Economic Commission for Europe

Inland Transport Committee

Working Party on the Transport of Dangerous Goods **5 July 2013**

Joint Meeting of the RID Committee of Experts and the Working Party on the Transport of Dangerous Goods

Geneva, 17-27 September 2013
Item 6 (b) of the provisional agenda
Proposals of amendments to RID/ADR/ADN: new proposals

Periodic inspection and test of some transportable refillable LPG steel cylinders in RID/ADR

Transmitted by the European Liquefied Petroleum Gas Association (AEGPL)

Annexes to document ECE/TRANS/WP.15/AC.1/2013/43

Annex 1

EN1439 :2008 (LPG equipment and accessories. Procedure for checking LPG cylinders before, during and after filling) annex G

Annex G (informative)

Inspection procedure for a particular design of protected cylinder

G.1 Application and cylinder description

This annex is applicable for protected cylinders such as polyurethane protected cylinders (see Figure G. 1) or other cylinders with the same protection.

All of the requirements of this standard shall apply except where specific reference is made to this annex. These requirements are listed below.

G.2 Cylinders suitable for filling

The age of the protected cylinder shall be less than the periodic inspection interval for this design of cylinder or the protected cylinder shall be from a batch that has been tested in accordance with EN 1440 (batch testing).

G.3 Cylinders for periodic inspection

The selection of protected cylinders for periodic inspection shall be done by sampling in accordance with EN 1440.

G.4 Cylinders requiring further assessment

Damaged protected cylinders shall be reassessed in accordance with G.5

G.5 Reassessment of cylinders

Rejection criteria for physical and material defects or heat damage on the cylinder shell are contained in Table G.1.

Table G.1 — Defects of protected cylinders and rejection criteria before filling

Defect on	*Description*	*Rejection limit*
Casing	Visible material gouge, cut or crack	Depth > 4 mm Length > 10 mm
Casing	Visible depression	All
Casing	Visible swelling	All
Feet and handles	Visible material gouge, cut or crack	Depth > 20 mm Length > 50 mm Missing feet
Handles	Broken handles	For each handle if more than one crack. Parts of handle missing.
Electronic tag	Illegible tag	All
Fire damage	Excessive general or localized heating of a cylinder usually indicated by: – surface charring or burning; – distortion of the cylinder; – melting of metallic valve parts; – melting of any plastic components	All
Depressed bung	Damage to the bung, which has altered the profile of the cylinder.	All, except a limited level of depression/alignment deviation, as agreed by the competent body.
Valves	Broken valves	All

Annexe 2

Document presented in 2004, during ESOPE symposium, on specific periodic inspection procedure for protected over-moulded cylinders

ESOPE is a symposium done every 3 years in France to bring together experts and actors in fixed and transportable pressure equipment "community", to meet up and discuss all the developments in their field.

TRANSPORTABLE REFILLABLE WELDED STEEL CYLINDER "protected over-moulded cylinder" FOR LIQUID PETROLEUM GAS (LPG) – PERIODIC INSPECTION AND TEST BY INDIVIDUAL CONTROLS AT FILLING, BATCH SAMPLING AND DESTRUCTIVE TESTS

O. AUBERTIN[1] et C. BINETRUY[2]

[1] BUTAGAZ S.N.C, BOB/ML RN 113, 13340 ROGNAC FRANCE

[2] ECOLE DES MINES DE DOUAI, Technology of Polymers and Composites Department, 941 Rue Charles Bourseul, 59508 DOUAI, France

Summary

This method has been developed like an alternative to individual hydraulic pressure test for periodic inspection.

It is meant for reduced capacity welded steel cylinders totally covered with a protective plastic case in polyurethane (PU) acting as a protection against impacts and corrosion. It has been used for the last 4 years for "the Cube" cylinder by Butagaz.

Members having taken part in developing this step-by-step progressing method are:

- Ministry of Industry (gas and pressurized equipment dept),
- Ecole des Mines in Douai (Polymer and Composites dept),
- Butagaz: a LPG operating company in charge of distribution, filling and cylinders maintenance.

It has been developed on the following basis: preliminary tests protocol showing amongst other properties, the link between PU adhesion on the inner receptacle and the non-appearance of corrosion the pressure receptacle wall during the cylinder's life.

Periodic inspection of such cylinders is composed of:

- Individual inspection and controls before, during and after filling,
- Periodic destructive tests by batch sampling.

Introduction

The BUTAGAZ Company, since 1997 markets a LPG cylinder called "The Cube" ranging from 5 to 6 kg (butane-propane).

First of all, it is a pressure steel device which manufacturing meets transportable pressure equipment directives 84/527/CE or 1999/36/CE.

This pressure receptacle is coated with a polyurethane case which ensures two primary functions: resistance to outside attacks (drops, impacts, corrosion) and marketing (meeting customer's needs).

Prior to commercialisation tests have been conducted during 3 years between 1995 and 1997 in the Shell and Butagaz R&D laboratories leading to the design of the cylinder and the approval to operate the "Cube". These tests have shown amongst other things the Cube's properties in its resistance to impacts and corrosion.

Partly based on those tests, the Cube periodic inspection method by sampling has been developed step by step taking in account experience feedback between Butagaz and the Ministry of Industry (DGAP, DRIRE) with the support of the Ecole des Mines de Douai, particularly the Polymer and Composite department. A preliminary test phase has been led in order to define periodic inspection method and to precise and determine content of the tests by sampling as well as acceptation criteria. Checking of the good conservation of the PU case adhesion properties was the main item of this communication.

Until now, the first four years of production (year *n*): 1997,1998, 1999 and 2000 destructive tests by sampling have been led in year *n* +3. Destructive tests in year *n* +3 have also been led on production 2001 ; in 2005 destructive tests on year N +3+5 will be led on production 1997, with double bursting tests.

Description of the cube

The Cube is made of a steel vessel covered with an anti-corrosion coating, the whole unit being protected by a non-removable polyurethane (PU) foam. The steel part of the cylinder guaranties leakproofness and a good pressure in cylinder. In addition, the PU foam coating closely glued on the steel vessel must ensure two functions: protection of vessel against outside attacks (corrosion, drops, impacts, fire resistance, chemical resistance) and marketing (esthetical appearance, stability, prehension, comfort…)

The design of this pressure vessel is the result of research for the best material for the functions required at the best cost. This approach has led to choosing hybridization between steel and polymer material. It offers many possibilities of conception as already proven by the design of composite vessels fitted with a steel liner reinforced with an organic matrix composite external layer. By analogy with those vessels, the Cube could be considered here as a transportable composite appliance which structural integrity is ensured by the liner realised by the steel vessel.

Periodic inspection methodology

By definition, the PU layer masks the external surface of the steel vessel and does not allow giving information on corrosion state through direct observation. An original and indirect method has been proposed and accepted. It is based on adhesion test results from PU foam pulling and also on checking the merit of the relation "**good adhesion of PU foam on the inner receptacle = non corrosion**".

The general structure of the Cube is ensured by the steel liner in association with the PU coating acting as a protection against environmental and mechanical aggressions of any type and allows it to maintain its mechanical properties in service. The periodical inspection method must take into account the synergy of material. Many destructive tests have been proposed to determine the Cube ability to safely fulfil its functions.

Method Purpose and Development: characterization of interface PU / cylinder

The difficulty of controls lies in controlling whether there is or not corrosion on the interface steel/PU since the PU coating is not removable. Corrosion developing at the surface of steel vessel would highlight presence of humidity through deteriorated PU foam. Different types of ageing like mechanical or physicochemical have been applied to the Cubes in order to induce failure in the PU layer barrier and to alter either adhesion properties on vessel or even its real mechanical performances. Definition of those tests relies on NF EN 12245 standard relative to fully wrapped composite cylinders (transportable gas cylinders).

In addition, in order to establish a link between PU adhesion and presence of corrosion, different tests have been carried out like PU foam adhesion test on vessels with corrosion and also on vessels coated, before foaming, with the product used to remove the over-moulded cylinder from the mould.

Main justification for choosing adhesion test relies on the fact that the PU foam has very good natural adhesion properties. Therefore, testing its adhesion on steel is like testing one of its main characteristic from its chemical nature and not manufacturing conditions. It keeps the reproducibility of adhesion measures and reliability of interpretations resulting from it.

Preliminary adhesion measure tests of PU foam on vessel

Accelerated ageing with cycling ("VA+C") according to EN 1442

The tests have been realised on 3 Cubes which have been stored approximately 2 years under external atmospheric conditions (in Sologne, non sheltered).

The 3 Cubes are tested under the following conditions:

- Salt spray > 200 hours,
- Climatic room: 5 cycles (rain, -20°C, hygrometry 0-100%, UV) on 5 days,
- Cycling tests 2-30-2 bars (12 000 cycles at 20°)

Assessing cylinders and adhesion measures have led to:

- No visible cracks on Cube surface,
- No burst has occurred along the interface steel/PU, burst values indicating an average 4,4 N/mm^2. Adhesion steel/PU is at least 3,6 N/mm^2.

Cycling to extreme temperatures ("CTE") according to EN 12245

Cycling tests to extreme temperatures according to NF EN 12245 are normally meant for transportable gas cylinders, fully wrapped in composite material. Here, the Cube is not seen as a steel vessel coated with polymer but as a polymer vessel with steel liner. These tests are meant to thermo mechanically test the polymer protection of the Cube.

3 Cubes, stored approximately 2 years outside, have been tested under the following conditions :

- 5000 cycles 2-20 bars at 50°C
- 5000 cycles 2-20 bars at -20°C
- 30 cycles 2-30 bars at 20°C

Results are as follows :

- No visible cracks on Cube surface
- No burst has occurred along the interface steel/PU, burst values indicating an average 4,4 N/mm^2. Adhesion steel/PU is at least 4,4 N/mm^2.

Accelerated ageing including cycling ("VA+C+CTE") according to EN 1442 and EN 12245

This test is particularly severe for the vessel since it accumulates the two previous tests. Three Cubes stored roughly two years in external conditions have been tested in the conditions previously quoted.

Results are as follows :

- No visible cracks on Cube surface
- No burst has occurred along the interface steel/PU, burst values indicating an average 4 N/mm^2. Adhesion steel/PU is at least 4 N/mm^2.

A slight weakening of mechanical properties of pulled PU foam can be seen which shows the high interest of adhesion test used as a method of PU foam ageing close following.

Vessels with corrosion ("xxx H Corrosion")

3 exposed steel vessels (without protective coating against corrosion) have been packed in a salt spray room during respectively 50, 120 and 200 hours before being sent for PU foaming. A fourth vessel without has also been foamed, as a reference.

The adhesion measured values are presented in chart 1

	REFERENCE	*50 HOUR of salt spray*	*120 HOUR of salt spray*	*200 HOUR of salt spray*
TYPE OF RUPTURE	Cohesive in the PU foam	Interface steel with corrosion/PU foam	Interface steel with corrosion /PU foam	Interface steel with corrosion /PU foam
ADHESION VALUE (N/mm^2)	4,4	0,5	0,2	0

Chart 1: adhesion value and burst types

These measures clearly show that presence of corrosion strongly affects characteristics of PU adhesion on the exposed steel vessel. This drop of properties is compared in the following test to the one possibly appearing after accidental contamination of steel by an anti-grip agent.

Vessels coated, before foaming, with the product used to remove the over-moulded cylinder from the mould ("agent démoulant")

Foaming the Cube requires coating the PU foam injection mould with a product. If it accidentally slips on steel before foaming, adhesion steel/PU would be affected or even inexistent. In such a case, there could be a gap of air, with humidity slowly progressing, given the time, through PU foam which would in the end contaminate vessel's surface however coated with protection against corrosion.

Two vessels from current production, protected with a paint to protect against corrosion are half coated with the product, then foamed.

Measured adhesion values are for:

- The halves of Cubes non coated with release product are an average of 4,2 N/mm^2. All bursts have been observed at foam heart. The PU/steel adhesion is at least 4,2 N/mm^2.
- The halves of Cubes coated with release product are an average of 2,8 N/mm^2. All bursts have been observed along interface steel/PU where the release product has been put, without bifurcation in foam. The PU/steel cohesion of foam is superior to 2,8 N/mm^2.

The 2,8 N/mm^2 value obtained represents two thirds of nominal characteristic, it is anyway quite superior to adhesion values measured on Cubes with corrosion.

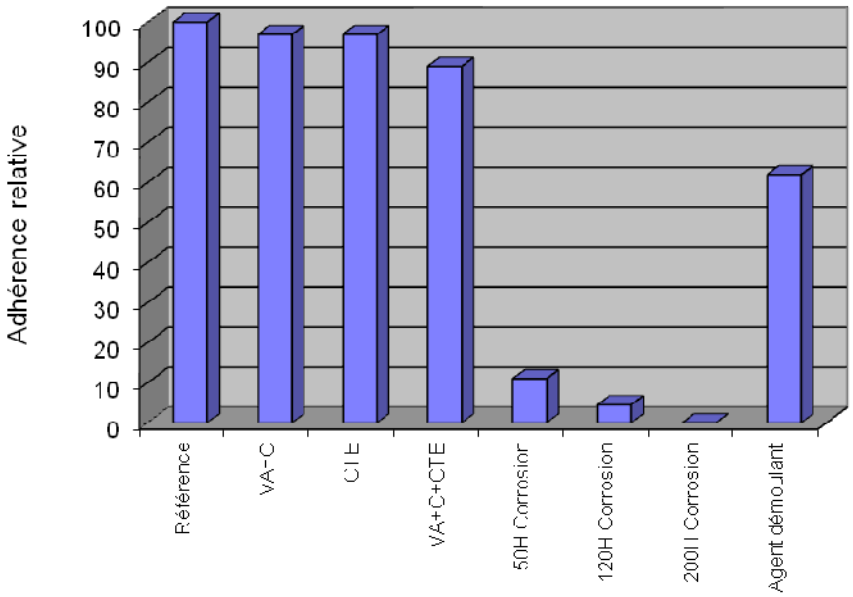


Figure 2 : Adhesion tests results chart

All adhesion measures results are presented in figure 2. This summary shows that only vessel with corrosion can lead to very weak adhesion values (inferior to 10% of nominal value). In comparison, Thermo mechanical ageing in severe environment and polluting products introduced along interface steel/PU has only led to minor adhesion weakening.

Periodical destructive test by proposed batch sampling

On a preliminary work basis, and in order to take into account presence of both material of different nature participating to the Cube structural integrity, it has been suggested to periodically sample Cubes for the following destructive tests :

- Burst under hydraulic pressure according to EN 1442 standard
- Peeling and corrosion according to ISO 4628/3 standard
- Adhesion according to EN 24264 standard
- Hydraulic burst test

In order to check the steel vessel is still able to stand the pressure, the hydraulic burst test is carried out according to prescription of EN 1442 standard.

- Peeling test

In order to check there is no corrosion along the weld, to ensure PU case remains indivisible from the welded vessel and to guaranty its protection function, destructive peeling tests will be carried out according to ISO 4628/3.

- Description of adhesion test by pulling

First of all the test consists in covering the 4 sides and both bottoms of the Cube with steel pull-off blocks glued on the PU. PU surface preparation is needed in order to guaranty optimal adhesion. Blocks are placed in traction through an adhesion dynamometer.

Traction adhesion tests done on the Cubes before ageing indicate that adhesion steel/PU is at least 4,5 N/mm^2.

Experience feedback on destructive tests

Since this procedure has been set up, experience feedback on destructive tests on a 5 year production after n+3 confirms the interest of the periodical inspection method including destructive tests by batch sampling among which PU/steel adhesion.

Electronic identification and database management system

Each “Le Cube” cylinder is equipped with an electronic indestructible identification tag relating it to a database.

Maintenance and exploitation of this data base are both ensured by Butagaz

The system guaranties for each cylinder, among others :

- identification
- manufacturing data
- periodical inspection status
- tare value

And allows then segregation before filling of any cylinder or batch of cylinders whatever the reason (example : periodical inspection tests sampling, periodical inspection failure, complementary sampling, …)

Moreover, it allows periodical inspection status marking for each cylinder.

Individual control before, during and after filling

The Cube cylinder is under a specialised organisation control, responsible for its distribution, its filling and its supervision when in service but also its maintenance: Butagaz.

Before, during and after filling, each cylinder is individually checked according to EN 1439. Additional specific criteria indicated below do consider physical defaults but also specifications of PU foam.

- External visual inspection: any cylinder that does not comply with the criteria is isolated before filling for treatment or disposal.
- When periodical status control is not known before filling, the cylinder is isolated for complementary investigation, treatment or disposal.
- Any cylinder isolated for treatment or disposal is examined by competent staff who will decide whether it can be filled, repaired or disposed according to EN 12816.

Conclusions

On the method

The main target for those adhesion tests by pulling PU coating is qualification of adhesion level between vessel and PU coat, but it also allows following PU mechanical performances on pulling in the long run.

When burst occurs on interface PU/steel, adhesion between those two materials is directly quantified. A burst in the middle of PU foam means cohesion forces of the foam are inferior to adhesion forces of steel/PU.

In the second case the mechanical characteristic of coating when being pulled is measured which allows by comparison with nominal values a follow up of PU foam's ageing.

A procedure for each test has been developed in order to practice them in optimal conditions i.e. ensuring maximum reproducibility.

It has been proved that good adhesion of PU foam on vessel means the vessel has no corrosion. A minimum adhesion criteria has been defined in order to evaluate PU capacity to ensure his protective function against corrosion in the long run.

On the other hand grip test by pulling PU coating led with all precaution described in this procedure allows to set up a close follow up of PU foam ageing state.

Requirements and limits of these methods

The periodic inspection method by sampling developed for the Cube vessel could be widened to other cylinder's periodical control problems or on an even wider scale, to transportable pressure device provided all following prescriptions are compliant:

- Large scale production through automatic procedures
- Reduced unit capacity
- Non corrosive content
- Individual visual check at filling
- Automatic control of periodical state control
- Automatic individual segregation before filling
- Computerized and automatized registration of each event of the cylinder's life (its initial test, first filling… until its disposal).

For "the Cube", Butagaz has the responsablity for exploiting its cylinders : distribution, filling, periodical inspection, maintenance, disposal. The process for "providing the Cube cylinder for filling" is certified in accordance with ISO 9001-2000.

The experience feedback after a 5 year experience successfully tested, confirms for the Cube validity of the periodical inspection method by associating controls and unit tests when filling with destructive periodical tests on batch samples.

Regulatory framework

This method is now applicable on Cubes manufactured according to the pre-existing French reglementation : January 18th 1943 modified. It has been confirmed by the decision DM-T/P n°32327 dated 9th December 2002.

According to experience feedback, evolutions of the method can be proposed to French administration.

Similar provisions are not today for transportable pressure equipments in international and European regulation texts: DESPT, RID/ADR, U.N. model regulation.

Adjustments to those texts must then be proposed for a similar periodical inspection method to be applicable to Cubes marked π, some of them also being exploited in Belgium and Portugal.

As a first approach, work has been carried within CEN TC 286 (equipment and accessories for LPG) to propose and introduce periodical inspection method, as it is carried on the Cube with review of standards relative to welded steel gas cylinders :

- EN 1439 : Before, during and after filling controls,
- EN 1440 : Periodical controls.

A similar approach will have to be taken within ISO TC 58 (gas cylinders).

Annexe 3

prEN14140 (Transportable refillable welded steel cylinders for LPG — Alternative design and construction) extracts about adhesion test

7.3.7.3 Protected over-moulded cylinders

7.3.7.3.1 Over-moulded protective case design

The over-moulded protective case shall be polyurethane or a material with, as a minimum, equivalent properties. The over-moulded protective case shall be applied to a coated cylinder which meets the requirements of 7.3.7.1. It shall have mechanical properties and adequate adhesion to the coating to prevent water ingress between the coating and the over-moulded protective case to guarantee the metallic cylinder properties during the life of the cylinder.

The design of the over-moulded protective case shall provide both impact and corrosion protection.

The over-moulding shall not cover the cylinder serial number and if the other permanent marks are covered by the over-moulding they shall be moulded into the over-moulding or on a plate entrained within the over-moulding. Where a separate plate is used it shall also be marked with the cylinder serial number.

The detailed design, manufacture and testing of over-moulded protective case against impact shall be approved by a competent authority.

Additional details on the design of protected over-moulded cylinder are given in annex B.

The manufacturer of the coated cylinder shall provide criteria for non-acceptance of cylinders that area to be over-moulded.

7.3.7.3.2 Adhesion test procedure

7.3.7.3.2.1 This additional test shall be carried out on one finished protected cylinder.

7.3.7.3.2.2 Preparation

The epoxy adhesive components used in this test procedure shall be stored according to the manufacturer instructions.

The adhesion test block shall be aluminium with a diameter of 20 mm and of suitable length for testing.

The protected over-moulded cylinder to be tested shall be stored at (23 ±2) °C for a minimum of 24 h before preparation and curing of the adhesive.

The test shall be carried out at (23 ±2) °C and at a relative humidity of (50 ± 5) %.

The ambient conditions shall be recorded on the test report.

The test area shall be prepared by lightly sanding with an abrasive material.

Any paint on the over-moulded protective case shall be removed with an abrasive material.

The adhesion test block shall be glued to the over-moulded protective case using an epoxy type adhesive. The epoxy adhesive shall be allowed to cure for a minimum period of 48 h after application and as required by the manufacturer's instructions.

The over-moulded protective case around the adhesion test block shall be cut through to the steel surface of the cylinder.

7.3.7.3.2.3 Breaking strength

The adhesion test block shall be placed in the pull-off adhesion tester, taking care to align the adhesion test block so that the tensile force is applied uniformly across the protected cylinder wall.

A tensile stress, increasing at a rate not greater than 1 MPa/s, perpendicular to the plane of the substrate shall be applied.

7.3.7.3.2.4 Results

The acceptance values shall be per Table 8 (type test) and Table 10 (production test).

The following data shall be recorded:

(a) the breaking strength measured by the pull-off adhesion tester; and

(b) the type of fracture and the percentage of pulled-off area.

7.3.7.3.2.5 Test report

The test report shall contain at least the following information:

(a) all details necessary to identify the product(s) tested;

(b) the results of the test as per 7.3.7.2.4;

(c) the type of the cutting tool employed to cut around the adhesion test block; and

(d) the date of the test.

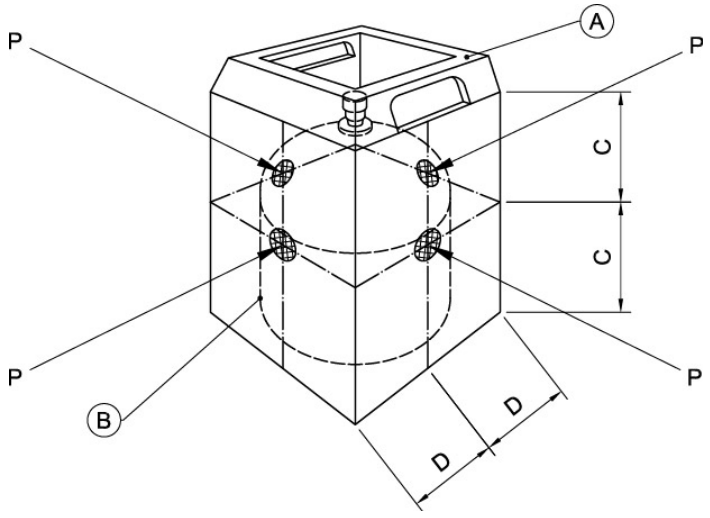
7.3.7.3.3 Requirements

The type test requirements and acceptance values are detailed in Table 8.

The production test requirements and acceptance values are detailed in Table 10.

Table 1 — Resistance to external corrosion type test for protected cylinders

Test type	*Test details*	*Acceptance value*
Adhesion of protecting material on coating test	5 pull-off tests at mid height (on the sides) every 90° and on the bottom as illustrated in figure 9. See procedure in 7.3.7.3.2.	Breaking strength > 2,5 MPa per test. Breaking shall occur into the protecting material layer or between the protecting material and the adhesive.



Key

A Over-moulded protective case

B Steel cylinder

C Equidistant dimension (4 places)

D Equidistant dimension (4 places)

P Location of adhesion test block for pull off test

Figure 1 — Pull-off test locations

And

9.10 Production adhesion test for protected over-moulded cylinder

Production testing for the adhesion of the over-moulded protective case shall be undertaken by the manufacturer that applies the over-moulded protective case.

The testing shall be carried per 7.3.7.3.2 and the test acceptance values shall per Table 10.

The production test for adhesion of protecting material on coating shall be carried out on one protected over-moulded cylinders every 1 000 cylinders produced.

In the event of cylinder failing the test, the test shall be repeated on two additional cylinders.

Table 2 — Resistance to external corrosion production test for protected cylinders

Test type	*Test details*	*Acceptance value*
Adhesion of protecting material on coating test	5 pull-off tests at mid height (on the sides) every 90° and on the bottom as illustrated in Figure 11 See procedure in 7.3.7.3.2	Breaking strength > 1 MPa per test. Breaking shall occur into the protecting material layer or between the protecting material and the adhesive.

And

Annex B (normative)

Protected over-moulded cylinder

B.1 Design

An example of a protected over-moulded cylinder is given in **Error! Reference source not found.** B.1.

Each protected over-moulded cylinder shall be fitted with an individual resilient identification electronic tag or any equivalent device linked to an electronic database.

The database shall be maintained under the responsibility of the organization that owns the cylinder. The database system shall record:

- identification of each cylinder;
- manufacturing information of each cylinder;
- status of each cylinder regarding periodic inspection;
- tare mass of each cylinder;
- segregation before filling of any identified cylinder or batches of cylinders for any reason (e.g., periodic inspection, sampling).

Note: In case of an issue with a cylinder (detected at filling plant, at customer's, during periodic tests..), the electronic tag linked to the database allows cylinders from for the same batch to be automatically withdrawn to perform relevant tests and to assess if it is a batch issue or not. If necessary, the whole batch can be automatically withdrawn and disposed

Relevant procedures shall be applied to prevent water ingress into the cylinder between the production of the coated cylinder and the moulding of the protection material on the coated pressure receptacle.

Manufacturers of protected over-moulded cylinder shall have a documented quality system to ensure that the requirements of this standard are fulfilled and correctly applied.

B.2 Environment

The design of the protected over-moulded cylinder shall minimise the waste of materials.

Over-moulded protective casings manufactured from recyclable plastic materials shall display the appropriate recycling symbol.

NOTE 1 The manufacturer should endeavour to minimise wastage of material by selecting appropriately sized materials related to the finished parts required for manufacture.

NOTE 2 The process should be designed to minimise VOC emission.

Annex 4

EN1440 (LPG equipment and accessories. Periodic inspection of transportable refillable LPG cylinders) annex G

Annex G (normative)

Periodic inspection procedure for a particular design of protected cylinder

G.1 Scope and cylinder description

This annex is applicable to polyurethane protected cylinders (see Figure G.1).

G.2 Cylinders design and manufacturing requirements

G.2.1 Steel cylinder

The metallic cylinder shall be designed and manufactured in accordance with EN 1442 or EN 14140.

G.2.2 External protection

The detailed design, manufacture and testing of polyurethane protection against impact and corrosion shall be approved by a competent authority.

G.2.3 Marking and recording requirements

The cylinders shall be under the control of a competent gas organisation responsible for their distribution, filling and maintenance.

Each cylinder shall be fitted with an individual resilient identification electronic tag or any equivalent device linked to an electronic database.

The database shall be maintained under the responsibility of the competent gas organisation.

The database system shall record:

- identification of each cylinder;
- manufacturing information of each cylinder;
- status of each cylinder regarding periodic inspection;
- tare mass of each cylinder;
- segregation before filling of any identified cylinder or batches of cylinders for any reason (e.g., periodic inspection, sampling).

G.3 Inspection at filling

Cylinders shall be individually checked before, during and after each filling in accordance with EN 1439.

G.4 Periodic destructive tests on batch sampling

G.4.1 Testing procedure

A periodic inspection testing procedure shall be established from this annex and agreed with the competent authority.

Testing shall occur:

- after 3 years of service, and
- every n years after the first tests.

"n" shall be established as result of experience of the ability of the polyurethane protection to maintain its properties against impact and corrosion. Initially "n" shall be 5 years and may be extended later to 10 years, or 15 years for cylinders meeting the requirements of **Error! Reference source not found.** with the agreement of the competent authority.

G.4.2 Destructive tests

The destructive test shall include at least the following:

- burst test in accordance with EN 1442 or EN 14140, and
- peeling and corrosion test in accordance with EN ISO 4628-3.

Additional adhesion destructive test in accordance with EN ISO 4624 shall be conducted if required by the competent authority.

G.4.3 Rejection criteria and batch sampling

Rejection criteria and sampling levels shall be in accordance with Table G.1.

Table G.1 — Batch sampling

Test interval (years)	*Test type*	*Standard*	*Rejection criteria*	*Batch sampling level*	*Test results*
3	Burst test	EN 1442	Burst pressure <70 bar or Volumetric expansion < 12 %	$3\sqrt[3]{Q}$ or $Q/200$ whichever is lower, and with a minimum of 20 per batch (Q)	If any test fails, repeat tests replacing Q with monthly production q and test for each month. For any month's tests having failures, the whole production for that month shall be rejected.
	Peeling and corrosion	EN ISO 4628-3	Max corrosion grade : Ri2	Q/1 000	
Every *n*	Burst test	EN 1442	Burst pressure <70 bar or Volumetric expansion < 12 %	$6\sqrt[3]{Q}$ or $Q/100$ whichever is lower, and with a minimum of 40 per batch (Q)	

Test interval (years)	*Test type*	*Standard*	*Rejection criteria*	*Batch sampling level*	*Test results*
	Peeling and corrosion	EN ISO 4628-3	Max corrosion grade : Ri2	*Q*/1 000	

Q Represents the total number of cylinders made by manufacturer in the same year.

q Represents a continuous production batch.

G.4.4 Periodic inspection tests reports and records

Periodic inspection reports shall be made available to the competent authority, and then with their agreement (if required), the database is updated.

Annex 5

prEN1440 (LPG equipment and accessories. Periodic inspection of transportable refillable LPG cylinders) annex G

Annex G (normative)

Periodic inspection procedure for protected over-moulded cylinders

G.1 Scope and cylinder description

This annex is applicable to protected over-moulded cylinders.

G.2 Cylinders design and manufacturing requirements

G.2.1 Protected over-moulded cylinder

The protected over-moulded cylinder shall be designed and manufactured in accordance with prEN 1442 or prEN 14140.

G.2.2 Marking and recording requirements

Each cylinder shall be fitted with an individual resilient identification electronic tag or any equivalent device linked to an electronic database as defined in prEN 1442 and prEN 14140.

This electronic database allows:

- To automatically withdraw a batch of cylinders to perform tests and / or manage the periodic inspection of test date;
- In case of an issue with a cylinder (detected at filling plant, at customer's, during periodic tests..), the electronic tag linked to the database allows cylinders from for the same batch to be automatically withdrawn to perform relevant tests and to assess if it is a batch issue or not. If necessary, the whole batch can be automatically withdrawn and disposed;
- To carry out the marking which indicates the successful completion of the periodic inspection.

Additional database recording requirements are listed in prEN 1442 and prEN 14140.

Each cylinder shall be fitted with an individual resilient identification electronic tag or any equivalent device linked to an electronic database.

G.3 Inspection at filling

Cylinders shall be individually checked before, during and after each filling in accordance with EN 1439.

G.4 Periodic destructive tests on batch sampling

G.4.1 Testing procedure

Testing shall occur:

- after 3 years of service, and
- every 5 years after the first tests.

G.4.2 Destructive tests

The destructive test shall include at least the following:

- burst test in accordance with EN 1442 or EN 14140,
- peeling and corrosion test in accordance with EN ISO 4628-3, and
- adhesion tests of the polyurethane material. The number of cylinders to be tested is set by ISO 2859-1:1999 (single sampling for normal inspection, inspection level 1) applied to one thousandth of the annual production. The minimum adhesion value is set to 0,5 N/mm². If the result does not comply with this criteria for at least one cylinder, a second sampling, whose quantity is fixed by the tightened sampling plan of the same standard applied to one thousandth of the production, is made. If at least one cylinder of the second sampling does not comply with the minimum value of the adhesion criteria, the periodic inspection of the batch depends on the results of the peeling and burst tests described in Table G.1.

  Adhesion test procedure is described in prEN14140:2013 in 7.3.7.3.2.

G.4.3 Rejection criteria and batch sampling

Rejection criteria and sampling levels shall be in accordance with Table G.1.

Table G.1 — Batch sampling

Test interval (years)	*Test type*	*Standard*	*Rejection criteria*	*Batch sampling level*	*Test results*
After 3 yers in service	Burst test	EN 1442	Burst pressure <70 bar in propane service or 50 bar in butane service Volumetric expansion < 15 or 9 % (**)	$3\sqrt{Q}$ or $Q/200$ whichever is lower, and with a minimum of 20 per batch (Q)	If any test fails, repeat tests replacing Q with monthly production q of representative sub-batches
	Peeling and corrosion	EN ISO 4628-3	Max corrosion grade : Ri2	Q/1 000	
Every 5 years	Burst test	EN 1442	Burst pressure <70 bar in propane service or 50 bar in butane service Volumetric expansion < 13, 12 or 9% (**)	$6\sqrt{Q}$ or $Q/100$ whichever is lower, and with a minimum of 40 per batch (Q)	
	Peeling and corrosion	EN ISO 4628-3	Max corrosion grade : Ri2	Q/1 000	
Q	Represents the total number of cylinders made by manufacturer in the same year.				

Test interval (years)	*Test type*	*Standard*	*Rejection criteria*	*Batch sampling level*	*Test results*
q	Represents a continuous production batch.				

(*)

For each of the two groups of figures (burst pressure and volumetric expansion), the “right” unilateral statistical tolerance interval is calculated for a confidence level of 95% and a fraction of population equal to 99%. The calculation is made in accordance with the standard ISO 16269-6:2005 (Statistical interpretation of data – Part 6: Determination of statistical tolerance intervals) admitting, for each of the groups of figures, the normality of the population and considering that the variance is unknown.

(**)

For the cylinders manufactured according to Directive 84/527/EEC, the volumetric expansion cannot be lower than:

- 15% for the tests done 3 years after manufacturing
- 13% for the tests done 8 years after manufacturing
- 12% for the following tests.

For the cylinders manufactured according to Directive 1999/36/EC or Directive 2010/35/EU and according to EN1442, the volumetric expansion cannot be lower than 9%.

For the cylinders manufactured according to Directive 1999/36/EC or Directive 2010/35/EU according to EN14140, it is necessary to have more than 15 years of experience related to the cylinder type to determine the criteria for the volumetric expansion.

G.4.4 Periodic inspection tests reports and records

Periodic inspection reports shall be made available to the competent authority upon request. At the end of the tests, the database is updated for the cylinders of the batch or sub-batch.

When the cylinders return to a filling plant, the cylinders from the relevant batch are:

- Marked provided the successful completion of the valve control or the valve replacement;
- Or, if the batch or sub-batch fails, withdrawn.

G.5 Lifetime

The design lifetime of the protected over-moulded cylinder is set at present to 30 years. However, this lifetime can then be extended every 5 years, as long as the tests undertaken at the periodic inspection demonstrate that the polyurethane adhesion to the inner receptacle has retained its properties.

The electronic tag linked to the database enables a batch of cylinders to be withdrawn when it has reached its lifetime.