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Economic Commission for Europe**Inland Transport Committee****Working Party on the Transport of Dangerous Goods**

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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 Liquefied Petroleum Gases Association
(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 associated 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 Table A 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 2012–2016 (ECE/TRANS/224, para. 94, ECE/TRANS/2012/12, programme activity 02.7 (A1c)).

² Circulated by the Intergovernmental Organisation for International Carriage by Rail (OTIF) under the symbol OTIF/RID/RC/2014/30.



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 test¹⁰ (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 Table A of Chapter 3.2 of RID/ADR for the following dangerous goods: UN 1011, UN 1075, UN 1965, UN 1969 and UN 1978.

3. 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, [and with the agreement of the expert approved by the competent authority who is authorised to carry out the periodic inspection] the hydraulic pressure test, at the time of the periodic inspection, may be replaced by the non-destructive testing (NDT) techniques listed below, either singularly or in combination as deemed suitable by the expert:

- **EN ISO 17640:2010** - Non-destructive testing of welds – Ultrasonic testing – Techniques, testing levels and assessment
- **EN ISO 17638:2009** - Non-destructive testing of welds – Magnetic particle testing, with defect acceptance in accordance with **EN ISO 23278:2009** (Magnetic particle testing of welds. Acceptance levels)
- **EN 1711:2000** - Non-destructive testing of welds - Eddy current examination of welds by complex plane analysis.
- **EN 14127:2011** - Non-destructive testing of welds - Ultrasonic thickness measurement
- **EN ISO 9712:2012** - Non-Destructive Testing. Qualification and Certification of NDT Personnel

¹⁰ In special cases and with the agreement of the expert approved by the competent authority, the hydraulic pressure test may be replaced by a pressure test using another liquid or gas, where such an operation does not present any danger.

Personnel involved in NDT shall be qualified, certified and have the appropriate theoretical and practical knowledge of the non-destructive tests they perform, specify, supervise, monitor or evaluate in accordance with;

All nuts, bolts and studs used on pressure retaining joints shall be removed and visually examined for damage or corrosion. [Any that show damage or corrosion that will reduce their strength shall be replaced by suitable new nuts, bolts or studs in accordance with the original specification.]

After any hot work (direct application of heat such as welding or cutting) to the pressure containing elements of the tank a hydraulic test must be carried out in addition to any prescribed NDT.

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

NDT shall be performed on the areas of the shell and equipment listed in the table below.

Area of Shell and Equipment	NDT
'Tee' junctions of butt welds in the shell	100 % ultrasonic testing, or magnetic particle or eddy current testing
Shell longitudinal butt welds	100 % ultrasonic testing, or magnetic particle or eddy current testing
Shell circumferential butt welds	100 % ultrasonic testing, or magnetic particle or eddy current testing
Shell, areas that cannot be visually inspected from the outside	Ultrasonic thickness survey, from inside, on a 150 mm (maximum) spaced grid
Attachments, manway, nozzles and opening welds (internal) direct to the 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 other equipment welds	100 % ultrasonic testing, or magnetic particle or eddy current testing

The defect acceptance levels shall be in accordance with the requirements of the relevant parts of **EN 12493:2013** (LPG equipment and accessories - Welded steel tanks for liquefied petroleum gas (LPG) Road tankers - design and manufacture), **EN ISO 23278:2009** (Non-destructive testing of welds. Magnetic particle testing of welds. Acceptance levels) or the acceptance standard referenced in the applicable NDT standard..

If an unacceptable defect is found in the tank by NDT methods it shall be repaired and retested (it is not permissible to hydraulic test the tank without undertaking the required repairs).

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

Justification

- There are three modes of failure that are associated with pressurised tanks, they are: corrosion, erosion and fatigue.
- Due to the nature of LPG and type of tank used internal corrosion or erosion are not credible modes of failure.

6. The only credible modes of failure are external corrosion or fatigue cracks that are either initiated or propagated due to pressure cycling or loads resulting from the transport operation. The techniques used should be capable of finding any reduction in wall thickness (the result of external corrosion) and any cracks.
7. The best method to find fatigue cracks before they can propagate to failure is to use a suitable NDT technique, rather than a hydraulic test.
8. A combination of techniques, including visual (internal and external examination) and suitable NDT, targeted at the critical areas to ensure the integrity of the mechanical components.
9. The NDT technique that is to be used should be to a plan agreed between the expert and the company/operative undertaking the NDT. The plan shall ensure that correct NDT techniques are used.
10. Suitable NDT techniques will detect all defects that would lead to failure if the tank was subjected to a hydraulic test and will ensure that all defects that could eventually lead to failure before the next periodic test are detected.

Titles of Standards referenced in this proposal

- **EN ISO 9712:2012** - Non-Destructive Testing. Qualification and Certification of NDT Personnel

EN ISO 9712 establishes principles for the qualification and certification of personnel who perform industrial non-destructive testing (NDT) The system described in this International Standard can also apply to other NDT methods, or to new techniques within an established NDT method, provided a comprehensive scheme of certification exists and the method or technique is covered by International, European, regional or national standards. This certification covers proficiency in one or more of the following methods:

- a) *eddy current testing*
- b) *magnetic testing (magnetic particle testing and flux leakage testing)*
- c) *penetrant testing*
- d) *ultrasonic testing*

- **EN ISO 17640:2010** - Techniques, testing levels and assessment for non-destructive and ultrasonic testing of welds

EN ISO 17640 is the international standard for manual ultrasonic testing of fusion-welded joints in metallic materials thicker than or equal to 8mm. The guidelines detail specific testing techniques for metals that show weakened ultrasonic levels at temperatures of up to 60°C. EN ISO 17640 is also primarily designed for penetration weld joints with iron based welded and parent metals. The standard specifies ultrasonic values based on steels with an ultrasonic sound velocity of (5 920±50) m/s for transverse waves.

EN ISO 17640 has four testing levels labelled as A, B, C and D. The standard focuses on level D which requires specific ultrasonic techniques for: tests on partial penetration welds; tests using automated equipment; and tests at temperatures below 0°C or above 60°C. You can achieve international compliance with EN ISO 17640 by testing signal length and echo or signal character and size using a probe. These comprehensive guidelines include how to use symbols and definitions and prepare metals, equipment and personnel requirements, probe parameters, testing volume and evaluating results.

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

EN ISO 17638 is an International Standard which specifies techniques for detection of surface imperfections in welds in ferromagnetic materials, including the heat affected zones, by means of magnetic particle testing. The techniques are suitable for most welding processes and joint configurations. Variations in the basic techniques that will provide a higher or lower test sensitivity, are described in Annex A.

- **EN 1711:2000** - Non-destructive examination of welds. Eddy current examination of welds by complex plane analysis

This standard defines eddy current examination techniques for detection of surface breaking and near surface planar imperfections, mainly in ferritic materials (weld material, heat affected zones, parent materials).

This eddy current technique can also be applied to other metallic construction materials (e.g. stainless steels) if required by the design specification.

The techniques can be applied to coated and uncoated objects during fabrication and in service, onshore and offshore.

The examination can be carried out on all accessible surfaces and on welds of almost any configuration.

Usually, it can be applied in the as-welded condition. However, a very rough surface can prevent an efficient examination.

- **EN ISO 23278:2009** Non-destructive testing of welds. Magnetic particle testing of welds. Acceptance levels
- **EN 14127:2011** Non-destructive testing. Ultrasonic thickness measurement
- **EN 12493:2013** - LPG equipment and accessories - Welded steel tanks for liquefied petroleum gas (LPG) Road tankers - design and manufacture

Suitability of the different NDT Techniques

As tankers in accordance with EN 12493 have carbon steel shells, the suitability of the standards listed below are only in regards to carbon steel.

- **EN ISO 17640:2010** - Ultrasonic weld examination will identify crack like defects (surface breaking minimum 3 mm long x 1 mm deep and non-surface breaking defect minimum 3 mm long x 2 mm deep) in a weld and the adjacent area, only suitable for materials with a minimum thickness of 8.0 mm.
- **EN ISO 17638:2009** – **Magnetic particle weld examination will identify crack like defects** (surface breaking minimum 3 mm long x 1 mm deep and non-surface breaking defects minimum 3 mm long x 2 mm deep) in a weld and the adjacent area.
- **EN 1711:2000** – Eddy current weld examination will identify crack like defects (surface breaking minimum 3 mm long x 1 mm deep and near surface laminar defects minimum 3 mm long x 2 mm deep) in a weld and the adjacent area.
- **EN 14127:2011** – Ultrasonic thickness measurement will measure the thickness to an accuracy of 0.1 mm (or better)
- **FprEN 14334** - LPG equipment and accessories – Inspection and testing of LPG road tankers”.

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

LPG tankers do not suffer from internal corrosion (LPG is non-corrosive) and internal erosion does not occur in the pipework/fittings (due to the nature and properties of LPG flow rates have to be minimised well below those where erosion could occur).

All corrosion will take place on the external surfaces of the tank, fittings and pipework – where the external surface cannot be fully inspected or if there is any doubt (as is current with the hydraulic test) a ultrasonic material thickness check shall be undertaken on the hidden areas from within the tank (a full external visual examination is already a requirement at the periodic test).

Experience and history has shown that for LPG tankers cracks initiate in the welds or heat affected zones. All the direct welds on the tank and pipework shall be subject to suitable NDT.

There is a requirement to remove and visually check all nuts, studs and bolts on the pressure retaining system (it should be taken into consideration that many flanged joints used on road tankers have a maximum test pressure around double what will be used for a hydraulic test of a tanker, so it is possible for it to pass a hydraulic test with the studs or bolts 50% corroded away. It should also be taken into account that many tankers (such as LPG) are dismantled for cleaning and internal inspection after the hydraulic test.

History

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 the periodic inspection, but other methods of non-destructive testing will provide an equivalent level of safety.

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 the welds and Ultrasonic thickness checks (of the shell) were identifying all critical defects and therefore 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.

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.

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.

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.

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 docketed federal regulation 'HM-201'.

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.*"

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.

Recent Experience

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:



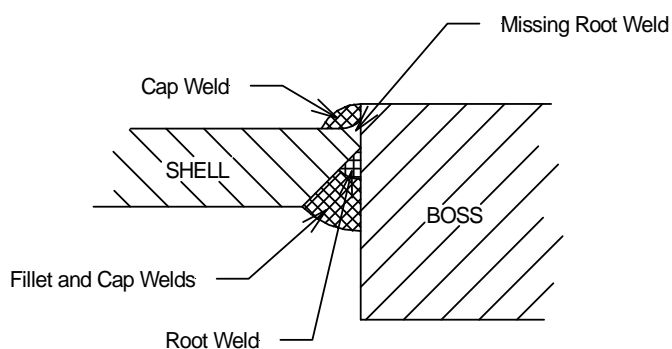
Nozzle 2 is the tanker filling connection (is connected to internal fill pipework) and has a 90 mm long crack as indicated below:



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

In addition to the possible contamination of components and the acceleration of oxidation 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.

Other examples of where NDT has replaced Hydraulic Testing

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.

Static LPG Tanks: In many countries the hydraulic test (at the periodic inspection) has been replaced by the NDT techniques listed in this proposal. This is covered by a European standard and annually many t_
