

# **SLOVENSKI STANDARD**

## **SIST EN 12493:2013**

**01-december-2013**

**Nadomešča:**

**SIST EN 12493:2008+A1:2012**

---

**Oprema in pribor za utekočinjeni naftni plin (UNP) - Varjene jeklene tlačne posode cestnih cistern za utekočinjeni naftni plin (UNP) - Konstruiranje in izdelava**

LPG equipment and accessories - Welded steel pressure vessels for LPG road tankers - Design and manufacture

Flüssiggas-Geräte und Ausrüstungsteile - Geschweißte Druckbehälter aus Stahl für Straßentankfahrzeuge für Flüssiggas (LPG) - Auslegung und Herstellung

Équipements pour GPL et leurs accessoires - Réservoirs sous pression en acier soudés des camions-citernes pour GPL - Conception et construction

**Ta slovenski standard je istoveten z: EN 12493:2013**

---

**ICS:**

23.020.30	Tlačne posode, plinske jeklenke	Pressure vessels, gas cylinders
43.080.10	Tovornjaki in priklopniki	Trucks and trailers

**SIST EN 12493:2013**

**en,fr,de**

**iTeh STANDARD PREVIEW**  
**(standards.iteh.ai)**

SIST EN 12493:2013

<https://standards.iteh.ai/catalog/standards/sist/71330c57-4242-4898-b183-97e502abe963/sist-en-12493-2013>

EUROPEAN STANDARD  
NORME EUROPÉENNE  
EUROPÄISCHE NORM

**EN 12493**

November 2013

ICS 23.020.30

Supersedes EN 12493:2008+A1:2012

English Version

**LPG equipment and accessories - Welded steel pressure  
vessels for LPG road tankers - Design and manufacture**

Équipements pour GPL et leurs accessoires - Réservoirs  
sous pression en acier soudés des camions-citernes pour  
GPL - Conception et construction

Flüssiggas-Geräte und Ausrüstungsteile - Geschweißte  
Druckbehälter aus Stahl für Straßentankfahrzeuge für  
Flüssiggas (LPG) - Auslegung und Herstellung

This European Standard was approved by CEN on 15 August 2013.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and United Kingdom.

[SIST EN 12493:2013](https://standards.iteh.ai/catalog/standards/sist/71330c57-4242-4898-b183-97e502abe963/sist-en-12493-2013)

<https://standards.iteh.ai/catalog/standards/sist/71330c57-4242-4898-b183-97e502abe963/sist-en-12493-2013>



EUROPEAN COMMITTEE FOR STANDARDIZATION  
COMITÉ EUROPÉEN DE NORMALISATION  
EUROPÄISCHES KOMITEE FÜR NORMUNG

**CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels**

## Contents

Page

Foreword.....	5
Introduction .....	6
1 Scope .....	7
2 Normative references .....	7
3 Terms and definitions .....	9
4 Materials .....	9
4.1 Environmental .....	9
4.2 Suitability .....	10
4.3 Pressure retaining parts .....	10
4.4 Non-pressure retaining parts .....	10
4.5 Welding consumables .....	10
4.6 Non-metallic materials (gaskets).....	10
4.7 Inspection documents for materials .....	10
5 Pressure vessel design .....	11
5.1 Design conditions .....	11
5.2 Minimum thickness.....	11
5.3 Surge plates .....	11
5.4 Doubler plates .....	12
5.5 Stresses due to motion .....	12
5.6 Self-supporting pressure vessels .....	12
5.7 Vacuum conditions .....	12
5.8 Pressure vessel mountings .....	13
5.9 Internal pipework .....	13
6 Openings .....	13
6.1 General.....	13
6.2 Reinforcement of openings .....	13
6.3 Threaded connections .....	13
6.4 Manhole .....	13
7 Non-pressure retaining parts .....	14
7.1 Attachment welds .....	14
7.2 Position of attachment welds .....	14
8 Workmanship and construction.....	14
8.1 General.....	14
8.2 Environment .....	14
8.3 Control of materials .....	14
8.4 Acceptable weld details .....	15
8.5 Heat treatment and forming .....	15
8.5.1 Cold forming.....	15
8.5.2 Hot forming.....	16
8.5.3 Testing of formed parts.....	16
8.5.4 Visual examination and control of dimensions .....	16
8.5.5 Marking .....	17
8.6 Welding .....	17
8.6.1 General.....	17
8.6.2 Longitudinal welds .....	17
8.6.3 Welding procedure specification (WPS) .....	17
8.6.4 Qualification of WPS .....	17
8.6.5 Qualification of welders and welding operators.....	17
8.6.6 Preparation of edges .....	17

8.6.7	Attachments and fastenings .....	18
8.6.8	Preheat.....	18
8.7	Post-weld heat treatment.....	18
8.8	Manufacturing tolerances.....	18
8.9	Repairs to pressure envelope and direct attachment welds .....	19
8.9.1	General requirements .....	19
8.9.2	Repair of surface imperfections in the parent metal .....	19
8.9.3	Repair of weld imperfections .....	19
9	Construction and workmanship of internal pipework .....	19
10	Manufacturing tests and examinations.....	19
10.1	General .....	19
10.2	Mechanical testing .....	20
10.2.1	Production test plates.....	20
10.2.2	Longitudinal welds .....	20
10.2.3	Circumferential welds .....	20
10.2.4	Mechanical tests.....	20
10.2.5	Test requirements .....	20
10.3	Non-destructive testing .....	21
10.3.1	General .....	21
10.3.2	Internal imperfections.....	21
10.3.3	Surface imperfections.....	21
10.4	Non-destructive testing for welds .....	21
10.4.1	Radiographic testing.....	21
10.4.2	Marking and identification of radiographs.....	22
10.4.3	Ultrasonic testing.....	22
10.4.4	Magnetic particle testing .....	22
10.4.5	Penetrant testing .....	22
10.5	Qualification of non-destructive testing personnel .....	22
10.6	Visual examination of welds.....	22
10.7	Acceptance criteria .....	23
10.8	Stress limitation and safety precautions at the hydraulic test .....	23
11	External corrosion protection and finishing.....	23
11.1	External protection.....	23
11.2	Finishing operations .....	23
12	Marking.....	23
13	Records and documentation.....	23
13.1	Documentation obtained by the manufacturer.....	23
13.2	Records prepared by the manufacturer .....	24
13.3	Retention and supply of documents .....	24
Annex A	(normative) Guidance on selection of material grades.....	25
Annex B	(normative) Reference temperatures for design.....	26
B.1	Introduction.....	26
B.2	General .....	26
B.3	Developed pressure .....	26
B.4	Filling .....	26
Annex C	(informative) Alternative reference temperatures for design .....	27
C.1	Introduction.....	27
C.2	General .....	27
C.3	Developed pressure .....	27
C.4	Filling .....	27
Annex D	(normative) Design.....	28
D.1	Design stresses .....	28
D.2	Design pressure .....	28
D.3	Design formulae .....	28
D.3.1	Cylindrical shell calculation .....	28

## EN 12493:2013 (E)

D.3.2	Dished ends.....	29
D.3.3	Conical shell calculations.....	32
D.4	Nozzle reinforcement .....	36
D.5	Nozzle reinforcement by pads or flanges .....	38
D.6	Nozzle reinforcement by branches .....	38
Annex E	(informative) Example of joints.....	43
Annex F	(normative) Allowable tolerances .....	47
F.1	Pressure vessels.....	47
F.1.1	External diameter.....	47
F.1.2	Out of roundness.....	47
F.1.3	Deviation of straightness.....	47
F.1.4	Irregularities in profile.....	48
F.2	Dished end tolerance .....	48
F.2.1	Thickness of material .....	48
F.2.2	Profile.....	48
F.3	Assembly tolerances .....	50
F.3.1	Middle line alignment .....	50
F.3.2	Surface alignment.....	50
F.4	Attachments, nozzles and fittings.....	50
F.5	Overall length .....	50
Annex G	(normative) Heat treatment.....	51
G.1	Method of post-weld heat treatment.....	51
G.2	Temperature control.....	51
G.3	Temperature limit.....	51
G.4	Temperature measurement.....	51
Annex H	(informative) Typical method for measurement of shell peaking.....	52
H.1	Profile gauge .....	52
H.2	Peaking survey.....	52
Annex I	(normative) Welding imperfections and test specimens.....	55
I.1	Imperfections .....	55
I.2	Test specimens .....	58
Annex J	(informative) Choice of non-destructive test methods for welds.....	59
J.1	Internal imperfections .....	59
J.2	Surface imperfections .....	59
Annex K	(normative) Hydraulic pressure test.....	60
K.1	Temporary fittings .....	60
K.2	Pressure gauges .....	60
K.3	Pressurizing agent.....	60
K.4	Avoidance of shock.....	60
K.5	Applied pressure.....	60
Annex L	(informative) Environmental checklist .....	61
Bibliography	.....	62

## Foreword

This document (EN 12493:2013) 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 May 2014, and conflicting national standards shall be withdrawn at the latest by May 2014.

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 12493:2008+A1:2012.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association.

This European Standard has been submitted for reference into the technical annexes of the ADR [10].

**NOTE** These regulations take precedence over any clause of this European Standard. It is emphasised that RID/ADR/ADN are being revised regularly at intervals of two years which may lead to temporary non-compliances with the clauses of this European Standard.

The following main changes have been introduced during the revision of EN 12493:2008+A1:2012:

- revision of the shell thickness calculations to avoid any confusion with ADR design pressures;
- revision of the hydraulic test pressure to avoid any confusion with ADR hydraulic test pressures and to reduce the maximum tensile stress (at the time of the hydraulic test);
- the addition of minimum thickness calculations;
- clarification of the surge plate requirements;
- references to Annex C (normative) changed to informative.

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, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

## 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: it does not absolve the user from their legal obligations at any stage.

Protection of the environment is a key political issue in Europe and elsewhere around the world. Protection of the environment in this document is understood in a very broad sense. The phrase is used, for example, in relation to the total life-cycle aspects of a product on the environment, including expenditure of energy, and during all phases of its existence, from mining of raw materials, to fabrication, packaging, distribution, use, scrapping, recycling of materials, etc. Annex L comprises an environmental checklist which highlights the clauses of this European Standard that address environmental aspects.

It is recommended that manufacturers develop an environmental management policy. For guidance, see EN ISO 14000 series (see [6], [7] and [8]).

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

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 gauged unless otherwise stated.

**NOTE** 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 might be beneficial to refer to the leaflet "measurement uncertainty leaflet" SP INFO 2000 27 [13].

[SIST EN 12493:2013](https://standards.iteh.ai/catalog/standards/sist/71330c57-4242-4898-b183-97e502abe963/sist-en-12493-2013)

<https://standards.iteh.ai/catalog/standards/sist/71330c57-4242-4898-b183-97e502abe963/sist-en-12493-2013>



## 1 Scope

This European Standard specifies minimum requirements for materials, design, construction and workmanship procedures, and tests for welded LPG road tanker pressure vessels and their welded attachments manufactured from carbon, carbon/manganese and micro alloy steels.

There is no upper size limit as this is determined by the gross vehicle weight limitation.

This European Standard does not cover pressure vessels for pressure vessel containers.

NOTE 1 In the context of this standard the term "road tanker" is understood to mean "fixed tanks" and "demountable tanks" as defined in ADR.

NOTE 2 The equipment for the pressure vessels and the inspection and testing after assembly is covered by EN 12252 and EN 14334, respectively.

NOTE 3 The design type of the road tanker is subject to approval by the competent authority, as required by ADR.

## 2 Normative references

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

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

EN 444, *Non-destructive testing — General principles for radiographic examination of metallic materials by X- and gamma-rays*

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

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

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 10204:2004, *Metallic materials — Types of inspection documents*

EN 12252, *LPG equipment and accessories — Equipping of LPG road tankers*

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

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

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

EN ISO 148-1, *Metallic materials — Charpy pendulum impact test — Part 1: Test method (ISO 148-1)*

EN ISO 3452-1, *Non-destructive testing — Penetrant testing — Part 1: General principles (ISO 3452-1)*

**EN 12493:2013 (E)**

EN ISO 3834-2, *Quality requirements for fusion welding of metallic materials — Part 2: Comprehensive quality requirements (ISO 3834-2)*

EN ISO 4136, *Destructive tests on welds in metallic materials — Transverse tensile test (ISO 4136)*

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

EN ISO 5178, *Destructive tests on welds in metallic materials — Longitudinal tensile test on weld metal in fusion welded joints (ISO 5178)*

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 allied processes — Classification of geometric imperfections in metallic materials — Part 1: Fusion welding (ISO 6520-1:2007)*

EN ISO 6520-2:2013, *Welding and allied processes — Classification of geometric imperfections in metallic materials — Part 2: Welding with pressure (ISO 6520-2:2013)*

EN ISO 6892-1, *Metallic materials — Tensile testing — Part 1: Method of test at room temperature (ISO 6892-1)*

EN ISO 9016, *Destructive tests on welds in metallic materials — Impact tests — Test specimen location, notch orientation and examination (ISO 9016)*

EN ISO 9712, *Non-destructive testing — Qualification and certification of NDT personnel (ISO 9712)*

EN ISO 14732, *Welding personnel — Qualification testing of welding operators and weld setters for mechanized and automatic welding of metallic materials (ISO 14732)*

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

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)*

EN ISO 17636-1, *Non-destructive testing of welds — Radiographic testing — Part 1: X- and gamma-ray techniques with film (ISO 17636-1)*

EN ISO 17636-2, *Non-destructive testing of welds — Radiographic testing — Part 2: X- and gamma-ray techniques with digital detectors (ISO 17636-2)*

EN ISO 17637, *Non-destructive testing of welds — Visual testing of fusion-welded joints (ISO 17637)*

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

EN ISO 17639, *Destructive tests on welds in metallic materials — Macroscopic and microscopic examination of welds (ISO 17639)*

EN ISO 17640, *Non-destructive testing of welds — Ultrasonic testing — Techniques, testing levels, and assessment (ISO 17640)*

EN ISO 19232-2, *Non-destructive testing — Image quality of radiographs — Part 2: Determination of the image quality value using step/hole-type image quality indicators (ISO 19232-2)*

### 3 Terms and definitions

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

#### 3.1

##### **liquefied petroleum gas**

LPG

low pressure liquefied gas composed of one or more light hydrocarbons which are assigned to UN 1011, UN 1075, UN 1965, UN 1969 or UN 1978 only and which consists mainly of propane, propene, butane, butane isomers, butene with traces of other hydrocarbon gases

#### 3.2

##### **yield strength**

upper yield strength  $R_{eH}$  or, for steels that do not exhibit a definite yield (non-proportional elongation), the 0,2 % proof strength

#### 3.3

##### **cold forming**

forming at temperatures not less than 25 °C below the maximum permissible temperature for stress relieving, in accordance with the applicable material specifications

#### 3.4

##### **hot forming**

forming at temperatures above the temperature for stress relieving as stated in the material specifications

#### 3.5

##### **sun shield**

shield covering not less than the upper third but not more than the upper half of the shell surface, separated from the shell by an air gap of at least 40 mm

#### 3.6

##### **pressure vessel**

assembly of the pressure-retaining envelope (including the openings and their closures) and non-pressure-retaining parts attached directly to it

Note 1 to entry: Also referred to as "tank" in the ADR.

#### 3.7

##### **competent authority**

authority or authorities or any other body or bodies designated as such in each State and in each specific case in accordance with domestic law

#### 3.8

##### **inspection body**

independent inspection and testing body approved by the competent authority

#### 3.9

##### **competent person**

person which by combination of appropriate qualification, training, experience, and resources, is able to make objective judgments on the subject

### 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.

**EN 12493:2013 (E)****4.2 Suitability**

**4.2.1** Unless otherwise specified by the design documents, the design temperature range shall be -20 °C to +50 °C.

**4.2.2** The materials of construction shall be suitable for operating within the envisaged temperature range. If the pressure vessel could be subjected to more severe lower ambient or product temperatures, the design temperature range shall be -40 °C to +50 °C.

**4.2.3** Guidance on selection of material grades is given in Annex A.

**4.2.4** If additional impact testing is required, it shall be carried out in accordance with EN ISO 148-1 to achieve the impact values specified in 10.2.5.4.

**4.2.5** The materials of the pressure receptacle which are in contact with the contents shall not contain substances liable to substantially weaken the material. The steel grades specified in EN 10028-2 and EN 10028-3, listed in Table A.1, are considered compatible with LPG complying with the limitations on corrosiveness as specified in ISO 9162.

**4.3 Pressure retaining parts**

Pressure-retaining materials shall be of appropriate steels conforming to EN 10028-2 or EN 10028-3 or shall conform to specifications agreed with the competent authority. All materials shall conform to 10.2.4 and the ratio of the specified yield strength ( $R_{eH}$ ) to minimum tensile strength ( $R_m$ ) shall not exceed 0,85 (i.e.  $R_{eH}/R_m \leq 0,85$ ). The percentage elongation at fracture shall be not less than 10 000 divided by the actual tensile strength in  $N/mm^2$ , and in any case shall be not less than 16 % for fine grained steels and not less than 20 % for other steels. Where fine grain steels are used, the guaranteed yield strength,  $R_{eH}$  shall not exceed 460  $N/mm^2$  and the upper tensile strength,  $R_m$ , shall not exceed 725  $N/mm^2$ .

**4.4 Non-pressure retaining parts**

SIST EN 12493:2013

<https://standards.iteh.ai/catalog/standards/sist/71330c57-4242-4898-6763-7c362ab905/sist-en-12493-2013>

Non-pressure retaining parts that are directly welded to pressure retaining parts shall be of suitable materials conforming to EN 10025-2 or materials with characteristics approved by a competent authority. All materials used for non-pressure retaining parts shall be compatible with the material of pressure retaining parts, and shall conform to the impact requirements of 10.2.5.4, tested in accordance with the method specified in EN ISO 148-1.

**4.5 Welding consumables**

Welding consumables shall be able to provide consistent welds with properties at least equal to those specified for the parent materials in the finished pressure vessel.

**4.6 Non-metallic materials (gaskets)**

Non-metallic materials (gaskets) shall be compatible with both phases of LPG over the range of pressures and temperatures for which the road tanker is designed (see 4.2, Annex B and Annex C).

**4.7 Inspection documents for materials**

Pressure retaining parts and non-pressure retaining parts directly welded to the pressure vessel shall be provided with the material manufacturers' certificates conforming to EN 10204:2004 certificate type 3.1. Other parts shall have certificates conforming to EN 10204:2004 certificate type 2.2.

## 5 Pressure vessel design

### 5.1 Design conditions

**5.1.1** Unless authorised by a national competent authority for use within its territory, in accordance with the provision of EU Council Directive 2008/68/EC [11], the reference temperatures shall conform to Annex B.

**5.1.2** Design calculations shall be carried out in accordance with Annex D.

**5.1.3** Account shall be taken of the fatigue loading on all component parts of the pressure vessel and its attachments by conducting an assessment or through proven operating experience.

**5.1.4** The design of the pressure vessel should take into account the following:

- minimizing the use of materials;
- fittings required for efficient operation of the pressure vessel;
- minimizing the environmental impact of in service maintenance and end of life disposal.

### 5.2 Minimum thickness

**5.2.1** The minimum thickness for pressure vessels not exceeding a diameter of 1,8 m shall be 5 mm of reference steel (as defined by ADR) or of an equivalent thickness if in a different steel.

**5.2.2** For pressure vessels exceeding a diameter of 1,8 m, the minimum thickness shall be 6 mm of reference steel (as defined by ADR) or of an equivalent thickness if in a different steel.

**5.2.3** The equivalent thickness shall be calculated using the Formula (1):

$$e_1 = \frac{464e_0}{\sqrt[3]{(R_{m1}A_1)^2}} \quad (1)$$

SIST EN 12493:2013  
<https://standards.iteh.ai/catalog/standards/sist/71330c57-4242-4898-b183-97e502abe963/sist-en-12493-2013>

where

$A_1$  minimum elongation at fracture (%) of steel chosen under tensile stress;

$e_1$  minimum shell thickness in chosen steel, in mm;

$e_0$  minimum thickness in reference steel, in mm;

$R_{m1}$  minimum tensile strength of steel chosen, in N/mm<sup>2</sup>.

### 5.3 Surge plates

**5.3.1** Where it is intended that pressure vessels will be operated in excess of 20 % full or less than 80 % full, surge plates shall be fitted. The surge plates shall be designed to permit full internal inspection of the pressure vessel. The volume between any two plates or a plate and the end of the pressure vessel shall not exceed 7 500 l.

**5.3.2** Pressure vessels in excess of 4,0 m in length that are intended to be operated in excess of 20 % full or less than 80 % full shall be fitted with transverse surge plates at a maximum spacing of 4,0 m and shall be designed to permit full internal inspection of the pressure vessel.

**5.3.3** The area of each surge plate shall be at least 70 % of the cross-sectional area of the pressure vessel in which the plates are fitted.

**EN 12493:2013 (E)**

**5.3.4** Surge plates shall be able to withstand the load imposed by a full capacity liquid content of the section between the plates in either direction.

**5.3.5** Surge plates shall be at least 2 mm thick.

**5.3.6** Provision shall be made for communication and drainage between sections.

**5.3.7** For pressure vessels over 1,8 m diameter, having a wall thickness less than 6 mm, and for pressure vessels up to 1,8 m diameter, having a wall thickness less than 5 mm, the surge plates shall have the same thickness as the shell and the volume between any two plates or a plate and the end of the pressure vessel shall not exceed 7 500 l.

**5.4 Doubler plates**

To reduce stress concentration on the pressure vessel, load-carrying attachments shall incorporate a doubler plate between the attachment and the pressure vessel shell.

Non-circular doubler plates shall be designed with as generous as practicable corner radii (minimum radius 25 mm) to reduce stress concentrations.

If doubler plates are provided with test sockets they shall be closed with threaded plugs after testing.

**5.5 Stresses due to motion**

Pressure vessels and their permanent attachments shall be able to absorb, under maximum permissible load, forces exerted by the design pressure, and the following dynamic forces:

- in the direction of travel: twice the total mass times gravity;
- at right-angles to the direction of travel: the total mass times gravity;
- vertically upwards: the total mass times gravity;
- vertically downwards: twice the total mass times gravity.

Under the forces defined above, the stresses in the pressure vessel and its fastenings shall not exceed the following:

- a) general membrane stress in the shell, remote from the supports:
  - the normal design stress as defined in D.1;
- b) stresses local to the supports, determined either by experimental analysis or calculation/special analysis:
  - the limits specified in EN 13445-3.

**5.6 Self-supporting pressure vessels**

Self-supporting pressure vessels shall be designed to carry bending stresses that would otherwise be carried by the chassis or frame.

**5.7 Vacuum conditions**

Pressure vessels shall be designed to withstand vacuum conditions generated by the product during operation or other operational conditions, but as a minimum, this shall be equivalent to an external pressure of at least 40 kPa (0,4 bar) gauge pressure.

Suitable design methods may be applied from EN 13445-3.

**NOTE** Some liquefied petroleum gases have vapour pressures below atmospheric pressure at temperatures that could occur during normal operations in winter, and this could create partial vacuum conditions within the carrying pressure vessel.

## 5.8 Pressure vessel mountings

**5.8.1** Mounting structures shall be fabricated in steel and designed to limit movement of the pressure vessel in relation to the chassis.

**5.8.2** Pressure vessel mountings and their method of attachment to the shell shall be of sufficient strength to support the pressure vessel when full of water.

**5.8.3** The design of the pressure vessel mountings shall be co-ordinated with the design of the vehicle chassis. The designer shall assess the effect of the pressure vessel and its mountings, including the additional loadings given in 5.5.

The chassis manufacturer should be notified at the pressure vessel design stage that the pressure vessel, while on the chassis, could be subjected to a hydraulic test, during which the pressure vessel can contain twice the normal weight of carrying capacity.

**5.8.4** Pressure vessel mountings designed as an integral attachment to the shell shall be fitted with doubler plates as specified in 5.4. Stitch welding shall not be used.

## 5.9 Internal pipework

**5.9.1** The mechanical strength of internal pipework and supports shall be sufficient to withstand the service conditions, including dynamic load.

**5.9.2** Internal pipework may be attached directly to a pressure vessel boss.

**5.9.3** Pipework shall be located so as to avoid inadvertent entry of liquid LPG from the liquid inlet line into other pipework terminating in the vapour space.

## 6 Openings

### 6.1 General

For the equipping of LPG road tankers, see EN 12252.

Valves and other accessories shall be protected against damage by external impact either by their positioning on the pressure vessel, when mounted on the vehicle, or by specific pressure vessel design. Provision in pressure vessel design shall be either by mounting and fitting valves and other accessories in a recess within the contour of the pressure vessel shell or end, or by use of a guard able to withstand a collision with another vehicle and the forces experienced in a pressure vessel roll-over.

### 6.2 Reinforcement of openings

Openings shall be reinforced and designed in accordance with D.4.

### 6.3 Threaded connections

The maximum nominal diameter of threaded connections shall be 80 mm.

### 6.4 Manhole

**6.4.1** Pressure vessels with a volume over 3 000 l shall be fitted with a manhole either:

— at least 500 mm in diameter; or