer adopting sound engineering practice and cylinders were IS: 15490:2004 standard. Additional three cylinders were installed by the bus owner and two were IS: 15490:2004 standard and the other was unapproved unknown standard. Installation of these three cylinders was supplied by the local unapproved vendor. The three additional cylinders were two separate potable filling facilities which were against the Rule 45 of Gas Cylinder Rule 2004. After examination of the sample piece of the burst cylinder, the result is evident that Tensile Strength and Yield Strength, Carbon, Chromium, Molybdenum and Manganese content are at variance with higher degree with the standard cylinder. This cylinder is not fit for CNG service.

In an intentional way, the violations occurred where the bus operator deliberately carries out actions that are contrary to organizational rules, operating procedures, etc. The violations worked as routine violations to become the normal way of working because the bus owner and operator installed unapproved three additional CNG cylinders with two portable filling facilities which is the violation of Rule 45 of Gas Cylinder Rules 2004. Worker of the filling station had not properly trained by the management and committed unsafe activity on refuelling, which is violation Rule 16 of Gas Cylinder Rules 2004. Gas supplier had also failed to impart training to their dealer.

The bus operator and the worker in the filling station are overloaded thus under stress due to work load may neglect the normal procedures of the CNG filling operation.

8. Lessons learnt and recommendations

This accidental risk is greater with a bus than with a smaller vehicle, since the large volume of fuel stored on bus increases the volume of the inflammable mixture, and the structure of the bus body can trap gas underneath where it is exposed to ignition sources. Both government and industry could not explain this type of CNG burst incidents to assure public fears (http://www.cseindia.org/campaign/ape/pdf/SAFETYREPDF, dated 11.5.09). The main cause of this accident is human error, resulted one person died and four persons injured. The following are the suggested measures.

(1) Traffic accidents and driver errors (human errors) can never be eliminated completely, but the appropriate design can reduce the probability of uncontrolled release of gas. So some combination and high-quality safety maintenance designs are required.

(2) CNG cylinder should undergo a detail safety inspection at least every 3 years or 36,000 miles or when they have been involved collisions, accidents, fires or other damage (ANSI/CSA NGV-2000 Sections 4.1.4 and 4.1.5).

(3) CNG cylinders are requiring periodic inspection particularly the cyclic loading and corrosion tests as specified by ANSI (American National Standards Institute) standard.

(4) It is responsibility of any test agency to issue a type approval certificate when a vehicle meets the specified norms.

(5) To reduce human error (knowledge based mistakes), the bus owner should provide the necessary instructions about periodic inspections, safety checks and "dos and don'ts" to the bus operators.

(6) To train periodically to the dealer/bus operator/bus owner by the gas supplier for the safety aspect of CNG.

(7) To provide the bus operator necessary training, tools and gadgets to carry out the installation, periodic inspection and maintenance procedure.

(8) Responsibility of owners and also the bus operator to follow the instructions while filling CNG gas to be carry out leakage test periodically at least one in a year. Appropriate training given to the bus operator.

(9) Each and every converted bus should undergo inspection to assure that the CNG installation is safe and proper by the appropriate authorities.

(10) Emissions certification of a particular CNG kit for a particular engine should apply to all applications of the same engine model in different vehicle types.

(11) The approval authority, ARAI (Automotive Research Association of India) the only test agency presently in operation in India, should issue guidelines on how to interpret current laws, regulations and other relevant documents and eliminate unnecessary and duplicative tests.

9. Conclusion

In India, during refuelling CNG, an unauthorized cylinder burst in a passenger bus and resulting in death of one person and injury to four persons. The seats and windowpanes of the bus were found badly damaged. After investigation, it is shown that the bus operator got additional cylinder fitted without obtaining the technical approval of bus manufacturer. Human errors, both unintentional and intentional errors, occurred. In unintentional way, mistakes and intentional way violation occurred. At last, it is concluded that to avoid such type of accident, reduce human error and provide necessary safety instructions about handling CNG cylinders to the bus owner and also the bus operator.

References

CHLORINE LEAKAGE FROM THE BOTTOM OF A BABY CHLORINE CYLINDER – HUMAN FACTOR AND LESSON LEARNED

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ABSTRACT
Accidental release of chlorine from a baby cylinder, 60 kg capacity occurred in a congested locality of Kolkata in one winter night from a small factory. The chlorine gas dispersed over the nearby area resulting in death of 4 persons and injury to 87 persons. This paper presents the incident, the factor involved and the lesson-learned. What-if analysis was used to identify the possible errors, and to identify the unsafe activities. The necessary safe preventive measures are also discussed.

Keywords: Chlorine, baby cylinder, inhalation, human error, what-if analysis.

INTRODUCTION
Chlorine is a toxic, corrosive gas that can cause severe burns if inhaled or upon skin contact. It is a greenish-yellow nonflammable liquefied compressed gas packed in cylinders under its own vapor pressure. It form fume on contact with moisture in air. The degree of fuming is related to the amount of humidity in the air. It is also an oxidizer and will support the combustion. Products of combustion gases are generally toxic in nature. Chlorine exposure occurs through inhalation or skin or eye contact. Inhalation irritates the mucous membranes of the eyes, nose, throat, and lungs. Prolonged exposure or exposure to high concentrations is fatal, as outlined below (The chlorine Institute, Inc., 2000),

1-3 ppm mild mucus membrane irritation
5-15 ppm moderate irritation of upper respiratory tract
30 ppm immediate chest pain, vomiting, dyspnea, and cough
40-60 ppm toxic pneumonitis and pulmonary edema
430 ppm lethal over 30 mins.
1,000 ppm death within a few minutes

Although inhalation is the primary mode of exposure, direct skin contact with gaseous or liquid chlorine may result in chemical burns as the chlorine reacts with moisture on the skin. In addition, the extremely cold temperatures associated with liquid chlorine and vaporized gas escaping from pressurized containment can cause frostbite. The exposure limits are as follows,
Chlorine is widely used in making large numbers of everyday products. It is used to produce safe drinking water throughout the world. It is extensively used in the production of paper, dye stuffs, textiles, petroleum products, medicines, antiseptics, paints, insecticides, plastics and many other consumer products. The potential for leaks and spills of chlorine is present with its use (Gangopadhyay and Das, 2007). MHIDAS database indicated that 96 accidents of chlorine release to atmosphere occurred in the period 1964-1996 (Macro et al., 1998). These resulted in 39 deaths and over 2700 injured. They also showed that the contribution of human errors were 26% of incidents resulting in chlorine release. In general the chlorine leakage from a cylinder occurs due to the operational error, maintenance error; crack or rupture due to miscellaneous causes. In some cases human errors are also responsible for operational and maintenance errors. Fig. 1 shows the generalized fishbone diagram of accident causes that release of chlorine from chlorine cylinder.

![Fig. 1](image)

Human error defined by Chemical Manufacturer’s Association (1990) as “any human action that exceeds some limit of acceptability (i.e. an out-of-tolerance action) where the limits of human performance are defined by the system”. Fig. 2 shows categorization of human errors (HSE, 2005).

![Fig. 2](image)

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OSHA : PEL = 1 ppm  
ACGIH : TWA/TLV = 0.5 ppm  
NIOSH : IDLH = 10 ppm

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Some times human attention about various information, perceptions towards safety, capacity for remembering things and logical thinking not work properly as

1. Ignorance – one does not have the necessary/ knowledge for the activity;
2. Pseudo knowledge – one does not have the necessary knowledge for the activities, but believes they have the adequate knowledge;
3. Imprudence – one has the necessary knowledge for the activities but due to faulty thinking has convinced herself or himself that she or he is the exception to the rule.

The important task is to identify and reduce human errors for minimize the accident. Literature review shows that Human Reliability Analysis (HRA), Process Hazard Analysis (PHA) What-if analysis, HAZOP, Checklist, Failure mode and Effect analysis etc. use to predict the errors occurred which resulted an accident. Among them “what-if analysis” one of the useful applicable techniques to find out predictable human error, improve the safety levels and manages the risk successfully. This paper deals with the description of the incident, identification of errors and the lesson learned from the accidental release of chlorine from a baby cylinder.

THE INCIDENT

A small unit manufactured calcium hypochloride solution by passing chlorine into lime solution. The occupier brought a cylinder of chlorine (baby cylinder – 60 kg capacity) from the nearby dealer for the preparation of hypochloride solution. In the night time the cylinder, which was, kept lying in the ideal condition started leaking from its bottom all on a sudden (Anandabazar Patrika, 1990). The worker brought some ice from the nearby shop and kept the cylinder in the ice pot with anticipation that the chlorine leak from the cylinder will stop if the cylinder is cool down by ice. After a few minutes the leak increased instead of stopping.

Chlorine gases profusely spread from the cylinder and dispersed according to the direction of wind affecting the people on its path in the adjacent houses, four people died by the chlorine gas and other person who were sleeping in the nearby areas and on the passage of the dispersion of the gas was also died. The calcium hypochloride unit was located in a heavily populated area in a metropolitan city, Kolkata and most of the buildings were multistoried, normally shops were in the ground floor and residential accommodation on the first floor onward. As the chlorine gas is heavier (vapor density of 2.48 gm/cc) than air it spreads very little quantities in the first floor level. 87 people were affected need only first aid treatment for the minor injury by inhalation of the chlorine gas.

Nature and extent of damage

1. Within the establishment:
   Casualties : Nil
   Material damage : Nil
   Damage to environment : Could not be ascertained

2. Outside the establishment:
   Casualties : Killed : 4
               : Injured: 87
   Material damage : Nil
   Damage to environment : Could not be ascertained

Incident analysis

The main event was identified as
1. The chlorine cylinder was badly corroded.
2. Chlorine dispersed according to the wind direction and caused the death and injury.
3. No emergency first aid response was there.

Major contributing conditions were also identified:
4. The man engaged in the manufacturing process had no knowledge regarding the hazards of the chlorine.
5. Due to the management and worker’s ignorance, the management’s reaction was to put the chlorine cylinder on the ice pot and the reaction of the metals of the chlorine cylinder with chlorine and water ultimately increases the diameter of the leaky portion of the cylinder.
Corrosion mechanism

In dry chlorine service, carbon steel is most commonly used material of construction for system piping. The iron in carbon steel is reactive with dry chlorine

$$2\text{Fe} + 3 \text{Cl}_2 \rightarrow 2 \text{FeCl}_3$$  \hspace{1cm} (1)

The ferric chloride ($\text{FeCl}_3$), forms a passive layer on the steel surface, which protects the underlying iron. Ferric chloride is a very hygroscopic salt; it absorbs moisture and water very quickly when exposed to the atmosphere, which accelerates the overall corrosion rate. Carbon steel is corrosion resistance to chlorine as long as high water concentrations or temperatures do not deliquesce the protective layer (The Chlorine Institute, 2000). The corrosion mechanism for chlorine attack on steel is a water-rich phase and also increases with increase in temperature. In both cases, ferric chloride forms; this solution is an electrolyte, a very strong oxidizer, and a strong acid. The water-rich phase not only dissolves the protective layer of ferric chloride, but also forms an acid medium by reaction of chlorine with water (Updyke, 1982, Saroha, 2006). The chlorine-water reaction forms hypochlorous acid (HOCl) and hydrochloric acid (HCl) as,

$$\text{Cl}_2 + \text{H}_2\text{O} \rightarrow \text{HOCl} + \text{HCl}$$  \hspace{1cm} (2)

The hypochlorous acid is not very stable and further dissociates according to following equation,

$$2\text{HOCl} \rightarrow 2\text{HCl} + \text{O}_2$$  \hspace{1cm} (3)

The acids and the dissolved ferric chloride form a concentrated solution that is corrosive to steel.

Lessons learned from this incident

1. Understanding of the Hazards and Effects Management Process needs to be implemented.

2. Incident scenarios and appropriate job safety analysis (task risk assessment) should be performed with the involvement of first line supervision. Methods statements should be prepared which clearly define roles, responsibilities and the controls to be applied.

3. Chlorine cylinder supplier’s recommended practices for safe handling of the cylinder should be understood, communicated and applied.

4. Cylinder leakage should be addressed to the manufacturer or local task force to tackle this problem immediately and to provide rescue staff with breathing apparatus and resuscitation equipment.

5. The awareness of the hazard of chlorine should be enhanced for all staff.

Human errors

The “What-if” table generated for the human factor analysis shown at Table 1.

After investigation it was observed that the worker was illiterate and he had no knowledge about the hazardous nature of chlorine. The small establishment did not have a telephone for communication. The following human errors are identified,

• Lack of knowledge – awareness of the hazards of chlorine.

• Lack of logical thinking – In any technological situation logical procedures are necessary, but illogical thinking or the behavior lead to accident. Liquid chlorine is leaking from the cylinder if the cylinder was tilted to facilitate the leak of chlorine gas, then the amount of chlorine leak is minimum, as the gas release is 15 times less compared to the liquid release from the same size. The worker put the leaked cylinder on the ice pot which increases the leak diameter.

• Mental inefficiency – A situation which does not have the mental capacity to deal with the information that must be processed in the activity. The worker is illiterate and his mental capacity is also very limited to process any information in acute condition.
<table>
<thead>
<tr>
<th>What-if</th>
<th>Consequences</th>
<th>Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. If the chlorine cylinder tilted to facilitate the leak of chlorine gas</td>
<td>The amount of chlorine leak is minimum</td>
<td>Ideal solution for initial period of liquid chlorine leakage</td>
</tr>
<tr>
<td>2. If the leak cylinder put on the ice-pot</td>
<td>Increases the leak due to corrosive action with water</td>
<td>Educating workers about the hazards of chlorine and also encourage to participate in training and monitoring programs in the work place and set up emergency plan</td>
</tr>
<tr>
<td>3. If chlorine gas come out from chlorine cylinder</td>
<td>It may fume while on contact with moist air and create highly corrosive atmosphere</td>
<td>Establish an emergency response plan for responding to leaks and also arrange the proper training for workers</td>
</tr>
<tr>
<td>4. If chlorine gas spreads offsite</td>
<td>Severe irritant to the eyes and respiratory system and also burn the skin</td>
<td>Establish an emergency response plan for responding to leaks</td>
</tr>
<tr>
<td>5. If the workers are illiterate or if the operating procedure is not properly follow</td>
<td>Accidents may occurred</td>
<td>General chemical and hazardous information should be displayed and provide contact no. for possible help. Proper information and training for proper handling chlorine should give all the workers.</td>
</tr>
<tr>
<td>6. If chlorine cylinder become corroded</td>
<td>There is a possibility of leakage</td>
<td>Cylinder should be checked in regular interval of time</td>
</tr>
</tbody>
</table>

Table 1 What-if analysis

Accident prevention and recommendation as preventive measures

Fig. 3 shows the general accident prevention methodology in a fish bone diagram. There is a need for major precautions while working with chlorine, which when mis-handled is a very dangerous gas.
The following outlines a programme governing the moving, storage, and maintenance procedures to be used for handling chlorine gas. Consult the Safety Engineer/supplier’s safety officers for procedures to be followed in an emergency, and the type of first treatment to be rendered to persons exposed to chlorine fumes (Spellman, 2003: http://erd.dli.mt.gov/safetyhealth/brochures/chlorinesafety.pdf; http://www.tdi.state.tx.us/pubs/videoresource/t5chlorine.pdf; Gangopadhyay et al., 2005, Gangopadhyay and Das, 2007).

Some general recommendations set up as per “What – if analysis” for handling chlorine, control human error, administrative control and safety work procedure control were followed.

Handling chlorine

**Cylinder movement**

The appropriate technique for cylinder movement is the valve cap should be placed and dropping a cylinder or allowing an object to strike the container with extreme force must be prevented. Never expose a cylinder to heat and never lift a cylinder by its hood. Always use clamp support for cylinder movement. Lifting the cylinder by crane, rope sliding chain or magnetic device should not be use. Lifting the cylinder by holding the valve cap or its neck is prohibited.

**Cylinder storage**

The chlorine cylinder storage area is to be a well ventilated, secured and protected from weather away from heavily traveled areas and emergency exits. Never cylinder stored near salted or other corrosive, combustible or flammable materials. Full or empty cylinder should be marked. To prevent full container from being stored for stored long periods of time use first-in first-out inventory system. Check the cylinders visually at last weekly for any indication of leakage or other problems. Provide leak detectors and high concentration audio visual alarm in storage area. To avoid liquid/water ingress in the cylinder while consuming the chlorine, outlet line from cylinder to consumption point should be provided with 32 ft high barometric leg.

**Control human error**

i. The workers need proper education and training about the hazards of chlorine.
ii. They must have knowledge about the emergency response plan for responding to leaks or accidents.
iii. Workers must wear appropriate protective clothing and respirators when handling chlorine cylinders or compounds.
iv. Follow the manufacturer’s instructions during emergency and display the instructions from the material safety data sheet.
v. Never spray water on leaking containers; it can make the leak worse.
vi. Workers must not eat, drink or use tobacco products during handling chlorine. The hands and face should be washed before eating or drinking.

**General control**

i. Dragging, rolling or dropping of cylinder should be avoided.
ii. Fusible plug safety device on containers should not be tampered.
iii. Chlorine supplier is to be immediately contacted if any damage is found.
iv. Repair a container or its part like valve should not be done – immediately contact the supplier.
v. Never place a container in hot water, or apply direct heat to increase the flow rate, or for any other reason.
vi. Once the cylinder has been connected to the process, cylinder is to be opened slowly and carefully.
vii. If user experiences any difficulty in operating cylinder valve, disconnect use and contact supplier.
viii. Never perform maintenance work on a system unless the tank valves are closed.
Administrative control

i. Train workers on the health hazards from exposure to chlorine and the safe work procedures developed by the employer.

ii. Establish an emergency response plan for responding to leaks and spills of chlorine at the work site.

iii. Prepare escape plans from areas where there might be a chlorine emission. Always remember to move uphill and upwind.

iv. Comply with requirements for handling and storage of hazardous materials.

v. Ensure that the need for ventilation is properly assessed and systems that are installed are properly designed and maintained. Workers also need to be trained on the proper operation and maintenance of these systems.

vi. Provide proper and approved self-contained breathing apparatus in areas where chlorine is stored or used.

vii. The ventilation system in the chlorine storage room should be on and functional when workers are in the room.

viii. Chlorine alarm system should be installed, with an indicator located outside the room.

ix. Clean up chlorine spill, if any, quickly and properly using appropriate protective equipment and clothing.

CONCLUSION

The incident of chlorine leakage from a baby cylinder and the off-site consequences are described. The analysis of the incident has been carried out with respect to human errors and causes due technical faults.

REFERENCES


Newspaper Anandabazar Patrika, 18 February (1990).


Workplace Health and Safety Bulletin. Chlorine at work site.
Safety Knowledge of LPG Auto Drivers and LPG Tank Drivers

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Abstract

The paper deals with the survey about the knowledge of safety during their occupational time in the LPG auto drivers and tank drivers. A structured questionnaires was developed and used for interview on LPG auto (N = 150) and LPG tanker (N = 150) drivers. Statistical results show that there is a significant difference on auto driver’s safety knowledge without training and tanker driver’s knowledge with training at regular interval of time.

Keywords: Auto LPG, Safety Knowledge, Training, Drivers

1. Introduction

In the mid to late 90’s, air pollution has become an issue attracting wide public concern. To alleviate the air pollution problem, one of the measures identified was to replace diesel vehicles with vehicles using cleaner fuel, i.e., Liquefied Petroleum Gas (LPG), which is a readily available fuel. In an order on July 18, 2008 a Division Bench of the Calcutta High Court has ordered that only four-stroke auto rickshaws running on Liquefied Petroleum Gas (LPG) will be allowed to ply on Kolkata’s roads and also order banning all commercial vehicles older than 15 years. The Bench comprising Chief Justice S. S. Nijjar and Justice P. C. Ghosh observed that there would be no conversion of two-stroke auto-rickshaws. They will have to be replaced by new four-stroke autos with LPG engines [1].

Auto LPG or Liquefied Petroleum Gas is a generic name for mixtures of hydrocarbons (mainly propane and butane) which exists as vapor under ambient conditions and can be changed into liquid state by applying moderate pressures [2]. Auto LPG is a gas at atmospheric pressure and normal temperatures, but it can be liquefied when moderate pressure is applied or when the temperature is sufficiently reduced. This property makes the fuel an ideal energy source for a wide range of applications, as it can be easily condensed, packaged, stored and utilized. When the pressure is released, the liquid makes up about 250 times its volume as gas, so large amounts of energy can be stored and transported compactly [3].

Safety knowledge or safety education means improving knowledge, skill, attitude and morale of the workers. It means it is a process of systematic instructions and development of character or mental powers of the workers. It must prevent both unsafe conditions in the working areas as well as unsafe acts committed by the workers. Safety training alone is the remedy for correcting unsafe acts of the workers. Safety education is vital and essential for all accident prevention work in industries. It is generally true by the evidences that well-trained and careful men may avoid injury on dangerous work than that of the untrained and careless man may be injured under the same condition [4]. The safety educated person is more likely to regard an accident as being predictable, preventable, and non-accidental. Hence safety education plays an important role in the preventive measures. As knowledge increases, one’s behaviour becomes more intentional, so that unanticipated events are less likely to occur. The role of safety education is to increase knowledge, thereby decreasing the proportion of unintended behaviour and increasing the level of anticipation, and the possibility of avoiding danger [5]. Safety training is one of the solutions to perform safe work practices and a tool for motivating the employees to change [6].

2. The Present Study

The present study is conducted to measure safety knowledge of the auto LPG users. Survey method was con-
ducted through questionnaire and then the responses are statistically analysed. The objectives of the study are

1) To determine safety knowledge among LPG auto drivers and LPG tanker drivers.

2) To find out how safety training increases safety knowledge of auto LPG users.

3) Creating a general awareness of health and safety issue on LPG among auto and tanker drivers.

4) To investigate what is the real situation of safety knowledge among LPG auto and tanker drivers and the personal attributes of participants like age, educational qualification, and monthly income.

To fulfil the objectives the Null hypotheses was used for both cases, i.e.,

1) Safety knowledge of auto drivers on LPG is positively high without training;

2) Safety knowledge of tanker drivers on LPG positively low with training.

3. Methods

3.1. Participant and Procedures

This study surveyed on LPG auto drivers and tanker drivers in an around Kolkata and Haldia. The sample size of auto drivers (N = 150), tanker drivers (N = 150) and total was 300. Statistical analysis conducted on the basis of the responses of the questionnaire as shown in Appendix 1 and 2 for auto drivers and tanker drivers respectively. Initially questionnaires have been prepared, then experts from M/S Petroleum and Explosive Safety Organisation, East Circle, Govt. of India, have corrected the questionnaires and used for survey.

3.2. Sample 1

Data of auto drivers were collected from various LPG filling stations at Mniktala, Kankurgachi, Sealdah, Sintheemore and Silpara in Kolkata, West Bengal, India. With the help of the filling station manager and explaining the aim of the study, the questionnaires were distributed to the LPG auto drivers and they were requested to fill up the questionnaire.

3.3. Sample 2

The questionnaires were distributed to the tanker drivers at the M/S IOC Petronas Limited, Haldia, who came to fill up their tankers. The major route of these tankers are Haldia to Patna, Raninagar; Kalyani; Paharpur; Durgapur; Kolaghat; Budge Budge; different parts of Orissa, Assam and Jharkhand; Baksara, Banaras, Hazimbag, Jamshedpur, Siliguri, Balasore and Kolkata. After explaining the aim of the study they were asked to fill up the questionnaires. Structured questionnaire was used in the assessment. The participants’ responded to the questionnaire during their free time. It was presented in English language and where respondents with poor literacy skills had problem understanding the language, there was an interpreter is explained in their local language.

3.5. Scoring

After collecting the data from the sample the responses of each subject were scored. In this investigation the questionnaire of LPG auto drivers consisted of 20 questions and for LPG tanker drivers consisted 25 questions, each had two options, “YES” and “NO”. Score of 2 was given for “YES” responses; score of 1 was given for “NO”. After scoring each question the total score was computed for each individual subject by scoring up the item score. Then the scores were tabulated for statistical analysis. The two questionnaires have different number of items, so the total score will vary for the two groups of sample. Subsequently mean will vary because of difference in total scores.

3.5. Statistical Analysis

After scoring the responses and computing the total score for each individual the mean and standard deviation (SD) were calculated of these scores were computed for LPG auto drivers and LPG tanker drivers separately. Then the difference between the means was computed and the t value for the independent samples of equal sizes was calculated to see the level of significance.

3.6. Reliability

Reliability is the consistency or repeatability of the measures as collected from the questionnaires for auto and tanker driver respectively. In this survey the internal consistency method is used. The internal scale reliability (Cronbach Alpha) of the questionnaire for LPG auto driver estimated as 0.47 which is below the acceptable limit where as for the LPG tanker drivers it was 0.65 which is above acceptable limit of 0.6 [7]. So, it was decided to keep the questionnaire further in validation in case of auto driver. The F ratio of the scores of questionnaire for auto driver was 4.00 which were significant at p < 0.05 level. Hence, it was decided that the questionnaire for auto driver is also valid for this study.

4. Results and Discussion

4.1. Auto Driver

After statistical analysis it is shown that in case of auto
drivers mean score of “YES” and “NO” are 10.45 and 14.77 respectively. The calculated $t$ value is 10.843 which is greater than the table value at $p < 0.05$ level [8]. So, the first null hypothesis is rejected and alternative hypothesis is accepted. The knowledge of LPG auto drivers on safety is low, because they did not get any safety training from any authorities. So, their mean score of “NO” is greater than the mean score of “YES” and for these reasons the LPG auto drivers are known little about safety aspects on LPG. Beside this the other general information are also important for the measurement of safety perceptions likes age, income, educational qualification which are also related to occupational satisfaction, accidental risks, emergency responses. Table 1 shows age range of auto drivers. Most of auto drivers’ fall on the age range between 26 - 35 yrs. and maximum age of auto driver is 73 yrs. Table 2 shows income range of LPG auto drivers. The maximum income range of LPG auto drivers is Rupees 5001 - 6000 per month and highest income is Rupees 15000 per month. Table 3 shows educational qualifications. The sample was categorized into four educational groups based on their responses, basic education, secondary education, higher secondary, graduation level. Most of the auto drivers educational qualification is secondary level (Class V-X). Table 4 represents the percentage score on safety knowledge of LPG auto drivers. This table shows that only 3% drivers acquired 91% - 100% which is high range of percentage scores and 17% drivers acquired 10% - 20% achievement of safety knowledge which is low range of percentage scores on LPG auto driver. The majority of scores of the LPG auto drivers falls on between 51% - 60%.

### 4.2. Tanker Driver

After statistical analysis it is shown that in case of tanker drivers mean score of “YES” and “NO” are respectively 41.16 and 4.42. The calculated $t$ value is 96.48 which is greater than the table value at $p < 0.05$ level [8]. So, the second null hypothesis is rejected and alternative hypothesis is accepted. The knowledge of LPG tanker drivers on safety is high, because they get safety training from various authorities at regular interval of time, i.e., yearly once or twice. So, their mean score of “YES” is greater than the mean score of “NO” and for these reasons the LPG tanker drivers knowledge are high about safety aspects of LPG. Table 5 shows age range of tanker drivers. Most of tanker drivers fall on the age range between 26 - 35 yrs. and maximum age of tanker driver in between 56 - 65. Table 6 shows income range. Tanker drivers’ maximum income range is rupees 1000 - 2000 per month and highest income is Rupees 7000 per month. Table 7 indicates that most of tanker drivers educational level is secondary level (Class V-X). Table 8 represents the percentage scores on safety knowledge of LPG tanker drivers. This table shows that 19% tanker drivers acquired 91% - 100% which is high range of percentage scores and 1% tanker drivers acquired 40% - 50% achieve-
Table 5. Age range of LPG tanker drivers.

<table>
<thead>
<tr>
<th>Age range</th>
<th>No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>15-25</td>
<td>33</td>
</tr>
<tr>
<td>26-35</td>
<td>74</td>
</tr>
<tr>
<td>36-45</td>
<td>31</td>
</tr>
<tr>
<td>46-55</td>
<td>8</td>
</tr>
<tr>
<td>56-65</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 6. Income range of LPG tanker drivers.

<table>
<thead>
<tr>
<th>Income range</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000 - 2000</td>
<td>59</td>
</tr>
<tr>
<td>2001 - 3000</td>
<td>40</td>
</tr>
<tr>
<td>3001 - 4000</td>
<td>9</td>
</tr>
<tr>
<td>4001 - 5000</td>
<td>3</td>
</tr>
<tr>
<td>5001 - 6000</td>
<td>2</td>
</tr>
<tr>
<td>6001 - 7000</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 7. Educational qualifications of LPG tanker drivers.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Basic (Class I-IV)</th>
<th>Secondary (Class V-X)</th>
<th>Higher secondary (Class XI-XII)</th>
<th>Graduation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tanker driver</td>
<td>10</td>
<td>111</td>
<td>14</td>
<td>1</td>
</tr>
<tr>
<td>Mean</td>
<td>0.06</td>
<td>1.48</td>
<td>0.28</td>
<td>0.02</td>
</tr>
</tbody>
</table>

evement of safety knowledge which is low range of percentage scores on LPG. The majority of scores of the LPG tanker drivers falls on between 81% - 90%.

During the survey many auto drivers told about the safety problems on their job. They are not trained, so they are worried about in emergency situation. But tanker drivers are well trained, so they know the primary emergency preparedness. For auto driver they informed and gain some knowledge about the general awareness, health and safety issues on LPG. The real situation is large quantities of auto LPG use in vehicle at present in West Bengal particularly in and around Kolkata. The Government of West Bengal forced recently that all auto should run by LPG by the law of court but neither the LPG supplier of the Govt. itself arrange any training programme for auto drivers. So, their safety knowledge is very poor. They had no idea about what to do in emergency situation.

5. Recommendations

Some general recommendations on auto LPG operations,

1) Safety should be the prominent place in the training of anyone who works with LPG. So, first and most important safety equipment is workers knowledge also to know the physical and chemical properties of LPG.

2) All LPG operations must be carried out by personnel well trained in LPG operations.

3) Engage only trained and competent workers in LPG filling station and filling vehicle related jobs.

4) When working on road sides, ensure safe places for parking and working on vehicles, e.g., away from drains, pits and other openings in the ground and all sources of ignition.

5) Safety equipment like personal protective equipment, safety cloths, goggles etc. to be always use in working place to avoid any damage.

6) Gas detectors to be provided at different locations of the LPG filling stations. Whenever leak is detected then the system gives an audible alarm.

7) Avoid the roadside check for leaks and other damages to the LPG system on the auto rickshaw or tankers.

8) If leak detected do not panic, stop the vehicles and starts emergency plan, inform local police station, fire station, emergency medical facilities, public awareness system, warning people away from the area and also switch off electricity and all ignition sources.

9) Provides the operators suitable first aid kit.

10) Phone numbers of the local fire department, emergency medical facility, and other appropriate public safety agencies to be available to the drivers. Note book containing these emergency numbers to be carried out by the drivers.

11) Smoking to be avoided as it may produce flame or sparks which may create an accidental situation.

12) Never leave vehicle unattended while in operation or when set up for operation.

13) Drivers to be advice do not wear clothing made of synthetic fibres or any other material that tends to produce static electricity.

14) Drivers to be advice to carry out mock drill at least once in a year to review and practice emergency procedures.

15) Periodical training for the drivers to be provided by the oil companies or the Government and also provides them certificates.

6. Conclusions

A structured questionnaire was developed and used for interview on LPG auto and LPG tanker drivers to know the knowledge of safety and emergency preparedness. Statistical results show that there is a significant difference on auto drivers’ safety knowledge as they were not received any training and tanker driver’s knowledge with training at regular interval of time. A list of recommendations is incorporated for used to train both types of drivers.
7. Acknowledgements

Authors are very thankful to Mr. Amalesh Dutta, Indian Oil Petronas Pvt. Ltd., Haldia for his kind help in survey process. Authors are also thankful to Rahul Ghosh, Sreedip Ghose, Pinaki Naskar, Girija Sankar Mundra students of B.Tech Chemical Engineering, University of Calcutta for participating to complete the survey.

8. References


Nomenclature

F: Compare the variance of the two independent samples

p: In rejection region, this is the area in the tail beyond the observed value of the test statistics

N: Sample size

SD: Standard deviation

r: Judging the significance of the mean of difference between the two related samples
Appendix 1. Self-constructed questionnaire for LPG auto drivers.

**SAFETY INVESTIGATION QUESTIONNAIRE**

**General information**

<table>
<thead>
<tr>
<th>Name -</th>
<th>Age -</th>
</tr>
</thead>
<tbody>
<tr>
<td>Educational Qualification -</td>
<td>Time -</td>
</tr>
<tr>
<td>Location -</td>
<td>Time -</td>
</tr>
<tr>
<td>Monthly / Daily income -</td>
<td>Time -</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>QUESTIONS</th>
<th>YES/NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Do you know the full form of LPG?</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Do you know why we use auto LPG?</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Is there adequate supply of auto LPG?</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Do you know any risks of health for using LPG?</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Do you know the safety operations of auto LPG?</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Did you receive any training before running auto LPG?</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Do you know how refill the empty container?</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Did you receive any training for handling any emergencies?</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Does training include hands on experience?</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Do you know how to diagnose the leakage or any failure of LPG?</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Is there any technical support available during emergencies?</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Can operators confidentially report problems, errors?</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Is information used and acted upon to minimize risks?</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Are there sufficient communication resources and personnel to handle communications during emergencies?</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Do you know any sign of leakage?</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Do you know the procedure to remove the leak cylinder?</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Do you know the right procedure of maintain the containers?</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Is station operators and there staff are well trained about the safe use of auto LPG?</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Do you own the vehicle?</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Are you satisfied with Auto LPG?</td>
<td></td>
</tr>
</tbody>
</table>
Appendix 2. Self-constructed questionnaire for LPG tanker drivers.

SAFETY INVESTIGATION QUESTIONNAIRE

General information

<table>
<thead>
<tr>
<th>Name</th>
<th>Age</th>
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</thead>
<tbody>
<tr>
<td>Educational Qualification</td>
<td>Tank registration no.</td>
</tr>
<tr>
<td>Location</td>
<td>Time</td>
</tr>
<tr>
<td>Monthly/Daily income</td>
<td>Date</td>
</tr>
</tbody>
</table>

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<th>QUESTIONS</th>
<th>YES/NO</th>
</tr>
</thead>
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<td>Do you know the full form of LPG?</td>
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<td>Do you know why we use auto LPG?</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Is there adequate supply of auto LPG?</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Do you know any risks of health for using LPG?</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Are you using any personal protective equipment?</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Do you know the safety operations of auto LPG?</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Are you trained on about hazardous nature of LPG?</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Do you know the procedure of refill/delivery of the tank?</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Did you receive any training for handling any emergencies?</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Does training include hands on experience?</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Whether training programme organized periodically?</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Any instruction booklets/operating manuals provided in local languages?</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Whether important Do's and Don'ts displayed prominently?</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>'No Smoking' and other caution signs in local language displayed at prominent places?</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Do you know how to diagnose the leakage or any failure of LPG?</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Whether gas detector system has been provided in the vehicle?</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Whether inspection/visual checks are done to detect leaky/defective cylinders?</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Whether cylinder repairs/valve change etc. are supervised?</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Is there any technical support available during emergencies?</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Whether important telephone no./emergency service center provided for emergency communication?</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>Can operators confidentially report problems, errors?</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>Do you know the right procedure of maintain the cylinders?</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>Is station operators and there staff are well trained about the safe use and handle of auto LPG?</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>Whether explosimeter checks are done before releasing the truck?</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>Do you own the vehicle?</td>
<td></td>
</tr>
</tbody>
</table>