SLOVENSKI STANDARD

SIST EN 14620-2:2007

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Naļ rtovanje in proizvodnja na mestu postavitve grajenih navpiļ nih, valjastih jeklenih posod z ravnim dnom za shranjevanje hlajenih utekoļ injenih plinov z delovnimi temperaturami med 0 ÁC in ï 165 ÁC - 2. del: Kovinski deli

Design and manufacture of site built, vertical, cylindrical, flat-bottomed steel tanks for the storage of refrigerated, liquefied gases with operating temperatures between 0 °C and -165 °C - Part 2: Metallic components

Auslegung und Herstellung standortgefertigter, stehender, zylindrischer Flachboden-Stahltanks für die Lagerung von tiefkalt verflüssigten Gasen bei Betriebstemperaturen zwischen 0 °C und -165 °C - Teil 2: Metallische Bauteile

Conception et fabrication de réservoirs en acier a fond plat, verticaux, cylindriques, construits sur site, destinés au stockage des gaz réfrigérés, liquéfiés, dont les températures de service sont comprises entre 0 °C et - 165 °C - Partie 2 : Constituants métalliques

Ta slovenski standard je istoveten z: **EN 14620-2:2006**

ICS:

23.020.10	Nepremiļ ne posode in rezervoarji	Stationary containers and tanks

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Design and manufacture of site built, vertical, cylindrical, flat-bottomed steel tanks for the storage of refrigerated, liquefied gases with operating temperatures between 0 °C and -165 °C - Part 2: Metallic components

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This European Standard was approved by CEN on 20 February 2006.

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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Contents

Foreword

This European Standard (EN 14620-2:2006) has been prepared by Technical Committee CEN/TC 265 "Site built metallic tanks for the storage of liquids", the secretariat of which is held by BSI.

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 March 2007, and conflicting national standards shall be withdrawn at the latest by March 2007.

EN 14620 *Design and manufacture of site built, vertical, cylindrical, flat-bottomed steel tanks for the storage of refrigerated, liquefied gases with operating temperatures between 0 °C and -165 °C* consists of the following parts:

— Part 1: General;

— Part 2: Metallic components;

— Part 3: Concrete components;

— Part 4: Insulation components;

— Part 5: Testing, drying, purging and cool-down.

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, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

1 Scope

This European Standard specifies general requirements for the materials, design, construction and installation of the metallic components of refrigerated liquefied gas storage tanks.

This European Standard deals with the design and manufacture of site built, vertical, cylindrical, flat-bottomed steel tanks for the storage of refrigerated, liquefied gases with operating temperatures between 0 °C and –165 °C.

2 Normative references

The following referenced documents are indispensable for the application of this European Standard. 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 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, *Non-destructive testing — Qualification and certification of NDT personnel — General principles*

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

EN 584-1, *Non-destructive testing — Industrial radiographic film — Part 1: Classification of film systems for industrial radiography*

EN 584-2, *Non-destructive testing — Industrial radiographic film — Part 2: Control of film processing by means of reference values*

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

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

EN 1011-2, *Welding — Recommendations for welding of metallic materials — Part 2: Arc welding of ferritic steels*

EN 1092-1:2001, *Flanges and their joints — Circular flanges for pipes, valves, fittings and accessories, PN designated — Part 1: Steel flanges*

EN 1290, *Non-destructive testing of welds — Magnetic particle testing 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 1515-1:1999, *Flanges and their joints — Bolting — Part 1: Selection of bolting*

EN 1593, *Non-destructive testing — Leak testing — Bubble emission techniques*

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

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

EN 1759-1:2004, *Flanges and their joint — Circular flanges for pipes, valves, fittings and accessories, Class designated — Part 1: Steel flanges, NPS 1/2 to 24*

EN 1993-1-1, *Eurocode 3: Design of steel structures — Part 1-1: General rules and rules for buildings*

ENV 1993-1-6, *Eurocode 3: Design of steel structures — Part 1-6: General rules — Supplementary rules for the strength and stability of shell structures*

ENV 1993-4-2:1999, *Eurocode 3: Design of steel structures — Part 4-2: Silos, tanks and pipelines — Tanks*

EN 1994-1-1, *Eurocode 4: Design of composite steel and concrete structures — Part 1-1: General rules and rules for buildings*

EN 10025:2004 (all parts), *Hot rolled products of non-alloy structural steels*

EN 10029:1991, *Hot rolled steel plates 3 mm thick or above — Tolerances on dimensions, shape and mass*

EN 10045-1, *Metallic materials — Charpy impact test — Part 1: Test method*

EN 10160:1999, *Ultrasonic testing of steel flat product of thickness equal or greater than 6 mm (reflection method)*

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

EN 10216-1, *Seamless steel tubes for pressure purposes — Technical delivery conditions — Part 1: Non-alloy steel tubes with specified room temperature properties*

EN 10216-2, *Seamless steel tubes for pressure purposes — Technical delivery conditions — Part 2: Non-alloy and alloy steel tubes with specified elevated temperature properties*

EN 10216-3, *Seamless steel tubes for pressure purposes — Technical delivery conditions — Part 3: Alloy fine grain steel tubes*

EN 10216-4, *Seamless steel tubes for pressure purposes — Technical delivery conditions — Part 4: Non-alloy and allow steel tubes with specified low temperature properties*

EN 10217-1, *Welded steel tubes for pressure purposes — Technical delivery conditions — Part 1: Non-alloy steel tubes with specified room temperature properties*

EN 10217-2, *Welded steel tubes for pressure purposes — Technical delivery conditions — Part 2: Electric welded non-alloy and alloy steel tubes with specified elevated temperature properties*

EN 10217-3, *Welded steel tubes for pressure purposes — Technical delivery conditions — Part 3: Alloy fine grain steel tubes*

EN 10217-4, *Welded steel tubes for pressure purposes — Technical delivery conditions — Part 4: Electric welded non-alloy steel tubes with specified low temperature properties*

EN 10217-5, *Welded steel tubes for pressure purposes — Technical delivery conditions — Part 5: Submerged arc welded non-alloy and alloy steel tubes with specified elevated temperature properties*

EN 10217-6, *Welded steel tubes for pressure purposes — Technical delivery conditions — Part 6: Submerged arc welded non-alloy steel tubes with specified low temperature properties*

EN 10220, *Seamless and welded steel tubes — Dimensions and masses per unit length*

EN 12062:1997, *Non-destructive examination of welds — General rules for metallic materials*

EN 14015:2004, *Specification for the design and manufacture of site built, vertical, cylindrical, flat-bottomed, above ground, welded, steel tanks for the storage of liquids at ambient temperature and above*

EN 14620-1:2006, *Design and manufacture of site built, vertical, cylindrical, flat-bottomed steel tanks for the storage of refrigerated, liquefied gases with operating temperatures between 0°C and −165 °C — Part 1: General*

EN ISO 5817:2003, *Welding — Fusion-welded joints in steel, nickel, titanium and their alloys (beam welding excluded) — Quality levels for imperfections (ISO 5817:2003)*

EN ISO 15607:2003, *Specification and qualification of welding procedures for metallic materials — Part 1: General rules (ISO 15607:2003)*

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

EN ISO 15614-1:2004, *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)*

ISO 261, *ISO general purpose metric screw threads — General plan*

ISO 965-2:1998, *ISO general purpose metric screw threads — Tolerances — Part 2: Limits of sizes for general purpose external and internal screw threads — Medium quality*

API 620:2004, *Design and construction of large, welded, low-pressure storage tanks*

3 Terms and definitions

For the purposes of this European Standard, the terms and definitions given in EN 14620-1:2006 and the following apply.

3.1
amplitude of strain
one half of the range of strains

3.2
progressive deformation
phenomenon in which the deformations in each part of the membrane increase progressively under the cyclic loads

3.3
range of strain
difference between the maximum and minimum values in the cyclic strain curves

3.4
ratcheting
progressive incremental inelastic deformation or strain, which can occur in a component that is subject to variation of mechanical stress

3.5
unstable collapse
phenomenon in which the assessment of the process of deformation under static load becomes ambiguous

4 Materials

4.1 General

The temperature to which the steel may be exposed under all conditions is important, and shall be determined.

4.2 Temperatures

4.2.1 Minimum design temperature

The minimum design temperature shall be used as the design metal temperature for material selection of the primary and secondary liquid container.

4.2.2 Lodmat

The purchaser shall specify the lodmat.

4.2.3 Design metal temperature

When a steel component is protected from the low liquid or vapour temperature by thermal insulation, the design metal temperature shall be calculated based on the most pessimistic assumption under that loading (accidental actions included).

4.3 Primary and secondary liquid container

4.3.1 Steel selection

4.3.1.1 General

The material requirements for the primary and secondary liquid container given in 4.3.1.2 have been selected primarily for their high level of toughness at the design metal temperature. For each product to be stored, specific material requirements are specified.

4.3.1.2 Material requirements

4.3.1.2.1 Steel classification

Plate materials shall be classified as follows:

— type I steel: low temperature carbon-manganese steel;

— type II steel: special low temperature carbon-manganese steel;

— type III steel: low nickel steel;

— type IV steel: improved 9 % nickel steel;

— type V steel: austenitic stainless steel.

For each product to be stored, the steel types shall be in accordance with Table 1.

Table 1 — Product and steel class

Product	Single containment tank	Double, or full containment tank	Membrane tank	Typical product storage temperature
Butane	Type II	Type I		- 10 °C
Ammonia	Type II	Type II		- 35 °C
Propane/ Propylene	Type III	Type II	Type V	- 50 °C
Ethane/Ethylene	Type IV	Type IV	Type V	- 105 °C
LNG	Type IV	Type IV	Type V	- 165 °C
NOTE Service related effects, such as stress corrosion cracking, should be considered during material selection.				

4.3.1.2.2 General requirements

The following general requirements shall apply:

a) **Type I steel:**

A Type I steel is a fine-grained, low carbon steel, which shall be specified for pressure purposes at temperatures down to - 35 °C. The steel shall meet the following requirements:

1) The steel shall be specified to meet the requirements of an established European Standard (e.g. EN 10028-3). Steels with a minimum yield strength greater than 355 N/mm^2 shall not be used.

2) The steel shall be in the normalized condition or produced by a thermo mechanical rolled process.

3) The carbon content shall be less than 0,20 %. The carbon equivalent C_{eq} shall be equal to or less than 0,43 with

$$C_{eq}=C+\frac{Mn}{6}+\frac{(Cr+Mo+V)}{5}+\frac{(Ni+Cu)}{15}$$

b) **Type II steel:**

A Type II steel is a fine-grained low carbon steel, which shall be specified for pressure purposes at temperatures down to - 50 °C. The steel shall meet the following requirements:

1) The steel shall be specified to meet the requirements of an established European Standard (e.g. EN 10028-3). Steels with a minimum yield strength greater than 355 N/mm^2 shall not be used.

2) The steel shall be in the normalized condition or produced by a thermo mechanical rolled process.

3) The carbon content shall be less than 0,20 %. The carbon equivalent C_{eq} shall be equal to or less than 0,43 with

$$C_{eq}=C+\frac{Mn}{6}+\frac{(Cr+Mo+V)}{5}+\frac{(Ni+Cu)}{15}$$

c) **Type III steel:**

A Type III steel is a fine-grained low nickel alloy steel, which shall be specified for pressure purposes at temperatures down to - 80 °C. The steel shall meet the following requirements:

1) The steel shall be specified to meet the requirements of an established European Standard (e.g. EN 10028-4);

2) The steel shall have been heat treated to obtain a fine, uniform grain size or produced by a thermo mechanical rolled process.

d) **Type IV steel:**

A Type IV steel is an improved 9 % -nickel steel, which shall be specified for pressure purposes at temperatures down to - 165 °C. The steel shall meet the following requirements:

1) The steel shall be specified to meet the requirements of an established European Standard (e.g. EN 10028-4);

2) The steel shall be quenched and tempered.

e) **Type V steel:**

Type V steel is an austenitic stainless steel according to a European Standard (e.g. EN 10028-7).

4.3.1.2.3 Maximum shell plate thickness

The maximum shell plate thickness shall be:

— Types I, II and III: 40 mm;

— Types IV: 50 mm;

— Type V: no upper limit on thickness.

When material thickness is required in excess of these values, additional material investigation and testing shall be carried out to demonstrate that the same level of resistance to brittle fracture is available as would be required for the type of material and maximum thickness indicated above.

4.3.1.2.4 Plate tolerances

The plate tolerances shall be:

— in accordance with EN 10029:1991, Class C, for parts where the thickness is established by calculation;

— in accordance with EN 10029:1991, Class B, for parts where the thickness is based on minimum nominal thickness considerations.

4.3.2 Charpy V-notch impact test requirements

The Charpy V-notch impact test values for base material, heat-affected zone (HAZ) and weld metal shall be in accordance with Table 2.

The values specified shall be the minimum average of three specimens, with only one value less than the value specified, but not less than 70 % of the value specified.

For material thickness less than 11 mm, the largest practical sub-size specimen shall be used. The minimum Charpy V-notch impact test value for sub-size specimen shall be in direct proportion to the values specified for full size specimens.

The degradation effect due to welding shall be taken into account.

NOTE For certain materials, higher Charpy V-notch values or lower test temperatures may be needed for the base material to meet the requirements in the heat-affected zone.

Impact testing shall be carried out for each liquid containing shell plate and each completed plate from which liquid containing tank annular plates are cut. For other components, impact testing shall be carried out per heat/cast of the material.

Impact testing shall be carried out in accordance with EN 10045-1 and EN 875.

Table 2 — Minimum Charpy V-notch impact test energy

Classification	Steel type	Impact test energy	Specimen orientation for plate
Type I	Low temperature carbon-manganese steel	27 J at – 35 °C	Transverse
Type II	Special low temperature carbon-manganese steel	27 J at – 50 °C	Transverse
Type III	Low nickel steel	27 J at – 80 °C	Transverse
Type IV	Improved 9 % nickel steel	80 J at –196 °C	Transverse
If nickel base weld metals are used (types II, III and IV steel) then the impact toughness energy for weld metal and heat effected zone shall be 55 J.			

4.3.3 Certification

For materials with a design metal temperature below 0 °C an Inspection Certificate in accordance with EN 10204:2004, type 3.1 shall be required.

4.4 Vapour container/outer tank

4.4.1 Material for plate and structural sections

The steel of the vapour container/outer tank shall be selected in accordance with Table 3.

NOTE Alternative types of steels may be used provided equivalent properties (e.g. chemical composition and mechanical properties) can be demonstrated.

Table 3 — Steel for vapour container/outer tank

Design metal temperature T_{DM} °C	**Thickness** e mm	**Material grade according to EN 10025:2004**
$T_{DM} \geq 10$	$e \leq 40$	S235JRG2 or S275JR or S355JR
$10 > T_{DM} \geq 0$	$e \leq 13$ $13 \leq e \leq 40$	S235JRG2 or S275JR or S355JR S235JO or S275JO or S355JO
$0 > T_{DM} \geq -10$	$e \leq 13$ $13 < e \leq 40$	S235J0 or S275J0 or S355J0 S235J2G3 or S275J2G3 or S355J2G3
$-10 > T_{DM} \geq -20$	$e \leq 13$ $13 < e \leq 40$	S235J2G3 or S275J2G3 or S355J2G3 S235J2G3 or S275J2G3 or S355J2G4
For design metal temperatures below -20 °C and/or for thicknesses above 40 mm, the plate shall be impact tested at a temperature not exceeding the design metal temperature and show an impact value of at least 27 J longitudinal. For design metal temperatures below) 0 °C, the impact tests of the weld metal and the HAZ of the vertical shell joint shall show at least 27 J at the design metal temperature.		

4.4.2 Certification

For materials with design metal temperatures below 0 °C an inspection certificate in accordance with EN 10204:2004 type 3.1 shall be required.

All other materials shall be supplied with a test report in accordance with EN 10204:2004, type 2.2.

4.5 Other components

4.5.1 Bolting

4.5.1.1 Selection of bolting

Bolting shall be in accordance with EN 1515-1:1999, Table 1 and Table 2.

In selecting the material, the application, design pressure, design temperature and fluid service conditions shall be taken into account.

In the case of ferritic and martensitic steels, the bolting bar material shall have a tensile strength < 1 000 N/mm^2 and an elongation A5 > 14 %.

Ferritic and martensitic steels for use between –10 °C and –160 °C shall be impact tested at the design metal temperature and shall show an impact energy value of 40 J average in the longitudinal direction.

At design metal temperatures below –160 °C, the impact testing shall be performed at –196 °C.

NOTE 1 Where austenitic steel is used, bolts may relax on cooling to sub zero temperatures. This is caused by a permanent transformation of the structure from austenitic to martensitic, which results in an increase of length. The extent of transformation increases with the applied stress.

NOTE 2 Bolts that cannot be retightened after cooling should be made from steel having a stable structure, such as 25 Cr 20 Ni or nitrogen bearing austenitic steel.

4.5.1.2 Studbolts

Studbolts shall be threaded over the full length. The points shall be chamfered or rounded. The height of the points shall be maximum one times the pitch of thread.

The length of studbolts shall include points. The lengths are stepped by increments of 5 mm for lengths up to 80 mm, 10 mm for lengths above 80 mm and up to 200 mm and by increments of 20 mm for lengths above 200 mm.

Threads shall be in accordance with ISO 261, tolerances shall be in accordance with class 6g of ISO 965-2:1998. Type of thread shall be either, ISO M course, or above M 39, fine thread with 4 mm pitch.

4.5.1.3 Spring washers

Special spring washers shall be considered where different materials are used and different thermal contractions can take place.

4.5.2 Mountings

Nozzle necks, insert and reinforcing plates and permanent attachments shall have the same strength and notch ductility as the plates to which they are attached. Materials of lower strength can be used for nozzle necks provided that the neck area shall not be used as a contributing part in the area replacement calculation.

4.5.3 Piping components

Materials for piping components shall be in accordance with EN 1092-1:2001, EN 10216-1, EN 10216-2, EN 10216-3, EN 10216-4, EN 10217-1, EN 10217-2, EN 10217-3, EN 10217-4, EN 10217-5, EN 10217-6.

5 Design

5.1 Design theory

5.1.1 General

For the actions (loadings), reference is made to EN 14620-1:2006, 7.3.

The design of the steel components shall be based on either the allowable stress or limit state theory.

NOTE The inclusion of the two options recognizes that, at the present time, there is only limited experience available in the application of limit state for the design of steel storage tanks.

Since the elasto-plastic approach is used for the design of the membrane, the allowable stress/limit state criteria is not appropriate and shall be replaced with the stress/strain curve for the specified material.

5.1.2 Allowable stresses

5.1.2.1 General

The maximum allowable tensile stress in any plate or weld metal shall be in accordance with Table 4.