



SLOVENSKI STANDARD
oSIST prEN 1993-4-1:2024
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Nadomešča:
SIST EN 1993-4-1:2007

Evrokod 3 - Projektiranje jeklenih konstrukcij - 4-1.del: Silosi

Eurocode 3 - Design of steel structures - Part 4-1: Silos

Eurocode 3 - Bemessung und Konstruktion von Stahlbauten - Teil 4-1: Silos

Eurocode 3 - Calcul des structures en acier - Partie 4-1: Silos

Ta slovenski standard je istoveten z: prEN 1993-4-1

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91.010.30	Tehnični vidiki	Technical aspects
91.080.13	Jeklene konstrukcije	Steel structures

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English Version

Eurocode 3 - Design of steel structures - Part 4-1: Silos

Eurocode 3 - Calcul des structures en acier - Partie 4-1:
Silos

Eurocode 3 - Bemessung und Konstruktion von
Stahlbauten - Teil 4-1: Silos

This draft European Standard is submitted to CEN members for enquiry. It has been drawn up by the Technical Committee CEN/TC 250.

If this draft becomes a European Standard, 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.

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Recipients of this draft are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

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

CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

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European foreword

This document (prEN 1993-4-1:2024), has been prepared by Technical Committee CEN/TC250 “Structural Eurocodes”, the Secretariat of which is held by BSI. CEN/TC 250 is responsible for all Structural Eurocodes and has been assigned responsibility for structural and geotechnical design matters by CEN.

This document is currently submitted to the CEN Enquiry.

This document will supersede EN1993-4-1:2007 and its amendments and corrigenda.

The first generation of EN Eurocodes was published between 2002 and 2007. This document forms part of the second generation of the Eurocodes, which have been prepared under Mandate M/515 issued to CEN by the European Commission and the European Free Trade Association.

The Eurocodes have been drafted to be used in conjunction with relevant execution, material, product and test standards, and to identify requirements for execution, materials, products and testing that are relied upon by the Eurocodes.

The Eurocodes recognize the responsibility of each Member State and have safeguarded their right to determine values related to regulatory safety matters at national level through the use of National Annexes.

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0 Introduction

0.1 Introduction to the Eurocodes

The Structural Eurocodes comprise the following standards generally consisting of a number of Parts:

- EN 1990, Eurocode — Basis of structural and geotechnical design
- EN 1991, Eurocode 1 — Actions on structures
- EN 1992, Eurocode 2 — Design of concrete structures
- EN 1993, Eurocode 3 — Design of steel structures
- EN 1994, Eurocode 4 — Design of composite steel and concrete structures
- EN 1995, Eurocode 5 — Design of timber structures
- EN 1996, Eurocode 6 — Design of masonry structures
- EN 1997, Eurocode 7 — Geotechnical design
- EN 1998, Eurocode 8 — Design of structures for earthquake resistance
- EN 1999, Eurocode 9 — Design of aluminium structures
- New parts are under development, e.g. Eurocode for design of structural glass.

0.2 Introduction to EN 1993 (all parts)

EN 1993 applies to the design of buildings and civil engineering works in steel. It complies with the principles and requirements for the safety and serviceability of structures, the basis of their design and verification that are given in EN 1990 – Basis of structural and geotechnical design.

EN 1993 is concerned only with requirements for resistance, serviceability, durability and fire resistance of steel structures. Other requirements, e.g. concerning thermal or sound insulation, are not covered.

EN 1993 is subdivided in various parts:

EN 1993-1, *Design of Steel Structures — Part 1: General rules and rules for buildings;*

EN 1993-2, *Design of Steel Structures — Part 2: Bridges;*

EN 1993-3, *Design of Steel Structures — Part 3: Towers, masts and chimneys;*

EN 1993-4, *Design of Steel Structures — Part 4: Silos and tanks;*

EN 1993-5, *Design of Steel Structures — Part 5: Piling;*

EN 1993-6, *Design of Steel Structures — Part 6: Crane supporting structures;*

EN 1993-7, *Design of steel structures — Part 7: Sandwich panels.*

EN 1993-1 does not exist as a physical document, but comprises the following 14 separate parts, the basic part being EN 1993-1-1:

EN 1993-1-1, *Design of Steel Structures — Part 1-1: General rules and rules for buildings;*

EN 1993-1-2, *Design of Steel Structures — Part 1-2: Structural fire design;*

EN 1993-1-3, *Design of Steel Structures — Part 1-3: Cold-formed members and sheeting*;

NOTE Cold formed hollow sections supplied according to EN 10219 are covered in EN 1993-1-1.

EN 1993-1-4, *Design of Steel Structures — Part 1-4: Stainless steel structures*;

EN 1993-1-5, *Design of Steel Structures — Part 1-5: Plated structural elements*;

EN 1993-1-6, *Design of Steel Structures — Part 1-6: Strength and stability of shell structures*;

EN 1993-1-7, *Design of Steel Structures — Part 1-7: Plate assemblies with elements under transverse loads*;

EN 1993-1-8, *Design of Steel Structures — Part 1-8: Joints*;

EN 1993-1-9, *Design of Steel Structures — Part 1-9: Fatigue*;

EN 1993-1-10, *Design of Steel Structures — Part 1-10: Material toughness and through-thickness properties*;

EN 1993-1-11, *Design of Steel Structures — Part 1-11: Tension components*;

EN 1993-1-12, *Design of Steel Structures — Part 1-12: Additional rules for steel grades up to S960*;

EN 1993-1-13, *Design of Steel Structures — Part 1-13: Beams with large web openings*;

EN 1993-1-14, *Design of Steel Structures — Part 1-14: Design assisted by finite element analysis*.

All subsequent parts EN 1993-1-2 to EN 1993-1-14 treat general topics that are independent of the structural type such as structural fire design, cold-formed members and sheeting, stainless steels, plated structural elements, shell structures, etc.

All subsequent parts numbered EN 1993-2 to EN 1993-7 treat topics relevant for a specific structural type such as steel bridges, towers, masts and chimneys, silos and tanks, piling, crane supporting structures, etc. EN 1993-2 to EN 1993-7 refer to the generic rules in EN 1993-1 and supplement, modify or supersede them.

0.3 Introduction to prEN 1993-4-1

prEN 1993-4-1 gives design guidance for the structural design of silos and design rules that supplement the generic rules in the parts of EN 1993-1.

prEN 1993-4-1 is intended for clients, designers, contractors and relevant authorities.

0.4 Verbal forms used in the Eurocodes

The verb “shall” expresses a requirement strictly to be followed and from which no deviation is permitted in order to comply with the Eurocodes.

The verb “should” expresses a highly recommended choice or course of action. Subject to national regulation and/or any relevant contractual provisions, alternative approaches could be used/adopted where technically justified.

The verb “may” expresses a course of action permissible within the limits of the Eurocodes.

The verb “can” expresses possibility and capability; it is used for statements of fact and clarification of concepts.

prEN 1993-4-1:2024 (E)**0.5 National Annex for prEN 1993-4-1**

National choice is allowed in this standard where explicitly stated within notes. National choice includes the selection of values for Nationally Determined Parameters (NDPs).

The national standard implementing prEN 1993-4-1 can have a National Annex containing all national choices to be used for the design of buildings and civil engineering works to be constructed in the relevant country.

When no national choice is given, the default choice given in this standard is to be used.

When no national choice is made and no default is given in this standard, the choice can be specified by a relevant authority or, where not specified, agreed for a specific project by appropriate parties.

National choice is allowed in prEN 1993-4-1 through notes to the following clauses:

4.3.2(4)	4.3.3(1)	4.3.3(3)	4.3.3(8)
4.4.1.2(3)	4.4.2(2)	4.5.3(1)	5.4(1)
6.1.4(6)	7.5.4(3)	12.5.2(9)	

National choice is allowed in prEN 1993-4-1 on the application of the following informative annexes:

None

The National Annex can contain, directly or by reference, non-contradictory complementary information for ease of implementation, provided it does not alter any provisions of the Eurocodes.

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1 Scope

1.1 Scope of EN 1993-4-1

(1) prEN 1993-4-1 provides rules for the structural design of steel silos of circular or rectangular plan-form, being free-standing (on ground) or supported on a structural framework (elevated).

(2) prEN 1993-4-1 is applicable to silos constructed from isotropic rolled plates that are stiffened or unstiffened, from corrugated sheeting that is stiffened or unstiffened and from flat or corrugated plates assembled into box structures of different geometries. It applies to vertical walls, hoppers, roof structures, transition junctions and support structures.

(3) prEN 1993-4-1 does not apply to storage vessels for silage and haylage, or to the storage of materials that are not free-flowing (see EN 1991-4). This Part 4-1 also does not cover:

- resistance to fire;
- cylindrical silos with internal subdivisions;
- internal structures within a single silo (except for internal ties, as defined in 12.5);
- silos with capacity less than 100 kN (10 tonnes);
- hoppers that are supported on a structural framework;
- cases where special measures are necessary to limit the consequences of accidents.

(4) This document is applicable to silos within the following dimensional limits (see EN 1991-4):

- Silo aspect ratio $h_b/d_c < 10$
- Silo total height $h_b < 70$ m
- Silo equivalent diameter $d_c < 60$ m

NOTE These dimensional limitations are more limited than those of EN 1991-4 which also applies to silos constructed from other materials.

(5) Where this standard applies to circular planform silos, the geometric form is restricted to axisymmetric structures, but unsymmetrical actions on them and supports that induce forces in the silo structure that are not axisymmetric are included.

(6) This part is concerned only with the requirements for resistance and stability of steel silos. For other requirements (such as operational safety, functional performance, fabrication and erection, quality control, details like man-holes, flanges, filling devices, outlet gates and feeders, etc.), see other relevant standards and information.

(7) This part is concerned with both isolated silo structures and silos that are connected to others to form a battery of silos, but throughout this document the term silo refers to a single cell within a battery.

(8) Provisions relating to special requirements of seismic design are provided in EN 1998-4, which complements or adapts the provisions of Eurocode 3 specifically for this purpose.

(9) The structural design of supporting structures for the silo are dealt with in EN 1993-1-1. The supporting structure is deemed to consist of all structural elements beneath the bottom flange of the lowest ring of the silo (see Figure 1.1), though information on some forms of support structure is given in Clause 8 of this document.

prEN 1993-4-1:2024 (E)

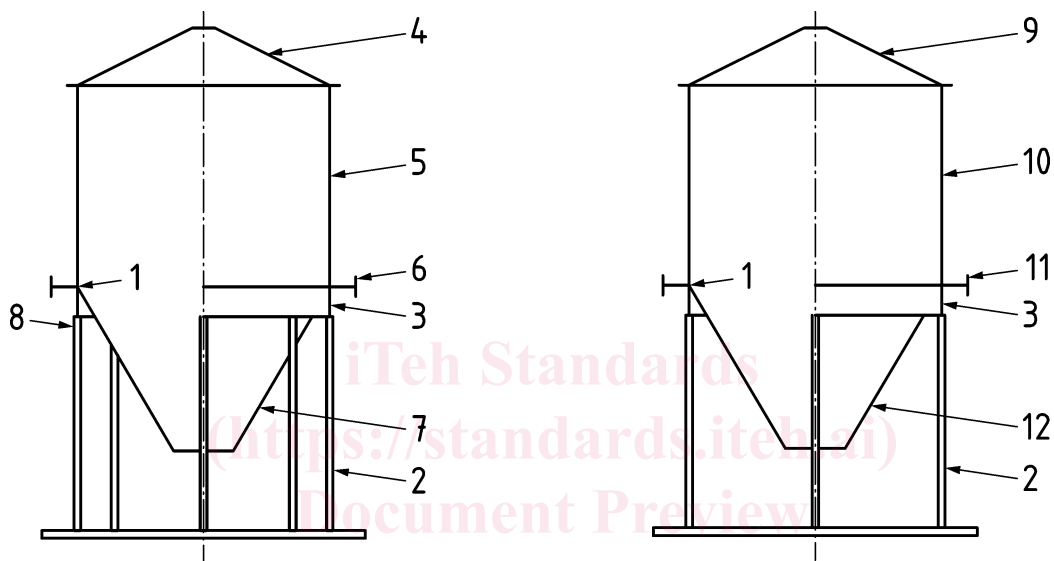
(10) Foundations in reinforced concrete for steel silos are dealt with in EN 1992 (all parts) and EN 1997 (all parts).

1.2 Assumptions

(1) Unless specifically stated, the provisions of EN 1990, EN 1991 (all parts) and EN 1993-1 (all parts) apply.

(2) The design methods given in EN 1993-4-1 are applicable if:

- the execution quality is as specified in EN 1090-2, and
- the construction materials and products used are as specified in the relevant parts of EN 1993 (all parts), or in the relevant material and product specifications.



a) Circular planform silo **b) Rectangular planform silo**

Key

1	transition	7	conical hopper
2	column: supporting structure	8	EN 1993-1-1 applies below this line
3	skirt	9	pyramidal roof
4	conical roof	10	rectangular box
5	cylindrical shell or barrel	11	ring girder
6	ring	12	pyramidal hopper

Figure 1.1 — Terminology used in silo structures

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 1090-2, *Execution of steel structures and aluminium structures — Part 2: Technical requirements for steel structures*

EN 1990:2023¹, *Eurocode — Basis of structural and geotechnical design*¹

EN 1991 (all parts), *Eurocode 1 — Actions on structures*

EN 1993 (all parts), *Eurocode 3 — Design of steel structures*

ISO 8930, *General principles on reliability for structures — Vocabulary*

3 Terms, definitions, symbols, sign conventions and units

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 1990, ISO 8930 and the following apply.

3.1.1

axial direction

vertical tangent to a cylindrical silo wall

Note 1 to entry: For the cylinder alone, it coincides with the meridional direction.

3.1.2

axisymmetric shell

shell structure whose geometry is defined by rotation of a meridional line about a central axis

3.1.3

base ring

structural member that passes around the circumference of the structure at the base and provides means of attachment of the structure to a foundation or other element

Note 1 to entry: It is required that the assumed boundary conditions are achieved in practice.

3.1.4

box

structure formed from an assembly of flat plates into a three-dimensional enclosed form

Note 1 to entry: For the purposes of this Standard, the box has dimensions that are generally comparable in all directions.

3.1.5

circumferential direction

horizontal tangent to the silo wall at any point

Note 1 to entry: The circumferential direction varies around the silo, lies in the horizontal plane and is tangential to the silo wall irrespective of whether the silo is circular or rectangular in plan.

¹ As impacted by EN 1990:2023/prA1:2024.

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3.1.6

continuously supported silo

silo in which all positions around the circumference are supported in an identical manner

Note 1 to entry: Minor departures from this condition (e.g. a small opening) need not affect the applicability of the definition.

3.1.7

corrugated silo wall

shell strake of a circular silo that is formed from sheet that has been rolled before construction into a corrugated form (rounded or trapezoidal undulations) that provides enhanced bending resistance in one direction

Note 1 to entry: See 6.5. This term also refers to a wall in a rectangular or polygonal silo where trapezoidal undulations are used to enhance the bending resistance.

3.1.8

course

section of the height of a cylindrical wall constructed from a single plate thickness or between ring stiffeners, usually made up of several strakes

Note 1 to entry: See 3.1.32.

3.1.9

cylindrical shell

vertical walled section of a circular planform silo

Note 1 to entry: See Figure 1.1.

3.1.10

discrete support

position in which a silo is supported using a local bracket or column, giving a limited number of narrow supports around the silo circumference

Note 1 to entry: Four or six discrete supports are commonly used, but three or more than six are also found.

3.1.11

hopper

converging section towards the bottom of a silo, normally conical in form

Note 1 to entry: It is used to channel solids towards a gravity discharge outlet.

3.1.12

isotropic conical hopper

conical hopper that is formed from rolled flat sheets

Note 1 to entry: These sheets can be welded or bolted together.

3.1.13

isotropic shell

shell segment of a silo that is formed from rolled flat sheets

Note 1 to entry: These sheets can be welded or bolted together.