

## **A-1 MARINE LIQUEFIED PETROLEUM GAS (LPG) SYSTEMS**

*Based on ABYC's assessment of the existing technology, and the problems associated with achieving the goals of this standard, ABYC recommends compliance with this standard for all systems and associated equipment manufactured and/or installed after July 31, 2007.*

### **1.1 PURPOSE**

These standards and recommended practices are guides for the design, construction, installation, and maintenance of liquefied petroleum gas (LPG) systems on boats.

### **1.2 SCOPE**

These standards apply to liquefied petroleum gas (LPG) systems used for cooking, heating, air conditioning, and refrigeration on all boats up to the point of interface with the appliance. These standards and recommended practices do not apply to liquefied petroleum gas (LPG) systems used for internal combustion engines on boats.

### **NOTES:**

**1. The U.S. Coast Guard has promulgated regulations set for LPG systems on inspected vessels (e.g. small passenger vessels). See 46 CFR, Chapter I, Sub-chapter T, Sub-part B, Section 184.240.**

**2. Requirements for marine compressed natural gas (CNG) systems are covered by ABYC A-22 Marine Compressed Natural Gas (CNG) Systems.**

**3. Requirements for marine liquefied petroleum (LPG) fueled galley stoves are covered by ABYC A-3 Galley Stoves.**

**4. Requirements for LPG appliances, other than galley stoves, are covered by ABYC A- 26 LPG and CNG Fueled Appliances.**

**5. Requirements for cooking appliances with integral LPG cylinders are covered by ABYC A-30 Cooking Appliances With Integral LPG Cylinders.**

### **1.3 REFERENCED ORGANIZATIONS**

ABYC - American Boat & Yacht Council, 613 Third Street, Suite 10, Annapolis, MD 21403 Phone (410) 990-4460 Fax: (410) 990-4466. Web site: [www.abycinc.org](http://www.abycinc.org)

ASME - American Society of Mechanical Engineers, 3 Park Avenue, New York, NY 10016-5990 Phone (212) 591-7722. Web site: [www.asme.org](http://www.asme.org)

ASTM - American Society for Testing and Materials, 100 Barr Harbor Drive, W. Conshohocken, PA 19428 Phone (610) 832-9585. Web site: [www.astm.org](http://www.astm.org)

DOT - Department of Transportation, 400 Seventh Street, SW, Washington, DC 20590 Phone (202) 366-4000. Web Site: [www.dot.gov](http://www.dot.gov)

SAE - Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096 Phone (412) 776-4841. Web site: [www.sae.org](http://www.sae.org)

UL - Underwriters Laboratories, POB 13995, 12 Laboratory Drive, Research Triangle Park, NC 27709 (919) 549-1400. Web site: [www.ul.com](http://www.ul.com).

#### 1.4 DEFINITIONS

For the purposes of this standard, the following definitions apply.

Accessible - capable of being reached for inspection, removal, or maintenance without removal of permanent boat structure.

Cylinder - any vessel or container used to transport or store LPG.

Liquefied Petroleum Gas (LPG) - a gas that includes any products predominately composed of any of the following hydrocarbons: propane, propylene, butanes, i.e., normal butane or isobutane, butylenes, or a mixture thereof.

LPG Locker - an enclosure to hold only the LP gas bottle(s) and the associated regulator(s), safety equipment and hose(s). See [A-1.8](#) for requirements on purpose designed enclosures.

**NOTE: These lockers are often aftermarket items.**

Readily Accessible - capable of being reached quickly and safely under emergency conditions without the use of tools.

Static Floating Position - the attitude in which a boat floats in calm, fresh water with fuel tanks filled to rated capacity, but with no person or item of portable equipment aboard; The boat shall include all permanently installed factory supplied equipment and options such as, but not limited to, engine(s), battery(s), seats, engine oil, railings, fishing towers, etc., but not portable gear such as flags, searchlights, movable cushions, mattresses, portable fire extinguishers, lines, fenders, chairs, tables, anchors, chain or PFDs. Other tanks such as water, holding, and live bait well tanks are to be empty.-

System - the arrangement of cylinders, safety devices, regulators, connections, valves, piping, tubing, hose, fittings, and devices intended to store, supply, monitor, or control the flow of LPG up to but not including the appliance.-

Unattended Sources of Ignition - non-ignition protected electrical devices intended to function without attention by an operator, and/or that can cycle on and off automatically.

#### 1.5 GENERAL REQUIREMENTS

1.5.1 Comprehensive printed instructions and a labeled diagram(s) covering details of proper installation, maintenance, and operation shall be provided with each LPG system installed on a boat. These instructions shall state that a test be made every time the cylinder supply valve is opened for use, and after any events that may have affected the system such as grounding, fire, or collision. See [A- 1.10.3.1](#) and [A-1.11](#).

1.5.2 Each system shall be fitted with a pressure gauge. The gauge shall read the cylinder pressure side of the pressure regulator.

**NOTE: The purpose of the gauge is to provide a quick and easy way to test the system for leakage.**

1.5.3 All components of LPG systems subject to cylinder pressures shall have a rated pressure of at least 250 psi (1,725 kPa) above ambient.

1.5.4 Each LPG system installed on a boat shall be provided with a plainly visible sign located in the immediate vicinity of the cylinder.

1.5.4.1 The sign shall comply with the requirements in section [A-1.11](#), Safety Signs and Labels, and

1.5.4.1.1 the sign shall withstand the effects of exposure to water, oil, salt spray, direct sunlight, heat, cold, and wear expected in normal operation of a boat without loss of legibility, and

1.5.4.1.2 on boats that have a gasoline engine(s), the sign shall also contain at least the information shown in the example of the sign in section [A-1.11.3](#).

1.5.5 The system and all its components shall be capable of operation within an ambient temperature range of 0°F (-18°C) to 140°F (+60°C).

1.5.6 Only systems using LPG cylinders of the vapor withdrawal type are permitted. Cylinders designed or installed so as to admit liquefied gas into any other part of the system are prohibited.

1.5.7 All devices and appliances using LPG shall be secured so as to prevent upset or displacement that will place strain upon the fuel distribution system or appliance connections.

## 1.6 **ELECTRICAL DEVICE IGNITION PROTECTION**

1.6.1 If LPG is provided on the boat, all electrical sources of ignition located in a compartment containing LPG appliances, cylinders, fittings, valves, or regulators shall be ignition protected.

***EXCEPTION: For boats with LPG systems installed in accordance with ABYC A-1 Marine Liquefied Petroleum Gas (LPG) Systems, or ABYC A-22 Marine Compressed Natural Gas (CNG) Systems, and stoves that comply with ABYC A-3 Galley Stoves, electrical devices in the following compartments are excepted:***

***1. Accommodation spaces.***

***2. Open compartments having at least 15 square inches (0.0096 m<sup>2</sup>) of open area per cubic foot (0.028 m<sup>3</sup>) of net compartment volume exposed to the atmosphere outside of the craft.***

## 1.7 **CYLINDERS, VALVES, AND SAFETY DEVICES**

1.7.1 Cylinders used in LPG systems shall meet applicable DOT regulations or ASME requirements.

1.7.2 Each appliance shall be served by a separate low pressure, i.e., 14 in. water column (5 kPa), regulated supply line that shall originate inside the cylinder locker or protective enclosure.

1.7.3 A readily accessible manual or electrically operated (e.g., solenoid) shut-off valve shall be installed in the low or high-pressure line at the fuel supply. See the requirements in A-1.7.6.1 for valve location requirements.

1.7.3.1 The valve(s) or its control must be operable in the vicinity of the appliance(s) in the event of a fire at any appliance(s). If the cylinder shut-off valve is readily accessible from the vicinity of the appliance, the shut-off valve on the supply line is not required.

1.7.3.1.1 The valve or its control shall be operable without reaching over the top of any open flame appliance, e.g., cooking appliance burners.

1.7.4 In addition to the valve required at the cylinder, a multiple cylinder system shall be provided with a shut-off valve, or automatic check valve, at the cylinder manifold so that each cylinder can be isolated from pressure feedback from other cylinders.

1.7.5 Pressure Regulators

1.7.5.1 Each LPG system shall be provided with a pressure regulator specifically designed for use with LPG.

1.7.5.2 The LPG pressure regulator shall deliver gas, under varying appliance loads, at a pressure not in excess of 14 in. water column (5 kPa).

1.7.5.3 A low side pressure relief device shall be integral with each regulating system, and it shall discharge at between two and three times the delivery pressure of the regulator.

1.7.5.4 All relief valve outlets shall discharge into the dedicated locker or to the open atmosphere outside the boat.

1.7.5.5 A relief valve's point of discharge shall be at least 20 inches (508mm) distant from any opening to a cabin or the hull interior.

1.7.6 Cylinder and Connected Devices - Location and Installation

1.7.6.1 LPG cylinders, cylinder valves, regulating equipment, and safety devices shall be readily accessible, secured for sea conditions, and protected from the weather and against mechanical damage, and shall be

1.7.6.1.1 installed in a ventilated location on the exterior of the boat where escaping gases will flow directly overboard, or

1.7.6.1.2 if the escaping vapors will not flow directly overboard, the cylinder shall be installed in a dedicated locker meeting the requirements of A-1.8.

## **1.8 LPG LOCKERS**

1.8.1 Lockers used to contain LPG cylinders, cylinder valves, regulating equipment and safety devices shall be designed to minimize the likelihood of use as a gear storage locker and shall be,

1.8.1.1 vapor tight to the hull interior, and

1.8.1.2 located above the waterline, and

1.8.1.3 constructed of, or lined with, corrosion resistant materials, and

1.8.1.4 shall open only from the top with

1.8.1.5 a gasketed cover that shall latch tightly, and

1.8.1.6 shall be capable of being quickly and conveniently opened without tools.

1.8.2 Installation

1.8.2.1 LPG lockers shall be installed so that the locker opens only directly to the outside atmosphere, and

1.8.2.2 If a LPG locker is installed inside a boat locker, the LPG locker shall be located as high and as close to the boat locker's opening as possible in order to comply with A-1.8.2.1.

1.8.3 When means of access to the LPG equipment locker or housing is open, the cylinder valves shall be capable of being conveniently and quickly operated, and the system pressure gauge dials shall be fully visible.

1.8.4 Lockers shall be vented at the bottom by a dedicated vent, with a minimum diameter of any component in the vent system that shall be not less than 1/2 inch (12.5 mm) inside diameter.

1.8.5 Locker vents shall be led outboard, without pockets, through the hull to a point lower than the locker bottom and above the waterline with the boat in the static floating position.

**NOTE: See ABYC H-27 Seacocks, Thru-Hull Connections and Drain Plugs, for requirements for seacocks.**

1.8.6 Locker vent openings shall be located at least 20 inches (508 mm) from any hull opening to the boat interior.

1.8.7 LPG lockers shall not be used for storage of any equipment other than LPG cylinders, cylinder valves, regulating equipment, and LPG safety devices. See A-1.8.1.

1.8.8 Storage provisions for unconnected reserve cylinders, filled or empty, shall be the same as for the cylinder in use.

## **1.9 FUEL LINES**

1.9.1 As installed, the fuel supply line system and its components shall be compatible with LPG, and shall withstand the stresses and exposure of the marine environment.

1.9.2 LPG fuel supply line shall comply with the construction, performance, manufacturing and test, and marking requirements of UL 21, *LP Gas Hose*, or

1.9.2.1 be corrosion resistant metallic tubing such as annealed copper tubing, standard type, Grade K or L, conforming to ASTM B88-75a, *Specifications for Seamless Copper Water Tube*, with a wall thickness of not less than 0.032 inches (0.815 mm).

**NOTE to A-1.9.2:** *The scope of UL 21 states that the standard is not intended to apply to hose used in confined areas. A-1.9.2 does not require that the hose be UL listed, only that it complies with the specified requirements of the UL standard.*

1.9.3 Flexible LPG supply line shall be equipped with permanently attached end fittings, such as a swaged sleeve or sleeve and threaded insert.

1.9.4 Metal tubing shall be connected by means of flare fittings.

**NOTE:** *“Long nut” flare fittings should be used. The short nut type fitting used in refrigeration systems can precipitate fatigue failure due to vibration.*

1.9.5 Fuel Line Location and Installation

1.9.5.1 Fuel supply lines shall be protected from physical damage, and

1.9.5.1.1 shall be accessible for inspection.

1.9.5.2 A flexible LPG fuel line section shall be used to allow free swing of gimbaled stoves.

1.9.5.3 Fuel supply lines shall be supported by clips or straps or other suitable means such as conduit or tray to prevent vibration damage, and

1.9.5.3.1 the clips or straps or other devices shall be corrosion resistant, and

1.9.5.3.2 shall be designed to prevent cutting, abrading, or damage to the lines, and

1.9.5.3.3 shall be galvanically compatible with fuel supply line material.

1.9.5.4 Fuel supply lines shall be protected by close fitting grommets, sleeves, or sealant of non-abrasive material wherever they pass through decks or watertight bulkheads, and the method used shall be watertight.

1.9.5.5 Fuel supply lines passing through bulkheads that need not be watertight shall be installed so that the bulkheads will not cut, abrade, or damage the line.

1.9.5.6 Fuel supply lines shall be continuous lengths of tubing, piping, or hose from the regulating device, solenoid valve, or leak detector to the appliance, or to the flexible section at the appliance.

1.9.5.7 LPG fuel supply lines shall not be used for an electrical ground.

## 1.10 **INSTALLATION TESTS**

1.10.1 The fuel supply line and fittings shall be tested with air pressure of not less than 5 psi (35 kPa). This test shall be performed after installation, but prior to connection to the regulator and appliance(s).

1.10.2 The cylinder valve shall be checked for leakage at its connection to the cylinder by application of a leak detection fluid prior to connection to the system.

1.10.3 After the above tests, the complete system shall be connected and shall be subjected to the following pressure test.

1.10.3.1 With the appliance valves off, open the cylinder supply valve. Close the cylinder supply valve. Observe the pressure gauge reading. The pressure indicated should remain constant for not less than three minutes. If any leakage is indicated by a drop in pressure, check the entire system with a leak detection fluid or detergent solution to locate the leak. Test solutions shall be non-corrosive and non-toxic. Repairs shall be made before retesting and operating the system.

**NOTES:**

**1. Never use flame to check for leaks.**

**2. Never use solutions containing ammonia. Ammonia, present in some soaps and detergents attacks brass fittings. Undetectable at first, in a matter of months these fittings may develop cracks and leaks.**

**1.11 SAFETY SIGNS AND LABELS**

1.11.1 Warnings and safety labels and signs required by this standard shall comply with ABYC T-5, Safety Signs and Labels, and shall contain at least the following informational elements:

1.11.1.1 the hazard intensity signal word;

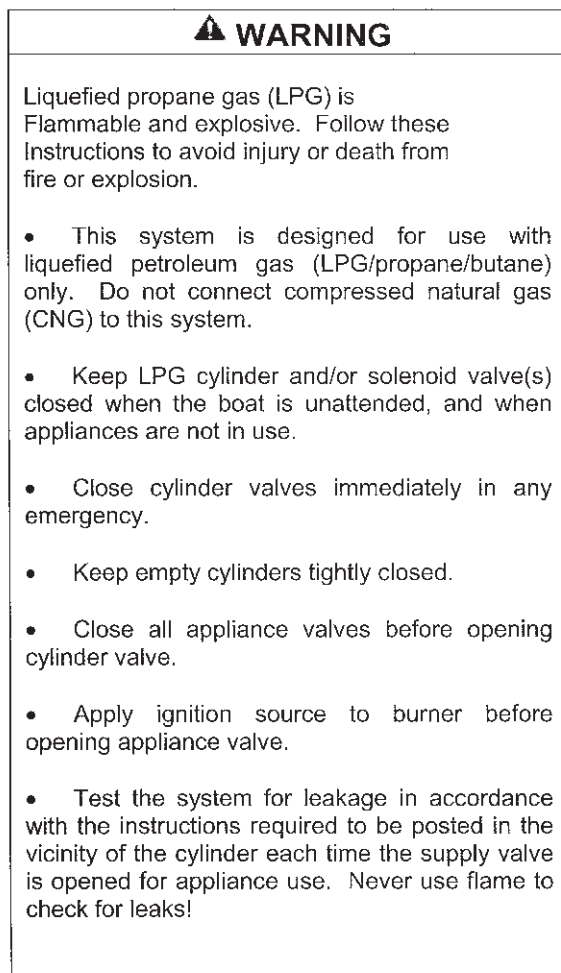
1.11.1.2 the nature of the hazard;

1.11.1.3 consequences that can result if the instructions to avoid the hazard are not followed; and

1.11.1.4 instructions on how to avoid the hazard.

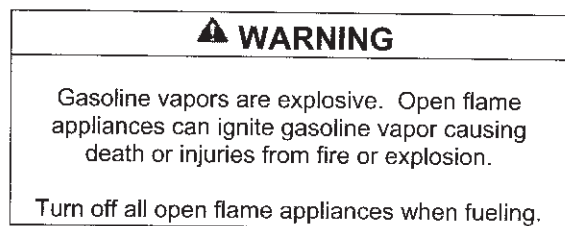
1.11.2 A sign containing a warning against connecting the LPG system to a compressed natural gas (CNG) fuel supply shall be installed in accordance with the requirements of section A-1.5.4.

**NOTE: An example of such a sign follows:**



1.11.3 On boats with gasoline engines, the sign required in [A-1.5.4](#) shall include an additional warning about the hazards of gasoline vapors and open flame appliances.

**NOTE: An example of such a sign follows:**



#### **APPENDIX - LIQUEFIED PETROLEUM GAS SYSTEM (LPG)**

This appendix provides information about, and properties of, liquefied petroleum gas (LPG). For similar information about compressed natural gas (CNG), see [ABYC A-22 Marine Compressed Natural Gas \(CNG\) Systems](#), Appendix.

#### PROPERTIES OF GASES

**NOTE: In the interest of safety, it is important that the properties of liquefied petroleum gas (LPG) be understood, and that safe practices for its use be followed. It is also important that the difference in properties between LPG and CNG be compared to distinguish between these two types of fuels and their respective hazards.**

Ap.1 LPG is two-phased, i.e., liquid/vapor, fuel with a higher calorific value than CNG, and is stored at a lower cylinder pressure than CNG.

Ap.2 LPG is heavier than air and will fall or settle if released.

Ap.3 LPG, in a natural state, is non-toxic and invisible, but can displace the air necessary to sustain life.

Ap.4 By law, commercially available LPG has an odorous gas added to facilitate leak detection. Since LPG is a two-phased fuel, the odor concentration can vary depending on the volume of fuel remaining in the cylinder. Following a release of gas, the detectability of the odorous gas can dissipate, even though the concentration of LPG gas may be present.

Ap.5 The properties of LPG must be understood. It is a gas at normal room temperature and atmospheric pressure. Under moderate pressure it liquefies, vaporizing upon release of the pressure. It is this property that permits the convenience of transporting and storing these hydrocarbons in concentrated form, while normally using them in a vapor form.

Ap.6 Released from its liquid state, LPG gas tends to sink to the bottom of an enclosed compartment. Gas that is diffused throughout the compartment is not readily dispelled by overhead ventilation. If mixed with air in certain proportions, and confined, it will explode if ignited. In its gaseous state LPG presents a fire and explosion hazard.

Ap.7 Cylinders shipped by land or airfreight must be packed and marked in accordance with DOT regulations.

Ap. TABLE I - PROPERTIES OF LPG

PROPERTIES	COMPONENTS OF LPG	
	Propane	Butane
Formula	C <sub>3</sub> H <sub>8</sub>	C <sub>4</sub> H <sub>10</sub>
boiling point, F	-44	32
specific gravity of gas (air = 1.00)	1.53	2.00
specific gravity of liquid (water = 1.00)	0.51	0.58
lbs. per gallon of liquid at 60°F	4.24	4.81
BTU per gallon of gas at 60°F	91,690	102,032
BTU per lb. of gas	21,591	21,221
BTU per cu. ft. of gas at 60°F	2,516	3,280
cu. ft. of vapor at 60°F/gal. of liquid at 60°F	36.39	31.26
cu. ft. of vapor at 60°F/lb. of liquid at 60°F	8.55	6.51
Combustion data: cu. ft. air required to burn 1 cu. ft. gas	23.86	31.02
ignition temperature in air, F	920-1020	900-1000
maximum flame temperature in air, F	3,595	3,615
limits of flammability, percentage of gas by weight in air mixture: at lower limit - % at upper limit - %	2.4 9.6	1.9 8.6
flame propagation rate feet per second	2,800	3,000
normal cylinder storage pressure, PSI @ 100°F @ 70°F	172 109	37.5 17.0