GE Nr 1- 144

TECHNICAL SPECIFICATION
PERIODIC RE-QUALIFICATION OF CNG SEAMLESS STEEL CYLINDERS ACCORDING TO IRAM 2529 STANDARD.

1991
GAS DEL ESTADO

1. PURPOSE

1.1 The aim of the mandatory periodical scheduled inspection and its testing on each cylinder is to verify the necessary requirements to ensure reliability and acceptability, according to the applicable technology, so that they are fit for service for another term based on the established frequency.

2. SCOPE

2.1 This Standard covers CNG seamless steel cylinders.

3. DEFINITIONS

3.2. Periodical inspection: Verification of technical conditions of a cylinder for correct and safe operation. This is done after a period of continuous or sporadic operation in accordance to the normative has expired.

It shall consist of a scheduled mandatory inspection regardless of its condition, or when requested as a result of other inspections or upon request of the authority having jurisdiction.

3.2 CNG: Compressed Natural Gas, hydrocarbon mainly made up of methane.

a. For vehicle use, at a normal working pressure of 200 bar at 21 + or - 1°C (GE N° 1-115 standard, point 3.1.1).
b. For use at the filling outlet, at a normal working pressure of 250 bar at 21 + or - 1°C (GE N° 1-118 standard, point 4.2.1.8)

3.3. Periodicity of inspections: interval between periodical inspections. Mandatory Scheduled Periodical Inspections shall be performed every five (5) years. The first one shall take place five years as of the manufacturing date.

3.4. Cylinder mass or tare: It is the one expressed in Kg and tenths of Kg of the cylinder and permanent fixed constructive elements. The valve shall not be considered.

3.5. Dent: Permanent hollow or cavity on the cylinder surface due to an impact, not affecting its thickness.

3.6. Gouges: lines or cuttings – where material is lacking – on the cylinder surface as a result of an impact or friction, reducing its thickness.

3.7. Blisters: Permanent projection or protrusion on the cylinder surface due to its outward distortion caused by internal pressure.

3.8. Dent containing gouges: distortion or hollow in the cylinder containing cuts.

3.9. Crack: deep or superficial fissure.

3.10. Lamination: Flaw arising as crack or split from the cylinder's manufacturing process (folding, spinning, etc.) and/or the raw material (tubes), generally due to inclusions during the manufacturing process.

3.11. Fold: manufacturing defect that may be propagated by pressure or corrosion.

3.12. Cylinder body wear: material removal as a result of the relative cylinder displacement as regards its anchorage or other components

3.13. Fire Damage: general or localized cylinder overheating, usually indicated by:

a) Burnt or blistered paint

b) Burnt metal base

c) Cylinder distortion

d) Melted valve parts

3.14. Blowtorch or welding point: Flaw consisting on burning of the cylinder metal, hardening of areas affected by heat, ends with added or missing metal caused by electric arc or blowtorch

3.15. Distorted circular section: Cylinder's distortion or crushing affecting its symmetry.

3.16. Thickness

a) Nominal (NT): Thickness of material used for cylinder manufacturing (value provided by the manufacturer)

b) Design or calculation thickness (CT): thickness resulting from calculation. It is the one used in this standard according to the criteria applied for granting or refusing approval.

3.17. Uniform corrosion: Wide area affected by different levels of corrosion.

3.18. Pitting corrosion: Corrosion reducing thickness of a small internal or external area. It does not include other types of corrosion such as the ones indicated in 3.19 and 3.20.

3.19. Pit: Corrosion of a very small area or circular cavity of different depths (internal or external). It may pit wall thickness and cause leaks. When pit concentration is higher than one every 500 mm2, it is considered as pitting corrosion (3.18)

3.20. Strip *: Set of close knit pits grouped in such a way that they form a line, band or continuous strip. This flaw is more serious than pits since it may dangerously weaken the cylinder wall, especially when found along the cylinder.

Note: Commonly known as "corrosion line".

3.21. Corrosion channel: a line showing higher degree of corrosion due to metal erosion. It may be external or internal.

3.22. Approved cylinder: Cylinder that has been successfully inspected and may continue in service.

3.23. Refused cylinder: Cylinder that is taken out of service after the inspection until a later control allows to continue the periodical inspection or condemns the cylinder.

3.24. Condemned cylinder: When a cylinder does not comply entirely with the parameters set forth in this Technical Specification it must be destructed so as to prevent it from being put into service. Its original marking must not be eliminated during this process.

3.25. Letter of conformance signed by the cylinder owner: It is the document by which the owner or his legal representative, agree to the destruction of the cylinder in case it is condemned.

4. GENERAL ASPECTS

4.1 Every CNG cylinder shall be exclusively inspected by skilled and trained technical staff of the cylinder inspection centers approved by Gas del Estado, fitted with the minimum equipment set forth in annex 1.
The Inspection Center shall submit the Organization and Procedure manual according to the present specification for the purpose of this certification.
These documents must comply with the quality assurance system guidelines set forth in standards IRAM- IACC E20 and their subsequent and related ones.

4.2. Quality control processes of Cylinders Inspection centers shall be supervised by Gas del Estado or other Certification Organizations that meet the guidelines set forth in IRAM 352 and 354 experimental standard and other equivalent ones. GAS DEL ESTADO may however, verify or audit the supervision process performed by these Certification Organizations, in accordance to what is stated in GAS DEL ESTADO standards N° 1-115 points 3 and subsequent ones, points 3.2 and subsequent ones and tables 1, 2, 3 and 4.

4.3. CNG cylinder's lower generatrix shall be marked with a line drawn with an indelible marker, from the ogive to its base, before removing the CNG cylinder from the installation that secures it to the vehicle and in compliance with GAS DEL ESTADO standard N° 1-116, Part 1, point 4.4 and Part 2 (Points: 1.1.3 and 1.1.3.2.a) so as to detect the types of corrosion and their relation with the location of the CNG cylinder in the vehicle as well as previous uses of this cylinder.

4.4. CNG cylinder and its assembled valve shall be delivered to the Cylinder Inspection Center indicated in point 4.1 as installed, regardless of its condition and use.

4.5. Precautions in the cylinder's handling and use.

4.5.1. Cylinder shall be carefully transported and handled during the Mandatory Scheduled Periodical Inspection so as to avoid damages.

4.5.2. The cylinder shall not be violently dropped on the floor or on any other hard surface.

4.5.3. In case of using a hoisting device its design shall be such to guarantee the cylinder's integrity.

4.5.4. Precautions must be taken in all cases to prevent the cylinder from slipping off the platform or slings.

4.5.5. A cylinder shall never be rolled for transport.

5. FREQUENCY AND TYPE OF INSPECTION (According to 3.1 and 3.3)

5.1 General: Table I

5.1.1. Regardless of the cylinder's previous use and condition, a Mandatory Scheduled Periodical Inspection consisting of the following steps, shall be performed:

a) Identification control and letter of conformance
b) Content emptying
c) Valve removing and inerting
d) External cleaning
e) External visual inspection
f) Thread control
g) Control of fixed and disassembled fittings
h) Valve operation control
i) Valve inspection
j) Cylinder neck defects control
k) Inner cleaning
l) Inner visual inspection
m) Mass or tare control
n) Ultrasonic cylinder's wall thickness measurement
o) Cylinder volume expansion hydrostatic test
p) Cylinder drying
q) Re marking of cylinder (at the ogive, inspection date)
r) Cylinder paint
s) Verification of approved cylinder documentation
t) Destruction of condemned cylinder
u) Annexes to this Technical Specification for the inspection of CNG Seamless steel cylinders.

Note: Annex 1 - Minimum equipment necessary for Periodical Inspection of CNG seamless steel cylinders.

6. PREPARATION FOR PERIODICAL INSPECTION

6.1 Identification control:

a) Verifications must be performed to check that the cylinder bears the following identification marks and that they are accurate and legible. (see standard IRAM 2643 and/ or applicable ones):

b) Identification

1. Manufacturer
2. Manufacturing month and year
3. Cylinder number
4. Original Tare or Mass
5. CNG and capacity
6. Seal of approval of GAS DEL ESTADO or IRAM or any other foreign organization or Entity if the cylinder is imported.
7. Testing and work pressure
8. Last mass or tare value
9. Date of last hydrostatic pressure test and Cylinder Inspection Center identification

6.1.2. Lack of data or uncertainty about data accuracy: 1, 2, 3 and 7 (any of these shall be reason enough to condemn the cylinder)

6.1.3. The original data engraved on the cylinder shall neither be modified nor erased

6.1.4. Inspections shall not be performed on the cylinder if the following documents are not provided: letter of conformance, conversion documentation and certificate issued by the workshop upon dismounting it (so as to guarantee that the cylinders are part of a conversion equipment).

6.2. Content emptying and verification

6.2.1. Before the Mandatory Scheduled Periodical Inspection is carried out, the cylinder shall be completely emptied by an elimination system compliant with the laws in force.

6.2.2. Once this process is through, the valve shall be removed and replaced by a plug adjusting to the cylinder's thread and acting tightly such as to avoid entry of foreign matter.

6.2.3. Small amounts of liquid or undesirable substances may not be detected rather than by other means like tilting down the cylinder and allowing the content to fall into a container for its later analysis.

6.2.4. Inert gas shall be introduced through a sleeve into the valve inlet, developing slight pressure inside the cylinder and allowing the content to flow freely with the gas stream for the possible content control to be more effective.

6.2.5. In case the Inspection routine is interrupted and the cylinder has to be in the inspection queue, it must be verified that the plug is tight so as to avoid wet air inlet.

6.3. EXTERNAL CLEANING

6.3.1. Before inspection procedure takes place, If during the visual external inspection, elements that affect the condition of the cylinder's surface are detected, it shall be adequately cleaned to eliminate dirt (dust, oil, labels, etc) by conventional methods such as water, steam, etc.

In case of detecting signs of corrosion hiding, dents, pits or if the Inspection Center technical staff considers that the safety of the cylinder is impaired, paint shall be removed by adequate methods using blasting, sand blasting, steel rotating brushing, etc., except chemical corrosive cleaning, until the metal base of the doubtful area is exposed

7 EXTERNAL VISUAL INSPECTION

7.1. The following defects shall be assessed and inspected after the external cleaning of the cylinder. The inspector, however, may distinguish other elements that have not been indicated but that according to his criteria may be assessed.

7.2 The following material or physical defects are the most common ones and may affect the cylinder's service life:

1. Blisters
2. Dents
3. Gouges

4. Dent containing gouges
5. Cracks
6. Lamination
7. Body wear
8. Fire and heat damages
9. Welding or blowtorch points
10. Distorted circular section
11. Marking or stamping defects
12. Corrosion
13. Other
14. As regards permanent fittings and the associated zone, they shall be carefully inspected together with the part of the cylinder they are affixed to. Welding is not allowed and the ring shall be eliminated when it produces cylinder corrosion.

TABLE II
REJECTION LIMITS RELATED TO MATERIAL AND PHYSICAL DEFECTS

Defect	Limit for refusal or condemnation
1) Blisters	All
2) Dents	All, when the depth of any dent exceeds 2 mm or when their diameter is 30 times smaller than its depth
3) Gouges	When the length of any cut is more than 2% of the cylinder length or more than 5% of the cylinder wall thickness. Any deep cut shall be a point where strengths concentrate and may be eliminated through grinding, verifying the remaining thickness
4) Dent containing gouges	When the size of the dent or cut or splitting is greater than the refusal limit as an individual flaw (see 2 and 3). When the depth of any dent exceeds 1.5 mm or its diameter is 35 times smaller than its depth and the length of the cut is at least equal to the diameter of the dent
5) Cracks	All
6) Lamination	All
7) Body wear	When the wall thickness in the most severe worn area is less than the minimum one required by design Note: this flaw may also be produced by corrosion, in which case the same limit indicated shall be considered.
8) Fire or heat damage	When fire damage includes (b) or (c) (see definition 3.13), it shall be condemned When fire damage is only type (a) or (d), it may be heat treated Note: depending on the condition of the cylinder surface (burnt, scorched or smoked paint) the decision to accept, repair or refuse the cylinder shall lie on the technical personnel. If repaired, heat treatment and pressure test shall be performed according to the manufacturer's standards. When the container is only darkened or smoked, or its paint is slightly blistered, it shall not be considered damaged according to this specification.
9) Welding or blowtorch points	When any cylinder shows damage due to electric arc or blowtorch, it must be refused and tested
10) Distorted circular section	When the difference between both diameters of one section exceeds 1% for diameters less than 140 mm and exceeds 1.5% for larger diameters
11) Flaw from marking or stamping	Whenever a cylinder's marking is inadequate or illegible or has been altered, it must be refused. Note: It must be re-marked, whenever it may be clearly demonstrated – by documents or tests - that the cylinder complies with the requirements of the corresponding manufacturing standard.

NOTE: Grinding defects that may affect the identification marks shall not be admitted under any circumstance.

7.3. CORROSION

7.3.1. Sometimes, the external wall of the cylinder may be affected by atmospheric actions of corrosive substances found in the areas where the cylinders are located, as well as physical damage caused by debris and impacts, if they are mounted below the vehicle body. Likewise, the internal wall may be corroded by external agents.

7.3.2. When rust can hide the true corrosion depth, it must be mechanically removed until metal base is exposed.

7.3.3. Types of corrosion

a) Pits
b) Corrosion lines
c) Corrosion channels
d) Pitting corrosion
e) Uniform corrosion
f) Uniform corrosion with pits

Note: Corrosion type f) combining a) and e) is usual and poses difficulties in testing. However, when there is a considerable amount of pits in a uniform corrosion area, the depth of the pit "p", is close to twice the loss of thickness due to uniform corrosion "c". Nevertheless, this is not a general rule.

7.3.4. Corrosion limits:
Limits shall be usually determined according to cylinder type, design, standard, etc, and may refer to the minimum thickness (without additional corrosion) established by the corresponding standard or calculation and shall be closely related to the type of corrosion affecting them. Generally, when a defect is assessed, the cylinder may be approved or refused as the case may be, but when there is uncertainty in the test, the cylinder shall be subject to a more detailed inspection with the adequate equipment. However, the cylinder shall be condemned if corrosion can not be assessed, even through specialized inspection.

7.3.5. a) Cylinder with uniform corrosion: The cylinder shall be refused if:

1) Thickness loss is greater than the one defined in table III

2) The original surface cannot be recognized

3) It complies with 1) and 2), a hydrostatic test with volumetric expansion shall not show a permanent distortion exceeding 5% of the total volumetric expansion.

b) Cylinder with pitting corrosion: The cylinder shall be refused if:

1) Thickness loss is greater than the one defined in table III

2) The original surface cannot be recognized

3) It complies with 1) and 2), a hydrostatic test with volumetric expansion shall not show a permanent distortion exceeding 5% of the total volumetric expansion.

c) Cylinder with corrosion line or channel: The cylinder shall be refused if:

1) Corrosion length in any direction exceeds the cylinder's circumference.

2) Corrosion depth exceeds the one defined in table III. Grinding area shall be eliminated for its verification

d) Cylinder with isolated pits: The cylinder shall be refused if:

1) The depth of pits which diameter exceeds 5 mm is greater than the one described in table III

Note: The depth of pits which diameter is less than 5 mm may be assessed whenever possible to ensure that the thickness of the remaining wall is suitable for the cylinder operations.

7.3.6. Table III indicates the limit values for the different corrosion levels, and shall be used as test guide for cylinder condemnation

7.4. VALVE OPERATION CONTROL

7.4.1. PROCEDURE AND CONTROL

a) Upon disassembling the valve, a label with the following information shall be placed on it:

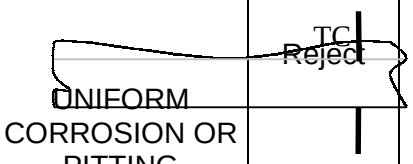
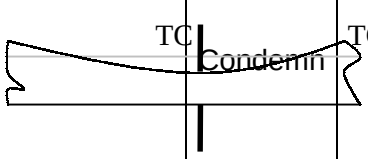
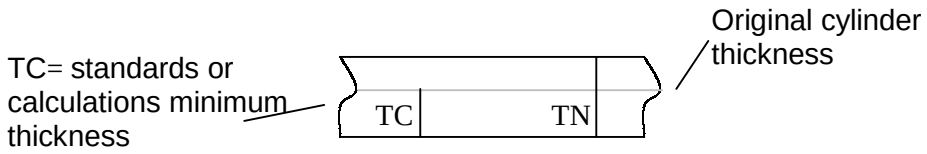
- Cylinder Number
- Owner
- Installation workshop
- Date
- Observations

b) Controls shall be carried out to ensure that the valve opens and closes smoothly, and to check that the stem is free from twists or wear. Valves showing signs of distortion, twists or damage shall be refused. Excessive wear or damage shall constitute enough grounds for replacement.

c) Controls shall be performed to ensure that the valve body is not corroded or damaged and to check the condition of the threads (that their diameter, sides, shape and length comply with the Standards approved by GAS DEL ESTADO).

7.4.2. The valves that comply with the previous requirements shall be returned together with the corresponding cylinder for re-valving at the Installation workshop.

TABLE III CORROSION LIMITS FOR CNG CYLINDERS

<table>
<tr><td rowspan="3"> 
</td><td colspan="2">Continuous loss of thickness covering wide areas compared to the cylinder's surface</td><td>Minimum allowed value based on "TC"</td></tr>
<tr><td></td><td>When the remaining wall in the area of corrosion is equal or slightly different from</td><td>= TC
> 0,95 TC</td></tr>
<tr><td> 
</td><td>When the remaining wall in the area of corrosion is equal to:</td><td>≤ 0,95 TC</td></tr>
<tr><td colspan="4"> 
</td></tr>
</table>

7.4.3. Refused valves shall be returned to the Installation workshop with their respective report.

Note: Installation Workshop Personnel shall verify valve operation under pressure.

7.5. PROCEDURE WHEN A CYLINDER VALVE APPEARS TO BE OBSTRUCTED.

WARNING: IT MUST BE NOTED THAT HANDLING HIGH PRESSURE OBSTRUCTED OR BLOCKED VALVES IS VERY DANGEROUS AND HAS TO BE PERFORMED BY TRAINED AND EXPERIENCED PERSONNEL. NECESSARY PRECAUTIONS MUST BE TAKEN TO AVOID UNFORESEEN EVENTS RESULTING FROM UNCONTROLLED RESIDUAL CNG DISCHARGE.

7.5.1. If upon opening a gas cylinder valve, there is no certainty as to whether CNG has been released and it is suspected that the cylinder may still contain some residual CNG under pressure, it shall be verified that valve's free flow is not obstructed through the following method or a similar one: Inert gas is introduced at 5 bar pressure and discharge is verified.

7.5.2. Once it is determined that CNG flow is not obstructed in the cylinder valve, it may be removed.

7.5.3. Once it is determined that the cylinder has a CNG flow obstructed valve, it shall be set aside for special service, applying an adequate previously approved system.

7.5.4. These procedures shall only be performed by trained personnel

7.6. NECK DEFECTS

7.6.1. Cracks, fissures, overlapping, etc, shall be controlled in the cylinder's neck.

7.6.2. Usually, these defects may be detected by a non destructive examination and volumetric expansion hydrostatic test.

7.6.3. After removing the valve, the condition of the cylinder's thread shall be controlled.

7.6.4. Cylinders shall be refused when the amount of effective threads is less than 80% of the normal amount, according to IRAM 2539 standard or the standard of the country of origin.

7.6.4.1. Before preparing the thread, its condition shall be checked with calipers.

7.6.4.2. The threads must be carefully cleaned before they are checked with the caliper

Note: the most common thread defects are: peaks wear or corrosion, ruptures, notches, cuts or dragging.

7.7. INTERNAL CLEANING (Procedure after inerting)

7.7.1. Before performing the inner cleaning, the plug (originally placed to avoid the inlet of substances or gases to the cylinder during all the stages after valve removal) shall be removed; in case of corrosion matter or other undesirable substances are found, the cleaning operation shall be performed according to the substance to eliminate.

7.7.2. If a cylinder shows loose particles such as dust, flakes or oxide particles, they may be completely eliminated by a dry air flow through a sleeve introduced along the valve inlet or connected to a vacuum machine. These operations may be enhanced if the cylinder is located such as to facilitate material going out.

7.7.3. If a cylinder shows wet areas and impurities that cannot be eliminated as described in point 7.7.2, it shall require a more effective cleaning or washing by water flush, chain blasting, internal blasting and others (except corrosive chemical flush), easy to handle, and effective, thus ensuring the elimination of such material without affecting the heat treatment and steel of the cylinder.

7.7.4. Steam generally ensures in depth cleaning. The cylinder is placed in a vertical position with the valve inlet facing downwards and a tube is introduced like a javelin to inject steam, thus performing a hydrodynamic cleaning on the cylinder's bottom and walls, in turn dragging out undesirable substances. Once the cylinder is clean, it shall be hot enough (50 to 70°C) to dry rapidly and efficiently with a dry air flow (for example: dew point: -40°C) using the same javelin or another one. Then, the inspection shall be resumed.

7.7.5. Blasting or chain blasting: The internal part of the cylinder may be mechanically cleaned by different means such as blasting or chain blasting. However, internal sand blasting of the cylinder shall not be used.

7.8. INTERNAL VISUAL INSPECTION

7.8.1. In every case, after cleaning and drying the cylinder, it shall be inspected with a strong light and the operations shall be repeated if necessary.

7.8.2. A luminous inspection probe shall be used to identify any of the previously mentioned defects and those mentioned in tables II and III (such as material, physical or corrosion defects, etc).

7.8.3. Any cylinder showing signs of internal corrosion or dirt may be cleaned by the methods previously mentioned, without exceeding however, 300°C so as to avoid damages to the cylinder. After this new internal cleaning, the visual inspection shall be repeated.

7.8.4. The limits for rejection or condemnation foreseen for the same defects described in external inspection shall be followed.

7.9. MASS OR TARE CONTROL

7.9.1. The following shall be previously verified:

a. The cylinder must be totally empty, dry and free from any dismountable accessory

b. The calibrated scale to be used shall have a capacity of between 1.5 to twice the cylinder mass.

c. The scale shall ensure weighing fractions of at least 100 grams

7.9.2. Mass shall be determined as the simple average of at least three (3) weighing on the same scale.

7.9.3. Verifications shall be performed to check that cylinder's resulting value coincides with the value engraved on it

7.9.4. A difference of more than 2% compared with the original cylinder's mass shall be an alert, and the cylinder shall be set aside for observation

7.9.5. Depending on the difference between both values, the cylinder shall be classified as indicated on Table IV.

TABLE IV, MASS LOSS

Mass loss	**Result**
$\Delta m < 4\%$	Approved
$4\% \leq \Delta m < 10\%$	Refused
$\Delta m < 10\%$	Condemned

7.10. THICKNESS MEASUREMENTS

7.10.1. Thicknesses shall be measured by ultrasonic method or similar ones.

7.10.2. The equipment to be used shall be of recognized brand, in perfect conditions and operated by skilled personnel. A calibrated probe shall be used to regulate them. This instrument shall allow the reading of 0.1 mm.

7.10.3. The surface to be controlled shall be conditioned; paint, dirt, rust and other irregularities shall be eliminated in order to allow a good contact between the scanner and the cylinder wall. Control of the cylinder lower generatrix thickness and one helix (pitch to be determined) thickness, according to point 4.3. with spacing not exceeding 200 mm shall be mandatory.

7.11. Bottom thickness measurement: It shall be performed in compliance with IRAM 2628 standard.

7.11.1. Thickness in the cylinder's support area is measured on a perpendicular line drawn to the points of contact between this area and the floor, with the cylinder in operation position, as indicated in point 4.3 of this Technical Specification, at least in three points.

7.12. CYLINDERS' HYDROSTATIC GENERAL TEST METHOD:

a) Test pressure shall be the one indicated by the manufacturer and stamped on the cylinder. It shall not be exceeded under any circumstance.

b) Before exerting pressure on the cylinder, its outer surface must be completely dry

c) Test pressure must be kept for at least two minutes and during that period the recorded pressure must not vary

d) Under these circumstances, the cylinder must not show leaks, visible distortion or defects.

e) In case of leaks in the system or in the cylinder connection, they must be corrected and the cylinder must be re tested.

f) The lower part of the cylinder shall be carefully leak verified.

g) A good practice consists of increasing the pressure to approximately 2/3 of total pressure, purging the system especially prepared for that purpose and then completing the pressure.

7.13. VOLUMETRIC EXPANSION HYDROSTATIC TEST

7.13.1. The volumetric expansion test shall be performed according to the specifications of IRAM 2587 standard.

7.13.2. Test pressure shall be the one marked in the cylinder

7.13.3. The cylinder permanent volumetric expansion expressed as a percentage of the total expansion at test pressure shall not be higher than 10% except what is indicated in points 7.3.5.a 3) and 7.3.5.b.3) as may correspond

7.13.4. In case the permanent volumetric expansion is higher than the values indicated in 7.13.3 or in 7.3.5.a.3) and 7.3.5.b.3), as may correspond, the cylinder shall be condemned

7.13.5. Internal pressure applied on the cylinder before the expansion test must not exceed 90 % of the test pressure. If the test cannot be completed due to failures in the installation, it may be repeated at a pressure increased by 10% or 0.7 MPa, whichever the lowest. Pressure shall be maintained for at least one minute to ensure complete cylinder expansion.

7.14. CYLINDER DRYING

7.14.1. After internal visual inspection, ultrasonic thickness measurements, volumetric expansion tests and before cylinder paint, its internal and external surfaces must be dried according to the requirements of these tests and inspections.

7.14.2. According to what has been stated in points 7.7.4, 7.9.1.a and 7.12.b, guidelines have been provided in these regards.

However, if a cylinder cannot be previously heated or when not enough dry and hot air is obtained, the drying procedure may be performed by introducing such air with a javelin, ensuring that dampness has been completely eliminated.

7.15. CYLINDER RE-MARKING

7.15.1. After the Periodical Inspection has been satisfactorily completed and when due to mass change reasons, its loss is significantly different from the one shown in the cylinder, the new mass shall be stamped as indicated below:

If the cylinder approves all the controls and tests and is evidenced by a technical report, a new mass or tare shall be engraved with its date, without eliminating the original one adding an “x”.

7.16. CYLINDER PAINTING

7.16.1. Cylinders shall be repainted, if necessary, according to the indications of IRAM 2641 standard. To this effect, its surface must be conveniently prepared to bare metal.

7.16.2. The surface to be painted, free from dampness, shall be first coated with anti corrosive paint (preferably with corrosion inhibitors), its thickness shall be such to ensure the quality of the protection system chosen. The protecting cover and final identification shall comply with the indications of IRAM 2641 standards and with standard GE N° 1-117, Part II, Point 15.

7.17. CYLINDER RE-VALVING

7.17.1. Each cylinder must be re-valved by the Installation workshop. A tight plug shall be placed on it for transport, to protect the thread from damages and to prevent the filtering of strange matter or dampness into the cylinder.

7.17.2. Blind covers or plugs shall be in good conditions and shall protect the connection threads.

7.18. DOCUMENTATION - approved cylinder

7.18.1. A copy of the record of the daily inspections shall be kept, and the original one shall be legally signed and sent to GAS DEL ESTADO.

7.19. DESTRUCTION OF CONDEMNED CYLINDERS

7.19.1. Unfit, useless or dangerous cylinders shall be destructed through one of the following methods. Previously, the cylinder shall be prepared as indicated in point 7.7, that is to say, free from any substance:

The cylinder shall be mechanically crushed and, in case the distance to any of its edges is greater than 1m, it shall be crushed several times with intervals of 1m between each crushing.

Crushing shall comply with the minimum requirements of standard IRAM 2526 for cylinder crushing test.

8 FORMULAS

1. The following formula shall be applied for cylinders manufactured according to ISO standards, to determine thickness calculation (EC=e)

$$e = \frac{Ph \times D}{\frac{20\,\mathrm{Re}}{1.3} + Ph}$$

Given that: e= wall thickness in mm
Ph= Hydrostatic test pressure in bar
Re= Yield strength in N/ mm2
D= cylinder's diameter in mm

2. The following formula shall be applied to cylinders manufactured according to IRAM 2526 standard:

$$e = \frac{D}{2}\left(1 - \sqrt{\frac{1 - \frac{0.13 \times Ph}{\sigma_{adm}}}{1 + \frac{0.04 \times Ph}{\sigma_{adm}}}}\right)$$

Where:

e= wall thickness in mm

D= cylinder’s diameter in mm

Ph= Hydrostatic test pressure in bar

$\sigma_{adm} = \frac{5}{6} \times \sigma_f$ for class B steel in N/mm^2

$\sigma_{adm} = \frac{2}{3} \times \sigma_f$ for class B steel in N/mm^2

$\sigma_f =$ Yield strength

3. The Center of Cylinders Inspection shall count with information about the characteristics of the cylinders to inspect. This information shall include: brand, manufacturing standard, size and material used. GAS DEL ESTADO shall issue this information based on the technical documentation submitted by the Manufacturers and importers, according to points 3.1 and 3.2 of GE N°1-115 standard.
The cylinders manufacturers and/or importers shall also deliver to GAS DEL ESTADO the affidavit of the following design values for each cylinder type.

- Minimum thickness
- Yield strength
- Breaking strength
- Maximum hardness
- Minimum thickness calculation report (EC)

ANNEX 1

Minimum equipment necessary for CNG seamless steel cylinders' Periodical Inspection. GAS DEL ESTADO may require other equipment depending on the needs.

General:

A.1. Every piping, valve, fitting and system component shall be designed to withstand a pressure that is twice the maximum test pressure of any cylinder that may be tested.

A.2 Pressure gauges shall comply with the specifications of IRAM- IAP A 51 – 65 Standard

A.3 The installation shall be designed to avoid and eliminate gas trapped in the cylinder, complying with the legal regulations in force.

A.4 The Center of Cylinder Inspection must comply with:

A. 4.1 Requirements for registration at Gas del Estado Center of CNG Cylinder Inspection Registry including a technical, commercial and administrative organization of Human resources and materials, with adequate training, experience and skills in this area.

A.4.2 Worksheets and documents of: Record, follow up and daily report of processed cylinders and components as of their reception at the Installation workshop to their delivery. Approved tasks flow diagram according to the organization of the Inspection Center.

B Equipment

B.1 Gas elimination equipment according to the applicable laws

B.2 Low pressure inert gas compression equipment (5 bars)

B.3 De-valving equipment

B.4 Containers for collecting individual samples of substances found in cylinders, for their later control, identifying the sample adequately.

B.5 Type calipers for cylinders and valve threads.

B.6 Obstructed valve extraction equipment (under pressure)

B.7 Amount and type of adequate protection plugs for the different types of threads approved by GAS DEL ESTADO for CNG.

B.8 Steel wire brusher or external blaster or sand blaster, non corrosive chemical cleaner or any other type of equipment to remove paint until metal base is exposed.

B.9 Grinder

B.10 Dehumidifier or air heater with its corresponding javelins.

B.11 Equipment for the internal cleaning of the cylinder and non corrosive chemical cleaner

B.12. Cylinders' internal inspection luminescent equipment

B.13 Calibrated scale, with capacity and accuracy of 100 grams

B.14 Ultrasonic thickness meter of acknowledged brand, with measurement caliper ensuring 0.1 mm reading

B.15 Complete Hydrostatic testing equipment with volumetric expansion and recorder, according to 2587 IRAM standard

B.16 Paint equipment (anti corrosive and for finishes)

B.17 Condemned cylinder crushing press

B.18 Complete die set (letters and numbers) for cylinders re marking

B.19 IBM compatible PC