Periodic inspection and test of some transportable refillable LPG steel cylinders

Transmitted by the European Liquefied Petroleum Gas Association (AEGPL) on behalf of the Working Group on Alternative Methods for Periodic Inspections

General

Following the last session of the Working Group on Alternative Methods for Periodic Inspections, and parallel to the Working Paper ECE/TRANS/WP.15/AC.1/2017/33, the Working Group has agreed to propose to the Joint Meeting, at the next September Session in Geneva, the following presentation.

This presentation gives explanations and illustrates:

- The global process and format that has to be respected in case of a request for an alternative method to be introduced in the RID/ADR (according to the General Provision given in Proposal 1 of the aforesaid Working Paper)
- An application to a real case called Over-Moulded Cylinders.
Over-moulded Cylinder:
- A coated steel inner cylinder with a bonded and non-removable over-moulded protective case made of polyurethane

Periodic Inspections:
- Due to inherent properties of the design, small defects can be hidden by the cover during Hydraulic Pressure test:
  - Check 6.2.1.6.1 d) is not relevant

An alternative method had to be defined
Demonstration of non-relevance of other Non-Destructive methods for substitution:

- Ultrasonic technology
  - Attempts with various sensors and frequencies
  - Conclusions: PU absorbs waves before reaching steel
- Acoustic Emissions
  - No possible contacts with steel → sensors cannot be applied
  - PU thickness attenuates waves
- X-rays
  - Does not detect holes lower than 200µm, which is above our usual criteria
  - Does not detect surface or spot corrosion

Destructive Tests had to be considered
Over-Moulded Cylinders — Alternative Method

An alternative method has been defined to substitute Check d), based on:
- Burst Tests, combined with statistical evaluation
- Additional Peeling and Corrosion Tests and Adhesion Tests

- Test procedures, Acceptance Criteria have been defined from related Standards, Expertises or Regulation, and agreed by French Authorities (step by step process in 2000, 2001 and 2002)
- Statistical evaluation of tests results has been based on the probabilistic approach*, which is visualized in the Sample Performance Chart (SPC) developed by BAM.

Statistical procedures of this method have been developed under BAM supervision to ensure conformity and a Survival Rate of 99,9999%.

Over-Moulded Cylinders — Real application in SPC

Sample Evaluation by Normal-Distribution,
Survival rate $SR_{99999\%}$, confidence level 95%

- Manufacturer A
- Manufacturer B
- Manufacturer C

Specific Case:
Manufacturer C inspected in 2002-2007-2012-2017

Butagaz
Over-Moulded Cylinders - Real application in SPC

Sample Evaluation by Weibull-Distribution.
Survival rate $SR_{est} = 99.9999\%$, confidence level 95%.

- Butane service
  - MSP = 15 bar
  - $SR_{est} > 99.9999\%$

- Propan service
  - MSP = 30 bar
  - $SR_{est} < 99.9999\%$

Specific Case:
- Manufacturer C inspected in 2002-2007-2012-2017

Manufacturer A
Manufacturer B
Manufacturer C
Over-Moulded Cylinders – Additional Tests

Complementary to the bursts Tests, these tests enable:
- Measurements of the performances at different ages
- Follow up of Quality and Ageing behaviour all along the life of the cylinders

- Peeling and Corrosion Tests
- Adhesion Tests
Over-Moulded Cylinders — Periodic Inspection Operational Process

Identification of Population Groups requiring PI

- **Operator:** Owner
  - With compliance to P200 (7) and (11)

Individual Checks of cylinders according to 6.2.1.6.1 (except d)

- **Sampling**
- **Destructive Tests**
- **Statistical Assessment**

Conclusions about PI of Population Groups

- **Negative**
  - **Database update & Decommissioning**
    - **Operator:** Owner
      - With compliance to P200 (7) and (11)

- **Positive**
  - **Database update & Marking**
    - **Operator:** Owner
      - With compliance to P200 (7) and (11)

- **Operator:** Owner
  - According to Manufacturer information and Database recordings
  - With compliance to P200 (7) and (11)

- **Operator:** Owner
  - With compliance to P200 (7) and (11)

- **Operators:** Testing House + Notified Body

- **Operator:** Notified Body

- **Operator:** Notified Body

Restricted
### Over-Moulded Cylinders — FeedBack after 20 years

**Total amount of Cylinders tested between 2000 & 2016 (manufactured between 1997 & 2013)**

<table>
<thead>
<tr>
<th></th>
<th>Number of Tests</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Burst</td>
</tr>
<tr>
<td>2000-2016</td>
<td>18184</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>27877</strong></td>
</tr>
</tbody>
</table>

**Feedback from filling and testing centers**

<table>
<thead>
<tr>
<th>Year</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaks</td>
<td>17</td>
</tr>
<tr>
<td>Leaks</td>
<td>17</td>
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</tbody>
</table>

- Leaks on the valve: 16
- Leaks on the cylinder: 1

- Welding of the boss (in 2005)

- No rust detected

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*Butagaz*
Over-Moulded Cylinders - Standard structure

Design and Construction

- **EN 1442**
  - Specifications for OMC given in Appendix B and C

- **EN 14140**
  - Specifications for OMC given in specific paragraphs and Appendix B

Periodic Inspection

- **RID/ADR**
  - Under process

- **EN 16728**
  - Specifications for OMC Periodic Inspections given in Appendix F and G.

Proc. for Checking before, during and after filling

- **EN 1439**
  - Specifications for OMC given in Appendix G