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Document Name: ABYC A-22: Marine Compressed Natural Gas Systems

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Standards Body: American Boat and Yacht Council

APPROVED

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THE EXECUTIVE DIRECTOR
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WASHINGTON, D.C.

A-22 MARINE COMPRESSED NATURAL GAS (CNG) 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.

22.1 *PURPOSE*

These voluntary technical practices and engineering standards are guides for the design, construction and installation of compressed natural gas (CNG) systems on boats.

22.2 *SCOPE*

These voluntary technical practices and engineering standards apply to all compressed natural gas (CNG) systems used for cooking, heating and refrigeration on all boats.

NOTES: ***1. Attention is directed to the U.S. Coast Guard Regulations which prohibit the use of Compressed Natural Gas (CNG) on certain vessels and set different standards for Small Passenger Vessels.***

2. Another gaseous fuel used in boats is Liquefied Petroleum Gas, (LPG). See ABYC A-1, "Marine - Liquefied Petroleum Gas (LPG) Systems".

3. Requirements for CNG galley stoves are covered by ABYC A-3, "Galley Stoves".

22.3 *DEFINITIONS*

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

Attended Appliance - An attended appliance is one which is intended for use when the occupants are in the accommodation space in which the appliance is installed, and requires frequent attention by an operator, such as cooking stoves and ovens and demand type water heaters with piezo electric ignition.

Compressed Natural Gas - Consists principally of methane in gaseous form and includes naturally occurring mixtures of hydrocarbon gases. CNG is a natural gas that is normally supplied as a fuel by a gas utility and is stored under pressure in portable cylinders. Certain physical properties of CNG are listed in the Appendix.

Cylinder - Any vessel or container used to transport or store CNG.

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.

Unattended Appliance - Unattended appliances are those which are intended to function without frequent attention by an operator and may cycle on and off automatically, such as storage type water heaters, refrigerators, or thermostatically controlled cabin heaters.

22.4 *REFERENCED ORGANIZATIONS*

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

AGA - American Gas Association, 1515 Wilson Blvd., Arlington, VA 22209. (703)841-8400.

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, DC 20590. (202)366-4000.

NFPA - National Fire Protection Association, Batterymarch Park, Quincy, MA 02269. (617)770-3000.

SAE - Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096-0001. (412)776-4841.

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

22.5 *REQUIREMENTS - IN GENERAL*

22.5.1 Comprehensive printed instructions and a labeled diagram(s) covering details of proper installation, maintenance, and operation shall be provided with each CNG system installed in a boat. These instructions shall include that a test be made every time the cylinder supply valve is opened for use.

22.5.2 Components of this system, subject to cylinder pressure, shall have a working pressure that is at least 133 percent of the maximum fill pressure of the cylinder.

22.5.3 With each CNG system installed on a boat a sign shall be provided. It shall be located in the immediate vicinity of the cylinder 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 COMPRESSED NATURAL GAS (CNG) ONLY. DO NOT CONNECT LIQUEFIED PETROLEUM GAS (LPG) 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 cylinders tightly closed.

(3) Close all 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 shut-off 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!**

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

22.5.4 On boats with 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!

22.5.5 The system and all its components, as installed, shall be suitable for operation within an ambient temperature range of -18°C (0°F) to 60°C (140°F).

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

22.6 *ELECTRICAL DEVICES - IGNITION PROTECTION*

22.6.1 If CNG is provided on a boat, unattended electrical potential sources of ignition shall be ignition protected in accordance with UL 1500 "Ignition Protection Test for Marine Products" or SAE J1171, "External Ignition Protection of Marine Electrical Devices", if located in compartments containing CNG appliances, cylinders, fittings, valves, regulators, and the unattended electrical devices located within one meter of or located above the level of the cylinder valve.

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

2. Open compartments: having at least 15 square inches of open area per cubic foot of compartment volume exposed to the open atmosphere outside of the craft.

22.7 *CYLINDERS*

22.7.1 Cylinders used in CNG systems shall meet the applicable DOT and AGA Regulations and standards.

22.8 *CYLINDER VALVES AND SAFETY DEVICES*

22.8.1 A readily accessible manual or electrically operated (solenoid) shut-off valve(s) shall be installed in the low pressure line to each attended appliance(s). The valve(s) or its control shall be operable from within the vicinity of the appliance(s) in the event of a fire at the appliance(s). If the cylinder valve(s) is readily accessible from the vicinity of the attended appliance(s), the above shut-off valve(s) on the supply line is not required.

22.9 *PRESSURE REGULATOR*

22.9.1 Each CNG system shall be provided with pressure regulators specifically designed for use with CNG, made of materials that are compatible with CNG.

22.9.2 The CNG pressure regulator system shall be adjusted to deliver gas at any or each appliance, under varying appliance loads, at a pressure not in excess of 16 mbar (six inches water column, approximately 0.22 psig).

22.9.3 The CNG pressure regulators shall be connected directly to the cylinder shut-off valve, using one CGA series 350 connection.

22.9.4 Each regulating system shall include a pressure gauge. The gauge shall read the cylinder pressure side of the pressure regulator.

NOTES: The purpose of this gauge is twofold:

1. To monitor the amount of CNG fuel remaining in the storage cylinder, and

2. to provide a quick and easy way to test the system for leakage.(Ref. A-22.13)

22.9.5 The pressure regulation system shall include a high flow restrictor located on the cylinder pressure side of the regulator which shall:

22.9.5.1 actuate and control gas flow through the vent system to the open atmosphere in the event of regulator malfunction, and

22.9.5.2 The vent system shall be designed to contain the gas flow at the pressure present when the high flow restrictor is activated.

22.9.6 The high flow restrictor vent system shall be designed to contain the gas flow at the pressure which actuates the high flow restrictor.

22.9.6.1 Relief vent outlet(s) shall not discharge to the interior of the vessel.

22.9.7 The vent discharge system shall be located and designed to prevent water from entering the regulation system. The vent hole shall be protected against entry of other foreign material.

22.10 *FUEL SUPPLY LINES*

22.10.1 The fuel supply line system and its components, as installed, shall be designed to be compatible with CNG and to withstand the stresses and exposure to the marine environment.

22.10.2 Copper tubing, unless internally tinned, is prohibited.

22.10.3 CNG hose shall meet the applicable requirements of NFPA 52.

22.10.4 CNG supply hose shall be equipped with permanently attached end fittings such as swaged sleeve or sleeve and threaded insert or other fittings specifically designed for use with that hose.

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

22.11 *LOCATION AND INSTALLATION - FUEL LINE*

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

22.11.2 A flexible section shall be used to allow the free swing of gimbaled stoves.

22.11.3 Fuel supply lines shall be supported by clips, straps or other suitable means, such as a conduit or tray, to prevent vibration damage. The clips, straps or other means 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.

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

22.11.5 Fuel supply lines shall be continuous lengths of tubing, piping or hose from the regulating appliance or to the flexible section at the appliance. Each appliance shall be served by a separate supply line.

22.11.6 CNG fuel supply lines shall not be used for an electrical ground.

22.12 *LOCATION - CYLINDER AND CONNECTED DEVICES*

22.12.1 CNG systems with connected capacity greater than 100 cubic feet shall provide for storage lockers (see A-22.13.5.2).

22.12.2 CNG cylinders and regulation equipment shall be located in a well ventilated area. The area shall provide protection from water or mechanical damage.

22.12.3 CNG cylinders and regulating equipment shall be readily accessible and secured (in a vertical or horizontal position).

22.12.4 CNG cylinders shall not be installed in compartments containing an internal combustion engine.

22.12.5 CNG cylinder storage compartments shall not have openings which communicate with the engine space above the level of the pressure regulator.

22.12.6 CNG cylinders shall be located at least one meter (three feet) from any attended open flame device, in the same compartment.

22.13 *INSTALLATION - CYLINDER AND CONNECTED DEVICES*

22.13.1 CNG cylinder location shall be readily accessible such that the cylinder valve hand wheel can be conveniently and quickly operated and the system pressure gauge dial is fully visible.

22.13.2 If CNG cylinders are installed in a space other than a dedicated locker, the regulators, valves and fittings shall be protected from the weather and against mechanical damage.

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

22.13.4 Compartments and lockers in which CNG cylinders are stored shall have a ventilation opening located above the cylinder.

22.13.5 If the CNG installation includes attached cylinders of greater than 2.8 cubic meters (100 cubic feet) combined capacity, the cylinders shall be:

22.13.5.1 located on the exterior of the boat where escaping gases can directly escape into the open air, or

22.13.5.2 installed in a locker which shall be:

a. vapor tight to the hull interior,

b. vented to the open atmosphere outside the boat,

c. constructed of or lined with corrosion resistant materials,

d. equipped with a means to discharge incidental accumulated water,

e. equipped with a cover which

i. opens directly to the atmosphere,

ii. latches tightly,

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

22.14 *TESTING*

22.14.1 The fuel supply line and fittings shall be tested by an 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).

22.14.2 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.

22.14.3 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 solenoid shut-off valve if installed, 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 SOME SOAPS AND DETERGENTS, ATTACKS BRASS FITTINGS. UNDETECTABLE AT FIRST, IN A MATTER OF MONTHS THESE FITTINGS MAY DEVELOP CRACKS AND LEAKS.

Appendix Follows

APPENDIX - COMPRESSED NATURAL GAS SYSTEMS (CNG)

This appendix provides information about and properties of Compressed Natural Gas (CNG). For similar information about and properties of Liquefied Petroleum Gas (LPG) see ABYC A-1, "Marine - Liquefied Petroleum Gas Systems (LPG)", Appendix.

PROPERTIES OF GASES

TABLE I -PROPERTIES OF CNG

PROPERTIES	COMPONENTS OF CNG Methane
Formula	CH
Specific Gravity of Gas (Air = 1.0)	0.55
Flammable Limits in Air (Explosive Range), Percent by volume, LOWER UPPER	 5.0 15.0
Calorific Value - Net BTU per cubic foot 14.7 psig	1000
Ignition Temperature	704°C (1300°F)
Flame Propagation Rate Feet per second	229 MS 750
Normal Cylinder Storage Pressure @ 38°C (100°F) @ 20°C (70°F)	 16.7 MPa (2423 psi) 15.5 MPA (2250)

NOTE: In the interest of safety, it is important that the properties of Compressed Natural Gas (CNG), be understood and that safe practices for its use be followed. It is also important that the differences in properties between Compressed Natural Gas (CNG), and Liquefied Petroleum Gas (LPG), as covered in ABYC A-1, "Marine - Liquefied Petroleum Gas Systems (LPG)", be compared to distinguish between these two types of fuels and their respective hazards.

22.Ap.1 CNG - Compressed Natural Gas, being always in the vapor phase and having a lower calorific value (heating value) then LPG, Compressed Natural Gas (CNG), must be stored at higher pressures than LPG fuels to provide a fuel supply.

22.Ap.2 Natural gas is lighter than air, and if released will rise and dissipate into the atmosphere if some means of overhead ventilation is provided.

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

22.Ap.4 Commercially available CNG, by law, has an odorant added to facilitate leak detection. CNG is always in the vapor phase and has an odor concentration which will not change.

22.Ap.5 CNG, if unignited and released, will diffuse and intermix with air at a comparatively rapid rate and will tend to rise to the top of an enclosed compartment into which it is released. CNG is readily dispelled by overhead ventilation. Mixed with air in certain proportions and confined, CNG will explode if ignited. In its gaseous state CNG presents a fire and explosion hazard.

22.Ap.6 The cylinder shall be returned to an authorized fuel distributor for refilling.

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

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