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**Document Name:** ABYC A-01: Marine Liquefied Petroleum Gas Systems

**CFR Section(s):** 46 CFR 184.240(a)

**Standards Body:** American Boat and Yacht Council



*Official Incorporator:*

THE EXECUTIVE DIRECTOR  
OFFICE OF THE FEDERAL REGISTER  
WASHINGTON, D.C.



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

*Based on ABYC's assessment of the state of existing technology and the problems associated with achieving the requirements of the standard, ABYC recommends compliance with this standard by August 1, 1994.*

### **1.1 PURPOSE**

These voluntary technical practices and engineering standards are guides for the design, construction and installation of Liquefied Petroleum Gas (LPG) systems on boats.

### **1.2 SCOPE**

These voluntary technical practices and engineering standards apply to all Liquefied Petroleum Gas (LPG) Systems used for cooking, heating and refrigeration on all boats up to the point of interface with the appliance. These recommended practices and engineering standards do not apply to Liquefied Petroleum Gas (LPG) systems used for internal combustion engines.

**NOTES: 1.** *Attention is directed to the U.S. Coast Guard Regulations which prohibit the use of Liquefied Petroleum Gas (LPG) on certain vessels and sets different standards for Small Passenger Vessels (reference 46 CFR Part 184.5).*

**2.** *Requirements for Compressed Natural Gas, (CNG) are covered by ABYC A-22, "Marine - Compressed Natural Gas (CNG) Systems".*

**3.** *Requirements for LPG galley stoves are covered by ABYC A-3, "Gallery Stoves".*

**4.** *Requirements for LPG heating are covered by ABYC A-7.*

**5.** *Requirements for appliances with integral LPG cylinders are covered by ABYC A-30.*

**6.** *Requirements for other LPG fueled appliances are covered by ABYC A-26. (Draft in committee).*

### **1.3 DEFINITIONS**

*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)* - Includes any products predominately composed of any of the following hydrocarbons: propane, propylene, butanes (normal butane or isobutane), butylenes, or a mixture thereof (with physical properties as listed in the Appendix).

*Locker* - An enclosure intended for storage of one or more cylinders.

*Readily Accessible* - Capable of being reached quickly and safely for effective use under emergency conditions without the use of tools.

*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 fuel gas up to but not including the appliance.

### **1.4 REFERENCED ORGANIZATIONS**

ABYC - American Boat & Yacht Council, 3069 Solomon's Island Road, Edgewater, MD 21037-1416. (410)956-1050.

ASME - American Society of Mechanical Engineers, 345 E. 47th Street, New York, NY 10017. (212)705-7722.

ASTM - American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103. (215)299-5400.

DOT - Department of Transportation, 400 Seventh Street, S.W., Washington, D.C. 20590. (202)366-4000.

SAE - Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096. (412)776-4841.

UL - Underwriters Laboratories, Inc., 12 Laboratory Drive, P.O. Box 13995, Research Triangle Park, NC 27709. (919)549-1565.

### **1.5 REQUIREMENTS - IN GENERAL**

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 include that a test be made every time the cylinder supply valve is opened for use and after any events which may have affected the system such as grounding, fire, or collision.

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 1,725 KPA above ambient (250 pounds per square inch gauge).

1.5.4 With each LPG system installed on a boat a sign shall be provided. It shall be located in the immediate vicinity of the cylinder enclosure and shall be plainly visible.

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 shall include the following informational elements:



(1) **CAUTION**  
**THIS SYSTEM IS DESIGNED FOR USE WITH LIQUEFIED PETROLEUM GAS (LPG) ONLY. DO NOT CONNECT COMPRESSED NATURAL GAS (CNG) TO THIS SYSTEM.**

(2) Keep cylinder valve(s) and solenoid valve(s) closed when boat is unattended. Close them immediately in any emergency. When on board, cylinder valve(s) or solenoid valve(s) shall be closed when appliances are not in use. Keep empty cylinder valve(s) tightly closed.

(3) Close appliance valves before opening cylinder valve.

(4) Test for system leakage each time the cylinder supply valve is opened for appliance use. Close all appliance valves. Open solenoid valve if installed. Open, then close cylinder supply valve. Observe pressure gauge at the regulating device and see that it remains constant for not less than three minutes before any appliance is used. If any leakage is evidenced by a pressure drop, check system with a leak detection fluid or detergent solution which does not contain ammonia and repair before operating system.

(5) **NEVER USE FLAME TO CHECK FOR LEAKS**

***This sign shall be installed in the vicinity of the cylinder and shall be plainly visible.***

1.5.5 On boats which have a gasoline engine, the sign shall also contain at least the following:



**WARNING**

**GASOLINE VAPORS ARE EXPLOSIVE.  
OPEN FLAME APPLIANCES CAN IGNITE  
GASOLINE VAPOR CAUSING FIRE OR  
EXPLOSION.  
TURN OFF ALL OPEN FLAME  
APPLIANCES WHEN FUELING!**

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

1.5.7 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.

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

#### 1.6 **REQUIREMENTS - ELECTRICAL DEVICE IGNITION PROTECTION**

1.6.1 If LPG is provided on a boat, unattended potential sources of ignition of an electrical nature below the main deck shall be ignition protected in accordance with SAE J1171, "External Ignition Protection of Marine Electrical Devices" or UL 1500, "Ignition Protection Test for Marine Products" if located in compartments containing LPG appliances, cylinders, fittings, valves or regulators. (See ABYC E-8, E-9).

**EXCEPTIONS:** 1. *Accommodation spaces.*

2. *Open compartments having at least 15 square inches of open area per cubic foot of net compartment volume (0.34 m<sup>2</sup> open area per m<sup>3</sup>) exposed to the open atmosphere outside the craft.*

#### 1.7 **CYLINDERS**

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

#### 1.8 **CYLINDER VALVES AND SAFETY DEVICES**

1.8.1 A readily accessible manual or electrically operated (solenoid) shut-off valve shall be installed in the low or high pressure line at the fuel supply (see A-1.12 for

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

1.8.2 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 such that each cylinder can be isolated from pressure feedback from other cylinders.

1.8.3 Cylinder valves and safety relief devices shall be installed in, or be directly connected to the vapor space or cylinder.

### 1.9 **PRESSURE REGULATORS**

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

1.9.2 The LPG pressure regulator shall be adjusted to deliver gas at any or each appliance, under varying appliance loads, at a pressure not in excess of 50 mbar (19 inches water column, approximately 0.735 psig).

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

1.9.4 All relief valve outlets shall discharge into the locker or to the open atmosphere. The point of discharge shall be at least two feet distance from any opening to a cabin or the hull interior or from any engine exhaust terminus which is below the level of the vent discharge.

### 1.10 **FUEL SUPPLY LINES**

1.10.1 The fuel supply line system and its components, as installed, shall be designed to be compatible with LPG and to withstand the stresses and exposure to the marine environment. One type is annealed copper tubing, standard type, Grade K or L, conforming to Specifications for Seamless Copper Water Tube (ASTM B88-75a) with a wall thickness of not less than 0.815 mm (0.032").

1.10.2 The flexible LPG fuel line shall comply with UL 21 *LP Gas Hose*.

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

1.10.4 Metal tubing shall be connected by means of flare fittings. Metal to metal compression sleeve type fittings shall not be used.

### 1.11 **LOCATION AND INSTALLATION - FUEL LINES**

1.11.1 Fuel supply lines shall be protected from physical damage and shall be accessible for inspection.

1.11.2 A flexible section shall be used to allow the free swing of gimballed stoves.

1.11.3 Fuel supply lines shall be supported by clips or straps or other suitable means such as conduit or tray to prevent vibration damage. The clips or straps or other devices shall be corrosion resistant and shall be designed to prevent cutting, abrading or damage to the lines and shall be compatible with fuel supply line material.

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

1.11.5 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.

1.11.6 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.

1.11.7 Each appliance shall be served by a separate low pressure (50 mb) regulated supply line which shall originate inside the cylinder locker or protective enclosure.

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

### 1.12 **LOCATION AND INSTALLATION - CYLINDER AND CONNECTED DEVICES**

LPG cylinders, cylinder valves, safety devices and regulating equipment shall be secured for sea conditions and readily accessible, and shall be located:

1.12.1 on the exterior of the boat where escaping gases will flow directly overboard, the cylinder valve, regulators, and safety devices shall be in a ventilated location protected from the weather and against mechanical damage, or

1.12.2 in a dedicated locker which shall be:

1.12.2.1 vapor tight to the hull interior,

1.12.2.2 located above the waterline,

1.12.2.3 constructed of or lined with corrosion resistant materials,

1.12.2.4 equipped with gasketed cover which:

1.12.2.4.1 opens directly to the atmosphere outside the boat,

1.12.2.4.2 opens only from the top,

1.12.2.4.3 latches tightly,

1.12.2.4.4 is capable of being quickly and conveniently opened without tools for operating the cylinder valves, testing the system for leakage and viewing the pressure gauge.

1.12.2.5 vented at the bottom by a dedicated vent,

1.12.2.5.1 led outboard without pockets through the hull sides to a point lower than the locker bottom but above the waterline,

1.12.2.5.2 located at least two feet distant from any hull opening to the boat interior, and

1.12.2.5.3 located at least two feet distant from an engine exhaust terminus which is below the level of a vent outlet.

1.12.2.5.4 with a minimum diameter of any component in the vent system not less than 12.5 mm (1/2 inch) inside diameter.

1.12.3 When means of access to the 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.

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

1.12.5 Lockers shall not be used for storage of any other equipment.

### 1.13 **TESTING**

1.13.1 The fuel supply line and fittings shall be tested with air pressure of not less than 34.5 kPa (5 psig). This test shall be after installation, but prior to its connection to the regulator and appliance(s).

1.13.2 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.

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

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 operating the system.

**NOTES: 1. NEVER USE FLAME TO CHECK FOR LEAKS!**

**2. NEVER USE SOLUTIONS CONTAINING AMMONIA. AMMONIA, WHICH IS PRESENT IN SOAPS AND DETERGENT ATTACKS BRASS FITTINGS. UNDETECTABLE AT FIRST, IN A MATTER OF MONTHS THESE FITTINGS MAY DEVELOP CRACKS AND LEAKS.**

APPENDIX FOLLOWS

## APPENDIX - LIQUEFIED PETROLEUM GAS SYSTEMS (LPG)

This appendix provides information about and properties of Liquefied Petroleum Gas (LPG). For similar information about and properties of Compressed Natural Gas (CNG), see ABYC A-22 "Marine - Compressed Natural Gas Systems (CNG)", 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 Liquefied Petroleum Gas (LPG) and Compressed Natural Gas (CNG), as covered in ABYC A-22, Marine - Compressed Natural Gas Systems (CNG)", be compared to distinguish between these two types of fuels and their respective hazards.

A-1.Ap.1. LPG - Liquefied Petroleum Gas is two-phased (liquid/vapor) fuel with a higher calorific value than Compressed Natural Gas (CNG) and is stored at a lower cylinder pressure than CNG.

A-1.Ap.2. LPG is heavier than air and will fall or settle if released.

A-1.Ap.3. LPG, in a natural state, is non-toxic and invisible, but can displace the air necessary to sustain life.

A-1.Ap.4. Commercially available LPG, by law, has an odorant added to facilitate leak detection. Since LPG is a two-phased (liquid/vapor) fuel, the odor concentration can vary depending on the volume of fuel remaining in the cylinder.

A-1.Ap.5. The properties of LPG must be understood. They are gases at normal room temperature and atmospheric pressure. Under moderate pressure they liquefy, vaporizing upon release of the pressure. It is this property which permits the convenience of transporting and storing these hydrocarbons in concentrated form while normally using them in a vapor form.

A-1.Ap.6. Released from its liquid state, unignited 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.

A-1.Ap.7. Cylinders shipped by land or air freight must be packed and marked in accordance with DOT regulations.

TABLE 1 - PROPERTIES OF LPG

PROPERTIES	COMPONENTS OF LPG	
	Propane	Butane
Formula	C3H8	C4H10
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	91690	102032
BTU per Lb. of Gas	21591	21221
BTU per Cu. Ft. of Gas at 60°F	2516	3280
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	8.547	6.506
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	3595	3615
Limits of Inflammability, Percentage of Gas in Air Mixture:		
At Lower Limit - %	2.4	1.9
At Upper Limit - %	9.6	8.6
Flame Propagation Rate Feet per second	2800	3000
Normal Cylinder Storage Pressure		
@ 100° F	172 PSI	37.5 PSI
@ 70° F	109 PSI	17.0 PSI

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