

5 | Liquefied Petroleum Gas



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LPG

Afrox is the leading supplier of Liquefied Petroleum Gas (LPG) in sub-Saharan Africa and pioneered the LPG industry in South Africa under the brand name Handigas in the early 1950s, which is still the leading brand name in LPG today. With more than 2,5-million LPG cylinders and the largest bulk LPG storage and distribution infrastructure on the sub-continent, Afrox is uniquely positioned to meet the energy demands of industrial, commercial, agricultural and domestic applications, across a broad-based market sector.

Highly qualified in-house engineering expertise enables Afrox to offer end-to-end gas solutions from industrial and commercial space heating to large furnaces and curing ovens. From small boutique hotels to the largest casino resort complexes in Africa, from industrial catering to most fast food and restaurant franchise chains in the biggest shopping malls, Handigas is the gas chosen by chefs and project engineers alike.

Handigas is a clean burning fuel that provides all energy users with a safe, efficient and economical alternative for a diverse range of applications and is available through our extensive Afrox network of Gas & Gear sales centres and Handigas agents, which means that no matter where you are, Handigas is there.

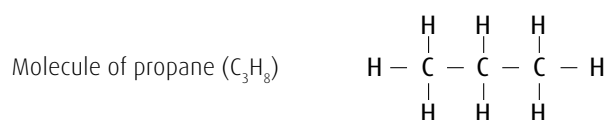
Definition of LPG

LPG (Liquefied Petroleum Gas) is the term applied to those hydrocarbons which are vapours at room temperature and can be liquefied by compressing them slightly. When LPG is liquefied, its volume decreases considerably so that it requires much less storage space. The liquid is transported in relatively light pressure cylinders and the customer converts it to gas by opening the valve on the cylinder which causes the liquid to vaporise as a result of a drop in cylinder pressure. LPG is composed of a mixture of mainly propane and butane (approximate ratio 60:40 by mass) but may contain some propylene and butylene as well as traces of ethane, ethylene, pentane and butadiene. It is colourless and odourless, but commercial LPG is usually stented with a substance called ethyl mercaptan to give it a characteristic odour.

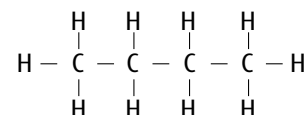
The Chemistry of LPG

Atoms of hydrogen (H) and carbon (C) combine to form hydrocarbon molecules which can be made up of different numbers of hydrogen and carbon atoms, hence the term 'hydrocarbon'.

A molecule containing three carbon atoms and eight hydrogen atoms is called propane:



In a like manner, four carbon atoms bonded to 10 hydrogen atoms forms butane:



Molecule of butane (C_4H_{10})

There are two possible configurations for the butane molecule. The above arrangement consists of a straight C-chain and is called normal butane or n-butane. If the C-chain is branched, it is called iso-butane. Such a rearrangement of the atoms is known as isomerisation and has no significant effect on the fuel properties.

Hydrocarbons with single carbon bonds are known as saturated hydrocarbons while those with double or triple bonds are unsaturated hydrocarbons. Examples of saturated hydrocarbons are methane (CH_4), ethane (C_2H_6), propane (C_3H_8) and butane (C_4H_{10}). Unsaturated hydrocarbons include ethylene (C_2H_4), propylene (C_3H_6), butylene (C_4H_8) and acetylene (C_2H_2).

Physical Properties of LPG

The properties of LPG mixtures can usually be calculated from the properties of the individual constituents (propane, butane, etc.) provided the proportions of the constituents are known. Following is a description of the most important physical properties of LPG mixtures.

1. Density

The density of LPG is defined as its mass per unit volume (kg/ℓ) at a given temperature. LPG liquid has a density of about 0,54 kg/ℓ at 15°C and is therefore lighter than water. It varies slightly with LPG composition and every batch of LPG produced at a refinery will have a specified density at a given temperature. LPG liquid is fairly light - about half the weight of water. To convert litres of LPG to kilograms, simply multiply the number of litres by the density.

LPG vapour has a density of about 1,9 times that of air and is therefore heavier than air. This is important when considering ventilation requirements and has an influence on the design of burners and certain meters for measuring vapour flow. Buildings used for storing LPG cylinders must have adequate floor level ventilation; in the event of a leak, the vapour being heavier than air will flow along the ground to the lowest level and remain there for a considerable period of time, and can be an explosion hazard.

2. Calorific Value (CV)

All substances which burn generate energy in the form of heat, which varies in quantity with the nature of the substance. The total amount of heat liberated by burning a substance is known as its Calorific Value or CV. It is usually expressed in megajoules per kg (MJ/kg). For LPG, it is 49,6 MJ/kg.

3. Thermal rate of expansion (expansion and contraction)

The thermal rate of expansion of liquid LPG is about 10 times that of water and since liquids can not be compressed, it is probably the most important property of LPG affecting the way the gas is stored, handled and filled. Storage tanks and portable cylinders filled to allow for an ullage space in the vessel and cylinders must never be filled to more than about 85% of the internal volume.

When the valve of an LPG is opened, the pressure inside the cylinder is reduced and the liquid starts to vaporise (boil) at lower pressure. This vaporisation of the gas causes cooling to occur and the temperature of the gas will decrease. If the gas off-take rate is too high, the gas temperature will decrease to below 0°C and ice will start to form on the lower outside wall of the cylinder. Because LPG contains propane and butane, with boiling points of -42,1°C and -0,5°C respectively, the mixture begins to separate – propane continues to boil off while the butane remains in liquid form at temperatures below its boiling point of -0,5°C. To avoid this situation, vaporiser units are used for LPG or pure propane can be used instead of Handigas (butane/propane mixture). It should be noted that low winter temperatures will aggravate this situation.

4. Vapour pressure

One litre of liquid Handigas will rapidly and totally vaporise when exposed to atmospheric pressure (100 kPa) to form about 275 litres of vapour at 15°C. In a closed cylinder containing some liquid Handigas, a relatively small quantity will vaporise in the restricted volume of the cylinder, to produce a cylinder pressure of about 250 kPa at 0°C. This closed cylinder pressure is equal to the vapour pressure, and it increases dramatically with temperature to 500 kPa at 20°C and 1 550 kPa at 60°C.

A liquid leak is far more serious than a gas leak due to the high volume of gas formed. This is why cylinders must always be stored, transported and used in the upright position. In air a gas leak will form a highly flammable mixture of about 10 000 litres from one litre of liquid gas.

As LPG consists of a mixture of propane and butane and since propane has a much higher vapour pressure than butane, the vapour pressure in a cylinder containing mostly propane will be much higher than that of a cylinder containing mostly butane. This relationship between pressure and temperature of pure propane and butane, and LPG (60:40 mix) is illustrated below.

Temp (°C)	Propane (kPa)	Butane (kPa)	LPG (kPa)
-20	150	0	±80
0	370	<5	±250
20	710	110	±500
40	1 250	280	±910
60	1 970	520	±1 550

This table clearly shows the high pressures that can develop due to an increase in temperature, particularly in the case of pure propane.

5. Table of the properties of propane, butane and a typical 60:40 LPG mix

Property	Propane	Butane	Handigas
Molecular weight	44,09	58,12	49,7 (av.)
Carbon content (wt%)	81,72	82,66	82,15
Hydrogen content (wt%)	18,28	17,34	17,85
Carbon: hydrogen ratio by weight	4,47	4,77	4,60
Density of liquid at 15°C (kg/ℓ)	0,510	0,575	0,536
Boiling point of liquid at atm. pres. (°C)	-42,1	-0,5	-42,1 -0,5
Density of gas at 15°C & atm. pres. (kg/m³)	1,86	2,46	2,10
Volume ratio of gas:liquid at STP*	274:1	233:1	258:1
Volume of gas from 1 kg liquid at STP (ℓ)	537	405	484
Mass ratio of gas:air at 15°C & atm. pres.	1,52:1	2,01:1	1,716:1
Latent heat of vaporisation at 15°C (kJ/kg)	20,43	21,27	20,77
Vapour pressure at 20°C (kPa abs.)	710	110	500
Sp. heat of vapour at atm. pres. (cal/g.°C)	0,388	0,397	0,392
Net calorific value at 25°C (MJ/kg)	46,0	45,6	45,8
Gross calorific value at 25°C (MJ/kg)	49,8	49,4	49,6
Wobbe number (kcal/Nm³)	19 000	21 600	
Limits of flammability in air (vol% gas)	2,2 – 10	1,8 – 9	1,8 – 10
Limits of flammability in oxygen (vol% gas)	2 – 50	2 – 50	2 – 50
Max. flame temperature in air (°C)	1 930	1 900	1 900
Max. flame temperature in oxygen (°C)	2 740	2 700	2 700
Max. flame speed in 25 mm tube (cm/sec)	82	82	82
Air reqd for combustion at STP* (m³/kg LPG)	12,10	11,93	12,03
Air:gas vol. ratio for combustion at STP	22,5	29,5	24,9
O ₂ vol. for combustion at STP* (m³/kg fuel)	2,56	2,51	2,54

*STP: Standard Temperature & Pressure, defined as 0°C and 100 kPa absolute

6. Stench additive

LPG is practically odourless and colourless which makes leak detection difficult. A small amount of stenching additive (ethyl mercaptan) is therefore added to LPG before going to market. The additive is non-corrosive, non-toxic and the odour can be smelt in very low concentrations of vapour.

LPG Cylinders

Although a 'full' LPG cylinder contains 85% liquid, the ullage volume will contain vapour at a pressure that varies with temperature. As the temperature rises, more vaporisation occurs, resulting in an increase in the vapour pressure inside

the cylinder (cylinder pressure). If the temperature falls, some of the vapour will condense and the vapour pressure will decrease. The cylinder pressure is dependent on the LPG composition (propane: butane ratio).

Handigas and propane cylinders are available in two valve types, namely vapour withdrawal or dual liquid/vapour withdrawal. The liquid withdrawal valves are for high demand applications where the vapour withdrawal capacity of vapour cylinders cannot supply the high demand required.

Note: Liquid withdrawal and propane cylinders **are not for domestic use**.

Physical Data for Various LPG Cylinders

Capacity (kg)		Water Capacity (l)	Tare Mass (kg)	Height incl. Valve (mm)	Diameter (mm)
LPG	Propane				
48,0	45,0	113,4	45,0	1 288	375
19,0	18,0	45,4	21,0	890	295
14,0	n/a	34,0	17,5	720	295
9,0	8,0	22,7	13,3	545	295
6,0			9,45	370	295

Nominal Sizes for Low Pressure LPG Cylinders

Afrox currently supplies Handigas and propane in five different sized cylinders as shown above. However, propane in 8 kg and 18 kg size cylinders has to be specially requested.

When LPG is drawn from a cylinder at a fairly high rate, the liquid content will cool down noticeably. The cylinder becomes cold, cooling down the surrounding air as heat is withdrawn from it. Ideally, the rate of heat transfer must be sufficient to allow the liquid to keep boiling and so maintain an adequate gas pressure. If the liquid cools to below 0°C, condensation in the form of dew or frost may form on the outside of the cylinder adjacent to the liquid. When this happens, preferential propane vaporisation occurs, resulting in an accumulation of liquid butane that will not vaporise at such low temperatures.

When the transfer of heat to the liquid is insufficient and the gas becomes very cold, the rate of evaporation will slow down

and the gas supplied from the cylinder will be reduced and could even stop altogether. This may occur in the following situations:

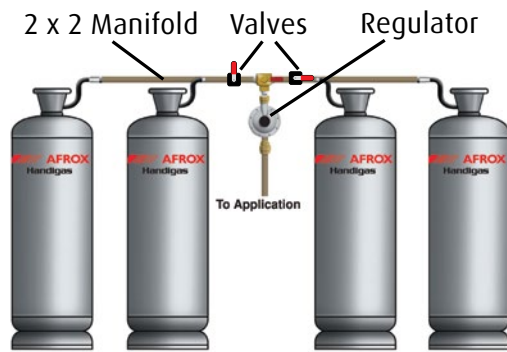
- Cylinder is located in a cold area with no warmth from the sun
- Cylinder is nearly empty, resulting in less heat absorption and more rapid cooling
- Cylinder is too small for application and cannot absorb sufficient heat from the air temperature to maintain draw-off rate.

Experience has shown that the various size LPG cylinders are capable of continuous gas delivery at maximum draw-off rates as given in the following table.

Cylinder Size (kg)	Max. Draw-Off Rate (kg/hr)	Rate of Energy Supply	
		(MJ/hr)	(kW)
48,0	1,0	48	13,3
19,0	0,5	24	6,6
14,0	0,4	16	4,4
9,0	0,25	10	2,8
6,0	0,15	7	1,9

The method of supplying LPG to a customer is dependent on a number of factors including the type of application and quantities of gas required. Most small to medium-sized customers are supplied in cylinders, either for single-user point or multi-user points. However, for fixed user points where high draw-off rates are required, a cylinder-manifold and pipe line reticulation can be installed on the customer's premises as shown below.

Double 2 Handigas Cylinder Manifold



Bulk Handigas

When significant quantities of Handigas or propane are required, a bulk storage/supply facility is recommended.

Storage tanks for LPG are pressure vessels designed and manufactured in accordance with international standards and comply with the Occupational Health and Safety Act requirements for pressure vessels and equipment.

The majority of storage tanks used by Afrox are of the horizontal (bullet) type. However, in cases where the storage area is limited, vertical tanks may be used. The Afrox range of tanks includes the following:

- Horizontal: 2,25 m³, 4,5 m³, 9 m³, 22,5 m³, 45 m³, 70 m³ and 90 m³. Larger tanks are available on special order and can be viewed at some Afrox branches.
- Vertical: 4,5 m³, 9 m³, 22,5 m³, 45 m³ and 70 m³.

The Market Place

LPG is marketed by Afrox under the brand name of Handigas and is an efficient source of energy that is relatively simple to store, transport and handle and will compete well against most other forms of energy.

Afrox is a major player in the development of industrial projects, shopping complexes, hotel/casino resorts, community and industrial townships, formal and informal urbanisation and other projects where fuel and energy is required.

The market can be broadly divided into the five following sectors:

- Industrial
- Commercial
- Agricultural
- Materials handling (forklift trucks)
- Retail
- Domestic
- Hospitality.

Handigas

(60:40 Propane - Butane mixture)

Gas	Purity
Propane	>60%
Butane	<40%
Other Hydrocarbons	<2%

Features	Benefits	Hazards
High calorific value. Highly combustible, having explosive limits in air of between 2,2 and 9,5% by volume	For profile cutting, oxy-LPG gives fast, clean cuts on thick plate	Fire and explosion hazard
Twice as heavy as air	High heating range	Heavier than air - collects in low-lying areas such as drains or ducts
Stenched to give a distinctive fish-like odour	Clean burning	Requires air ventilation when in use
Liquefiable gas	Compatible with air/fuel or oxy/fuel equipment	Can cause dizziness at high concentrations
Non-poisonous	Accidental discharge is quickly detected	Can asphyxiate (does not support life)
Available as a vapour or liquid withdrawal from cylinders	Highly combustible, compact, portable fuel with clean burning characteristics	
Supplied in cylinders or bulk tanks		

Applications

General light and heavy industrial sector

- Used for oxy-LPG or oxy-propane cutting and brazing. Can be used as an alternative fuel gas to acetylene for steel cutting applications when high cutting speed and efficiencies are not required
- Oxy-fuel equipment is widely used with LPG for preheating
- Glass and plastic industry heating and finishing applications
- Shrink wrap applications
- Space heating for small and large work areas
- Firing of many types of oven and furnace heating and curing processes
- Firing granular material drying ovens
- Ink and paint solvent drying
- Water proofing application
- Heating of road surfacing bitumen
- Large volume fluid tank heating
- Dual-fuel (Autogas) for cars and light delivery vehicles
- Fuel for forklift trucks
- Propane is used for carburising atmospheres in the heat treatment of steels.

Agricultural sector

- Heating of chicken brooders and greenhouses
- Crop drying
- Organic flame weeding
- Pest control
- General heating
- Many process and packaging processes.

Commercial, domestic and leisure sectors

- Most cooking applications, for both hob and oven uses
- General space heating for both indoors and outdoors
- Large central and small direct water heating applications in hotels and lodges
- Laundry heating and drying
- Outdoor aesthetic lighting effects
- Outdoor catering and special events
- Home cooking, heating and lighting
- Patio braaing, heating and lighting
- Camping cooking, heating and lighting.

Cylinder Size	Gas Content (kg)	Pressure kPa @ 20°C	Valve Outlet Connection	Item Number
Handigas 48	48,0	± 500	5/8" LH-F	3634 LF
Handigas 48 (wet)	48,0 (wet)	± 500	Dual - 5/8" LH-F & 3/8" (SAE Flare) RH-M	3634 L F-W
Handigas 19	19,0	± 500	5/8" LH-F	3634 LE
Handigas 14	14,0	± 500	5/8" LH-F	3634 LD
Handigas 9	9,0	± 500	5/8" LH-F	3634 LC
Private gas fills	Various	± 500	3/8" RH-F (camping)	3634 P

Cylinder colours:

- Gas withdrawal - Dark Admiralty Grey, with Handigas branding
- Liquid withdrawal (wet) - Dark Admiralty Grey, with Handigas branding and vertical yellow strip on length of cylinder.

Most cylinders are available at all Afrox outlets.

Please check with your local Afrox branch or call 0860 020202.

MSDS available from www.afrox.com.



Afrox LPG 2 Burner Hotplate

Item Number	W012671
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6 kg Handi Cooker

Material	Description	Gas Content (kg)	Pressure kPa @ 20°C	Valve Outlet Connection	Item Number
Handipack Cyl/Cooker		6,0	± 500	3/8" RH-F (camping)	W902216

Cylinder colours:

- Gas withdrawal - Dark Admiralty Grey, with Handigas branding.

Available at all Afrox outlets.

Please check with your local Afrox branch or call 0860 020202.

MSDS available from www.afrox.com.

*Note: Privately owned cylinder

Cooker Ring and Deflector Plate

Item Number	W902125
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Mixer Tube and Burner

Item Number	W902126
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Forklift (Autogas)

Gas	Purity
Propane	>60%
Butane	<40%
Other Hydrocarbons	<2%

Cylinder Size	Gas Content (kg)	Pressure kPa @ 20°C	Valve Outlet Connection	Item Number
Forklift 19	19,0	± 500	1½" Acme RH-M	3634 LE.FV
Forklift 14	14,0	± 500	1½" Acme RH-M	3634 LD.FV



Propane (C₃H₈)

Gas	Purity
Propane	>98%
Other Hydrocarbons	<2%

Cylinder Size	Gas Content (kg)	Pressure kPa @ 20°C	Valve Outlet Connection	Item Number
Propane 48	45,0	± 500	5/8" LH-F	34 LF
Propane 48 (wet)	45,0 (wet)	± 500	Dual - 5/8" LH-F & 3/8" (SAE Flare) RH-M	34 LF.W
Propane 18	18,0	± 500	5/8" LH-F	34 LE
Propane 8	8,0	± 500	5/8" LH-F	34 LC

Cylinder colours:

- Gas withdrawal - Dark Admiralty Grey, with propane branding
- Liquid withdrawal (wet) - Dark Admiralty Grey, with propane branding and vertical yellow strip on length of cylinder.

45 kg cylinders are not available at all Afrox outlets.

Please check with your local Afrox branch or call 0860 020202.

8 kg and 18 kg cylinders are available by special arrangement.

MSDS available from www.afrox.com.



Handigas Dumpy (Mini Bulk)

Gas	Purity
Propane	>60%
Butane	<40%
Other Hydrocarbons	<2%

Dumpy Size (mm)	Content (kg)	Pressure kPa @ 20°C	Valve Outlet Connection	Item Number
900 dia, 1 600 high	193,0	± 500	ACME	1122

Dumpy installations are fixed installations installed on customers' premises by Afrox Customer Engineering Services and are filled on site by bulk road tankers.

MSDS available from www.afrox.com.



Handigas Bulk

Gas	Purity
Propane	>60%
Butane	<40%
Other Hydrocarbons	<2%

Vessel Sizes (m³)	Vessel Content	Pressure kPa @ 20°C	Road Tanker Connection	Item Number
Horizontal: 9, 22,5, 45, 70, 90	As per vessel size	± 500	ACME	1122
Vertical: 4,5, 9, 22,5, 45, 70	As per vessel size	± 500	ACME	

Bulk installations are fixed installations installed on customers' premises by Afrox Customer Engineering Services and are filled on site by bulk road tankers.

MSDS available from www.afrox.com.

Propane Bulk

Gas	Purity
Propane	>98%
Other Hydrocarbons	<2%

Vessel Sizes (m³)	Vessel Content (t)	Pressure kPa @ 20°C	Road Tanker Connection	Item Number
Horizontal: 9, 22,5, 45, 70, 90	4,5 - 45	± 710	ACME	5410
Vertical: 4,5, 9, 22,5, 45, 70	2,25 - 22,5	± 710	ACME	

Bulk installations are fixed installations installed on customers' premises by Afrox Customer Engineering Services and are filled on site by bulk road tankers.

MSDS available from www.afrox.com.

