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TECHNICAL SPECIFICATION
CNG CARBON FIBER COMPOSITE
CYLINDERS INSTALLATION, USE
AND CONTROL



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TECHNICAL SPECIFICATION CNG CARBON FIBER COMPOSITE CYLINDERS INSTALLATION, USE AND CONTROL

SECTION 1

GENERAL

1.1. PURPOSE

This Specification intends to set the requirements for the installation, use and control of high pressure cylinders for compressed natural gas (CNG) system manufactured according to US ANSI/IAS-NGV2 or international ISO 11439 standards, applicable to carbon fiber composite cylinders .

This document applies to Type 3 cylinders with aluminum liner. It may also be used for other types of carbon fiber wrapped cylinders, approved according to the standards stated above, but it shall only apply if accepted by the manufacturer or importer, the intervening Certification Organization and the Authorized Entity.

It covers the use of this type of cylinders in passenger public transport supplementing the legislation in force. Its use in cargo fleets shall depend upon the evaluation carried out by the Authorized Entity.

1.2. SCOPE

This Specification comprises all those persons related to the CNG system defined by Resolution ENARGAS N° 139/95 or one superseding it, who shall strictly comply with the provisions contained herein in all cases in which this Technical Specification applies.

The staff of the Cylinders Periodic Inspection Center (CRPC) that carry out those controls included in Annex 1 and the CNG Fuel System Suppliers (PEC) and Installation Workshops (TdM) shall be acquainted with the contents of this document and comply with it.

Whenever applicable, the provisions included in GE-N1-116 and its Annex 1, and Resolution ENARGAS N° 139/95, its amendments or related ones shall be considered only if they are consistent with this Specification.

1.3. APPLICABLE AND REFERENCE DOCUMENTS

For drafting this Specification the following was considered:

- a) ANNEX Nr. 1 of GE-N1-116 Standard "Passenger Public Transport".

- b) ANSI/IAS - NGV 2 - 1998 "American National Standard for Basic Requirements for Compressed Natural Gas Vehicle (NGV) Fuel Containers".
- c) ANSI/IAS - PRD 1-1998 "Pressure Relief Devices for Natural Gas Vehicle (NGV) Fuel Containers".
- d) CANADIAN GAS ASSOCIATION STANDARD B 149.4 - M 91 "Installation of NGV Fuel Systems Components & Containers on Highway Vehicles for the Motive Power".
- e) COMPRESSED GAS ASSOCIATION CGA C 6.4- 1998 "Methods for External Visual Inspection of Natural Gas Vehicle (NGV) Fuel Containers and Their Installations".
- f) Technical Specification – Fastening devices for CNG cylinders ET-ENRG-GD N° 1/1997, ENARGAS.
- g) ISO 11439 "Gas cylinders - High pressure cylinders for the on-board storage of natural gas as a fuel for automotive vehicles", first edition: Sept. 2000.
- h) NATIONAL FIRE PROTECTION ASSOCIATION NFPA 52 - 1998 "Compressed Natural Gas (CNG) Vehicular Fuel Systems Code".
- i) GE-N1-115 Standard -1984 Regulations, Definitions and Terminology. Specifications and Procedures.
- j) GE-N1-116 Standard - 1984 Minimum Technical and Safety Specifications and Standards for Mounting CNG Equipment in Motor Vehicles and Methods of Test.
- k) GE-N1-117 Standard - 1984 Technical Standards for components designed to operate with compressed natural gas (CNG) in vehicles carburetion systems and operation requirements.
- l) GE-N1-119 Standard – Parking and Garages. Difficulties and accidents. Tank filled with CNG.
- m) GE-N1-144 Standard -1991 Technical Specification for periodic inspection of CNG seamless steel cylinders.

Other codes, specifications or standards from recognized technologically developed countries experienced in the use of CNG may be used only if their equivalence as regards safety and efficacy can be demonstrated by the comparative technical analysis carried out by the TR. It shall be submitted to consideration of the CO according to the regulation in force.

1.4. DEFINITIONS

The following definitions apply to this Specification:

- a) **TYPE 3 CYLINDER:** CNG cylinder which service pressure does not exceed 200 bar, made of a resin impregnated continuous filament (carbon fiber) wound over an aluminum liner, fully wrapped, approved according to standard ANSI/IAS-NGV2 or ISO 11439 , and qualified by a CO.
- b) **CRPC:** Cylinders Periodic Inspection Center
- c) **AUTHORIZED ENTITY:** Ente Nacional Regulador del Gas (ENARGAS) or other appointed by it.
- d) **EQUIPMENT:** Set including cylinders Installation mounted on a motor vehicle considering at least the following:
 - mechanical protection,
 - high pressure tubing,
 - fastening devices,
 - fittings,
 - manifolds,
 - manual and excess flow valves or other automatic shut off device,
 - venting and pressure relief safety devices,
 - filling valve,
 - gas detector (when required).
- e) **FLEET:** Group of vehicles of a transportation company, each of them identified by an internal number.
- f) **CNG:** Compressed Natural Gas.
- g) **CERTIFICATION ORGANIZATION (CO):** Organization accredited by the Authorized Entity according to Resolution ENARGAS N° 138/95, amendments or related ones.
- h) **PEC:** CNG Fuel System Supplier registered at the ENARGAS Registry of Qualifying Licenses, according to Resolution ENARGAS N° 139/95.
- i) **FLEET REPRESENTATIVE:** Person from the transportation company staff in charge of fleet maintenance, trained enough so as to detect possible

anomalies in the equipment installation, which finding or potential anomaly makes him ordering a thorough inspection and repair to be done by the CNG Fuel System Supplier. The Fleet Representative should have been trained by the PEC that issued the first qualification.

- j) **TR:** Technical Representative of PEC or CRPC.
- k) **TdM:** Installation Workshop of CNG Fuel System to be used in passenger public transport qualified by PEC.
- l) **CYLINDER SERVICE LIFE:** The service life for which these cylinders are safe shall be specified by the cylinder manufacturer. The maximum service life shall be twenty (20) years.

1.5. TECHNICAL DOCUMENTATION

For the CNG Fuel System approval, PEC shall submit before a CO or any other person appointed by the Authorized Entity, at least, the documents stated below. They shall be written in Spanish and shall bear the signature of the TR on every page. Measurements shall be expressed in the Argentine Legal Metric System (SIMELA).

If the documents are written in another language, they shall be translated into Spanish by a Certified Translator.

1.5.1. Statement of service issued by the cylinder manufacturer or importer

1.5.1.1 Installer's guide:

It shall include, at least:

- a) A statement that the cylinder design is suitable for use in the service conditions defined in this Specification for cylinder service life.
- b) Service life and inspection periods specifications.
- c) In-service control and inspection requirements, including the annual inspection.
- d) Fastening methods, mechanical protection, etc. required but not provided with the cylinder.
- e) Any other information necessary to ensure cylinder safe life, as indicated in point 3.5.8.
- f) Recommendation for cylinders correct use and installation.

- g) Method or guidelines for stowage and handling of transported or stored cylinders according to what is set forth in point 1.7. of this Technical Specification.

1.5.1.2. User's guide:

It shall be included in the cylinder guarantee, stating at least the following:

- a) Specifications of service life and inspection periods.
- b) Recommendations for correct use.

1.5.2. Drawings:

Plans for mounting the equipment shall be according to technical drawing IRAM standards, and shall show at least the following:

- a) Title, reference number, date of issuance, inspection number and any other data for its correct identification. Other formats from the country of origin of the product may be accepted only if they can be interpreted similarly.
- b) Material specifications, including minimum mechanical properties tolerance ranges and dimensions.
- c) Other data such as design pressure, test pressure, weights, details of the fire protection system, external mechanical protection, anchorage systems. These are the main parameters on which approval by the CO shall be grounded and shall not exclude other parameters.

1.5.3. Cylinder fastening device:

Fastening system for supporting the cylinder on the motor vehicle shall be stated.

For device design and approval, the provisions contained in ENARGAS Technical Specification, ET-ENRG-GD N° 1 "Fastening devices for CNG cylinders", or one superseding it shall be considered.

1.5.4. Pressure relief device:

According to the provisions of point 2.7.

1.6. EQUIPMENT APPROVAL

Prototypes and installation, use and control procedures shall be approved by a CO.

1.7. STOWAGE AND HANDLING OF IN SERVICE AND STORED CYLINDERS

- 1.7.1 The external surface of these types of cylinders is made of carbon fiber and resin, thus they shall be handled and stored carefully complying with provisions of 1.7.2, 1.7.3 and 1.7.4.
- 1.7.2 Avoid rolling, striking, dropping or stepping on cylinders since they may be scuffed or damaged with objects lying on the floor or stuck to the shoes.
- 1.7.3 The following shall be considered:
- During stowage, cylinders are not stable and tend to rotate on their axis; therefore, PVC or other non abrasive wedge shaped material shall be used to avoid floor contact or cylinder friction and rolling.
 - When the cylinders are wet or contain dust, their external surface is slippery.
 - During stowage, valves and fittings mounted on the cylinder may be damaged; therefore, they shall be handled with care. Strikes or deformations may cause irreversible damages.
 - Cylinders shall be stowed in a dry and sheltered place so as to protect them from sun, rain, etc.
- 1.7.4 Maximum quantity of cylinders to be stowed shall be indicated in the Statement of Service by their manufacturer or importer.

1.8. TESTS

The CO shall test the prototype for ensuring that pressure relief devices, excess flow or automatic valves operate correctly.

SECTION 2

INSTALLATION

2.1. REQUIREMENTS

Equipment installation shall comply with the provisions set forth by the cylinder manufacturer and by the ones included in point 1.6. of this Technical Specification.

Once the equipment is installed, it may not be modified or altered without previous authorization and later approval and re-authorization of the CO that approved the prototype

2.2. INSTALLATION CONTROLS

PEC's TR shall ensure that the equipment was installed according to the approved type. Likewise, the following minimum controls shall be carried out:

- Pneumatic test at working pressure, checking absence of pressure leaks in valves, joints, etc. with soapy water or other adequate means.
- Complete visual inspection, controlling surfaces, welding, cleanliness, threads adjustment, linearity and perpendicularity, manifold construction, vibrations, etc. so as to verify compliance with standards and art rules.

Those tests and assays shall be carried out in compliance with the guidelines included in the approved documentation.

Structural modifications that may arise during equipment installation shall be expressly approved by the unit manufacturer.

2.3. LOCATION OF CYLINDERS IN THE MOTOR VEHICLE

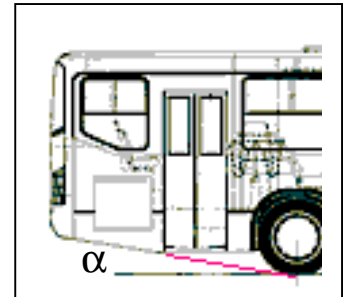
2.3.1. Cylinders shall be distributed such that all the installed instruments, valves and controls are readily accessible.

Besides, cylinder surface shall not be in contact or near objects that may cut or scratch, etc. them including friction produced by cables, tubes, vehicle or mounting components. A 20 mm clearance around the cylinder is recommended. In those areas where the vehicle structure is flexible, an additional clearance is required.

2.3.2. When the cylinders are located between the motor vehicle axes, the minimum distance to the floor, calculated as of the low part of the CNG equipment, considering the vehicle filled with the maximum load settled by the manufacturer, may not fall below 400 mm, nor be placed on the lowest part of the body.

The lower part of the CNG equipment shall never be lower than the vehicles rear axle height.

- 2.3.3. When the cylinders are located behind the vehicle back axle, considering the vehicle filled with the maximum allowable load, their extreme planes must be placed at a distance not less than 500 mm from the extreme edges of the body and at the rear part, distance shall not be less than 100 mm from the external edge of the body and above the unit's departure angle (α), depending on the height of the back bumper, determined by the legislation in force.



- 2.3.4. Cylinder covered in this Technical Specification may be installed on the vehicle's roof covered according to point 2.5.2. For this issue, the body and chassis manufacturers shall express their approval to the PEC.

Vehicle structure shall be designed such as to bear cylinders weight considered with the maximum load and fittings. Height shall not exceed the one stated in point 2.5.3. of this Technical Specification.

Inside the vehicle and readily visible to the driver a legend shall be included stating the minimum necessary height for crossing a bridge at a certain speed.

- 2.3.5. Each cylinder shall be securely mounted such as not to contact the other cylinders.
- 2.3.6. When more than one cylinder is installed, they 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. If cylinders need to be connected in another layout, it must be assessed by the CO so as to ensure safety level required by Annex 1 of GE-N1-116 standard, its amendments or related ones and the tests required by point 1.8 of this Specification.

2.4. CYLINDERS FASTENING

- 2.4.1. Supports and fastenings shall be designed according to Technical Specification ENRG-GD N° 1/1997. Cylinder manufacturer or importer shall specify the fastening device to be used; this being approved by a CO.
- 2.4.2. A fastening device design and mounting shall consider the effects of cylinder contraction and expansion, based on the inner gas temperature and pressure.

- 2.4.3. Other supports and fastening devices not included by the cylinder manufacturer or importer shall not be used.
- 2.4.4. Contact between support and cylinder shall include an elastomer with the characteristics stated in the Technical Specification ENRG-GD N° 1/1997.
- 2.4.5. Supports shall be placed such as not to cover the cylinder warning and identification labels. They shall be readily visible.

2.5. CYLINDERS PROTECTION

- 2.5.1. Cylinders located under the chassis shall be fitted with an external protective cover against impacts. There shall be a minimum all around clearance of 20 mm between the cover and the cylinder parts and fittings, and it shall be designed such as to prevent internal build up of solid or liquid matter, and shall be corrosion resistant.

Cylinders shall be protected by a metal reticulated structure or similar device clearly separated. It shall be designed such as to prevent equipment damage in case of impact with stationary objects at a vehicle speed of 8 km/h in both directions (forward and backwards) or with moving objects at the circulation speed.

- 2.5.2. When cylinders are located on the top of the vehicle, there shall be a cover with a minimum all around clearance of 20 mm. It shall be designed such as to prevent internal build up of solid or liquid matter and shall be detachable for inspection. It shall be fitted with grids or venting conduits

Cylinders shall be protected by a metal reticulated structure or similar device clearly separated. It shall be designed such as to prevent equipment damage in case of impact with stationary objects at a vehicle speed of 8 km/h in both directions (forward and backwards).

- 2.5.3. Maximum allowable height on the vehicle circulation surface including the cover stated in 2.5.2 shall not exceed 4,000 mm. It shall be calculated as of the highest protective cover point with the vehicle empty and tires filled at maximum pressure specified by the tire manufacturer.
- 2.5.4. Avoid exposure to corrosive acids and to any other environmental condition that may deteriorate the protective cover specified by the cylinder manufacturer or importer
- 2.5.5. The compartment in which the cylinders are mounted shall not be used for storing or placing any other element.

2.6. CYLINDER MANUAL VALVE

A manual valve shall be assembled on the cylinder. Both shall be fitted with cylindrical threads. In this type of thread, valve and cylinder are sealed by means of a rubber O'Ring fit for contact with hydrocarbons.

Ring wrapping during Installation shall be avoided.

The following instructions shall be taken into account for correct assembling of the valve in the cylinder:

- The cylinder and valve sealing ring housings shall be cleaned with a damp cloth. Solvents (thinner, acetone, turpentine, gasoline, etc.) **must not be used**.
- The installed valve torque shall be enough for ensuring joint gas-tightness during service.
- Teflon tape, sealants or other adhesive shall not be placed on the valve thread.

2.7. PRESSURE RELIEF SAFETY DEVICE

Each cylinder shall be fitted with a manual valve and a pressure relief device.

Pressure relief device shall be designed and approved according to US ANSI/IAS PRD 1 Standard, last edition.

Venting manifold shall be designed such as to vent the cylinder's CNG in not more than 10 minutes in case of an emergency.

The pressure relief device shall be heat activated by a fusible component with a nominal melting temperature of $100^{\circ}\text{C} \pm 4^{\circ}\text{C}$.

If the cylinder is greater than 1.65 m length it shall be fitted with:

- Other pressure relief device at the opposite end of the cylinder.
- An additional pressure relief device in the manifold tubing connecting a group of no more than four cylinders, designed such as to allow fast cylinders venting, in case one of them is activated.

Installation design shall be such that all the pressure relief devices shall be interrelated and operate either when the cylinder manual valve is in open or in closed position.

2.8. FASTENING OF VENT AND HIGH PRESSURE TUBING

High pressure tubing shall be installed according to what is stated in GE-N1-116 standard.

Vent tubing shall be secured to the vehicle, with a 600 mm clearance to avoid improper vibrations.

Pressure relief devices vent tubing shall be high pressure type so as to avoid strikes during activation. They may be fitted with a non sparking (brass) flap type cap for avoiding accumulation of dirt inside such ventilation piping.

2.9. VENTILATION

Cylinders installed under the chassis shall be vented according to the provisions of Annex 1 GE-N1-116 standard.

If design is such that ventilation grids are smaller than the preset ones, gas detection devices fitted with sound and luminous alarm shall be installed in the driver's cabin.

If the cylinders are installed in the vehicle's roof according to 2.3.4., protective cover stated in 2.5.2 shall ensure ventilation on 5% of its surface.

SECTION 3

INSTALLATIONS INSPECTION

3.1. GENERAL ASPECTS

- 3.1.1 PEC shall indicate the equipment inspection requirements, including the conditions specified in Statement of Service mentioned in point 1.5.1 for cylinder inspection.
- 3.1.2 CRPC shall inspect the cylinder according to the procedure included in Annex 1 and the manufacturer's recommendations. Inspections shall be documented by the CRPC and such documents shall be available for the authority having jurisdiction following the procedure of ENARGAS Resolution N°139/95, its amendments or related ones. Documents shall be signed and sealed by the CRPC's TR.
- 3.1.3 Fleet responsible shall keep a record of the unit's inspections, according to the training given by PEC.

3.2. PERIODIC INSPECTIONS

3.2.1 Annually:

PEC shall inspect the vehicle so as to check cylinders deterioration and leakages, fastening and mounting, and that they have not been altered or changed.

If severe external damage is observed, the cylinder shall be dismantled and delivered to a CRPC for its verification.

3.2.2. Three-yearly:

Any TdM qualified by a PEC or the PEC itself shall dismantle the cylinders and deliver them to a CRPC for visual inspection, according to Annex 1.

3.3. NON PERIODIC INSPECTIONS AND TESTS

- 3.3.1 If safety has been affected by a repair, alteration, accident or if the original characteristics may have been altered, additional tests shall be requested.
- 3.3.2 In case of a motor vehicle accident, cylinders shall be inspected according to Annex 1.

3.4. INSPECTION EQUIPMENT AT THE INSTALLATION WORKSHOP (TdM)

3.4.1.- High intensity lamp: shall be used for inspecting cylinders external surface, fastening system, valves, venting lines, etc.; lighting on the inspected area shall be at least, 500 Lux.

3.4.2.- Inspection mirrors: shall be used as a supplement for inspecting those areas of the cylinder surface which are not readily visible.

3.4.3.- Manual tools: shall be used during the annual inspection for removing cylinder caps or protective coatings, etc., for inspecting the equipment components.

3.4.4.- Torque wrench: shall be used for checking cylinders fastening and valve torque.

3.4.5.- Visual comparators: cylinder manufacturer or importer shall provide a catalog as visual comparator in which the usual defects of these types of cylinders are included, to be used during inspection for a better assessment.

3.5. INSTALLATION INSPECTION

TdM personnel shall verify:

3.5.1 The lack of damages that may be produced by tools, road rubble or debris or by proximity to the exhaust pipe system on the cylinders, based on the provisions of point 1.5.1.1. c).

3.5.2 That clearance all around the cylinder complies with provisions of point 2.3.1.

That clearance between the cylinder and its protective cover complies with provisions of point 2.5.

3.5.3 That equipment installation complies with verification requirements stated in point 2.9.

Tubing shall be free from debris, insects, etc.

3.5.4 That cylinder tubing is installed such as to avoid vibration or friction damages, complying with provisions of point 2.8.

3.5.5 That there are no signs of damage resulting from chemical products or moisture exposure. Installation shall ensure an effective drainage of water or other fluids preventing them from contacting the cylinders fastening devices.

Among the alterations that may be produced by chemical damage, the following are included: corrosion, discoloration, holes, swelling, etc. and the composite coating may even be ruptured in small blocks limited by net and deep cuts.

3.5.6 Signs of strikes or impacts on the equipment or body

This cylinder type is highly resistant to impact, but its structure may be seriously damaged if subjected to excessive loads applied in a specific area.

Impact damage may arise during cylinder transportation or service life. Dropping or striking the cylinder before installation or certain conditions during service life, for example car accidents, may produce those impacts.

Impact damage differs from other type of damages in which the cylinder wall, instead of the cylinder surface, is the one affected by deterioration. Composite cylinders surface tends to recover after impact not showing dents as steel cylinders do.

3.5.7 That cylinders service life has not expired; in this case, cylinder may be removed from service and delivered to a CRPC for destruction.

3.5.8 In any of the following cases, cylinder shall be disassembled for CRPC assessment.

3.5.8.1 If the cylinder was affected by fire, subjected to a bullet or strike impact, fiber cuts or if damaged by any other means.

3.5.8.2 In case there is spontaneous gas smell, unexpected loss of gas pressure, unjustified friction, etc.

Cylinders with apparent gas leaks shall be removed from service and delivered to a CRPC.

Gas leaks may be verified using a soapy solution or an explosive mixture detector

Detectors shall be calibrated according to manufacturer's preset frequency.

3.5.8.3 For installation in another vehicles.

3.5.9 Cylinders fastening device.

If the cylinders fastening device is loose, its components shall be inspected in detail and the instability source eliminated. Likewise, care shall be exercised to inspect supports, bolts and elastomer used as protective joint so as to detect signs of wear or corrosion, replacing damaged components.

3.5.10 Pressure relief devices and valves inspection.

Cylinder manual valve and pressure relief device connections inspection shall include the following:

- a. Valve inspection and pressure relief device Installation. No signs of distortion or other damages shall be observed. Damaged components shall be replaced.
- b. Detection of gas leaks in high pressure tubing and joints with cylinder manual valve and pressure relief device connection. Leaks shall be immediately eliminated. Leaking tubing shall be replaced.
- c. External inspection of pressure relief devices for detecting corrosion, damages, rust, strikes, mechanical defects, leakages, extrusion of fusible metal, loose components, etc.

Recommendations for clearing pressure relief devices shall be provided by the manufacturer or importer.

If a pressure relief device is not suitable for service, it must be destroyed. Use of defective operation or condemned pressure relief devices is forbidden.

When a cylinder valve is dismantled, the sealing ring shall be replaced by another ring which characteristics shall comply with the ones provided by the cylinder valve manufacturer.

ANNEX 1

METHOD FOR VISUAL INSPECTION OF TYPE 3 CARBON FIBER FULLY WRAPPED CYLINDERS WITH ALUMINUM LINER

1. INTRODUCTION

This Annex is intended for providing enough information and detail concerning type 3 carbon fiber composite cylinders for CNG vehicle service so as to provide the necessary elements to the CRPC for assessing safety conditions.

Guidelines of US CGA C-6.4 - 1998 “*Methods For External Visual Inspection Of Natural Gas Vehicle (NGV) Fuel Containers And Their Installations*” specification, edited by US Compressed Gas Association were considered for drafting this Annex.

The CRPC shall comply, at least, with the stated inspection method regardless any other assessment or test deemed convenient for a correct inspection and shall follow the cylinder manufacturer recommendations.

Although carbon fiber coating provides the cylinder high resistance against impact and wear, it does not eliminate the occurrence of potential accidents due to incorrect installation, improper use or lack of maintenance of safety devices.

2. GENERAL ASPECTS

Only the pertinent CRPC’s qualified personnel shall carry out the inspection process stated in this Specification. CA shall verify that control procedures are stated in the CRPC’s Procedure Manual.

The cylinder shall only be inspected visually. **Hydrostatic test shall not be carried out**, unless the manufacturer or importer, with manufacturer’s consent, authorizes or recommends such test for a specific case.

If there is any doubt regarding defects or issues not considered in this Technical Specification, the CRPC shall inform the manufacturer or importer so as to define how to proceed.

3. DEFINITIONS

In this Annex, the following shall mean:

- 3.1. **Fiber wrapping:** Automated process to provide higher resistance to fibers and plastic resins for cylinders construction.
- 3.2. **Letter of commitment:** Document issued by the cylinder owner authorizing destruction of the cylinder, valve or both when condemned.

- 3.3. **Condemned cylinder:** Cylinder that may not be refilled because its service life has expired or contains irreversible damages posing a risk on its integrity.
- 3.4. **Rejected cylinder:** Cylinder withdrawn from inspection due to defect or failure, until later verifications or controls allow continuing inspection or condemning that cylinder.
- 3.5. **Stress corrosion:** Crack in composite materials, usually sharp and perpendicular to the fiber direction. It may appear in group or isolated. Stress corrosion may result from serious exposure to chemical liquids and it is very unusual.
- 3.6. **Neck:** opening at the cylinder ends where the manual valve, the pressure relief device or a blind plug is installed.
- 3.7. **Impact damage:** Damage resulting from drops or strikes produced by other objects. Impact damages may affect the surface, the inner part or both.
- 3.8. **Damage - Level 1:** This is not a serious damage and it is considered normal. It shall not affect cylinder safety or continuous use. For example: few or not so deep scuffing, cuts or notches.
- 3.9. **Damage - Level 2:** This damage is more serious than Level 1, but cylinder may be repaired and returned to service according to the recommendations of the manufacturer. Level 2 cuts or gouges are deeper or greater in surface than the ones included in Level 1. Cylinders with Level 2 damages may not remain within that level after inspection. They may be at least repaired for being included in Level 1 or passed to Level 3 for condemnation.
- 3.10. **Damage – Level 3:** Cylinders included in this level shall be condemned. Damage is such that the cylinder is not suitable for service.
- 3.11. **Cut damage:** Damage resulting from a sharpie object in contact with the cylinder surface.
- 3.12. **Abrasion damage:** Damage resulting from wear, friction or intense rubbing of the cylinder material.
- 3.13. **Destruction:** Cylinder alteration rendering it useless for service.
- 3.14. **Pressure relief device:** Device installed in the cylinder or integrated with the cylinder manual valve that shall release the inner gas in case of emergency.

- 3.15. **Cylinder fastening device:** Support used for securing the cylinders to the motor vehicle designed such as to prevent cylinders damage and to absorb pressurization expansion.
- 3.16. **Hoop-wrap:** An over-wrap reinforcement parallel to the cylinder longitudinal axis withstanding most of the load in a substantially circumferential pattern rather than longitudinally.
- 3.17. **Full-wrap:** An over-wrap reinforcement for providing longitudinal load for cylindrical areas and ends. Reinforcement filaments are oriented parallel to the longitudinal axis of the cylinder.
- 3.18. **Manufacturing label:** It contains data required by the cylinder manufacturing standard.
- 3.19. **Ends:** Bottom and ogive cylinder parts.
- 3.20. **Carbon fiber:** Fiber used as liner reinforcement.
- 3.21. **Direct impact:** hard strike of cylinder without producing significant cut or damage to the surface. This impact may produce internal delamination and cannot be detected by visual inspection.
- 3.22. **Inspection marking:** Label or card placed by the inspector on the cylinder surface denoting approval. This label shall identify the CO, CRPC and periodic inspection date.
- 3.23. **Service pressure:** Settled pressure, marked in the cylinder label.
- 3.24. **Scuffs.** Minor abrasions damaging coating.
- 3.25. **External coating:** Treatment application on the external surface for providing environmental protection and enhancing its appearance.
- 3.26. **Resin:** Plastic material among reinforcement individual fibers.
- 3.27. **Cracking:** Effect that alters the resin coating providing opacity and “crystallized” appearance.
- 3.28. **Liner:** internal cylinder component preventing gas leakage from the cylinder structure.
- 3.29. **Delamination:** Damage resulting from the separation of the composite material into layers. Usually due to excessive load on the laminate surface.
- 3.30. **Overpressure:** pressure exceeding the maximum allowable pressures during filling process.

3.31. **Manual valve:** Device installed in the cylinder neck used for blocking gas outlet.

4. DESIGN GENERAL INFORMATION

4.1. General aspects.

CNG carbon fiber composite cylinders are suitable for CNG service. They are designed and approved according to the provisions of ANSI/AGA NGV2 or ISO 11.439 standard, or any other determined by the Authorized Entity, and classified as type 3 (fully reinforced). Their aluminum liner prevents gas leakage. As it is not resistant and thick enough for withstanding the entire load upon burst pressure, its whole surface is reinforced with carbon fiber.

Composite cylinders safe operation also depends upon correct installation and use of safety elements and devices, as for example fuse plugs.

4.2. Data included in the cylinder labels:

Data in the cylinder label shall be in Spanish and shall include, at least:

- The statement: "**User's Guide explains how to use the cylinder; in case of doubt regarding this cylinder proper use, installation or maintenance, contact:** (national manufacturer or importer name, address and telephone)".
- "**CNG ONLY**".
- The statement: "**Made on** (month and year of cylinder manufacture).
- "**DO NOT USE AFTER (month, year)**".
- "**Service pressure 200 bar**".
- Certification Standard and cylinder type (type 3).
- Pressure relief devices or valves, qualified for use with the cylinder, or how to get that information.
- Identification logotype of approved components according to ENARGAS Resolution N° 138/95, its amendments or related ones.
- Serial number.
- Part or batch number.
- Weight.

- Nominal water capacity.
- Approval date.

5. CYLINDER INSPECTION

5.1. Requirements for CRPC personnel

The personnel that shall inspect the cylinder, valve and pressure relief device shall comply, at least, with the following requirements:

- Two years of experience as CNG cylinder inspector.
- Be supervised by CRPC's TR, also counting with at least two years of experience as cylinders inspector.
- To evidence he has been trained by the cylinder Manufacturer or Importer who shall provide such training upon request of a CRPC.

5.2. Equipment.

CRPC shall include at least the following equipment besides that stated in GE-N1-144 standard or one superseding it:

5.2.1. Depth gauge: It shall be used for measuring accurately cuts, scuffs and abrasions depth. The use of a depth gauge model designed to this effect is recommended. An equipment for establishing flaws depth may be accepted.

5.2.2. Tape: A metal tape in mm shall be used for establishing cuts abrasion general area length and for assessing cylinder bulging.

5.2.3. High intensity lamp: An instrument for internal inspection, for example an optic fiber with at least 350 Lux lighting level, shall be used. It shall allow the identification of defects included in point 6 of this Annex and in Table Nr. 1.

The instrument shall be explosion proof when the absence of explosion mixture inside the cylinder has not been previously checked. Resolution capacity of these systems shall be at least similar to that achieved by direct visual inspection.

5.3. Intervals of periodic inspection.

CRPC shall inspect the cylinders every 3 (three) years, as of the manufacture or last inspection date.

5.4. Cylinder dismounting

Cylinder shall only be dismounted at a TdM, according to standards GE-N1-115 and GE-N1-116, related ones and amendments.

5.5. Cylinder transportation

When transported, it shall be adequately secured so as to prevent its displacement to the inner part of the transporting vehicle.

5.5.1. Cylinder transportation by the CRPC

CRPC shall be responsible for the cylinder.

5.5.2. Cylinder transportation by the PEC/TdM

Such PEC that authorized TdM, stated in the Letter of Commitment shall be responsible for the cylinder.

5.5.3. Cylinder transportation by the user

The user shall be responsible for the cylinder, which must be previously depressurized to the atmospheric pressure by the TdM.

6. MINIMUM REQUIREMENTS AND PERIODIC INSPECTION STEPS

All the cylinders taken to the CRPC shall be inspected as follows.

6.1. Integrity, identification and letter of commitment control

The cylinder shall be controlled so as to verify it is fitted with the manual activation valve as installed regardless its condition or use upon being taken to the CRPC.

If a cylinder is not fitted with the identification label or it is not in Spanish, or if the measurement units do not correspond to the Argentine Legal Metric System or if data is illegible, it must be condemned.

Cylinder **inspection shall not start** if the letter of commitment is not attached (see form in Annex 3).

6.2. Cylinder depressurization

Depressurization shall be carried out as follows:

- a) Consult the manufacturer's cylinder manual and any other document so as to determine if additional care is necessary. In case of doubt, consult the cylinder, manual valve or pressure relief device manufacturer or importer, as it corresponds, for further information.
- b) A grounding system shall be used, since a sudden discharge may generate enough static electric load to ignite the vented gas.
- c) Gas venting shall be subject to the CRPC's jurisdiction local regulations.

- d) When valve is open, gas outlet shall not be directed towards people or heat source.
- e) Valve shall open manually and smoothly so that remaining gas may be detected by the sound or pressure indicators; then, it shall be vented.
- f) Cylinder emptiness is not indicated by the absence of leaks, as valve may be blocked or cylinder may withhold liquids at low pressure.
- g) If there is any doubt regarding the existence of residual gas pressure, one or more trials shall be carried out so as to verify that valve passage is not blocked. Such trials shall include, for example, the incorporation of inert gas at 5 bar pressure, gauging its discharge.
- h) In case the gas flow in the cylinder valve is not blocked, it may be removed.
- i) If a cylinder valve is blocked, the cylinder shall be set aside so as to be emptied by an adequate method previously approved by the CO. If necessary, valve manufacturer or importer shall be consulted so as to determine how to proceed.

**IMPORTANT:**

Please remember that handling blocked pressure gas valves is highly risky. Only trained and skilled personnel may handle those valves. Safety precautions for preventing uncontrolled discharge of residual gas shall be taken.

6.3. De-valving

6.3.1. When the cylinder is emptied, valve shall be disassembled.

6.3.2. Remaining liquid shall be removed and checked so as to control if there are any substance that may pose a risk to cylinder integrity. In this case, later controls shall be intensified and, if necessary, the CO shall be notified.

6.3.3. Legislation in force within CRPC's jurisdiction shall apply to effluents.

6.3.4. If inspection is interrupted, a plug suitable for the cylinder thread shall be placed so that its tightness prevents the inlet of humid air or foreign matter.

6.4. Valve inspection and operation control.

After de-valving, the valve shall be controlled as follows:

6.4.1. It shall be clearly identified such as to easily determine its corresponding cylinder.

6.4.2. Valve shall be opened and closed without any difficulty; stem condition shall be controlled through inspection so as to ensure there are no signs of twisting, wear, deformation or other deterioration.

6.4.3. Valves shall be controlled for corrosion

6.4.4. Threads condition shall be controlled (diameters, sides, shape and length).

6.4.5. Valves complying with these requirements shall be returned together with the pertinent cylinder for reinstallation at the TdM.

6.4.6. Valves not complying with these requirements shall be rendered useless and the TdM shall return them to the user with material evidence of the defect and the pertinent report.

Note: The PEC enabling the installation shall be responsible for controlling pressure valve operation.

6.5. External and internal cleaning

Cylinder shall be adequately cleaned as indicated by the manufacturer or importer.

6.6. External visual inspection

After external cleaning, the whole external cylinder surface shall be visually inspected. The inspected area shall be lighted by, at least, 500 Lux.

Cylinder shall be carefully inspected since it may not evidence damage on its surface.

Cylinder surface shall be cleaned and free from powder or any other element which may prevent clear and safe assessment of cylinder condition and status as visual inspection is the first stage for control.

Evidences of strikes, swelling, loss of resin, broken fibers, leakages or ruptures are considered as damages – Level 3; therefore; such cylinders shall be removed from service and condemned.

Cylinder surface shall be inspected so as to detect signs of damages which shall be assessed and classified according to the following:

6.6.1. Cuts, scuffs and gouges:

Cuts or scuffs are defined as damages – Level 1 (Table 1) regardless of their quantity, length or orientation. For damages – Levels 2 and 3, the manufacturer or

importer's intervention is required.

6.6.2. Fire or excessive heat damages:

CNG cylinders maximum service temperature is 82 °C, except otherwise specified in their label. Excessive heat resulting if cylinders are not located conveniently away from the exhaust system or if they are involved in a fire may produce serious damages.

Burnt resin or surface burns may be evidence of temperature damage.

When high temperature exposure burns the resin it may result in loose fibers

Other signs of fire or heat exposure may be protective coating discoloration, label deterioration, connection distortions, etc.

Cylinders exposed to fire or high temperature are classified as damage – Level 3 and must be removed from service and condemned.

6.6.3. Chemical attack:

Cylinder shall be inspected to detect signs of chemical attack.

Chemical damage shall alter cylinder surface, for example: corrosion, discoloration, holes, swelling and rarely, composite coating shall rupture into small blocks limited by net and deep cuts.

Minor discoloration is considered as damage – Level 2 and shall be accepted only if it is proved that the chemical product was removed and surface cleaned according to the manufacturer's instructions

6.6.4. Environmental conditions:

Cylinder's external protective coating may be degraded due to sun exposure or other adverse conditions producing discoloration and potential deterioration of exposed external surfaces. This damage is considered as Level 2 only if fibers do not show signs of loss, looseness or rupture.

After inspection process, a protective coating shall be applied according to the manufacturer or importer's procedures for repairing the damaged cylinder surface.

Surface shall be prepared and conditioned according to the manufacturer or importer's procedures.

6.6.5. Projection:

if the cylinder's external deformation is significant, it shall be considered as severe structural damage. Cylinders showing projections shall be considered as damage

– Level 3.

6.6.6. Dents:

When dents depth is greater than 1.6 mm or their diameter is greater than 50.8 mm or both, they are considered as damages – Level 3 and the cylinder must be condemned.

On smaller dents, the manufacturer or importer's procedure shall be carried out.

6.6.7. Abrasions:

When some elements rub the cylinder surface it may result in abrasion. When such rubbing is gentle, surfaces are usually smooth and, sometimes, shiny. Otherwise, surfaces appear as a group of parallel cuts.

Cylinders showing evidence of strong abrasion shall be checked so as to detect if their surface underwent any impact or strike.

If abrasions or scuffs depth is smaller than 0.25 mm, they shall be considered as damages Level 1 and shall be accepted regardless of size, quantity or orientation. Exposed fibers shall be coated according to the manufacturer or importer instructions. If abrasion depth is equal to 0.25 or greater, it shall be considered as damage Level 3.

6.6.8. Impact damage:

Impact damage may result in delamination and rupture of composite layers used for cylinder manufacture.

Impact damaged surface includes cuts, strikes, projections, holes and fiber looseness, resin loss or change in color or appearance.

Impact areas shall be localized such as to facilitate inspection process.

Damage signs in cylinder walls include:

- **Surface permanent deformation:** Dents constitute signs of severe internal damages; therefore, cylinders shall be carefully inspected considering them as potential damage Level 2 or 3.

NOTE: This condition does not include surface holes that may be produced by certain impacts as for example with a small rock.

- **Projections:** If localized projections are found in cylinder walls, the cylinder must be condemned.
- **Color differences:** usually, impacted cylinders show differences in their

surface appearance, producing color changes as a result of protective coating delamination, cracking or scuffing, etc. When color differences are detected, such areas shall be checked for potential damages – Level 2 or 3.

- **Localized areas or surface ruptures:** External surface rupture areas of impacted cylinders may be semi elliptical, circular or linear and their color may change as indicated above. These areas shall be checked for potential damages – Level 2 or 3.

6.7. Threads control

The gauge shall be used for controlling that the thread meets the thread type stated in the cylinder approval certificate.

Defects shall be verified with the adequate instruments, for example: peaks wear or corrosion, ruptures, notches, cuts or thread dragging.

Cylinders are condemned when:

- a) their thread tolerance does not comply with the standard; or
- b) their required number or effective threads are less than 80% of regular threads according the manufacture standard.

7. REMOVED AND CONDEMNED

If the CRPC finds a cylinder with alterations, defects, etc it shall either:

- 7.1.** Condemn it if it evidences the conditions set forth in this Annex or Table 1; or
- 7.2.** remove it from the inspection process in order to reassess, re-qualify or retest it together with the CO, manufacturer or importer.

One of the following possibilities shall apply:

7.2.1. If reassessment, re-qualifications or retests determine that the alterations, defects, etc do not affect cylinder safety until the next three yearly inspection, inspection process shall continue.

7.2.2. If the cylinder complies with any of the conditions for condemnation, the point "Condemned cylinders destruction" shall apply.

8. CONDEMNED CYLINDERS DESTRUCTION

Before destroying the cylinder it shall be ensured that it does not contain any explosive mixture; however, inerting through inert gases, steam or water is not recommended.

The cylinder shall be destroyed by performing a longitudinal cut in the middle of its body covering at least 50% of its circumference.

After this process, cylinder defects causing its condemnation and cylinder label shall be visible.

9. PROCEDURES AFTER INSPECTION

9.1. Inspection result.

9.1.1. When the result is satisfactory:

De-valved cylinder and its valve shall be returned to the TdM or to the user, together with the documentation according to Annex 2.

Cylinder's integrity during transport shall be ensured according to point 5.5.

9.1.2. When the result is not satisfactory:

TdM shall provide the user a certificate issued by CRPC, the useless cylinder and its disassembled valve.

10. DOCUMENTATION OF INSPECTION RESULT

10.1. Inspection certificate.

A CRPC certificate shall be issued according to the model indicated in Annex 2, including cylinder and owner identification; it shall clearly state if the cylinder has «**FULFILLED**» or «**NOT FULFILLED**» the specific tests and the inspection procedure.

Three perfectly legible copies of this certificate shall be drafted to be submitted to: the owner, PEC and CRPC who shall file it with the test report during ten (10) years.

Each of these copies shall bear the original signature and seal of the CRPC Technical Representative.

10.2. Test report

Each inspected cylinder shall include a test report with all the corresponding inspection data. This report shall be correlatively numbered and filed during the term stated in 10.1. and for five (5) additional years as requested by the CO, on any means ensuring that the data shall not be altered.

The reports shall at least include:

- a) Test identification: number and date.

- b) Data compiled before cylinder inspection: make; serial number; initial approval date, working pressure; test pressure; volume; external diameter and thread type.
- c) Cylinder manufacturer or importer's CO.
- d) Valve inspection result.
- e) External visual inspection result, indicating defects noted during inspection and their assessment.
- f) Internal visual inspection result, indicating defects noted during inspection and their assessment.
- g) Thread verification result.
- h) Weight
- i) Responsible Inspector's Identification and signature for each inspection step.
- j) Observations.
- k) Signature and seal of the CRPC's TR guaranteeing the entire test report and determining the final result of the inspection.

10.3. Documentation traceability.

All the documents (Letter of Commitment, Test Report, Inspection Certificate, process control sheet, etc.) related to the same test shall allow their traceability.

10.4.- Condemned cylinders record

CRPC shall create and update a record of type 3 condemned composite cylinders, including at least, data about detected failure and service time.

Every condemned cylinder shall be reported to the CO and to the Authorized Entity, providing all the necessary background.

If condemnation is only due to internal causes, CRPC must inform the Authorized Entity within forty eight (48) hours as of condemnation.

10.5. Photograph record.

CRPC shall create and update a photograph record of the detected significant failures and shall deliver a copy to the Authorized Entity.

Each photograph shall clearly evidence the failure features and shall be identified by the cylinder make, model and serial number. It shall also include inspection date and CRPC name or logotype.

11. CYLINDER RE-VALVING

TdM in charge of installation shall re-valve the cylinder.

A blind cap or plug for protecting thread against damages and preventing the inlet of foreign matter or moisture shall be placed for transport.

Table 1

Damage Levels

| Condition | Level 1 | Level 2 | Level 3 |
|-------------------------------|----------------|--|---|
| Dents | -- | <1.6 mm depth or <50.8 mm diameter. | ≥1.6 mm depth or ≥ 50.8 mm diameter. |
| Abrasions | <0.25 mm depth | According to manufacturer or importer's recommendations. | □ 0.25 mm depth. |
| Environmental conditions | -- | Discoloration and deterioration of external surface | Excessive surface deterioration |
| Cuts, scuffs, gouges | <0.25 mm depth | ≥0.25 mm depth but lower than the one settled by the manufacturer or importer. | Greater than the one indicated by the manufacturer or importer. |
| Fire or excessive heat damage | -- | -- | Condemnation |
| Label | -- | -- | If identification is not possible or if service life expired. |
| Impact | -- | According to manufacturer or importer's recommendation | Permanent deformation |
| Gas leak | -- | -- | Condemnation |
| Projection | -- | -- | Condemnation |

ANNEX 2

CYLINDERS PERIODIC INSPECTION CENTER (CRPC) CERTIFICATE

(CRPC NAME)

CRPC Code:

(ADDRESS AND TELEPHONE NUMBER)

CRPC Internal Code:

TECHNICAL REPRESENTATIVE:

TECHNICAL REP. LICENSE NUMBER:

PEC :

INSTALLATION WORKSHOP (TdM):

TYPE 3 CYLINDER:

Make:

Serial number:

Homologation code:

Manufacture Month - year:

Material: Aluminum liner with carbon fiber

Capacity (dm^3):

OWNER

Name:

Identity Document N°:

Telephone:

Address:

Locality:

Province:

Zip Code.:

License Nr.:

The cylinder **FULFILLED** / **NOT FULFILLED** satisfactorily the requirements of Annex 1, Technical Specification ET-ENRG-GD N° 5.

Detected anomaly:

 Blisters Localized wear Dents Corrosion Cuts and scuffs Cracks Labeling defect Impact damage Abrasions Piercing Thread defect Heat or fire damage Others: Service life expired

INSPECTION DATE:

EXPIRATION DATE:

Signature and seal of the Technical Representative

ANNEX 3**LETTER OF COMMITMENT FORM**

Place and Date:

Form Nr:

Sirs (PEC/TdM name)

I am writing to you as regards ENARGAS (ET-ENRG GD N° 5) Technical Specification for the installation, use and periodic controls of CNG carbon fiber composite cylinders.

I hereby authorize the destruction of the cylinder, its valves or both in case of condemnation according to the inspection result, complying with the abovementioned Technical Specification.

I do hereby certify that I am the owner of the cylinders and valves included below and covered by this authorization:

| CYLINDER | | | VALVE | | | NOTES |
|----------|-----------|----------|-------|-------|-----------|-------|
| Make | Serial N° | Capacity | Make | Model | Serial N° | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

OWNER:

Name:

Identification Document (CI, DNI, LE, LC Nr):

Address:

Locality:

Zip code:

Province:

Telephone:

License Nr:

INSTALLATION WORKSHOP:

Address:

Telephone:

CNG FUEL SYSTEM SUPPLIER:

PEC/TdM TR Signature, type or print and document

Owner Signature and type or print

Form for proposals on Technical Specification for the installation, use and controls of CNG composite cylinders with carbon fiber.

Company:

Technical Representative:

Address:

Zip code:

Telephone Nr.:

Page:

Point:

Paragraph:

Quote:**proposal:****Substantiation for Proposal:****Signature:****Type or print:****Title:**

page of

INSTRUCTIONS TO COMPLETE THE FORM FOR PROPOSALS

- 1) Complete in bold letters (hand written or printed), with indelible ink.
- 2) In the space identified as "Quote", copy the text you propose to modify or else summarize it as long as there are no doubts or ambiguities about the text it refers to.
- 3) In the space identified as "Proposal", indicate the exact wording to be inserted.
- 4) In the space identified as "Substantiation for Proposal", state the problem that will be resolved or improved by your recommendation. Give the specific reason for your proposal including the technical bibliography on which it is grounded providing copies, if possible, or else describing the experience it is based on.
- 5) This Proposal must be submitted to the Distribution Management of the ENTE NACIONAL REGULADOR DEL GAS (ENARGAS) Suipacha 636 4° Piso, (C1008UAF) Ciudad de Buenos Aires