Guide to
Good Industry Practices for LPG in Commercial Kitchens

WLPGA

The World LPG Association

The World LPG Association was established in 1987 in Dublin, Ireland, under the initial name of The World LPG Forum.

The World LPG unites the broad interests of the vast worldwide LPG industry in one organisation. It was granted Category II Consultative Status with the United Nations Economic and Social Council in 1989.

The World LPG Association exists to provide representation of LPG use through leadership of the industry worldwide.

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Guide to Good Industry Practices
LPG in Commercial Kitchens

Foreword – José Andrés, World Central Kitchen

"When people use clean cooking fuels instead of firewood or charcoal, they are saving their lives, saving their forests and saving their farming and fishing industries"

- José Andrés, World Central Kitchen

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Executive Summary

This Guide is a deviation from the previous Guides published by the WLPGA. Whereas the subjects in other WLPGA Guides have focussed on specific parts of the downstream distribution chain, this Guide looks specifically at one of its most popular applications: Cooking, but specifically cooking in commercial restaurants.

Almost half the world's consumption of LPG is used in the residential sector where it is used mainly as a cooking fuel.

In communities where LPG is challenging the use of traditional fuels (wood, charcoal, coal, animal waste) and kerosene in domestic kitchens, lies also the opportunity to use LPG in commercial kitchens.

These commercial kitchens can be found in establishments such as schools, orphanages, prisons etc. and the use of LPG here can be an opportunity to encourage change at home.

The use of traditional fuels and kerosene in households for cooking (and heating water and rooms) is often seen as an indicator of energy poverty. The increasing use of LPG in households is one of several pathways to meet the objective of universal access to clean cooking and heating solutions by 2030.

This is one of the three pillars of the UN Sustainable Energy for All (SE4All) initiative, along with doubling the global rate of improvement in energy efficiency and doubling the share of renewable energy in the global energy mix.

This Guide is a toolkit for change. The information included here can be used by those stakeholders grappling with the decision to move away from those dirty, inefficient traditional fuels and kerosene to LPG.

This Guide contains important advice on the decision to change, designing the LPG system, operation and maintenance and the important question of keeping the kitchen safe.

In 2012, the WLPGA launched the *"Cooking For Life"* campaign to communicate the health benefits of switching communities from wood, charcoal, coal, dung and other traditional fuels, and kerosene, to LPG for cooking.

In October 2013, SE4All and the WLPGA announced the goal to transition one billion people from traditional fuels to LPG.

To secure this, they agreed to support a multi-stakeholder partnership that would build on best practices and sustainable business models in order to overcome the multitude of policy, market regulation, business environment, and local financing bottlenecks inhibiting the ability of governments and the private sector to meet the need for LPG.

LPG is a clean-burning, efficient, versatile and portable fuel, produced as a co-product of natural gas extraction and crude oil refining. It is either used or lost; from whence came the phrase *'Use it or Lose it'*.

It is consistently among the most efficient heating options and can be up to five times more efficient (higher calorific value) than traditional fuels.

LPG produces less air pollutants than kerosene, wood or coal and emits about 20% less CO2 than heating oil and 50% less than coal; it also reduces black carbon emissions.

It can be transported in small or large quantities by sea, rail or land, including being carried in small cylinders by people. This enables it to be used in the most remote rural areas.

While accidents are very uncommon, LPG is highly flammable, and does require safety precautions in use.

The information in this Guide will provide stakeholders with some sound advice in the decision making process to change to LPG from traditional fuels and kerosene, including some important lessons in the design and operation of the installations.

This Guide has been written with the support of the *World Central Kitchen (WCK)* and a **Chapter Seven** has been written by *WCK* as well as an important Foreword to the document by José Andrés who also provides a recipe which is in Appendix Six.

Chapter One

Background

1.1. The Need for this Document

The WLPGA is committed to providing independent advice to LPG stakeholders to ensure safety in the operation of LPG equipment.

The two WLPGA Guidelines - Good Business Practices and Good Safety Practices - have been used extensively worldwide during the last fifteen years to provide practical guidance across all areas of the LPG industry.

These two Guidelines have been designed to provide general advice to all stakeholders on best practices throughout the supply and distribution chain. They have become flagship documents for the industry in eliminating bad practices.

Following the success of these two Guidelines it was decided to develop and publish more detailed advice in certain areas of the supply and distribution chain that are considered more critical and where more prescriptive advice would be helpful.

There have been several of these more prescriptive Guides published so far including *LPG Cylinder Management*, *Bulk LPG Road Transport* and *Bulk LPG Storage*.

This Guide, entitled *LPG in Commercial Kitchens*, has been produced in support of the WLPGA *Cooking For Life* project which aims to transition a billion people from traditional fuels and kerosene to LPG by 2030.

This Guide focuses on the issues impacting on the decision to transition from traditional fuels and kerosene to LPG in commercial establishments such as schools, orphanages, prisons etc.

The Guide has been written with support from the WCK which has contributed valuable material for which the WLPGA and its members are extremely grateful.

The information in this document has been adopted from globally recognised LPG Standards and Codes of Practice as well as using best practices from major LPG companies.

It is recommended that the advice given here is applied in conjunction with any local laws or regulations to enhance the overall safety performance of the LPG business.

1.2. Who is the Audience for this Guide?

The information in this document will be useful for all stakeholders involved in commercial kitchens seeking to transition from using traditional fuels - such as wood, charcoal, coal, and animal waste, and kerosene - to LPG.

This will include all those involved in the decision to switch energy forms such as governing policy makers, investors, establishment owners, architects, kitchen/commercial building designers, chefs and consumers.

This document contains important facts about traditional fuels and the dangers and threats they pose to public health, safety, society, the environment and the economic fabric of an activity or business that includes a commercial kitchen.

Arguments for switching from traditional fuels to LPG are presented for the decision makers.

Practical advice on designing and sizing an LPG storage and distribution facility are included for the planners and project managers.

Information about using LPG for the first time, and operating a commercial kitchen with LPG, are included here for the chef and his/her team, together with maintenance staff who have to deal with keeping the appliances working efficiently and safely.

Information about the important issue of safety and good maintenance of the equipment is also included for this group.

There is also an important section on hygiene in the kitchen, together with some exciting recipes from Jose Andres.

It is hoped that the answers to every question that might be asked about transitioning from traditional fuels to LPG is found here.

1.3. General Introduction

Today there are three billion people still without access to modern energy. These people rely on traditional fuels such as wood, charcoal, coal. Even animal waste and rice husks. In fact anything that can be burnt and generates heat is a target fuel for these impoverished people.

The more fortunate amongst them will use kerosene. But to climb further up that mythical energy ladder to use natural gas and electricity will be a pipe dream.

The vast majority of these people will live far beyond the reach of gas and electricity grids, leaving LPG as the only real opportunity to escape from the traditional fuel trap. Realistically, in the short term, the top step of the energy ladder for them is LPG.

The ease of handling, cleanliness, energy concentration and portability of LPG enables it to reach out to these people and transform their lives.

No longer is there a need to spend many hazardous hours a day collecting firewood, especially for the woman and children who are normally tasked with that job.

No longer the frustration of trying to light a fire with damp fuel on a wet day.

No longer the appalling polluted air inside the kitchen, caused by the burning of these traditional fuels, creating health risks for all the family.

Figure 1.3a - Wood fired stove in commercial kitchen

Figure 1.3b - Coal briquette stove

No longer the need to sustain the fire throughout the day to cook the evening meal. The photo above shows a wood burning stove in a commercial kitchen. The state of the floor gives an indication of the hygiene levels in this establishment.

The use of coal briquettes has been, and still is many countries, the only really alternative to burning wood in commercial kitchens.

The photo (left) shows coal briquettes being used in a hotel kitchen in South East Asia. The lack of flame control, dirty environment and poor air quality in the kitchen are just some of the challenges. Finding coal dust in the food is a common occurrence for the consumers.

Commercial kitchens that use solid fuel require storage areas for the wood, charcoal, coal etc. These must be designed to keep the fuel dry, especially during winter months or monsoon periods.

Aspiring to using kerosene brings its own hazards, especially to children. Because kerosene is often stored in bottles that resemble water or soft drink containers, it is often mistakenly drunk and is one of the most common causes of paediatric poisoning (Lang, et al., 2008). Kerosene is also highly inflammable and poses a serious fire risk when used carelessly.

If there is no access to the gas grid, or a reliable electric power supply, the only real opportunity to move away from traditional fuels to a modern form of energy is to use LPG.

Even if there is access to a gas grid or a reliable electric power supply LPG still makes a compelling case because of its suitability as a cooking fuel.

LPG has a very hot flame, which is easily controlled to use with both woks and simmering pans, and very clean, both to use and burn.

The versatility of LPG also allows it to be used as an engine fuel (perhaps in a gas generator for power generation), powering refrigerators and heating water.

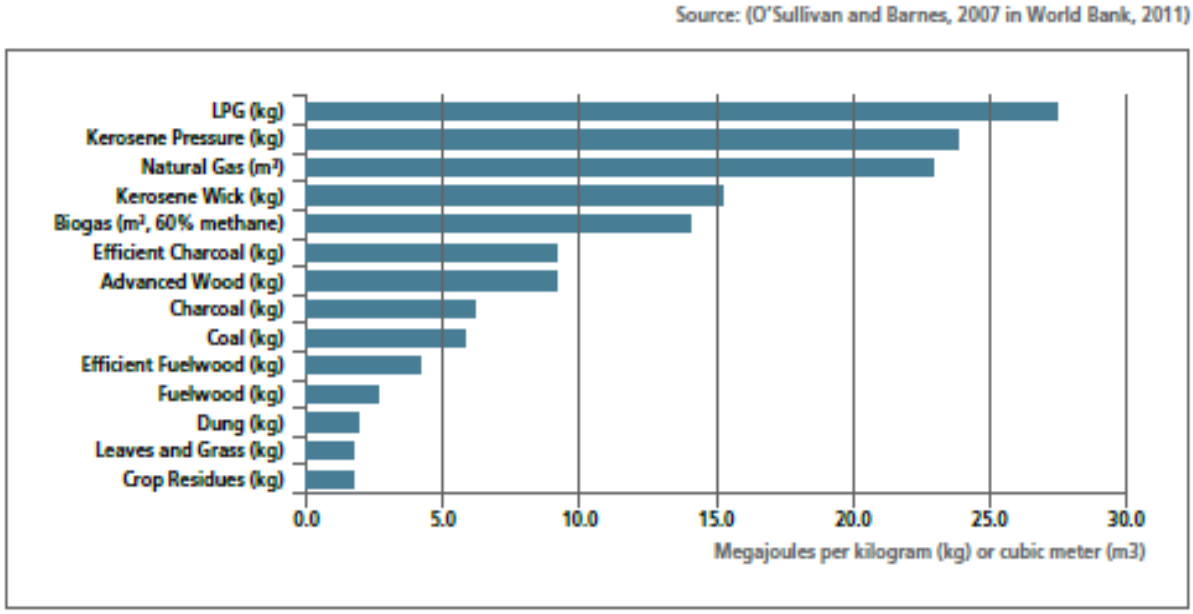


Figure 1.3c - Comparative energy table with different fuels

LPG clearly leads other fuels when comparing gross energy content. If the relative efficiencies are taken into account - and also the greater controllability of the LPG flame against traditional fuels - the gap is wider (see Figure 1.3c).

Many of the fuels shown here have to be mined, collected or gathered, in often dangerous circumstances and frequently by women and children.

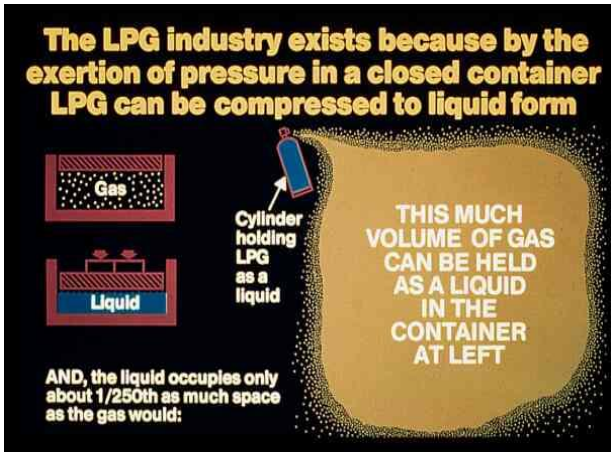


Figure 1.3 d - Illustrative diagram showing the power of LPG

One of the properties of LPG is the ease in which it can be liquefied. In a liquid state LPG contains around 250 times the amount of energy than in a vapour state (see Figure 1.3d opposite).

The pressure required to liquefy LPG is relatively low allowing it to be stored in convenient pressure vessels designed for moderate pressure.

These pressure vessels are generally made of steel but more recently the use of composite plastics has been used to reduce the weight of the container, resist corrosion and to also allow the contents to be seen.

Figure 1.3e - 45kg cylinder storage

For commercial operations LPG can be supplied in large cylinders, (shown here in figure 1.3e on the right) or if the demand warrants it, small bulk tanks (shown below in figure 1.3f).

Typically large cylinder installations are designed to ensure continued operation even if the cylinders become empty.

This is done by having a changeover valve that detects when one set of cylinders are becoming empty and switching across to the full ones automatically.

Figure 1.3f - Small above ground bulk tank

Small bulk tanks are installed when the demand is higher and deliveries by bulk truck are possible.

Both forms of storage are addressed in this document together with detailed information on the benefits of each types of storage and the design implications for both.

Important properties and hazards of LPG are included in Appendix One.

Chapter Two

The Case for LPG versus Traditional Fuels

2.1. Summary of Benefits of LPG Over Traditional Fuels (Health, Social, Environmental, Economic)

Behind the burning of traditional fuels such as wood, charcoal, coal and kerosene lies a very dangerous and challenging story.

The mining of coal has a long history of injuries and deaths associated with bringing it to the surface. The subsequent transportation, storage and combustion of coal is far from being described as clean, and brings with it challenges to human health. Especially when used in old and badly designed equipment.

Traditionally the collection of wood is done by women and children. It is a painstaking daily task that starts early in the morning and can take several hours. The forests are often remote and can be dangerous. Personal attacks are not uncommon.

Figure 2.1a - Women carrying wood

It is not the older, well established, trees that are felled. These trees are far too big to collect. No, it is the young trees that are taken, undermining the future of the forests (see Figure 2.1a)

The woman and children can take several hours to collect the wood and the trees get further away from the villages every day.

The other consequences impact on the social and economic aspects of the family. Very young children are left by their mothers with other family members, often the grandparents. Or sometimes parents take their young children with them to collect wood and that impacts the children's schooling and education. Time spent collecting the wood could be more usefully employed by the woman if the opportunity was there.

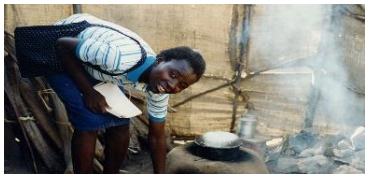


Figure 2.1b - Woman burning wood

When these fuels are burnt they are often used in open stoves that release damaging emissions in the kitchen. This results in respiratory and cardiovascular related infections and diseases following the inhaling of smoke.

The use of firewood is also a major risk for burns, especially with children, and a major cause of homes being destroyed by fire.

Figure 2.1c - Children buying charcoal

Charcoal is another dirty fuel to handle and use, generating a similar type of environment as wood. Because it is relatively light and easy to carry, children are frequently asked to collect the charcoal. This creates risk because they are carrying money and are vulnerable to assault and theft.

The traditional LPG distribution channel is well established and involves trained and professional people delivering the LPG to the consumer.

In the case of a commercial kitchen the demand will be relatively high probably requiring either a small bulk tank or a bank of large cylinders.

LPG is very clean to store and use. A small leak of LPG will disperse, whereas a leak of kerosene is not only smelly it is dangerous.

LPG is also very clean to burn, resulting in very low emissions. Extremely low when compared to traditional fuels. The LPG flame is also very hot and extremely easy to control.

Once lit, wood and coal burning stoves have to be kept sustained throughout the day and evening, resulting in unnecessary harmful emissions streaming into the kitchen. The real relative efficiencies of using LPG versus traditional fuels often don't take this fully into account.

2.2. Case Studies of Where this Type of Transition has already Occurred and Some of the Lessons Learned

2.2.1 Case Study One - Tandoor Oven (Wood to LPG)

The traditional way to cook naan bread, commonly used in the Indian sub-continent, is in a tandoor oven fuelled by wood. This example is of a small restaurant outside Karachi in Pakistan using four tandoor ovens that the owner wanted to convert to LPG.

In this example the change was driven by the owner who wanted to make savings on his fuel costs. He decided to arrange for the conversion of one of the ovens from wood to LPG, and invited a major LPG company to advise him on the process.

There were concerns from several stakeholders about changing from wood to LPG.

Figure 2.2.1a - Tandoor oven burning wood

One of the key concerns that was identified was the fear that the customers eating the naan bread in the restaurant would notice any difference in taste. The owner believed there would be significant benefits from switching to LPG from wood but he didn't want any adverse impact on his clientele who were mostly regular customers.

He decided not to tell his customers about the switch beforehand and seek their comments and feedback afterwards.

The trial was conducted by modifying one of the ovens to run on LPG instead of wood. The same oven was used except the wood grate was removed and a LPG burner was fitted into the base of the one of the tandoor ovens. The owner was expected to create space for LPG storage later on but for the trial he used one LPG cylinder connected directly to the oven.

The time taken to cook the naan bread, and the amount of gas used, were both measured. The staff was thoroughly trained in the storage, handling and operations of using LPG beforehand.

The restaurant ran a trial for two weeks and then the results were assessed. The customers of the restaurant were asked about their views of the taste of the naan bread, especially the ones receiving the bread from the LPG fired oven. The owner made an excuse about a new oven but didn't mention the change of fuel.

The result of the trial was positive with a number of benefits:

- The Restaurant Owner was Happy because the Fuel Cost, per Cooked Naan, was much Lower with LPG
- The customers did not notice any difference in taste (which was positive)
- The wood distributor was concerned about losing a key customer (until he was told he could become a LPG distributor and supply the restaurant, and others who were to switch later)
- One of the head cooks in the kitchen was unhappy. It was discovered he regularly inhaled the smoke from the wood fired tandoor oven and that activity would stop with a total switch of all ovens to LPG

Following the trial a calculation was done on the amount of LPG used and a small storage installation was designed based on large LPG cylinders. All four ovens were subsequently converted to run on LPG enabling the transition to be made with minimum change to the facilities.

At that stage the individual who had been inhaling wood smoke in the kitchen was replaced.

After the conversion the delivery time for getting the naan bread to the tables was shortened and savings were made on the restaurant's energy costs because the ovens could be heated quicker and the flame could be controlled more efficiently.

The key lessons learned were that all stakeholders need to be fully involved with any change process and the impact of the change needs to be fully understood.

Secondly there needs to be an accurate measure of the energy costs in order to quantify the savings. In the case of the restaurant that was measurement of the amount of energy used during the opening hours and linking that to the output of the ovens (number of naan bread cooked in a shift versus kg of LPG used).

2.2.2 Case Study Two – Street Restaurant (Coal to LPG)

Conversion of a coal briquette fired restaurant to LPG in Asia.

This example looks at a road side commercial kitchen that was using coal briquettes, and targeted to switch to LPG.

The coal briquettes (see Figure 2.2.2b) are small cylindrical blocks of compressed coal dust, held together with a binder, with several holes running though their length in order for the air to circulate.

Figure 2.2.2b - Coal briquettes in basket

These coal briquettes are dirty to store, handle and burn and difficult to control the heat output once lit. Often the stall holder will control the heat by having several stoves with the fires at various stages of intensity (see Figure 2.2.2c).

The challenge was to convert this application to LPG without disrupting the commercial operation of the restaurant.

The owner of the stall was interested in the proposition to switch away from coal, but needing convincing about using LPG, was nervous about the impact that running a trial would have on his business, and needed evidence that it would save him money.

Demonstrating the benefits of LPG to the owner was not so difficult. A small demonstration, with a LPG cylinder and hot plate, and boiling a kettle of water was simple enough.

Especially when running the demonstration with a coal briquette stove alongside with a similar kettle of water (three kettles of water could be boiled on a LPG flame while the one on the coal stove was still waiting to boil).

Apart from the interruption in the kitchen during any trial, the main challenge was the compatibility of the LPG stove with the existing appliances in the kitchen (woks, pans etc.) and how the LPG stove would fit into the kitchen environment.

Figure 2.2.2c - Commercial wood burning stove

It was decided to run the trial in a way that two objectives could be met:

1. The concept of using LPG would be tested in a separate stove that had the same configurations, and height, as the coal briquette stove. This would allow the existing pans to be used, and replicating the environment of the existing kitchen.
2. The existing coal briquette stoves would be converted to run on LPG rather than introduce new equipment. This would not only reduce costs it would minimise change.

A clay coal briquette stove commonly found in domestic kitchens (see Figure 2.2.2d) was used for the trial. The stove is used in domestic households not only as a cooking stove but also a room heater in the winter months.

The conversion of the stove shown in Figure 2.2.2d opposite allowed the existing equipment to be used.

Also the workers at the restaurant were very familiar with the clay stove and this limited the degree of change they would face in the trial. The alternative would have been to use a LPG stove.

To conduct the trial, a simple LPG burner head was modified and placed inside the clay stove with the hose running down the centre and out the bottom to the cylinder.

This allowed the existing equipment to be used on the LPG fired stove alongside the existing five burner coal fired stove.

Figure 2.2.2d – Coal briquette burner modified to use LPG (4.5kg cylinder)

The result was very positive with all workers keen to switch because of the ease of use, powerful and controllable flame, and cleanliness of operation.

Having run the trial the existing coal stove was quickly converted using the same configuration shown in Figure 2.2.2d and the restaurant had switched from coal to LPG in less than an hour.

One of the benefits of such a highly visible application as a street side restaurant is the number of people who have the opportunity to see it in operation. As a result of this successful conversion, not only did other restaurants in the town switch to LPG but many domestic users also switched because the conversion was so simple.

The key lessons from this example are the need to keep the switch simple by minimising the amount of change.

The use of a popular, clay, coal burning stove removed a barrier that the LPG stove might otherwise have presented. By modifying this stove to use LPG allowed the kitchen equipment to be re-used with LPG. It also opened up bigger opportunities in the domestic sector where the conversion from the clay coal burning stove to LPG could be done using the same equipment.

Finally minimising the disruption to the day to day operation of the busy restaurant by retaining the existing five burner stove and converting to LPG with confidence was important to everybody involved, especially the restaurant owner.

After this successful conversion a vigorous campaign was run targeting the domestic users focussing on a demonstration outside the LPG dealer's retail outlet. The crowds stopped traffic in what was to be a very successful campaign that saw the beginning of the demise of the coal briquette stove in both small restaurants and domestic households. The LPG cylinder shown in the photo is 4.5kg. This was used to penetrate the domestic market because the total weight of a full 4.5kg cylinder was no more than a large bag of rice which the woman in the household could carry. The stove used for the launch sat on top of the cylinder, replicating the dimensions of a clay coal fired oven.

Chapter Three

Converting from Traditional Fuels to LPG

3.1. Preparation for the Transition to LPG

For so many people in the world the use of traditional fuels is not challenged. There simply is no alternative.

The chore and hazards of collecting the fuel, storing it in a dry secure place, struggling to light the fire every day, tolerating the filth and dangers that come with the smoke emissions; these are never questioned.

Figure 3.1a - Wood pile at retail outlet

Aspiring to an alternative, cleaner and more efficient fuel is often not considered simply because of the lack of knowledge, availability and understanding of alternatives.

This presents a big challenge to all stakeholders when there is an opportunity to convert to an alternative fuel, especially LPG.

Unlike traditional fuels, which are very visible, LPG is a gas.

LPG is contained inside a cylinder or tank under pressure. It cannot be seen or touched or stacked. Traditional fuels, such as a pile of wood, creates a constant visual reminder of the energy available to the distributor or user.

The difference between using traditional fuels and LPG as a primary energy source in kitchens is significant and impacts on all the stakeholders in the supply and distribution channel.

3.1.1 Engaging Stakeholders

Identifying and engaging the stakeholders who are impacted by the change to LPG from traditional fuels is an important first step to take in the change process in order to gain their acceptance.

Who are these stakeholders? The diagram below suggests some of the stakeholders that can have an influence in the change process, either in a positive way and/or a negative way.

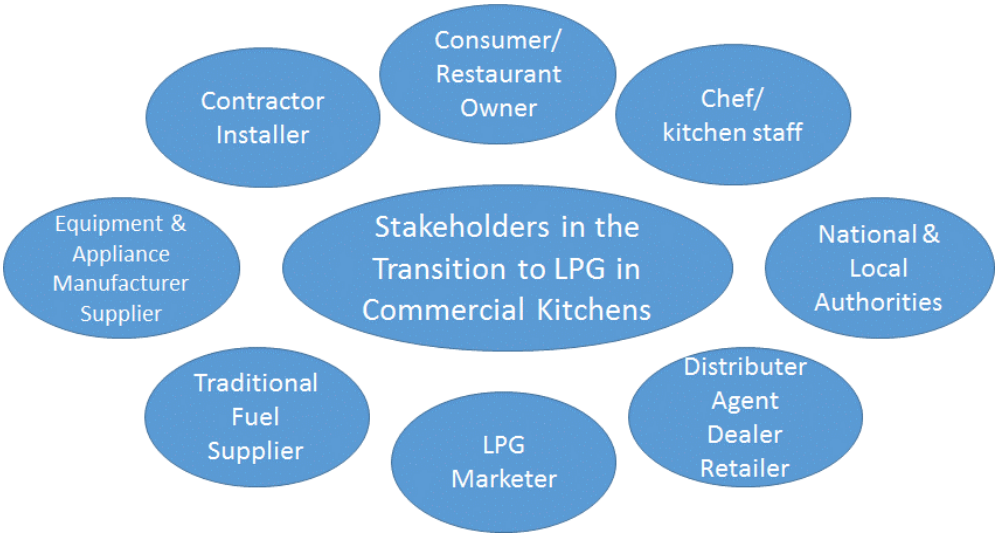


Figure 3.1.1a - Stakeholders in the LPG transition process

Some of the most important stakeholders are the ones involved in the fuel supply and distribution chain. For the traditional fuel suppliers, like the ones shown in Figure 3.1.1b, the emergence of LPG as a competing fuel will be a threat. To lose commercial business for these suppliers of wood would be a big blow and they will resist change.

During the conversion programme in Indonesia when tens of millions of kerosene users, including small and medium sized enterprises were switching to LPG, there were complaints from kerosene distributors about the impact on their business. That had to be managed.

Often these distributors can readily change their fuel supply business from traditional fuels to LPG but it may take persuasion, and will certainly take education and training, before they can take on that new role.

They have to understand the benefits of change. Not simply the benefits to their bottom line but also they need to become champions of LPG and promote the benefits to health, to the environment and to the economy.

Figure 3.1.1b - Wood seller in East Timor

Figure 3.1.1c - Multi fuel outlet in Indonesia

This fuel supplier in Indonesia (see Figure 3.1.1c) saw the opportunity of diversification and was able to supply wood, charcoal, kerosene and LPG depending on your choice. But he admitted the introduction of LPG was seen first as a threat, and then an opportunity.

This is a business in transition. The move from the old game to the new game. By still retaining an interest in the traditional fuels allows him to protect his business during the transition to LPG.

Equipment suppliers are also impacted by change. The need to understand modern gas appliances and all the associated equipment such as pipework, regulators, vapourisers etc.

3.1.2 Securing Budget for the Transition

To convert a commercial kitchen from traditional fuels to LPG requires investment. Unlike wood or coal which is often just stored on the ground under cover LPG is a fuel under pressure. The pressure is not excessive but still requires a vessel that is able to safely retain the product up to around 17.5bar.

System design is covered under CHAPTER FOUR and the equipment and appliances needed to switch to LPG is fully explained. The investment for designing and installing a system to convert a commercial kitchen from traditional fuels to LPG will need to be found. This may be achieved through government, private or non-government support.

Justification for transitioning away from traditional fuels to LPG will not be difficult when all the benefits are factored in. Apart from the obvious improvements in hygiene, cleanliness, health and safety in the work environment there are the tangible benefits in energy consumption.

The easy to control 'turn down' or 'turn off' of a LPG flame will eliminate the need for sustaining a fire under a traditional fuel stove and associated wasted fuel. These will benefit the stakeholders in the kitchen and encourage investment in LPG.

Then there are the environmental benefits associated with cutting back on deforestation and these might encourage investment or grants from a government keen to assist in arresting the use of wood as a commercial fuel.

It is mentioned elsewhere but it is worth repeating the need for planning for expansion. An option to add an additional storage tank or new kitchen appliances should be factored into the design to minimise the need for additional investment when time occurs.

3.1.3 Establishing the Regulatory Framework, Enforcement and Compliance

Although LPG may be a new product for organisations and consumers looking to transition from traditional fuels it is far from a new fuel. LPG has been in use for over 100 years and during this time there have been some sound standards and codes of practice produced to ensure the product keeps its fine safety record.

LPG is a hazardous product and must be stored, handled and used correctly. It is important for new users to understand the need for good safety practices and equally important for regulatory authorities to ensure enforcement and compliance to these. If standards/code of practises are not in existence, industry will have to work with the authorities to put standards in place.

The LPG business sometimes attracts illegal activities such as using recycled cylinders that have already been scrapped, under filling of cylinders and illegal filling of other company cylinders.

It is important these illegal activities are stopped and all efforts should be made to outlaw them, both by the LPG industry through vigilant attention to the distribution channel and by government through an efficient and enforceable legal structure.

3.1.4 Developing the Supply Chain

Although LPG is used in most countries in the world for situations where traditional fuels are commonly still used there may not be a well-established supply chain for LPG.

LPG is a co-product from the crude oil refining process and natural gas production. In some countries it may be necessary to import LPG to meet the growing demand. LPG may therefore be supplied from refineries, natural gas terminals or import terminals. A typical established supply chain is shown in APPENDIX TWO.

For countries in transition between traditional fuels and LPG the supply chain may not be so established. One of the characteristics of LPG is its portability and this manifests itself in the supply chain. LPG can be supplied in cylinders or bulk.

LPG supplied in cylinders to commercial kitchens with relatively small offtake might be satisfied with supplies in cylinders. The majority of cylinders supplied to the domestic sector are generally below 15kg in capacity but for small commercial consumers, such as kitchens, cylinders can be typically between 45kg to 50kg capacity. Refer to CHAPTER FOUR for more details.

LPG in bulk or large cylinders is typically supplied by road either directly or through a distributer network. Countries in transition from traditional fuels to LPG will require a supply chain to develop the market. Initially this might focus on cylinders but as the market develops the need for bulk supplies will grow. Supplies in bulk require not only bulk storage facilities but also a bulk road transport operation to deliver in bulk.

3.1.5 Converting Traditional Fuel Suppliers to LPG Dealers/Retailers

One of the obvious opportunities for stakeholders in the traditional fuel business is to move with the transition and become involved in the LPG business. This removes some of the obstacles to change and creates a less complicated transition.

This stakeholder group is aware of the different types of energy available and are driven by commercial opportunities.

3.1.6 Training on LPG safety and regulations for all stakeholders

With this developing supply chain comes a need for education and training. Training of cylinder filling plant operators, contractors, dealers, retailers and consumers. It is possible that training facilities are available in the country of transition but it is probably more likely that training courses are organised in country using overseas resources with expert knowledge on LPG operations.

On-site training and education is another powerful tool that can be used. Taking the information to the user through demonstrations is an effective method.

This LPG supplier in India was able to educate new users of LPG of its benefits and important properties by taking a small 'road show' into the community together with personnel having expert knowledge on LPG operations.

Figure 3.1.6a - Hands on training in India

3.2. Basic Considerations When Converting to LPG

3.2.1 Choosing LPG Supplier and Installer

LPG suppliers play an important role in the success of the conversion program. They may be a producer, primary marketer or a distributor appointed by a marketer. LPG suppliers should be selected based on their track record of providing reliable supply and compliance to safety standards.

LPG suppliers are responsible for the quality of the LPG supplied i.e. conformance to agreed specifications or declared standards and for the quantity of LPG delivered i.e. declared volume in bulk delivery or weight in the cylinders filled.

LPG suppliers should ensure reliable supply to consumers by maintaining sufficient inventory in its terminal or depot or in the case of distributor should have sufficient filled cylinders to meet the requirements of its consumers. Reliable supply also means having the logistics capability to bring the products to the consumers when they need it. Any disruption in supply will discourage consumers from converting to LPG.

LPG suppliers that provide cylinders and tanks to consumers should ensure these containers meet applicable standards and are always maintained to safe working conditions i.e. cylinders supplied should always be within their requalification validity date. This minimises risks of any incidents associated with poor LPG cylinders or tanks.

Installers provide the service for connecting the LPG containers to the consuming appliance. They are responsible for designing the piping system suitable to the consumer's needs and for ensuring that the pipework conforms to statutory or code requirements.

Installers should be competent and possess the right qualifications to carry out LPG piping works. Some countries have accreditation or licensing requirements for installers which should be one of the factors for choosing installers.

Installers are also responsible for instructing the consumer on the correct way of using the LPG installation and the safety features and actions to take in case of an emergency. These should be done when the piping works have been completed and before they are handed over to the consumer.

It is not unusual for LPG suppliers to be installers as well. In this case, the whole LPG system from container to piping up to the appliance is under the responsibility of one party.

3.2.2 LPG Supply Contracts

There are different types of LPG supply contracts between consumer and suppliers. Each of these will have their own advantages and disadvantages and consumers must choose the supply contract most beneficial to them based on their own situation. Some examples of the more common LPG supply contracts are as follows:

1. LPG Supplier provides cylinders, tanks and piping

   Under this contract, LPG supplier provides the consumer with the LPG container and piping and is responsible for maintaining it to a safe and serviceable condition. The LPG supplier retains ownership over these assets and if any of these become defective i.e. corrosion, dents, leaking, etc., the LPG supplier is responsible to repair or replace them. The cost of the LPG facility provided by the LPG supplier is typically recovered through the LPG price and binds the consumer to an exclusive supply contract over a period. The contract duration is typically long enough for LPG supplier to recover his investment and make a reasonable return.

2. Consumer owns the LPG cylinders, tanks and piping

   Under this contract, the consumer buys and owns the LPG cylinders, tanks and piping. He is responsible for maintaining the entire LPG facility in safe and operating condition and this is usually contracted out to an installer. The LPG supplier's role is to deliver the gas. Since the consumer owns the LPG facility, he is not tied down to any exclusive supply contract with one supplier and has the benefit of shopping around for the best price whenever he needs LPG. For this type of contract the consumer should take out a maintenance agreement to ensure the tanks and pipework are always in serviceable condition.

3. Other Contracts

   There are variations to the above contracts. One variation is where the consumer owns the cylinders, tanks and piping and opts to have an exclusive supply contract with one LPG supplier. This type of contract is useful if LPG supply in the locality is unstable and having an exclusive contract will guarantee continuous supply and minimise risks of stock outs. The consumer may opt to include inspection and maintenance as part of the contract. This contract typically has a shorter duration since the supplier does not have any upfront investment to recover. Another variation is one where the containers and piping are invested initially by the LPG supplier and paid by the consumer through a monthly amortisation scheme over the duration of the contract. By the end of the contract, the containers and piping become of the property of the consumer

3.2.3 Space for LPG Installation

Consumers converting from traditional fuels to LPG should be prepared to allocate a suitable space for their LPG installation. The location must comply with safety standards so as not to pose a hazard to people in the building as well as the surrounding community (see section 4.2).

LPG installations should be outdoors and the space required will depend on the size of the installation. Cylinder installations will typically require a smaller footprint compared to bulk tank installations.

Where cylinder installations are allowed by law to be indoors, they must be in an isolated section of the building and ventilated to outside air. It must comply with all safety requirements.

The location of the LPG installation should be accessible to delivery trucks, particularly bulk storage facilities. Deliveries can take a few minutes to an hour depending on the quantity of LPG to be unloaded. This should be considered when selecting a site to avoid inconvenience to occupants of the building and minimise any risks during delivery.

The installer is usually the person qualified to assess the suitability of a space for LPG installation and to give recommendations, if any, to meet safety requirements.

3.2.4 LPG Appliance

LPG appliances are efficient and convenient to use compared to traditional stove using charcoal or firewood. They provide a flame that is easily controlled and a heat which is powerful and consistent.

LPG appliances emit no smoke and other toxic fumes that can be health hazards. They must however be placed in a location with sufficient ventilation to disperse the products of combustion consisting mainly of carbon dioxide and water vapour. This minimises risks of build-up of carbon monoxide and asphyxiating (oxygen deficient) conditions.

There are many types of LPG appliance available that can meet the different cooking needs of the consumer i.e. burners, ovens, etc. The right appliance should be chosen for consumers to optimise the benefits of switching to LPG.

Consumers must buy appliances that are certified and/or meets applicable standards or regulations. Buying uncertified appliances may pose a risk to the user.

The LPG appliance chosen must be compatible with the grade of LPG used. Propane burners are typically adaptable for use with LPG with minor adjustments of the air vent. The installer must be consulted regarding any adjustments to be made on the appliance.

LPG appliances used should have automatic igniter and flame failure device. The latter is a safety feature that cuts off the flow of LPG to the burner in case the flame is extinguished for some reason (i.e. blown out by weather) to avoid the discharge of unburnt gas.

A conventional LPG burner follows a simple combustion principle. Gas passing through the injector draws in about half of the air required (called primary air) for combustion which then mixes together in the burner mixing tube. The rest of the air required (called secondary air) is drawn into the outer envelope of the flame itself from the surrounding atmosphere.

The amount of primary air entering the burner mixing tube can be adjusted on some appliances by an aeration screw or shutter to achieve a clean blue flame that does not result in soot. On other appliances where there is no provision for adjustment, the burner has a fixed aeration pre-set by the manufacturer, to entrain the correct amount of primary air. The amount of secondary air is not normally regulated and is dependent on the ventilation of the room.

Insufficient air will result in yellow tipping of flame. On the other hand, excessive air will cause lifting flames. It is the appliance installer's responsibility to ensure there is adequate supply of air for combustion and for the comfort and safety of the occupant. It is recommended to get the LPG appliances installed and serviced by an approved installer.

Chapter Four

Designing the LPG Installation

4.1. General

A properly designed LPG installation ensures safe and reliable usage. This benefits both the consumer and LPG supplier and encourages non-users to convert from traditional fuel to LPG.

A good installation is one that has the correct storage capacity, used the right pipe size, sited in a safe location and is fully compliant to local regulations and international LPG standards or codes of practice.

All materials and equipment used must be compatible to the grade of LPG used.

LPG installations should be designed and installed by a competent and qualified installer.

4.2. Components of LPG System

A basic LPG system consists essentially of the LPG container (cylinder or tank), piping or tubing, a regulator and an appliance. The container stores LPG under pressure in liquid form and generates vapour when pressure is released. The container can be cylinder(s) or bulk tank(s) depending on the needs of the consumer. The piping or tubing conveys the vapour from the container to the appliance where it is ignited to create the flame for cooking. LPG vapour pressure inside the container fluctuates with changes in temperature which is not good for the appliance. The regulator is used to control the vapour pressure to a constant and appropriate level for efficient performance of the appliance.

In cases where containers do not have capacity to generate sufficient vapour for the appliances connected, a vapouriser is used. The vapouriser withdraws liquid LPG from the container and vapourises it by means of electrical power or circulating hot water supplied from a boiler or water heater.

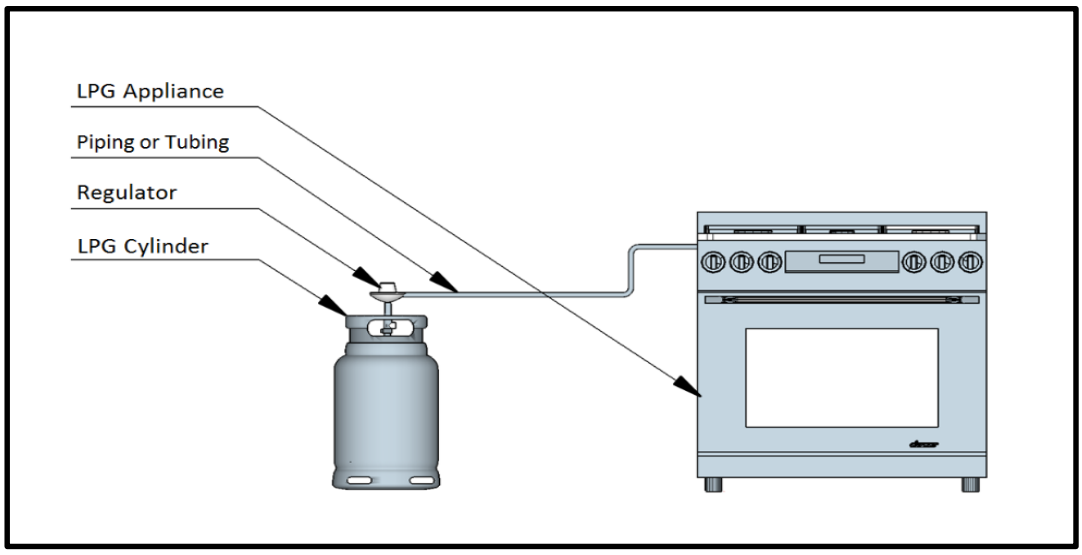


Figure 4.2a - Basic components of a LPG system

4.3. Sizing the LPG installation

4.3.1 Determine the Total Load

In order to properly determine the size of the LPG installation, regulator to be used, the pipe size, etc., the total consumption must first be estimated. This can be determined by adding up the rated consumption of all the appliances to be connected to the gas pipeline. The rated consumption (or BTU input) can be seen on the nameplate of the appliance or it can be obtained from the manufacturer's manual. The rated consumption of some appliances may be expressed in CFH (cubic feet per hour) in which case must be converted to BTU by multiplying with the unit heating value of LPG.

Appliances to be installed in the future must be considered when planning the LPG installation to eliminate the need for a later revision of the piping and storage facilities.

The size of the installation should also take into account the frequency of replenishment and delivery lead time of the supplier.

4.3.2 Evaporative Capacity of LPG Containers

The LPG containers capacity to generate vapours (also called evaporative capacity) depends on ambient temperature and the 'wetted' surface which is the area in the container in contact with liquid LPG. Heat from the surrounding entering the container through the 'wetted' surface helps in 'boiling off' LPG to turn it into vapour. The bigger the 'wetted' surface, the more vapours the container can generate. The evaporative capacity of the container therefore is higher when the container is full and diminishes as the liquid level drops.

The evaporative capacity of LPG containers is a key input in deciding how many cylinders or what tank size to install. For a typical commercial LPG cylinder of 50kg capacity, the rule of thumb is to take the evaporative capacity of a third full cylinder and this can range anywhere from 50,000 to 140,000 BTU/Hr depending on the climactic conditions of the area and the consumption pattern i.e. intermittent or continuous (see Appendix Three). For bulk tanks, the evaporative capacity can be estimated if the tank dimensions are known.

When extremely high vapour withdrawal rates are applied to the container, the temperature of the liquid LPG will drop and the 'wetted' surface will cause condensation to collect on the container's exterior. In cold weather the condensate may freeze and become a barrier for the heat transfer needed for vapourisation. It is critical to ensure that the evaporative capacity of the LPG facility is sufficient to meet the requirements of the connected appliances when designing a LPG system.

4.3.3 Deciding on Cylinders or Bulk Tanks

LPG installations can either use cylinders or bulk tanks. There are pros and cons for each and the installer is the best person to recommend which type will best serve the needs of the consumer.

Generally, a bulk installation is preferred for consumers with high consumption while cylinder installations are used mostly for low consumption or where space is limited. A comparison of bulk versus cylinder installation is shown below:

Cylinder Installations

- Generally for low consumption applications but can serve large requirements by adding more cylinders
- Requires less space
- Allowed indoors in some countries
- Installation is comparatively simpler
- Cylinder handling can be tedious for big installations
- May have residual gases left inside cylinder
- Flexibility of replenishment – deliveries can be arranged by the consumers, or the supplier, depending on the agreement

Bulk Tank Installations

- For high consumption application
- Needs bigger space
- Must be outdoor and away from building
- Can be installed above or underground
- Higher initial cost of installation
- Replenishment via road tanker entails less manual handling but …
- … Requires road access

Vapourisers can be used with both cylinder and bulk tank installations to improve the evaporative capacity of the site. Vapouriser for small commercial applications are usually electrically heated. For larger applications, the vapouriser system may be designed to use circulating hot water from a boiler or water heater. Vapourisers using other heat sources have been introduced into the market recently.

4.4. Selecting location for LPG installation

4.4.1 Compliance with Local Regulations and LPG Standards

LPG is highly flammable and its storage and handling is usually governed by strict rules. If the local regulations are less stringent than international standards or codes of practice, then the more stringent requirements must be followed.

NFPA 58 and the UK LP Gas Codes of Practice are useful references for storage and handling of LPG and used widely across the world.

4.4.2 Safety Considerations for LPG Installation Site

Some requirements that should be considered when deciding on location for LPG installation are as follows:

Cylinder installation

- Must be outdoor and in a well-ventilated area
- Base must be on a firm base which is level , non–combustible, not resting on soil, clean, and dry
- Must not be below ground level i.e. basement, etc.(LPG vapour is heavier than air)
- Away from entrance and exit of buildings
- At least 1.0m away from any openings i.e. drains, culverts, doors, etc.
- At least 1.5 m from any source of heat i.e. air conditioner, steam pipes and boilers.
- At least 3.0m away from any open flames
- Preferably on ground level unless suitable lifting facilities are available to transfer cylinders to higher floors
- Must be accessible to changing and quick removal in case of emergency
- Must not be stored together with oxygen and other flammable material i.e. gasoline, etc.
- Should be protected from vehicular collision or damage
- Secured by suitable fence to prevent unauthorized tampering.
- If permitted indoors by local regulations, this should be in a separate and isolated section of the building exclusively for this purpose. It must have access to outside air for ventilation.
- In some countries cylinders shall be restrained against seismic activity

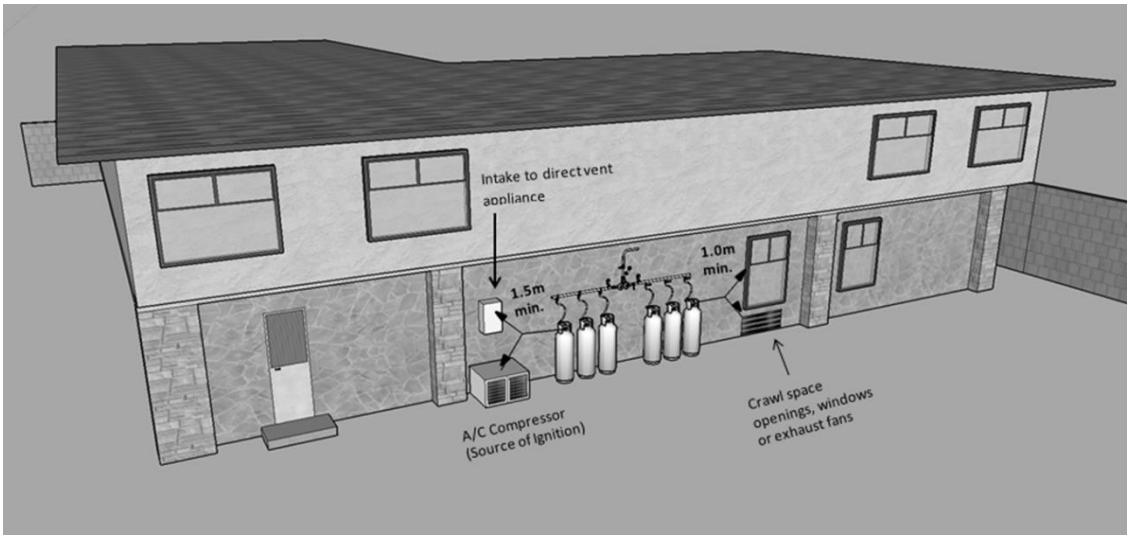


Figure 4.4.2a - LPG cylinder installation location

Bulk Tank Installation

- Must comply with applicable safety distance requirement (see NFPA 58 Table 6.3.1.1 in Appendix Four) and the regulations/standards of the country in use
- No open drains, or ducts located within the storage tank safety distance. If this is unavoidable, they must be fitted with a water trap or suitably sealed to prevent passage of LPG vapours
- The ground beneath or adjacent to tank connections or ancillary equipment should be cemented or compacted and arranged to prevent either the accumulation of any liquid beneath them or its flow affecting other tanks or important areas
- Provision should be made for handling the run-off of cooling water applied under fire conditions.
- The vicinity of LPG storage tanks should be free from pits and depressions within the required separation distance to prevent the formation of gas pockets
- Must not be stored within the bunded enclosure with oxygen and other flammable materials i.e. gasoline, etc.
- At least 1.8m away from high voltage power lines
- Site must be accessible to delivery vehicles for unloading. It must allow truck to be positioned in a way that does not require reversing to drive off in case of an emergency
- To improve the evaporative capacity of the tank, the site must be exposed to direct sun rays and not be in shade

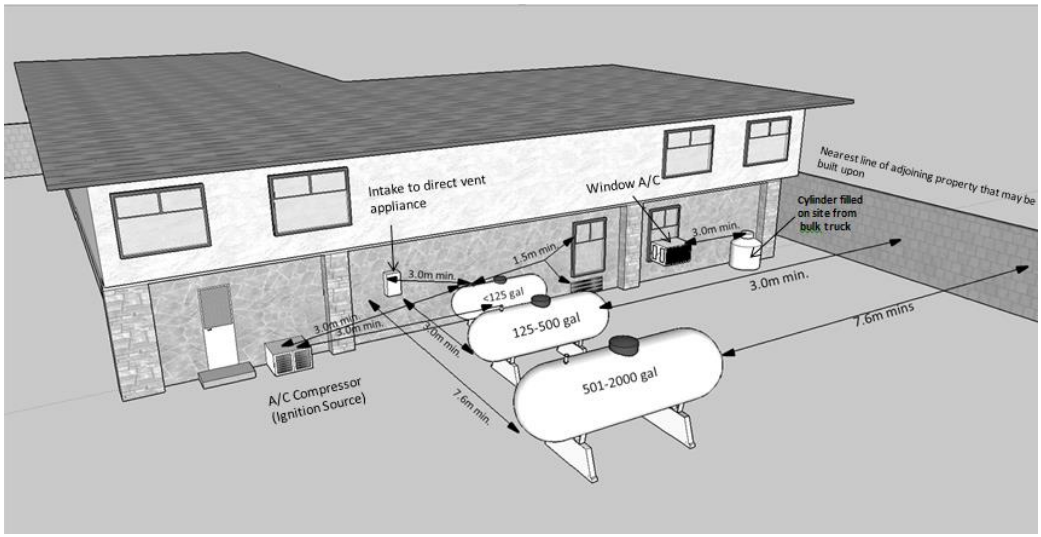


Figure 4.4.2b - Bulk tank installation location

Where the initial capacity planned caters only to current requirements only, consideration should be given to allocating space for additional cylinders or tanks in the future if there are plans to expand.

4.5. Installing LPG Piping

4.5.1 Materials

Pipe and Pipe Fittings

Materials used for LPG piping should be suitable for the range of temperatures and pressures that could occur in service. Acceptable materials include carbon steel, copper, brass, and polyethylene plastics.

Carbon steel pipes are very common material used in LPG pipeline. They are rigid and strong and can withstand mechanical damage better than other materials. Carbon steel pipes used may either be black or galvanized and should be at least standard weight (Schedule 40). Extra strong pipe (Schedule 80) may be required depending on pipe size, working pressure and method of jointing. Jointing can be by thread, welding or flange connections.

Cast iron fittings must not be used.

Copper tubing is often used for domestic and small commercial installations. Although tubing costs much more than steel pipes of the same capacity, there is considerable saving of labour in its installation and maintenance. Since tubing may be bent readily, it is more easily installed and fewer fittings are required. However, it is more vulnerable to mechanical damage and it does not generally produce neat piping unless it is installed with particular care. Copper tubing can be affected by sulphur so it must be used with a LPG low in sulphur content.

Polyethylene (PE) pipes are normally used for buried pipe sections. They are lightweight and corrosion-resistant. Jointing can be by means of compression fitting, factory assembled fitting or heat fusion. The latter is usually done automatically with a fusion machine which ensures a good joint. PE pipes and pipe fittings used should be PE80 or PE100 rating.

Other materials used for LPG piping includes Corrugated Stainless Steel Tubing (CSST) and multilayer pipes. These materials are flexible and corrosion-resistant and jointing method is by use of proprietary fittings and tools. Additional information should be sought from manufacturer when such materials will be used.

All piping and tubing must only be installed by approved installers.

Flexible Hoses

Flexible hoses if used should be of the correct pressure rating and material designed for LPG. This is usually reinforced rubber or plastic with metal braiding and marked with 'LPG Hose'. There are no specific recommendations on the replacement intervals for hoses but 5 years is considered a normal useful life for rubber hoses which should not be exceeded. Note that adverse operating conditions could shorten the useful life of hoses.

Metal flexible hoses made of corrugated stainless steel are also available for connecting appliances to the gas pipe. These hoses have a longer life span and in some countries are allowed to be used for 10 years before they are replaced.

It is important to use qualified and approved flexible hoses.

There are flexible hoses in the market made of inferior material and using them may lead to accidents.

4.5.2 Pressure Regulation

LPG appliances supplied with incorrect inlet pressure will result in inefficient burner performance or may not function at all.

LPG piping is typically designed to have two-stage pressure regulation to minimise risks of the regulator freezing and condensation in the pipeline. First stage pressure reduces tank pressure to not more than 1.4 bar (20 psig). The second

stage further reduces the LPG pressure entering the building to not more than what the cooking appliance required which is typically 300mm water column WC (11 inch WC).

Twin stage regulators are available that combines the first and second stage pressure regulation in one device and is usually used for sites with low consumption.

Some LPG piping design may require three stages of pressure regulation i.e. if the appliance is located far from the second stage regulator. In this case, the second stage regulator will reduce it to an intermediate pressure of 340 mbar (5 psig) or the maximum allowed by local regulation whichever is lower. The third and final stage regulator reduces the pressure to the appliance requirement of 300mm (WC) - 11 inch WC.

Pressure regulators are available with Over Pressure Shut Off (OPSO) and Under Pressure Shut Off (UPSO) devices. These devices shut off the flow of LPG downstream of the regulator when the pressure exceeds or falls below the set levels to prevent any incident from arising due to abnormal LPG line pressures. Some local regulations may require use of such devices on the LPG piping.

4.5.3 Pipe Sizing

The proper selection of pipe and tubing sizes is critical to the efficient performance of the LPG appliance. Piping must be sized to provide sufficient gas to meet the maximum demand without undue loss of pressure.

Pipe size is essentially determined based a combination of operating pressure and length of piping. It is usual for segments of LPG piping which operate at different pressures to have different pipe sizes. The lower the operating line pressure, the bigger the pipe diameter required to achieve the same flow capacity.

Pressure loss increases with length of piping and number of fittings on the piping. Choosing the right pipe size will ensure pressure loss is kept to within allowable limits and the correct pressure is delivered at the inlet of the appliance.

Pipe sizes can be calculated using gas flow formulas or using pipe sizing charts available from engineering or LPG serviceman's handbook.

4.5.4 Good Practices on Piping Installation

LPG piping conveys a flammable product from the container to the appliance and faulty workmanship can lead to a hazardous situation. Below are good piping practices which should be considered.

Piping shall be adequately supported with a gap between the piping and any wall or structure carrying it. The piping must also be secured in position to prevent it being moved accidentally from its original position.

Piping should not run in or through air or ventilation ducts, elevator shaft, chimney or flues.

Piping that passes through concrete walls or floors should be suitable sleeved and the gap between sleeve and pipe should be sealed.

Concealed piping must be protected against inadvertent damage (from nails, impact) either by location, type of material used, or by sheathing.

Provision shall be made to avoid damage to the piping by its expansion, contraction, vibration or by settlement of the building by which it is carried.

Underground pipes should be buried at least two feet (600mm), and if butane or mixtures rich in butane are used, the pipe should be buried deep enough to avoid frost and to prevent condensation. Pipes should be buried in backfilled trenches.

Steel piping if buried and/or located in corrosive atmospheres must be suitably protected against corrosion. This may be done by painting, galvanizing or wrapping with anti-corrosion tapes.

Piping shall be free internally and externally of cutting burrs, loose scale, dirt, dust and other foreign matter before the installation is completed. Foreign matter left in the piping may end up damaging regulators and appliances.

Threaded connections if used shall have tapered threads. Sealing tape or jointing compound which is resistant to the action of LPG shall be used to provide gas tight joints. These must be applied only on the male threads.

Hoses used shall be kept as short as possible with a maximum length of two meters and secured appropriately at the ends i.e. by metal clamps, etc. They shall not be use in concealed places and exposed to high temperatures.

Ends of piping should be suitably plugged with pipe caps and plugs to prevent accidental discharge of LPG. Cork, wood, paper, etc. should not be used as plug.

Suitable shut-off valves should be fitted for every appliance and should be installed at every point where safety, convenience of operation and maintenance demands.

If LPG piping needs to be distinguished from piping of other services, it should be painted yellow and/or marked with 'LPG' for identification.

4.5.5 Leak Testing

After the piping has been completed and before it is put into service, the whole piping system must be subjected to a leak test. This is an important step in the installation and should be made with great care and in strict compliance with local regulations wherever such exists. Basic points to consider are:

Appliances and equipment which are not included in the test or are designed for operating pressure less than the test pressure must be isolated or disconnected from the piping during the test.

The test medium introduced in the gas line for testing leaks may be air, nitrogen, carbon dioxide or any inert gas. In no instance must oxygen be used for this purpose as this will create an inflammable mixture. LPG may be used as a test medium for testing gas piping joints between the low pressure regulator and low pressure appliance.

Where any part of the piping is to be enclosed or concealed, the test must be done prior to the work of closing in, unless the concealed sections of the piping have been pretested. Piping should be tested before they are painted or applied with any corrosion protection which would inhibit detection of a leak.

The test should be carried out at appropriate pressures.

For section of the piping subjected to full cylinder pressure, the test pressure should be 1.5 times the normal working pressure or 10 bars (150 psig) whichever is greater.

For piping section after first stage regulator with pressure above 500mm WC, the test pressure should be 2.5 times the maximum expected working pressure or 3.5bars (50psig) whichever is greater.

For piping sections subject to 20 inches (600mm) WC or less, the test pressure should be 5 times the expected operating pressure or 5 psig whichever is greater.

Test duration should not be less than 10 minutes for LPG installation used by single family house. For longer pipeline, test should not be less than 30 minutes for every 14m^3 of pipe volume or fraction thereof. In no case is the test duration required to go beyond 24 hours.

A drop in pressure as indicated by a pressure gauge shall be a sign of the presence of a leak. The source of leakage should be determined by the use of non-corrosion leak detection fluid or an approved gas detector. Soapy solution is commonly used to identify the source of leak. A match or other open flame should never be used to test for leaks.

Any leak detected should be rectified by applying correct procedure and retested before the piping system is commissioned.

The consumer or any other responsible party should witness and confirm that the test has been satisfactorily completed.

A pressure test certificate must be kept for record.

4.5.6 Commissioning and Handover of Completed Installation

4.5.6.1 Purging

After testing, the piping should be purged of air or other test medium used for leak testing up to the appliance using LPG vapour. Any residual air or other test medium left in the pipeline can interfere with the proper functioning of the burner.

Care must be taken to prevent accumulation of gas-air mixtures released during purging inside premises or in confined spaces.

When purging through individual appliances a source of ignition shall be held adjacent to the burner to ensure immediate ignition when the gas is rich enough.

Steps shall be taken to ensure no other sources of ignition are present and to prevent inadvertent operation of electric switches or appliances and to prohibit smoking or naked lights in the vicinity of the purge point.

Purging is completed when all appliances connected to the piping can be lighted without problem.

4.5.6.2 Delivery and Lock-up Pressure

After purging the piping, the gas delivery pressure at the appliances as well as the lock-up pressure must be tested.

The delivery pressure must not fall below the required minimum for efficient functioning of the appliance with all burners operating.

Lock-up pressure is the pressure of the gas between the low-pressure regulator and the appliances when all outlets are closed and there is pressure on the container side of the regulator. Lock up pressure which is more than twenty percent of the regulator outlet setting indicates a problem with the regulator.

4.5.6.3 Customer Instruction

Once all the tests have been completed, the consumer must be instructed on the safe operation of the LPG piping system before this is handed over. This will be the responsibility of the installer. The safety instructions should include:

- How to recognise LPG leaks
- Action to be taken in case of leakage
- Action to be taken in case of fire
- Action to be taken in case of damage to, or failure of, any part of the installation
- When to re-order LPG
- Cylinder or bulk LPG delivery procedure

Consumers must also be instructed on good practice of keeping the LPG tank site or cylinder storage area free from combustible materials. The area should be secured to prevent unauthorized entry and access to the site should not be blocked.

The need for periodic maintenance of the appliance and the piping system must be emphasised to the consumer to ensure a safe and reliable use of LPG.

4.5.7 Fire Protection Equipment

A sufficient number of 9 kg dry powder fire extinguishers should be provided near the cylinder and/or tank storage site and other locations around the premises. These are to be used for extinguishing small fires around the cylinders or tanks.

Larger installations may be required by regulation to have fixed water sprays over the tanks or fire hose reels nearby.

4.5.8 Safety Devices

The use of safety devices, while not prescribed by regulations or LPG standards, can enhance safety and should not be discouraged. Consumers should however not be overly dependent on them since such devices have their limitations.

Gas detectors and alarms are useful in raising alarms in case of accumulation of gas i.e. LPG or Carbon Monoxide for people with impaired sense of smell.

Excess flow valves and valves equipped with a thermal fuse if installed on the appliance end can stop the flow of gas in case of hose rupture or fire.

4.6. Sample Diagrams of LPG installations

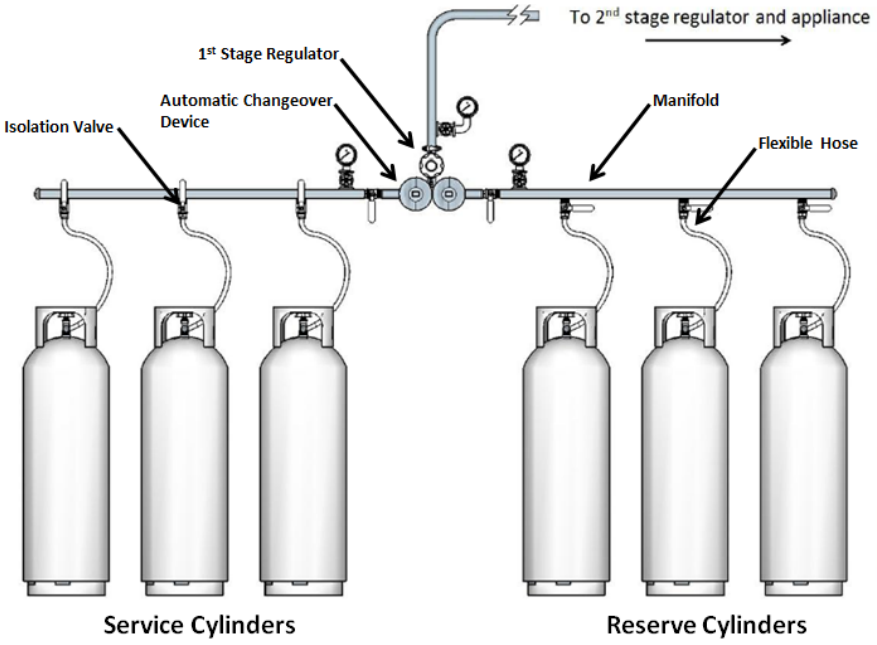


Figure 4.6a - Cylinder installation

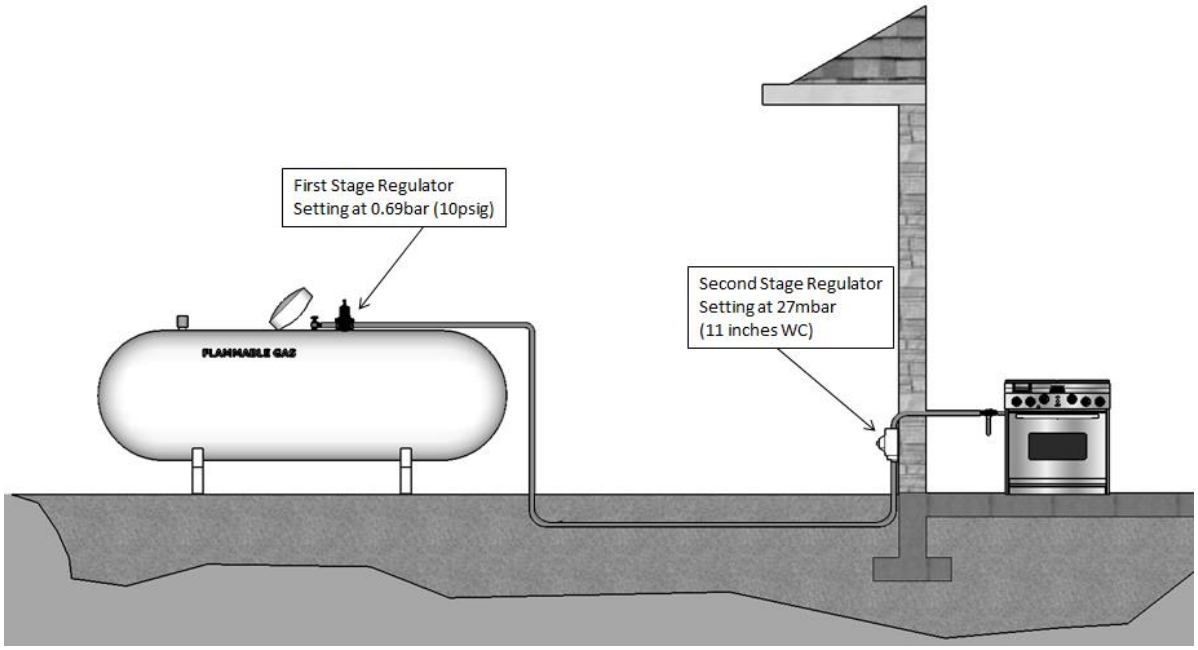


Figure 4.6b - LPG bulk Installation

Chapter Five

Operating the LPG System

5.1. Safety Tips on Using the LPG Installation

Everyone involved in handling and using LPG should be given training on basic LPG product knowledge and safe handling to increase safety awareness and avoid bad practices which can result in accidents. Below are some safety tips consumers should be aware of.

LPG is stored under pressure and any small gaps and pinholes can cause LPG to leak out. Pipes must never be stepped on or used to hang kitchen equipment or other objects that may create undue force on it.

The boiling point of LPG is low and any contact with bare skin can cause cold burns. People handling liquid LPG i.e. during bulk delivery should wear proper personal protection equipment (PPE) that includes suitable gloves, long sleeves and eye goggles.

LPG can be detected by means of its 'rotten egg' odour. It is odorised in such a concentration that even the presence of a small amount of LPG is discernible by smell. Gas valves should be closed immediately once LPG is detected by smell and all ignition sources should be put out.

Use leak detection fluid or soapy water to check for leaks on the piping system. Apply on all joints and hoses and check for bubbles which indicate a source of leak. Never use naked flames.

When appliances are disconnected from the gas piping for servicing or, removed to clean the area, the connection should be checked for vapour tightness when they are reconnected.

Cooking utensils should match the burners used. A burner whose flame exceeds the base of a pan throws away heat and wastes LPG.

Appliance gas valves should always be closed when the appliance is not being used. When LPG will not be used for an extended period of time, the main gas valve and LPG container valves should be shutoff for safety reasons.

When using appliance without a spark igniter, the lighter or match must be lighted before opening the appliance gas valve to avoid accumulation of LPG vapour which could cause a flash fire.

Never leave the cooking appliance unattended with the flame on.

Keep the cooking area well ventilated to dispose of products of combustion and ensure sufficient supply of air for combustion. Some kitchens may be equipped with an exhaust fan which needs to be turned on before cooking begins.

Cylinders should always be used in the upright position. Never shake the cylinder or turn it upside down to draw out residual LPG. This may result in heavy ends clogging the valve and/or regulator.

5.2. Managing stocks and re-ordering

5.2.1 Maximum tank fill level

Liquid LPG has a high co-efficient of volumetric expansion which is why they should never be allowed to become liquid full inside the container. An ullage or space is left in the container to allow liquid LPG to expand when temperature rises.

Overfilling of LPG containers can results in the container being subjected to hydraulic pressure and the pressure relief valve popping to relieve LPG. This is a hazardous situation which should be avoided.

The maximum fill level is dependent on climactic conditions of the location and typical figures would be 85% for small bulk tanks and 80% for LPG cylinders.

Bulk tanks are equipped with maximum level gauges to indicate when the maximum fill level has been reached and filling should be terminated. Overfill prevention devices on filler valves are also available which can automatically stop the filling when the maximum level is reached.

5.2.2 Monitoring Consumption Pattern

Some consumers will have a steady pattern of consumption while others may experience seasonal fluctuations. In either case, it is essential to monitor consumption so that replenishment can be scheduled and risks of stock outs minimised.

Consumption for bulk users can be tracked using the level gauge on bulk tanks which is typically in percentage or a fraction of the tank capacity. For cylinder users, consumption rate can be established during the first few cylinder replacement periods. Alternatively, consumption can be tracked using gas meters. The gas meter reading is in volume which has to be converted to weight.

Out of pattern consumption may indicate a problem with the appliance, an undetected leakage in the piping or even pilferage which needs to be investigated.

5.2.3 Replenishing Stocks

LPG suppliers require lead time for delivery therefore consumers must always maintain sufficient stocks until replenishment. Delivery lead times may vary among suppliers and distance to source may be a key factor. This should be taken into consideration when selecting supplier.

Cylinder installations usually have two equal banks of cylinders connected on the manifold. One side is in service and the other reserve. When the service side has been consumed, supply is shifted to the reserve bank and order for replenishment should be placed with the supplier.

Bulk users should take note of the critical stock level in their tank beyond which the tank can no longer supply sufficient vapour for the appliance. Factoring in the normal lead time for the supplier would give the point where order must be placed for replenishment to avoid stock out.

5.3. Ensuring Safe LPG Delivery

5.3.1 Basic Safety Precautions

During delivery all sources of ignition around the LPG storage area should be extinguished. If the ignition sources cannot be controlled, then delivery should not proceed.

A notice shall be displayed near the filling point indicating “NO SMOKING, NO NAKED FLAMES”

Electrical equipment not needed during the delivery should be switched off and removed from the area i.e. mobile phones, two-way radios, etc.

Any piles of rubbish and/or combustible material within the LPG storage area should be removed from the site by the consumer.

Access to the LPG site should be clear and free of obstruction. Delivery truck must be able to park in such a way as to drive away without reversing in case of emergency.

Delivery personnel must be using the required personal protective equipment i.e. gauntlet, safety shoes, goggles, etc.

LPG containers, piping and other equipment installed at the site should be inspected to confirm that they are in safe working condition before delivery.

5.3.2 Cylinder Delivery Procedure

Cylinders must be moved in a manner that avoids damage to the floor. Pushcarts or similar equipment should be used for transferring cylinders between truck and the storage site.

Cylinders to be replaced must be checked by delivery personnel that they are indeed empty before removing from the manifold.

Close all cylinder valves and individual isolation valves on the manifold and slowly disconnect the empty cylinders. Allow the gas in the flexible hose to bleed down before entirely disconnecting the cylinder. If the residual gas continues to bleed off, the source of leakage should be identified. If necessary, other cylinders should be shut off to prevent escape of LPG. Any defective valve identified should be replaced to prevent leakage.

Remove the empty cylinder and position the full cylinder where flexible hoses can reach without straining. The condition of the hose end coupling threads should be examined to check for wear and if necessary they should be replaced.

Check the connection for leaks by opening the cylinder valve slightly to let gas flow and apply soap solution. If connection is leak free, open fully all the cylinder valves and individual isolation valves on the manifold. The cylinder bank is now ready for service when the other bank becomes empty.

Delivery crew should ensure everything is in order before leaving the site.

5.3.3 Bulk Delivery Procedure

Check to make sure the correct grade of LPG is to be unloaded.

Confirm that the quantity to be unloaded fits the ullage without overfilling.

Confirm that the bulk truck coupling is compatible with tank fittings.

Layout the bulk truck hose and ensure it is not place on public path or pavement that may pose a significant hazard.

Connect the bulk truck coupling to tank filler valve and open liquid line partially to check for tightness of connection. If there are no signs of leak, fully open the liquid line and start truck pump to unload.

The driver should stay within the vicinity to monitor the liquid level of the tank while unloading and to lookout for any signs of leakage. The driver should never leave the site while unloading is ongoing.

Reduce the pumping rate when the tank content approaches the maximum fill level. The maximum fixed ullage gauge should be used to prevent overfilling.

Stop the pump when the maximum fill level is reached and close all valves on the bulk truck and tank.

Disconnect the bulk truck coupling slightly to bleed off residual LPG between the coupling and the tank filler valve. If LPG continues to vent off, the coupling should be reconnected and the source of the leak investigated. If venting stops, fully disconnect the road tanker coupling and stow the hose back on the truck.

If the tank is inadvertently overfilled, the driver should inform his supervisor and the consumer and take appropriate action to remove the excess LPG in a safe manner. Overfilled tanks must not be left in an unsafe condition.

The driver should ensure everything is in order before leaving the site.

5.4. Training of Personnel Involved in LPG

Training is an essential element of ensuring safety in handling and using LPG. It helps create awareness for the hazards and risk associated with LPG and minimises bad practices that may lead to an incident with serious consequences.

It is the responsibility of the people in charge to ensure all personnel involved with handling LPG undergoes training by a competent person before they are allowed to carry on with their normal activities. The personnel who should be trained include managers, kitchen staff, administrative staff, maintenance workers, and security guards.

The LPG supplier should be responsible for training their drivers and delivery personnel.

Training should cover topics such as LPG product knowledge, relevant procedures, and emergency actions. In particular, the following topics should be covered:

- Basic characteristics and properties of LPG
- Cylinder handling procedures
- Bulk LPG delivery procedures
- Proper use and maintenance of LPG appliances
- Basic principles of combustion
- Actions in case of emergency
- First aid

The amount of training for each person will depend on his/her level of involvement with LPG. Training should be done on a periodic basis and whenever there are new staff joining the organization.

Training should include regular emergency exercise with the participation of local fire service.

Training records should be kept with the site owner.

5.5. Actions in case of emergency

5.5.1 Basic Principles

The primary objective in emergency response is to prevent harm to people who include those working in the site as well as the public. Being prepared on how to handle emergency situations can minimise the risk of minor incidents becoming major incidents.

An emergency team should be organised within the organisation and the roles and responsibilities of each member of the team should be clearly defined.

Emergency procedures should be documented in clear and concise language and a copy posted near the LPG storage site where it is easy to read.

5.5.2 Basic Guidelines on Handling LPG Emergencies are as follows:

Assess the situation and organise appropriate response.

Evacuate all people (staff, general public, etc.) not needed to handle the emergency to a predetermined safe location.

Call the local fire and emergency services for assistance.

If safe to do so, emergency response teams to tackle the emergency wearing appropriate Personal Protective Equipment.

Treat any injuries.

Account for all personnel – Carry out a roll call

5.5.3 Handling a Leak without a Fire

Keep personnel upwind of the leak.

Remove ignition sources downwind of the leak. Do not switch on or off any electrical switch which might cause a spark.

Close a valve upstream of the leak if possible.

If the leak is indoors, open windows and doors to increase ventilation.

If the leak is on a cylinder, remove and position it in a well-ventilated location with the leak uppermost if safe to do so. Clearly marked the cylinder as defective to alert supplier.

A leak may be stopped by 'freezing' by wrapping with a wet cloth and spraying water.

Disperse vapour with water spray/monitor/fan sprays.

Check if there is vapour still in the area with portable gas detectors before allowing people to enter.

Constantly monitor wind direction and take necessary action if the direction changes.

5.5.4. Handling a Leak with a Fire

If a vapour cloud ignites it will be of short duration before becoming a jet fire.

Give first aid to any personnel caught in the cloud and get immediate medical attention.

Extinguish any secondary fires caused by the ignited vapour cloud.

Try to stop the jet fire by closing an upstream valve.

Do not extinguish the flame unless the leak has been stopped.

Keep all nearby equipment, especially storage tanks, cool with water from fixed sprays or monitors

If the jet fire is impinging on other equipment "bend" the flame away using water spray.

5.5.5 Emergency Exercise

Regular emergency exercise should be conducted to test the preparedness of the local response team in handling emergencies.

Learnings from each exercise should be discussed with the team during the de-briefing session and practiced in the succeeding exercise. Emergency exercise should involve local fire service.

Chapter Six

Inspection and Maintenance

6.1. General

LPG installations should be kept in a safe and good working condition by a combination of routine and periodic inspection and maintenance. This is a legal requirement in most countries with defined scope and frequency.

Failure to comply not only increases risks of incidents but may result in penalties and shutdown of LPG facilities by authorities.

Inspection and maintenance can be the responsibility of either the consumer or the LPG supplier depending on the signed contract stipulations. Whatever the case, only trained and competent personnel should be allowed to carry out work on the LPG installation.

Inspection and maintenance should cover LPG containers, piping and all other equipment that affects the integrity of the LPG system.

Where inspections reveal defects or significant deterioration, this should be recorded and the inspection methods used plus any remedial action taken should be detailed. The competent person should also assess the effects of such deterioration, defect or repair and either endorse or revise the safe working limits of the tank or equipment

6.2. Routine Inspection and Maintenance

Frequency of routine inspection should be risk-based and recommended by a competent person. It should cover external inspection of visible parts of containers, pipe and pipe fittings, vapourisers if used, fire protection equipment and other equipment installed. It should be carried out by an appropriately trained person and should cover the following:

For Cylinder Installation

- Inspect the storage site and surrounding area for any flammable materials stored and sources of ignition.
- Inspect the cylinders and piping for signs of corrosion, damage and leakage
- Particular emphasis should be paid to the undersides of pipe and areas in contact with supports
- Check hoses for signs of cracks or leakage and if they are suitably clamped. They should be replaced when damaged or have reached the end of their recommended useful life

For Bulk Installation

- Inspect the storage site and surrounding area for any flammable materials stored and sources of ignition.
- Check tank and tank fittings for signs of corrosion, damage or leakage.
- Inspect the pressure relief valve for corrosion and if drain holes are blocked which can cause water retention leading to corrosion.
- Check if the thread on the filler valve is worn out and needs replacement.
- Inspect piping for signs of corrosion, damage and leakage. Particular emphasis should be paid to the undersides of pipe and areas in contact with supports

- Check hoses for signs of crack or leakage and if they are suitably clamped. They should be replaced when damaged or have reached the end of its recommended useful life
- Check that the grounding cable is connected to tank and in satisfactory condition.
- Check the concrete piers and pads for damages and differential settlement.
- Cathodic protection system of underground installation if provided should be check if readings is still within specification

Vapourisers should be checked for signs of corrosion, damage and leaks. For indirectly heated type, check for sufficiency of water level and satisfactory condition of electrical connections.

Fire extinguishers should be inspected if still in satisfactory condition and properly recorded. Test fixed water sprays of bulk installation if provided to check for blockage of nozzles and if water pressure is sufficient.

All inspection and maintenance records should be kept on site.

6.3. Periodic Inspection and Maintenance

6.3.1 Frequency

Periodic inspection and maintenance applies to bulk tanks and should be carried out based on frequency stated under local regulations. If the frequency is not prescribed under local regulations, the following WLPGA guideline may be adopted:

Equipment	Frequency
Above ground tank	Every five years
Underground tank	
with Cathodic Protection	Every ten years
without Cathodic Protection	Every five years
Pipework	
Aboveground	Every ten years
Underground	Every five years
Vapouriser	
Direct fired	Annual
Indirectly fired	Every five years

6.3.2 Scope of Work

Periodic inspection and maintenance should be carried out to a written scheme of examination prepared by a competent person. In addition to the scope covered under routine inspection it should include the following:

Aboveground tank

- Visual examination of external surfaces and all welds for signs of defects such as damage, corrosion, cracking, erosion, deformation, leakage, etc.
- A check of wall thickness by internal visual examination or a wall thickness survey (e.g. by the use of an ultrasonic thickness gauge)

- Replacement of pressure relief valves with new or reconditioned units that meet the tank design requirements
- Inspection of shut off valves and other tank fittings for effective operation, corrosion or damage or replacement. Shut off valves and other tank fittings should be replaced when they reached 20 years of service regardless of condition

Underground tank

- A visual check of exposed surfaces for signs of corrosion, damage, leakage, etc.
- Replacement of pressure relief valves with new or reconditioned units that meet tank design requirements.
- Where cathodic protection is provided, the operation of sacrificial anodes or impressed current systems should be checked in accordance with a written procedure and replaced as necessary. Records should be maintained to allow comparisons of the readings obtained so as to allow investigation of any anomalous readings.
- Where cathodic protection is not provided, an internal visual examination should be conducted and either a wall thickness check or a hydraulic test. Where internal examination is not reasonably practicable the external surfaces of the tank should be exposed for examination as directed by the competent person.
- Inspection of shut off valves and other tank fittings for effective operation, corrosion or damage or replacement. Shut off valves and other tank fittings should be replaced when they reached 20 years of service regardless of condition.

Pipework

- Aboveground piping should be inspected for signs or corrosion, damage or leaks with emphasis on the areas where pipe passes thru supports. Piping should be pressure tested.
- Buried piping should be tested for leakage by appropriate means i.e. pressure testing, gas detection, etc. In some cases the piping should be exposed by excavation to check for corrosion.

Vapourisers

- Check for satisfactory operation of items such as level control, heat input controls, emergency valves (other than pressure relief valves), flame control devices, pressure controllers, etc. Safety devices such as solenoid valves and similar items should be given particular attention.
- Check for corrosion and damage. Flame impingement areas of direct fired equipment should be given special attention.
- Check for LPG leakage under normal operating pressure and with hydraulic test.

6.4. Appliance Maintenance

It is unavoidable for LPG appliances to not develop undesirable flame characteristics with constant use. Regular inspection and maintenance will keep it functioning safely and efficiently. Manufacturers usually provide instruction manuals accompanying their appliance on how to care of their product which should be followed.

Here are some simple tips on maintaining a typical LPG appliance:

- The best type of flame is shown by a bluish and evenly distributed halo of flame surrounding the burner. Flames showing yellow tip or lifting from the burner ports require maintenance. The air flow path should be inspected for any blockage and/or the air shutter adjusted to attain the bluish flame.
- Burners with difficulty lighting should have their spark igniter inspected and/or cleaned.
- Burner ports should also be cleared of any blockage from food debris, soot or other particles. Use only suitable tools to avoid damage to burner ports.
- Exhaust kitchen hood if installed should be regularly cleaned to prevent accumulation of grease which is often the cause of fire.
- Some ovens may require calibration of their thermostat to keep the settings accurate

- Always use genuine parts when replacement is needed.
- Always use trained technicians to repair and maintain LPG appliances.

Chapter Seven

Sink to Stove by World Central Kitchen

7.1. About World Central Kitchen (WCK)

WCK, founded by Chef José Andrés, is a group of chefs that use the power of food to strengthen economies and empower communities.

With a focus on empowering the people to be a part of the solution, WCK focuses on clean cook-stove conversion, food safety and sanitation training, job creation, and job training.

Today, WCK's smart solutions to hunger and poverty are implemented in Haiti, Dominican Republic, and Zambia.

7.2. Sink to Stove (The Importance of Hygiene in the Kitchen)

About Food Safety

Food safety and sanitation is crucial in preventing the spread of transferrable diseases and food borne illness. WCK'sfood safety and sanitation training focuses on the core basic practices that lead to healthier and safer meal preparation. The methods in this manual are designed to provide a basic understanding of how to prevent disease and food borne illness in the food preparation process.

The practices can be implemented in both rural and urban settings and are especially helpful in communities that lack access to medical care. Training these communities on preventative practices is a crucial initial step to a healthy community.

The three practices in this guide are the core of our food safety and sanitation curriculum. The equipment used is adaptable based on the availability of the equipment. For instance, where plumbing is not available, color-coded plastic buckets can be used to replace a "three compartment sink."

Food safety and sanitation training is a vital component of healthy and safe meal preparation. These are preventative practices that are designed to reduce the spread of disease and food borne illnesses.

BEST PRACTICES: The three core practices in food safety and sanitation are **Washing Hands, Preventing Cross-Contamination**, and **Proper Washing and Sanitising** of dishes, and cooking equipment.

Hand Washing

Hand washing is the critical first step in the food safety and sanitation process. Washing hands removes unwanted bacteria and pathogens from your hands and prevent those pathogens from invading into your food.

Three and a half million children die every year from diarrhoea and respiratory infections; many of these infections can be prevented through proper hand washing practices.

Steps for proper hand washing technique:

- Wet hands with water from a clean source
- Use soap and rub hands together – ensure you clean the "hard to reach" areas on your hands including underneath nails, wrists, in-between fingers for 30 seconds. TIP: You can teach meal preparers to sing the "Happy Birthday Song" twice while washing their hands.
- Rinse your hands again with water, cleaning off all soap
- Use a paper towel to dry

Wash your hands frequently: Harmful bacteria can live on your hands for as long as 150 hours.

<u>Remember, wash your hands:</u>

- Before preparing food
- After touching raw meats
- After using the bathroom
- After cleaning the cooking area and touching trash

Do this every day, many times a day to help keep food safe from growing bacteria and keep your food safe to eat.

Cross Contamination

2.2 million people die annually from food and waterborne diseases. Reduce likelihood of contracting and spreading these diseases by separating produce, fish and meat.

The following are steps to be taken to prevent cross-contamination that can be taught around the world.

- Keep raw food separate from cooked food
- Keep poultry, meats, raw vegetables SEPARATE when preparing
- CLEAN cutting boards and utensils well between preparation
- **Bacteria from raw food can spread to cooked food**
    - Example: You can contaminate the rice with juices from uncooked meats.
- Cut and prepare the meats and vegetables on separate surfaces. Coloured cutting boards.
- After cutting raw meats, wash knives and cutting surfaces well with clean water and soap.
- **Prepare raw meats at different times and store them before preparing the vegetables, rice and pasta.**

Note – In most developing countries, food preparation often does not incorporate cutting boards or surfaces, but these techniques can be taught (using coloured cutting boards), with an emphasis on sustained practice. You will find more interest in new techniques and new equipment than you expect!

Three compartment wash

Bacteria can live on your pots, pans and other cooking equipment after you are done cooking. Prevent the growth of bacteria by properly washing, rinsing, and sanitising your equipment.

- Cleaning tables, stoves and pots to remove bacteria
- **You must clean anything that touches food** - knives, spoons, pots, pans, tables and cutting boards.
- **USE three compartment system**
    - Wash
    - Rinse
    - Sanitise – with one tablespoon bleach per gallon water
- **Scrub surfaces** with **a clean cloth** and **soap** and **clean water**.
- **Sanitise the surface** with sanitising liquid and let the surface air-dry.

NOTE – Equipment is often washed with two compartments – Soap and Rinse. The most effective practice is the third step – Sanitising. By dipping each pot, pan, dish or utensil in a 10% bleach solution, you are disinfecting the equipment for future use and dramatically reducing the number of bacteria that can live on the equipment.

Appendix One

LPG Properties and Hazards

LPG - Comprises Commercial Propane and Commercial Butane, and mixtures thereof. They are hydrocarbon gases that can be changed into a liquid and changed back into a gas by the simple application and release of pressure

Density – LPG vapour is heavier than air and tends to gather at low areas such as drains, pits, cellars and other depressions. As a colourless liquid, LPG occupies around 0.4% of its vapour volume, but is about half the density of water and will float on water before vapourising

Cooling effect – LPG liquid vapourises and cools rapidly; it can therefore inflict severe cold burns if it came in contact with bare skin.

Non-toxic – LPG is not toxic. However it has an anaesthetic effect when mixed in high concentrations with air. The greater the concentration (i.e. as available oxygen declines), the greater the risk of asphyxiation.

Smell - What people know and recognise as the 'LPG smell' is usually added to LPG before distribution. This smell can be detected if the LPG content of air is as little as 0.4% (or just 20% of the lower limit of flammability). However, odour is not the only means of detection. Large leaks will also be obvious through hissing or condensation or frosting around the leak; small leaks will show up as bubbles if detergent mixed with water is applied to the suspected leak area. **NEVER try to detect leaks with a naked flame or other kinds of ignition!**

Flammability – LPG can ignite when it forms between 2 and 10% of a vapour/air mixture, so the risks associated with poor handling, storage or usage should be obvious. Uncontrolled ignition of LPG can cause serious fires or explosions (i.e. if ignited within a confined space). A fire started some distance from an LPG leak can very quickly travel back to the source of the leak itself. An LPG cylinder involved in a fire may overheat and rupture violently. The power and intensity of an LPG fire or explosion should never be underestimated.

Liquid Expansion – LPG liquid has a high coefficient of expansion. Tanks, cylinders, pipelines and equipment must be protected against the high pressure resulting from liquid expansion with temperature rise.

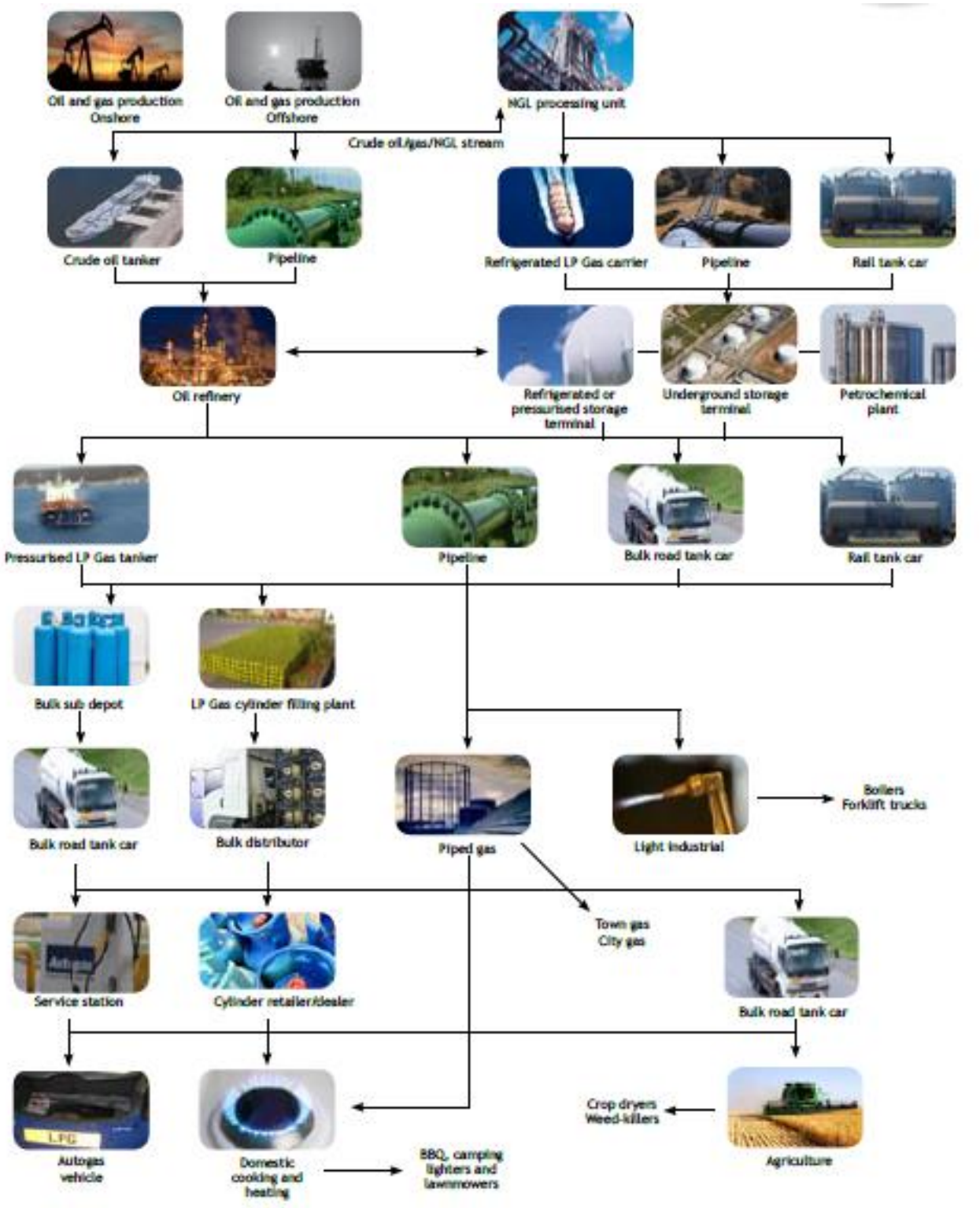
Table 1 overleaf shows some typical physical properties of LPG

Table 1

Typical Characteristics of Propane and Butane **PHYSICAL PROPERTY**		**COMMERCIAL PROPANE**	**COMMERCIAL BUTANE**
Litres/tonne of liquid at 15°C Litres/ton of liquid Litres/kg of liquid US barrels/tonne		1,965 – 2,019 1,996 – 2,051 1.96 - 2.02 12.4 – 12.7	1,723 – 1,760 1,750 - 1788 1.72 - 1.76 10.8 – 11.1
Relative density (to water) of liquid at 15°C		0.50 - 0.51	0.57 - 0.58
Ratio of gas to liquid volume at 15°C and 1015.9 mbar		274	233
Relative density (to air) of vapour at 15°C and 1013.25 mbar		1.40 - 1.55	1.90 - 2.10
Volumes of gas/air mixture at lower limit of flammability from 1 volume of liquid at 15°C and 1015.9 mbar		12,450	12,900
Boiling point °C		Minus 45	Minus 2
Vapour pressure at 0°C	barg	4.5	0.9
Vapour pressure at 15°C	barg	6.9	1.93
Vapour pressure at 38°C	barg	14.5	4.83
Vapour pressure at 45°C	barg	17.6	5.86
Upper limit of flammability,	% v/v	10.0	9.0
Lower limit of flammability,	% v/v	2.2	1.8
Gross calorific value	MJ/m^3 dry	93.1	121.8
	BTU/ft^3 dry	2,500	3,270
	MJ/kg	50.0	49.3
	BTU/lb	21 500	21 200
Net calorific value	MJ/m^3 dry	86.1	112.9
	$BTUu/ft^3$ dry	2,310	3,030
	MJ/kg	46.3	45.8
	BTU/lb	19,900	19,700
Latent heat of vapourisation Latent heat of vapourisation	kJ/kg at 15 °C BTU/lb at 60 °F	358.2 154	372.7 160

Appendix Two

LPG Supply Chain



Courtesy of Argus Media

Appendix Three

Evaporative Capacity of LPG Cylinders

Product	Cylinder Size (kg)	Temperate		Tropical	
		Continuous (Kg/hr)	Intermittent (Kg/hr)	Continuous (Kg/hr)	Intermittent (Kg/hr)
Propane	12.5	0.5	1.0	1.0	2.0
	50.0	1.0	2.0	2.0	4.0
Butane	12.5	0.35	0.6	0.6	1.2
	50.0	0.7	1.2	1.2	2.4

Appendix Four

Extract from NFPA 58 Table 6.3.1.1 – Separation Distances Between Containers, Important Buildings and Line of Adjoining Property that can be Built upon (extract from NFPA 58 2014)

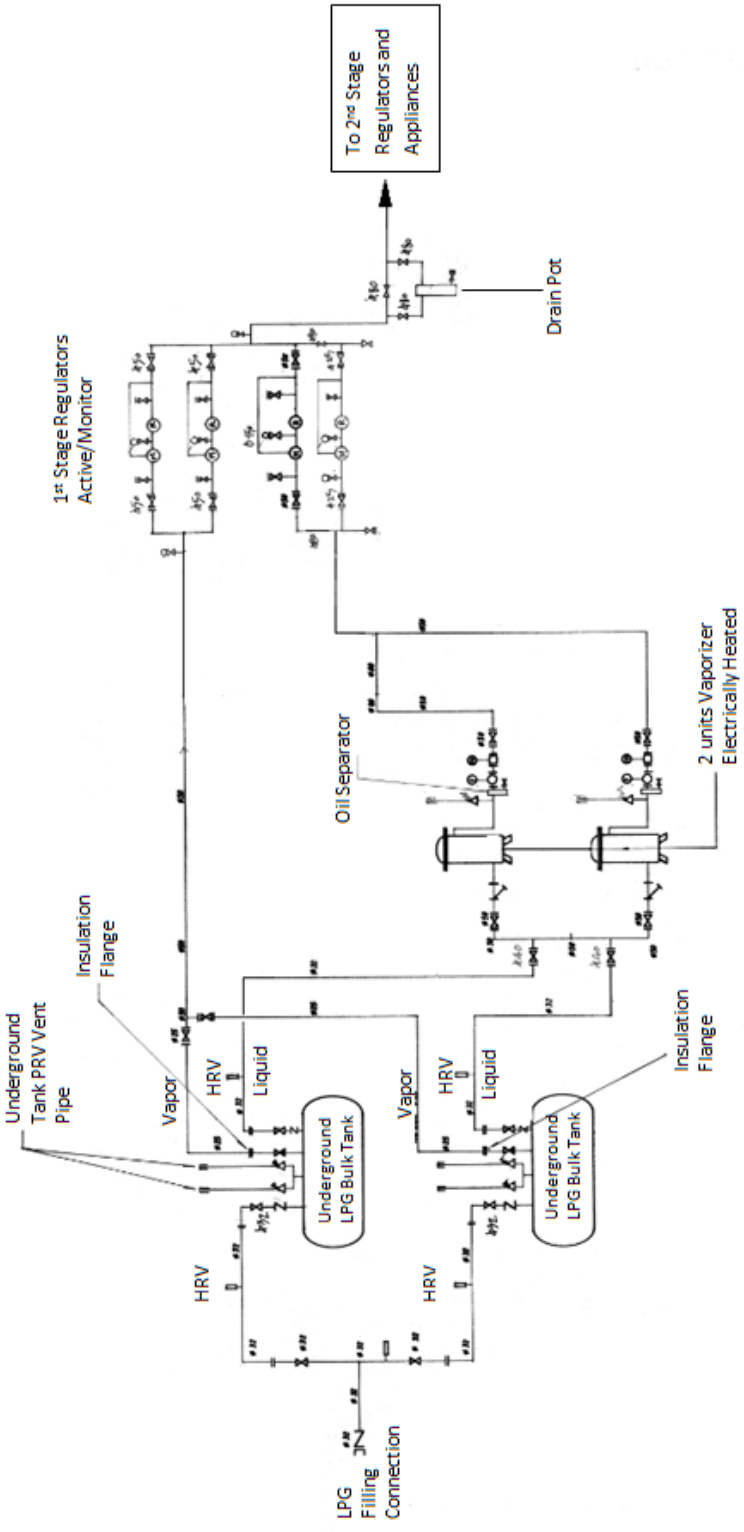
Extract from NFPA 58 2014 Table 6.3.1.1 Separation Distances Between Containers, Important Buildings and Line of Adjoining Property That Can Be Built Upon

Tank Water Capacity per Container (Litre)	Minimum Separation Distances		
	Mounded or underground Containers[a] (Metre)	Aboveground Containers (Metre)	Between Containers[b] (Metre)
<500[c]	3	0[d]	0
500 – 1000	3	3	0
>1000 – 1900	3	3	1
>1900 – 7600	3	7.6[e]	1
>7600 – 114000	15	15	1.5
>114000 – 265000	15	23	1/4 of sum of diameters of adjacent tanks
>265000 – 341000	15	30	
>341000			

[a] See NFPA 58 2014 6.3.2.1
[b] See NFPA 58 2014 6.3.4.5
[c] See NFPA 58 2014 6.3.4.4
[d] See NFPA 58 2014 6.3.4.1, 6.3.4.2, 6.3.4.3 and 6.3.4.4
[e] See NFPA 58 2014 6.3.1.1
Courtesy - NFPA

Appendix Five

Underground Tank Installation with Vapouriser, Piping and Instumentation Diagram (Example)



Appendix Six

Recipe from José Andrés, World Central Kitchen

POLLO AL CHILINDRÓN

Chicken with Peppers, Tomatoes, Onions and Spanish Ham

Serves 4

¼ cup extra-virgin olive oil, plus 1 tablespoon

4 chicken legs, thighs and drumsticks separated

Salt, to taste

2 cups diced onions

½ cup diced green bell pepper

½ cup diced red bell pepper

2 tablespoons minced garlic

1 cup dry white wine

½ cup thinly sliced and diced jamón Serrano (Spanish cured ham)

½ teaspoon sweet pimentón (Spanish smoked paprika)

2 cups plain canned tomato sauce

1 fresh rosemary sprig

1 bay leaf

2 cups water

POLLO AL CHILINDRÓN

Photo courtesy of Thomas Schauer

Heat 1 tablespoon of the olive oil in a 12-quart pot over medium-high heat. Season the chicken pieces with salt. Working in batches, brown them on all sides. Transfer the chicken to a platter and set aside.

Add ¼ cup olive oil to the same pot and, when the oil is hot, add the onions and peppers. Reduce the heat to low and cook slowly until the vegetables are dark golden brown, about 30 minutes. Add 1 tablespoon of water if the onions start to burn. Add the garlic and cook for 5 more minutes. Add the white wine and cook until it evaporates, 4 to 5 minutes.

Add the jamón and browned chicken pieces, as well as any juices that have collected, and cook for 5 more minutes. Stir in the pimentón, tomato sauce, rosemary, bay leaf and the water and simmer over low heat for 1 hour or until the meat starts to fall off the bone. Season with salt, to taste, before serving.

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