



SLOVENSKI STANDARD
SIST EN 13094:2004
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Tanks for the transport of dangerous goods - Metallic tanks with a working pressure not exceeding 0,5 bar - Design and construction

Tanks für die Beförderung gefährlicher Güter - Metalltanks mit einem Betriebsdruck von höchstens 0,5 bar - Auslegung und Bau

Citernes destinées au transport de matières dangereuses - Citernes métalliques ayant une pression de service inférieure ou égale à 0,5 bar - Conception et construction

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23.020.20	Posode in vsebniki, montirani na vozila	Vessels and containers mounted on vehicles

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EUROPEAN STANDARD
NORME EUROPÉENNE
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March 2004

ICS 23.020.20

English version

Tanks for the transport of dangerous goods - Metallic tanks with
a working pressure not exceeding 0,5 bar - Design and
construction

Citernes destinées au transport de matières dangereuses -
Citernes métalliques ayant une pression de service
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Tanks für die Beförderung gefährlicher Güter - Metalltanks
mit einem Betriebsdruck von höchstens 0,5 bar -
Auslegung und Bau

This European Standard was approved by CEN on 21 February 2004.

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 Central Secretariat 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 Central Secretariat has the same status as the official versions.

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

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EN 13094:2004 (E)**Foreword**

This document (EN 13094:2004) has been prepared by Technical Committee CEN/TC 296 "Tanks for transport of dangerous goods", the secretariat of which is held by AFNOR.

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 September 2004, and conflicting national standards shall be withdrawn at the latest by September 2004.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports the objectives of the framework Directives on Transport of Dangerous Goods [1].

This European Standard has been submitted for reference into the RID and/or in the technical annexes of the ADR. Therefore in this context the standards listed in the normative references and covering basic requirements of the RID/ADR not addressed within the present standard are normative only when the standards themselves are referred to in the RID and/or in the technical annexes of the ADR [2].

Annexes A, B and C are normative. Annex D is informative.

This document includes a Bibliography.

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

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1 Scope

This European Standard specifies minimum requirements for the design and construction of metallic tanks with a maximum working pressure not exceeding 50 kPa gauge used for the transport of dangerous goods by road and rail for which Tank Code with letter "G" is given in chapter 3.2 of ADR [2]. It also includes requirements for a system of identification of materials used in the construction of these tanks.

This European Standard specifies requirements for openings, closures and structural equipment; it does not specify requirements for service equipment.

This European Standard is not applicable to aircraft refuellers, except where they are used on public roads, or to fixed rail tank wagons. It is applicable to inter-modal tanks (e.g. tank containers and tank swap bodies) for the transport of dangerous goods by road and rail, for which additional dynamic loads are specified by the railway Competent Authority.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text, and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

- EN 287-1, *Approval testing of welders - Fusion welding - Part 1: Steels*
- EN 287-2, *Approval testing of welders - Fusion welding - Part 2: Aluminium and aluminium alloys*
- EN 288 (all parts), *Specification and approval of welding procedures for metallic materials*
- EN 473, *Non destructive testing - Qualification and certification of NDT personnel - General principles*
- EN 729-1, *Quality requirements for welding - Fusion welding of metallic materials - Part 1: Guidelines for selection and use*
- EN 910:1996, *Destructive tests on welds in metallic materials - Bend tests*
- EN 970, *Non-destructive examination of fusion welds - Visual examination*
- EN 1435, *Non-destructive examination of welds - Radiographic examination of welded joints*
- EN 1714, *Non-destructive examination of welds - Ultrasonic examination of welded joints*
- EN 10002-1, *Metallic materials - Tensile testing - Part 1: Method of test at ambient temperature*
- EN 10045-1, *Metallic materials - Charpy impact test - Part 1: Test method*
- EN 10204:1991, *Metallic products - Types of inspection documents*
- EN 12972:2001, *Tanks for transport of dangerous goods - Testing, inspection and marking of metallic tanks*
- EN 14025, *Tanks for the transport of dangerous goods - Metallic pressure tanks - Design and construction*
- EN 25817:1992, *Arc-welded joints in steel - Guidance on quality levels for imperfections (ISO 5817:1992)*
- EN 30042:1994, *Arc-welded joints in aluminium and its weldable alloys - Guidance on quality levels for imperfections (ISO 100042:1992)*
- EN ISO 7500-1, *Metallic materials - Verification of static uniaxial testing machines - Part 1: Tension/compression testing machines (ISO 7500-1:1999)*

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ISO 1496-3, *Series 1 freight containers - Specification and testing - Part 3: Tank containers for liquids, gases and pressurized dry bulk.*

3 Terms, definitions and symbols**3.1 Terms and definitions**

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

3.1.1**baffle**

any structure, other than a surge plate, intended to inhibit the movement of the shell contents

3.1.2**capacity**

gross volume contained between adjacent surge plates or partitions, or by the whole shell, as appropriate

3.1.3**competent authority**

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

NOTE

Attention is drawn to ADR [2] and to the OTIF regulations (commonly referred to as RID) [3] in respect of Competent Authorities.

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3.1.4**maximum working pressure**

highest of the four pressures P_d , P_r , P_v and P_{ts}

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3.1.5**partition**

hermetically sealed dividing wall between adjacent compartments in compartmented tanks

3.1.6**section modulus**

second moment of area of a structure (and, where appropriate, its associated shell) about its neutral axis divided by the maximum distance from the neutral axis to the extreme fibre of the section used in the calculation

3.1.7**shell**

sheathing containing the substance carried (including the openings and their closures)

3.1.8**specific resilience**

integral of the applied force and the measured deflection of a test piece up to the point at which the test bar punctures the test piece, as indicated by the point of maximum force

3.1.9**steel****3.1.9.1****mild steel**

steel with a guaranteed minimum tensile strength of 360 N/mm² to 440 N/mm² and a guaranteed minimum elongation at fracture conforming to the requirement for steel specified in 5.2.2.3.1

3.1.9.2**reference steel**

steel with a tensile strength of 370 N/mm² and an elongation after fracture of 27 %

3.1.10**surge plate**

non-hermetically sealed wall in tanks or compartments of shells intended to reduce the effect of surge, mounted at right angles to the direction of travel, having an area of at least 70 % of the cross-sectional area of the shells where the surge plate is located

3.1.11**test pressure**

highest effective pressure which arises in the tank during the pressure test

3.1.12**maximum permissible mass**

tare of the tank and heaviest load authorised for carriage

3.2 Symbols

For the purposes of this European Standard, the following symbols apply.

A	percentage (%) elongation after fracture
A_1	minimum percentage (%) elongation after fracture of the metal used (see 6.8.1)
B	pitch circle diameter or, if elliptical, average of major and minor diameters, in millimetres (mm)
c	distance from the start of a knuckle bend to the edge of a shell, in millimetres (mm)
NOTE 1	This is used for the attachment of a dished end to a shell.
e	shell thickness, in millimetres (mm)
e_c	thickness of a flat closure, in millimetres (mm)
e_d	thickness of a domed closure, in millimetres (mm)
e_f	thickness of a tank end or partition, in millimetres (mm)
e_{rs}	thickness of a reinforcing section
e_r	thickness of an opening flange, in millimetres (mm)
e_{rd}	thickness of a domed closure flange, in millimetres (mm)
e_v	thickness of a shell, in millimetres (mm)
$e_{v, \min}$	minimum thickness of a shell according to 6.8, in millimetres (mm)
e_0	minimum thickness of shell in reference steel, in millimetres (mm)
e_1	thickness of the thickest part of a shell, in millimetres (mm)
e_2	thickness of the thinner part of the metal used, in millimetres (mm)
g	acceleration due to gravity, in metres per second squared (m/s^2)

NOTE 2 The value of g is $9,81 m/s^2$.

L overlap of a lapped joint

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L_c	length of reinforcing piece
L_r	length of reinforcing ring
L_0	initial gauge length of the test piece used in the tensile test, in millimetres (mm)
l	length of transition between plates of different thickness
l_1	length of overlap of swaged edge
l_2	length of weld at base of swaged joint
m	distance, in millimetres (mm), between any two bolts on pitch circle diameter B
N	safety factor
P_d	highest effective pressure allowed in a shell during discharge ("maximum discharge pressure allowed"), in MegaPascals (MPa)
P_r	highest effective pressure allowed in a shell during filling ("maximum filling pressure allowed"), in MegaPascals (MPa)
P_{ts}	opening pressure of the venting system, in MegaPascals (MPa)
P_v	effective pressure to which a shell is subjected by the substance carried (including such extraneous gases as it might contain) at the design temperature, in MegaPascals (MPa)
P_x	design pressure of tank (MPa)
R	internal radius of a domed closure, in millimetres (mm)
R_d	determined tensile strength, in Newtons per square millimetre (N/mm^2)
R_e	apparent yield strength for steels having a clearly defined yield point or guaranteed 0,2 % proof strength for steels with no clearly defined yield point (1 % proof strength for austenitic steels)
R_{et}	apparent yield strength for steels having a clearly defined yield point or guaranteed 0,2 % proof strength for steels with no clearly defined yield point (1 % proof strength for austenitic steels) at minimum design temperature
R_m	tensile strength, in Newtons per square millimetre (N/mm^2)
R_{mt}	tensile strength at minimum design temperature, in Newtons per square millimetre (N/mm^2)
R_{m1}	minimum tensile strength of the metal used, in Newtons per square millimetre (N/mm^2)
S_B	total tensile area, in square millimetres (mm^2)
S_0	initial cross-sectional area of a test piece used in the tensile test, in square millimetres (mm^2)
w	effective depth of fillet weld (i.e. distance from the surface of the weld to the minimum penetration point of the molten metal into the base material)
Z_0	minimum section modulus in reference steel, in cubic centimetres (cm^3)
Z_1	minimum section modulus in the metal used, in cubic centimetres (cm^3)

σ_c design stress for cover material, according to 6.7, in Newtons per square millimetre (N/mm²)

σ_f design stress for flange material, according to 6.7, in Newtons per square millimetre (N/mm²)

4 Safety device

Tanks shall have a venting system and a safety device to prevent the contents from spilling out if the tank overturns.

5 Materials

5.1 General

5.1.1 The designer shall select the materials to be used in the construction of the tank using ferritic steel, austenitic steel or aluminium alloy material standards published by a national or international standards body. The material shall meet the requirements specified in 5.2.

5.1.2 Materials used in the construction of shells shall be suitable for shaping. Materials shall be deemed unsuitable if, even though they meet the material requirements of this European Standard, the degree of shaping required by a particular shell design generates cracking or other signs of distress in the shell material.

5.1.3 Materials shall be used that are known to be resistant to brittle fracture and to stress corrosion cracking.

5.1.4 When tested in accordance with the appropriate part of EN 288, the properties of materials used in the fabrication of welded shells shall be not less than the minimum values specified for the material selected, see 5.1.1 throughout the welded area after welding without post-weld heat treatment.

5.2 Material properties

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5.2.1 Impact strength

Ferritic steel materials shall have an impact strength of not less than 34 J/cm² at –20 °C (or at the minimum design temperature where this is lower), when tested in accordance with EN 10045-1 using a V-shaped notch. Impact tests shall be carried out on sheets of materials, or on their weld seams, where the sheet thickness is more than 5 mm.

5.2.2 Yield strength, tensile strength and elongation after fracture

5.2.2.1 General

5.2.2.1.1 The values of A , R_e and R_m to be used shall be the minimum values specified for the material selected, see 5.1.1, with the exception of 5.2.2.1.2 and 5.2.2.1.3.

5.2.2.1.2 When austenitic steels are used, the value of R_e used in the calculation may exceed the minimum value specified for the material selected, see 5.1.1, provided that:

- the higher values are attested in an inspection certificate issued in accordance with EN 10204:1991, 3.1;
- the value of R_e used in the calculation does not exceed 1,15 multiplied by the value of R_e as specified for the material selected, see 5.1.1.

5.2.2.1.3 When fine-grained steels are used, the value of R_e shall not exceed 460 N/mm² and the value of R_m shall not exceed 725 N/mm² in accordance with the specifications of the material.

EN 13094:2004 (E)**5.2.2.2 Yield strength and tensile strength**

Steels with a ratio of R_e/R_m exceeding 0,85 shall not be used in the construction of welded tanks. The values specified in a certificate issued in accordance with EN 10204:1991, 3.1 A, 3.1 B or 3.1 C shall be used to determine the R_e/R_m ratio.

5.2.2.3 Elongation after fracture

5.2.2.3.1 When measured in accordance with EN 10002-1 (see 5.2.2.3.3), the percentage elongation after fracture, A, shall be not less than:

- a) 16 % for fine grained steels;
- b) 20 % for other steels;
- c) 12 % for aluminium alloys.

5.2.2.3.2 Additionally, for steel, the percentage elongation after fracture, A, shall be not less than the value calculated using equation 1.

$$A = \frac{10\,000}{R_d} \quad (1)$$

5.2.2.3.3 For sheet metal, when measuring the percentage elongation after fracture in accordance with EN 10002-1, the axis of the tensile test piece shall be at right angles to the direction of rolling; where the material standard gives lower values in the direction of rolling, these values shall be used in the calculation.

5.2.2.3.4 When measuring the percentage elongation after fracture, a test piece of circular cross-section shall be used in which the initial gauge length is equal to five times the diameter. If test pieces of rectangular section are used, the gauge length shall be calculated using equation 2.

$$L_0 = 5,65 \sqrt{S_0} \quad (2)$$

NOTE Elongations based on fixed lengths can be converted to proportional elongations using EN ISO 2566-1 or EN ISO 2566-2 as applicable.

5.3 Compatibility of shell materials with substances carried

5.3.1 The manufacturer, in association with the Competent Authority shall make available a list of the dangerous goods that may be carried without damage to the tank, or its lining. The substances or group of substances approved in the certificate shall be compatible with the characteristics of the tank and its service equipment.

5.3.2 If contact between the substance carried and the material used for the construction of the shell is deemed likely to entail a progressive decrease in the thickness of the walls, this thickness shall be increased at manufacture by an appropriate amount.

NOTE This additional thickness, to allow for corrosion, is not taken into consideration in determining the minimum shell thickness (see 6.8).

5.3.3 If the shell is fitted with a non-metallic protective lining, only materials and their means of bonding to the shell that are known to remain leakproof shall be used.

5.3.4 If shells intended for the carriage of flammable liquids having a flashpoint of not more than 61 °C are fitted with non-conductive protective linings, precautions shall be taken to prevent the accumulation of electrostatic charges that could present a danger of ignition.

6 Design

NOTE A shell can have a circular or a non-circular cross-section.

6.1 Design verification

The design of a tank shall be verified in accordance with one or a combination of the following methods:

- a) for shells with a circular cross-section, EN 14025 or any one of the methods specified in annex A;
- b) for shells with non-circular cross-sections:
 - 1) dynamic testing (A.2);
 - 2) finite element stress analysis (A.3);
 - 3) reference design based on experience of the Competent Authority with existing tank designs (A.4);
 - 4) calculation method (A.5).

A dossier giving evidence of the design verification shall then be prepared and submitted to the Competent Authority for approval.

The design shall in any case conform to the minimum requirements of this standard.

6.2 Shell cross-section

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6.2.1 For shells of non-circular cross-section:

- a) the radius of convexity of the shell wall shall not exceed 2 m at the sides and 3 m radius at the top and the bottom;
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- b) there shall be a minimum radius of 200 mm linking the top/bottom and side convexities; and
- c) an equivalent diameter shall be calculated on the basis of the cross-sectional area.

6.2.2 Shell projections outside the basic cross-section of a shell shall be kept to a minimum and protection shall be provided from all directions on the shell.

6.3 Dynamic conditions

6.3.1 The dynamic conditions appropriate to the design temperature specified in 6.6, and requirements of the pressure test in EN 12972, shall be met without exceeding the stress levels specified in 6.7.

6.3.2 Shells, their attachments and their structural equipment (including partitions) shall be designed to withstand the forces and dynamic pressures resulting from the combination of maximum working pressure (P_v or P_{ts}) with, separately, each of the following, without exceeding the design stress in 6.7:

- in the direction of travel, an acceleration of 2g on the maximum permissible mass (in the case of self-supporting trailers the maximum permissible mass shall include the mass of axles, wheels and tyres and shall be deemed to act at the coupling point). If any account is taken of surge plates in calculations, their effect shall be proven;
- at right angles to the direction of travel, an acceleration of 1g acting on the maximum mass;
- vertically upwards, an acceleration of 1g acting on the maximum mass;
- vertically downwards, an acceleration of 2g acting on the maximum mass.

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6.3.3 Tanks for inter-modal road/rail transport shall be designed to withstand the inertia loads in the longitudinal directions specified by the competent rail authority.

6.3.4 With the following exceptions, a tank which has a maximum length of less than 2,9 m shall be designed to withstand the forces specified in 6.3.2, except that in all horizontal directions the forces shall be twice the total mass:

- a tank permanently mounted on a vehicle chassis;
- a demountable tank on a road vehicle which can be fitted to the chassis only in one orientation.

6.4 Pressure conditions

6.4.1 The tank shell shall be designed to withstand a maximum test pressure which shall be the greater of:

- a) the pressure created by a column of water equal to twice the depth of the tank multiplied by the relative density of the most dense substance to be carried;
- b) the pressure created by a column of water equal to twice the depth of the tank;
- c) 1,3 times the maximum working pressure.

6.4.2 Compartmented tanks shall be designed to withstand a compartment test pressure which subjects all parts of a compartment to a pressure at least equal to 1,3 times the appropriate maximum working pressure, taking account of the liquid head of the most dense substance to be carried.

6.4.3 Tanks for inter-modal road/rail transport shall be designed to withstand whichever is the higher of the following two values:

- a) either a compartment test pressure as calculated in 6.4.2; or
- b) the pressure generated within the compartment length by the most dense substance carried when subjected to the acceleration specified by the competent rail authority (see 6.3.3).

NOTE This can result in the compartment pressure being higher than the test pressure for the whole tank.

6.5 Partial vacuum conditions

The shell and partitions shall be designed to withstand a vacuum condition of at least -3 kPa.

6.6 Design temperature

The minimum design temperature range shall be -20 °C to $+50$ °C. Where the tank is likely to be subjected to more severe conditions, the design temperature range shall be extended within the range -40 °C to $+50$ °C, as applicable. The design temperature range of tanks intended for substances to be carried at elevated temperatures shall be extended at least to the maximum working temperature.

6.7 Design stress

The maximum stress in the material of the tank and its supporting structure shall not exceed the lower of $0,75 R_e$ or $0,5 R_m$; for tank containers and tank swap bodies, the stress in the material of the supporting structure shall not exceed $0,66 R_e$.

6.8 Shell thickness**6.8.1 Minimum shell thickness**

The thickness of shells made of mild steel shall be not less than the following values, unless the conditions specified in 6.8.2 are met:

- 5 mm if the tank diameter is not more than 1,8 m;
- 6 mm if the tank diameter is greater than 1,8 m (except in the case of shells intended for the carriage of powdery or granulated substances).

If the shell is made of another material, the equivalent minimum thickness shall be determined in accordance with equation 3.

$$e_1 = \frac{464e_0}{\sqrt[3]{\left(\frac{R_{m1}A_1}{4}\right)^2}} \quad (3)$$

If the shell thickness is increased to allow for corrosive substances, this additional thickness shall not be taken into consideration in calculating the minimum shell thickness.

The actual minimum thickness shall not be below the absolute minimum shown in Table 1.

Table 1 — Absolute minimum shell thickness

Diameter ^a m	Minimum shell thickness			
	Austenitic steels mm	Other steels mm	Pure aluminium mm	Aluminium alloys mm
≤ 1,80	2,5 ^b	3	6	4
> 1,80	3	4	8	5

^a For non-circular cross-sections, see 6.2.1.

^b For tank-containers and tank swap bodies not protected against damage, the shell thickness shall in no case be less than 3 mm whatever the material used.

6.8.2 Reduction of shell thickness

6.8.2.1 Where protection against damage of the shell is provided in accordance with 6.8.2.2 to 6.8.2.4, the minimum thickness may be reduced by a maximum of 2 mm of reference steel (or equivalent thickness in another material, calculated using equation 3) from that specified in 6.8.1, but shall not be below the absolute minimum shown in Table 1.

6.8.2.2 Tank vehicles and demountable tanks shall be deemed to be protected against damage when one of the following measures is adopted.

- a) for shells with a circular or elliptical cross-section having a maximum radius of curvature of 2 m, the shell is equipped with strengthening elements comprising partitions or surge plates, or external or internal rings, so placed that at least one of the following conditions is met:

- the distance between two adjacent strengthening elements is less than or equal to 1,75 m;
- the volume contained between two partitions or surge plates is less than or equal to 7 500 l.

A ring, and associated shell shall have a section modulus of at least 10 cm³ in reference steel, or an equivalent section modulus in another metal (see 6.13.2.5), when calculated around the neutral axis parallel to the shell.

External strengthening elements shall not have projecting edges with a radius of less than 2,5 mm;

- b) for shells made with double walls having an intermediate layer of rigid solid material (e.g. foam, at least 50 mm thick), the outer wall has a thickness of at least 0,5 mm of steel, 0,8 mm of aluminium or 2 mm of a plastic material reinforced with glass fibre. For other materials (e.g. mineral-wool, at least 100 mm thick), the outer wall has a thickness of at least 0,8 mm of austenitic steel.