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Item 2 of the provisional agenda
Tanks

Periodic inspection of LPG tank-vehicles

Alternatives to the hydraulic test

Transmitted by the European Liquid Petroleum Gases (AEGPL)[1, 2]

Summary

Executive summary: This proposal justifies alternatives to the hydraulic test that can be used on LPG tank vehicle carbon steel fixed and demountable tanks and their carbon steel service equipment at the 6 yearly periodic inspection. It is not intended to replace the internal visual inspection.

Action to be taken: Add a TT11 code to column 13 of the dangerous goods list in chapter 3.2 of the RID/ADR for the following dangerous goods; UN 1011, UN 1075, UN 1965, UN 1969 and UN 1978.

Add a new special provision (TT11) to 6.8.4 (d).

[1] In accordance with the programme of work of the Inland Transport Committee for 2010–2014 (ECE/TRANS/208, para. 106, ECE/TRANS/2010/8, programme activity 02.7 (c)).

[2] Circulated by the Intergovernmental Organisation for International Carriage by Rail (OTIF) under the symbol OTIF/RID/RC/2013/41.

Introduction

1. The current text of the ADR paragraph 6.8.2.4.2 requires that every 6 years a LPG fixed tank and service equipment is required to undergo a hydraulic test:

Shells and their equipment shall undergo periodic inspections no later than every

six years. | five years.

These periodic inspections shall include:

- An external and internal examination;
- A leakproofness test in accordance with 6.8.2.4.3 of the shell with its equipment and check of the satisfactory operation of all the equipment;
- As a general rule, a hydraulic pressure test [9] (for the test pressure for the shells and compartments if applicable, see 6.8.2.4.1).

Experience over the last 30 years in the United Kingdom and Northern America has shown that the hydraulic test can be replaced by suitable Non Destructive Testing (NDT) techniques.

Proposal

2. Add a TT11 code to column 13 of the dangerous goods list in chapter 3.2 of the ADR for the following dangerous goods; UN 1011, UN 1075, UN 1965, UN 1969 and UN 1978.

Add a new special provision (TT11) to 6.8.4 (d) as below:

"For fixed and demountable tanks in dedicated LPG service, with carbon steel shells and service equipment, the hydraulic test may be replaced by the NDT testing techniques listed below.

- Ultrasonic techniques in accordance with **EN ISO 17640**
- Magnetic particle techniques in accordance with **EN ISO 17638**
- Eddy current testing in accordance with **EN 1711**

The NDT techniques in accordance with the above standards shall be performed by personnel qualified and certified in accordance with **EN ISO 9712**

The hydraulic test on the tank cannot be replaced by NDT where hot work has been undertaken on the tank or the tank has been used to transport other dangerous goods, since the last hydraulic test of the tank.

The hydraulic test on the equipment (this may be limited to a separate component or section of the equipment that has had hot work) cannot be replaced by NDT where hot work has been undertaken on the equipment since the last hydraulic test of the equipment.

The non-destructive testing (NDT) must verify the integrity of the parent metal and the construction welding. The techniques used must yield at least the same level of safety as that afforded by the hydraulic test.

The NDT does not replace the leakproofness test that is to be undertaken on the complete tank and equipment assembly.

NDT shall be performed on the areas of the tank, piping and equipment listed in the table below.

Area of Tank Shell and Equipment	*NDT*
'Tee' junctions of butt welds in the tank shell	100 % ultrasonic testing, or magnetic particle or eddy current testing
Tank longitudinal butt welds	100 % ultrasonic testing, or magnetic particle or eddy current testing
Tank circumferential butt welds	100 % ultrasonic testing, or magnetic particle or eddy current testing
Tank shell, areas that cannot be visually inspected from the outside	Ultrasonic thickness survey, from inside, on a 150 mm (maximum) spaced grid
Attachment and opening welds (internal) direct to the tank shell	100 % ultrasonic testing, or magnetic particle or eddy current testing
High stress areas of tank fastening attachment doubling plates (over the saddle horns plus 400 mm)	100 % magnetic particle or eddy current testing
Piping and equipment welds	100 % ultrasonic testing, or magnetic particle or eddy current testing

The defect acceptance levels shall be in accordance with the requirements in EN **12493**.

Tanks with defects falling outside the acceptance levels shall undergo a suitable repair or shall be disposed of safely.

The results of the NDT shall be recorded and retained for the lifetime of the tank."

Titles of Standards referenced in this proposal

- **EN ISO 9712** - Non-Destructive Testing. Qualification and Certification of NDT Personnel
- **EN ISO 17640** - Techniques, testing levels and assessment for non-destructive and ultrasonic testing of welds
- **EN ISO 17638** - Non-destructive testing of welds. Magnetic particle testing
- **EN 1711** - Non-destructive examination of welds. Eddy current examination of welds by complex plane analysis
- **EN 12493** - LPG equipment and accessories - Welded steel tanks for liquefied petroleum gas (LPG) - Road tankers design and manufacture

Justification

3. Hydraulic testing became popular in the 19th century as the only method of ensuring the integrity of pressure vessels (mainly steam boilers), long before any other (technological) methods became available. Following the initial construction or repair of a fixed tank (pressure vessel) it is still a basic requirement to hydraulic test. Hydraulic testing can be undertaken at periodic inspection, but other methods of non destructive testing will provide an equivalent level of safety.

4. The United Kingdom originally started to supplement the hydraulic testing of 'Fixed Tanks' by Magnetic Particle and Ultrasonic testing in the 1980's. Initially the Magnetic Particle inspection was limited to detect cracking, in the tank shell, over the horns of the saddle backing plates. It was found that at the Periodic Inspection the Magnetic Particle examination of welds and Ultrasonic thickness checks (of the shell) were identifying defects that were not being detected by a hydraulic test. The hydraulic test could be replaced by a combination of Magnetic Particle and Ultrasonic Examination methods. The Competent Bodies/Authority subsequently approved the substitution of suitable NDT methods in place of the hydraulic test (for non ADR tanks) and in 1984 issued an approved Code of Practice.

5. According to the figures published by UKLPG there are approximately 600 LPG tankers in operation in the UK. If it is assumed that during their working life they will normally go through their Periodic Inspection at 6, 12 and 18 years (with a total working life of 24 years) each year there will be an average of 25 new tankers and 75 Periodic Inspections.

6. Annually (since 1984), approximately 60 (of the 75) UK LPG tankers have been periodically inspected by using appropriate Non Destructive Testing (NDT) inspection methods in place of the hydraulic test (the other 15 have been hydraulically tested at the request of the Competent Person or as part of the operators inspection policy). During that time there has been no record of any failure of an LPG fixed tank (on a tanker) that has been periodically inspected using NDT or a hydraulic test.

7. In 1995 a United States of America rail tanker suffered a catastrophic failure only a short time after being re-qualified by a hydraulic test. The subsequent investigations found that the hydraulic test and visual examination had not identified the defects that caused the failure and that the hydraulic test had actually propagated some cracks.

8. Since 1998 The United States of America Department of Transport has required that suitable NDT is used for the requalification of tank cars (rail tankers) and this is mandated by the docked federal regulation 'HM-201'.

9. According to The United States of America Department of Transport, *"HM-201 is a federal regulation governing the qualification of DOT & AAR tank cars. It eliminates the hydrostatic tank test previously used and uses non-destructive testing which provides a better method of detecting defects and ensures tank car safety."*

10. The DOT also has an on-going program of research and study on developing the probability of detection curves for several NDT techniques, which can be found at

http://www.fra.dot.gov/downloads/Research/ord0910.pdf

The RID/ADR already permits alternatives to the hydraulic pressure test for some pressure receptacles – see clauses 6.2.1.6.1 Notes 2 & 3 and the Note under 6.2.3.5.1.

NDT techniques and standards

11. Both surface breaking and non-surface breaking cracks can be detected by NDT techniques, cracks that would not be found or detected by a visual examination or a hydraulic test.

12. Suitable NPT can identify surface breaking defect 3 mm long x 1 mm deep and non-surface breaking defect 3 mm long not x 2 mm deep. Defects of this size would not cause failure during a hydraulic test and would not be identified by normal visual examination.

- EN ISO 17638:2009 “Non-destructive testing of welds. Magnetic particle testing.”

  Magnetic particle testing will detect imperfections in welds in ferromagnetic materials, including the heat affected zones. The techniques are suitable for most welding processes and joint configurations.

- EN ISO 17640:2010 “Non-destructive testing of welds. Ultrasonic testing - Techniques, testing levels, and assessment.”

  Ultrasonic testing is suitable for fusion-welded joints in metallic materials of thickness greater than or equal to 8.0 mm which exhibit low ultrasonic attenuation (especially due to scatter) at object temperatures from 0^{o}C to 60^{o}C. It is primarily intended for use on full penetration welded joints where both the welded and parent materials are ferritic.

- EN 1711 - Non-destructive examination of welds. Eddy current examination of welds by complex plane analysis

  Eddy current techniques will detect surface breaking and near surface planar imperfections, mainly in ferritic steels and cast-iron (weld materials, heat affected zones, parent materials).

- FprEN 14334 - LPG equipment and accessories – Inspection and testing of LPG road tankers”.

  This standard sets out what NDT is required to replace the hydraulic test at the periodic inspection.

Recent Experience

13. As an example a LPG Fixed Tank (manufactured in 1995) recently passed a hydraulic test (in 2011) which was undertaken before any other tests were conducted. The subsequent visual and magnetic particle inspections of some of the nozzle welds found cracks between 25 – 90 mm long in three welds.

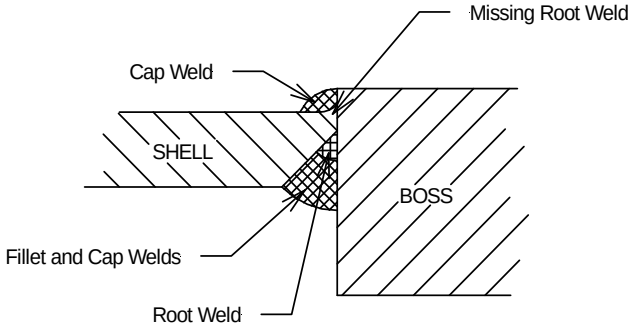
Following the initial indications of cracking light grinding of the surface was undertaken to ensure that it was not just weld overlap, however it was confirmed that all three were hairline cracks (the white background paint and black indicator has now made these very visible to the naked eye).

Nozzle 1 houses the temperature gauge blind pocket and has a 25 mm long crack as indicated below:

Nozzle 2 is the tanker filling connection (is connected to internal fill pipework) and has a 90 mm long crack as indicated below:

Nozzle 3 is the tanker vapour balance connection (and again is connected to internal pipework) and has a 50 mm long crack as indicated below:

The magnetic particle examination of a weld (undertaken in 1995 as part of a companies procedure when it purchasing a used fixed tank, that was constructed in 1973 by a very reputable tank manufacturer) around part of the main outlet connection nozzle identified that the internal root weld was missing and it just had a cap weld.



This missing weld gave an indication, during the MPI examination, that an internal crack was present along the length of the missing weld.

Other considerations

14. In addition to the possible contamination of components and the acceleration of oxidisation of the internal surfaces of the vessel, using water as a hydraulic test medium can generate large quantities of waste water that must be treated by a suitably licensed disposal company and cannot be discharged to the ground or water drainage systems.

Another example of where NDT has replaced hydraulic testing

15. Steam Boilers: For many years it was a requirement in UK law that all steam boilers were hydraulically tested every 10 years. This legal requirement was repealed some years ago and most boilers (that have not undergone hot work repairs) are now re-qualified by using NDT techniques.