BS EN 12542:2010

BSI Standards Publication

LPG equipment and accessories — Static welded steel cylindrical tanks, serially produced for the storage of Liquefied Petroleum Gas (LPG) having a volume not greater than 13 m³ — Design and manufacture

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National foreword

This British Standard is the UK implementation of EN 12542:2010. It supersedes BS EN 12542:2002 and BS EN 14075:2002 which are withdrawn.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.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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LPG equipment and accessories - Static welded steel cylindrical tanks, serially produced for the storage of Liquefied Petroleum Gas (LPG) having a volume not greater than 13 m³ - Design and manufacture

Equipements pour gaz de pétrole liquéfié et leurs accessoires - Réservoirs cylindriques fixes, aériens, en acier soudé, fabriqués en série pour le stockage de gaz de pétrole liquéfié (GPL) ayant un volume inférieur ou égal à 13 m³ - Conception et fabrication

Flüssiggas-Geräte und Ausrüstungsteile - Ortsfeste, geschweißte zylindrische Behälter aus Stahl, die serienmäßig für die Lagerung von Flüssiggas (LPG) hergestellt werden, mit einem Fassungsvermögen bis 13 m³ - Gestaltung und Herstellung

This European Standard was approved by CEN on 26 June 2010.

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Contents

Page

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Foreword

This document (EN 12542:2010) has been prepared by Technical Committee CEN/TC 286 “Liquefied petroleum gas equipment and accessories”, the secretariat of which is held by NSAI.

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of an identical text or by endorsement, at the latest by February 2011, and conflicting national standards shall be withdrawn at the latest by February 2011.

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.

This document supersedes EN 12542:2002, EN 14075:2002.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

For relationship with EU Directive(s), see informative Annex ZA, which is an integral part of this document.

The main technical changes in this revision include:

— widening of the Scope to include requirements for underground tanks;

— addition of environmental considerations;

— reference to the latest welding standards; and

— introduction of radioscopy as a permitted alternative to radiographic examination of welds.

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, Croatia, 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.

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Introduction

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

Protection of the environment is a key political issue in Europe and elsewhere. Protection of the environment is taken in a very broad sense. What is meant is the total life cycle aspects of e.g. a product on the environment, including expenditure of energy and during all phases from mining of raw materials, fabrication, packaging, distribution, use, scrapping, recycling of materials, etc.

NOTE 1 Annex J indicates which clauses in this standard address environmental issues.

Provisions should be restricted to a general guidance. Limit values are specified in national laws.

It is recommended that manufacturers develop an environmental management policy. For guidance see ISO 14000 series

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

All pressures are gauge pressures unless otherwise stated.

NOTE 2 This European Standard requires measurement of material properties, dimensions and pressures. All such measurements are subject to a degree of uncertainty due to tolerances in measuring equipment, etc. It may be beneficial to refer to the leaflet "Measurement Uncertainty Leaflet (SP INFO 2000 27 uncertainty.pdf)".

1 Scope

This European Standard specifies requirements for the design and manufacture of static welded steel cylindrical tanks, serially produced for the storage of liquefied petroleum gas (LPG) with a volume not greater than 13 m^3 and for installation above or below ground.

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 edition of the referenced document (including any amendments) valid at the time of publication of this standard applies.

EN 287-1, *Qualification test of welders — Fusion welding — Part 1: Steels*

EN 462-1, *Non-destructive testing — Image quality of radiographs — Part 1: Image quality indicators (wire type) — Determination of image quality value*

EN 462-2, *Non-destructive testing — Image quality of radiographs — Part 2: Image quality indicators (step/hole type) — Determination of image quality value*

EN 473:2008, *Non-destructive testing — Qualification and certification of NDT personnel — General principles*

EN 571-1, *Non destructive testing — Penetrant testing — Part 1: General principles*

EN 756, *Welding consumables — Solid wires, solid wire-flux and tubular cored electrode-flux combinations for submerged arc welding of non alloy and fine grain steels — Classification*

EN 837-2, *Pressure gauges — Part 2: Selection and installation recommendations for pressure gauges*

EN 875, *Destructive tests on welds in metallic materials — Impact tests — Test specimen location, notch orientation and examination*

EN 876, *Destructive tests on welds in metallic materials — Longitudinal tensile test on weld metal in fusion welded joints*

EN 895, *Destructive tests on welds in metallic materials — Transverse tensile test*

EN 970, *Non-destructive examination of fusion welds — Visual examination*

EN 1321, *Destructive tests on welds in metallic materials — Macroscopic and microscopic examination of welds*

EN 1418, *Welding personnel — Approval testing of welding operators for fusion welding and resistance weld setters for fully mechanized and automatic welding of metallic materials*

EN 1435:1997, *Non-destructive examination of welds — Radiographic examination of welded joints*

EN 1708-1, *Welding — Basic weld joint details in steel — Part 1: Pressurized components*

EN 1712:1997, *Non-destructive examination of welds — Ultrasonic examination of welded joints — Acceptance levels*

EN 1713:1998, *Non-destructive testing of welds — Ultrasonic examination — Characterization of indications in welds*

EN 1714:1997, *Non-destructive examination of welds — Ultrasonic examination of welded joints*

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EN 10025-2, *Hot rolled products of structural steels — Part 2: Technical delivery conditions for non-alloy structural steels*

EN 10028-2, *Flat products made of steels for pressure purposes — Part 2: Non-alloy and alloy steels with specified elevated temperature properties*

EN 10028-3, *Flat products made of steels for pressure purposes — Part 3: Weldable fine grain steels, normalized*

EN 10028-5, *Flat products made of steels for pressure purposes — Part 5: Weldable fine grain steels, thermomechanically rolled*

EN 10204:2004, *Metallic products — Types of inspection documents*

EN 12517-1:2006, *Non-destructive examination of welds — Part 1: Evaluation of welded joints in steel, nickel, titanium and their alloys by radiography — Acceptance levels*

EN 13445-2, *Unfired pressure vessels — Part 2: Materials*

EN 13445-3, *Unfired pressure vessels — Part 3: Design*

EN 13636, *Cathodic protection of buried metallic tanks and related piping*

EN 14717, *Welding and allied processes — Environmental check list*

EN 14784-1, *Non-destructive testing — Industrial computed radiography with storage phosphor imaging plates — Part 1: Classification of systems*

EN 14784-2, *Non-destructive testing — Industrial computed radiography with storage phosphor imaging plates — Part 2: General principles for testing of metallic materials using X-rays and gamma rays*

EN ISO 636, *Welding consumables — Rods, wires and deposits for tungsten inert gas welding of non-alloy and fine-grain steels — Classification (ISO 636:2004)*

EN ISO 2560, *Welding consumables — Covered electrodes for manual arc welding of non-alloy and fine grain steels — Classification (ISO 2560:2009)*

EN ISO 5173, *Destructive tests on welds in metallic materials — Bend tests (ISO 5173:2009)*

EN ISO 5817:2007, *Welding — Fusion-welded joints in steel, nickel, titanium and their alloys (beam welding excluded) — Quality levels for imperfections (ISO 5817:2003, corrected version:2005, including Technical Corrigendum 1:2006)*

EN ISO 6520-1:2007, *Welding and applied processes — Classification of geometric imperfections in metallic materials — Part 1: Fusion welding (ISO 6520-1:2007)*

EN ISO 14021, *Environmental labels and declarations – Self-declared environmental claims (Type II environmental labelling) (ISO 14021:1999)*

EN ISO 14024, *Environmental labels and declarations — Type I environmental labelling — Principles and procedures (ISO 14024:1999)*

EN ISO 14025, *Environmental labels and declarations — Type III environmental declarations — Principles and procedures (ISO 14025:2006)*

EN ISO 15609-1, *Specification and qualification of welding procedures for metallic materials — Welding procedure specification — Part 1: Arc welding (ISO 15609-1:2004)*

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EN ISO 15613, *Specification and qualification of welding procedures for metallic materials — Qualification based on pre-production welding test (ISO 15613:2004)*

EN ISO 15614-1, *Specification and qualification of welding procedures for metallic materials — Welding procedure test — Part 1: Arc and gas welding of steels and arc welding of nickel and nickel alloys (ISO 15614-1:2004)*

EN ISO 17632, *Welding consumables — Tubular cored electrodes for gas shielded and non-gas shielded metal arc welding of non-alloy and fine grain steels — Classification (ISO 17632:2004)*

EN ISO 17635, *Non-destructive testing of welds — General rules for metallic materials (ISO 17635:2010)*

EN ISO 17638*, Non-destructive testing of welds — Magnetic particle testing (ISO 17638:2003)*

EN ISO 23277:2009*, Non-destructive testing of welds — Penetrant testing of welds — Acceptance levels (ISO 23277:2006)*

EN ISO 23278:2009*, Non-destructive testing of welds — Magnetic particle testing of welds — Acceptance levels (ISO 23278:2006)*

ISO 9162, *Petroleum products — Fuels (class F) — Liquefied petroleum gases — Specifications*

3 Terms and definitions

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

3.1
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.

3.2
serially produced tanks
more than one tank manufactured in the same factory to a common design using the same material and manufacturing procedure and produced with no major interruption within a given period of time

3.3
manufacturer
manufacturer of the tank unless otherwise specified

3.4
yield strength
upper yield strength R_{eH} or, for steels that do not exhibit a definite yield, the 0,2 % proof strength $R_{p0,2}$

3.5
Pressure Equipment Directive
PED
Directive 97/23/EC of the European Parliament and of the Council of 29 May 1997 on the approximation of the laws of the Member States concerning pressure equipment

3.6
design pressure
gauge pressure used in design formulae

NOTE For tanks made to this standard, the design pressure is equivalent to the "Maximum allowable pressure", PS, in the PED.

3.7
climatic area
geographic area agreed or defined by the relevant national authorities, or other bodies, responsible for defining the design conditions for LPG storage tanks, in the country(ies) where the tank is intended to be operated

NOTE The area is used to define the reference temperature for design pressure and filling.

3.8
hot forming
forming at temperatures above the maximum permissible temperature for stress relieving in accordance with the material specification

3.9
cold forming
forming at temperatures at least 30 °C below the maximum permissible temperature for stress relieving in accordance with the material specification

3.10
Ar_3
critical point, on the iron-iron carbide equilibrium diagram, representing the temperature at the end of transformation of austenite to ferrite on cooling of the steel

NOTE The actual temperature varies with composition of the steel.

3.11
production-batch
group of pressure parts or finished tanks, made consecutively by the same manufacturer using the same manufacturing techniques to the same design, nominal size and material specifications on the same production machinery and subject to the same heat treatment conditions

NOTE In this context, consecutively need not imply continuous production.

4 Materials

4.1 Environmental

The manufacturer shall endeavour to acquire materials and components from suppliers who have a declared environmental policy, see EN ISO 14021, EN ISO 14024 and EN ISO 14025.

4.2 Shells and ends

4.2.1 Materials for shells and ends shall be selected from the range of steels specified in EN 10028-2, EN 10028-3 or EN 10028-5.

NOTE Other equivalent material specifications which have either European materials approval or have been subjected to a particular material appraisal may be used.

4.2.2 In all cases the materials used shall comply with the following:

— the chemical composition and mechanical properties shall meet the requirements of either Group 1 or Group 2, as defined in Table 1 — Material grouping;

— the minimum specified ultimate tensile strength shall not exceed 700 MPa;

— the minimum elongation after fracture shall be 14 %;

— the impact properties shall be not less than 27 J at the minimum design temperature or shall meet the requirements for low temperature design as detailed in EN 13445-2;

4.2.3 Steels shall be grouped in accordance with Table 1 — Material grouping.

4.2.4 Where materials subject to particular material appraisal have been used, satisfactory properties following welding shall be demonstrated by production weld test plates, see 9.7.

Table 1 — Material grouping

Group	Sub-group	Type of steel
1		Steels with a specified minimum yield strength $R_{eH} \leq 460$ MPa [a] and with analysis in percent: C ≤ 0,25 Si ≤ 0,60 Mn ≤ 1,70 Mo ≤ 0,70 [b] S ≤ 0,045 P ≤ 0,045 Cu ≤ 0,40 [b] Ni ≤ 0,5 [b] Cr ≤ 0,3 (0,4 for castings) [b] Nb ≤ 0,05 V ≤ 0,12 [b] Ti ≤ 0,05
	1.1	Steels with a specified minimum yield strength $R_{eH} \leq 275$ MPa
	1.2	Steels with a specified minimum yield strength 275 MPa < $R_{eH} \leq 360$ MPa
	1.3	Normalized fine grain steels with a specified minimum yield strength $R_{eH} > 360$ MPa
2		Thermomechanically treated fine grain steels and cast steels with a specified minimum yield strength $R_{eH} > 360$ MPa
	2.1	Thermomechanically treated fine grain steels and cast steels with a specified minimum yield strength 360 MPa < $R_{eH} \leq 460$ MPa

[a] In accordance with the specification of the steel product standards, R_{eH} may be replaced by $R_{p0,2}$.

[b] A higher value is accepted provided that Cr + Mo + Ni + Cu + V ≤ 0,75 %.

NOTE This table is based on ISO/TR 15608:2000.

4.3 Pressure parts other than shell or ends

Materials for pressure parts, other than shells and ends, shall comply with the appropriate harmonised European Standard for the material, or a similar specification which has European materials approval or particular material appraisal.

NOTE Examples of standards which may be used, include EN 10222-2 (Forgings), EN 10216-2 (Seamless tubes), EN 10217 series (Welded tubes) and EN 10273 (Bars).

Materials shall also meet the requirements of 4.2.2 and 4.2.3 and 4.2.4.

4.4 Parts welded to the tank

Non-pressure retaining parts that are directly welded to the pressure retaining parts shall be made from suitable materials selected from EN 10025-2 or a material which is compatible with the pressure retaining part material.

NOTE It may be necessary for these materials to be subject to the alternative material approval requirements of the PED.

In all cases, the material shall meet the requirements of 4.2.

4.5 Welding consumables

The welding consumables shall be such that they are capable of giving consistent welds with properties at least equal to those specified for the parent materials of the finished tank.

The welding consumables shall be selected from EN ISO 2560, EN 756, EN ISO 17632 or EN ISO 636, as appropriate. Suitability of the chosen consumables shall be demonstrated in accordance with 7.7.3.

4.6 Inspection documents for materials

The tank manufacturer shall obtain inspection documents showing the chemical analysis and details of the mechanical properties of the steel supplied for the construction of the tank. For the pressure retaining parts and non-pressure parts directly welded to the tank the documents shall be in accordance with EN 10204:2004, inspection certificate Type 3.1. Other parts shall have documentation in accordance with EN 10204:2004, test report Type 2.2. The documents shall include, or be supplemented by, the material manufacturer's documented affirmation of compliance to the material specification.

NOTE Annex 1 Essential Safety Requirement 4.3 of the PED gives specific requirements for material manufacturers and their quality management systems.

4.7 Non metallic materials (gaskets)

Non metallic materials shall be compatible with both phases of LPG over the full range of pressures and temperatures anticipated in service.

5 Design

5.1 General

Tank thicknesses shall be calculated in accordance with Annex E

No internal corrosion allowance is required for tanks intended to contain LPG which complies with ISO 9162 and is supplied to a national or international standard or other equivalent specification.

No external corrosion allowance is required for tanks protected against external corrosion in accordance with Clause 10.

The appropriate weld joint coefficient for the material used and the level of non-destructive testing to be adopted shall be selected in accordance with Table 2.

The tank shall be designed to withstand the forces of pressure, vacuum conditions and liquid load in accordance with 5.3, 5.4 and 5.5.

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For underground tanks, the weight of the surrounding ground in the operating condition and loadings from anti-flotation devices shall be taken into account.

Where necessary, attachments to the tank shall be welded using a backing plate.

A fully detailed, dimensional drawing shall be produced.

NOTE The design of the tank should take account of the following:

— required vaporisation capacity;

— footprint of the tank to minimise land use;

— minimising the use of materials;

— profile of the tank;

— fittings required for the tank;

— minimising the environmental impact of in service maintenance and end of life disposal;

— efficient transport of finished product.

5.2 Temperature

The design temperature range shall be – 20 °C to 50 °C. However, if temperatures lower than – 20 °C are envisaged, the manufacturer shall demonstrate that the material from which the pressure containing parts of the tank are constructed shall have properties suitable for a range of temperatures – 40 °C to 50 °C in accordance with EN 13445-2.

5.3 Pressure

The design pressure, *p* (see 3.5), shall not be less than the maximum allowable pressure.

For underground tanks, it shall be selected taking into account:

— the pressure developed by the LPG at the maximum soil temperature at 1 m depth; and

— the maximum pressure of the LPG delivered into the tank.

Recommended pressures for various climatic areas are given in Annex A.

5.4 Vacuum conditions

The tank shall be designed to withstand a minimum internal pressure of 0,3 bar absolute.

NOTE 1 This can be demonstrated by calculation in accordance with EN 13445-3.

NOTE 2 This requirement should ensure that the tank will withstand vacuum conditions generated by the product during operation or normal maintenance.

5.5 Support loadings

For above ground tanks, the tank and supports shall be designed to withstand the load when the tank is filled with water.

For underground tanks, the tank and its supports shall be designed to withstand the greater of:

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— the operating mass plus the mass of the backfill above the tank;

— the load from its supports when the tank is filled with water.

This shall be demonstrated by calculation in accordance with EN 13445-3 or by experimental testing.

5.6 Lifting lugs loadings

The lifting lugs shall be designed to accept the maximum loads anticipated during construction and handling. This shall be demonstrated by calculation in accordance with EN 13445-3 or experimental testing.

6 Openings

6.1 General

Tanks shall be provided with an adequate number of openings to satisfy the need for fittings to meet service requirements. Openings using screwed or flanged connections shall be positioned such that they remain accessible after installation.

6.2 Reinforcement

Each opening shall be reinforced by a boss, pad or compensating plate attached by welding and designed in accordance with E.3.

6.3 Position of welds and openings

The welds of openings shall be clear of longitudinal and circumferential welds and welds of other openings as measured between the weld edges by not less than the smaller of:

— twice the thickness of the shell or head (as appropriate);

— 40 mm.

7 Workmanship and manufacture

7.1 General

Tanks shall be manufactured according to drawings and specifications in accordance with the requirements of this standard and good engineering practice.

The manufacturer shall be responsible for the competence, training and supervision of its staff.

The forming, welding and heat treatment performed by the manufacturer shall ensure that the material properties in the finished tank meet the requirements of the design intent and this standard.

The manufacturer shall have a defined organisation for the control of manufacturing operations, which includes special processes such as forming, welding and heat treatment.

7.2 Environment

The environmental impact of welding and allied processes shall be assessed in accordance with EN 14717.

NOTE 1 The manufacturer should endeavour to minimise wastage of material by selecting appropriately sized materials related to the finished parts required for manufacture. Unavoidable waste/scrap material should be recycled.

NOTE 2 Noise levels from the production process should be evaluated and measures put into place to minimise the impact upon the external environment.

7.3 Control and traceability of materials

The manufacturer shall maintain a system of identification for the material used in fabrication in order that all material for pressure parts in the completed tank can be traced to its origin. The traceability system shall incorporate procedures for verifying the identity of material as received from the supplier via the material manufacturer's test certificates and/or acceptance tests.

The manufacturer shall ensure that the material used complies with that specified in the design and/or the drawings

In laying out and cutting the material, the material identification mark shall be so located as to be:

a) clearly visible when the pressure part is completed; or

b) traceable by operation of a documented system which ensures material traceability for all materials in the completed tank.

NOTE Where the material identification mark is unavoidably cut out during manufacture of a pressure part, it should be transferred by the pressure part manufacturer, to another part of this component. The transfer of the mark should be carried out by a person designated by the manufacturer.

When identification on materials is transferred, the method of stamping or marking shall not have any detrimental effect on the specified material properties.

Records of the welding consumables used shall be retained.

7.4 Manufacturing tolerances

Tolerances on the shape of tanks shall be in accordance with Annex B.

7.5 Acceptable weld details

7.5.1 General

Basic weld details shall be in accordance with EN 1708-1. Recommended weld details are given in Annex G.

7.5.2 Longitudinal welds

Shell welds shall be either helical butt welds or longitudinal butt welds. Where a tank is made from more than one shell strake, the longitudinal weld seams of adjacent strakes shall be staggered by at least 100 mm. This spacing shall be measured between weld edges.

7.5.3 Joggle joints

7.5.3.1 Joggle joints shall meet the following requirements:

— the offset section which forms the weld backing shall be a close fit within its mating section around the entire circumference (machining of the spigot of the offset section is permissible provided that the thickness remaining as backing material is not less than 75 % of the original thickness at any point);

— the profile of the offset shall be maintained, with a smooth radius without sharp corners throughout production;

— on completion of the welding the weld shall have a smooth profile and shall fill the groove to the full thickness of the plate being joined.

NOTE Recommended arrangement for joggle joints is shown in Figure G.2.

7.5.3.2 When the flange section of the dished end is joggled, the joggle shall be sufficiently clear of the knuckle radius to ensure that the edge of the circumferential weld is at least 12 mm clear of the knuckle.

7.5.3.3 When a strake edge is joggled the longitudinal or helical weld shall be ground flush internally and externally for a distance of approximately 50 mm prior to joggling with no reduction of plate thickness. On completion of the joggling, the area of the weld shall be proven to be free of cracks by magnetic particle testing in accordance with EN ISO 17638 or penetrant testing in accordance with EN 571-1.

7.6 Formed pressure parts

7.6.1 General

Formed pressure parts shall be either cold formed or hot formed.

Ends shall be made from one piece of plate.

Plates used for formed parts shall comply with 4.2.

The work-piece temperature during hot forming shall not exceed 1 050 °C.

7.6.2 Heat treatment after forming

7.6.2.1 Environment

Where heat treatment is performed the process shall be designed to minimise energy consumption, use of coolants, and ensure the environmentally friendly disposal of insulating material and other waste.

Where formed parts are supplied as components, reference shall be made to 4.2.

7.6.2.2 Heat treatment after cold forming of flat products

Cold formed ends shall be heat treated after forming, unless it can be demonstrated that the properties specified in 4.2 are met, or a burst test on a prototype tank demonstrates that the formed component is not the weakest part of the tank.

Where heat treatment is applied after cold forming, this shall be by normalising to achieve the required material properties.

NOTE The base material manufacturer's test certificate can be taken as an indication or recommendation for the type of heat treatment required.

7.6.2.3 Heat treatment after hot forming

If no subsequent heat treatment is intended, the forming process shall be proven, controlled and meet the requirements of 7.6.1.

If the forming temperature is less than Ar_3 or the elongation of the steel, after forming, is less than that specified in 4.2, formed parts shall be heat treated by normalising or another qualified procedure after hot forming in order to restore the mechanical properties to comply with 4.2.

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7.6.3 Testing of formed parts

For cold-formed parts not subject to heat treatment, no mechanical tests are required in respect of the forming operation except where required by 7.6.2.2 for ends.

All other formed parts where the material thickness is greater than or equal to 5 mm, shall have tests carried out after the last forming operation or any heat treatment, to demonstrate conformity to the material specification. Test pieces shall be taken from an excess length, or a redundant piece of the formed part, or from a separate piece formed by the same procedure. The test pieces, taken in accordance with the material specification, shall consist of one tensile and three impact specimens.

In the case of formed ends, the test pieces shall be taken from sample ends selected as follows:

— one from the first ten of each family; and then

— one from each 1 000 units produced, but not less than one per two years.

Ends belong to a family when they have the following characteristics in common:

— material specification;

— forming process;

— heat treatment; and

— geometrical similarity to ± 10 %.

7.6.4 Repeated tests

Where an unsatisfactory test result is due to poor testing technique or to a defect limited to one specimen, the test may be repeated.

Where the test results from correctly tested specimens do not comply with the specification, the test shall be repeated as follows:

— where the tensile or bend test fails, the test shall be repeated with two further specimens taken from the test piece. These two results shall then comply with the specification;

— where one of the three impact tests fail, three further test specimens shall be taken from the test piece and tested. The mean value of these six individual test results shall meet the specification. No more than two individual values shall fall below the minimum value and, of these two, one shall be at least 70 % of the minimum value.

Any pressure part, which fails to comply with the specification, shall be rejected. The testing shall be repeated on two other formed parts of the same production-batch where the test results shall comply with the specification.

Where the results of the repeated tests fail to meet the specification, the formed parts and the test pieces may be subject to one further heat treatment and the tests repeated.

If any of the tests on the re-heat treated parts fail, the formed parts or production-batch shall be rejected.

7.6.5 Visual examination and dimensional check

Formed parts, which require certificates according to EN 10204:2004, shall be subject to visual examination and dimensional check in the delivered condition by the manufacturer. The results of the visual examination and the dimensional check shall be certified by the manufacturer and included with the EN 10204:2004 certificate.

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7.6.6 Marking

Formed parts shall be marked in such a manner that the material and the manufacturer of the formed parts can be identified during manufacture of the tank. In the case of production-batch testing, individual formed parts shall be traceable to the production-batch.

7.6.7 Test certificate

Product certificates for formed parts shall include details of any heat treatment applied.

7.7 Welding

7.7.1 General

Welding shall comply with the following:

— the welding procedures shall be selected by the manufacturer for the field of application and the welders and welding personnel shall be qualified for the work allocated to them;

— longitudinal welds shall be by a mechanised/automatic welding process. All circumferential welds for tanks with diameter less than or equal to 1 250 mm shall be by a mechanised/automatic welding process.

NOTE For tanks required to conform to the PED, it will be necessary for the weld procedures and welder qualifications to be approved by a notified body or third party organisation recognised by a member state.

7.7.2 Welding procedure specification (WPS)

The manufacturer shall compile welding procedure specifications for all joints in accordance with EN ISO 15609-1.

7.7.3 Qualification of WPS

Welding procedure specifications shall be qualified by tests in accordance with EN ISO 15614-1 or EN ISO 15613.

7.7.4 Qualification of welders and welding operators

Welders shall be qualified in accordance with EN 287-1 and welding operators with EN 1418.

NOTE The training, supervision and control of welders and welding operators is the responsibility of the manufacturer.

The manufacturer shall maintain an up-to-date list of welders and welding operators, together with the records of their qualification tests.

7.7.5 Preparation of edges to be welded

NOTE Material can be cut to size and shape by any mechanical or thermal cutting process or by combination of both. This may be carried out before or after forming operations.

The surface to be welded shall be thoroughly cleaned of oxide scale, oil, grease or other foreign substance to avoid any detrimental effect on weld quality.

The edges to be welded shall be kept in position either by mechanical means or by tack welds or by a combination of both. The tack welds shall be removed or fully fused in the weld.

In both cases, the manufacturer shall take precautions to ensure that the tack welding does not generate metallurgical or homogeneity defects.

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When welding without a sealing run, the manufacturer shall ensure that the alignment and the gap between the edges to be welded will give the required penetration at the weld root. During the whole welding operation, the edges to be welded shall be suitably restrained so that the required weld geometry is maintained.

7.7.6 Execution of welded joints

After each weld run, any slag shall be removed and, where necessary, the weld cleaned and any surface defects removed.

Unless the welding process used provides effective and sound penetration, the second side of a welded joint shall be removed back to sound metal using a mechanical or thermal process or by grinding.

Stray arcing on pressure tank parts outside the weld preparation shall be avoided. Where it does occur accidentally the affected area (including the heat-affected zone) shall be repaired.

7.7.7 Attachments and supports

Attachments (whether temporary or not), including supports, shall only be welded to a part subject to pressure by qualified welders using a qualified procedure.

Temporary attachments shall be removed using a technique, which does not affect the properties of the metal, or the pressure part to which they are welded. The affected areas shall be dressed smooth and subjected to penetrant or magnetic particle testing, unless the areas are to be subsequently covered by further welding which shall be checked according to 9.2.

7.7.8 Preheating

7.7.8.1 The manufacturer shall include the preheating temperature in the WPS.

NOTE The preheat temperature depends on the composition of the metal being welded, the material thickness and the heat input being used. Recommendations on preheating are given in EN 1011-2.

7.7.8.2 No welding shall be carried out when the temperature of the parent metal adjacent to the joint is less than + 5 °C.

7.8 Post weld heat treatment

Post weld heat treatment is not required for the material types and weld thicknesses used for tanks built to this standard.

7.9 Repairs

7.9.1 Repairs of surface imperfections in the parent metal

If surface imperfections are only superficial, such as accidental arc strikes, tool marks, oxy-acetylene cutting marks, the imperfections may be removed by grinding so that the ground area has a taper with the adjoining surfaces. The grinding shall be followed by inspection for surface imperfections.

The thickness at the repair shall be checked to ensure that the design requirements are met.

Where the imperfections reduce the thickness of the wall below the minimum design thickness no repair shall be carried out and the tank shall be rejected.

7.9.2 Repair of weld imperfections

Weld imperfections not meeting the acceptance criteria shall be repaired or the tank shall be scrapped.

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NOTE EN 13109 gives advice on the scrapping of LPG tanks.

Imperfections shall be repaired by either removing and reinstating the complete weld or, by local repair, depending on the extent of the imperfections.

Repair shall be carried out using a qualified WPS in accordance with 7.7.2 or with a specific qualified repair procedure. When original the weld procedure is used for the repair, the procedure does not need to be re-qualified.

The repair shall be carried out by a qualified welder or operator.

Repaired areas shall be non-destructively tested in the same manner as the original weld and shall meet the requirements of Clause 9. Where the result of the examination is not satisfactory, a further repair is not permitted.

The manufacturer shall keep records of all weld repairs.

8 Non-pressure attachments

8.1 Attachments

Supports, lugs, pads, etc. not subject to tank pressure are permitted to be attached to the tank by welding provided that such attachments are made of weldable and compatible steel. All attachment welds shall be continuous.

8.2 Position

Attachments shall be designed to permit inspection of the weld and shall, where practicable, be clear of the longitudinal and circumferential joints by a minimum distance of 40 mm. Where not practicable the attachment and its welds shall cross the joint completely.

Attachments shall be positioned and designed so as to avoid collecting or trapping water.

8.3 Vent hole

Any backing pad or plate which covers a pressure containing weld shall be provided with a vent hole which shall be tapped and plugged.

9 Inspection and testing

9.1 Visual examination of welds

All welded joints shall be visually examined for surface imperfections in accordance with EN 970 on completion of welding and imperfections shall be assessed using the criteria in 9.6. The surface examined shall be well illuminated and shall be free from grease, dirt, scale, residue or protective coating of any kind.

Unacceptable imperfections shall be repaired in accordance with 7.9 or the tank shall be rejected.

NOTE It is recommended that visual examination is supplemented by magnetic particle or penetrant testing in case of doubt (see 9.3.4 and 9.3.5).

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9.2 Non-destructive testing (NDT)

9.2.1 Radiographic and/or ultrasonic testing of longitudinal or helical shell welds shall be carried out in accordance with 9.3.2 and 9.3.3 to the extent specified in Table 2. Any imperfections shall be assessed using the criteria in 9.6.

9.2.2 In the case of steel groups 1.1, 1.2 and 1.3 the extent of NDT can be reduced from 100 % to 10 % when satisfactory experience is achieved.

Satisfactory experience is defined as successful production, without any unacceptable imperfections, of 25 tanks or 50 m of weld, whichever is the greater, see 9.6.

If there is a change in welding procedure or following a break in production of more than four weeks, the criteria for satisfactory experience shall be re-established.

9.2.3 10 % of the aggregate length of all circumferential welds on each tank shall be tested by radiographic or ultrasonic testing in accordance with 9.3.2 or 9.3.3. Areas tested shall include all T junctions.

NOTE It is recommended that the manufacturer produces a location drawing of the tested areas.

Table 2 — Extent of non-destructive testing on longitudinal welds and weld joint coefficients

Steel group (see Table 1)	**2.1**	**1.1, 1.2, 1.3**	**1.1, 1.2, 1.3 2.1**
Extent of NDT [a]	100 %	100 % then 10 % [b c]	10 %
Weld joint coefficient	1	1	0,85

[a] The percentage relates to the percentage of welds of each individual tank.

[b] Limited to fully mechanised and/or automatic welding process where at least the weld head and the welding consumable movement is mechanised.

[c] First figure: initially; second figure: after satisfactory experience. See 9.2.2.

9.2.4 10 % of the aggregate length of all welds attaching nozzles, branches and compensating plates to the shell and ends and 10 % of all other attachment welds to pressure components shall be examined for imperfections by magnetic particle and/or penetrant techniques; see 9.3.4 or 9.3.5. Any imperfections shall be assessed using the criteria in 9.6.

9.3 Non-destructive testing techniques

9.3.1 General

The selection of non-destructive testing techniques shall be in accordance with EN ISO 17635. Other methods and techniques may be used provided the same level of imperfection detection is achieved.

9.3.2 Radiographic techniques

Radiographic examination shall be carried out in accordance with EN 1435:1997, class B, and in accordance with EN 14784-1 and EN 14784-2, where applicable.

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Radiographic sensitivity shall be determined in accordance with EN 462-1, EN 462-2 or with other techniques which achieve comparable sensitivities. Each section of weld radiographed shall have symbols affixed to identify the following:

— job or workpiece serial number, order number or similar distinctive reference number;

— joint;

— section of the joint; and

— outer edges of the weld.

NOTE 1 It is recommended that these are marked with arrows or other symbols alongside but clear of the edges to clearly mark their positions.

Where radiographs of the entire length of a weld are required, sufficient overlap shall be provided to ensure that the radiographs cover the whole of the weld and each radiograph shall exhibit a number near each end.

Radiographs of repair welds shall be clearly identified, e.g. "R1".

NOTE 2 The location of the weld may be identified with a letter "L" for a longitudinal weld, "C" for a circumferential weld, with the addition of a numeral (1, 2, 3, etc.) to indicate whether the weld was the first, second, third, etc., of that type.

Where radiographic examination is specified, it may be carried out using radioscopy provided that the process can be demonstrated to provide the same quality of examination, imperfection detection and the same level of records, as the radiographic examination.

9.3.3 Ultrasonic techniques

Ultrasonic testing techniques shall comply with EN 1714:1997, at least Class B.

Before carrying out ultrasonic examination of welds, the adjacent parent metal shall be ultrasonically examined to establish the thickness of the material and to locate any imperfections which may prevent effective examination of the weld.

9.3.4 Magnetic particle techniques

Magnetic particle inspection techniques shall be in accordance with EN ISO 17638.

Care shall be taken to avoid damage to surfaces by misuse of the magnetic equipment and if such damage occurs, it shall be repaired in accordance with 7.9.1.

9.3.5 Penetrant techniques

Penetrant testing of welds shall be carried out in accordance with EN 571-1.

9.4 Marking for non-destructive testing

For all non-destructive testing techniques, identifying marks shall be made alongside welds to provide reference points for the accurate location of the seam with respect to the test report, see 12.2, i).

9.5 Qualification of personnel

Testing personnel shall be qualified to EN 473:2008, level 1 or higher, and shall be supervised by personnel qualified to EN 473:2008, level 2 or level 3.

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NOTE For tanks required to conform to the PED Categories III and IV, it is necessary for testing personnel to be approved by a third party organisation recognised by a member state pursuant to Article 13 of the PED.

9.6 Acceptance criteria

9.6.1 Imperfections found by visual and non-destructive testing shall be characterised and assessed using the criteria detailed in Table 3.

Table 3 — Acceptance criteria

Examination/testing method	Characterisation	Acceptance criteria
Visual examination	EN ISO 5817:2007 (surface imperfections).	EN ISO 5817:2007. (surface imperfection level C), plus Table D.1 of this standard.
Radiography/Radioscopy	EN 12517-1:2006 and Table D.2 of this standard.	EN 12517-1:2006. Acceptance level 2, plus Table D.2 of this standard.
Ultrasonic testing	EN 1713:1998 (Note: recommendations only).	EN 1712:1997. Acceptance level 2. No planar imperfections permitted.
Magnetic particle testing	EN ISO 23278:2009.	EN ISO 23278:2009. Acceptance level 2X.
Penetrant testing	EN ISO 23277:2009.	EN ISO 23277:2009. Acceptance level 2X.

9.6.2 When isolated unacceptable imperfections are found during non-destructive testing, two additional areas of the weld containing the imperfection shall be tested by the same method. If further unacceptable imperfections are found then the weld seam shall be tested 100 % and the acceptance criteria applied to the 100 % tested.

9.6.3 If a recurrence of the same type of unacceptable imperfections (continuous or multiple) is found in a weld when the whole of a weld is inspected as required by 9.6.2, then the tank produced immediately before and after the tank being examined shall have the equivalent welds examined.

9.6.4 If no unacceptable imperfections are found in the appropriate welds of those two tanks, no further special testing is required.

9.6.5 If unacceptable imperfections are found in either of the preceding or following tanks, then further tanks in sequence, both before and after the tanks containing unacceptable imperfections, shall be assessed in accordance with 9.6.2 and 9.6.3 until a tank with no unacceptable imperfection is found. Where 9.2.2 is applicable, satisfactory experience shall be re-established during subsequent production.

9.7 Production test plates (coupon plates)

9.7.1 For each month of production and for each longitudinal or helical welding process the number of test plates shall be as follows:

— one test plate from 0 m to 60 m;

— one test plate from 60 m to 360 m;

— one test plate from 360 m to 1 860 m;

— one test plate from 1 860 m to 9 360 m.

Where the circumferential joints are welded to a procedure different to the longitudinal/helical joints, one test plate shall be produced per year.

These requirements apply to each material specification covered by a separate particular material appraisal.

9.7.2 Test plates on longitudinal/helical welds shall, wherever practicable, be attached to the shell plate on one end of the welds so that the edges to be welded in the test plate are a continuation and duplication of the corresponding edges of the tank weld. The weld metal shall be deposited in the test plates continuously with the welding of the corresponding longitudinal seam so that the welding procedure and technique are the same. When it is necessary to weld the test plates separately, such as in the case of circumferential joints, the welding procedure used shall duplicate that used in the construction of the tank.

9.7.3 The test plates shall be of sufficient size to allow for the required specimens, including an allowance for re-tests. The type and number of specimens taken from the test plate is specified in Table 4.

Testing shall be carried out in accordance with the following standards:

— Bend test EN ISO 5173;

— Macro examination EN 1321;

— Impact test EN 875;

— Longitudinal tensile test EN 876;

— Transverse tensile test EN 895.

9.7.4 A test record shall be prepared showing the test results compared with the specified requirements.

9.7.5 Where individual bend test results do not comply with the specified requirements, the reasons for the failure shall be investigated and, if no unacceptable imperfections are found, two further bend tests shall be made. If any of the retest results fail to conform, then the welds represented by the test plate shall be deemed not to be in conformance with this standard.

9.8 Final assessment

9.8.1 Pressure test

Tanks shall be hydraulically tested in accordance with Annex C. Tanks shall demonstrate no signs of leak or yield and show no pressure drop with the tank isolated from the pressure supply. After the test, the tank shall exhibit no sign of permanent distortion.

Tanks, which have been repaired subsequent to the pressure test, which affect the properties of the pressure containing parts shall be subjected to a further test after completion of repairs.

The minimum pressure applied during the test shall be 1,43 times the design pressure (see Annex A). However, calculations shall be made to ensure the general membrane stress occurring at the actual test pressure does not exceed 95 % of the guaranteed minimum material yield strength R_{eH}. Where this limit is exceeded the test pressure shall be reduced accordingly.

The duration of the test shall allow sufficient time for an examination to check for signs of leakage or general plastic yielding of the tank, but shall be not less than 10 min.

9.8.2 Final examination

Tanks designed and constructed in accordance with this standard shall be subject to an external and internal examination for compliance with the requirements of the construction drawings.

If, due to the size of the openings, an internal examination is not possible upon completion of the tank, the manufacturer shall ensure that the internal surfaces are examined prior to their final assembly.

The final examination shall be performed following completion of all welding activities, any post weld heat treatment, any repairs and the hydraulic pressure test, but before application of any coating.

Table 4 — Number of test specimens

Steel group (see Table 1)	**1.1, 1.2 and 1.3**		**2.1**	
Parent metal thickness, *e* mm	**$e \leq 12$**	**$e > 12$**	**$e \leq 12$**	**$e > 12$**
Face bend test	1	—	1	—
Root bend test	1	—	1	—
Macro examination	1	1	1	—
Impact test: parent material and weld deposit	3 [a]	3	3 [a]	3
Impact test: heat affected zone	—	3	—	3
Longitudinal weld tensile test	—	—	—	1 [b]
Transverse tensile test	—	—	—	1

NOTE It is permissible to apply non-destructive testing on the test plate prior to cutting the test specimens in order that they are selected from sound areas.

[a] Not required for thicknesses less than 5 mm.

[b] Where difficulty is experienced in obtaining an all weld metal test, this may be replaced by a full chemical analysis of the weld metal.

10 Surface treatment and finishing

10.1 Environmental considerations

The requirements of EN 14717 shall be applied where appropriate to shot blasting and thermal spraying. The environmental impact of the coating system selected, its application and the disposal of residues shall be minimised

The environmental impact of the surface treatment at the end of life disposal of the tank shall be taken into account when selecting the system

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10.2 Above ground tanks

10.2.1 General

Tanks shall be protected so as to prevent external corrosion arising from atmospheric exposure by the application of a protective coating system. The actual system applied shall take into account:

— local operating environment;

— periods between periodic inspections/maintenance; and

— any external fire protection coatings or other coating.

Details of the actual system used, expected life and coating maintenance recommendations shall be included in the operating instructions.

10.2.2 Reflectivity

The external finish shall be in a pale colour and be of a high reflectivity. Only colours of reflectivity of 1, 2 or 3 shall be permitted.

Table 5 gives a relationship between colours and indices which shall be used to determine design conditions in conjunction with Annex A.

Table 5 — Colours and indices

Index	Colour
1	white, ivory, zinc, aluminium and silver
2	yellow up to degree RAL 1021 grey up to degree RAL 7035 green up to degree RAL 6019
3	all other colours except dark blue and black

NOTE A method of determining reflectivity indices is described in Annex H.

10.3 Underground tanks

Tanks shall be protected so as to prevent external corrosion arising from:

— atmospheric exposure and handling during transport and storage;

— mechanical damage and corrosion from the backfill material and ground water during installation, burying and throughout the intended service life

by the application of a protective coating or other corrosion protection system, complying with Annex I.

The actual system applied shall take into account:

— environmental impact upon soil and groundwater of the protective system chosen;

— installation and burying method;

— soil/backfill characteristics;

— periods between periodic inspections/maintenance and any protection system monitoring periods.

Details of the system used, expected life and recommendations regarding installation and any repairs required as a result of transport and installation damage, system monitoring and maintenance shall be included in the operating instructions.

10.4 Finishing operations

Tanks shall be subjected to the following:

— complete examination of outer surface and visible parts of the inner surface;

— removal of any internal debris and complete drying of the tank;

— protection of all flanges and nozzles against impact and oxidation;

— protection of inner surface against oxidation from the atmosphere and against any introduction of foreign matter. This type of protection shall take into account any possible over-pressure caused by high ambient temperatures and any possible partial vacuum due to water vapour condensation.

NOTE 1 Finishing operations are all operations carried out after the tank has been pressure tested and before shipment/transport. The aim is to protect the tank from impact and pollution during transportation, installation and its connection to its equipment.

NOTE 2 Any packaging and protection used during storage/transport of the finished product should be selected to have the minimum environmental impact, i.e. use of recyclable or bio-degradable materials, minimum use of energy.

11 Marking and certification

Tank details shall be permanently marked on a corrosion resistant nameplate or other appropriate permanently attached non-pressure part. The position of the markings shall remain visible when the tank is installed. As a minimum the nameplate shall have the following information:

— name and address or other means of identification of the manufacturer;

— serial number;

— type or production-batch number;

— maximum and minimum allowable limits of temperature (TS) and pressure (PS);

— nominal water capacity in litres;

— date of manufacture;

— design code;

— test pressure (PT) in bars and date of test.

The letters shall be at least 4 mm high.

NOTE Where applicable, it could be necessary to include the CE symbol, a mark or identification of the notified body and any other information specified by the purchaser. The minimum height for the CE symbol is 5 mm.

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Certification shall be produced for each tank or production-batch of tanks, indicating compliance with the requirements of this document.

12 Records and documentation

12.1 Records to be obtained by the manufacturer

The manufacturer shall obtain the following documentation:

— certificates showing the chemical analysis and details of the mechanical properties of the steels used in the construction of the pressure retaining parts of the tanks;

— certificates for formed parts in accordance with EN 10204:2004 where required.

12.2 Documents to be prepared by the manufacturer

The manufacturer shall prepare and supply the following:

a) design documents, including a fully dimensioned drawing, material specifications, design calculations, etc.;

b) records of any heat treatment applied;

c) records of mechanical tests as in 9.7.4;

d) records of visual examination and dimensional checks on formed parts;

e) welding procedure specifications and welding procedure tests results;

f) up-to-date list of welders and records of their approval tests;

g) records of any weld repairs;

h) record of the result of the hydraulic pressure test;

i) radiographs where taken or results of other non destructive tests in accordance with 9.2 and 9.4;

j) certificate in accordance with Clause 11; and

k) operating instructions.

Annex A
(informative)

Design pressure and filling conditions

A.1 Above ground tanks

A.1.1 Design pressure (*p*)

Design pressure, *p*, is the gauge pressure specified for the appropriate climatic area in accordance with Tables A.1 and A.2.

Table A.1 — Design pressure – Reflectivity indices 1 and 2

Volume m³	**Climatic area I**	**Climatic area II**	**Climatic area III**	**Climatic area IV**
	Minimum design pressure bar			
< 7	20,0	18,5	17,0	16,0
≥ 7	19,0	17,5	16,0	14,0

Table A.2 — Design pressure – Reflectivity index 3

Volume m³	**Climatic area I**	**Climatic area II**	**Climatic area III**	**Climatic area IV**
	Minimum design pressure bar			
< 7	23,0	21,5	20,0	19,0
≥ 7	22,0	20,5	19,0	17,0

Tanks intended for use in more than one climatic area should be designed for the highest appropriate design pressure.

A.1.2 Filling conditions

The liquid volume and pressure of LPG in a closed system is a function of temperature.

Consequently, the safe filling level will be a function of the appropriate reference temperature for designated climatic areas, in accordance with Table A.3.

Table A.3 — Filling reference temperatures, in degrees Celsius

Climatic area I	Climatic area II	Climatic area III	Climatic area IV
50	48	45	38

A.1.3 Calculation of maximum fill

The maximum fill allowed in a tank is calculated from the following formula:

$$U_{\max} = 0{,}97 \frac{g_i}{g_t} \times V \qquad \text{(A.1)}$$

where

g_t is the relative density at the lowest likely temperature of filling;

g_i is the relative density at the filling reference temperature;

V is the internal volume of the tank as calculated from the stated water capacity;

U_{max} is the maximum permitted volume.

A.2 Underground tanks

A.2.1 Design pressure

The design pressure, p, is the gauge pressure specified for the appropriate climatic area in accordance with Table A.4.

Table A.4 — Design pressure

Climatic area I	Climatic area II	Climatic area III	Climatic area IV
Minimum design pressure bar			
17	16	14	12

Tanks which are intended to be capable of operating in more than one climatic area should be designed for the highest appropriate design pressure.

Annex B
(normative)

Tolerances on tanks

B.1 Mean external diameter

For the cylindrical shell the mean external diameter derived from the circumference shall not deviate by more than 1,5 % from the specified external diameter.

B.2 Out of roundness

Out of roundness, *O*, the ratio of the difference between the maximum and minimum and the mean diameter, as defined by:

$$\frac{2(D_{max} - D_{min})}{[D_{max} + D_{min}]} \quad \text{(B.1)}$$

shall not exceed 1,5 % of the specified external diameter with a maximum (in millimetres) of:

$$\frac{(D + 1\,250)}{200} \quad \text{(B.2)}$$

These tolerances shall apply to the cylindrical shell, including the straight flange length on the dished ends.

NOTE 1 The determination of the out of roundness need not consider the elastic deformation due to the dead-weight of the tank.

NOTE 2 At nozzle positions, a greater out of roundness may be permitted if it can be justified by calculation or strain gauge measurement.

Single dents or knuckles shall be smooth and their depth, which is the deviation from the surface of the shell, shall not exceed 1 % of their length or 2 % of their width respectively.

NOTE 3 Greater dents and knuckles are permissible provided they have been proven acceptable by calculation or strain gauge measurements.

B.3 Deviation from the straight line

The deviation from the straight line shall not be more than 0,5 % of the total cylindrical length of the tank.

B.4 Irregularities in circular profile

Irregularities in circular profile shall not exceed the following:

— 2 % of the gauge length (checked by a 20° gauge, see Figure F.1a)); or

— 2,5 % of the gauge length (checked by a 20° gauge) where the length of the irregularities along the length of the cylinder does not exceed the lesser of one quarter of the length of the shell strake between two circumferential seams, or 1,0 m.

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If either of the above is exceeded, proof by calculation or strain gauge measurement shall be required to show that the stresses are permissible.

If irregularity in the profile occurs at the welded seam and is associated with "flats" adjacent to the weld, the irregularity in profile or "peaking" shall not exceed *e*/3 (see Figure F.1), where *e* is the wall thickness.

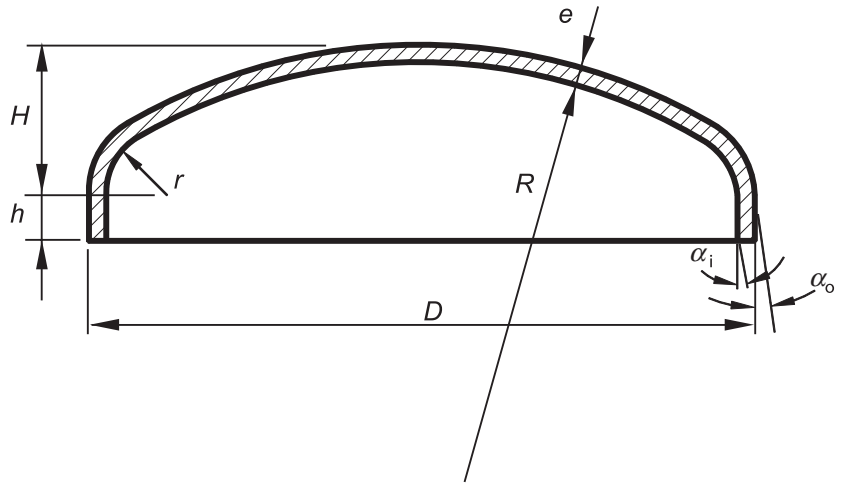
NOTE A suitable conservative method of measurement (covering peaking and ovality) is described in informative Annex F. Other types of gauges such as bridge gauges or needle gauges are also acceptable.

B.5 Thickness tolerance

The thickness of each part of the tank after forming shall not be less than the thickness determined in Annex E.

B.6 Profile

The dished ends shall be within the tolerances specified in Table B.1 for the elements shown in Figure B.1. The crown radius shall not be greater than the value specified in the design and the knuckle radius shall not be less than the value specified in the design.



Key

R crown radius
r knuckle radius
H dish height
h straight flange
e wall thickness
D external diameter
c circumference (πD)
Θ out of roundness $\dfrac{2(D_{max} - D_{min})}{(D_{max} + D_{min})}$

α_i deviation of the straight flange from cylindrical shape − inner side
α_o deviation of the straight flange from cylindrical shape − outer side

Figure B.1 — Example of a dished end

Table B.1 — Dished end tolerances

Elements		Tolerance of the element	Notes
c	$D \leq 1\,000$ mm $D > 1\,000$ mm	± 0,4 % ± 0,3 %	Special manufacturing conditions may require smaller tolerances.
O		1 %	Special manufacturing conditions may require smaller tolerances.
H		- 0 + 0,015 D or + 10 mm, whichever is the greater	The limit deviation shall not fall below zero.
$e \leq 10$ mm $e > 10$ mm		- 0,3 mm - 0,5 mm	The actual wall thickness shall not fall below that specified beyond the limit deviation given.
α_i α_o		≤ 2° ≤ 5°	In the case of ends where the outer side angle is influenced by the forming operation, the deviation of the straight flange from the cylindrical shape shall be measured only on the inner side of the end.

B.7 Surface alignment

The root faces of the weld preparations shall be aligned within the tolerances permitted by the welding procedure specification. The components shall be aligned as indicated on the construction drawings, as follows:

a) for longitudinal joints in the cylindrical shells the surfaces of adjacent plates shall be aligned to the following tolerances:

   1) for plate thickness e up to and including 10 mm: 1 mm;

   2) for plate thickness e above 10 mm: 10 % of thickness;

b) for circumferential joints the surfaces of adjacent plates shall be in alignment with the following tolerance: 10 % of the thinner part plus 1 mm.

B.8 Attachments, nozzles and fittings

All pads, reinforcing plates, lugs, brackets, supports and other attachments shall fit closely to the shell and the gap at all exposed edges to be welded shall not exceed 2 mm.

Except where specific dimensions are shown on the fully dimensioned drawing, the maximum gap between the outside of any nozzle and the inside edge of the hole in the shell, flange, reinforcing ring or backing ring shall not exceed 1,5 mm for openings less than or equal to 300 mm diameter and 3 mm for openings greater than 300 mm. To achieve this gap it is permissible to machine over a sufficient length of the outside diameter of the tank or nozzle to accommodate the attachment to which it is to be welded. This machined length shall not extend beyond the toes or edges of the attachment welds, and shall not reduce the nozzle wall thickness to a value less than the design thickness.

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Annex C
(normative)

Hydraulic pressure test

C.1 Temporary fittings

All temporary pipes and connections and blanking devices shall be designed to withstand the standard test pressure.

Jointing materials for flanged joints shall be of the same type as those to be used in service.

C.2 Pressure gauges

Pressure gauges shall be selected in accordance with EN 837-2. The gauge shall have an accuracy equal to or better than 1,6 % of the reading. The test pressure of the tank shall give a reading on the gauge between 50 % and 90 % of full scale deflection.

Alternative methods of pressure measurement may be used provided they achieve equivalent levels of accuracy.

C.3 Pressurising agent

Water shall normally be used as the pressurising agent. Care shall be taken to ensure the tank is positioned such that entrapped air is vented.

NOTE To avoid the risk of freezing, the temperature of the water during the test should be not less than 7 °C.

Consideration shall be given to re-use of the pressurising agent. When the agent needs to be disposed of, it shall be properly treated to minimise any environmental impact.

C.4 Avoidance of shocks

No tank undergoing pressure testing shall be subjected to any form of impact or pulsation loading

C.5 Test procedure

The pressure in the tank shall be gradually and regularly increased until the test pressure (see 9.8.1) is reached. The required test pressure shall be maintained for not less than 10 min.

On completion of the hydraulic test, release of pressure shall be gradual and from the top of the tank. Adequate venting shall be provided to ensure that the vacuum rating of the tank is not exceeded.

After draining, any residual water shall be removed by appropriate means.

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Annex D
(normative)

Imperfections

Tables D.1 and D.2 specify the acceptance criteria for imperfections in welded joints which are additional to the standards specified at 9.6.1.

Table D.1 — Imperfection levels for visual inspection

Imperfection	EN ISO 6520-1:2007 reference	Acceptance limit for detectable imperfection
Spatter	602	Spatter shall be removed from all pressure parts and from both load carrying attachment weld. Isolated, non-systematic spatter may however be permitted on components made from steels in Group 1. (Refer to Table 1.)
Arc Strike Spatter Tungsten spatter Torn surface Grinding mark Chipping mark	601 602 6021 603 604 605	Grind smooth, accept subject to thickness and crack detection test in accordance with 9.3.
Under flushing	606	Not permitted, any local under flushing shall be related to the design characteristics (calculated thickness = minimum thickness for base material). (Thickness shall be measured by ultrasonic method in case of doubt.)
Local excess penetration	5041	Occasional local protrusion exceeding *h* (see EN ISO 6520-1:2007, Table 1, reference 504) is permitted with a maximum that shall be related to the operating conditions.
Irregular surface	514 513	Reinforcement to be of continuous and regular shape with complete filling of groove.
Linear misalignment (surface)	507	See B.7.

Table D.2 — Imperfection levels for radiography/radioscopy

Imperfection	EN ISO 6520-1:2007 reference	Acceptance limit for detectable imperfection
Uniformly distributed porosity	2012	- Max. single porosity d = 0,3t but not greater than 4 mm; - Not permitted if the total projected surface porosity exceeds 2 % of the considered projected surface of weld. [a]
Localised (clustered) porosity	2013	a) Max. single porosity d = 0,3t but not greater than 4 mm; b) Not permitted if the total projected surface porosity exceeds 4 % of the considered projected surface of the weld, whichever is the greatest of the two following areas: 1) area 1) an envelope surrounding all the pores; 2) area 2) a circle with a diameter corresponding to the weld width.
Shrinkage cavity	202	l = 0,3t, maximum 4 mm; and w = 2 mm. Not permitted when occurring at a weld stop or restart.
Slag and flux inclusions and oxide inclusions (Parallel to the weld axis)	301 302 303	w = 0,3t, maximum 3 mm. In case of several linear slag inclusions with a distance between two of them less than twice the longest of them, the total length shall be considered a defect.
Slag and flux inclusions (random, not parallel to weld axis)	3012 3013 3022 3023	Individual length, maximum - 0,3t.
Lack of fusion and penetration	400	Not permitted if a full penetration weld is required.

NOTE
- a normal fillet weld throat thickness
- b width of weld reinforcement
- d diameter of pore
- h height of imperfections
- l length of imperfection
- t wall or plate thickness
- w width of imperfection

[a] Area is the maximum length of weld affected multiplied by the local width of weld.

Annex E
(normative)

Design formulae for tanks

E.1 Allowable stresses

R_{eH} guaranteed minimum upper yield strength specified in the material standard.

R_m guaranteed minimum tensile strength specified in the material standard.

Nominal design stress, $f = \min\left[\frac{R_{eH}}{1,5}; \frac{R_m}{2,4}\right]$

E.2 Design formulae

E.2.1 General

Tanks shall be designed using the formulae given in E.2.2 to E.2.5.

NOTE The resulting thickness is a minimum thickness and does not take into account the provision of any corrosion allowance.

E.2.2 Cylindrical shell calculation

The minimum thickness $e_{min} = \frac{pD_o}{2fz + p}$ (E.1)

where

D_O is the outside diameter of shell;

p is the design pressure;

z is the weld joint coefficient (1,0 or 0,85 as appropriate);

f is the nominal design stress.

E.2.3 Torispherical end calculation

The following rules only apply to ends for which:

$r \geq 0,06D_i$;
$r \geq 3e$;
$e \leq 0,08D_i$;
$e \geq 0,001D_i$;
$R \leq D_o$.

The minimum thickness e is the greatest of e_s, e_y and e_b, where:

$$e_s = \frac{pR}{2fz - 0{,}5p} \quad \text{(E.2)}$$

$$e_y = \frac{\beta p\left(0{,}75R + 0{,}2D_i\right)}{f} \quad \text{(E.3)}$$

and

$$e_b = \left[0{,}75R + 0{,}2D_i\right]\left[\frac{p}{111 f_b}\left(\frac{D_i}{r}\right)^{0{,}825}\right]^{\left(\frac{1}{1{,}5}\right)} \quad \text{(E.4)}$$

where

$f_b = R_{eH}/1{,}5$ for all materials.

D_o is the outside diameter of the shell;

p is the design pressure;

z is the weld joint coefficient, = 1,0 for one piece ends;

f is the nominal design stress;

f_b is the design stress for buckling calculation;

β is the factor determined from Figure E.1 or by calculation (see E.2.6);

e is the required thickness of the end;

e_s is the minimum thickness of end to limit membrane stress in central part;

e_y is the minimum thickness of knuckle to avoid axisymmetric yielding;

e_b is the minimum thickness of knuckle to avoid buckling;

D_i is the inside diameter of the end;

R is the inside radius of curvature of central part of the torispherical end;

r is the inside radius of the knuckle.

It is permissible to reduce the thickness of the spherical part of the end to the value e_s over a circular area that shall not come closer to the knuckle than the distance $\sqrt{R \times e}$.

Any straight cylindrical flange shall meet the requirements of E.2.2 for a cylinder, unless its length is no greater than $0{,}2\sqrt{D_i \times e}$, in which case it may be the same thickness as the knuckle.

E.2.4 Ellipsoidal end calculation

An ellipsoidal end is defined as one made in such a way as to produce a truly semi-ellipsoidal shape without distinct spherical and knuckle radii.

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The design method converts these ends to equivalent torispheres which are calculated in accordance with E.2.3.

These rules apply only to ends for which

$1{,}7 < K < 2{,}2$ and $z = 1$.

Ellipsoidal ends shall be designed as nominally equivalent torispherical ends with:

$$r = \left[\frac{0{,}5}{K} - 0{,}08\right] D_i \tag{E.5}$$

$$R = [0{,}44K + 0{,}02] D_i \tag{E.6}$$

where

$K = D_i/2h_i$ is the shape factor for ellipsoidal ends;

h_i is the inside height of the ellipsoidal end.

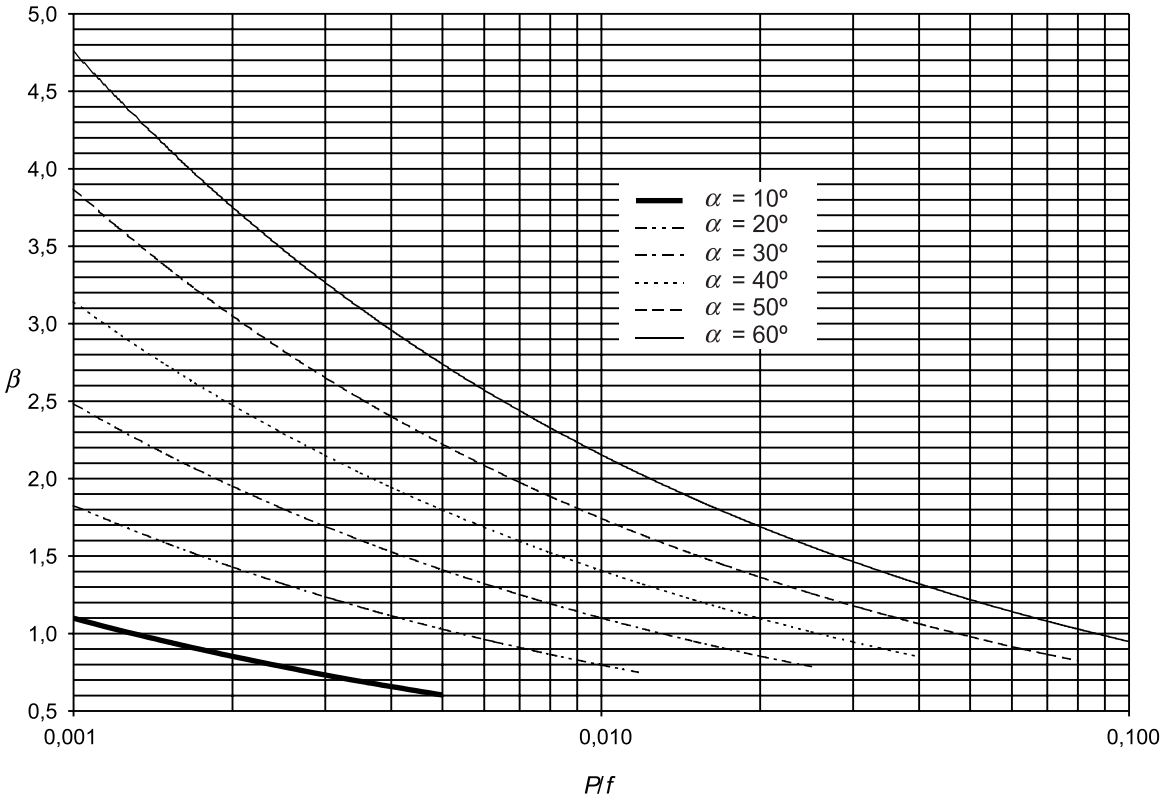

Figure E.1 — Parameter β for torispherical end – Design

E.2.5 Hemispherical ends

The required thickness of a hemispherical end is given by:

$$e_s = \frac{pR}{2fz - 0{,}5p}$$

where

R is the inside radius of the end;

p is the design pressure;

z is the weld joint coefficient, = 1,0 for one piece ends;

f is the nominal design stress.

This method is valid for $e/D_o \leq 0,16$.

The thickness of the cylinder to which the end attaches shall be kept at or above the minimum determined by E.2.2 for the cylinder up to the tangent line.

E.2.6 Equations for calculating β

$$Y = \min [e/R ; 0,04] \quad \text{(E.7)}$$

$$Z = \log (1/Y) \quad \text{(E.8)}$$

$$X = r/D_i \quad \text{(E.9)}$$

$$N = \left[1,006 - \frac{1}{6,2 + (90Y)^4} \right] \quad \text{(E.10)}$$

For $X = 0,2$

$$\beta_{0,2} = \max \{(0,56 - 1,94Y - 82,5Y^2)\ 0,95: 0,5\} \quad \text{(E.11)}$$

For $X = 0,1$

$$\beta_{0,1} = (- 0,183\ 3Z^3 + 1,038\ 3Z^2 - 1,294\ 3Z + 0,837)N \quad \text{(E.12)}$$

For $X = 0,06$

$$\beta_{0,06} = (- 0,363\ 5Z^3 + 2,212\ 4Z^2 - 3,293\ 7Z + 1,887\ 3)N \quad \text{(E.13)}$$

For $0,1 < X < 0,2$

$$\beta = 10\{(0,2 - X)\ \beta_{0,1} + (X - 0,1)\ \beta_{0,2}\} \quad \text{(E.14)}$$

For $0,06 < X < 0,1$

$$\beta = 25\{(0,1 - X)\ \beta_{0,06} + (X - 0,06)\ \beta_{0,1}\} \quad \text{(E.15)}$$

NOTE The equations for β, given above, lead to an iterative calculation. A computer procedure is recommended.

E.3 Nozzle reinforcement

E.3.1 General

The design method specified in this subclause is limited to the compensation of openings which comply with the geometric limitations specified.

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The design method specified in this subclause only applies to cylindrical shells and ends having circular or elliptical openings, where the assumptions and conditions specified in E.3.2 and E.3.9 are satisfied.

E.3.2 Size of openings

Size of openings shall be limited as follows:

a) cylindrical shells, $\frac{d_i}{2r_{im}} \leq 1$;

b) ends, $\frac{d_i}{2r_{im}} \leq 0{,}6$

where

d_i is the inside diameter of opening or branch;

r_{im} is the inside radius of main body (shell or end).

In all cases the ratio of branch thickness to main body thickness e_b/e_m shall comply with the limits of Figure E.2.

E.3.3 Distance between openings or branches

The distance between openings or branches, measured from the outside of the branches, pads, or compensation plates shall be not less than 2 l_m, where:

$$l_m = \sqrt{(2r_{im} + e_m)e_m}$$

where

for shells $r_{im} = D_o/2 - e_m$;

for hemispherical and torispherical ends $r_{im} = r_{ih}$; and

for ellipsoidal ends $r_{im} = D_i\left[\frac{0{,}22D_i}{h_i} + 0{,}02\right]$

where

D_o is the outside diameter of shell or dished end;

D_i is the inside diameter of shell or straight flange of dished end;

e_m is the actual thickness of the main body (shell or end) less any thinning allowance;

h_i is the inside height of an ellipsoidal end;

l_m is the length of the main body considered as effective compensation measured along the wall centreline from the edge of the opening or outside of the branch;

r_{im} is the inside radius of the main body (shell or end);

r_{ih} is the inside radius of the hemispherical end, or spherical portion of the torispherical end.

E.3.4 Openings and branches

Openings and branches and their reinforcements in dished ends shall be located entirely within the spherical portion of the torisphere or for elliptical ends within a circle with a diameter of 0,6 times the outside diameter of the end.

E.3.5 Cylindrical shells and ends with openings

Cylindrical shells and ends with openings shall be reinforced where necessary.

The reinforcement area of the main body with openings cannot be calculated directly, but shall be assumed in the first instance. That assumption may be verified by means of the method described in E.3.6 to E.3.14. The applied method is based on calculated thickness for pressure derived from E.2.2 for cylindrical shells, from E.2.3 for dished ends and E.2.5 for hemispherical ends, and leads to relationships between pressure loaded area A_p and stress loaded cross sectional area A_f (see Figure E.3). The calculation may need to be repeated using a corrected assumption of the reinforcement area.

E.3.6 Shell reinforcement

The reinforcement of the main body can be obtained by the following measures:

— by set-in welded pads, see Figure E.3a);

— by set-on welded compensating plates as shown in Figure E.3b); or

— by set-on or set-in welded branches as shown in Figure E.3c).

E.3.7 Extent of reinforcement

Where necessary, sufficient reinforcement shall be provided in all planes through the axis of the opening branch.

E.3.8 Elliptical openings

In the case of elliptical openings, the ratio between the major and the minor axis shall not exceed 1:4. For elliptical openings in cylindrical shells the axis along the length of the shell shall be taken as the diameter for design purposes.

E.3.9 Welded branches

Set on or set in welded branches, fillet welded only, may be considered as reinforcement where they are in accordance with Figure E.3. Each fillet shall have a throat thickness not less than 0,7 times the tank wall thickness.

E.3.10 Compensating plates

Reinforcement of openings by compensating plates is not limited by size. However, the effective width of such plates shall be calculated using only the main shell thickness, not the combined thickness.

E.3.11 Reinforcement − General

All openings shall satisfy the following general relationship:

$$p\left[A_p + 0{,}5(A_{fm} + A_{fb} + A_{fp})\right] \leq fA_{fm} + f_p A_{fp} + f_b A_{fb} \qquad \text{(E.19)}$$

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where

p is the design pressure;

A_p is the pressure loaded area;

A_{fb} is the cross sectional area of compensation in branch;

A_{fm} is the cross sectional area of compensation in main body (shell or end);

A_{fp} is the cross sectional area of compensation in pad;

f is the nominal design stress of the main body (shell or end);

f_b is the nominal design stress of the branch or f, whichever is the lesser;

f_p is the nominal design stress of the pad or reinforcing plate or f, whichever is the least.

E.3.12 Reinforcement by pads

Only pads of the set-in welded type in accordance with Figure E.3 shall be used.

The width of the pads l_p considered as contributing to the reinforcement shall not exceed l_m.

$$l_p \leq l_m$$

where

l_m is the length of main body considered as effective compensation measured along the wall centreline from the edge of the opening or outside of the branch.

The value of e_p used in the determination of A_{fp} shall not exceed twice e_m,

where

l_p is the maximum length of pad or reinforcing plate considered to be effective as compensation, measured along the pad or plate centreline from the edge of the opening or outside of the branch;

e_p is the thickness of pad or reinforcing plate;

e_m is the actual thickness of main body (shell or end), less any thinning allowance.

E.3.13 Reinforcement by branches

The wall thickness of branches (nozzles) shall, if necessary, be in excess of the thickness calculated to withstand internal pressure for a length l_b measured from the exterior wall of the main body. This requirement is independent of any reinforcement provided by fitting compensating plates.

E.3.14 Branch connections normal to the tank wall

For branch connections normal to the tank wall the areas A_p, A_{fb}, A_{fm}, and A_{fp}, shall be determined in accordance with Figure E.3c) where the lengths contributing to the reinforcement shall be not more than l_m, for the shell (see E.3.3), and

$$l_b = \sqrt{(d_{ob} - e_b)e_b} \qquad \text{(E.20)}$$

where

l_b is the external length of branch considered as effective compensation measured from the outside of the main body;

d_{ob} is the outside diameter of branch;

e_b is the actual thickness of the branch less any thinning allowance.

The maximum value to be used in the calculation of the part extending inside, if any, in the case of set-through branches (see Figure E.3c)) shall be:

$$l_{bi} = 0{,}5\ l_b \tag{E.21}$$

where

l_{bi} is the internal length of the branch considered as effective compensation, measured from the inside surface of the main body.

The dimensions of the compensating plate to be used in the calculation shall be:

$e_p \leq e_m$ and $l_p \leq l_m$

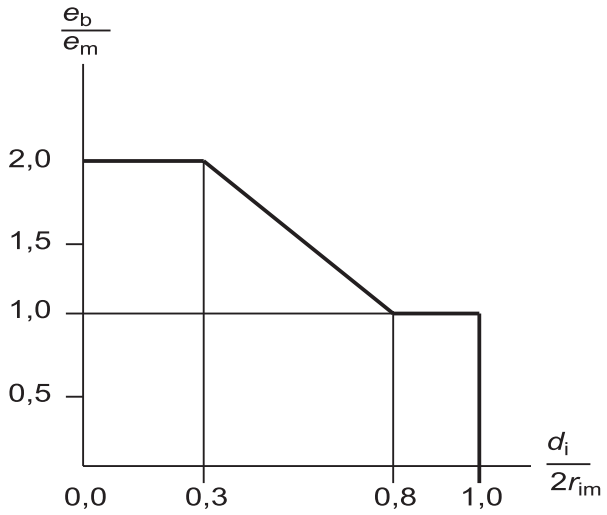
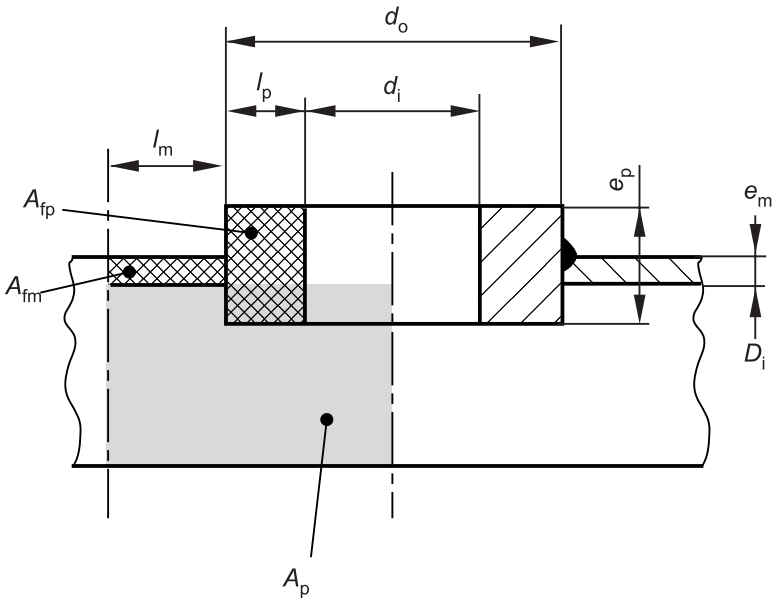


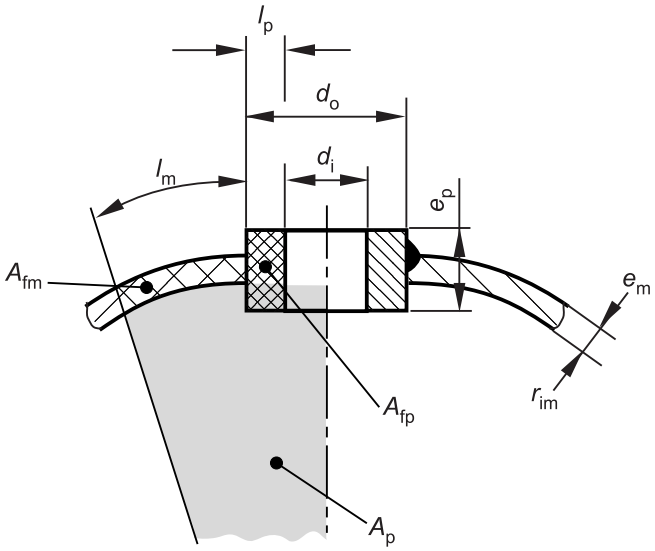
Figure E.2 — Maximum branch to body thickness ratio



$$A_p = \frac{D_i}{2}\left(l_m + \frac{d_o}{2}\right)$$

$$A_{fm} = e_m\, l_m$$

$$A_{fp} = e_p\, l_p$$



$$A_p = \frac{r_{im}}{2}\left(l_m + \frac{d_o}{2}\right)$$

$$A_{fm} = e_m\, l_m$$

$$A_{fp} = e_p\, l_p$$

a) Reinforcement by pads

Figure E.3 — Design of openings − Cylindrical shells with isolated openings

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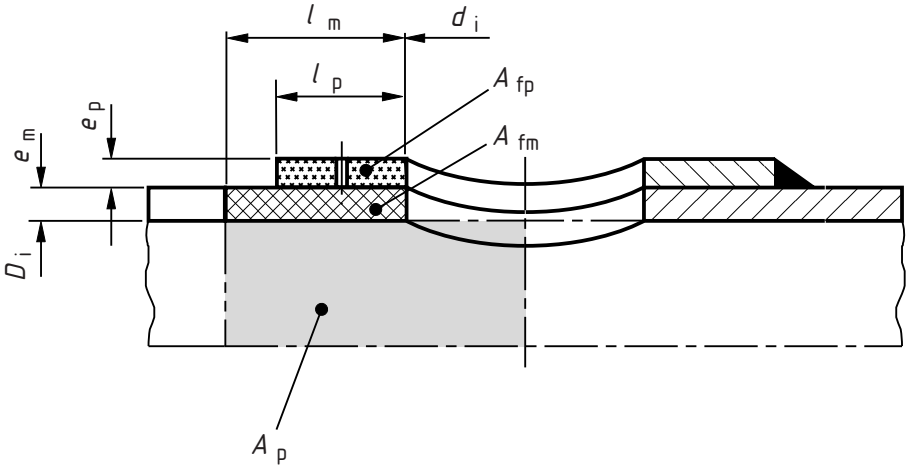
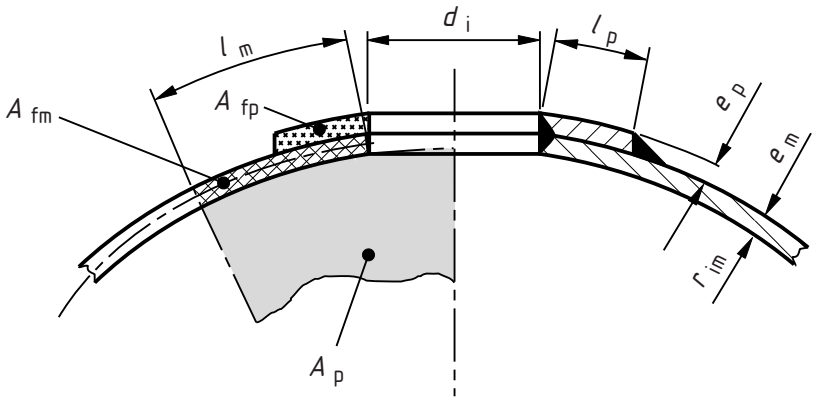


$$A_{\mathrm{p}} = \frac{D_{\mathrm{i}}}{2}\left(l_{\mathrm{m}} + \frac{d_{\mathrm{i}}}{2}\right)$$

$$A_{\mathrm{fm}} = e_{\mathrm{m}}\, l_{\mathrm{m}}$$

$$A_{\mathrm{fp}} = e_{\mathrm{p}}\, l_{\mathrm{p}}$$



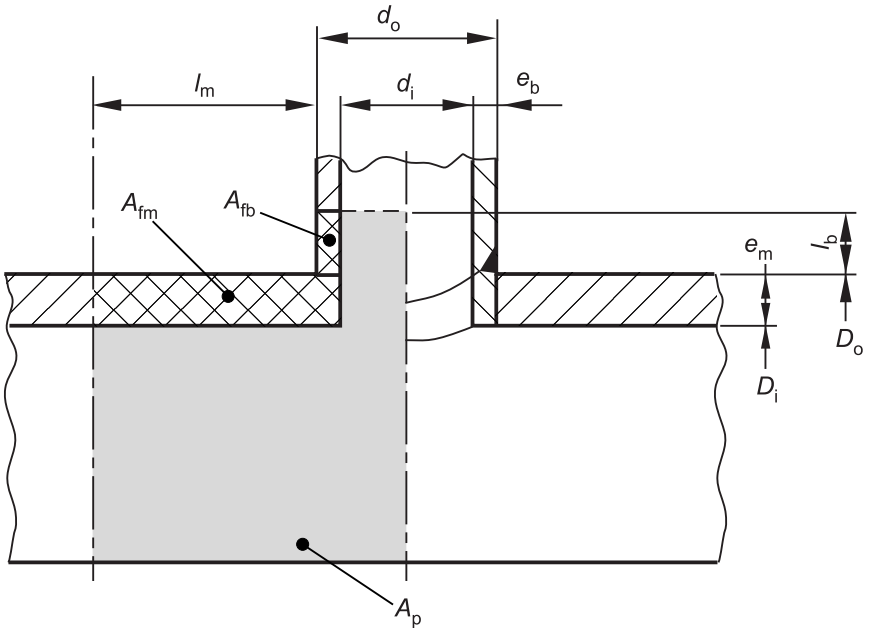
$$A_{\mathrm{p}} = \frac{r_{\mathrm{im}}}{2}\left(l_{\mathrm{m}} + \frac{d_{\mathrm{i}}}{2}\right)$$

$$A_{\mathrm{fm}} = e_{\mathrm{m}}\, l_{\mathrm{m}}$$

$$A_{\mathrm{fp}} = e_{\mathrm{p}}\, l_{\mathrm{p}}$$

b) Reinforcement by compensating plates

Figure E.3 — Design of openings − Cylindrical shells with isolated openings (continued)



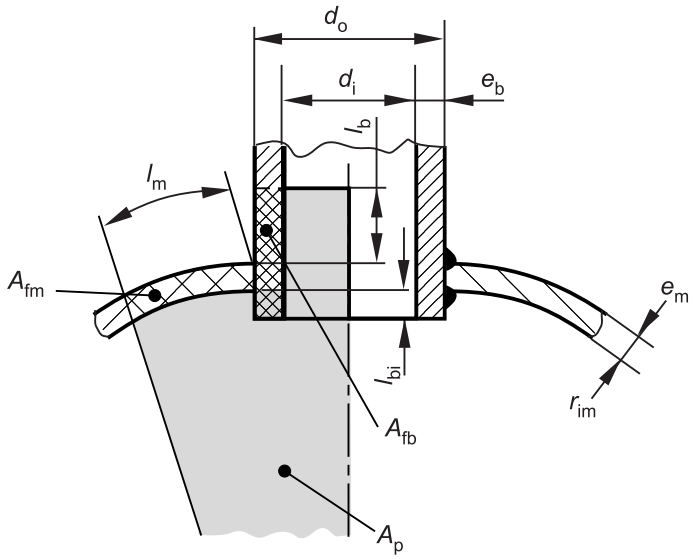
$$A_p = \frac{D_i}{2}\left(l_m + \frac{d_o}{2}\right) + \frac{d_i}{2}(l_b + e_m)$$

$A_{fm} = e_m l_m$ (set in)

$A_{fm} = e_m(l_m + e_b)$ (set on)

$A_{fb} = e_b(l_b + e_m)$ (set in)

$A_{fb} = e_b\, l_b$ (set on)



$$A_p = \frac{r_{im}}{2}\left(l_m + \frac{d_o}{2}\right) + \frac{d_i}{2}(l_b + e_m)$$

$A_{fm} = e_m\, l_m$

$A_{fb} = e_b(l_b + e_m + l_{bi})$

c) Reinforcement by branches

Figure E.3 — Design of openings − Cylindrical shells with isolated openings (concluded)

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Annex F
(informative)

Measurement of shell peaking

F.1 Profile gauge

To enable peaking to be measured a profile gauge should be made for each size of tank to be examined. Details of the gauge are given in Figure F.1a).

The minimum inner arc length should be 0,175D_o (20° of arc), where D_o is the external diameter of the tank. This diameter should be checked by measurement of the actual tank.

However, for some tanks the calculated arc length may not extend beyond the flats. Because of this, it is required that the minimum arc length of the gauge should be sufficient to clear the flats.

The recommended width of the weld cut is 28 mm but this can require to be increased to ensure that the cut out is clear of the weld (see Figure F.1a)).

F.2 Peaking survey

The approximate zone of the maximum peaking should be determined by taking readings at intervals of approximately 250 mm along the longitudinal welds using the profile gauge. When this has been found, the maximum peaking P should be determined by accurate measurement of P_1 and P_2 (see Figures F.1b) and F.1c)). Care should be taken to ensure that the gauge makes contact with the shell at points indicated in the note to Figure F.1.

It may be beneficial to make a taper gauge as shown in Figure F.2, for checking P_1 and P_2.

Approximate dimensions of the flats should be measured at the point of maximum peaking and recorded.

For Figure F.1b) the gauge should touch the shell at point A and as near to point B as possible. Likewise, when the gauge touches point D it should be as near as possible to point C. If there is a significant high spot between points A and B or between points D and C in Figure F.1c) then this method may overestimate the peaking and in this case a plaster cast should be made to verify the amount of peaking. Also note that points A and D should be clear of any flats.

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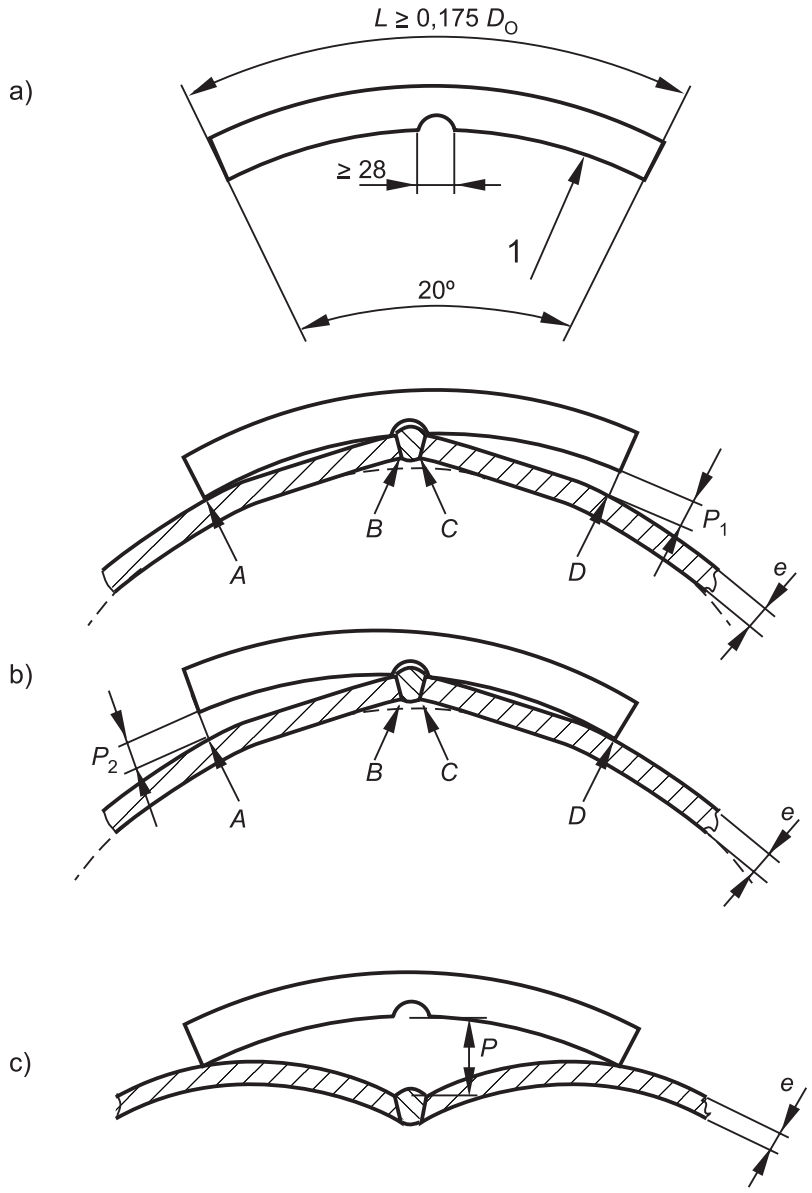


Key

a) 20° gauge details
b) Measurement of outside peaking
c) Measurement of inward peaking

NOTE In b) and c), main peaking $P = \frac{P_1 + P_2}{4}$

Figure F.1 — Measurement of shell peaking

Dimensions in millimetres

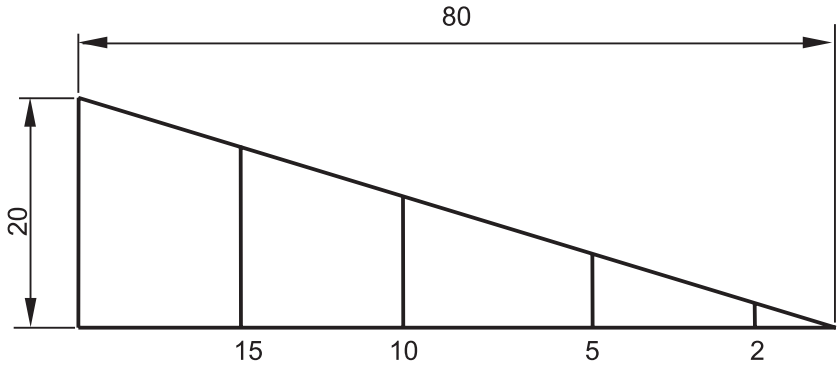


Figure F.2 — Taper gauge

Annex G
(informative)

Examples of joints

Examples of weld joints are shown in Figures G.1 to G.5.

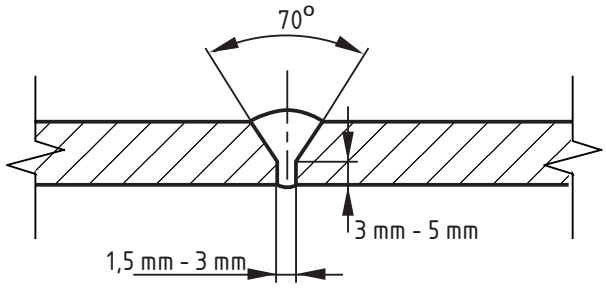
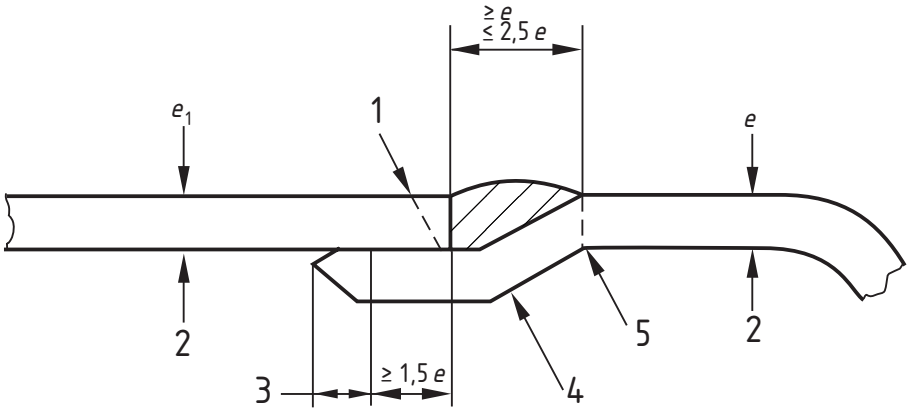


Figure G.1 — V-butt weld



Key

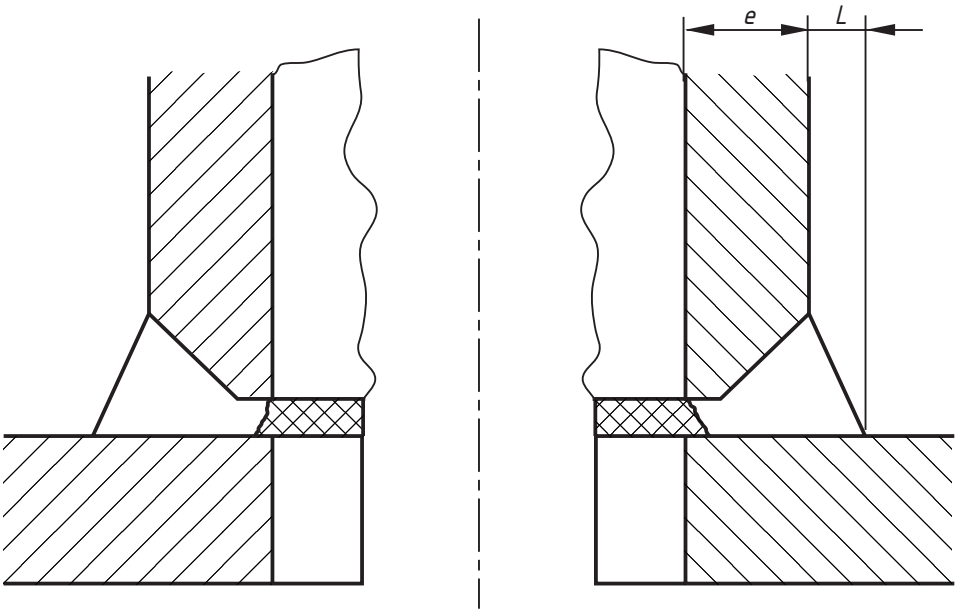
1 Bevel optional
2 Inside diameter
3 As desired
4 Depth of offset = e_1
5 Avoid sharp break

NOTE 1 The dimension limits (i.e. ≥ *e*, ≤ 2,5*e*) apply to weld preparation only.

NOTE 2 The finished weld should have a smooth profile and should completely fill the grooves to the full thickness of the plates being joined. See 7.5.3.

The offset section that forms the weld backing should be a close fit within the mating section round its entire circumference. This can be achieved by machining the spigot of the offset section, provided the thickness remaining as backing material is not less than 75 % of the original thickness.

Figure G.2 — Joggle joint



Key

$L = e/3$ minimum but not less than 6 mm.

Figure G.3 — Nozzle joints: set-on

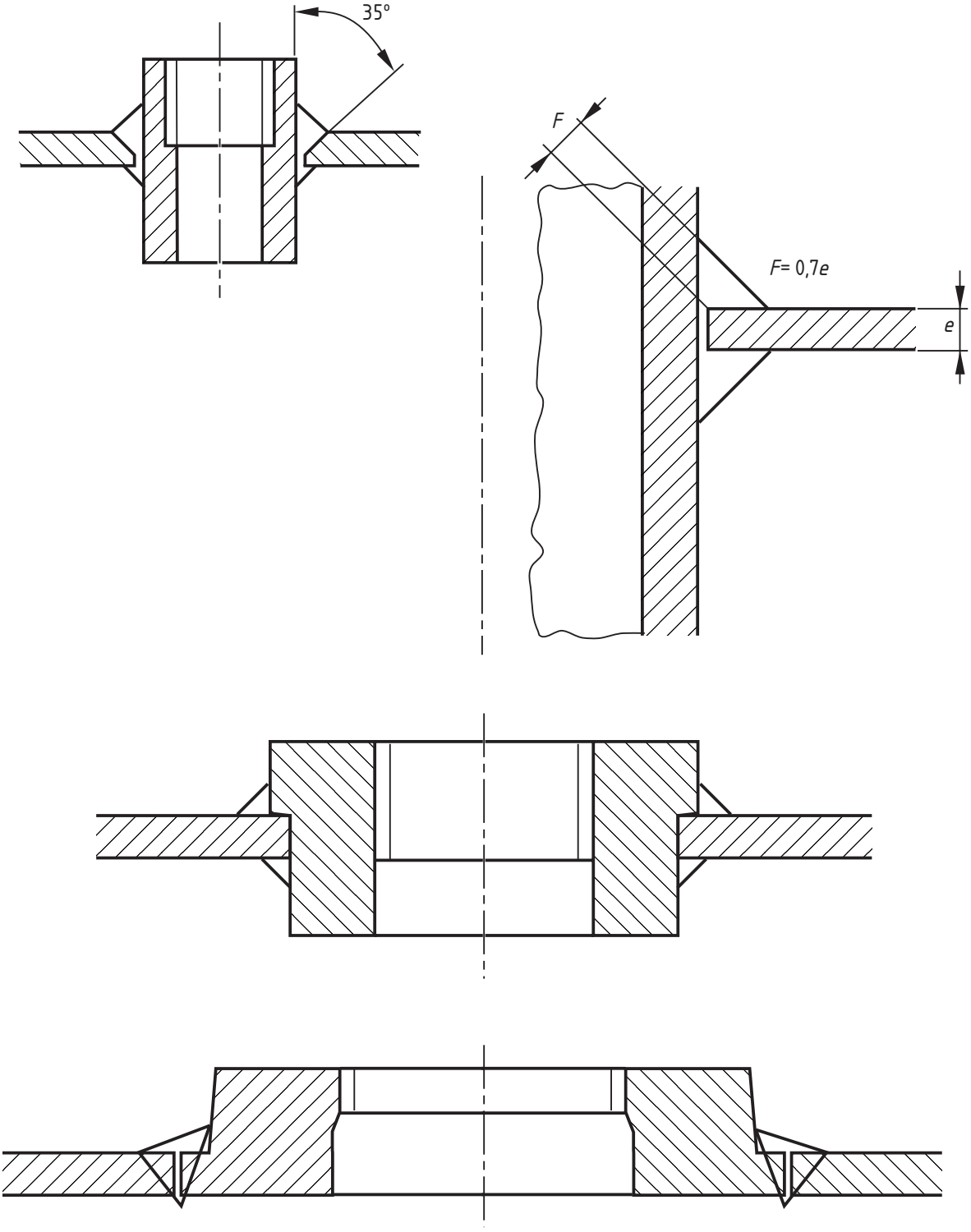


Figure G.4 — Nozzle joints: set-in

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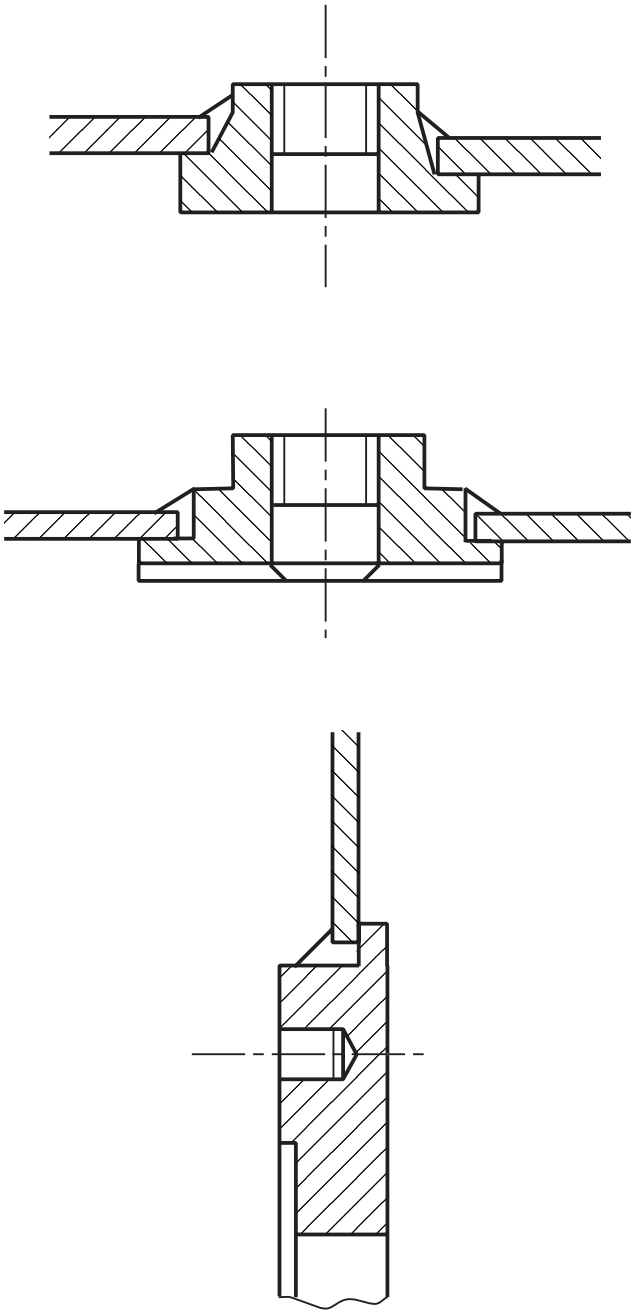

Figure G.5 — Nozzle joints: integral backing

Annex H
(informative)

Method of determining reflectivity indices (above ground tanks)

H.1 Method

A thermometer (or other temperature measuring instrument) is put into the pigmentation of lustreless colour mass.

The mass on the thermometer is allowed to dry.

At an outside shade reference temperature of 32 °C the instrument is placed in direct sunlight for 60 min.

The relationship between measured temperature and reflectivity index is given in Table H.1.

Table H.1 — Relationship between measured temperature and reflectivity index

Measured temperature °C	**Index**	**Examples of colour**
up to 44	1	White, ivory, zinc, aluminium and silver
up to 47	2	Yellow up to degree RAL 1021 Grey up to degree RAL 7035 Green up to degree RAL 6019
up to 50	3	All other colours except dark blue and black
up to 53	4	Dark blue and Black

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Annex I
(normative)

External protection of underground tanks

I.1 General

Protection systems shall be either:

— systems which cannot be monitored after installation. These systems ensure an efficient protection for a limited period of time related to the periodicity of maintenance operations or to the estimated burying period; or

— systems for which the corrosion control can be monitored periodically after the installation underground. These systems permit a tank to remain in service unless the results of the monitoring of the performance of the corrosion protection system become unsatisfactory.

Corrective measures may have to be taken when the result of the monitoring indicates a breakdown of the system.

I.2 Unmonitored protection systems

These systems consist of a passive protective coating which has demonstrated its ability to protect the steel for a specified period of time, by testing and by experience.

Testing and experience shall cover the following:

— adhesion of the coating to the tank;

— ageing;

— resistance to ground water;

— resistance to micro organisms likely to be present in the surrounding soil material;

— resistance to chemicals likely to be present in the surrounding soil material; and

— resistance to abrasion and impact.

I.3 Monitored protection systems

I.3.1 Systems incorporating cathodic protection

This system consists of an appropriate passive protective coating supplemented by a cathodic protection system by sacrificial anodes or impressed current.

The cathodic protection system shall comply with the requirements of EN 13636, and shall be designed by a competent person.

The coating shall be tested in accordance with I.2 and the following:

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— resistance to alkaline pH;

— resistance to cathodic disbonding effect.

I.3.2 Systems incorporating a protective envelope

These systems consist of an external protective envelope around the tank, insulating it from the surrounding soil.

The system shall:

— allow periodic inspections of the tank in order to check for the absence of corrosion using direct or remote visual examination; and/or

— be filled with a "control fluid" (liquid or gaseous) allowing demonstration, by physical or chemical measurements, that corrosive conditions do not exist.

The tank coating, if any, shall be compatible with the control fluid.

The external protective envelope shall be sufficiently tight and corrosion resistant to prevent any risk of leakage of the control fluid and the ingress of soil materials and/or water.

The external protective envelope shall be resistant to abrasion and impact.

I.3.3 Other systems

Other external protection systems can be used provided they ensure equivalent protection and checking facilities as those described in I.3.1 and/or I.3.2.

Annex J
(informative)

Environmental check list

Environmental Aspect	Stages of the life cycle										All stages
	Acquisition		Production		Use			End-of-Life			
	Raw materials and energy	Premanufactured materials and components	Production	Pack-aging	Use	Maintenance and repair	Use of additional products	Reuse / Material and Energy Recovery	Incineration without energy recovery	Deposition	Transportation
	a	b	c	d	e	f	g	h	i	j	k
Inputs											
1.1 Materials	Y 4.1	Y 4.1	Y 7.2	Y 10.4 NOTE 2		Y 5.1 NOTE	Y 5.1 NOTE	Y 5.1 NOTE		Y 7.9.2 NOTE	
1.2 Water			Y C.3			Y	Y	Y			
1.3 Energy	Y 4.1	Y 4.1	Y 7.2 7.6.2.1 7.8	Y 10.4 NOTE 2	Y	Y					Y 5.1 NOTE
1.4 Land					Y 5.1 NOTE						
Outputs											
2.1 Emissions to air			Y 7.2, 10.1		Y	Y		Y 10.1	Y 10.1	Y 10.1	Y 5.1 NOTE
2.2 Discharges to water			Y 10.1, 10.3		Y 10.3	Y		Y 10.1			
2.3 Discharges to soil			Y 10.1 10.3		Y 10.3 I.3.2	Y		Y 10.1			
2.4 Waste			Y 7.2, 10.1	Y 10.4 NOTE 2				Y 7.2		Y 5.1 NOTE	

2.5 Noise, vibration, radiation, heat losses			Y 7.2								Y 5.1 NOTE
Other relevant aspects											
3.1 Risk to the environment from accidents or unintended use			Y Intro		Y 12.2	Y					
3.2 Customer information					Y 12.2	Y					
NOTE	Where a "Y" is indicated with no clause reference, the product has an impact but it is outside the scope of this standard.										

Annex ZA
(informative)

Relationship between this European Standard and the Essential Requirements of EU Directive 97/23/EC

This European Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association to provide a means of conforming to Essential Requirements of the New Approach Directive 97/23/EC of the European Parliament and of the Council of 29 May 1997 on the approximation of the laws of the Member States concerning pressure equipment

Once this standard is cited in the Official Journal of the European Union under that Directive and has been implemented as a national standard in at least one Member State, compliance with the clauses of this standard given in Table ZA.1 confers, within the limits of the scope of this standard, a presumption of conformity with the corresponding Essential Requirements of that Directive and associated EFTA regulations.

Table ZA.1 — Correspondence between this European Standard and Directive 97/23/EC

Clause(s)/subclause(s) of EN 12542	Essential Requirements (ERs) of Directive 97/23/EC, Annex I	Qualifying remarks/Notes
Annex A, Annex E	2.2.1, 2.2.3	Design for adequate strength
5.1, 10.2, 10.3, Annex I	2.6	Corrosion or other chemical attack
7	3.1	Manufacturing procedures
7.6, 7.7.5	3.1.1	Preparation of component parts
4.5, 7.5, 7.7	3.1.2	Permanent joining
9.5	3.1.3	Non-destructive tests
7.6.2, 7.8	3.1.4	Heat treatment
7.3	3.1.5	Traceability
9.8.2	3.2.1	Final inspection
9.8.1, Annex C	3.2.2	Proof test
11	3.3	Marking and labelling
12.2	3.4	Documentation
4.6, 7.6.7, 12.1	4.3	Material certification
E.1	7.1	Allowable stresses
5.1, Table 2	7.2	Joint coefficients
9.8.1	7.4	Hydrostatic test pressure
4.2, 5.2	7.5	Material characteristics

WARNING — Other requirements and other EU Directives may be applicable to the product(s) falling within the scope of this standard.

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