**Economic Commission for Europe**

Inland Transport Committee

**Working Party on the Transport of Dangerous Goods**

**Joint Meeting of the RID Committee of Experts and the Working Party on the Transport of Dangerous Goods**
Geneva, 19-29 September 2017
Item 7 of the provisional agenda
**Reports of informal working groups**

# Report of the informal working group on alternative methods for periodic inspections

# Alternative methods for periodic inspection of refillable pressure receptacles

**Transmitted by the European Liquefied Petroleum Gas Association (AEGPL) on behalf of the informal working group on alternative methods for periodic inspections**

# Introduction

Following discussions in plenary about the ECE/TRANS/WP.15/AC.1/2017/33, and as agreed by the Joint Meeting, the working group proposes the following modifications to the related proposals. This informal paper provides the revised English version and the revised French and German versions will be provided in complementary INF Papers.

These modifications are indicated as ~~deletions~~ or supplements.

The numbering of the initial paper is kept or the purpose of better comparison.

# Proposals

## Proposal 1 - General provisions

14. Add a new 6.2.3.5.3 to read as follows:

"6.2.3.5.3 General provisions for the substitution of dedicated check(s) for periodic inspection required in 6.2.3.5.1

This ~~subsection~~ paragraph only applies to types of pressure receptacles designed and manufactured in accordance with the standards referred to in 6.2.4.1 or a technical code in accordance with 6.2.5, and for which the inherent properties of the design prevent the checks (b) and/or (d) for periodic inspection required in 6.2.1.6.1 to be applied or the results to be interpreted.

For such pressure receptacles, these check(s) shall be replaced by alternative method(s) related to the characteristics of the specific design, ~~as~~ to be specified in a paragraph under 6.2.3.5.4~~.X.Y~~, and detailed in a special provision ~~XYZ~~ of Chapter 3.3 or a standard referenced in ~~WWW~~6.2.4.2

The alternative method(s) shall be described in a document specifying which check(s) for periodic inspection according to 6.2.1.6.1 (b) and/or (d) is/are to be substituted.

The alternative method(s) in combination with the remaining checks according to 6.2.1.6.1 (a) to (e) shall ensure a level of safety at least equivalent to the safety level for pressure receptacles of a similar size and use which are periodically inspected in full compliance with 6.2.3.5.1.

The alternative method(s) shall moreover ~~document~~ detail all the following elements:

- A description of the relevant types of pressure receptacles;
- The procedure for the test(s);
- A specification of the acceptance criteria;
- A description of the measures to be taken in case of ~~with~~ rejection of pressure receptacles.

6.2.3.5.3.1 Non-destructive testing as an alternative method

The check(s) identified in 6.2.3.5.3 shall be supplemented and/or replaced by one (or more) non-destructive test method(s) to be performed on each individual pressure receptacle.

6.2.3.5.3.2 Destructive testing as an alternative method

If no non-destructive test method leads to an equivalent level of safety, the check(s) identified in 6.2.3.5.3, with exception of the internal inspection mentioned in 6.2.1.6.1 b) in that case,

shall be supplemented and/or replaced by one (or more) destructive test method(s) in combination with its statistical evaluation.

In addition to the elements described above ~~in 6.2.3.5.3~~, the detailed method for destructive testing shall document the following elements:

- A description of the relevant basic population of pressure receptacles;
- A procedure for the random sampling of individual pressure receptacles to be tested;
- A procedure for the statistical evaluation of the test results including rejection criteria;
- A specification for the periodicity of destructive sample tests;
- A description of the measures to be taken if acceptance criteria are met but a safety relevant degradation of material properties is observed, which could be used for the determination of the ~~predict an~~ end of service life;
- A statistical assessment of the level of safety achieved by the alternative method.".

## Proposal 2 – Alternative Method of Periodic Inspection dedicated to Over-Moulded Cylinders

15. Add the following definition in 1.2.1:

"*Over-moulded cylinder* means a cylinder intended for the carriage of LPG with a water capacity not exceeding 13 litres made of a coated welded steel inner cylinder with an over-moulded protective case made from cellular plastic, which is non-removable and bonded to the outer surface of the steel cylinder wall".

16. Insert "6XY" in column (6) of the Dangerous Goods list for the entries for UN numbers 1011, 1075, 1965, 1969 and 1978.

17. Add the following specification about periodic inspection for over-moulded cylinders in a new sub-section 6.2.3.5.4 to read as follows:

"6.2.3.5.4 Over-moulded cylinders shall be subject to periodic inspection and tests in accordance with special provision 6XY of Chapter 3.3".

18. Insert the following special provision in 3.3.1:

"6XY This special provision applies to periodic inspection of over-moulded cylinders as defined in 1.2.1.

Over-moulded cylinders shall be subject to periodic inspection in accordance with 6.2.1.6.1, adapted by the following alternative method:

- Substitute check 6.2.1.6.1 d) by alternative destructive tests.
- Perform specific additional destructive tests related to the ~~design~~ characteristics of over-moulded cylinders.

The procedures and requirements of this alternative method are described below.

Alternative method:

(a) General

The following provisions apply to over-moulded cylinders produced serially and based on welded steel cylinders in accordance with prEN 1442:2014, EN 14140:2015 or annex I, parts 1 to 3 to Council Directive 84/527/EEC. The design of the over-moulding shall prevent water from penetrating on to the

inner steel cylinder. The conversion of the base steel cylinder to an over-moulded cylinder shall comply with the relevant requirements of prEN 1442:2014 and EN 14140:2015.

Over-moulded cylinders shall be equipped with self-closing valves.

(b) Basic population

A basic population of over-moulded cylinders is defined as the production of cylinders from only one over-moulding manufacturer using inner cylinders manufactured by only one manufacturer within one calendar year, based on the same design type, the same materials and production processes, ~~owned/operated by one company~~.

(c) Sub-Groups of a basic population ~~group~~

Within the above defined basic population, over-moulded cylinders operated by different owners may be separated into specific ~~population~~ sub-groups.

(d) Traceability

Inner steel cylinder marks in accordance with 6.2.3.9 shall be repeated on the over-moulding. In addition, each over-moulded cylinder shall be fitted with an individual resilient electronic identification device. The detailed characteristics of the over-moulded cylinders shall be recorded by the owner in a central database. The database shall be used to:

- Identify the specific ~~population~~ sub-group;
- Make available to inspection bodies, filling centres and competent authorities the specific technical characteristics of the cylinders ~~(~~consisting of at least the following: serial number, steel cylinder production batch, over-moulding production batch, date of over-moulding~~)~~;
- Identify the cylinder by linking ~~the serial number and~~ the electronic device to the database with the serial number
- Check individual cylinder history and determine measures (e.g. filling, sampling, retesting, withdrawal);
- Record performed measures including the date and the address of where it was done.

The recorded data shall be ~~made~~ kept available by the owner of the over-moulded cylinders for the entire life of the ~~population~~ sub-group.

(e) Sampling for statistical assessment

The sampling shall be random among a ~~population~~ sub-group as defined in (c). The size of each sample per ~~population~~ sub-group shall be in accordance with the table in paragraph (g).

(f) Test procedure for destructive testing

The tests required by 6.2.1.6.1 shall be carried out except (d) which shall be substituted by the following test procedure:

- Burst test (according to EN 1442:2014 or EN 14140:2015)

In addition, the following tests shall be performed:

- Adhesion test (according to EN 1442:2014 or EN14140:2015)
- Peeling and Corrosion tests (according to EN ISO 4628-3:2004)

Adhesion test, Peeling and Corrosion tests, and Burst test shall be performed on each related sample according to the table in paragraph (g) and shall be conducted after the first 3 years in service and every 5 years thereafter.

(g) Statistical evaluation of test results – Method and minimum requirements

The procedure for statistical evaluation according to the related rejection criteria is described in the following ~~table, and its related comments~~.

**Table 1**

| **Test interval** (years) | **Type of test ~~type~~** | **Standard** | **Rejection criteria** | **~~Population Group~~ Sampling out of a sub-group ~~level~~** |
|---|---|---|---|---|
| | Burst test | EN 1442:2014 | ~~Representative~~ Burst pressure point of the representative sample must be above the lower limit of tolerance interval on the Sample Performance Chart<br>$\Omega_m \geq 1 + \Omega_s \times k3(n;p;1-\alpha)$ (*)<br>-<br>No individual test result ~~sample shall exhibit a burst pressure~~ shall be less than the test pressure | $3\sqrt[3]{Q}$ or $Q/200$ whichever is lower,<br>and<br>with a minimum of 20 per ~~population~~ sub-group (Q) |
| | Peeling and corrosion | EN ISO 4628-3:2004 | Max corrosion grade:<br>Ri2 | Q/1 000 |
| | Adhesion of Polyurethane | ISO 2859-1:2000<br>EN 1442:2014<br>EN 14140:2015 | Adhesion value > 0.5 N/mm² | See ISO 2859-1:2000 applied to Q/1000 |
| | Burst test | EN 1442:2014 | ~~Representative~~ Burst pressure point of the representative sample must be above the lower limit of tolerance interval on the Sample Performance Chart<br>$\Omega_m \geq 1 + \Omega_s \times k3(n;p;1-\alpha)$ (*)<br>-<br>No individual test result ~~sample shall exhibit a burst pressure~~ shall be less than the test pressure | $6\sqrt[3]{Q}$ or $Q/100$ whichever is lower,<br>and<br>with a minimum of 40 per ~~population~~ sub-group (Q) |
| | Peeling and corrosion | EN ISO 4628-3:2004 | Max corrosion grade:<br>Ri2 | Q/1 000 |
| | Adhesion of Polyurethane | ISO 2859-1:2000<br>EN 1442:2014<br>EN 14140:2015 | Adhesion value > 0.5 N/mm² | See ISO 2859-1:2000 applied to Q/1000 |

(*) ~~Representative~~ Burst pressure point (BPP) of the representative sample is used ~~Procedure~~ for the evaluation of test results by using a Sample Performance Chart[*],[†]:

[*] *BAM-GGR 021 Design Type Specific Determination of the Safe Service Life for Composite Pressure Receptacles on the basis of the Concept Additional Tests (CAT)* (from 21st Sept. 2017) https://www.tes.bam.de/en/regelwerke/amtliche_mitteilungen/index.htm*

[†] *Mair, Georg W.: Safety Assessment of Composite Cylinders for Gas Storage by Statistical Methods:, London : Springer Ltd. 2017.*

Step 1: Determination of the ~~representative~~ burst pressure point (~~R~~BPP) of a representative sample

Each sample is represented by a point whose coordinates are the ~~Sample~~ mean value of burst test results and the ~~Sample~~ standard deviation of burst test results, each ~~related~~ normalised to the relevant test pressure.

$$\text{~~R~~BPP: } \left( \Omega_m = \frac{x}{PH} ; \Omega_s = \frac{s}{PH} ; \Omega_m = \frac{x}{PH} \right)$$

with

x: sample mean value;

s: sample standard deviation;

PH: test pressure

Step 2: Plotting on a Sample Performance Chart

Each RBPP is plotted on a Sample Performance Chart with following axis:

- Abscissa : Standard Deviation normalised ~~related~~ to test pressure ( $\Omega_s$ )
- Ordinate : Mean value normalised ~~related~~ to test pressure ( $\Omega_m$ )

Step 3: Determination of the relevant lower limit of tolerance interval in the Sample Performance Chart

Results for burst pressure shall first be checked according to the Joint Test (multidirectional test) using a significance level of $\alpha$=0.05 (see paragraph 7 of ISO 5479:1997) to determine whether the distribution of results for each sample is normal or non-normal.

- For a normal distribution, the determination of the relevant lower limit of tolerance is given in step 3.1
- For a non-normal distribution, the determination of the relevant lower limit of tolerance is given in step 3.2

Step 3.1: Lower limit of tolerance interval for results following a normal distribution

In accordance with the standard ISO 16269-6:2005, and considering that the variance is unknown, the unilateral statistical tolerance interval shall be considered for a confidence level of 95% and a fraction of population equal to 99.9999%.

By application in the Sample Performance Chart, the lower limit of tolerance interval is represented by a line of constant survival rate defined by the formula:

$$\mathbf{\Omega_m = 1 + \Omega_s \times k3(n;p;1-\alpha)}$$

with

k3: tabulated factor function of n, p and 1-$\alpha$;

p: proportion of the population selected for the tolerance interval (99.9999%);

1- $\alpha$: confidence level (95%);

n: sample size.

The value for k3 dedicated to Normal Distributions shall be taken from the table at end of Step 3.

Step 3.2: lower limit of tolerance interval for results following a non-normal distribution

The unilateral statistical tolerance interval shall be calculated for a confidence level of 95% and a fraction of population equal to 99.9999%.

The lower limit of tolerance is represented by a line of constant survival rate defined by the formula given in previous step 3.1, with factors k3 based and calculated on the properties of a Weibull Distribution.

The value for k3 dedicated to Weibull Distributions shall be taken from the table at end of Step 3.

| Table for k3<br>p=99.9999% and (1- α)=0.95 | | |
|---|---|---|
| **Sample Size n** | **Normal Distribution k3** | **Weibull Distribution k3** |
| 20 | 6,901 | 16,021 |
| 22 | 6,765 | 15,722 |
| 24 | 6,651 | 15,472 |
| 26 | 6,553 | 15,258 |
| 28 | 6,468 | 15,072 |
| 30 | 6,393 | 14,909 |
| 35 | 6,241 | 14,578 |
| 40 | 6,123 | 14,321 |
| 45 | 6,028 | 14,116 |
| 50 | 5,949 | 13,947 |
| 60 | 5,827 | 13,683 |
| 70 | 5,735 | 13,485 |
| 80 | 5,662 | 13,329 |
| 90 | 5,603 | 13,203 |
| 100 | 5,554 | 13,098 |
| 150 | 5,393 | 12,754 |
| 200 | 5,300 | 12,557 |
| 250 | 5,238 | 12,426 |
| 300 | 5,193 | 12,330 |
| 400 | 5,131 | 12,199 |
| 500 | 5,089 | 12,111 |
| 1000 | 4,988 | 11,897 |
| ∞ | 4,753 | 11,408 |

Note : If sample size is between two values, the closest lower sample size shall be selected

(h) Measures if the acceptance criteria are not met

If a result of the burst test, peeling and corrosion test or adhesion test does not comply with the criteria detailed in the table in paragraph (g), the potentially affected ~~population~~ sub-group within ~~of~~ a basic population of over-moulded cylinders shall be segregated for further investigations and not be filled or made available for transport and use.

In agreement with the competent authority, its delegates or the Xa-body which issued the design approval, additional tests may be performed to determine the root cause of the failure. If ~~and the~~ parts of that ~~population~~ sub-group ~~which is (are)~~ can be proved to be not affected and behave like the rest of the basic population, those parts of the

~~population~~ sub-group ~~not affected by the root cause of the failure~~ may be authorized by the competent authority to return to service.

(i) Filling centre requirements

The owner shall make available to the competent authority documentary evidence that the filling centres:

- Comply with the provision of packing instruction P200 (7) of 4.1.4.1 and that the requirements of the standard on pre-fill inspections referenced in table P200 (11) of 4.1.4.1 are fulfilled and correctly applied;
- Have the appropriate means to identify over-moulded cylinders through the electronic identification device;
- Have access to the database as defined in (d);
- Have the capacity to update the database;
- Apply a quality system, according to the standard ISO 9000 (series) or equivalent, certified by an accredited independent body recognized by the competent authority.

19. Remove the exception about "3.5 and annex G" for EN 1439:2008 in table P200 (11).

20. Remove the exception about "Over-moulded cylinders" for EN 14140:2014+AC:2015 in the table in sub-section 6.2.4.1

21. Remove the exception about "clause 3.5, Annex F and Annex G" for EN 16728:2016 in the table in sub-section 6.2.4.2, awaiting the ongoing update.