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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*,****

* In accordance with the programme of work of the Inland Transport Committee for 2016-2017, (ECE/TRANS/2016/28/Add.1 (9.2)).

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Introduction

1. The informal working group on alternative methods for periodic inspections of refillable pressure receptacles met in Paris from 3-4 May 2017. It discussed the concerns that were expressed at the spring 2017 session of the Joint Meeting held in Bern, and offered explanations to the questions raised. A general provision is proposed in Proposal 1, and a specific provision dedicated to Over-Moulded Cylinders (OMC) is proposed in Proposal 2.

Note: Former Proposal 2 of informal document INF.9 (Spring 2017 session) has been postponed, see section B of Part I below.

I. Discussion

A. Concerns about Proposal 1 of informal document INF.9 (Spring 2017 session)

1. Scope of the statistical tests (tests and cylinders)

2. The informal working group accepted that ADR 6.2.1.6.1 checks (a to e) be reduced to b and d only. (See paragraph 6.2.3.5.3 of proposal 1).

3. The group accepted to be more rigorous about the scope dealing with cylinders and the scope dealing with tests (see proposal 1).

4. Regarding the remark that imposing limits of applications today would lead to future demands of exemption, only checks b and d are proposed because they are the most likely possible checks to be subject to substitution.

2. Wording improvement: «Inadequate» to be deleted or changed

5. The informal working group agreed that this word should be deleted.

3. Proposal to link such alternatives methods to life duration (by design / service life), and degradation monitoring

6. The group accepted this proposal (see Proposal 1)

B. Concerns about Proposal 2 of informal document INF.9 (Spring 2017 session)

7. During the last Joint Meeting session, views were expressed that the informal working group would have to deal with proposal 2 by considering that a general provision should include general principles and regulatory clauses. All technical details would be included in technical guidelines.

8. After discussion, the informal working group considers that Proposal 2 is not to be rejected but is not ready for submission to the Joint Meeting. In this respect:

(a) Essential general principles have then been introduced in the proposal 1 of this document;

(b) The informal working group recommends that:

- (i) The Joint Meeting invite the relevant committee of standardization organizations (CEN or ISO, to be determined) to consider commencing a New Work Item to produce a technical document that would specify the points identified in Proposal 1 based on the text to be found in Proposal 2 of informal document INF.9 (Spring 2017 session), as a starting point for such work; or
- (ii) The Joint Meeting define a new mandate

C. Concerns about Proposal 3 of informal document INF.9 (Spring 2017 session)

9. The informal working group focused on the specific method developed for the over-moulded cylinders, through a dedicated presentation of each step (operations and controls).
10. Real cases were presented. Specific explanations were given on the statistical assessment method of burst pressure results. A graphical method called the “Sample Performance Chart”, which had been developed by an independent expert in Statistics and Pressure Receptacles, was presented. This method for burst pressure results was described in Proposal 3 of informal document INF.9 and has been updated in proposal 2 of this document.
11. In particular, the consistent use of the wording « peeling and corrosion tests » (not just “peeling tests”) has been checked in all paragraphs
12. Regarding the question why volumetric expansion had not been selected as one of the criteria (compare to burst pressure), it should be noted that, from experience, no clear interaction between Volumetric expansion and Burst Pressure has been demonstrated. Moreover, due to experience, critical results in Volumetric Expansion were already noted from critical results in Burst Pressure. So Burst Pressure has been kept as a criterion for statistical assessment of OMC (but volumetric expansion could be relevant to other designs)
13. For the request for explanation when there are outliers on normal distribution, reference is made to Proposal 3 in informal document INF.9, paragraph (g), where step 1, Determination of Character of distribution, deals with outliers and select the right distribution to be used.

II. 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 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 inspections 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 specific types of design as specified in paragraphs 6.2.3.X.Y, and detailed in a special provision XYZ or a standard referenced in WWW.

The alternative method(s) shall document 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 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 with rejected 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 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 in 6.2.3.5.3, the detailed method for destructive testing shall document the following elements:

- A description of the relevant 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;
- 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 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 of over-moulded cylinders.

The procedures and requirements of this alternative method is 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 prEN1442:2014, EN14140:2015 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 prEN1442:2014 and EN14140:2015.

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) Population group

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

(d) Traceability

Inner steel cylinder markings 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 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;
- Check individual cylinder history and determine measures (eg, filling, sampling, retesting, withdrawal);
- Record performed measures including the date and the address of where it was done.

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

(e) Sampling for statistical assessment

The sampling shall be random among a population group as defined in (c). The size of each sample per population 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)	Test type	Standard	Rejection criteria	Population Group sampling level
After 3 years in service	Burst test	EN 1442:2014	Representative Burst pressure point of the sample must be above the lower limit of tolerance interval on the Sample Performance Chart $\Omega_m \geq 1 + \Omega_s \times k3(n;p;1-\alpha)$ (*) - No individual sample shall exhibit a burst pressure less than the test pressure	$3\sqrt[3]{Q}$ or $Q/200$ whichever is lower, and with a minimum of 20 per population group (Q)
	Peeling and corrosion	EN ISO 4628-3:2004	Max corrosion grade: Ri2	Q/1 000
	Adhesion of Polyurethane	ISO 2859-1:2000 EN 1442:2014 EN 14140:2015	Adhesion value > 0.5 N/mm ²	See ISO 2859-1:2000 applied to Q/1000
Every 5 years thereafter	Burst test	EN 1442:2014	Representative Burst pressure point of the sample must be above the lower limit of tolerance interval on the Sample Performance Chart $\Omega_m \geq 1 + \Omega_s \times k3(n;p;1-\alpha)$ (*) - No individual sample shall exhibit a burst pressure less than the test pressure	$6\sqrt[3]{Q}$ or $Q/100$ whichever is lower, and with a minimum of 40 per population group (Q)
	Peeling and corrosion	EN ISO 4628-3:2004	Max corrosion grade: Ri2	Q/1 000
	Adhesion of Polyurethane	ISO 2859-1:2000	Adhesion value > 0.5 N/mm ²	See ISO 2859-1:2000 applied to Q/1000

(*) Representative burst pressure point of the sample: Procedure for the evaluation of test results by using a Sample Performance Chart:

Step 1: Determination of the representative burst pressure point (RBPP) of a sample

Each sample is represented by a point whose coordinates are the Sample Mean of burst test results and the Sample Standard Deviation of burst test results, each related to the relevant test pressure.

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

with

x: sample mean;

s: sample standard deviation;

PH: test pressure

Step 2: Plotting on a Sample Performance Chart

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

- Abscissa : Standard Deviation related to test pressure (Ω_s)
- Ordinate : Mean related to test pressure (Ω_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:

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

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		
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 previous table, the potentially affected population group 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 and the part(s) of that population group which is(are) affected.

Those part(s) of the population 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) and that the requirements of the standard on pre-fill inspections referenced in table P200 (11) 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 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.
