Contents

About the Training Package

This training material is designed to provide you with learning support material that will help you to prepare for the Nationally Accredited Certification Scheme (ACS) changeover assessments from Domestic Natural Gas to Liquefied Petroleum Gas. You may want to attend a BPEC training course in order to gain a better understanding of the course content prior to sitting the assessments. There are many Bpec approved centres throughout the UK, where you can complete your training and assessment. If you choose to attend a training course, you will work in a classroom and workshop environment with the support of a tutor, working through this material. This training material contains six generic core Liquefied Petroleum Gas ACS modules (1 to 6) and four Liquefied Petroleum Gas appliance type modules (7 to 10). A final module is included to test your Knowledge and Understanding of modules 1 to 10 and give you an indication as to how you are progressing with the material. When you have completed the training material you should be ready to sit the Domestic Natural Gas to Liquefied Petroleum Gas changeover ACS assessment. If you are attending a BPEC training course your tutor will give you further guidance at this point.

Nationally Accredited Certification Scheme Assessment Criteria, Domestic Natural Gas to Liquefied Petroleum Gas

The Nationally Accredited Certification Scheme (ACS) requires that individual gas fitting operatives are assessed on their competence to carry out safe gas work and are certified to that effect by a certification body (such as BPEC Certification Ltd). The certification body has demonstrated conformity with the International Standard ISO IEC 17024 through assessment and accreditation by an approved body, which is a signatory to the European Accreditation of Certification multilateral agreement. It is important that you are fully aware of what the ACS requirements for each module are, so we have included details of the assessment criteria here.

Domestic Natural Gas to Liquefied Petroleum Gas Changeover (CoNGLP1) Pre-requisites

Before any of the Domestic Natural Gas to Liquefied Petroleum Gas changeover assessments can be undertaken, you must hold a Certificate of Competence in:

- Any Core Gas Safety Assessment.
- A valid ACS aligned Gas Services S/NVQ.

Module 1

Characteristics of Liquefied Petroleum Gas (LPG)

Contents

Module 1 Characteristics of Liquefied Petroleum Gas

Introduction

The purpose of this training module is to provide you with the knowledge and understanding of the characteristics of Liquefied Petroleum Gas (LPG). Satisfactory completion in this Core Competency will support the completion of the Nationally Accredited Certification Scheme (ACS) generic fuel changeover from Natural Gas to Liquefied Petroleum Gas (CoNGLP1).

By the end of this module you must be able to correctly answer gas safety questions in the following topics relating to characteristics of LPG:

1. Types of commercial LPG (propane and butane)
2. Storage pressures for both gas types in cylinders and vessels
3. Specific gravity of LPG vapour and its effect in relation to air and natural gas
4. Vaporisation of LPG liquid and off-take – effects of temperature
5. Limits of flammability
6. Calorific value of LPG and its relationship to natural gas

Liquefied Petroleum Gas as its name suggests is a by-product of the petroleum industry that is supplied in a liquid form. LPG is obtained during the refining process of crude oil. LPG is unique among the commonly used fuels in that it can be stored in a liquid form under moderate pressure and at normal ambient temperatures. When released at relatively low ambient temperatures, at atmospheric pressure, it vaporises and can be used and handled as a gas. In its gaseous state LPG can be utilised in the same way as natural gas albeit operating under different operating parameters and using slightly different control systems. In its liquid state LPG is similar to petrol in the way it is stored, transported and measured. There is, however, one essential difference, the liquid state is only maintained, at normal ambient temperatures, under pressure. It is a requirement of the many codes of practice covering LPG and its utilisation that all persons concerned, including customers should be familiar with the properties of and potential hazards that can arise from the improper use of LPG.

This module investigates the main characteristics of LPG, in particular when it is in its vapour stage, i.e. when utilised as a gas. It is intended to give the gas operative sufficient knowledge and understanding to work safely with LPG.

1. Types of commercial LPG (propane and butane)

There are two types of LPG, propane and butane. Butane is only sold in cylinders and is rarely sold as a bulk supply. Propane and butane are stored in purpose designed cylinders or in larger bulk storage vessels, these are generally coloured red for propane cylinders and blue for butane cylinders.

2. Storage pressures for both gas types in cylinders and vessels

LPG is always stored in a liquid form, the vessels are filled to only 85% of their liquid capacity, this allows for expansion of the liquefied gas due to the ranges of ambient temperature (weather changes). The range of expansion pressures are:

Propane	minimum pressure 2.7bar	approx maximum pressure 10bar
Butane	minimum pressure 0bar	approx maximum pressure 3 to 4bar

As gas is removed from the vessel, the liquid remaining boils, replacing the gas removed, and thereby maintaining a continuous gas flow. The normal storage pressures for LPG vessels at an ambient temperature of 15°C are:

Propane cylinders and bulk storage vessels	100psi (6.9bar)
Butane cylinders	28psi (1.93bar)

3. Specific gravity of LPG vapour and its effect in relation to air and natural gas

Every substance including gases have weight and mass. It is sometimes necessary to compare the weights of gases, and in order to do this a comparison is made between the density of a gas and that of air. This is known as the specific gravity (SG) which is also often referred to as the relative density (RD). The density of a substance is the weight of a given volume, the SI unit (International System) of density is kg/m^3. Specific gravity is a comparison of two substances measured in kg/m^3, it therefore has no units and is just a number. The specific gravity of air is 1. The specific gravity of LPG is 1.5, therefore LPG is 1.5 times heavier than air. LPG has an SG of 1.5 for propane and 2.0 for butane, therefore both of these gases if released into the atmosphere would fall to the ground – again this is an important point to remember.

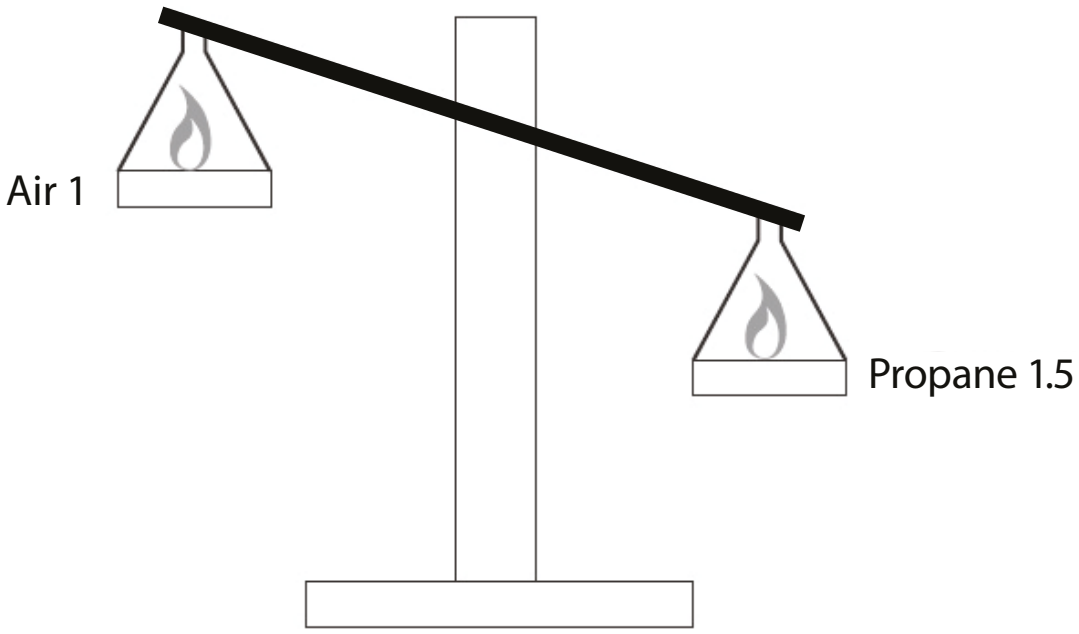

Figure 1: Specific gravity of propane

4. Vaporisation of LPG liquid and off-take – effects of temperature

As gas is drawn off from a LPG vessel, the boiling process draws heat into the liquid from its surroundings through the vessel wall, hence the amount of heat available is controlled by the surface area of the vessel in contact with the liquid. As a result the amount of gas that can be drawn off is limited by the vessel size the typical storage vessel sizes and off-take rates are:

Typical storage vessel sizes and off-take rates (Cylinders)					
Butane					
Cylinder size (kg)	kg/hr	kW	ft^3/hr	m^3/hr	Btu's/hr
4.5	0.36	5	5.3	0.14	17,060
7	0.50	7	7.5	0.20	23,884
15	0.71	9.9	10.5	0.28	33,778
Propane					
Cylinder size (kg)	kg/hr	kW	ft^3/hr	m^3/hr	Btu's/hr
3.9	0.54	7.5	10.2	0.28	25,590
6	0.79	11	15	0.42	47,532
13	1.08	15	20.4	0.57	51,180
19	1.37	19	25.9	0.71	64,828
47	2.46	34	46.4	1.27	116,008

Typical storage vessel sizes and off-take rates (Bulk Storage)				
Propane vessel capacity	380 Litres	1200 Litres	2000 Litres	3400 Litres
Vapour off-take capacity	2.3m^3/hr	5.7m^3/hr	7.1m^3/hr	10.2m^3/hr
Heat input	60kW	105kW	187kW	264kW

Bulk tanks and cylinders incorporate a safety valve which is designed to protect the vessel against over pressurisation which could be caused for example, exposure to heat. In the case of cylinders, the safety valve is part of the outlet valve and is designed to release over pressure at:

21bar for butane and 26bar for propane

Cylinders for both propane and butane are designed with a burst pressure of 96bar and are tested to one third of the burst pressure (32bar).

Bulk vessels have a separate pressure release valve (See Figure 2)

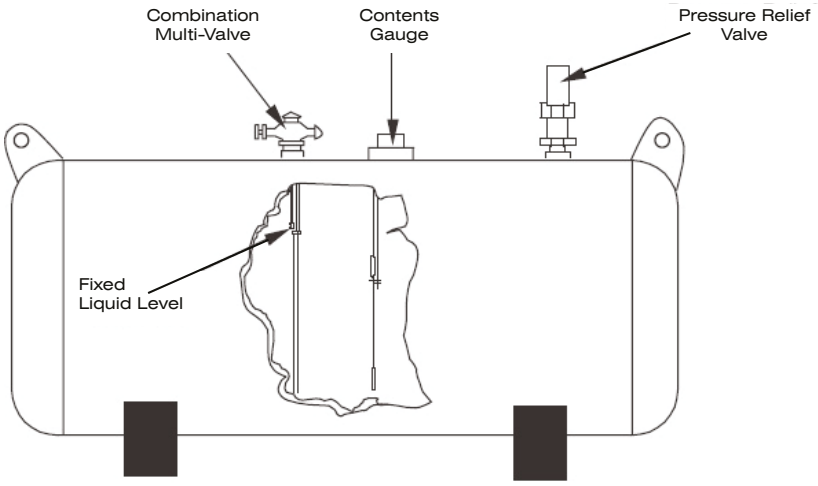

Figure 2: Bulk vessels

5. Limits of flammability

Mixtures of gas and air will only burn within specific limits; if there is either too much gas or too much air the mixture will not burn. Natural gas will ignite if between 5% – 15% is mixed with air. LPG will ignite if between 2% – 10% for propane and 1.8% – 9% for butane is mixed with air (obviously, there needs to be a spark for ignition to occur).

The lower limits are abbreviated as LFL (Lower Flammability Limits). The upper limits are abbreviated as UFL (Upper Flammability Limits).

Note: these figures may also be expressed as Lower and Upper Explosive Limits (LEL and UEL).

If gas is allowed to build up in the atmosphere, within a short time there would be a considerable risk of explosion. Therefore extreme care and caution is required whenever gas escapes are suspected or when purging installations.

The following charts give a visual account of the LFL and UFL for propane and butane.

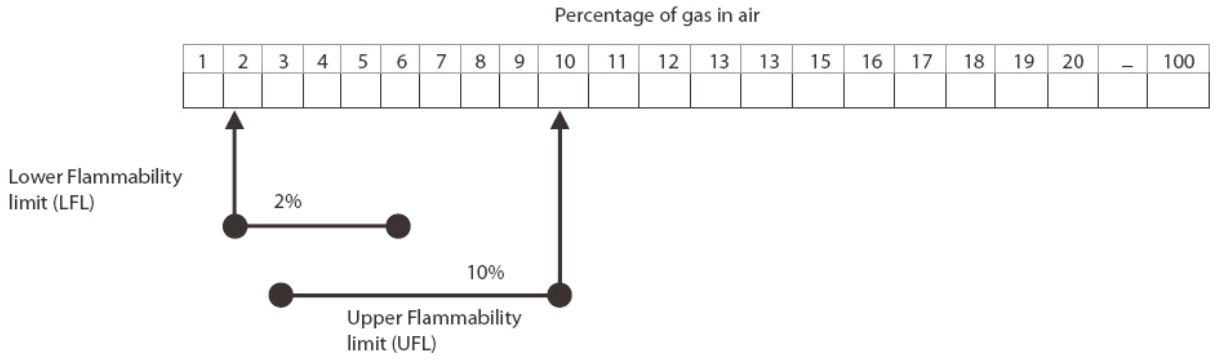

Figure 3: Propane Flammability Range

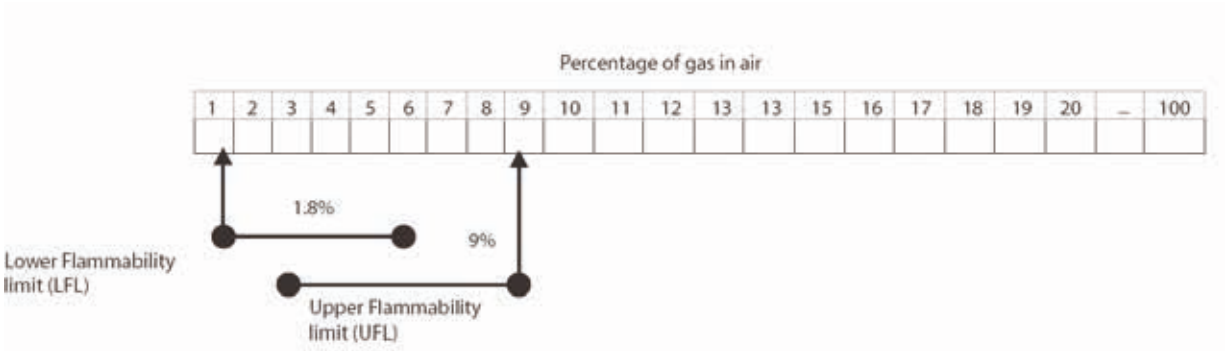

Figure 4: Butane Flammability Range

Complete combustion of LPG

1m^3 of propane requires 4.8m^3 of oxygen for complete combustion. The products of combustion produced consist of 3m^3 of carbon dioxide and 4m^3 of water. The atmosphere contains only 20.9% oxygen, therefore, to burn 1m^3 of propane requires approximately 24 volumes of air. This gives an air/gas ratio of 24 divided by 5 (100% divided by 20.9% oxygen in the atmosphere) = 4.8m^3. 1m^3 of butane on the other hand will require approximately 6.5m^3 of oxygen for complete combustion, i.e. approximately 30m^3 of air.

6. Calorific value (CV) of LPG and its relationship to natural gas

All gases that burn give off heat (energy) and the calorific value (CV) indicates the heating power. This is measured in mega Joules per cubic metre (MJ/m^3). The average CV of gas is $38.76MJ/m^3$, butane has an average CV of $121.8MJ/m^3$ and propane has an average CV of $93.1MJ/m^3$.

Calorific values can be expressed as either gross CV or net CV. If the amount of gas passing through an appliance is known, the CV can be used to calculate the rated heat input of the appliance. The calorific value of natural gas may vary depending on the source, but the supplier of gas has a responsibility to declare the current value, and this is printed on every gas bill.

Net and Gross CVs

A percentage of heat released in burnt gas is trapped in water vapour given off as part of the combustion process. This trapped heat is referred to as latent heat which (with the exception of a condensing appliance) is lost through the flue to the outside atmosphere.

Manufacturers of appliances are now required to conform to 'Europeanisation' of Appliance Safety Standards to express the net heat input of their appliance(s). The net heat input reflects the sensible heat, this is heat that is transferred into the heat exchanger, and does not include any latent heat which would be lost through the flue to the outside atmosphere.

Summary

	Commercial LPG	
Natural Gas	**Propane**	**Butane**
Is a 2nd Family Gas	Are 3rd Family Gases	
Lighter than air, rises when released into the atmosphere	Heavier than air, falls when released into the atmosphere	
Disperses readily if released into open air	Difficult to disperse in still air, readily collects at low levels in cellars, drains or any ground depression	
Is always encountered as a gas which is non-toxic	Stored under pressure as a liquid which boils furiously if spilled from storage vessel, causes severe frost burns if in contact with the skin	
		Butane can have a narcotic effect if inhaled
Calorific value NET 34.9MJ/m^3 Gross 38.76MJ/m^3	NET 86.1MJ/m^3 Gross 93.1MJ/m^3	NET 112.9MJ/m^3 Gross 121.8MJ/m^3
Supply pressure 21mbar at outlet of meter	Storage Pressure 100psi or 6.9bar (at 15°C)	Storage Pressure 28psi or 1.9bar (at 15°C)
Air to Gas ratio for complete combustion 10 to 1	24 to 1	30 to 1
Limits of flammability 5% to 15% gas in air	2% to 10% gas in air	1.8% to 9% gas in air
Ignition temperature 650°C	470°C	405°C
Non corrosive	The gas and liquid will attack natural based rubber, a neoprene based synthetic rubber should be used	

Module 2

Cylinder storage/location, safety requirements and sizing

Contents

Section 1 – Knowledge Assessment Questions

Module 1 Characteristics of Liquefied Petroleum Gas (LPG)

Self Assessment Progress Check

Review your progress so far by attempting the following questions.

Q1 The sensible heat is heat that is transferred into the room, what is the heat that is transferred into the heat exchanger called?

a) Rated heat
b) Latent heat
c) Gross heat
d) NET heat

Q2 LPG is a:

a) 1st family gas
b) 2nd family gas
c) 3rd family gas
d) 4th family gas

Q3 LPG is:

a) The same weight as air
b) Lighter than air
c) Heavier than air
d) Lighter than natural gas

Q4 The limits of flammability for propane are:

a) 1.8% to 9% gas in air
b) 2% to 10% gas in air
c) 5% to 15% gas in air
d) 5% to 10% gas in air

Q5 A neoprene based synthetic rubber should be used for LPG because:

a) Of the extremely high temperature of LPG
b) Of the extremely low temperature of LPG
c) LPG is heavier than air
d) LPG and liquid will attack natural based rubber

Q6 Manufacturers of appliances are now required to conform to:

a) The "Gas Safety (Installation and Use) Regulations"
b) The "Europeanisation' of Appliance Safety Standards"
c) The "Gas Safety (Management and Use) Regulations"
d) The "Gas Industry Unsafe situations regulations"

Q7 The specific gravity of air is 1. The specific gravity of LPG is 1.5. Therefore LPG is:

a) 1.5 times heavier than air
b) 0.5 times heavier than air
c) 2.5 times heavier than air
d) the same as air

Q8 Approximately how much oxygen is required to burn 1m^3 of propane?

a) 5m^3
b) 1m^3
c) 4.8m^3
d) 23m^3

Q9 The complete products of combustion are:

a) 3m^3 of carbon dioxide and 4m^3 of water vapour
b) 4m^3 of carbon dioxide and 4m^3 of water vapour
c) 3m^3 of carbon dioxide and 3m^3 of water vapour
d) 4m^3 of carbon dioxide and 3m^3 of water vapour

Q10 What is the flammability range of butane?

a) 5% to 15% gas in air
b) 2% to 11% gas in air
c) 1.8% to 9% gas in air
d) 2% to 15% gas in air

Q11 LPG is always stored in a liquid form, the vessels are filled to only:

a) 58%
b) 75%
c) 15%
d) 85%

Q12 Generally what are the colours of LPG cylinders?

a) Blue for propane cylinders and red/orange for butane cylinders
b) Orange for propane cylinders and blue for butane cylinders
c) Green for propane cylinders and blue for butane cylinders
d) Orange for propane cylinders and green for butane cylinders

Q13 Cylinders for both propane and butane are designed with a burst pressure of:

a) 96bar
b) 32bar
c) 21bar
d) 26bar

Q14 For cylinders, the safety valves are designed to release over pressure at:

a) 26bar for butane and 21bar for propane
b) 96bar for butane and 32bar for propane
c) 32bar for butane and 96bar for propane
d) 21bar for butane and 26bar for propane