BRITISH STANDARD

BS EN 12819:2009

LPG equipment and accessories — Inspection and requalification of LPG tanks greater than 13 m^3

ICS 23.020.30; 75.200

BSI British Standards

National foreword

This British Standard is the UK implementation of EN 12819:2009. It supersedes BS EN 12819:2002 and BS EN 12820:2002 which are withdrawn.

The UK participation in its preparation was entrusted to Technical Committee PVE/19, LPG containers and their associated fittings.

A list of organizations represented on this committee can be obtained on request to its secretary.

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LPG equipment and accessories - Inspection and requalification of LPG tanks greater than 13 m³

Équipements et accessoires GPL - Inspection et requalification des réservoirs GPL d'un volume supérieur à 13 m³ pour gaz de pétrole liquéfiés (GPL)

Flüssiggas-Geräte und -Ausrüstungsteile - Überprüfung und erneute Qualifizierung von Behältern für Flüssiggas (LPG) größer als 13 m³

This European Standard was approved by CEN on 7 November 2009.

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Foreword

This document (EN 12819:2009) has been prepared by Technical Committee CEN/TC 286 “Liquefied petroleum gas equipment and accessories”, the secretariat of which is held by NSAI.

This document supersedes EN 12819:2002 and EN 12820:2002.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by June 2010, and conflicting national standards shall be withdrawn at the latest by June 2010.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

Users of this EN, prepared in the field of application of Article 118A of the EC Treaty, should be aware that standards have no formal legal relationship with Directives that may have been made under Article 118A of the Treaty. In addition, national legislation in the Member states may contain more stringent requirements than the minimum requirements of a Directive based on Article 118A. Information on the relationship between the national legislation implementing Directives based on Article 118A and this EN may be given in a national foreword of the national standard implementing this EN.

The main modifications concern the following:

— merging of two European Standards: EN 12819:2002 and EN 12820:2002;

— improvement of Annex C which becomes normative;

— a new clause: normative references.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

Introduction

Periodic and routine inspection and requalification regimes for LPG tanks greater than 13 m^3 have developed in various countries in different ways that range from defined to variable inspection periods with requalification regimes achieved by various methods. This European Standard for periodic and routine inspection and requalification is based on European countries' legislation and codes of practice and industries' codes of practice. In addition, use of LPG in different applications has encouraged the industry to approach the requirements for routine and periodic inspection and requalification in different ways for each application.

This European Standard calls for the use of substances and procedures that can be injurious to health if adequate precautions are not taken. It refers only to technical suitability and does not absolve the user from legal obligations relating to health and safety at any stage.

It has been assumed in the drafting of this European Standard that execution of its provisions is entrusted to appropriately qualified and experienced people.

1 Scope

This European Standard specifies requirements for:

a) routine inspection, periodic inspection and requalification of fixed LPG storage tanks of sizes greater than 13 m^3, and associated fittings;

b) marking tanks and/or keeping records, as appropriate, as a result of routine inspection, periodic inspection and requalification.

This European Standard excludes refrigerated storage.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 1330-9, *Non-destructive testing — Terminology — Part 9: Terms used in acoustic emission testing*

EN 13477-1, *Non-destructive testing — Acoustic emission — Equipment characterisation — Part 1: Equipment description*

EN 13447-2, *Non-destructive testing — Acoustic emission — Equipment characterisation — Part 2: Verification of operating characteristic*

EN 13554, *Non-destructive testing — Acoustic emission — General principles*

EN 14584, *Non-destructive testing — Acoustic emission — Examination of metallic pressure equipment during proof testing — Planar location of AE sources*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
periodic inspection
external inspection of the visible parts of a tank and its fittings

3.2
routine inspection
external inspection of the visible parts of a tank and its fittings, carried out more frequently than periodic inspections

3.3
requalification
inspection/test carried out at intervals, in order to confirm that a tank is fit for a further period of service

3.4
competent body
person or corporate body, defined by a national competent authority, that, by appropriate qualification, training, experience, and resources, is able to make objective judgements related to inspection and testing of pressure equipment in LPG service

3.5
competent person
person who, by qualification, training, experience, and resources, is able to make objective judgements related to inspection and testing of pressure equipment in LPG service

3.6
national competent authority
organization, recognized or appointed by a member state, that oversees safe operation of LPG pressure equipment

3.7
written scheme
document, prepared by a competent body, containing inspection information

3.8
commissioning
preparation for safe service

3.9
decommissioning
removing from service and safe preparation for inspection/test

3.10
Liquefied Petroleum Gas
LPG
mixture of predominantly butane or propane with traces of other hydrocarbon gases classified in accordance with UN number 1965, hydrocarbon gases mixture, liquefied, NOS or UN number 1075, petroleum gases, liquefied

NOTE In some countries, UN numbers 1011 and 1978 may also be designated LPG.

4 Safety

4.1 Safety precautions

Appropriate safety precautions shall be taken during decommissioning, commissioning and inspection/requalification of a tank and its fittings.

4.2 Unsafe conditions

Any unsafe condition observed by a competent person on the site of an LPG storage tank shall be reported to the person responsible for safe operation of the tank/site, as appropriate, and action taken.

4.3 Leaks

Any leak discovered from the tank or its fittings shall be reported immediately to the person responsible for safe operation of the tank.

Action to make the tank or its fittings safe shall be taken by a competent person.

NOTE Methods for detecting leaks include:

— visual inspection;

— smell;

— listening;

— use of gas detectors.

5 Written scheme

5.1 Each tank and its fittings shall be included in a written scheme taking into account the requirements of Clauses 6 to 8.

5.2 If duties are shared between different parties then the written scheme shall clearly identify the respective areas of responsibility.

5.3 Intervals between inspections shall be determined by consideration of the following:

— the design specification of the tank and its equipment;

— the corrosion protection system on the tank;

— the system used to ensure that the LPG quality conforms to its specifications/standards, and that it does not contain components damaging to the material of the tank or its fittings;

— the level of control over filling and maintenance of the tank.

NOTE The maximum period between requalifications should not normally be greater than 12 years, and if conditions are not satisfactory the period should be reduced.

5.4 The written scheme shall contain the following information:

— the maximum interval between inspections;

— the parts to be inspected;

— the nature of the inspection;

— the critical parts that, if modified or repaired, must be inspected by a competent person/body before they can be put back into service;

— the requirements for pressure relief valves (see 7.5.1);

— the name of the competent body preparing the written scheme;

— the date of the preparation of the written scheme.

6 Tank inspection and requalification

6.1 Routine inspection

6.1.1 Each tank and its fittings shall be routinely inspected at intervals defined in the written scheme.

6.1.2 An inspection or exception test report shall be produced if repairs are required.

6.1.3 Routine inspections shall include 7.1, 7.2, 7.3, 7.4, 7.5.2, 7.5.3, 7.7, 7.14 and 7.16.

6.2 Periodic inspection

6.2.1 Each tank and its fittings shall be periodically inspected at intervals defined in the written scheme.

6.2.2 Periodic inspections shall include 6.1.3, 7.5.4, 7.6, 7.8, 7.12, 7.13 and 7.15.

6.2.3 A visual inspection of external surface shall be carried out (see Annex A). If tanks are provided with fixed passive fire protection, techniques described in Annex A are unsuitable. The written scheme shall specify alternative techniques to those specified in Annex A to ensure that no corrosion occurs on the external surface of the tank.

6.3 Requalification

6.3.1 Requalification of overground LPG tanks

Requalification intervals shall be specified in the written scheme. Requalification shall include 7.5.1, 7.9, 7.10, 7.11, an external visual inspection, and at least one of the following:

— an internal visual inspection (see Annex A);

— a hydraulic pressure test (see Annex B);

— an acoustic emission test (see Annex C);

— an ultrasonic thickness test (see Annex D);

— any other method equivalent to the above.

6.3.2 Requalification of underground LPG tanks

Requalification intervals shall be specified in the written scheme. Each tank shall include 7.5.1, 7.9, 7.10, 7.11, and shall be requalified, with at least one test from group 1 and one from group 2 of Table 1.

Table 1 — Requalification tests

Group 1	Group 2
Internal visual inspection (see Annex A)	External visual inspection (i.e. excavation)
Hydraulic pressure test (see Annex B)	Cathodic protection monitoring (see Annex E or Annex F)
Acoustic emission test (see Annex C)	
Ultrasonic thickness test (see Annex D)	
Other equivalent method	

6.3.3 Commissioning

At commissioning, leak checks shall be carried out at connections. Gaskets that have been removed when breaking connections shall not be reused.

7 Inspection of tank and tank fittings

7.1 Tank

Tanks shall be checked for severe external corrosion or visible damage.

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7.2 Tank fittings and immediate pipework

Tank fittings and immediate pipework shall be checked for the following:

— severe corrosion;

— damage;

— inoperative or leaking filler valves;

— worn or damaged filler valve thread or connection;

— damaged or lifting pressure relief valve;

— inoperative fixed liquid level gauge.

7.3 Valve cover

There shall be checks that the valve covers (if fitted) are in place, undamaged and able to be locked.

7.4 Bonding

7.4.1 The electrical bonding between the tank and earth point shall be visually checked, where fitted.

7.4.2 There shall be a check that the road tanker bonding tag is undamaged (if applicable).

7.5 Pressure relief valves

7.5.1 There shall be either:

a) a test of the set pressure of the pressure relief valve and, for an external pressure relief valve, a check of the condition of the spring; or

b) the pressure relief valve shall be replaced with a new or reconditioned valve if required.

WARNING — Do not remove a pressure relief valve from a pressure relief valve manifold or check-device while a tank is under pressure, unless a serviceable replacement is available for immediate fitting. Do not remove a pressure relief valve mounted in a tank under pressure unless the type and construction of the check device can be identified and the manufacturer's instructions for safe removal are complied with. A check device shall include positive means of confirming that the check device has closed before the pressure relief valve is unscrewed to an otherwise dangerous stage.

7.5.2 The pressure relief valve drain hole shall be checked to ensure it is clear.

7.5.3 Stack pipes shall be inspected for corrosion. Pressure relief valves shall also be externally inspected if corrosion is found in the stack pipes. There shall be a check that rain caps are present and in good condition.

7.5.4 Multiport mechanisms shall be checked to ensure that they move freely into position when operated.

WARNING — After testing, the mechanism shall be positioned so that pressure relief valve inlets are not obstructed.

7.6 Pressure gauges

Pressure gauges shall be checked against a test gauge or replaced.

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7.7 Contents gauges

Gauging devices or contents gauges that bleed to the atmosphere (e.g. rotary tubes, fixed tubes or slip tubes) shall be tested when filling the tank. Other types of contents gauges shall be checked as required (e.g. during product transfer to or from the tank).

7.8 Shut-off valves

Shut-off valves shall be tested for correct function.

WARNING — When checking the function of a shut–off valve do not shut off the gas supply unless the user has been informed. Do not restore a gas supply before checking that the appliance shut-off valves are closed.

Blanked or plugged liquid phase valves shall be checked for external leakage.

7.9 Studs, bolts, nuts, and washers

Studs, bolts, nuts, and washers shall be checked for damage or severe corrosion and replaced if necessary.

7.10 Emergency valves

Excess flow valves and non-return valves shall be checked for correct operation.

7.11 Gaskets

Gaskets between any separated connections shall be renewed before reconnecting.

7.12 Pressure switch

Pressure switches (if fitted) shall be checked for correct operation using a calibrated test pressure gauge.

7.13 Temperature gauge

The accuracy of temperature gauges shall be checked, using a calibrated instrument.

7.14 Remotely operated valves

Remotely operated valves (if fitted) shall be checked for correct operation when activated.

7.15 Corrosion protection system

Any check required for the selected corrosion protection system, as detailed in the written scheme, shall be carried out.

7.16 Piers and foundations

The condition of piers and foundations shall be checked to ensure that they are sound with no visible damage or uneven settlement. Anchoring bolts shall be visually inspected for deterioration, where fitted and accessible.

8 Competence

NOTE Definitions of the competence to do inspections/requalification per national legislations should be considered.

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8.1 Routine inspection

Persons shall be deemed competent to carry out routine inspections if they have received the appropriate training to carry out the routine inspection of 6.1 and to prepare an inspection test report.

8.2 Periodic inspection

Persons shall be deemed competent to carry out periodic inspections if:

— they are competent to carry out routine inspections (see 8.1); and

— they are part of an inspection team with the appropriate background, training and qualification, or have worked with or within the LPG industry, performing the relevant task, and have a good general knowledge of LPG and its operating environment.

The relevant attributes shall be documented.

8.3 Requalification

Persons shall be deemed competent to requalify a tank if they possess detailed knowledge of the technique(s) used in requalification, with relevant training and certification.

9 Records

9.1 Tank data

If the tank identification plate or tag is illegible, it shall be cleaned, repaired or replaced as appropriate.

All information on the tank data plate or tag or documentation shall be updated, as appropriate, after periodic inspection or requalification.

9.2 Test reports

A system shall be in place to ensure that routine inspections are carried out in accordance with the written scheme.

A test report shall be produced if a tank passes a periodic inspection or requalification.

If a tank fails a periodic inspection or requalification, a test report shall be prepared as part of a formal follow-up system. Decisions whether to exchange a tank or repair a fault on site shall be taken by the person responsible for safe operation of the tank in consultation with the competent body.

NOTE An example of a test report form that can be used for routine inspections or periodic inspections and requalification is given in Annex G.

Annex A
(informative)

Visual inspection

A.1 Internal and external visual inspections

The aim of internal and external visual inspections is to detect surface defects on the tank shell, including:

— deterioration of coating (where visible for underground tanks);

— corrosion;

— cracks, dents, gouges, lamination and bulges.

A.2 Inspection techniques

A.2.1 External visual inspection

External surfaces should be clean and dry. The condition of the coating should be checked and a note made of any corrosion, imperfections, or mechanical damage.

The inspection should be carried out visually, using, if required, the following:

— a beam of light directed along the surface of the tank to indicate imperfections by shadow;

— a straight edge placed along the surface to show the extent of a defect;

— a depth gauge to determine the depth of corrosion, dents or gouges;

— a magnifying glass for detailed inspections;

— a mirror.

A.2.2 Internal visual inspection

Internal surfaces should be clean, dry and free from foreign matter.

Surfaces should be checked for corrosion and mechanical damage using an endoscope, camera or other means.

If it is possible for a person to enter the tank, then the inspection techniques in A.2.1 can be used.

A.2.3 Records

Defects, including manufacturing problems, should be noted in the tank record. Deterioration in recorded defects should be assessed at the next inspection.

A.3 Additional inspection

A.3.1 Additional inspections can be required to confirm the suitability of a tank for further service.

A.3.2 Written instructions for additional inspections of a tank should be prepared by a competent person. Written instructions and results of additional inspections should be kept in the tank record.

Annex B
(informative)

Hydraulic pressure test

B.1 The hydraulic pressure test should be performed in accordance with this annex. All fittings should be removed before testing.

Water should normally be used as the test fluid. During the test, the water temperature should not fall below 7 °C.

The tank should be properly vented before the test pressure is applied to prevent formation of air pockets.

B.2 The test pressure for the tanks should be as specified on the data plate or documentation or as required by the competent person.

B.3 The pressure in the tank should be gradually increased up to the test pressure, and the tank isolated from the pressurizing pump. The pressure in the tank should be maintained for sufficient time to assess the tank, but not less than 10 min.

B.4 If no significant reduction in pressure is observed in the tank during the test, and there are no signs of general plastic yielding or leaks from the pressure envelope, the tank should be deemed to pass the test.

B.5 The tank should be carefully drained and dried out if required.

B.6 Gaskets, bolts, etc. should be changed as appropriate after the test.

Annex C
(normative)

Acoustic emission testing

C.1 Scope

This annex specifies the minimum requirements for the test equipment, the type and sequence of loading, data acquisition and data evaluation, for the performance of an AT (acoustic testing) on LPG tanks greater than 13 m^3.

NOTE Further requirements per National regulations should be considered.

These minimum requirements cover all types of LPG tanks, including those produced with joggle joints, both above and under ground.

The purpose of the AT is to detect and evaluate indications of flaws within the tank. The tests can be performed on-site and the pressurisation shall be performed with LPG and/or inert gas (e.g. N_2) or any other compatible gas or liquid.

C.2 Testing procedure

A testing procedure according to EN 13554 for AT shall be developed.

C.3 Instrumentation

C.3.1 Sensors

The resonant frequency of the sensors shall be in the range of 70 kHz to 180 kHz, except for bitumen coated tanks where the range shall be 30 kHz to 80 kHz.

C.3.2 Acquisition and evaluation system

The AE (acoustic emission) acquisition and evaluation system shall be checked and maintained in accordance with EN 13477-1 and EN13477-2.

The AE acquisition and evaluation system shall be able to acquire, record and evaluate all data to meet the requirements of C.6.1.

C.4 Testing

C.4.1 Test instruction

The written AT test instruction shall conform to EN 14584. The values for stop, acceptance and rejection criteria of the tank shall be included in the test instruction. Any intermediate position (e.g. active source, see Table 1) shall also be included in the test instruction. This test instruction shall be delivered to the tank owner/user and the supervision body, where required, before the test is performed.

C.4.2 Safety precautions

The tank shall not be overfilled.

If the acoustic signals indicate a leak, the leak shall be fixed before proceeding.

The test pressure equipment shall have an emergency shut-down system to stop the pressurisation and to initiate rapid depressurisation of the tank.

When pressurising a tank containing LPG, if the test pressure is to exceed P_S then:

a) the written agreement of the tank manufacturer shall be obtained or be assessed by a competent person;

b) the safety accessories shall be blanked and replaced by accessories set at a convenient pressure;

c) the pressure accessories shall be able to withstand the test pressure.

If using LPG as a pressure test fluid, the test shall not be carried out at a low external temperature (e.g. 0 °C) in order to avoid re-condensation in the pressurisation line.

If N_2 is used as a pressure test fluid, no re-condensation occurs and the external temperature may be under 0 °C.

C.5 Sensor location

C.5.1 Above ground tanks

The sensors shall be applied in accordance with EN 14584 and allow a location accuracy of at least 10 % of the maximum sensor spacing for the complete tank shell.

C.5.2 Underground or mounded tanks

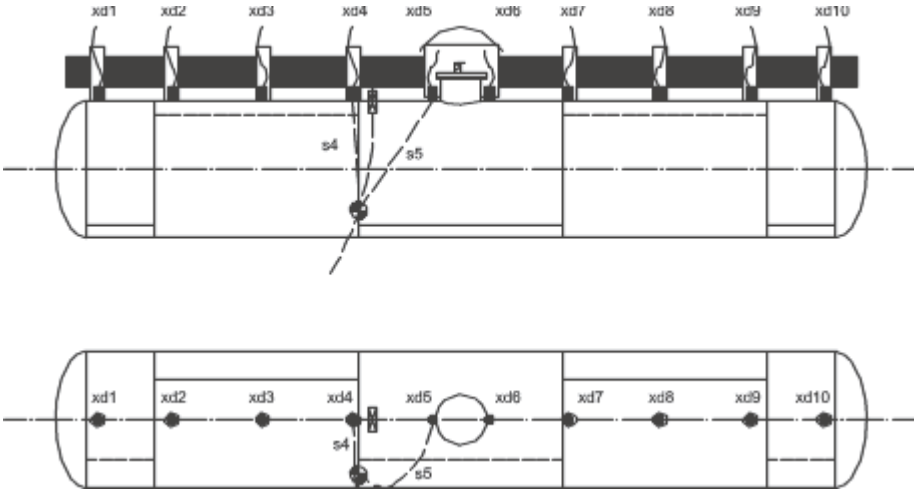
C.5.2.1 For the AT of underground or mounded LPG tanks greater than 13 m^3 sensors can only be applied according to the maximum sensor spacing specified in EN 14584. In order to achieve sufficient sensitivity the following considerations shall be taken into account.

C.5.2.2 The basis for the discrimination of AE event from the background noise is Δt, where Δt (delta t) is the measurement of arrival time difference in accordance with EN 1330-9. This Δt-clustering shall also be used to assign the AE event from the tank into different clusters.

NOTE Δt-clustering is a concentration of time dependent correlated acoustic events within a time frame. This clustering allows to be divided the tank into several rough location clusters.

C.5.2.3 To avoid digging out the complete tank, the following sensor locations shall be selected:

a) for cylindrical tanks with a diameter less or equal 2,5 m, the sensors shall be applied in the upper part of the tank, preferably at similar intervals. The maximum distance between two sensors shall take into account the longest travelling path of the acoustic wave in accordance with EN 14584. The AE wave shall reach at minimum of two sensors along the upper part of the tank with sufficient peak amplitudes, according to EN 14584;



Key

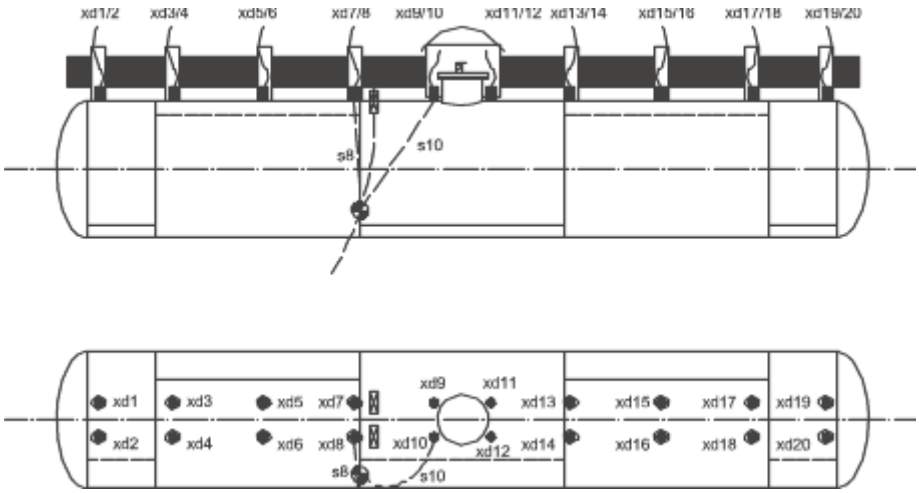
xd1, xd2 sensor position
s1, s2 travelling path

Figure C.1 — Example of sensor location on a large underground LPG tank, one row of sensors

b) for cylindrical tanks with a diameter greater than 2,5 m, the sensors shall be applied in two or more rows, situated on both sides of the upper part of the tank (e.g. 10 and 2 o'clock position), to allow meaningful distances of the sensors and to acquire the AE signal also from the lower part of the tank properly.

C.5.2.4 The maximum distance between the rows and between two sensors of the same row shall take into account the longest travelling path of the acoustic wave in accordance with EN 14584. The AE wave shall reach at minimum two sensors of the same row with the sufficient amplitude.

C.5.2.5 Planar location, compared to linear location, may give more clear results of the Δt clusters (AE bursts). If planar location is applied the AE wave has to reach four sensors with the sufficient amplitude.



Key

xd1, xd2 sensor position
s1, s2 travelling path

Figure C.2 — Example of sensor locations on a large underground LPG tank, two rows of sensors

C.5.2.6 The attenuation measurement may be verified using a tank with at least the same diameter, material, wall thickness and coating/insulation situated above the ground and containing the comparable level of liquid.

C.5.2.7 Application support devices may be used for the application of the sensors on the underground tank.

C.5.3 Pressurisation

C.5.3.1 The tank shall be AE monitored for a period of 10 min to 15 min before pressurisation in order to evaluate any emission resulting from active corrosion.

C.5.3.2 The tank shall be pressurised to a minimum of 10 % above the highest service pressure reached during the last year of operation, and should not exceed 110 % of the maximum allowable pressure P_S.

NOTE Some national regulations do not permit pressurisation to exceed the P_S value, see C.5.2.

C.5.3.3 Pressurisation shall be at a constant rate of less than 0,3 bar/min.

C.5.3.4 Once the maximum pressure is reached, pumping shall cease and the pressure is held for at least 10 min.

NOTE Pressure decays due to temperature changes are acceptable.

C.6 Data evaluation and analysis

C.6.1 Evaluation criteria

C.6.1.1 General

The values and numbers for the evaluation criteria shall be defined in the test instruction.

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C.6.1.2 Above ground tanks

The evaluation criteria shall be determined in accordance with EN 14584.

The values of A_1, A_2, N_1, N_2, N_3, Z and t_h for real time control and for subsequent source severity grading shall be given by the AE test organisation within the written test instruction.

C.6.1.3 Underground and mounded tanks

For greater accuracy in the AE-evaluation the value of the time difference Δt may be less than that required in EN 14584.

The criteria shall be based upon the following parts:

a) acquisition of a defined number N_1 of AE bursts (within the range of Δt-values used to identify AE events from the tank), above a high specified peak amplitude value A_1;

b) acquisition of a defined number N_2 of AE bursts (within the range of Δt-values used to identify AE events from the tank), above a low specified peak amplitude value A_2;

c) acquisition of a defined number of N_3 of AE bursts (within the range of Δt-values used to identify AE events from the tank), above the specified peak amplitude value A_2, 2 min after the beginning of the hold period at the end of the test;

NOTE 1 The values for the peak amplitudes A_1 and A_2 should take into account wave attenuation for the maximum propagation distance between source and sensors in the tank.

d) acoustic emission activity and/or energy rate as a function of the pressure;

e) an additional more complex evaluation criterion is required. This should be based upon evaluation criteria, combined to produce an evaluation factor C, which takes into account at minimum:

   1) number of the AE bursts within a Δt-cluster;

   2) AE peak amplitude and/or energy of the AE bursts within a Δt-cluster;

   3) AE burst activity within a Δt-cluster over the test period and/or shorter time and/or pressure periods sequentially distributed over the test time.

NOTE 2 Predominantly those AE parameters should be chosen, where the influence of the wave attenuation can be eliminated, as far as possible.

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C.6.2 Real time control and stop criteria

C.6.2.1 Above ground tanks

The pressurisation shall be stopped if:

a) one of the numbers N_1, N_2 or N_3 is exceeded; or

b) the AE energy doubles from any channel in two consecutive pressure intervals of 5 % of the maximum test pressure. The AE energy, from which the doubling leads to a test stop, shall be given within the written test instruction.

Before the pressurisation is continued the reasons for the suspension shall be investigated and if necessary appropriate NDT measurements made.

C.6.2.2 Underground and mounded tanks

The pressurisation shall be stopped if:

a) one of the numbers N_1, N_2 or N_3 is exceeded; or

b) the AE energy doubles from any channel in two consecutive pressure intervals of 5 % of the maximum test pressure. The AE energy, from which the doubling leads to a test stop, shall be given within the written test instruction; or

c) if the calculation of the evaluation factor C of C.6.1.3, e) is done automatically in real time, this factor shall also be included into the stop criteria and may replace the stop criteria according the value of N_2 and the doubling of the energy.

C.6.3 Post test analysis

The post analysis will be performed based on the evaluation criteria mentioned in C.6.1. For underground and mounded tanks the most important outcome is the value of the evaluation factor C, which during the post test analysis may be performed off site.

C.6.4 Tank grading

Following the test, the sources (Δt-clusters for underground or mounded tanks) shall be classified according to the result of the post analysis into three categories, see Table 1. The grading criteria, based on the post analysis, shall be defined in the test instruction prior to the test.

The interpretation of the results, including all necessary pressure stops, shall be recorded and the results of supporting NDT (non destructive testing) shall be added into the test report.

The final decision on the grading of the AE sources (Δt-clusters) is made by the AE supervisor (at minimum AT2 according to EN 473) based upon the values given in the written test instruction.

The tank grading shall be done according the highest value of the grading of the AE sources (Δt-clusters).

NOTE For above ground tanks, a dedicated software based on an extensive database can be used to provide an automatic evaluation of the identified sources.

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Table C.1 — Source severity grading

Source severity grading	Definition	Further actions
1	minor source	No further actions shall be necessary.
2	active source	Further NDT shall be required if the source is associated with specific parts of the pressure equipment (e.g. weld seams, attachments).
3	very active source	Further evaluation by other appropriate NDT shall be carried out. Before the pressure equipment returns into service, the safe conditions of the tank shall be established.

C.7 Data storage and reporting

All test data for the tank shall be kept on a database to assist in establishing the acceptance criteria.

The test report shall include at minimum:

— tank identification;

— test date;

— test pressure (start and end of acquisition);

— pressurisation rate;

— tank grading;

— value of the evaluation factor C;

— number of AE events above A_1 and A_2, if N_1 and/or N_2 or N_3 were exceeded.

The test report shall state if the tank has passed or failed the AE acceptance or rejection criteria or whether further tests are required.

Annex D
(informative)

Ultrasonic thickness test

D.1 General

Trained persons, with demonstrated competence with ultrasonic thickness testing equipment and interpretation of results, should carry out the ultrasonic thickness test.

D.2 Apparatus setting

The ultrasonic testing apparatus should be set up in accordance with the manufacturer's instructions.

D.3 Control measurement

The tank nominal wall thickness (control measurement) should be established by either:

— measuring the wall thickness in at least three places on the top dead centre of the tank, and taking the average; or

— using the tank wall thickness as specified in the original drawings.

Measurements should also be made just below the knuckle radius at each end of the tank.

D.4 Shell thickness measurements

Shell thickness measurements are taken:

— at 300 mm intervals along the shell at 30° below top dead centre of each side;

— at 90° below top dead centre and 20° above bottom dead centre and readings are recorded the test report.

D.5 End thickness measurements

End thickness measurements are made at 150 mm intervals and at the same angular pattern as in D.4 on the tank ends and readings are recorded on the test report.

D.6 Interpretation

If any reading is more than 10 % thinner than the control measurement (see D.3), the surrounding area is measured 25 mm intervals radiating outwards and the thin area is marked on the tank surface.

NOTE Lamination defects are normally indicated by an abrupt change in thickness at the edge of the thin area. Corrosion defects are normally indicated by a gradual return to full thickness away from the corroded area.

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D.7 Rejection criteria

Rejection criteria should be decided by a competent person and should take into account the original design, interval between successive tests, and previous test results if applicable.

Annex E
(informative)

Monitoring cathodic protection with sacrificial anodes for underground tanks

E.1 General

The cathodic protection system should be monitored by a competent person (see EN 15257).

E.2 Records

Details of the cathodic protection system should be retained with the tank records.

E.3 Procedure

E.3.1 An initial check conforming to E.4 should be carried out in accordance with the written scheme, normally between 6 months and 18 months after installation.

E.3.2 Subsequent checks should be carried out at intervals as defined in the written scheme. This interval should not normally be greater than three years.

E.3.3 The electrical connections of the cathodic protection system and the insulating joints, if fitted, should be inspected.

E.3.4 The galvanic current should be measured in accordance with E.4.

E.3.5 The potential difference of the tank to the reference electrode should be measured in accordance with E.5.

E.4 Measurement of the galvanic current

E.4.1 The current delivered by each anode linked to the tank should be measured.

E.4.2 If there is no current between the anodes and the tank, the electrical connections of the anodes should be checked. If current cannot be re-established, advice should be sought.

E.4.3 If there is current, the cathodic protective system is operating, and the relevant competent person should assess the residual lifetime of the anodes by reference to previous data.

E.5 Measurement of the potential difference of the tank to the reference electrode

E.5.1 The potential difference of the tank to the reference electrode should be measured without interrupting the anode connections.

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E.5.2 The potential difference between the system (tank and anodes connected together) and a reference $Cu/CuSO_4$ electrode (placed in the ground in one or more positions), should be measured.

If the potential difference of the cathodic protection system U is between – 1 700 mV and – 850 mV, the tank can be protected against corrosion.

If U is greater than – 850 mV, the cathodic protection system is not functioning properly, and the following procedure should be followed:

a) check that the wires to the connector box are properly connected;

b) check that one or more cables have not been cut;

c) if a) and b) are satisfactory, check the electrical insulation of the tank relative to the piping;

d) check the reference electrodes and the measuring instrument.

If the potential difference of the cathodic protection system U cannot be restored in the range between – 1 700 mV and – 850 mV, the competent person should be consulted.

If the potential difference of the cathodic protection system U cannot be restored after consulting the competent person, the installation should be shut down and the cathodic protection replaced and/or the tank excavated for further investigation.

E.5.3 If the potential difference of the tank to the reference electrode is measured when switching off the current, then it can be established whether all parts of the tanks are sufficiently protected. The following procedure should be carried out.

The potential difference between the tank and a reference electrode of $Cu/CuSO_4$ (placed in the ground) should be measured immediately after switching off the protection current.

NOTE 1 This method prevents from including in the measures the ohmic drop due to the protection current between the tank and the anodes.

NOTE 2 The measured value should drop after interruption of the current and then stay briefly constant (usually for less than 1 s).

If the value at this time is – 850 mV or less, the cathodic protection system is functioning, and the tank is fully protected against corrosion.

If the value at this time is greater than – 850 mV, the tank is not properly protected and further investigations should be carried out.

If the value of the potential, when the current is switched off, is less than – 1 000 mV for epoxy coating or − 1 200 mV for bitumen, the tank is overprotected and measures should be taken to lower the potential to prevent damaging the coating.

E.6 Results

Results should be presented to a competent person to verify the effectiveness of the cathodic protection and to ensure that the residual lifetime of the anodes is sufficient.

If corrective action is taken on the cathodic protection system, a further check should be made within 18 months.

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Annex F
(informative)

Monitoring cathodic protection by impressed current for underground tanks

F.1 General

The condition of the tank coating can be checked by assessing its isolation resistance and measuring the current through the coating under switched-on potential without digging up the tank.

F.2 Apparatus

The following apparatus should be used to carry out the assessment:

a) $Cu/CuSO_4$ electrode, with an electromotive force of (– 316 ± 10) mV. $CuSO_4$ solution should be saturated (min. 20 g crystals to 100 ml water);

b) potentiometer, with an internal resistance of at least 1 MΩ and an accuracy of at least 1 %;

c) ammeter, with a low internal resistance and an accuracy of at least 2 %;

d) measurement cables, with a minimum cross sectional area of 1,5 mm^2;

e) adjustable d.c. supply;

f) stainless steel earthing pin.

F.3 Conditions

The tank should be electrically isolated from the parts of the installation above ground.

F.4 Isolation resistance of the coating

F.4.1 Procedure

The cathodic protection system should be disconnected.

The negative pole of the d.c. supply should be connected to the earthing pin (which is located at least 10 m from the tank).

The positive pole should be connected to the tank.

The tank should be connected via the ammeter to the $Cu/CuSO_4$ electrode. The electrode should be placed in the ground near the middle of the tank so that the tank is between the earthing-pin and the electrode.

The potentiometer should be connected across the d.c. supply.

The potential should be adjusted to – 1 500 mV and the current measured.

F.4.2 Calculation

The potential difference U_c over the coating is:

$$U_c = U_s - U_n$$

where

U_s is the supplied potential in millivolts (mV);

U_n is the electrochemical potential of the steel in millivolts (mV).

The specific current through the coating I_c is:

$$I_c = I_m / A$$

where

I_m is the measured current at – 1 500 mV, in milliamperes (mA);

A is the surface area of the tank in square metres (m^2).

The isolation coating resistance R_c is:

$$R_c = U_c / I_c$$

F.5 Results

If R_c is equal to or greater than 200 kΩ/m^2, the coating is in good condition and corrosion should not occur.

If R_c is between 25 kΩ/m^2 and 200 kΩ/m^2, and there is no cathodic protection, a cathodic protection should be installed, unless the tank coating can be repaired.

If R_c is between 25 kΩ/m^2 and 200 kΩ/m^2, and there is a cathodic protection system in place, this should be checked by an expert.

If the cathodic protection system cannot achieve a potential of – 850 mV on disconnection from all tank parts, there may be defects in the tank coating that should be located and repaired (e.g. by Pearson measurement).

F.6 Checking intervals

Impressed current checks should be carried out at least every six years.

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Annex G
(informative)

Example of a test report

Table G.1 gives an example of a test report form that may be used for a routine inspection or periodic inspection and requalification.

Table G.1 — Static LPG tank inspection and/or requalification test report

Routine inspection ☐	**Periodic inspection ☐**	**Requalification ☐**
Site address	Tank data	
Check list	Fitting details	
Visual inspection of tank, fittings and site		
Requalification Method of requalification and test/inspection results	Work done/required	
Certificate for further period of service		
Name/details of inspector	Date of inspection	

Annex H
(informative)

A-deviations

A-deviation: National deviation due to regulations, the alteration of which is for the time being outside the competence of the CEN/ CENELEC Member.

This European Standard does not fall under any Directive of the EU. In the relevant CEN/CENELEC countries these A-deviations are valid instead of the provisions of the European Standard until they have been removed.

Clause	Deviation
1	**Austria:**
	Provisions for the first operating inspection and periodic inspections:
	In Austria provisions are given for the first operation inspection and periodic inspections in Austrian Federal Law concerning pressure vessels BGBl. Nr. 211/1992, §§13 and 15 (Federal Law Gazette No. 211/1992, Clauses 13 and 15).
1	**Sweden:**
	In Sweden tanks shall be inspected and requalified according to the regulations in the ordinance AFS 2005:3 from the Swedish Work Environment Authority regarding Pressure Retaining Devices.
1	**France:**
	The tanks shall be inspected and requalified according to "Arrêté ministériel du 15 mars 2000 modifié" relatif à l'exploitation des équipements sous pression (titres III et V).
1	**Denmark:**
	The tanks shall be inspected and requalified according to the regulations in Order No. 100 of 31 January 2007, regarding use of pressure equipment.

Bibliography

[1] EN 473, *Non-destructive testing — Qualification and certification of NDT personnel — General principles*

[2] EN 15257, *Cathodic protection — Competence levels and certification of cathodic protection personnel*

[3] EN 15495, *Non Destructive testing — Acoustic emission — Examination of metallic pressure equipment during proof testing — Zone location of AE sources*

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