BS EN 16125:2015

BSI Standards Publication

LPG Equipment and Accessories — Pipework systems and supports — LPG in liquid phase and vapour pressure phase

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National foreword

This British Standard is the UK implementation of EN 16125:2015.

The UK participation in its preparation was entrusted to Technical Committee PVE/19, LPG containers and their associated fittings.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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Flüssiggas-Geräte und Ausrüstungsteile - Rohrleitungssysteme und -befestigungen - Flüssigphase und ungeregelte Gasphase von Flüssiggas (LPG)

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European foreword

This document (EN 16125:2015) has been prepared by Technical Committee CEN/TC 286 “LPG Equipment and Accessories”, the secretariat of which is held by NSAI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by June 2016, and conflicting national standards shall be withdrawn at the latest by June 2016.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

According to the CEN-CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Introduction

This European Standard calls for the use of substances and procedures that may be injurious to health and/or the environment if adequate precautions are not taken. It refers only to technical suitability and does not absolve the user from legal obligations at any stage.

This European Standard is intended for users who take on the responsibility for the assembly of the pipework on site.

Protection of the environment is a key political issue in Europe and elsewhere. Protection of the environment is taken in a very broad sense, as in the total life cycle aspects of, e.g. a product on the environment, including expenditure of energy and during all phases from mining of raw materials, fabrication, packaging, distribution, use, scrapping, recycling of materials, etc.

NOTE 1 Annex D indicates which clauses in this standard addresses environmental issues.

It is recommended that manufacturers develop an environmental management policy. For guidance see the ISO 14001 [9]. It has been assumed in the drafting of this European Standard that the execution of its provisions is entrusted to appropriately qualified and experienced people.

All pressures are gauge unless otherwise stated.

NOTE 2 This standard requires measurement of material properties, dimensions and pressures. All such measurements are subject to a degree of uncertainty due to tolerances in measuring equipment etc. It may be beneficial to refer to the leaflet “measurement uncertainty leaflet (SP INFO 2000 27 uncertainty.pdf)”.

1 Scope

This European Standard specifies the requirements for the design, construction, testing, commissioning, operation and maintenance of LPG pipework in both the liquid phase and at full vapour pressure.

This European Standard is applicable to LPG pipework having a maximum allowable pressure of less than or equal to 25 bar.

This European Standard is applicable to new LPG pipework as well as to replacements of, or extensions to, existing LPG pipework.

This European Standard is not applicable to:

— pipelines and their accessories;

— pipework for the propulsion systems of road vehicles or boats; and

— pipework on ships.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 549, *Rubber materials for seals and diaphragms for gas appliances and gas equipment*

EN 751-1, *Sealing materials for metallic threaded joints in contact with 1st, 2nd and 3rd family gases and hot water - Part 1: Anaerobic jointing compounds*

EN 751-2, *Sealing materials for metallic threaded joints in contact with 1st, 2nd and 3rd family gases and hot water - Part 2: Non-hardening jointing compounds*

EN 751-3, *Sealing materials for metallic threaded joints in contact with 1st, 2nd and 3rd family gases and hot water - Part 3: Unsintered PTFE tapes*

EN 837 (all parts), *Pressure gauges*

EN 1045, *Brazing - Fluxes for brazing - Classification and technical delivery conditions*

EN 1057, *Copper and copper alloys - Seamless, round copper tubes for water and gas in sanitary and heating applications*

EN 1092-1, *Flanges and their joints — Circular flanges for pipes, valves, fittings and accessories, PN designated - Part 1: Steel flanges*

EN 1254-1, *Copper and copper alloys - Plumbing fittings - Part 1: Fittings with ends for capillary soldering or capillary brazing to copper tubes*

EN 1254-2, *Copper and copper alloys - Plumbing fittings - Part 2: Fittings with compression ends for use with copper tubes*

EN 1254-5, *Copper and copper alloys - Plumbing fittings - Part 5: Fittings with short ends for capillary brazing to copper tubes*

EN 1515-1, *Flanges and their joints - Bolting - Part 1: Selection of bolting*

EN 10216-1, *Seamless steel tubes for pressure purposes - Technical delivery conditions - Part 1: Non-alloy steel tubes with specified room temperature properties*

EN 10216-2, *Seamless steel tubes for pressure purposes - Technical delivery conditions - Part 2: Non-alloy and alloy steel tubes with specified elevated temperature properties*

EN 10216-3, *Seamless steel tubes for pressure purposes - Technical delivery conditions - Part 3: Alloy fine grain steel tubes*

EN 10216-4, *Seamless steel tubes for pressure purposes - Technical delivery conditions - Part 4: Non-alloy and alloy steel tubes with specified low temperature properties*

EN 10216-5, *Seamless steel tubes for pressure purposes - Technical delivery conditions - Part 5: Stainless steel tubes*

EN 10217-1, *Welded steel tubes for pressure purposes - Technical delivery conditions - Part 1: Non-alloy steel tubes with specified room temperature properties*

EN 10217-2, *Welded steel tubes for pressure purposes - Technical delivery conditions - Part 2: Electric welded non-alloy and alloy steel tubes with specified elevated temperature properties*

EN 10217-3, *Welded steel tubes for pressure purposes - Technical delivery conditions - Part 3: Alloy fine grain steel tubes*

EN 10217-4, *Welded steel tubes for pressure purposes - Technical delivery conditions - Part 4: Electric welded non-alloy steel tubes with specified low temperature properties*

EN 10217-6, *Welded steel tubes for pressure purposes - Technical delivery conditions - Part 6: Submerged arc welded non-alloy steel tubes with specified low temperature properties*

EN 10217-7, *Welded steel tubes for pressure purposes - Technical delivery conditions - Part 7: Stainless steel tubes*

EN 10226-1, *Pipe threads where pressure tight joints are made on the threads - Part 1: Taper external threads and parallel internal threads - Dimensions, tolerances and designation*

EN 10226-2, *Pipe threads where pressure tight joints are made on the threads - Part 2: Taper external threads and taper internal threads - Dimensions, tolerances and designation*

EN 10253-2, *Butt-welding pipe fittings - Part 2: Non alloy and ferritic alloy steels with specific inspection requirements*

EN 12007-1, *Gas infrastructure - Pipelines for maximum operating pressure up to and including 16 bar - Part 1: General functional requirements*

EN 12007-3, *Gas infrastructure - Pipelines for maximum operating pressure up to and including 16 bar - Part 3: Specific functional requirements for steel*

EN 12068, *Cathodic protection - External organic coatings for the corrosion protection of burried or immersed steel pipelines used in conjunction with cathodic protection - Tapes and shrinkable materials*

EN 12266-1, *Industrial valves - Testing of metallic valves - Part 1: Pressure tests, test procedures and acceptance criteria - Mandatory requirements*

EN 12266-2, *Industrial valves - Testing of metallic valves - Part 2: Tests, test procedures and acceptance criteria - Supplementary requirements*

EN 12542, *LPG equipment and accessories - Static welded steel cylindrical tanks, serially produced for the storage of Liquefied Petroleum Gas (LPG) having a volume not greater than 13 m^3 - Design and manufacture*

EN 12799, *Brazing - Non-destructive examination of brazed joints*

EN 13175, *LPG Equipment and accessories - Specification and testing for Liquefied Petroleum Gas (LPG) pressure vessel valves and fittings*

EN 14291, *Foam producing solutions for leak detection on gas installations*

EN 14324, *Brazing - Guidance on the application of brazed joints*

EN 15001-1, *Gas Infrastructure - Gas installation pipework with an operating pressure greater than 0,5 bar for industrial installations and greater than 5 bar for industrial and non-industrial installations - Part 1: Detailed functional requirements for design, materials, construction, inspection and testing*

EN ISO 3183, *Petroleum and natural gas industries - Steel pipe for pipeline transportation systems (ISO 3183)*

EN ISO 3452-1, *Non-destructive testing - Penetrant testing - Part 1: General principles (ISO 3452-1)*

EN ISO 5817, *Welding - Fusion-welded joints in steel, nickel, titanium and their alloys (beam welding excluded) - Quality levels for imperfections (ISO 5817)*

EN ISO 9454-2, *Soft soldering fluxes - Classification and requirements - Part 2: Performance requirements (ISO 9454-2)*

EN ISO 9606-1, *Qualification testing of welders - Fusion welding - Part 1: Steels (ISO 9606-1)*

EN ISO 9712:2012, *Non-destructive testing - Qualification and certification of NDT personnel (ISO 9712:2012)*

EN ISO 10380, *Pipework - Corrugated metal hoses and hose assemblies (ISO 10380)*

EN ISO 10497, *Testing of valves - Fire type-testing requirements (ISO 10497)*

EN ISO 16810, *Non-destructive testing - Ultrasonic testing - General principles (ISO 16810)*

EN ISO 17636-1, *Non-destructive testing of welds - Radiographic testing - Part 1: X- and gamma-ray techniques with film (ISO 17636-1)*

EN ISO 17637, *Non-destructive testing of welds - Visual testing of fusion-welded joints (ISO 17637)*

EN ISO 17638, *Non-destructive testing of welds - Magnetic particle testing (ISO 17638)*

EN ISO 17640, *Non-destructive testing of welds - Ultrasonic testing - Techniques, testing levels, and assessment (ISO 17640)*

EN ISO 17672, *Brazing - Filler metals (ISO 17672)*

EN ISO 17292, *Metal ball valves for petroleum, petrochemical and allied industries (ISO 17292)*

ASME B31.3, *Process piping*

ASME B31.4, *Pipeline transportation systems for liquids and slurries*

ASME B16.5, *Pipe flanges and flanged fittings: NPS 1/2 through NPS 24 metric/inch standard*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
accessible
capable of being reached for inspection, removal or maintenance without the removal of permanent structures

3.2
brazed joint
joint obtained by the joining of metal parts with alloys which melt at temperatures that is generally higher than 450 °C, but less than the melting temperatures of the joined parts

3.3
commissioning
preparation for safe service

3.4
competent person
person which by combination of appropriate qualification, training, experience, and resources, is able to make objective judgments on the subject

3.5
composite pipe
pipe manufactured from thermoplastic and/or stainless steel which is also reinforced with stainless steel or other non-metallic materials and has an outer thermoplastic protective cover

3.6
excess flow valve
device designed to close automatically, with a small residual flow, when the fluid flow passing through it exceeds a predetermined value, and to re-open when the pressure differential across the valve has been restored below a certain value

3.7
fitting
pressure containing component fitted to an LPG pressure system

3.8
flexible pipe
pipe that can be bent by hand by any radius above a set minimum without any change in performance

3.9
hydrostatic relief valve
self-closing valve which automatically, without the assistance of any energy other than that of the fluid concerned, discharges fluid at a predetermined pressure

3.10
Liquefied Petroleum Gas
LPG
low pressure liquefied gas composed of one or more light hydrocarbons which are assigned to UN 1011, UN 1075, UN 1965, UN 1969 or UN 1978 only and which consists mainly of propane, propene, butane, butane isomers, butene with traces of other hydrocarbon gases

3.11
maximum allowable pressure
maximum pressure for which the equipment is designed

Note 1 to entry: All pressures are gauge pressures unless otherwise stated.

3.12
mechanical joint
joint in which gas tightness is achieved by compression with or without a seal

Note 1 to entry: This joint can be readily disassembled and reassembled.

3.13
nominal diameter
DN
numerical designation of the size of a component, which is a convenient round number, approximately equal to the manufacturing dimensions in millimetres (mm)

EXAMPLE DN 50.

3.14
non-return valve
valve designed to close automatically to restrict reverse flow

3.15
multilayer pipe
pipe where more than one identified layer is present

3.16
pipeline
piping designed for the conveyance of any fluid or substance to or from an installation (onshore or offshore) starting from and including the last isolation device located within the confines of the installation, including all the annexed equipment designed specifically for pipelines

Note 1 to entry: This definition is extracted from 97/23/EC (PED) [2].

3.17
pipework
pressure containing enclosure used for the conveyance of LPG consisting of pipe, pipe fittings, valves and other accessories

3.18
purging
displacing LPG with a non-flammable gas, steam or water or the reverse procedure

3.19
road tanker
rigid vehicle, semi-trailer or trailer comprising of one or more fixed pressure vessels

Note 1 to entry: Referred to as fixed tanks (tank-vehicles) and demountable tanks in the ADR.

3.20
sleeve
protective pipe through which a gas pipe passes

3.21
strength test
specific procedure intended to verify that the pipework meets the requirements for mechanical strength

3.22
threaded joint
joint in which tightness is achieved by metal to metal contact within threads with the assistance of a sealant

3.23
void
any enclosed, generally inaccessible and unventilated, space other than a service shaft

3.24
welded joint
joining of two compatible components by melting their edges and melting a suitable material into a space between the components, or by raising the temperature of their edges to the fusion temperature and applying pressure to join the two together

Note 1 to entry: While this is most commonly applied to steel it is also applicable to other materials such as copper.

Note 2 to entry: Due to the application of heat, welded joints can be subject to complex stress pattern and therefore the joints should only be made by suitably trained personnel.

3.25
working pressure
pressure under normal operating conditions

4 Design safety considerations

4.1 General

4.1.1 Any person who is responsible for the design of an LPG installation shall be competent.

4.1.2 The pipework designer shall provide information on the design and location of the pipework to the persons responsible for the construction, installation, testing, commissioning and operation of the pipework.

4.1.3 The pipework shall be designed, installed and constructed to allow testing and purging to be safely carried out.

4.1.4 Pipework joints shall be kept to a minimum.

4.2 Environmental considerations

The designer shall consider the selection of pipe material and components with regard to the use of production processes, practices, materials or products that avoid, reduce or control pollution, including

recycling, treatment, process changes, control mechanisms, efficient use of materials and material substitution.

NOTE Every product has some impact on the environment. These impacts may occur at any or all stages of the product's life cycle and can be local, regional or global, or a combination of all three.

4.3 Operating conditions

Pipework used in accordance with this Standard shall be suitable for the following conditions:

— a minimum operating temperature of −20°C. In service, temperatures below this can be encountered during short periods, for example, when filling. In some parts of Europe and in certain applications where a lower temperature than −20°C can be encountered, the minimum design temperature shall be −40°C;

— the maximum working temperature shall be 65°C for above ground pipework and 40 C for underground pipework;

— the maximum allowable pressure for pipework shall be less than or equal to 25 bar;

— pipes shall be suitable for transport and storage at −40°C and 65°C.

NOTE Vacuum conditions on the pipework arising from butane at low temperature or evacuation of the pipework can expose the pipework to a vacuum of 50 mbar absolute. The minimum pressure to which pipework is normally exposed is 0 bar.

4.4 Protection against hazards

4.4.1 Protection against mechanical damage

Pipework shall be protected against mechanical damage. For protection of underground pipework, see 6.6.1.4

4.4.2 Resistance to corrosive substances and atmospheres

All pipework and fittings, including supports, shall be protected from corrosion according to the environment and operating conditions they will be subjected to during their service life.

NOTE Stainless steel pipework and fittings can be subject to chloride induced stress cracking, e.g. coastal areas or other areas where salt laden atmospheres can occur.

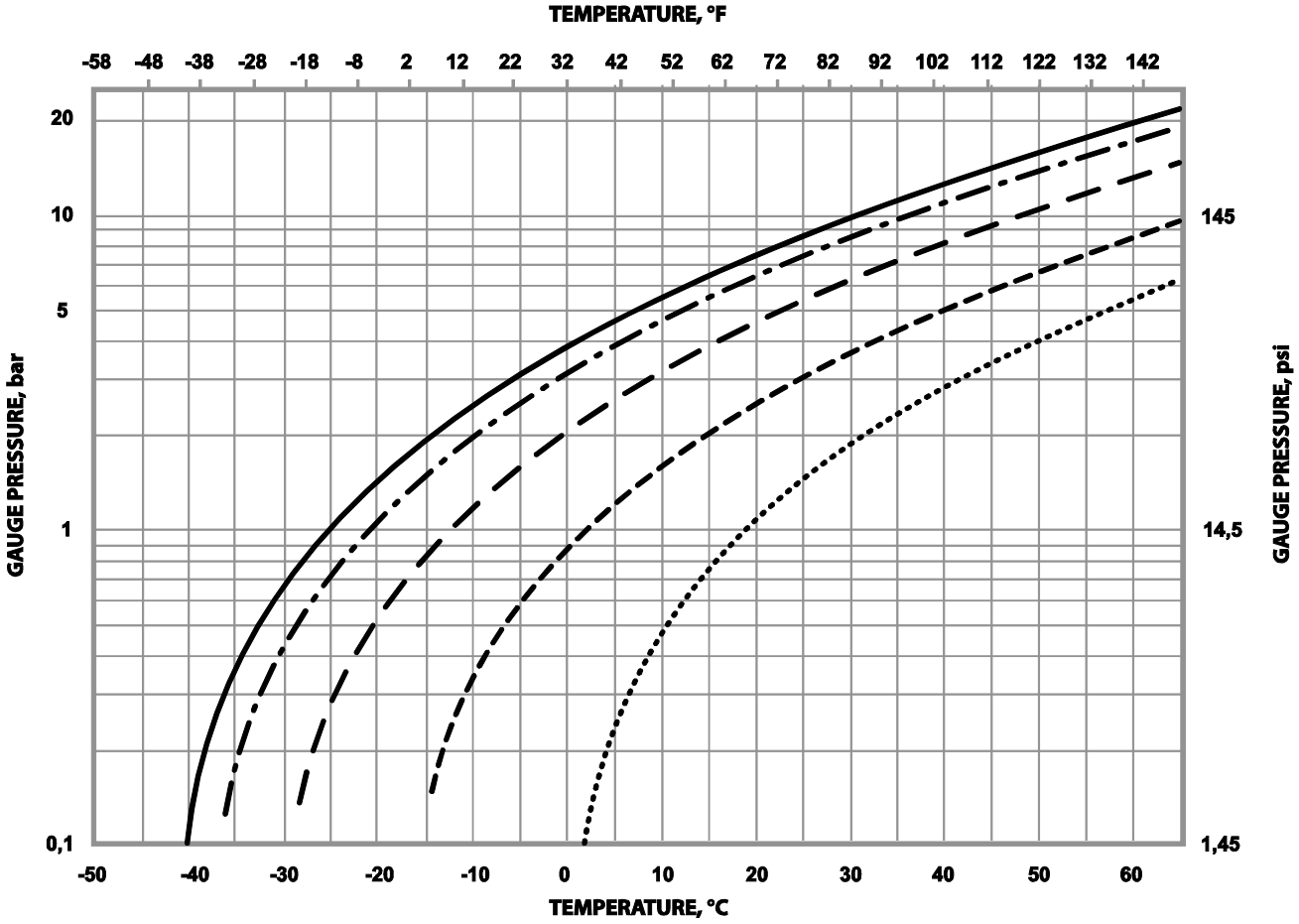
4.4.3 Protection against condensation

For vapour pressure pipework, precautions shall be taken to avoid problems occurring in the pipe and downstream equipment due to condensate forming. Figure 1 indicates temperatures and pressures for propane, mixes of propane/butane and butane.

NOTE 1 Where the stored LPG liquid temperature is higher than the temperature of the downstream pipework, the LPG can condense to a liquid. This is known as the dew point.

NOTE 2 In Figure 1, where the LPG is exposed to a pressure above the curve, the LPG vapour will condense.

In order to prevent condensation of LPG, trace heating of the pipework shall be considered. Alternatively the pipework shall drain back to the vessels. If this is not possible a suitably located vapour-liquid separator (knockout pot) may be installed in the line to allow condensation to collect and subsequently boil off without causing problems.



Literature Reference: Buecker,D. and Wagner, W. "Reference equations of state for thermodynamic properties of fluid phase n-Butane and Isobutane" J. Phys. Chem. Ref. Data, 35(2):929-1019,2006

Key

X	temperature in °C
Y	pressure in bar
———	100% Propane
— · — · —	80% Propane 20% Butane
— — — ·	50% Propane 50% Butane
– – – –	20% Propane 80% Butane
·····	100% Butane

Figure 1 — Dew point graph

5 Materials

5.1 Environmental

The manufacturer should acquire materials and components from suppliers who have a declared environmental policy, see EN ISO 14021 [10], EN ISO 14024 [11] and EN ISO 14025 [12].

5.2 General

5.2.1 All materials in contact with LPG shall be physically and chemically compatible with LPG under all operating conditions for which the pipework is designed.

5.2.2 Materials for pipework shall be selected to give adequate strength in service. Consideration shall also be given to other modes of failure such as atmospheric corrosion, brass dezincification, stress corrosion, impact or material failure.

Electrolytic corrosion of dissimilar metals at joints shall be prevented by the selection of compatible materials.

Materials and components shall comply with one or more of the standards listed in Table 3, Table 4, Table 5 and Table 6.

Materials and components can be reused where they comply with the following requirements:

— are suitable for the proposed service in light of the history of the material or component, and;

— are inspected since the previous use to reveal any defect that could impair the safety, strength or pressure tightness.

Flexible hoses shall be in accordance with EN ISO 10380.

5.3 Accessories

5.3.1 General

Accessories shall be capable of withstanding the service conditions for which the system is designed.

5.3.2 Gaskets and ring joints

Gasket and ring joint materials shall be compatible with LPG over the range of operating conditions, see EN 549.

5.3.3 Valves and fittings

5.3.3.1 Ball valves, globe valves, and non-return valves shall be pressure tested to the relevant requirements of EN 12266-1 and EN 12266-2 or EN 13175, where appropriate.

5.3.2.2 All isolation valves (except those for instrumentation) shall have the means for indicating the settings of the valve e.g. closed, open.

5.3.3.3 Shut-off valves greater than DN 25, excluding vessel valves, in liquid service pipework shall be ball valves in accordance with EN ISO 17292 and fire safe in accordance with EN ISO 10497.

5.3.3.4 Except where proprietary components are being installed, all liquid connections larger than DN 50 and all vapour connections larger than shall DN 80 shall be flanged. For road tankers, connections up to DN 80 may be threaded.

5.3.3.5 Compression fittings shall suit the material, size of the pipe and the maximum working pressure of the system.

5.3.3.6 , Bolts, screws, studs and nuts for flanges shall be correctly sized and compatible with the material and class of the flange design, see EN 1092-1.

5.4 Lubricants, sealants and adhesives

Where used on threads and seals, lubricants, sealants, and adhesives shall be compatible with LPG and not interfere with the operation of the valves and fittings. Sealants shall comply with EN 751-1, EN 751-2 or EN 751-3.

6 Design

6.1 General

6.1.1 For guidance on pipe sizing for liquid pipework see Annex A.

6.1.2 For guidance on pipe sizing for vapour pipework see Annex B.

6.2 LPG pipework installation technical documentation

The designer shall ensure that technical documentation contains the following information (with parts lists where appropriate):

a) the location and design of supports;

b) the location and design of wall and floor transits, points where pipework crosses or runs parallel with other systems, etc.;

c) the location of pumps, compressors, meters and other equipment, stating the make, type and connection sizes;

d) types of joints, gaskets, bolts, etc.;

e) the pipe diameters, maximum allowable pressure, design pressure, materials and types of coatings;

f) the location and sizes of valved points for testing and purging;

g) maximum flow; and

h) cathodic protection system, where fitted.

6.3 Measuring instruments

LPG installations shall incorporate such measuring instruments and test points as are necessary for their safe operation.

6.4 Over Pressure protection

6.4.1 For sections of pipework where liquid can be trapped in between isolation valves, suitable pressure relief protection shall be provided (e.g. by a hydrostatic relief valve discharging to a safe location).

6.4.2 Where hydrostatic relief valves are used they shall be set to discharge above the maximum working pressure of the system but not greater than the maximum allowable pressure of the pipework.

6.4.3 The positioning and/or discharge point of hydrostatic relief valves shall be located so as not to impinge on personnel, vessels or equipment, in the event of a release.

6.4.4 Hydrostatic relief valves shall not be installed in the bottom quarter of horizontal pipe runs.

6.4.5 Hydrostatic relief valves shall have caps fitted to prevent the entry of debris and water without affecting the operation of the valve.

6.4.6 When hydrostatic relief valves are installed in enclosed spaces, especially where personnel are present, suitably sized discharge pipework, which will not restrict the capacity of the hydrostatic relief valve, shall be fitted and piped to the outside, discharging at high level or, where practical, piped back to the storage vessel. Where the discharge is not to atmosphere, the effect of the backpressure on the outlet setting of the hydrostatic relief valve shall be considered.

Hydrostatic relief valve piping connections shall not impose strain on the relief valve.

Where self-closing isolating devices are used for hydrostatic relief valve connections to pipework, they shall only close when the hydrostatic relief valve is removed from the device.

6.4.7 Where stored and handled as individual grades or products (e.g. propane, butane), storage and handling systems shall be totally segregated or physically separated using valve interlocks etc. Where product mixes are handled, components shall be designed for the most onerous case e.g. propane design pressure and minimum design temperature, relief system capacity, ability to withstand vacuum conditions etc.

6.5 Above-ground pipework

6.5.1 Clearance above ground

6.5.1.1 Pipework shall not be laid directly on the ground.

6.5.1.2 Pipework shall have at least a 50 mm clearance from the finished ground level.

6.5.1.3 Pipework shall be suitably located so as not to cause a trip hazard.

6.5.1.4 Pipework shall be suitably protected from vehicular and other mechanical damage.

6.5.1.5 Pipework shall be designed to allow for easy access for inspection and maintenance.

6.5.2 Pipework separation distances from above-ground electrical services

The separation distance shall be at least 250 mm between any pipework and any above-ground:

— metal electrical conduit;

— electrical wire or cable; or

— electrical earthing electrode.

NOTE This requirement does not apply to equipotential bonding of the pipework or heat tracing of the pipework.

6.5.3 Ventilation of concealed piping

6.5.3.1 Pipes through ducts or sleeves

Ducts or sleeves shall be ventilated at either one or both ends. Where ventilation is at one end only, it shall be the lowest end of a non-horizontal duct or sleeve.

Ventilation openings shall terminate in a safe location.

All openings shall be the full cross-sectional area of the duct or sleeve, less the cross sectional area of the pipe.

No other pipes or cables shall run through ducts or sleeves containing LPG pipes.

6.5.3.2 Pipes through walls

All pipes that pass through walls shall be ducted or sleeved, with the duct or sleeve in compliance with 6.5.3.1.

6.5.3.3 Pipes through voids

Pipes shall not be installed directly in an unventilated void unless one of the following options is used:

— the pipes shall be sleeved continuously through the unventilated void, with the sleeve ventilated at one or both ends into a safe place; or

— the unventilated void shall be filled with a crushed inert infill to reduce to a minimum the volume of any gas which may accumulate. The infill material should be of a dry, chemically neutral and fire resistant nature, e.g. crushed slate chippings or dry washed sand.

6.5.4 Pipe supports

6.5.4.1 Pipe supports shall be capable of supporting the pipework and its contents.

6.5.4.2 Pipe supports shall not interfere with the integrity of the supporting structure.

6.5.4.3 The spacing of pipe supports shall be suitable for the material type, diameter, weight and thickness. Table 1 provides indicative spacing requirements for pipework. Pipe support spacing's for flexible pipes shall be obtained from the manufacturer.

6.5.4.4 Pipe supports shall be capable of maintaining the pipework in the intended position and controlling movement of the piping system.

6.5.4.5 Pipe support material shall be compatible with the pipework material or shall be insulated from the pipework to prevent electrolytic corrosion.

6.5.4.6 Vibration, surge pressures and the valve operating torque shall be considered in the design of pipework and supports incorporating mechanical equipment such as pumps and valves.

Table 1 — Spacing of pipe supports for rigid pipework

Nominal diameter (DN) (mm)	Support spacing (m)		
	Steel pipe	Copper pipe	Stainless steel
8	2	1	1
10	2	1,5	1,5
15	2	1,5	1,5
18	-	1,5	1,5
20	2,5	1,5	1,5
25	2,5	2	2
32	3	2,5	2,5
40	3	2,5	2,5
50	3	3	3
65	3	3	3
80	4	4	4
100	5	4	4
125	7	4	4
150	8	4	4
200	9	4	4

6.6 Underground pipes

6.6.1 General

6.6.1.1 Pipes shall be located at least 1 m away from the outside of any building except at the point of entry or where there are alternative national requirements.

6.6.1.2 Pipe routes shall be chosen to minimize the length of pipe required.

6.6.1.3 Buried metallic pipes shall have active or passive means of protection (e.g. cathodic protection, protective coating or wrapping etc.) or shall be inside a buried outer pipe or conduit which terminates above ground level or in a suitable inspection pit. Provision shall be made to facilitate periodic leak testing.

6.6.1.4 Underground pipes shall have a depth of cover of at least 600 mm or shall be protected in such a way as to protect the pipe from physical damage.

6.6.1.5 Pipes installed underground shall be bedded on a firm compacted surface along its entire length.

NOTE To satisfy this requirement it may be necessary to trim the trench base to 'let in' the fittings, collars or flanges to ensure the whole length of pipe is evenly supported.

6.6.1.6 Bedding material and backfill shall be of a type which will not have an adverse effect on the pipe or pipe coating. The bedding material, within 75 mm of the pipe, shall be free of stones or other materials, which could damage the pipe or pipe coating or, as required by the pipe manufacturer.

6.6.1.7 Identification warning tape shall be placed at least 150 mm above the top of the pipe.

6.6.1.8 Bedding material, backfill material and installation procedures for pipework using composite pipes shall comply with the pipe manufacturer's instructions, see E.3.2.

6.6.2 Underground pipe separation distances

6.6.2.1 The separation distances horizontal and/or vertical in Table 2 shall be applied for underground LPG pipes and underground services.

6.6.2.2 Any underground pipes crossing any other service shall cross at an angle of not less than 45°.

Table 2 — Separation distances for underground pipes

Service type	Separation distance – (mm)
Non-ducted electrical supply cable less than 1000 V AC [a]	300
Electrical earthing electrode	500
Communications cable	300
Pipework carrying oxygen	500
Pipework carrying toxic or corrosive substances	1500
Pipework carrying steam or hot water above ambient temperature	300
Any other service pipework	300
[a] For electrical supply cables greater than 1000 V AC specialist advice should be sought.	

6.7 Pipework loading

6.7.1 All pipework shall have sufficient flexibility to prevent:

— excessive stress in the piping material and attached equipment caused by thermal expansion and contraction;

— excessive bending or loading at joints; and

— movements at points of connection to equipment, at anchorage points or guide points.

NOTE This can be achieved by the use of bends, loops etc. formed in the piping system.

6.7.2 Flexible hose connections shall be as short as possible. The operating conditions shall not exceed the manufacturer’s recommendations and the flexible hose connections shall not be subjected to strain, abrasion, kinking or permanent deformation.

6.8 Equipotential bonding

6.8.1 All metallic pipework shall be equipotentially bonded to ensure electrical continuity between pipework sections and the earth connection e.g. by connecting straps or wires.

6.8.2 Where underground or mounded vessels are equipped with a cathodic protection system, the cathodic protection system shall be electrically isolated from the pipework.

6.8.3 In the case of an insulating plastic pipe system, without electrical continuity or dissipative capability, specialist advice on additional earthing shall be sought.

6.8.4 The design of equipotential bonding of pipework and other equipment shall be carried out by competent persons.

7 Identification and corrosion protection of above-ground pipework

7.1 Corrosion protection

7.1.1 Pipework shall be protected so as to prevent external corrosion, arising from atmospheric exposure, by the application of a protective coating system.

7.1.2 The protection system applied shall take into account:

— the local operating environment;

— the periods between periodic inspections/maintenance; and

— any external fire protection coatings or other coating.

7.1.3 Protection shall be applied in accordance with the coating manufacturers' instructions.

7.1.4 Details of the actual system used, the expected life and coating maintenance recommendations shall be included in the operating instructions.

7.2 Colour coding

7.2.1 LPG pipework shall be clearly identified or colour coded.

7.2.2 Flow direction shall be marked where necessary.

7.3 Reflectivity

The external finish shall be in a pale colour and be of a high reflectivity. Only colours of reflectivity of 1, 2 or 3 shall be permitted, see EN 12542.

Table 3 — Criteria for steel pipe (operating limit ≤ 25 bar)

Acceptable pipe		**Acceptable fittings**		**Acceptable jointing**	
Pipe	**Limiting conditions**	**Fitting**	**Limiting conditions**	**Method**	**Limiting conditions**
EN 10216–1, 2, 3 and 4 and EN 10217–1, 2, 3, 4 and 6 as appropriate. EN ISO 3183 ASME B31.3 ASME B31.4	External corrosion protection required. Not permitted for underground service unless wrapped with a protective covering, painted or sheathed or, where buried, can be fitted with cathodic protection in accordance with EN 12007–1 and EN 12007–3. Not permitted for underground service beneath a building.	Screwed flange, carbon steel in accordance with EN 1092–1. Taper external and taper internal threads shall be in accordance with EN 10226–1 or EN 10226–2.	Shall not to be used for joining pipe lengths unless other joining methods are impracticable. Flanges forming a joint are to be of the same size and face type. External corrosion protection required. Above ground only. Not suitable for use with schedule 40 pipe.	Fillet weld in accordance with EN 15001–1.	Where welding is being carried out, the welder shall be approved in accordance with EN ISO 9606-1. External corrosion protection required.
		Steel butt-welded pipe fittings shall be in accordance with EN 10253–2.	External corrosion protection required.	Butt weld in accordance with EN 15001–1.	
		Socket-welded fittings such as tee, bend, reducer and cap shall be welded in accordance with EN 10253–2.	External corrosion protection required.	Fillet weld in accordance with EN 15001–1.	
		Welded flange carbon steel or steel alloy shall be in accordance with EN 1092–1 and EN 1515–1.	Shall not to be used for joining pipe lengths unless other joining methods are impracticable. Flanges forming a joint shall be of the same size and face type. External corrosion protection required.	Slip-on type flanges and other types of flanges shall be fillet welded in accordance with EN 15001–1.	

Table 4 — Criteria for stainless steel pipe (operating limit ≤ 25 bar)

Acceptable pipe		**Acceptable fittings**		**Acceptable jointing**	
Pipe	**Limiting conditions**	**Fitting**	**Limiting conditions**	**Method**	**Limiting conditions**
Stainless Steel Welded pipe in accordance with EN 10216–5. Seamless pipe in accordance with EN 10217–7.	Shall not be permitted for underground service beneath a building. Not permitted for underground service unless provided with protective covering in accordance with EN 12068.	Suitable welded fittings should be used in accordance with EN 10253–2.		Butt weld in accordance with EN 15001- 1.	Where welding is being carried out, the welder shall be approved in accordance with EN ISO 9606-1.
		Welded flange in accordance with EN 1092–1.	Shall not be used for joining pipe lengths unless other joining methods are impracticable. Flanges forming a joint shall be of the same size and face type.		
Composite stainless steel flexible pipe with or without permeation barrier filler coating and with external PE-LD jacket, see Annex E.	Shall not be permitted for use as a final connection to an appliance.	Components that terminate with a NPT thread, welding end and flanges in accordance with EN 1092–1 or ASME B 16.5. Component specified or provided by the pipe manufacturer.		Mechanical jointing using components specified or provided by the pipe manufacturer.	Joints shall be accessible for inspection and maintenance. Jointing shall be carried out by persons certified by the manufacturer.

Table 5 — Criteria for copper tube (operating limit ≤ 25 bar)

Acceptable pipe		Acceptable fittings		Acceptable jointing	
Pipe	**Limiting conditions**	**Fitting**	**Limiting conditions**	**Method**	**Limiting conditions**
Copper tube DN 6 −32 (outside diameter) in accordance with EN 1057.	Shall not be permitted for underground service beneath a building.	Copper alloy compression fittings in accordance with EN 1254–2.	Not permitted in the ground or beneath a building.	Compression	Not permitted underground or beneath a building.
		Junctions can be formed in 'hard drawn' tube only.	Shall be formed with appropriate mechanical branch forming tools.	Brazing in accordance with EN 14324.	Filler materials in accordance with EN ISO 17672. Brazing fluxes shall be in accordance with EN 1045 or EN ISO 9454-2.
		Copper alloy brazing capillary fittings shall be in accordance with EN 1254–1 and EN 1254–5.			
		Socket formed in tube (spigot and socket joining lengths of tube).	Shall be formed with appropriate tube expanding tool.		

Table 6 — Composite Piping (operating limit ≤ 25 bar)

Acceptable pipe		Acceptable fittings		Acceptable jointing	
Pipe	**Limiting conditions**	**Fitting**	**Limiting conditions**	**Method**	**Limiting conditions**
Composite thermoplastic piping, see Annex E.	Permitted for use as a final connection to the appliance but shall be protected against climatic conditions and fire and according to manufacturers' requirements. Not permitted for above ground use.	Component specified or provided by the pipe manufacturer.	Fittings underground shall be accessible for inspection and testing according to manufacturers' requirements.	Mechanical jointing using components specified or provided by the pipe manufacturer.	Mechanical jointing using components specified or provided by the pipe manufacturer.

8 Welded pipes and fittings

8.1 General

Galvanised pipe shall not be welded.

Before the start of any work, procedures, including those for inspection, shall be established in accordance with the appropriate welding standard, see Table 3 and Table 4.

Pipe and fittings shall not have a metal temperature below 5°C when any hot cutting or welding is carried out.

8.2 Competency

Welding competency shall be in accordance with Table 3 and Table 4.

Welding shall only be carried out by a suitably qualified welder using the appropriate procedures for the materials, type and position of the weld.

The welders carrying out the work shall have been rated as satisfactory in accordance with EN ISO 9606-1. Weld procedures and welder qualification may need to be approved by a competent third party.

8.3 Inspection of welds

All welds shall be visually inspected as work progresses and by non-destructive examination.

The level of non-destructive examination shall be in accordance with Table 7.

If one or more unacceptable welds are found in the random sample, another 10 % of the unexamined welds and the repaired welds shall be examined.

Non-destructive examination is not required where DN is less than or equal to 25.

The application of equivalent acceptability standards for other non-destructive examination procedures shall require approval in advance.

The number of welds examined by non-destructive examination shall be spread evenly over the different diameters.

Non-destructive testing shall be carried out in accordance with the standards listed in Table 8.

Reports on the weld quality shall be available for the welds examined by non-destructive examination.

Table 7 — Minimum extent of non-destructive examination

Design pressure (bar)	Type/position of weld	Radiographic and/or ultrasonic examination	Magnetic particle and/or penetrant testing
≤ 16	Circumferential welds on pipes and pipe fittings	10 %	
	Branches, fillet welds; including socket welds.		10 %
> 16	Circumferential welds on pipes and pipe fittings	20 %	
	Branches, fillet welds; including socket welds.		20 %

Table 8 — Inspection standards

Examination	Standard(s)
Visual inspection	EN ISO 17637
Ultrasonic examination	EN ISO 16810 and EN ISO 17640
Radiographic examination	EN ISO 17636-1
Magnetic particle testing	EN ISO 17638
Penetrant testing	EN ISO 3452-1

8.4 Testing personnel

Non-destructive examination shall be carried out by persons who are competent and appropriately qualified for the duties they are to perform.

Non-destructive examination personnel shall be qualified to at least level 2 of EN ISO 9712:2012.

All companies providing such personnel should be certificated according to an appropriate standard e.g. EN ISO/IEC 17020 [1].

8.5 Acceptance criteria

Acceptance criteria shall be in accordance with EN ISO 5817.

8.6 Repairing welds

Before proceeding with the repair of a weld, consideration shall be given to whether the repair can reasonably be expected to improve the quality of the weld. If not, the weld shall be rejected. Rejected parts of welds shall be cut out and the pipe shall be re-welded before being re-examined.

Parts of welds containing unacceptable defects shall be removed by grinding or cutting down to sound metal before proceeding with repair. Slag and oxide deposits shall be removed. Repairs shall be carried out in accordance with an approved procedure. No further repairs are permitted on repaired parts of a weld.

All weld repairs shall be examined and be subjected to 100 % non-destructive examination as per 8.3.

8.7 Brazed copper joints

Non-destructive examination of brazed joints shall be in accordance with EN 12799.

9 Inspection and documentation

9.1 General

Before testing and commissioning, the installation and associated documentation shall be inspected to ensure that it meets the design specification and will be safe to operate within the design parameters. The technical file and operating manual shall be available to those involved in the inspection.

The following points shall be considered during the inspection:

— the complete installation shall be checked to confirm it is correctly assembled using the specified materials/components and that there is no mechanical damage;

— control and safety devices (e.g. regulators, hydrostatic relief valves) shall be checked to confirm location, orientation and correct set pressures. Any equipment that meets the operating pressure requirements but is not suitable for the proof test pressure shall be replaced with a spool piece or shall be blanked off;

— non-return valves are installed in the correct orientation;

— welded joints have been tested and/or inspected as required by the relevant design and welding standards, see Clause 8;

— fittings, flanges, gaskets and bolts shall be examined to ensure that they are of the correct specification and that they are correctly assembled and aligned;

— threaded connections shall be examined to ensure that they are correctly assembled, sealant is appropriately used and that there are no excessive exposed threads (i.e. the threads are correctly engaged and not mismatched);

— compression joints shall be examined to ensure that there is no undue distortion of the tube and that the nuts have not been over tightened;

— capillary joints shall be visually examined to confirm that the spelter or solder has run correctly between the tube and fitting;

— joints on non-metallic pipework shall be examined to ensure that they are correctly made and that there is appropriate above-ground pipe protection;

— there shall be no undue strain on any joint, pipe or support;

— pipe supports shall be checked to confirm the support distances are not exceeded;

— verification of corrosion protecting measures;

— specific requirements for the inspection of composite pipe required by the manufacturer, see E.3.2; and

— the pipework is safe for subsequent purging and commissioning.

The results of the inspection shall be recorded in writing.

9.2 Inspection and testing of corrosion protection

9.2.1 Coatings on underground pipework

Carbon steel pipe joints, bends and fittings that require the application of a coating on site, and any visible coating damage that has been repaired, shall be checked for defects e.g. with a spark tester (holiday detection).

If any air is found trapped under the coating, the defective coating shall be removed, and re-applied.

9.2.2 Above-ground pipework protection

Any protection shall be checked for defects and any damage shall be repaired.

9.2.3 Recording of test results

The result of the inspection of each component shall be recorded in the technical file and shall be clearly traceable in the examination and radiographic reports.

10 Testing

10.1 General

The completed tests for each section and a leak test on the full installation shall be recorded.

10.2 Test media

The test water shall be tested to establish its initial quality and to ensure that the water is of the required quality for both flushing and hydraulic test use. Depending on the water source, filtering of the water to remove contaminants, such as debris, shall be undertaken.

The environmental impact of any chemical treatment or addition of anti-freeze shall be assessed and confirmed to be acceptable. The impact of chemical treatment on the bulk modulus of test water (e.g. volume change affecting pressure), particularly use of anti-freeze, should also be established.

If test water is transferred from one test section to another, the quality of the water shall be checked and additional chemicals shall be added, as required, to bring it back up to specification.

Pneumatic testing shall be performed with dry and oil free air or inert gas.

10.3 Strength testing

10.3.1 General

A hydraulic test shall be applied as a strength test.

Where a hydraulic test is not always practical, a pneumatic test should be used, provided that appropriate safety precautions have been taken.

NOTE A strength test is not always necessary where pipework contains components that have already been tested and certified by the manufacturer as being strength tested to at least 1,43 times the maximum allowable pressure.

10.3.2 Test Procedure

The procedure shall consider the following:

— type of test;

— pressurising medium to be used;

— maximum safe working pressure of the installation being tested. This may vary in different parts of the system;

— extent of the installation to be tested;

— test pressure(s);

— rate of pressure rise and release;

— duration of test(s). For leak tests the period of temperature stabilization shall be established;

NOTE Temperature changes can be induced by air compressors (increasing temperature) or by compressed gas cylinders (reducing temperature by expansion).

— test equipment and point(s) to apply the pressure;

— how to retest any connections that may need to be undone to allow the pressure to be applied;

— means of positive isolation, and where necessary, protection of appliances or parts of the installation not being included in the tests;

— identification of items, which may isolate sections, e.g. non-return/back check valves, pressure regulators etc., and invalidate the test;

— any additional securing of pipework for the duration of the test;

— precautions including the provision of warning signs and, if necessary, barriers to keep unauthorised persons from the test area;

— precautions shall be taken when carrying out pneumatic testing due to the potential energy stored in the system, which could be released in the event of a catastrophic failure of the equipment. A safety exclusion zone of at least 5 m from any part of the system under test is therefore required. The test pressure and monitoring of the test pressure should be done from a point outside of this exclusion zone.

10.3.3 Test pressure and duration

The test pressure shall be at least 1,43 times the maximum allowable pressure.

The test duration shall be such as to reliably expose any defects in the construction that might lead to a failure of the pressurized pipework.

The test pressure shall be initially raised to 1 bar to check for gross leakage and then the pressure shall be raised at a rate not exceeding 5 bar per minute. The release of the test medium shall be at the same rate.

The minimum temperature stabilization and test period for hydraulic testing of pipework shall be 30 min.

On completion of hydraulic testing, the water shall be immediately drained.

NOTE LPG is not a potential contaminant of water.

When LPG equipment is subjected to a hydraulic test or other pressure tests, the water shall be disposed of in an environmentally friendly manner.

10.3.4 Acceptance criteria

The test pressure shall be read at the beginning and at the end of the test.

Loss of test pressure during the test shall not exceed 5 % of the test pressure.

The joints shall be inspected for leaks at the beginning, during and at the end of the test period.

No additional pressure shall be introduced during the test period.

There shall be no leak on any part of the pipework system during the test period.

For pneumatic tests inspection shall not take place until the pressure in the pipe has been stable for at least 5 min.

10.3.5 Repairs and retest

If leaks are identified, the system shall be de-pressurized before any repairs are undertaken. Pipework shall be retested after repairs are completed.

10.4 Leak testing

10.4.1 General

All installations shall be leak tested before being commissioned.

All pipework shall be leak tested initially with air or inert gas, using either a pressure decay method or leak detector fluid to EN 14291.

After a satisfactory air or inert gas leak test, the pipework shall be purged and LPG vapour introduced. The leak test shall then be repeated.

10.4.2 Gauge Selection

The pressure gauge for leak testing shall comply with EN 837.

The gauge pressure range, resolution and accuracy shall be suitable to detect pressure loss resulting from leakage in the leak testing period.

10.4.3 Test pressure and duration

The test pressure of the pipework shall be above the nominal operating pressure and a minimum of 5 bar.

The test pressure shall be raised to an initial 1 bar to check for gross leakage and then the pressure shall be raised at a rate not exceeding 5 bar per minute. The release of test medium shall be at the same rate.

The minimum temperature stabilization period shall be 15 min.

The minimum leak test period shall be 2 min. The test period shall be sufficient to show any leakage for the method of test chosen.

10.4.4 Test media

Pneumatic testing shall be performed with dry and oil free air or inert gas.

The LPG vapour shall be at the saturation pressure (vessel pressure).

Liquid LPG shall not be used for leak testing.

The pressure source should be disconnected during the test. Where this is not possible for the LPG vapour leak test when the pressure source is the LPG vessel, the valve upstream of the pipework under test shall be leak tested after the vapour test has been completed.

10.4.5 Acceptance criteria

The test pressure shall be read at the beginning and at the end of the test.

The joints shall be inspected for leaks at the beginning, during and at the end of the test period.

No additional pressure shall be introduced during the test period.

The pass criteria shall be in accordance with national requirements applicable for the country.

10.4.6 Repairs and retest

If leaks are identified, the system shall be de-pressurized before any repairs. Re-testing of the pipework shall be carried out after repairs have been completed.

11 Commissioning

If the LPG is not introduced into the pipework after testing, the pipework shall be purged with an inert gas, pressurized at 1 bar and the pipework labelled accordingly.

Purging shall only be undertaken by competent persons, following comprehensive written procedures.

After purging the pipework all testing and equipment documentation, with certificates, shall be submitted to the pipework owner.

12 Maintenance

All pipework shall have a written scheme covering periodic inspection and maintenance.

The electrical continuity shall be confirmed at regular intervals.

NOTE Annex C gives an example of an inspection scheme for an LPG installation.

Annex A
(informative)

Pipe sizing – liquid phase

A.1 General

The Darcy – Weisbach formula is utilized in the calculations of liquid LPG. The following stages shall be adopted for the correct calculation of pipe sizing for liquid pipework:

— calculation of the velocity of flow in pipework;

— calculation of the Reynolds number; and

— calculation of flow capacity and pressure drop, see Table A.3 for a worked example.

For composite pipes, the flow shall be determined from the manufacturers supplied flow charts.

A.2 Viscosity of LPG

Refer to Table A.1 for viscosity values necessary for calculations.

Table A.1 — Viscosity values

Temperature (°C)	**Type of product**	**Viscosity** (centipoise)
−20	propane	0,15
	butane	0,22
+50	propane	0,085
	butane	0,14

For liquid calculations, a viscosity of 0,10 centipoise can be used.

A.3 Calculation of liquid velocity flow in pipework

A.3.1 Because of the low viscosity, LPG has a tendency to build-up electrostatic charges in the pipework, especially in non-metallic pipework.

To ensure that electrostatic charges do not accumulate, the velocities should be limited below the critical velocity as specified in A.3.2.

A.3.2 Where the velocity of the liquid in the pipe exceeds 5 m/s, further calculations shall be carried out to see if special precautions against static generation are necessary.

A.3.3. The mean velocity of flowing liquid can be calculated from the following formula:

$$v = 1\,273{,}2 \times 10^3 \frac{q}{d^2} = 21{,}22 \frac{Q}{d^2} = 353{,}7 \frac{W}{d^2 \rho}$$

where:

$v =$ Mean velocity of flow, (m/s)

$q =$ Rate of flow, (m^3/s at flowing conditions)

$d =$ Internal diameter of pipe, (mm)

$Q =$ Rate of flow, (l/min)

$W =$ Rate of flow, (kg/h)

$\rho =$ Weight density of fluid, (kg/m^3)

A.4 Calculation of Reynolds number

The Reynolds number may be calculated from the following formula to determine laminar or turbulent flow conditions.

$$\mathrm{Re} = 1\,273 \times 10^3 \frac{q\rho}{du} = 21{,}22 \frac{Q\rho}{du} = 354 \frac{W}{du}$$

where:

$\mathrm{Re} =$ Reynolds number

$q =$ Rate of flow, (m^3/s at flowing conditions)

$d =$ Internal diameter of pipe, (mm)

$Q =$ Rate of flow, (l/min)

$W =$ Rate of flow, (kg/h)

$\rho =$ Weight density of fluid, (kg/m^3)

$u =$ Dynamic (absolute) viscosity, (centipoise)

A.5 Liquid flow capacity and pressure drop in pipework

A.5.1 General

Due to the low viscosity of LPG, flow conditions in LPG pipework are generally turbulent. Therefore, the following formulas can be used to determine the pressure drop and pipe size at flow conditions.

Where the Reynolds number, from the calculation above is less than 2 000, use the laminar flow calculation.

Where the Reynolds number, from the calculation above is greater than 2 000, use the turbulent calculation.

A.5.2 Laminar flow calculation

$$\Delta p_{100} = 679 \frac{uQ}{d^4}$$

A.5.3 Turbulent flow calculation

$$\Delta p_{100} = 225 \frac{f \rho Q^2}{d^5} = 62\,530 \frac{f W^2}{d^5 \rho}$$

Where:

Δp_{100} = Pressure drop (bar) for 100 m of pipe

u = Dynamic (absolute) viscosity (centipoise)

d = Internal diameter of pipe, (mm)

Q = Rate of flow, (l/min)

W = Rate of flow, (kg/h)

ρ = Weight density of fluid, (kg/m^3)

f = Friction factor (see Table A.2)

A.6 Liquid flow capacity and pressure drop through valves and fittings

The liquid flow calculations for pipework in A.5 do not allow for pressure losses due to valves, fittings, vertical risers and the pressure head required at the end of the pipework, e.g. dispenser, filling machine.

For the purposes of simplification, 10 % to 20 % shall be added onto the result from the calculation for the pressure drop of valves and fittings. In addition, the physical vertical rise in elevation and final pressure head required at the discharge point shall be taken into account.

Table A.2 — Pipe friction factors

Pipe size (DN)	Factor (f)
13	0,028
19	0,026
25	0,023
32	0,0215
40	0,02
50	0,019
65	0,018
80	0,017
100	0,0165
125	0,0155
150	0,015
200	0,014

Table A.3 — Pipe sizing table (allowance of 0,3 bar pressure drop and to a maximum velocity of 5 m/s)

Liquid LPG flow (l/min)	Steel pipe											
	6 (DN)	8 (DN)	10 (DN)	15 (DN)	20 (DN)	25 (DN)	32 (DN)	40 (DN)	50 (DN)	65 (DN)	80 (DN)	100 (DN)
	1/8"	1/4"	3/8"	1/2"	3/4"	1"	1–1/4"	1–1/2"	2"	2–1/2"	3"	4"
	K – friction factor for steel pipe											
	0,0319	0,0302	0,0285	0,0270	0,0250	0,0230	0,0220	0,0210	0,0190	0,0180	0,0180	0,0170
	Internal diameter (mm)											
	6,83	9,24	12,52	15,79	20,93	26,64	35,05	40,57	52,50	62,71	77,93	102,26
	Maximum pipe length (m)											
1	107	487										
2	27	122										
3	12	54										
4	7	30										
5	4	19	89									
6	3	14	62									
7	2	10	45									
8	2	8	35									
9	1	6	27	88								
10	1	5	22	71								
11	1	4	18	59								
12		3	15	49								
13		3	13	42								
14		2	11	36								
15		2	10	32								
16		2	9	28								
17		2	8	25	101							
18		2	7	22	90							
19		1	6	20	80							
20		1	6	18	73							
25			4	11	46							
30			2	8	32	108						
35			2	6	24	79						
40				4	18	61						
45				4	14	48						

Liquid LPG flow (l/min)	**Steel pipe**											
	6 (DN)	**8 (DN)**	**10 (DN)**	**15 (DN)**	**20 (DN)**	**25 (DN)**	**32 (DN)**	**40 (DN)**	**50 (DN)**	**65 (DN)**	**80 (DN)**	**100 (DN)**
	1/8”	**1/4”**	**3/8”**	**1/2”**	**3/4”**	**1”**	**1–1/4”**	**1–1/2”**	**2”**	**2–1/2”**	**3”**	**4”**
	K – friction factor for steel pipe											
	0,0319	**0,0302**	**0,0285**	**0,0270**	**0,0250**	**0,0230**	**0,0220**	**0,0210**	**0,0190**	**0,0180**	**0,0180**	**0,0170**
	Internal diameter (mm)											
	6,83	**9,24**	**12,52**	**15,79**	**20,93**	**26,64**	**35,05**	**40,57**	**52,50**	**62,71**	**77,93**	**102,26**
	Maximum pipe length (m)											
50				3	12	39						
55				2	10	32						
60					8	27	106					
65					7	23	91					
70					6	20	78					
75					5	17	68					
80					5	15	60					
85					4	13	53					
90					4	12	47	98				
95					3	11	42	98				
100					3	10	38	79				
150						4	17	35				
200						2	10	20				
250						2	6	13				
300							4	9	32			
350							3	6	34			
400							2	5	18			
450							2	4	14			
500							2	3	12	28		
550							1	3	10	23		
600								2	8	19		
650								2	7	17		
700								2	6	14		
750								1	5	12		
800								1	5	11		
850									4	10		
900									4	9		

Liquid LPG flow (l/min)	**Steel pipe**											
	6 (DN)	**8 (DN)**	**10 (DN)**	**15 (DN)**	**20 (DN)**	**25 (DN)**	**32 (DN)**	**40 (DN)**	**50 (DN)**	**65 (DN)**	**80 (DN)**	**100 (DN)**
	1/8”	**1/4”**	**3/8”**	**1/2”**	**3/4”**	**1”**	**1–1/4”**	**1–1/2”**	**2”**	**2–1/2”**	**3”**	**4”**
	K – friction factor for steel pipe											
	0,0319	**0,0302**	**0,0285**	**0,0270**	**0,0250**	**0,0230**	**0,0220**	**0,0210**	**0,0190**	**0,0180**	**0,0180**	**0,0170**
	Internal diameter (mm)											
	6,83	**9,24**	**12,52**	**15,79**	**20,93**	**26,64**	**35,05**	**40,57**	**52,50**	**62,71**	**77,93**	**102,26**
	Maximum pipe length (m)											
950									3	8		
1 000									3	7	21	
1 050									3	6	19	
1 100									2	6	17	
1 150									2	5	16	
1 200									2	5	14	
1 250									2	4	13	
1 300									2	4	12	
1 350									2	4	11	44
1 400									1	4	11	41
1 450									1	3	10	38
1 500										3	9	36
1 550										3	9	34
1 600										3	8	32
1 650										3	8	30
1 700										2	7	28
1 750										2	7	26
1 800										2	6	25
1 850										2	6	24
1 900										2	6	22
1 950										2	5	21
2 000										2	5	20

Annex B
(informative)

Pipe sizing – gas phase

B.1 General

The Darcy – Weisbach formula is utilized in the calculations of vapour LPG.

For composite pipes, the flow shall be determined from the manufacturers supplied flow charts.

B.2 Calculation of full vapour flow and pressure drop in pipes

The pressure drop of flowing vapour can be calculated from one of the following formulas.

$$\Delta p_{100} = 62\,530 \times \frac{fW^2 \bar{V}}{d^5} = 62\,530 \frac{fW^2}{d^5 p}$$

or

$$\Delta p_{100} = 93\,650 \frac{f\left(q'h\right)^2 S_g{}^2}{d^5 p}$$

where:

Δp_{100} = Pressure drop in bar for 100 m of pipe

d = Internal diameter of pipe, (mm)

$q'h$ = Rate of flow, (m^3/h)

W = Rate of flow, (kg/h)

$\bar{V}$ = Specific volume of fluid, (m^3/kg)

f = Friction factor (see Table A.2)

S_g = Relative density of a gas relative to air

p = Pressure, (bar gauge)

B.3 Vapour flow capacity and pressure drop through valves and fittings

The vapour flow calculations for pipework in B.2 do not allow for pressure losses due to valves, fittings, vertical risers and the pressure head required at the end of the pipe.

For the purposes of simplification, 10 % to 20 % shall be added onto the result from the calculation for the pressure drop of valves and fittings.

B.4 Gas velocity

Where the velocity of the gas in the pipe exceeds 10 m/s flow-induced pulsation calculations are necessary to investigate whether further precautions need to be taken to prevent excess noise or erosion.

Annex C
(informative)

Pipework Integrity Management Systems (PIMS)

C.1 Pipework Integrity Management

A comprehensive integrated Pipework Integrity Management System (PIMS) is a set of tools for an inspection and maintenance programme. It is a management system encompassing engineering, operation, inspection, maintenance, safety and corporate communication.

PIMS requires that operating procedures to be planned, effectively monitored and integrated into the workflow.

C.2 Basic PIMS for LPG plants

The purpose of PIMS is to establish an integrated process for the maintenance and inspection of piping systems on LPG plants. These are the minimum requirements and are subject to variation to accord with national requirements. PIMS covers the following areas:

— format and content of inspection;

— frequency of inspection and maintenance; and

— repair plans

The inspection plan is established for pipework as part of the requirements of PIMS, covering all component parts of the pipework.

The inspection plan focuses upon the following key steps:

— assessment of condition;

— response (remedial action/ future monitoring or inspection).

C.3 Assessment of condition

The written scheme should detail the frequency of visual inspections of the various parts of the pipework. The process piping should be visually inspected noting any external corrosion and damage. All defects should be noted and assessed.

An example of a visual inspection protocol is given in Table C.1.

The visual inspection may result in a requirement for further examination e.g. ultrasonic testing.

C.4 Response (remedial action/ future monitoring or inspection)

All damage found should be reported for remedial action.

Any damaged sections should be replaced, repaired or repainted. Replacement of process piping requires a hydraulic test to be performed on the replaced section.

C.5 Frequency of inspection and maintenance

Inspection scope and frequency should be based upon a risk assessment which should consider and evaluate the risks associated with the loss of pipework integrity in terms of the following consequences:

— safety;

— environment.

Inspection and maintenance frequencies for the pipework can be established by referring to the risk assessment.

Table C.1 — Example of visual inspection protocol

Visual inspection of process piping	**Inspected by:**		**Date:**	
Pipe section – Rail Tanker Car off loading bays to storage tanks.		**Product: Propane**		
Section of pipe between valves	**Corrosion**	**Dent**	**Gouge**	**Weld crack**
Comments				
Actions				
Additional comments:				

Annex D
(informative)

Environmental checklist

Environmental Aspect	Stages of the life cycle										All stages
	Acquisition		Production		Use			End-of-Life			
	Raw materials and energy	Pre-manufactured materials and components	Production	Packaging	Use	Maintenance and repair	Use of additional products	Reuse / Material and Energy Recovery	Incineration without energy recovery	Deposition	Transportation
Inputs											
Materials	4.2 5	4.2 5	4.2 5	4.2		4.2 12	4.2 6.5	4.2 5.3			
Water			10			12					
Energy	5	5	5		4.4 8	10 12					
Land					6.5 6.6						
Outputs											
Emissions to air			4.2		10	12 C.5					
Discharges to water			4.2			10 12					
Discharges to soil											
Waste			4.2	4.2		12					
Noise, vibration, radiation, heat losses					6.5						
Other relevant aspects											
Risk to the environment from accidents or unintended use					6.5 6.6						
Customer information					11	11					
Comments:											

Annex E
(informative)

Manufacturing and type testing of composite pipes

E.1 General

This annex applies to pipes made of thermoplastics, which may include some degree of reinforcement, and to flexible metal pipework. It does not apply to fibre reinforced thermosets, commonly referred to as glass fibre reinforced plastic (GRP), nor rigid metals or corrugated metal hoses to EN ISO 10380.

E.2 Materials

E.2.1 Environmental

The manufacturer should acquire materials and components from suppliers who have a declared environmental policy, see EN ISO 14021 [10], EN ISO 14024 [11] and EN ISO 14025 [12].

E.2.2 General

E.2.2.1 All materials in contact with LPG shall be physically and chemically compatible with LPG under all operating conditions for which the pipework is designed.

E.2.2.2 Materials for pipework shall be selected to give adequate strength in service.

Materials and components shall comply with one or more of the following standards; EN 1555-1 [2], EN 1555–2 [3], EN 1555-3 [4], EN 1555-4 [5], EN 1555-5 [6], EN 13463-1 [7], ISO 11922-1 [8] and EN 10088-1 [13].

Materials and components can be reused where they comply with the following requirements:

— are suitable for the proposed service in light of the history of the material or component, and;

— are inspected since the previous use to reveal any defect that could impair safety, strength or pressure tightness.

E.2.3 Fittings

All pipes shall include fittings to provide leak-tight attachment to other systems, terminations, branches and changes of direction.

E.2.4 Dimensional tolerances

The external diameter and wall thickness shall be stated by the manufacturer. For thermoplastic pipes the tolerance on the external diameter and out-of-roundness shall be in accordance with ISO 11922-1 [8], Grade B.

E.3 Physical properties

E.3.1 Pressure

E.3.1.1 General

Operating and test pressures shall be in accordance with 4.3.

E.3.1.2 Estimated working life

Only composite pipes which can demonstrate that they have an estimated working life of at least 25 years shall be used.

E.3.2 Temperature

Pipes and fittings used in accordance with this European Standard shall comply with the requirements of 4.3.

E.4 Manuals

E.4.1 Product manual

Manufacturers of plastic pipe systems shall make available a manual covering:

— correct applications for pipes and fittings;

— estimated working life;

— static electricity.

E.4.2 Installation manual

Manufacturers shall make available a written manual covering:

— transport, storage and handling;

— static electricity. The manufacturers shall give guidance to any necessary precautions that their pipe may need to prevent accumulation of static electricity. The precautions shall consider the requirements in accordance with EN 13463-1 [7];

— protection against weathering;

— bend radius;

— tools and equipment;

— maintenance;

— safety;

— check list of actions to achieve correct installation;

— installation testing;

— proper back filling.

Consideration should be given to providing the manual in the user's language.

E.5 Records

The manufacturer shall maintain a technical file containing details of the materials use, the necessary data on their long-term performance, plus any calculations and supporting data necessary to relate this to the design of the pipe, e.g. wall thickness.

Unless otherwise specified, all records shall be maintained for a minimum of 10 years.

Bibliography

[1] EN ISO/IEC 17020, *Conformity assessment - Requirements for the operation of various types of bodies performing inspection (ISO/IEC 17020)*

[2] EN 1555-1, *Plastics piping systems for the supply of gaseous fuels - Polyethylene (PE) - Part 1: General*

[3] EN 1555-2, *Plastics piping systems for the supply of gaseous fuels - Polyethylene (PE) - Part 2: Pipes*

[4] EN 1555-3, *Plastic piping systems for supply of gaseous fuels – Polyethylene (PE) – Part 3: Fittings*

[5] EN 1555-4, *Plastics piping systems for the supply of gaseous fuels - Polyethylene (PE) - Part 4: Valves*

[6] EN 1555-5, *Plastics piping systems for the supply of gaseous fuels - Polyethylene (PE) - Part 5: Fitness for purpose of the system*

[7] EN 13463-1, *Non-electrical equipment for use in potentially explosive atmospheres - Part 1: Basic method and requirements*

[8] ISO 11922-1, *Thermoplastics pipes for the conveyance of fluids — Dimensions and tolerances — Part 1: Metric series*

[9] ISO 14001, *Environmental management systems - Requirements with guidance for use*

[10] EN ISO 14021, *Environmental labels and declarations - Self-declared environmental claims (Type II environmental labelling) (ISO 14021:1999)*

[11] EN ISO 14024, *Environmental labels and declarations - Type I environmental labelling - Principles and procedures (ISO 14024:1999)*

[12] EN ISO 14025, *Environmental labels and declarations - Type III environmental declarations - Principles and procedures (ISO 14025:2006)*

[13] EN 10088-1, *Stainless steels - Part 1: List of stainless steels*

[14] Sommer B., Baeckmann W.:**Stahlrohr Handbuch**, 12. Edition, 1995, Vulkan-Verlag Essen (ISBN 3-8027-2693-6)

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