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Guidance for the design, commissioning and maintenance of LPG systems in small craft

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Summary of pages

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Foreword

Publishing information

This Published Document is published by BSI Standards Limited, under licence from The British Standards Institution, and came into effect on 31 March 2016. It was prepared by Technical Committee GME/33, *Small craft*. A list of organizations represented on this committee can be obtained on request to its secretary.

Supersession

This Published Document supersedes PD 5482-3:2005, which is withdrawn.

Relationship with other publications

This document is a supplement to BS EN ISO 10239:2014, unlike its predecessor, PD 5482-3:2005, which was a stand-alone document. As such, reference might need to be made to BS EN ISO 10239:2014 for more information in certain circumstances, including the fitting of additional appliances or major system modification. However, for design, commissioning and maintenance, this document gives sufficient guidance. If any conflict arises between the two documents, then BS EN ISO 10239:2014 takes precedence.

Information about this document

This is a full revision of the Published Document, and introduces the following principal changes:

- the identifier has been changed to PD 54823, as the Published Document has been revised in such a way that it no longer belongs in the 5482 series;
- the text has been revised to supplement BS EN ISO 10239:2014, concerning the design, commissioning and maintenance of small craft LPG installations;
- gas tightness testing of LPG supply line and appliances has been improved; and
- an annex covering cooking appliances with integral LPG cartridges has been added.

Hazard warnings

WARNING. This Published Document calls for the use of substances and/or procedures that can be injurious to health if adequate precautions are not taken. It refers only to technical suitability and does not absolve the user from legal obligations relating to health and safety at any stage.

Use of this document

As a guide, this Published Document takes the form of guidance and recommendations. It should not be quoted as if it were a specification or a code of practice and claims of compliance cannot be made to it.

Presentational conventions

The provisions of this Published Document are presented in roman (i.e. upright) type. Its recommendations are expressed in sentences in which the principal auxiliary verb is "should".

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Contractual and legal considerations

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

Compliance with a Published Document cannot confer immunity from legal obligations.

Particular attention is drawn to the Gas Safety (Installation and Use) Regulations [1], [2], [3], [4].

NOTE Guidance on the individual competency for gas work and other guidance regarding legislation is given in the Health and Safety Executive's Approved Code of Practice L56 (ACOP) [5].

1 Scope

This Published Document gives guidance for the design, commissioning and maintenance of LPG (liquefied petroleum gas) systems, including replacement appliances, replacement hose and replacement piping. It covers permanently installed gas burning installations in small craft ¹⁾ of up to 24 m in length, using LPG operating at a nominal pressure of up to 50 mbar ²⁾. The LPG is from either cylinders stowed on board or the on-board aspects of the gas system in the situation of a fixed shore bulk supply.

This Published Document also covers cooking appliances with integral LPG cartridges, for which guidance is given in Annex A.

This Published Document does not cover:

- new system installation requirements as covered in BS EN ISO 10239:2014;
- major system modification for which BS EN ISO 10239:2014 is to be used for installation requirements;
- additional appliances (including additional piping and additional hose) added to an existing system for which BS EN ISO 10239:2014 is to be used for installation requirements;
- on-shore installation of bulk supplies of LPG;
- catering equipment;
- portable LPG-burning appliances not covered in Annex A;
- the installation of LPG generators; or
- the use of LPG for propulsion of vessels for which guidance is given in UKLPG Code of Practice 18 [6] or BS EN 15609.

NOTE Further information on gas supply systems to permanently moored craft can be found in IGEM/G/6 [7].

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.

BS 669 (both parts), *Flexible hoses, end fittings and sockets for gas burning appliances*

BS 1552, *Specification for open bottomed taper plug valves for 1st, 2nd and 3rd family gases up to 200 mbar*

BS 6172, *Specification for installation, servicing and maintenance of domestic gas cooking appliances (2nd and 3rd family gases)*

BS 6362 (ISO 7598), *Specification for stainless steel tubes suitable for screwing in accordance with BS 21 "Pipe threads for tubes and fittings where pressure-tight joints are made on the threads"*

BS 6956 (all parts), *Jointing materials and compounds*

BS 7838, *Specification for corrugated stainless steel semi-rigid pipe and associated fittings for low-pressure gas pipework of up to DN 50*

¹⁾ Attention is drawn to the various Merchant Shipping Acts that apply to British registered ships.

²⁾ 1 mbar = 102 N/m² = 0.1 kPa = 100 Pa.

BS EN 331, *Manually operated ball valves and closed bottom taper plug valves for gas installations in buildings*

BS EN 449, *Specification for dedicated liquefied petroleum gas appliances – Domestic flueless space heaters (including diffusive catalytic combustion heaters)*

BS EN 549, *Specification for rubber materials for seals and diaphragms for gas appliances and gas equipment*

BS 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*

BS 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*

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

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

BS EN 13878, *Leisure accommodation vehicles – Terms and definitions*

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

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

BS EN 15266, *Stainless steel pliable corrugated tubing kits in buildings for gas with an operating pressure up to 0,5 bar*

BS EN 16129:2013, *Pressure regulators, automatic change-over devices, having a maximum regulated pressure of 4 bar, with a maximum capacity of 150 kg/h, associated safety devices and adaptors for butane, propane, and their mixtures*

BS EN 28846, *Small craft – Electrical devices – Protection against ignition of surrounding flammable gases*

BS EN ISO 8434-1:2007, *Metallic tube connections for fluid power and general use – Part 1: 24 degree cone connectors*

BS EN ISO 9094 (all parts), *Small craft – Fire protection*

BS EN ISO 10239:2014, *Small craft – Liquefied petroleum gas (LPG) systems*

BS EN ISO 17672, *Brazing – Filler metals*

ISO 7-1, *Pipe threads where pressure-tight joints are made on the threads – Part 1: Dimensions, tolerances and designation*

3 Terms and definitions

For the purposes of this Published Document, the terms and definitions given in BS EN 13878 and the following apply.

3.1 accessible

capable of being reached for inspection, removal or maintenance, without removal of a permanent vessel structure

NOTE Hatches are not deemed to be permanent vessel structures, even if tools are required to open them.

3.2 additional appliance

appliance that would be an extra appliance to a system

3.3 additional hose

hose required for the fitting of a new appliance

3.4 additional piping

piping required for the fitting of a new appliance

3.5 bourdon gauge

dial-type pressure gauge

NOTE Examples of bourdon gauges are those conforming to BS EN 837-1.

3.6 combustion products discharge safety device

device that causes at least safety shutdown of the main burner when there is an unacceptable spillage of combustion products from the draught diverter of type B_{11BS} water heaters

3.7 conventionally flued instantaneous water heater

water heater of the B_{11BS} type

NOTE A type B_{11BS} is a type B₁₁ appliance fitted with a combustion products discharge safety device. A type B₁₁ is a natural draught type B₁ appliance. A type B₁ is a type B appliance incorporating a draught diverter. A type B is an appliance intended to be connected to a flue that evacuates the products of combustion to the outside of the room containing the appliance. The combustion air is drawn directly from the room in which the appliance is installed.

3.8 cylinder

portable and refillable vessel of approved design, used to contain LPG under pressure

3.9 cylinder housing

ventilated enclosure intended solely for storage of one or more LPG cylinders, pressure regulation device and safety devices, and located so that leakage flows to the outside

[SOURCE: BS EN ISO 10239:2014, 3.3]

3.10 cylinder locker

enclosure which is vapour tight to the interior of the craft with a drain to the outside intended solely for storage of one or more LPG cylinders

NOTE The cylinder locker need only be vapour tight to the highest point of the cylinder valve, pressure regulation device or high pressure side components.

3.11 existing system

LPG system installed prior to the implementation of this document

NOTE Annex A of the previous edition of this standard (PD 5482-3:2005) defined an existing system as one which was installed prior to 15 May 1999. This definition also applies.

3.12 flame supervision device

device that has a sensing element, that causes the inlet of the LPG supply to a burner to be opened in the presence of a flame and closed in the absence of a flame

3.13 high pressure side

part of an installation between the cylinder valve and the inlet of a pressure regulation device in an LPG system

NOTE 1 Vapour pressure at 20 °C for propane = 700 kPa and for butane = 175 kPa.

NOTE 2 1 kPa = 10 mBar.

NOTE 3 This was formerly known as the high pressure stage.

- 3.14 hose**
pipeline of flexible material
[SOURCE: BS EN ISO 10239:2014, 3.13]
- 3.15 interior space**
enclosed space that is surrounded by permanent boat structure and that is intended to remain dry during normal use
[SOURCE: BS EN ISO 10239:2014, 3.6]
- 3.16 let-by**
internal gas leakage past a shut-off valve seat when fully closed
- 3.17 liquefied petroleum gas (LPG)**
mixture of light hydrocarbons, gaseous under conditions of normal temperature and pressure, and maintained in the liquid state by increase of pressure or lowering of temperature
NOTE 1 The principal components are propane, propene, butanes or butenes.
NOTE 2 LPG can be obtained as commercial butane, commercial propane or a mixture of the two.
[SOURCE: BS EN ISO 10239:2014, 3.1]
- 3.18 LPG system**
system consisting of an arrangement of cylinder(s), safety device(s), pressure regulation device(s), connection(s), valve(s), piping, tubing, hose, fitting(s) and devices intended to store, supply, monitor or control the flow of LPG up to and including the appliance
NOTE The cylinders are replacement items and might or might not be supplied with the LPG system in the craft.
- 3.19 low pressure side**
part of an installation exposed to the regulated pressure of the LPG pressure regulation device in an LPG system
NOTE This was formerly known as the low pressure stage.
- 3.20 main shut-off valve**
device to isolate the entire LPG system from the high pressure side of the supply
[SOURCE: BS EN ISO 10239:2014, 3.15]
- 3.21 major system modification**
changes to a system such that the majority of the piping is replaced
- 3.22 operating pressure**
inlet pressure of the LPG appliances
[SOURCE: BS EN ISO 10239:2014, 3.17]
- 3.23 permanently installed**
securely fastened so that tools need to be used for removal
[SOURCE: BS EN ISO 10239:2014, 3.2]
- 3.24 piping**
pipeline of rigid metallic material
[SOURCE: BS EN ISO 10239:2014, 3.12]

- 3.25 pressure regulation device**
device to reduce the high pressure of the LPG system to the required operating pressure of the appliances
NOTE This was formerly known as the low pressure regulator.
- 3.26 readily accessible**
capable of being reached quickly and safely for maintenance or effective use under emergency conditions without the use of tools
[SOURCE: BS EN ISO 10239:2014, 3.7]
- 3.27 replacement appliance**
appliance that is not an extra appliance to a system
- 3.28 replacement piping**
piping fitted due to maintenance of a system
- 3.29 room-sealed appliance**
appliance with a system in which incoming combustion air and outgoing combustion products pass through sealed ductwork connected to an enclosed combustion chamber and terminating outside the vessel
- 3.30 shut-off valve**
device to isolate an appliance from the gas supply
NOTE This was formerly known as the appliance isolation valve.
- 3.31 supply control valve**
isolating valve immediately upstream of the test section during the tightness test
NOTE This can be the cylinder or tank outlet valve or an intermediate valve depending on the section of pipework to be tested.
- 3.32 ventilator**
device that allows air to pass into and out of an interior space
[SOURCE: BS EN ISO 10239:2014, 3.18]

4 General

An LPG system and all its components should be capable of withstanding storage at $-20\text{ }^{\circ}\text{C}$ to $+60\text{ }^{\circ}\text{C}$.

LPG systems should be of the vapour withdrawal type, i.e. LPG released only under gas phase conditions.

Nominal system pressures in the 28 mbar to 50 mbar range can be found. The pressure regulation system should be designed to provide a fixed nominal pressure suitable for the consuming appliances.

When designing a cylinder installation, the cylinder(s) selected and other supply equipment (e.g. the pressure regulation device) should be of sufficient capacity to ensure safe and satisfactory operation of all appliances simultaneously.

NOTE 1 The gas consumption details for each installed appliance can be found on the appliance data badge.

Table 1 provides guidance on the conversion from heat input to gas rates.

Table 1 Conversion of heat inputs (kW) to gas rate (kg/h)

kW	0	1	2	3	4	5	6	7	8	9
0	0.00	0.07	0.15	0.22	0.29	0.37	0.44	0.51	0.58	0.66
10	0.73	0.80	0.88	0.95	1.02	1.10	1.17	1.24	1.31	1.39
20	1.46	1.53	1.61	1.68	1.75	1.83	1.90	1.97	2.04	2.12
30	2.19	2.26	2.34	2.41	2.48	2.56	2.63	2.70	2.77	2.85
40	2.92	2.99	3.07	3.14	3.21	3.29	3.36	3.43	3.50	3.58
50	3.65	3.72	3.80	3.87	3.94	4.02	4.09	4.16	4.23	4.31
60	4.38	4.45	4.53	4.60	4.67	4.75	4.82	4.89	4.96	5.04
70	5.11	5.18	5.26	5.33	5.40	5.48	5.55	5.62	5.69	5.77
80	5.84	5.91	5.99	6.06	6.13	6.21	6.28	6.35	6.42	6.50
90	6.57	6.64	6.72	6.79	6.86	6.94	7.01	7.08	7.15	7.23

NOTE Due to the very similar gas rates of butane and propane and for practical purposes, this table covers both gases.

For a continuous supply, multiple cylinders should be installed. These should be installed in pairs or in banks of cylinders, interconnected via an automatic changeover device that switches gas supply as cylinders empty. Alternatively, they should be directly connected through wall block arrangements.

Table 2 provides recommended off-takes for temperate climates.

Table 2 – Recommended off-takes for temperate climates

Butane			Propane		
Cylinder size kg	Off-take		Cylinder size kg	Off-take	
	kg/h	kW		kg/h	kW
4.5	0.418	5.75	3.9	0.527	7.39
7	0.487	6.67	6	0.777	11.08
15	0.696	9.45	13	1.054	15.04
–	–	–	19	1.319	18.74

For butane cylinders, satisfactory service might not be obtained at a temperature of less than 10 °C; the most suitable temperature range is from 13 °C to 30 °C. For temperatures lower than 13 °C, the use of propane should be evaluated.

An example calculation for the cylinders needed is shown as follows.

- a) Calculate the total heat input in kilowatts of all gas appliances to be supplied by cylinder(s) as follows.

Cooker 10.0 kW

Boiler 6 kW

Total 16.0 kW

NOTE 2 For cookers, 70% of the maximum gas rate may be used.

- b) Convert the kW input to the gas rate (kg/h). For 16 kW the gas rate would be 1.17 kg/h (deduced from Table 1). Alternatively, as 10 kW relates to a cooker, this can be taken as 7 kW, giving 13 kW in total and a gas rate of 0.95 kg/h (deduced from Table 1).

- c) Calculate the number of cylinder(s) required. Divide the gas rate by the cylinder off-take rates given in Table 2 and then round up to the next integer.
- 1) For butane: 1.17 kg/h divided by 0.696 (take-off rate for 15 kg cylinders) = 1.68 . Alternatively, based upon a lower cooker rating, 0.95 kg/h divided by $0.696 = 1.36$. Hence, in both cases, two 15 kg butane cylinders would be required.
 - 2) For propane: 1.17 kg/h divided by 1.054 (take-off rate for 13 kg cylinders) = 1.11 . Alternatively, based upon a lower cooker rating, 0.95 kg/h divided by $1.054 = 0.9$. Hence, depending upon the choice of cooker rating either one or two 13 kg propane cylinders would be required.

5 Pressure regulation devices

Replacement pressure regulation and automatic changeover devices should conform to BS EN 16129:2013 and should have an overpressure (OPSO) device, with any discharge inside the cylinder locker or housing, or be separately vented to outside the craft. The pressure regulation device should give a suitable outlet pressure for the installed appliances.

NOTE 1 In existing systems, it is acceptable for the pressure regulation and automatic changeover devices to conform to BS EN 16129:2013, BS 3016, BS EN 12864, BS EN 13785 or BS EN 13786.

NOTE 2 The selection of a pressure regulation and automatic changeover device with a limited relief device can help to prevent nuisance OPSO trips.

Pressure regulation and automatic changeover devices should be located such that the inlet to them is at or above the level of the cylinder outlet valve connection.

Vent holes in pressure regulation devices should be carefully orientated or otherwise protected against the possible ingress of water or substances that could cause blockage, and should also allow for drainage.

The appropriate size of pressure regulation device should be determined according to the maximum gas rate, calculated in accordance with Table 1.

Pressure regulation devices with external manual output pressure adjustment should not be fitted.

Pressure regulation devices marked in imperial units, or more than 10 years old, should be replaced. The date of manufacture should be found on the body or union nut of the device.

High pressure side components should be installed in the same location as the LPG cylinder.

High pressure side components not directly attached to the cylinder valve should be secured in a position that provides protection from mechanical damage or be otherwise protected.

High pressure side components not directly attached to the cylinder valve should be connected by hose. The hose should be of the minimum practicable length to allow replacement of cylinders.

In most circumstances, a high pressure side hose length of no more than 1 m should be sufficient.

6 LPG supply line

6.1 General

Piping and hose should be sized so that any pressure drop due to pipe resistance does not reduce the operating pressure at any appliance below that required by the appliance manufacturer when all appliances are operating simultaneously. See Annex B for guidance on pressure drop due to pipeline resistance.

Piping and hose sizing should be designed to ensure a pressure drop due to pipe resistance does not exceed 2 mbar from the outlet of the pressure regulation device to the inlet of each appliance, with all appliances running.

NOTE For an existing system, a pressure drop with all appliances running in excess of 2 mbar is accepted, provided that the pressure at any appliance does not drop below the minimum pressure of appliance given in Table H.1.

6.2 Piping

All additional piping should be installed in accordance with BS EN ISO 10239:2014.

The following should be used for replacement piping:

- a) seamless copper tube conforming to BS EN 1057;

NOTE 1 Copper tube conforming to BS EN 12449 is equivalent to that conforming to BS EN 1057.

- b) rigid stainless steel tube conforming to BS 6362;
- c) pliable corrugated (stainless steel) tubing (PCT) conforming to BS 7838; and
- d) copper nickel alloy, of a grade suitable for use with LPG and a marine environment (for existing systems only).

Except for PCT, wall thickness for piping should be equal to or greater than 0.6 mm for piping up to 12 mm outside diameter, and a minimum of 0.9 mm for piping greater than 12 mm outside diameter.

Care should be taken to ensure that PVC does not come into contact with exposed stainless steel, owing to the risk of corrosion.

The following materials should not be used for piping for the reasons given:

- 1) aluminium (due to corrosion, low melting point, vibration);
- 2) lead (due to creep);
- 3) brass tubing (due to season cracking);
- 4) non-stainless steel tubing, e.g. mild steel, cast iron (due to corrosion);
- 5) plastics (due to low melting point, low-temperature embrittlement); and
- 6) tubing of the type fabricated from sheet steel, coated internally and externally and wrapped (due to atmospheric corrosion).