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Evrokod 3: Projektiranje jeklenih konstrukcij - 4-3.del: Cevovodi

Eurocode 3 - Design of steel structures - Part 4-3: Pipelines

Eurocode 3 - Bemessung und Konstruktion von Stahlbauten - Teil 4-3: Rohrleitungen

Eurocode 3 - Calcul des constructions en acier - Partie 4-3: Tuyauterie

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Eurocode 3 - Design of steel structures - Part 4-3: Pipelines

Eurocode 3 - Calcul des constructions en acier - Partie 4-3: Tuyauterie

Eurocode 3 - Bemessung und Konstruktion von Stahlbauten - Teil 4-3: Rohrleitungen

This European Standard was approved by CEN on 12 June 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 CEN 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 Management Centre has the same status as the official versions.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
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EUROPÄISCHES KOMITEE FÜR NORMUNG

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Content

Foreword

This European Standard EN 1993-4-3, "Eurocode 3: Design of steel structures – Part 4.3: Pipelines", has been prepared by Technical Committee CEN/TC250 « Structural Eurocodes », the Secretariat of which is held by BSI. CEN/TC250 is responsible for all Structural Eurocodes.

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of an identical text or by endorsement, at the latest by August 2007, and conflicting National Standards shall be withdrawn at latest by March 2010.

This document supersedes ENV 1993-4-3:1999.

According to the CEN-CENELEC Internal Regulations, the National Standard Organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, 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.

Background of the Eurocode programme

In 1975, the Commission of the European Community decided on an action programme in the field of construction, based on article 95 of the Treaty. The objective of the programme was the elimination of technical obstacles to trade and the harmonisation of technical specifications.

Within this action programme, the Commission took the initiative to establish a set of harmonised technical rules for the design of construction works which, in a first stage, would serve as an alternative to the National rules in force in the Member States and, ultimately, would replace them.

For fifteen years, the Commission, with the help of a Steering Committee with Representatives of Member States, conducted the development of the Eurocodes programme, which led to the first generation of European codes in the 1980's.

In 1989, the Commission and the Member States of the EU and EFTA decided, on the basis of an agreement[1)] between the Commission and CEN, to transfer the preparation and the publication of the Eurocodes to the CEN through a series of Mandates, in order to provide them with a future status of European Standard (EN). This links de facto the Eurocodes with the provisions of all the Council's Directives and/or Commission's Decisions dealing with European standards (e.g. the Council Directive 89/106/EEC on construction products - CPD - and Council Directives 93/37/EEC, 92/50/EEC and 89/440/EEC on public works and services and equivalent EFTA Directives initiated in pursuit of setting up the internal market).

The Structural Eurocode programme comprises the following standards generally consisting of a number of Parts:

EN1990 Eurocode 0: Basis of structural design
EN1991 Eurocode 1: Actions on structures
EN1992 Eurocode 2: Design of concrete structures
EN1993 Eurocode 3: Design of steel structures
EN1994 Eurocode 4: Design of composite steel and concrete structures

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1) Agreement between the Commission of the European Communities and the European Committee for Standardisation (CEN) concerning the work on EUROCODES for the design of building and civil engineering works (BC/CEN/03/89).

EN1995 Eurocode 5: Design of timber structures
EN1996 Eurocode 6: Design of masonry structures
EN1997 Eurocode 7: Geotechnical design
EN1998 Eurocode 8: Design of structures for earthquake resistance
EN1999 Eurocode 9: Design of aluminium structures

Eurocode standards recognise the responsibility of regulatory authorities in each Member State and have safeguarded their right to determine values related to regulatory safety matters at national level where these continue to vary from State to State.

Status and field of application of Eurocodes

The Member States of the EU and EFTA recognise that EUROCODES serve as reference documents for the following purposes:

- as a means to prove compliance of building and civil engineering works with the essential requirements of Council Directive 89/106/EEC, particularly Essential Requirement N°1 - Mechanical resistance and stability - and Essential Requirement N°2 - Safety in case of fire;
- as a basis for specifying contracts for construction works and related engineering services;
- as a framework for drawing up harmonised technical specifications for construction products (ENs and ETAs)

The Eurocodes, as far as they concern the construction works themselves, have a direct relationship with the Interpretative Documents[2)] referred to in Article 12 of the CPD, although they are of a different nature from harmonised product standards[3)]. Therefore, technical aspects arising from the Eurocodes work need to be adequately considered by CEN Technical Committees and/or EOTA Working Groups working on product standards with a view to achieving full compatibility of these technical specifications with the Eurocodes.

The Eurocode standards provide common structural design rules for everyday use for the design of whole structures and component products of both a traditional and an innovative nature. Unusual forms of construction or design conditions are not specifically covered and additional expert consideration will be required by the designer in such cases.

National Standards implementing Eurocodes

The National Standards implementing Eurocodes will comprise the full text of the Eurocode (including any annexes), as published by CEN, which may be preceded by a National title page and National foreword, and may be followed by a National Annex.

The National Annex may only contain information on those parameters which are left open in the Eurocode for national choice, known as Nationally Determined Parameters, to be used for the design of buildings and civil engineering works to be constructed in the country concerned, i.e. :

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2) According to Art. 3.3 of the CPD, the essential requirements (ERs) shall be given concrete form in interpretative documents for the creation of the necessary links between the essential requirements and the mandates for harmonised ENs and ETAGs/ETAs.

3) According to Art. 12 of the CPD the interpretative documents shall :
(a) give concrete form to the essential requirements by harmonising the terminology and the technical bases and indicating classes or levels for each requirement where necessary ;
(b) indicate methods of correlating these classes or levels of requirement with the technical specifications, e.g. methods of calculation and of proof, technical rules for project design, etc. ;
(c) serve as a reference for the establishment of harmonised standards and guidelines for European technical approvals.
The Eurocodes, de facto, play a similar role in the field of the ER 1 and a part of ER 2.

- values and/or classes where alternatives are given in the Eurocode,
- values to be used where a symbol only is given in the Eurocode,
- country specific data (geographical, climatic, etc), e.g. snow map,
- the procedure to be used where alternative procedures are given in the Eurocode,
- decisions on the application of informative annexes,
- references to non-contradictory complementary information to assist the user to apply the Eurocode.

Links between Eurocodes and harmonised technical specifications (ENs and ETAs)

There is a need for consistency between the harmonised technical specifications for construction products and the technical rules for works[4]. Furthermore, all the information accompanying the CE Marking of the construction products which refer to Eurocodes shall clearly mention which Nationally Determined Parameters have been taken into account.

Additional information specific to EN 1993-4-3

EN 1993-4-3 gives design rules for the structural design of buried pipelines, in particular for the evaluation of the strength, stiffness and deformation capacity.

The rules for local buckling in this part EN 1993-4-3 are in line with those in other pipeline standards. The design critical curvatures according to EN 1993-4-3 are larger than those that could be deduced from EN 1993-1-6. The main reasons are that the loading in buried pipelines is mainly deformation controlled and the consequences of local buckling are less severe than in structures where the loading is mainly load controlled.

It is recognized that many standards exist for the design of pipelines covering many different aspects. Examples are routing, pressure safety systems, corrosion protection, construction and welding, operation and maintenance. For aspects other than the structural design of the pipeline itself, reference is made to the relevant European standards listed in 1.3. This is also the case for elements like valves, fittings, insulating couplings, tees and caps.

Because up till now in EN 1991, no rules exist for actions (loads) on pipelines, reference is made to relevant EN standards on pipelines e.g. EN 1594 on gas transmission pipelines and EN 14161 on pipeline transportation systems for the petroleum and natural gas industries.

National Annex for EN 1993-4-3

This standard gives alternative procedures, values and recommendations for classes with notes indicating where national choices may have to be made. Therefore the National Standard implementing EN 1993-4-3 should have a National Annex containing all Nationally Determined Parameters to be used for the design of buildings and civil engineering works to be constructed in the relevant country.

National choice is allowed in EN 1993-4-3 through paragraphs:
2.3 (2)
3.2 (2)P, (3), (4)
3.3 (2), (3), (4)
3.4 (3)
4.2 (1)P

4) see Art.3.3 and Art.12 of the CPD, as well as clauses 4.2, 4.3.1, 4.3.2 and 5.2 of ID 1.

5.1.1 (2), (3), (4), (5), (6), (9), (10), (11), (12), (13)
5.2.3 (2)
5.2.4 (1)

1 General

1.1 Scope

(1) This Part 4-3 of EN 1993 provides principles and application rules for the structural design of cylindrical steel pipelines for the transport of liquids or gases or mixtures of liquids and gases at ambient temperatures, which are not treated by other European standards covering particular applications.

(2) Standards dealing with specific pipeline applications should be used for these purposes, notably

- EN 805 : 2000 for water supply systems (drinking water);
- EN 1295: 1997 for buried pipelines under various conditions of loading (waste water);
- EN 1594: 2000 for gas supply systems for operating pressures over 16 bar;
- EN 12007: 2000 for gas supply systems up to and including 16 bar;
- EN 12732: 2000 for welding;
- EN 13941: 2003 for pre-insulated bonded pipe systems for district heating;
- EN 13480: 2002 for industrial pipelines;
- EN 14161: 2004 for pipeline transportation systems for the petroleum and natural gas industries.

(3) Rules related to special requirements of seismic design are provided in EN 1998-4 (Eurocode 8: Part 4 "Design of structures for earthquake resistance: Silos, tanks and pipelines"), which complements the rules of Eurocode 3 specifically for this purpose.

(4) This Standard is restricted to buried pipelines, corresponding to the scope of Eurocode 8 Part 4 for pipelines. It is specifically intended for use on:

- Buried pipelines in settlement areas and in non-settlement areas;
- Buried pipelines crossing dykes, traffic roads and railways and canals.

(5) The design of pipelines involves many different aspects. Examples are routing, pressure safety systems, corrosion protection, construction and welding, operation and maintenance. For aspects other than the structural design of the pipeline itself, reference is made to the relevant European standards listed in 1.2. This is also the case for elements like valves, fittings, insulating couplings, tees and caps.

(6) Pipelines usually comprise several associated facilities such as pumping stations, operation centres, maintenance stations, etc., each of them housing different sorts of mechanical and electrical equipment. Since these facilities have a considerable influence on the continued operation of the system, it is necessary to give them adequate consideration in the design process aimed at satisfying the overall reliability requirements. However, explicit treatment of these facilities, is not included within the scope of this Standard.

(7) Although large diameter pipelines are within the scope of this Standard, the corresponding design criteria should not be used for apparently similar facilities like railway tunnels and large underground gas reservoirs.

(8) The provisions in this Standard are not necessarily complete for particular applications. Where this is the case, additional provisions specific to those applications should be adopted.

(9) This Standard specifies the requirements regarding material properties of plates and welds in terms of strength and ductility. For detailed guidelines and requirements about materials and welding, reference should be made to the relevant standards listed in 1.2.

(10) The scope of this Standard is limited to steel grades with a specified minimum yield strength not exceeding 700 N/mm^2.

1.2 Normative references

This European Standard incorporates, by dated and undated reference, provisions from other standards. 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 the European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

EN 805	*Water supply – Requirements for systems and components outside buildings;*
EN 1011	*Recommendations for arc welding of steels;*
EN 1090-2	*Execution of steel structures and aluminium structures – Technical requirements for steel structures;*
EN 1295	*Structural design of buried pipelines under various conditions of loading (waste water);*
Part 1:	*General requirements;*
EN 1594	*Gas supply systems: Pipelines - Maximum Operating Pressure over 16 bar, Functional requirements;*
EN 1990	*Basis of structural design;*
EN 1991	*Actions on structures;*
EN 1993	*Eurocode 3: Design of steel structures;*
Part 1.1:	*General rules and rules for buildings;*
Part 1.3:	*Supplementary rules for cold formed members and sheeting;*
Part 1.6:	*Strength and stability of shell structures;*
Part 1.7:	*Strength and stability of planar plated structures transversely loaded;*
Part 1.8:	*Design of joints;*
Part 1.9:	*Fatigue;*
Part 1.10:	*Material toughness and through-thickness properties;*
Part 1.12:	*Additional rules for the extension of EN 1993 up to steel grades S 700;*
Part 4.1:	*Silos;*
Part 4.2:	*Tanks;*
EN 1997	*Eurocode 7: Geotechnical design;*
EN 1998	*Eurocode 8: Design provisions for earthquake resistance of structures;*
Part 4:	*Silos, tanks and pipelines;*
EN 10208	*Steel pipes for pipelines for combustible fluids (1993);*
Part 1:	*Pipes of requirement class A;*
Part 2:	*Pipes of requirement class B;*
EN 12007	*Gas supply systems - Pipelines for maximum operating pressure up to and including 16 bar.*
Part 1:	*General functional recommendations;*
Part 2:	*Specific functional recommendations for polyethylene;*
Part 3:	*Specific functional recommendations for steel.*
EN 12732	*Gas supply systems - Welding steel pipe work -functional requirements;.*
EN 13445	*Unfired pressure vessels series*
EN 13480	*Metallic industrial piping series*
EN 13941	*Design, calculation and installation of pre-insulated bonded pipes for district heating;*
EN 14161	*Petroleum and natural gas industries – Pipeline transportation systems;*
ISO 1000	*SI Units;*

ISO 3183 *Petroleum and natural gas industries; Steel pipe for pipelines; Technical delivery conditions (1996);*
Part 1: *Pipes of requirement class A;*
Part 2: *Pipes of requirements class B;*
Part 3: *Pipes of requirement class C;*
EN 14870
Parts 1,2,3 *Induction bends, fittings and flanges for pipeline transportation systems*
ISO 13623 *Petroleum and natural gas industries; Pipeline transportation systems;*
ISO 13847 *Welding steel pipeline (2000);*
Part 1: *Field welding;*
Part 2: *Shop welding;*

NOTE 1: EN 1295 is intended for sanitation, and water supply: it is chiefly concerned with principles and equations are presented only in an annex.

NOTE 2: EN 1594 is applicable to new pipelines with a maximum operating pressure (MOP) greater than 16 bar for the carriage of processed, non-toxic and non-corrosive natural gas according to ISO/DIS 13686 in on land gas supply systems. It is prepared by WG 3 Gas Transmission of CEN/TC 234 Gas Supply.

NOTE 3: For more references on gas supply, gas transmission, gas storage, etc., see EN 1594.

NOTE 4: EN 12007 was also prepared by CEN/TC 234.

NOTE 5: EN 13941 is intended for district heating and was prepared by a joint WG of CEN/TC 107 and CEN/TC 267.

NOTE 6: Standard ISO 13623 is prepared by SC2 "Pipeline transportation for the Petroleum and Natural Gas industries", of ISO/TC 67 "Materials, Equipment and Offshore Structures for Petroleum and Natural Gas Industries".

1.3 Assumptions

(1) The general assumptions of EN 1990 apply.

1.4 Distinction between principles and application rules

(1) Reference is made to 1.4 of EN 1993-1-1.

1.5 Definitions

(1) The terms that are defined in EN 1991-1 for common use in the Structural Eurocodes apply to this Part 4-3 of EN 1993.

(2) Unless otherwise stated, the definitions given in ISO 9830 also apply to this Part 4-3.

(3) Supplementary to Part 1 of EN 1993, for the purposes of this Part 4-3, the following definitions apply:

1.5.1 pressure: The gauge pressure of the gas or fluid inside the system, measured in static conditions.

1.5.2 design pressure (DP): The pressure on which the design calculations are based.

1.5.3 operating pressure (OP): The pressure, which occurs within a system under normal operating conditions.

1.5.4 maximum operating pressure (MOP): The maximum pressure at which a system can be operated continuously under normal conditions.

NOTE: Normal conditions are: no fault in any device or stream.

1.5.5 design temperature (DT): The temperature on which the design calculations are based.

1.5.6 operating temperature (OT): The temperature, which occurs within a system under normal operating conditions.

1.6 S.I. units

(1)P S.I. units shall be used in accordance with International Standard ISO 1000.

(2) For calculations, the following consistent units are recommended:

-	dimensions and thicknesses	:	m	mm
-	unit weight	:	kN/m^3	N/mm^3
-	forces and loads	:	kN	N
-	line forces and line loads	:	kN/m	N/mm
-	pressures and area distributed actions	:	kPa	MPa
-	unit mass	:	kg/m^3	kg/mm^3
-	acceleration	:	km/s^2	m/s^2
-	membrane stress resultants	:	kN/m	N/mm
-	bending stress resultants	:	kNm/m	Nmm/mm
-	stresses and elastic moduli	:	kPa	MPa (=N/mm^2)

(4) Conversion factors
1 mbar = 100 N/m^2 = 0.1 kPa

1.7 Symbols

The symbols in EN 1990 and EN 1993-1 apply. Further symbols are given as follows:

1.7.1 Roman upper case letters

For the purposes of this Standard, the following symbols apply:

A	cross-sectional area of a pipe
C	curvature due to bending
D_e	external diameter
D	diameter of the mid-line of pipe wall
E	modulus of elasticity
F	normal force in the pipe in longitudinal direction
M	bending moment in the pipeline conceived as a beam
M_p	plastic moment
M_t	torsional moment
N	effective normal force in a pipeline
V	shear force in the cross-section
Q	earth pressure
Q_d	directly transmitted earth pressure
Q_i	indirectly transmitted earth pressure (support reaction)
Q_{eq}	equivalent earth pressure to transform Q_i to a quantity Q_d that gives the same average shell wall moments in the circumferential direction as Q_i
R	radius of unstressed bend

1.7.2 Roman lower case letters

a ovalisation parameter
$f_{y,d}$ design value of yield strength
$f_{y,nom}$ nominal value of yield strength
$f_{u,nom}$ nominal value of ultimate tensile strength
$f_{y,min}$ specified minimum yield strength
$f_{y,max}$ maximum value of the yield strength
$f_{u,min}$ specified minimum value for the ultimate tensile strength
$f_{u,max}$ maximum value of the ultimate tensile strength
m shell wall moment per unit width
m_e shell wall moment per unit width at the end of the elastic region
m_p full plastic moment per unit width of shell wall
m_x, m_y shell wall moment per unit width in longitudinal and circumferential direction respectively
n shell wall normal force per unit width
n_p plastic normal force per unit width of shell wall
n_x, n_y normal force per unit width of shell wall in longitudinal and circumferential direction respectively
p_i internal pressure in the pipeline (positive outward)
p_e external pressure on the pipeline (negative when acting inward)
p effective pressure: $p = p_i - p_e$
r radius of a pipe: $r = D/2$
t pipe wall thickness
t_{min} specified minimum wall thickness (nominal wall thickness minus the specified tolerance)
t_r, t_b pipe wall thickness in the straight pipe and the bend respectively

1.7.3 Greek letters

α, β, γ loading angle and bearing angle for Q_d and for Q_i and Q_{eq} respectively
ν Poisson's ratio
γ_F partial factor for actions
γ_M partial factor for material strength
θ circumferential coordinate around shell
σ direct stress
τ shear stress

1.8 Terminology

Supplementary to Part 1 of EN 1993 (and Part 4 of EN 1991), for the purposes of this Part 4.3, the following terminology applies:

1.8.1 emergency: A situation which could affect the safe operation of the pipeline system and/or the safety of the surrounding area, requiring urgent action.

1.8.2 incident: An unexpected occurrence, which could lead to an emergency situation. This includes a leakage of contents.

1.8.3 inspection: The process of measuring, examining, testing, gauging or otherwise determining the status of items of the pipeline system or installation and comparing it with the applicable requirements.

1.8.4 installation temperature: The temperature arising from ambient or installation conditions during laying or during construction.