

GE 1-116

**ON-BOARD CNG FUEL SYSTEM
INSTALLATION AND TESTING**

MINIMUM TECHNICAL AND SAFETY REQUIREMENTS

PART I

1. Consulted background and standards

- a) "Installation of compressed natural gas fuel systems and containers on highway vehicles and requirements for refueling stations" – CANADA - October 1982.
- b) "Reglamento al codice della strada - Dispositivi de alimentazione con combustibili in pressione o gassosi" ITALY Ed. 1978.

2. Purpose

These standards and specifications aim at defining the characteristics of CNG storage cylinders to be mounted in motor vehicles using CNG in their propulsion system, their fittings and those corresponding to the carburetion system. The requirements to comply with during configuration and mounting, the tests and verifications to be performed on the system and on the motor vehicle and the feature enabling the identification of motor vehicles fitted with CNG equipment are also defined by these standards.

3. Scope

- 3.1 The provisions contained in these standards and specifications are applicable to motor vehicles fitted with fixed CNG cylinders; suitable for refueling at compression and refueling stations.
- 3.2 They shall apply to converted motor vehicles: liquid hydrocarbons – CNG.
- 3.3 They shall apply to motor vehicles designed to use exclusively CNG in their propulsion system or to original motor vehicles that have been modified.
- 3.4 The fuel to be used shall be Natural gas with a predominance of methane in its content.

Depending on the gas fields, treatment plants in operation and transported product mixes, percentages vary for each component; however, in the case of inert gases (CO₂+N₂), water and sulfur free, (already odorized gas), averages remain within the maximum limit.

Two very different specific compositions are used to illustrate the point:

Components	Composition 1	Composition 2
Methane (CH ₄)	95%	86%
Ethane (C ₂ H ₆)	0.05%	5.2%
Propane, Butane and Higher	0.50%	7.4%
N ₂	2.7%	0.7%
CO ₂	1.8%	0.5%
H.C.V	8,950 Kcal/m ³	9,750 Kcal/m ³
Gravity(air= 1)	0.572	0.650
Wobbe Index (not corrected)	11,900	12,110

Maximum inert content = (CO₂ + N₂) ≤ 4.5%

Maximum free sulfur content = 50 mg/ m³

Maximum water content = 113 mg/ m³

Practically all the compositions yield as a result, gases which Wobbe index that do not differ from one another in more than 400 - 500 units; that is to say, totally interchangeable compositions.

4. General specifications

- 4.1 The cylinders to be installed in a motor vehicle for feeding the carburetion system with CNG shall be of a model approved by Gas del Estado
 - 4.1.1 They shall comply with what is set forth in the Standard, Code or specification used and with all the corresponding requirements stated in these technical and safety Standards and specifications.
- 4.2 Motor vehicles carburetion system may be either dedicated (CNG) or bi-fuel. In this last case, the original fuel system for liquid fuel shall be complemented with the necessary components: cylinders, valves, tubing, couplings, pressure regulator, gas-air mixer, etc.; and the selector system shall be equipped with solenoid valves, so that the vehicle can alternatively operate with CNG, regulated at the required value according to the gas-air mixer design.
- 4.4 All the carburetion system components shall be of type approved by Gas del Estado, and shall comply with 1-117 standard (Technical standard for components designed to operate with CNG in motor vehicles carburetion systems and operation requirements) or other equivalent Standards that might be accepted by Gas del Estado.

The components may be reinstalled in another motor vehicle, provided they are in good use and operation conditions.

- 4.4 Installation of CNG cylinders in the motor vehicle shall be fixed. The use of interchangeable containers shall not be allowed.

The filling capacity shall be indicated by gauge pressure and shall not exceed 200 bar M at a temperature of $21 \pm 1^\circ\text{C}$.

- 4.5 Any fitting, component, equipment or material used in one installation must be of approved type and capacity to meet the use requirements.

PART II

1. Installation of On-Board CNG Fuel System

1.1. CNG Cylinders

1.1.1 CNG cylinders to install in the motor vehicle must:

- a) Be constructed to operate at a normal pressure of 200 Bar
- b) Be approved by Gas del Estado
- c) Not be modified nor altered, once installed

1.1.2 Components of CNG cylinders

1.1.2.1 Pressure relief safety device

Every CNG steel cylinder shall have in one or both ends, depending on its length, a combined safety device: pressure burst disc of 340 ± 34 bar and fusible plug to melt at nominal $100^\circ\text{C} \pm 4^\circ\text{C}$.

When cylinder length is no more than 1.65 m (thread is not considered), the safety device shall be placed in the operating valve provided with each cylinder.

Cylinders larger than 1.65 m must be fitted with a calibrated orifice at one end and a threaded part with the already described combined safety device.

1.1.2.2 Pressure Gauge

- a) Every CNG fuel system shall be fitted with a pressure gauge indicating storage pressure, and complying with the requirements of GE 1-117 Standard or a similar one approved by Gas del Estado.

- b) The pressure gauge shall be placed next to the filling nozzle, so that it remains visible during the refueling operation. High pressure tubes shall not be allowed inside the enclosure. Every load indicator placed in the enclosure shall be an electric analog instrument.

1.1.2.3 Check valve

The cylinder filling system in the vehicle must be fitted with a check valve in order to avoid the gas flow returning from the cylinder to the filling connection.

1.1.2.4 Material Compatibility

Fittings directly mounted on the cylinders must be electrochemically compatible with the CNG cylinder material.

1.1.3 Installation of CNG cylinders on motor vehicles

1.1.3.1 A CNG container shall never be installed on the vehicle roof or in the engine compartment

1.1.3.2 A CNG container must be installed:

- a) Permanently and adequately fixed to avoid displacement, slippage or rotation.
- b) So as to avoid unnecessary stresses on containers and on fittings.
- c) Such as to avoid serious weakening of the vehicle structure. If the motor vehicle manufacturer considers it should be reinforced, the specific components must be added in the location and with the characteristics he indicates.
- d) So that the necessary strength to separate the container from the vehicle is not lower than:

1) Twenty times the weight of the full container, longitudinal to the motor vehicle.

2) Eight times the weight of the full container, in any other direction.

1.1.3.3 It shall be considered that requirements of provision 1.1.3.2 are complied with, if the installation fulfills the following requirements:

a) For containers of up to 110 kg

They shall be fixed to the vehicle with at least two iron straps of 30 mm minimum width and enough thickness so to confer it a resistance equivalent to a 90 mm² section of a common steel bar; 10 mm diameter bolts shall be used

b) For containers over 110 kg

They shall be fixed to the vehicle with at least two iron straps of 45 mm minimum width and enough thickness so as to confer it a resistance equivalent to a 225 mm² section of a common steel bar. 12 mm diameter bolts shall be used.

c) When more than two iron straps are used, the total area of their section shall be at least equal to that of the two iron straps mentioned above.

d) When the container is fixed to the motor vehicle by means of brackets and bolts, at least four steel bolts of equivalent resistance shall be used.

1.1.3.4 The axle loads resulting from the motor vehicle own weight plus the CNG equipment and the useful load (that may differ from the original one) must not exceed the ones specified by the vehicle manufacturer.

1.1.3.5 When a container is located in a compartment that has been designed or that may be used for passenger transport:

a) The end of the cylinder containing the valve and other fittings must be locked in a strong gas-tight housing venting outside the vehicle.

b) The container must be installed according to provisions 1.1.3.2, 1.1.3.3 and 1.1.3.4.

c) The burst disc must vent directly outside the vehicle through a steel tube.

1.1.3.6 When a container is located in a compartment that has not been designed or that may not be used for passenger transport:

a) The end of the cylinder containing the valve and other fittings must be locked in a gas-tight housing that shall vent outside the vehicle or else, the compartment must be sealed compared to that of the passenger, and must have a ventilation opening with a free area of at least 1100 mm² located at the highest possible place.

b) The container must be installed according to provisions 1.1.3.2, 1.1.3.3 and 1.1.3.4.

c) The burst disc must vent directly outside the vehicle through a steel tube.

As an alternative for discharging gas to the atmosphere, as set forth in items 1.1.3.5 and 1.1.3.6:

- a) Self-extinguishable, non-flammable flexible bags may be used. They shall be protected or otherwise installed in locations where they are safe from damage caused by objects, abrasion, etc.
- b) They shall exhaust gas to the external lower part of the vehicle, through semi rigid tubes of identical material used in a) with a section of at least 1100 mm². They shall not discharge on the fender area.

1.1.3.7 According to provision 1.1.3.1, a container located outside the vehicle must:

- a) Be installed according to what is set forth in items 1.1.3.2 and 1.1.3.3.
- b) Not projecting beyond the highest point of the vehicle.
- c) Not projecting beyond the sides of the vehicle
- d) Not projecting beyond the front axis.
- e) Have container connections and valves protected against damage caused by contact with stationary objects or objects thrown up from the road.
- f) Be located at least 50 mm from the pipe or gas exhaust system.
- g) When longitudinally installed, it must adequately absorb any impact and transmit it to the vehicle structure.
- h) Neither affecting nor altering the driving feature of the vehicle.

1.1.3.8 When a container is installed between the motor vehicle axles, the minimum distance to the floor, considering the vehicle filled with the maximum load, calculated as of the cylinder or any other fitting, the lowest one, must not be less than:

- a) 175 mm, for vehicles which distance between axles is less than or equal to 3175 mm.
- b) 225 mm, for vehicles which distance between axles is more than 3175 mm.

1.1.3.9 When a container is installed behind the rear axle and below the structure, the minimum distance to the floor, considering the vehicle filled with the maximum load, calculated as of the cylinder or any other fitting, the lowest one, must not be less than:

- a) 200 mm, and for vehicles with rear protrusion, up to 1125 mm
- b) 0.18 times the distance between the central line of the back axle and the central line of the container bottom, provided this one is installed more than 1125 mm behind the central line of the back axle.

1.1.4 Tubing, fuel lines and hoses of the carburetion system

1.1.4.1 They must be constructed so as to withstand a pressure of:

- a) 4 (four) times the working pressure when located upstream of the first regulation stage.
- b) 5 (five) times the working pressure when located downstream of the first regulation stage.

1.1.4.2 The material to be used shall be resistant to the chemical action of gas and to operating conditions. It shall comply with ANSI B 31-3 or similar regulations.

1.1.4.3 It must be of adequate size so as to provide the required gas flow according to the characteristics of the motor vehicle in which the system is used.

1.1.4.4 Fuel lines and components must be clean cut and free from debris resulting from threading, flakes or any other type of dirt or flaw.

1.1.4.5 The ends of fuel lines and tubing must be carefully reamed.

1.1.4.6 Fuel lines and fittings shall be safely mounted, fixed and secured such as to compensate vibrations, by means of metal clamps, galvanized or protected by any other system or treatment. They may be fastened with nylon bands or any other product of identical resistance and neutral reaction.

The distance among fastening devices shall not exceed 600 mm.

1.1.4.7 CNG delivery lines follow the shortest, most practical path between the cylinders and the gas-air mixer, compatible with their flexibility and must be protected against damages or ruptures caused by collisions, overstresses or friction wear.

They must have a lining when necessary.

1.1.4.8 They shall not be located in exhaust pipes and shall be made of corrosion-resistant material or adequately treated so as to guarantee their good performance in corrosive environments.

1.1.4.9 Joints and connections

- a) Steel cylinder tapered thread. It shall be female, conic, metric type according to N/DIN 477 or N/ UNI 339 or N/BS 341 or IRAM 2539 or non-metric type according to N/ ANSI B-57.1
- b) Valve thread for steel cylinder thread. It shall be male, conic, metric type according to N/DIN 477 or N/ UNI 339 or N/BS 341 or IRAM 2539 or non metric type according to N/ ANSI B-57.1
- c) Thread in the outlet valve indicated in b) shall be female, cylindrical, internal, of 12 mm x 1 according to N/DIN 2353 or UNI 4535-64 or

SAE J 403-H with an external thread male bushing, and an opening which diameter shall depend on the tube used and on the intermediate double conic part.

- d) Tapered thread in aluminum cylinders. It shall comply with regulation CGA 1125-12 UNF-2 A

1.1.4.9.1 When a sealant is required, it shall only be applied to the male thread of the fuel line and must be approved according to the requirements of a recognized international standard.

1.1.4.10 The following is prohibited:

- a) Connections located in areas that are difficult to access
- b) Location of tubing or fuel lines in places where gas may accumulate due to undetected releases.
- c) Connection of bushings and use of different materials like brass or steel.
- d) Joints using pipes that contain a right and a left thread on the same part
- e) Bending of pipes or tubes when such operation weakens those elements.
- f) Joints with closed nipples or nipples close to one another.
- g) Cuts in the structure that reduce their resistance for the installation of fuel lines, tubing or hoses, and altering the design aim.
- h) Repairs of flaws in CNG line. Flawed elements must be replaced.

1.1.5 Carburetion system components

Manual valves, fuel selectors, solenoid valves, check valves, inlet valves for refueling, automatic shut off valves, pressure regulators and gas-air mixers / carburetors used as CNG carburetion system components, must comply with the requirements specified in standard GE 1-117 or other equivalent standard approved by Gas del Estado.

1.1.5.1 A manual valve must be installed in a place that may isolate the cylinder (cylinders) from the rest of the system. It must be protected against shock or collisions.

1.1.5.2 An automatic valve must be installed downstream the manual valve so as to prevent the flow of gas to the carburetor when the motor is idle or not ignited.

1.1.5.3 In the case of bi-fuel motor vehicles, the fuel selection system shall be installed in the most practical way and as close to the point of injection as possible, being easily accessed from the driver's seat.

1.1.5.3.1 These vehicles shall be fitted in their gasoline line with an automatic valve which when shut off prevents the flow of liquid to the carburetor if its line is connected to CNG supply

1.1.5.4 A pressure regulator must be installed safely and in an easy to access location. It must be protected against shocks, excessive heat and electrical equipment and installations.

1.2 Required tests

1.2.1 To be carried out by CNG Fuel System Suppliers

CNG Fuel System Suppliers shall perform the tests indicated in item 3.5.1 of GE 1-115

1.2.2 To be carried out at Installation Workshops

1.2.2.1 After mounting the CNG Fuel System on the motor vehicle as indicated in the corresponding scheme, by the CNG Fuel System Supplier, verification is carried out through a leak test at 200 bar, using air or inert gases up to the regulator outlet, so as to ensure there are no gas leaks through the connections. Verification shall be performed with twice the regulated pressure in the low pressure section.

1.2.2.2 Once gas-tightness of the connections has been verified, the workshop manager shall fill the cylinders with CNG after purging air in the system with inert gas and shall give the user a driving demo. He will obviously start the engine, drive the car at different gears, press and release the accelerator on several occasions and alternatively change from liquid to gas fuel and vice versa.

NOTE: Specifications set forth in 3.6.2.1 a) of GE N° 1-115 apply to item 1.1.2.1

ANNEX "A"
PUBLIC PASSENGER TRANSPORT

1. PURPOSE

- 1.1 To determine the additional safety conditions for motor vehicles using Compressed Natural Gas (CNG) as fuel in their propulsion system, included in the Regulation for the Permit of Passenger Public Transport, last version, issued by the Transport Under Secretariat.

2. GENERAL ASPECTS

- 2.1 Modifications in new and used motor vehicles
Vehicle modifications to allow the use of CNG, regardless of whether the unit is in use or has just come out of the factory, must agree with the Regulation for the Permit of Passengers Public Transport, and provincial and municipal regulations in force.
- 2.2 Equipment for the use of CNG in Passengers Public Transport units.
Assembly of the components mentioned in subsection 1.2.1 of G. E. 1-115 standard with added components and with the necessary technology for the adequate conversion and operation of the units, completely in accordance with the regulations stated in 2.1
- 2.3 CNG Fuel System Supplier for the use of compressed natural gas in Passengers Public Transport units.
Physical or legal entity who assembles the different components integrating the CNG equipment in Passengers Public Transport units, and complies with what is indicated in standard GE N°1-115, subsections 1.2 and 3.5.
- 2.4 Responsible persons in Public Transport companies.
Apart from the duties of each CNG user, Public Transport companies must keep a record of periodical reviews performed on converted units. To this effect, they shall appoint responsible persons to record the reviews carried out on each unit, to ensure that they are carried out at authorized workshops, and to control repair works that may or may not be related to the CNG system.

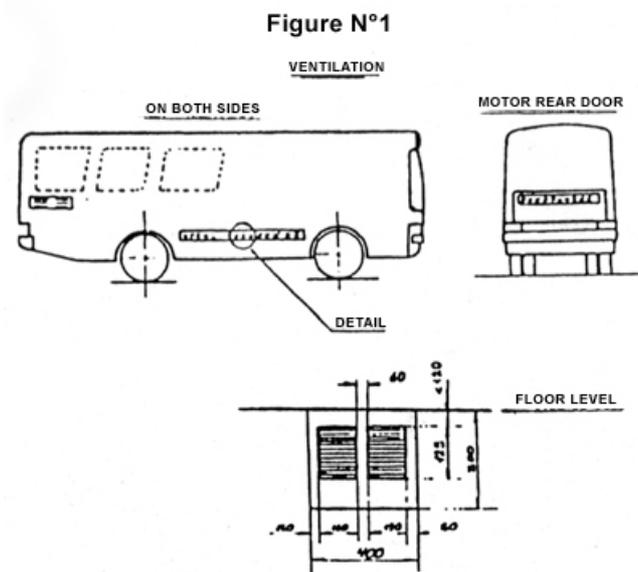
3. ADDITIONAL MODIFICATIONS TO STANDARD GE Nr 1-116

3.1 Mounting of cylinders

- 3.1.a. When the cylinders are located between the motor vehicle axles, the minimum distance to the floor, calculated as of the low part of the CNG system, considering the vehicle filled with the maximum load settled by the

manufacturer, may not fall below 300 mm, nor be placed on the lowest part of the car body.

- 3.1.b. When the cylinders are located behind the vehicle back axle, considering the vehicle filled with the maximum allowed load, their extreme planes must be placed at a distance that shall not be less than 500 mm from the extreme edge of the car body and above the unit's fleet angle, depending on the height of the back bumper, determined by the legislation in force.
- 3.1.c. For the protection of cylinders located according to 3.1b against impacts and in crossings of paved drainage, railroads, and roads, or objects in roads, two adequate resistance supports must be provided in the lower part of the equipment.
- 3.1.d. Storage must be divided into sets of no more than four (4) connected cylinders in parallel and each set must be connected to a valve manifold.
- 3.1.e. An automatic valve shall be placed in the joint between the valve manifold and the main tubing, blocking gas leaks in case of tubing system ruptures.
- 3.1.f. The assembly of the set of no more than four cylinders according to figure #2, is done to allow the operation of excess flow valves of cylinders, in case a rupture is produced in any of the pipes joining the cylinder to the valve manifold.
- 3.1.g. If cylinders need to be connected in another layout, it must be done in compliance with the safety level of the system proposed by this annex.
- 3.1.h. Minimum distance between the cylinders and the lateral part of the motor vehicle body must not be lower than 100 mm.

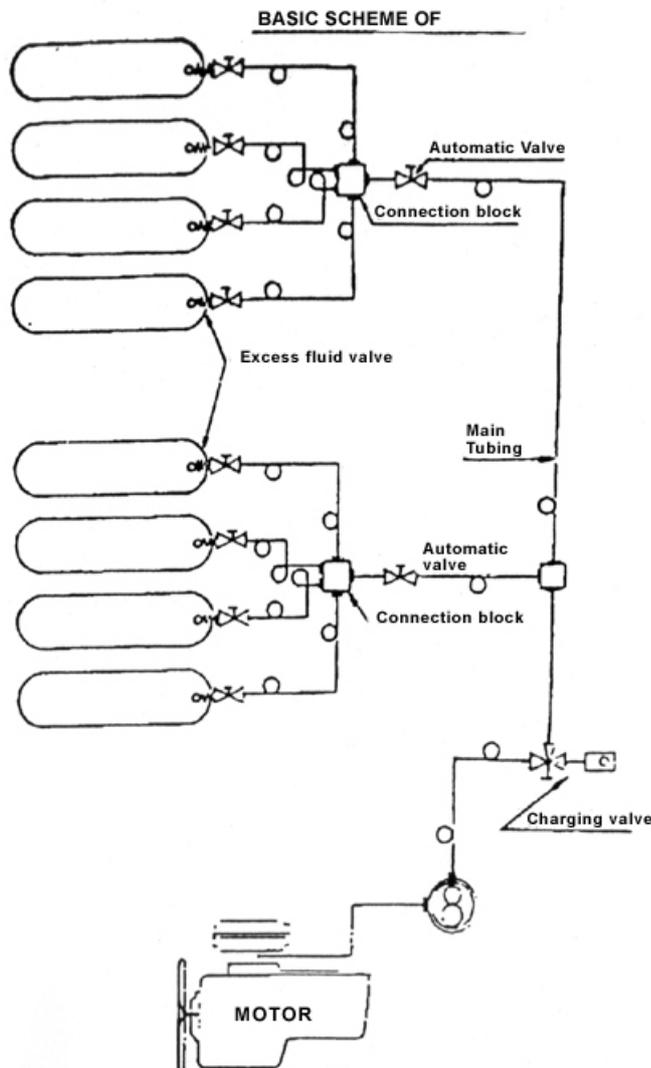


- 3.1.i. Cylinders shall be mounted with supports to withstand stresses equivalent to 8 times the weight of the full container, in any direction.
- 3.1.j. Supports shall be fixed on each end with two bolts which size allows each of them to withstand the full joint load.

3.2. Tubing and Fittings

- 3.2.a. Valves, tubing and other fittings fixed in the lower part of the motor vehicle shall be mechanically protected against impact or wheel particles.
- 3.2.b. The critical sections of valve and fittings through which fluid flow must be verified so that filling and consumption of CNG are not affected by the different services provided to the motor vehicle.
- 3.2.c. The fueling valve shall be safely located in the engine area or at the right size of the vehicle's body, at a distance of not less than 250 mm from its outer edge.
- 3.2.d. In case of valves, filling nozzles, fittings or other parts fixed on sides of the chassis, they shall be placed at a distance of not less than 250 mm from the outer part of the vehicle's body and shall contain reinforced structures ensuring the protection of the CNG equipment installation.
- 3.2.e. In case another filling system is proposed, its approval shall be subject to design assessment and operational reliability.

Figure N°2



3.3 Motor vehicle body

- 3.3.a. The CNG system shall be isolated from the Passengers or load compartment, in a gas-tight enclosure.
- 3.3.b. The side flaps must be ventilated by means of grids or fixed openings on both sides of the car body, at a maximum distance of 120 mm below the floor, along the whole length of the cylinders, in order to avoid the gas accumulation in case of leaks. (See Figure N°1)
- 3.3.c. The same criteria must be applied to the engine area in all the vehicle's width locating the ventilation in the highest part of the engine span

3.4 Electrical system

Batteries shall be located in an area where its electrolyte does not sparge any CNG circuit component and does not produce short circuits between cables and terminals that may make the system peril.

3.5 Engine

Whether a motor vehicle's conversion to use natural gas in its propulsion system implies modifying its engine or not, it must be ensured during the approved type tests that the operation is fully reliable.

3.5.1 Exhaust gases temperature.

Adding to what has been set forth in point 7 of section 3.5.1 of GE N° 1-115 Standard, in the CNG converted engines operation tests, verifications shall be performed to ensure that the maximum temperatures of exhaust gases do not exceed the limits recommended by engine manufacturers, considering that high temperatures not only damage material in hot areas of the engine, but also increase the emission of pollutants in exhaust escape.

4. CONVERSION WORKSHOPS FOR CNG EQUIPMENT TO BE INSTALLED IN PASSENGERS PUBLIC TRANSPORT UNITS.

4.1 Installation workshops

Workshops certified to convert equipment to be installed in Passenger Public Transport units using this equipment in their propulsion system shall directly depend on the companies that manufacture this type of equipment.

4.2 Guarantee

Once the equipment has been mounted and all the safety issues have been reviewed, the CNG Fuel System Supplier shall provide the motor vehicle owner a guarantee covering the CNG equipment.

This guarantee shall remain open for the first 15000 km and shall be completed by the technical responsible once all the safety items have been supervised.

The vehicle owner will also receive a certificate and an operation and maintenance manual.

4.3 Tools

Workshops shall be equipped with installations and tools as the ones recommended in Standard GE N° 1-115, subsections 3.6.1 to 3.6.5 and the test elements required by standard GE N° 1-116.

4.4 Workshop layout

Workshops layout shall be designed with the following different areas:

- a) CNG fixing elements construction and welding area

- b) Conversion kits mounting area
- c) Engine adaptation or modification area
- d) Converted motor vehicles maintenance area
- e) Testing area

4.5 Equipment

The minimum equipment required at these workshops, besides the equipment required by standard G.E. N°1-115 shall consist of the following:

- a) Air compressor (working pressure: 7 bar)
- b) Assembly of inert gas cylinders
- c) Hydrostatic pump (minimum test pressure: 300 bar)
- d) Assembly with minimum hoist capacity of 500 kg
- e) Inspection pit
- f) Oxyacetylene and static electric welder

4.6 Personnel

The Installation workshop personnel must comply at least, with the following requirements:

The CNG Fuel System Supplier's technical supervisor shall be fully responsible for his own conversion workshop and for possible third party owned workshops contractually related to him for the mounting of CNG equipment.

The technical supervisor and experts in some of the following fields shall run these workshops:

- Mechanical technician
- Electromechanical technician
- Motor vehicle technician
- Technician in aeronautics, naval expert or equivalent

Experts must be certified by Gas del Estado and must have received training courses on CNG, delivered by the technical expert.

Mounting lines must be integrated by qualified workers and assistants accrediting specific training in CNG

5. HYDROSTATIC TEST

Once the CNG Fuel System has been fully mounted, if a leak test at 200 bar cannot be performed according to section 1.2.2 of Standard GE 1-116, a hydrostatic test shall be performed with the following procedure:

- 5.1. Filling of the whole system with CNG, including cylinders, with N₂ to 4 bar pressure gauge through the fueling valve, ensuring there are no leaks.
- 5.2. Storage cylinder shutting of valves.
- 5.3. Slow disconnection of the CNG regulator high pressure inlet connection, to allow venting of N₂ in the tubing system.

- 5.4. Through the disconnected high pressure connection, hydraulic liquid (water) is injected and pressure is slowly increased until it reaches the test pressure of 300 bar at many stages, maintaining the system pressurized for 5 minutes and verifying the absence of leaks and alterations in the installation.
- 5.5. Slow reduction of pressure and subsequent purging of the fuel lines, removing hydraulic liquid by means of N₂ remaining in the cylinders, ensuring that the pressure inside the cylinders is equalized at a slightly higher value than that of atmospheric pressure, to prevent air from entering the system.
- 5.6. Careful reinstallation of the high pressure connection to the regulator and any other connection that needs to be activated to completely eliminate hydraulic fluid.
- 5.7. When the first CNG tank fill is performed, the absence of leaks throughout the whole installation must be verified, including the low pressure stage and carburetor, before igniting the engine.

6. TECHNICAL DOCUMENTATION

CNG Fuel System Suppliers for Passengers Public Transport units that use CNG in their propulsion system must submit the following technical documentation.

- 6.1. In addition to what is included in section 4.5, standard G.E 1-115, the following technical documentation must be submitted to GAS DEL ESTADO for each vehicle type:
 - a) Plan of cylinders layout with fixing details
 - b) Lay out of tubes and fittings, identifying installation supports and protective devices.
 - c) Details of foreseen gas tight housing, ventilation and vents.
- 6.2. According to what is stated by the Regulation for the Permit of Passengers Public Transport Vehicles, for each CNG modified or new vehicle model, the following certifications must be obtained.

7. APPROVED TYPE PERMIT

Permit of each unit model (Approved type) shall strictly comply with point 3.5.1 of standard G.E N° 1-115, especially considering:

Frame
Brake system
Suspension system

The professional representing the CNG Fuel System Supplier, must submit the technical reports and corresponding verifications performed at their own workshops or at third party ones. Once this documentation is approved, the pertinent certificate of conformance shall be issued.

8. POLLUTANTS

Atmosphere pollutants are: carbon monoxide (CO), Hydrocarbons (HC), Nitrogen Oxides (NO_x) expressed as (NO₂), suspension particles and fumes of vehicles with diesel engines (diesel and CNG) or spark ignited (gasoline or CNG)

The methods for assessing atmospheric pollutants shall be established by competent National, Provincial or Municipal agencies.

9. POLLUTION LEVELS

9.1. Level resulting from the homologation of new engines or engines converted to use CNG.

Atmosphere generated by exhaust gases from new or modified engines using CNG must not exceed the maximum limits accepted in the Air Quality Standards stipulated by Law N° 20.284/73 of Preservation of air resources and in the code of Environmental Pollution Prevention of the Buenos Aires Municipality (ordinance Nr. 39025, May 31st, 1983)

9.2. Acceptable levels

Pollutants	
Suspension particles	
C.A.P.C	0.500 mg/m ³
C.A.P.L	0.150 mg/m ³
Carbon monoxide (CO)	
C.A.P.C	15.0 mg/m ³
C.A.P.L	3.0 mg/m ³
Nitrogen Oxides (NO ₂)	
C.A.P.C	0.4 mg/m ³
C.A.P.L	0.1 mg/m ³

C.A.P.C: Acceptable concentration for short periods.

It is the concentration of pollutants which value shall not be exceeded in 20 consecutive minutes that may affect the health and assets of the community

C.A.P.L: Acceptable concentration for long periods.

It is the concentration of pollutants which value shall not be exceeded in 24 consecutive hours that may affect the health and assets of the community.

9.3. Requirements to drive on public roads

Any CNG new or converted motor vehicle shall not be able to circulate along public roads if it does not comply with the following limits of emission through the exhaust pipe or ventilation case, calculated in slowed mode (ralenti).

Carbon monoxide (CO) = 4.5% maximum in exhaust gas volumes

Hydrocarbons (HC) = 0.15% maximum in mass weight of fuel used by the engine

Black fumes = Maximum opacity of six (6) of the Bacharach scale

- 9.4. Acceptable levels for each component must be periodically inspected by the pertinent authority while technological improvements achieve their reduction and optimize the air quality.

RESOLUTION 165 (ANNEX 1, standard GE N 1-116)

ADLA L-D

To this effect we shall consider July 1990 as a basis, and as current index, the one corresponding to the second month, previous to payment date.

AUTHORIZED SIGNATURE AND SEAL

CERTIFICATION FROM NATIONAL OR PROVINCIAL AUTHORITIES HAVING
JURISDICTION.

RESOLUTION 165 (UNDER SECRETARIAT OF ENERGY)

Passenger Public Transport - Safety Standards for the use of Compressed Natural Gas - Approval.

Date: October 12, 1990

Issuance: B O 11/1/90

Laws quoted: law N# 20.284: XXXIII-B.1409; ord. 39.025 (Municipality): XLIII-B, 1844.

1. To approve annex N 1, Passenger Public Transport, included in standard GE N 1- 116 - Minimum technical and safety specifications and standards for mounting CNG equipment in motor vehicles and methods of testing included in Annex 1 of that specification.
2. The workgroup for Natural gas implementation in Transport, formed by resolution 428/86 must compile the experiences and observations arising from the use of these standards and suggest the modifications it deems convenient.
3. Communicate, etc. - Araoz

ANNEX 1, standard GE N 1-116

PASSENGER PUBLIC TRANSPORT

3. PURPOSE

- 1.2 To determine the additional safety conditions for motor vehicles using Compressed Natural Gas (CNG) as fuel in their propulsion system, included

in the Regulation for the Permit of Passenger Public Transport, last version, issued by the Transport Under Secretariat.

4. GENERAL ASPECTS

- 2.5 Modifications in new and used motor vehicles
Vehicle modifications to allow the use of CNG, regardless of whether the unit is in use or has just come out of the factory, must agree with the Regulation for the Permit of Passengers Public Transport, and provincial and municipal regulations in force.
- 2.6 CNG Fuel System for Passengers Public Transport units.
Components assembled as a system described in subsection 1.2.1 of G. E. 1-115 standard with added components and with the necessary technology for the adequate CNG conversion and operation of the units, completely in accordance with the regulations stated in 2.1
- 2.7 CNG Fuel System Supplier for the use of compressed natural gas in Passengers Public Transport units.
Physical or legal entity who assembles the different components integrating the CNG Fuel System for Passengers Public Transport units, and complies with what is indicated in standard GE N°1-115, subsections 1.2 and 3.5.
- 2.8 Responsible persons in Public Transport companies.
Apart from the duties of each CNG user, Public Transport companies must keep a record of periodical inspections performed on CNG units. To this effect, they shall appoint responsible persons to record the inspections carried out on each unit, to ensure that they are carried out at authorized workshops, and to control repair works that may or may not be related to the CNG Fuel System.

3. ADDITIONAL MODIFICATIONS TO STANDARD GE N° 1-116

3.2 Mounting of cylinders

- 3.1.k. When the cylinders are located between the motor vehicle axles, the minimum distance to the floor, calculated as of the low part of the CNG system, considering the vehicle loaded with the maximum load settled by the manufacturer, shall not fall below 300 mm, nor be placed on the lowest part of the vehicle body.
- 3.1.l. When the cylinders are located behind the vehicle back axle, considering the vehicle loaded with the maximum allowed load, their extreme planes must be placed at a distance that shall not be less than 500 mm from the extreme edge of the car body and above the unit's departure angle,

depending on the height of the back bumper, determined by the legislation in force.

- 3.1.m. Two adequate resistant profile bars must be provided in the lower part of the equipment for the protection of cylinders located according to 3.1b, against impacts and in crossings of paved ditches, railroads, and roads, or objects in roads.
- 3.1.n. Storage must be divided into sets of no more than four (4) connected cylinders in parallel and each set must be connected to a manifold block.
- 3.1.o. An automatic valve shall be placed in the joint between the manifold block and the main tubing, for the purpose of shutting off gas flow in case of tubing system rupture.
- 3.1.p. The mounting of the set of no more than four cylinders according to figure #2, in case a rupture is produced in any of the pipes joining the cylinder to the manifold block, is done to allow the operation of cylinders excess flow valves.
- 3.1.q. If cylinders need to be connected in another layout, it must be done in compliance with the safety level of the system proposed by this annex.
- 3.1.r. Minimum distance between the cylinders and the lateral part of the vehicle body must not be lower than 100 mm.
- 3.1.s. Cylinders shall be equipped with anchorage supports to withstand stresses equivalent to 8 times the weight of the full container, in any direction.
- 3.1.t. Anchorage support shall be fixed with two bolts which size allows each of them to withstand the full joint load.

3.2. Tubing and Fittings

- 3.2.f. Valves, tubing and other fittings fixed below the vehicle floor shall be mechanically protected against impact of particles thrown through the wheels
- 3.2.g. The critical areas of valve and fittings through which fluid flows must be verified so that filling and consumption of CNG are not affected by the running requirements.
- 3.2.h. The filling valve shall be safely located, in the engine area or at the right size of the vehicle's body, at a distance of not less than 250 mm from its outer edge.
- 3.2.i. In case of valves, filling inlet, fittings or other parts fixed on sides of the chassis, they shall be placed at a distance of not less than 250 mm from the outer part of the vehicle's body and shall contain reinforced structures ensuring the protection of the CNG Fuel System installation.
- 3.2.j. In case another filling system is proposed, its approval shall be subject to design assessment and operational reliability.

3.3 Vehicle body

- 3.3.d. The place where the CNG Fuel System is located shall be tight regarding the passengers or load compartment.
- 3.3.e. The lower body side must be ventilated by means of grids or fixed openings on both sides of the vehicle body, at a maximum distance of 120 mm below the vehicle floor, along the whole length of the cylinders, in order to avoid the gas accumulation in case of leaks. (See Figure N°1)
- 3.3.f. The same criteria shall be applied to the engine area in all the vehicle's width locating the ventilation in the highest part of the engine compartment inspection door

3.4 Electrical system

Batteries shall be located in an area where its electrolyte does not sparge any CNG circuit component and does not produce short circuits between cables and terminals that may make the system fail.

3.5 Engine

Provided a motor vehicle's CNG conversion implies modifying its engine or not, it must be ensured during the approved type tests that the operation is fully reliable.

3.5.1 Exhaust gases temperature.

Adding to what has been set forth in point 7 of section 3.5.1 of GE N° 1-115 Standard about CNG engine's performance tests, verifications shall be performed to ensure that the maximum temperatures of exhaust gases do not exceed the limits recommended by engine manufacturers, considering that high temperatures not only damage material in hot areas of the engine, but also increase the emission of contaminants in exhaust gases.

4. CNG FUEL SYSTEM INSTALLATION WORKSHOPS FOR PASSENGERS PUBLIC TRANSPORT UNITS.

4.1 CNG Fuel System Supplier Owned Installation workshops.

Installation workshops for CNG Passenger Public Transport units shall directly depend on the CNG Fuel System Supplier.

4.2 Guarantee

Once the equipment has been mounted and all the safety requirements have been checked, the CNG Fuel System Supplier shall provide the motor vehicle owner a guarantee covering the CNG equipment.

This guarantee shall remain open for the first 15,000 km and shall be closed by the technical responsible once all the safety items have been supervised.

The vehicle owner will also receive a certificate and an operation and maintenance manual.

4.3 Tools

Workshops shall be equipped with installations and tools as the ones recommended in Standard GE N° 1-115, subsections 3.6.1 to 3.6.5 and the test elements required by standard GE N° 1-116.

4.4 Installation workshop layout

Workshop area shall be divided into different sections:

- CNG fuel system fixing elements construction area, and welding area.
- CNG Fuel System mounting area
- Engine adaptation or modification area
- Converted motor vehicles maintenance area
- Testing area

4.5 Equipment

The minimum equipment required at these workshops, besides the equipment required by standard G.E. N°1-115 shall consist of the following:

- Air compressor (working pressure: 7 bar)
- Inert gas cylinders
- Hydrostatic pump (minimum test pressure: 300 bar)
- Hoist with minimum 500 Kg lifting capacity.
- Inspection pit
- Oxyacetylene torch and static electric welding equipment.

4.6 Personnel

The conversion workshop personnel must comply at least, with the following requirements:

The CNG Fuel System Supplier technical supervisor shall be fully responsible for his owned conversion workshop and for possible third party workshops contractually related to him, for the mounting of CNG Fuel Systems.

The technical supervisor and experts in some of the following fields shall run these workshops:

- Mechanical technician
- Electromechanical technician

Motor vehicle technician

Technician in aeronautics, naval expert or equivalent

Experts must be certified by Gas del Estado and must have received training courses on CNG, delivered by the Technical Representative.

Assembly lines must be integrated by qualified workers and assistants accrediting specific training in CNG.

6. HYDROSTATIC TEST

Once the CNG Fuel System has been fully installed, if a leak test at 200 bar cannot be performed in accordance to section 1.2.2 of Standard GE N° 1-116, a hydrostatic test shall be performed with the following procedure:

- 5.8. Filling of the whole system with CNG, including cylinders, with N₂ to 4 bar pressure gauge through the filling valve, ensuring there are no leaks.
- 5.9. Storage cylinder valves closed.
- 5.10. Slow disconnection of the CNG regulator high pressure inlet connection, to allow venting of N₂ in the tubing system.
- 5.11. Through the disconnected high pressure connection, hydrostatic liquid is injected and pressure is slowly increased until it reaches the test pressure of 300 bar at many stages, maintaining for 5 minutes the system pressurized and verifying the absence of leaks and alterations in the installation.
- 5.12. Slow reduction of pressure and subsequent purging of the fuel lines, removing liquid by means of N₂ remaining in the cylinders, ensuring that the pressure inside the cylinders is equalized at a slightly higher value than that of atmospheric pressure, to prevent air from entering the system.
- 5.13. Careful reinstallation of the high pressure connection to the regulator and any other connection that needs to be activated to completely eliminate hydrostatic fluid.
- 5.14. When the first CNG tank fill is performed, the absence of leaks throughout the whole installation must be verified, including the low pressure stage and carburetor, before igniting the engine.

6. TECHNICAL DOCUMENTATION

CNG Fuel System Supplier for Passengers Public Transport units that use CNG in their propulsion system shall submit the following technical documentation.

- 6.3. The following technical documentation must be submitted to GAS DEL ESTADO SE for each vehicle type, in addition to what is included in section 4.5, standard G.E 1-115:

d) Plan of cylinders layout with fixing details

- e) Layout of tubes and fittings, identifying installation supports and protective devices.
 - f) Details of tightness, ventilation and vents.
- 6.4. According to what is stated by the Regulation for the Permit of Passengers Public Transport Vehicles, for each CNG modified or new vehicle model, the following certifications must be obtained.

7. APPROVED TYPE PERMIT

Permit of each unit model (Approved type) shall strictly comply with point 3.5.1 of standard G.E N° 1-115, especially considering:

Frame
Brake system
Suspension system

The professional representing the CNG Fuel System Supplier must submit the technical reports and corresponding verifications performed at their own workshops or at hired ones. Once this documentation is approved, the pertinent certificate of conformance shall be issued.

8. AIR CONTAMINANTS

Air contaminants considered are carbon monoxide (CO), Hydrocarbons (HC), Nitrogen Oxides (NO_x) expressed as (NO₂), particulate matter and smoke emitted by vehicles with diesel engines (diesel and CNG) or spark ignited ones (gasoline or CNG)

Pertinent National, Provincial or Local agencies shall issue the air contaminants assessment methods.

9. AIR POLLUTION LEVELS

9.5. About environmental control

Environment affected by exhaust gases from new or modified CNG engines shall not exceed the maximum allowable limits ruled by the Air Quality Standards stipulated in Preservation of Air Resources Law N° 20.284/73 and in the Buenos Aires City Environmental Pollution Prevention Code (ordinance Nr. 39025, May 31st, 1983)

9.6. Acceptable levels

Contaminants	C.A.P.C	C.A.P.L
Particulate matter	0.500 mg/m ³	0.150 mg/m ³
Carbon monoxide (CO)	15.0 mg/m ³	3.0 mg/m ³
Nitrogen Oxides (NO _x)	0.4 mg/m ³	0.1 mg/m ³
Sulfur dioxide (SO)	0.5 mg/m ³	0.03 mg/m ³
Lead (Pb)	0.01 mg/m ³	0.01 mg/m ³
Ozone-oxidant (O ₃)	0.1 mg/m ³	0.03 mg/m ³

C.A.P.C: Acceptable concentration for short periods.

It is the limit concentration of pollutants in 20 consecutive minutes interval of time that may affect the health and assets of the community.

C.A.P.L: Acceptable concentration for long periods.

It is the limit concentration of contaminants in 24 consecutive hours interval of time that may affect the health and assets of the community.

9.7. Driving requirements on public roads

Any CNG new or converted motor vehicle shall not be able to circulate along public roads if it does not comply with exhaust pipe or from ventilation crankcase emission limits, calculated in ralenti mode.

Carbon monoxide (CO) = 4 % maximum in exhaust gas volumes

Hydrocarbons (HC) = 0.10 % maximum in mass weight of fuel used by the engine

Black smoke = Maximum opacity of four (4) of the Bacharach scale

9.8. Acceptable levels for each component must be periodically reviewed by the pertinent authority provided technological improvements achieve their reduction and optimize the air quality.

9.9. Motor Vehicles with diesel engine

Any motor vehicle fed with dual fuel diesel and CNG circulating along public roads shall not exhaust black smoke equivalent to 5 or higher of the Bacharach scale. For control purposes, the local authorities pertinent practice procedures shall apply.

9.10. Spark ignited motor vehicles

Local homologation requirements shall be complied with any CNG new or converted motor vehicle, in accordance to Buenos Aires City Environmental Pollution Prevention Code as a guidance, once fulfilling the manufacturer or importer's required procedures of adjustment, tuning and verifications, before the vehicle is delivered to the user.

9.11. Tests

Type I test: Air contaminant exhaust gases evaluation, by testing a simulated predetermined circuit in an intensive traffic urban area, after cold ignition.

Type II test: CO₂ emission in ralenti mode evaluation.

Type III test: HC crankcase emission.

The methods of gas collection and analysis must be those set forth in the previously mentioned code. Carbon monoxide, hydrocarbons and nitrogen oxide masses must not exceed the values of the following table, depending on the reference weight (Pr) of each vehicle.

Pr Kg	NO ₂ Mass grams / test	CO Mass grams / test	HC Mass grams/ test
Pr < 750	10	80	6.8
750 < 850	10	87	7.1
850 < 1020	10	94	7.4
1020 < 1250	12	107	8.0
1250 < 1470	14	122	8.6
1470 < 1700	14.5	135	9.2
1700 < 1930	15	149	9.7
1930 < 2150	15.5	162	10.3
2150 < Pr	16	176	10.9

CNG converted vehicle shall be tested on a dynamometric bench fitted with brake system and inertia wheel. A continuous totalizing 13 minute test of four cycles shall be performed. Each cycle includes 15 different modes (ralenti, acceleration, stabilized speed and speed down)

Exhaust gases shall be collected in one or more bags during the test and shall be analyzed once the filling is completed.

10. Permanent Advisory Committee

A Permanent Advisory Committee, made up of M.O.S.P (Ministry of Works and Public Services) representatives from the Under secretariats of Energy and Transport, Gas del Estado S.E, Municipalidad de la ciudad de Buenos Aires and CNG Fuel System Suppliers for CNG Passenger Public transport, shall deal with all the issues indicated in this standard.

Figure N°1

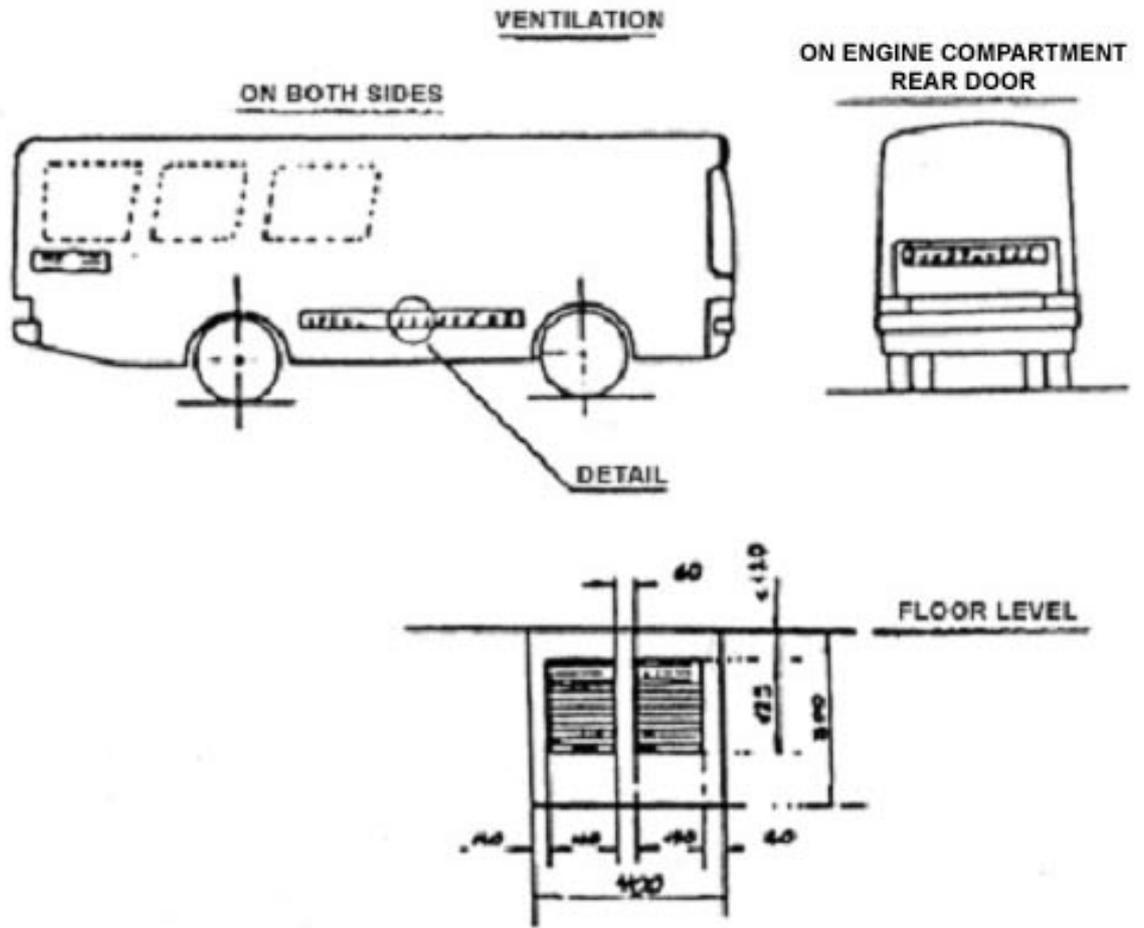


Figure N°2

