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Kovinski industrijski cevovodi – 3. del: Konstruiranje in izračun

Metallic industrial piping - Part 3: Design and calculation

Metallische industrielle Rohrleitungen - Teil 3: Konstruktion und Berechnung

Tuyauteries industrielles métalliques - Partie 3: Conception et calcul

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Metallic industrial piping - Part 3: Design and calculation

Tuyauteries industrielles métalliques - Partie 3: Conception et calcul

Metallische industrielle Rohrleitungen - Teil 3: Konstruktion und Berechnung

This amendment A2 modifies the European Standard EN 13480-3:2002; it was approved by CEN on 25 September 2006.

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Foreword

This document (EN 13480-3:2002/A2:2006) has been prepared by Technical Committee CEN/TC 267 "Industrial piping and pipelines", the secretariat of which is held by AFNOR.

This Amendment to the European Standard EN 13480-3:2002 shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by May 2007, and conflicting national standards shall be withdrawn at the latest by May 2007.

This document amends Clauses 2, 6.6, 13.3.3.9, D.1 and D.4.1 of EN 13480-3:2002.

This document contains informative Annex P to be added to EN 13480-3:2002.

This document includes the text of the amendment itself. The corrected pages of EN 13480-3 are delivered as Issue 8 of the standard.

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.

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2 Normative references

Add the date of publication for the following references to read the following:

EN 287-1:2004, *Qualification test of welders — Fusion welding — Part 1: Steels*

EN 1591-1:2001, *Flanges and their joints — Design rules for gasketed circular flange connections — Part 1: Calculation method*

EN 12953-3:2002, *Shell boilers — Part 3: Design and calculation for pressure parts* EN 13480-1:2002, *Metallic industrial piping — Part 1: General*

EN 13480-1:2002, *Metallic industrial piping — Part 1: General*

EN 13480-2:2002, *Metallic industrial piping — Part 2: Materials*

Add the following references:

EN 288 (all parts), *Specification and approval of welding procedures for metallic materials*

ENV 1591-2:2001, *Flanges and their joints — Design rules for gasketed circular flange connections — Part 2: Gasket parameters*

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Replace 6.6 of EN 13480-3:2002 with the following:

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6.6 Bolted flange connections

The design of flanges other than flat face flanges shall be performed in accordance with the following:

— if a standard flange is specified in a European Standard, and no further requirement is given, the flange shall be selected by means of the P/T rating;

— if a non-standard flange is used, the design shall be done by applying the calculation method in EN 1591-1, using for example Annex P, or by applying the algorithm shown in the Taylor-Forge method.

If there is a specific requirement on tightness for the flange connection, this shall be calculated in accordance with EN 1591-1, using Annex P.

Allowable stresses for bolts shall be in accordance with Annex D.

The designer shall consider section loadings caused by the connected piping system.

NOTE 1 The Taylor-Forge method does not ensure tightness.

NOTE 2 The algorithm given in EN 1591-1 includes a consideration of section loadings.

NOTE 3 The bolt torque should be specified by the designer.

NOTE 4 Attention should be paid in such cases to the method of tightening. Guidance of scatter band when applying the different methods of tightening are given in EN 1591-1.

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Replace 13.3.3.9 of EN 13480-3:2002 with the following:

13.3.3.9 The dimensioning of intermediate or secondary steelwork supplied for supporting the pipe shall be based on good industrial practice as defined in ENV 1993.

Replace D.1 of EN 13480-3:2002 with the following:

D.1 Purpose

This annex gives requirements for the design of circular bolted flange connections. Flanges with full face and narrow face gaskets, subject to internal and external pressure are included, as are reverse flanges and seal welded flanges. The requirements provided in this clause are based on the well established Taylor Forge rules.

Replace D.4.1 of EN 13480-3:2002 by the following:

D.4.1 Introduction

Circular bolted flanged connections, either sealed with a gasket or seal welded, used in the construction of vessels to this European Standard shall conform to either:

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— an appropriate European Standard for pipework flanges, and the requirements of D.4.2, or

— the requirements for bolted flanged connections specified in this clause.

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Alternative rules for bolted flanges connections are given in Annex P.

Both flanges of a mating pair shall be designed to the same standard or set of requirements. This applies when one of the pair is a bolted flat end or cover. The requirements for bolted flat ends in Clause 10 and bolted domed ends in Clause 12 are considered part of the same set of requirements as this clause.

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Annex P
(informative)

Bolted flange connections – Application of EN 1591

P.1 Introduction

According to EN 13480-3, two methods may be used to check bolted connections:

— the Taylor Forge method and

— the procedure detailed in EN 1591-1 and ENV 1591-2.

However, the proper application of this European Standard to bolted connections in the field of piping requires additional explanations.

The following two parts of European Standard EN 1591, based on German developments, define an analytical procedure for the design of bolted flange connections with gasket:

— EN 1591-1, *Flanges and their joints — Design rules for gasketed circular flange connections — Part 1: Calculation method*;

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— ENV 1591-2, *Flanges and their joints — Design rules for gasketed circular flange connections — Part 2: Gasket parameters*.

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This procedure allows the verification of the connection taking account of strength criteria and tightness criteria.

The parameters taken into account are as follows:

— fluid pressure;

— mechanical strength of flange, bolting and gasket;

— gasket coefficients;

— bolt nominal loads

and, other than the Taylor-Forge method (see EN 13480-3:2002, 6.6), the following additional factors:

— operating conditions and specifically creep/relaxation behaviour;

— dispersions due to initial tightening where relevant;

— variations of gasket loading due to the deformation of the different components of the connection;

— effects of the connected shell or piping;

— effects of external axial forces and moments;

— effects of temperature difference between bolts and flanges.

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P.2 Scope

P.2.1 General

This procedure shall apply to the following arrangements:

— two circular flanges (identical or different);

— four identical bolts, as a minimum, regularly spaced;

— a circular gasket entirely within the circle enclosed by the bolt holes.

The procedure does not apply to metal-metal connections.

P.2.2 Materials

Bolt and flange materials shall conform to the requirements of EN 13480-2 regarding ductility properties. Where these requirements are not fulfilled, lower nominal design stress shall be used.

P.2.3 Loadings

The following loadings are taken into account in this procedure:

— internal and external fluid pressure;

— external loads: axial forces and bending moments (equivalent axial load);

— thermal expansion of flanges, bolts and gasket.

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P.2.4 Assumptions

P.2.4.1 The deformations of the cross-section of the plate are not taken into account. Only the rotation of the cross-section is considered.

P.2.4.2 The plate of an integral flange is connected to a cylindrical shell or to an equivalent cylindrical shell (conical or spherical shell).

P.2.4.3 The effective width b_{Ge} of contact between the gasket and the flanges may be less than the actual width of the gasket. This effective width shall be calculated for seating condition and considered as constant for all other conditions.

P.2.4.4 The modulus of elasticity E_G of the gasket is a function of the applied compressive stress.

P.2.4.5 Creep behaviour of the gasket is taken into account using the factor P_{QR}.

P.2.4.6 The thermal and mechanical deformations of flanges, bolts and gasket are considered.

P.2.4.7 External moments are taken into account as equivalent axial bolt loads.

P.2.4.8 Transitions between a condition to another lead to variations of bolt and gasket loads.

P.2.4.9 Acceptance of component loadings is based on limit analysis which covers failure by gross plastic deformation.

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P.2.4.10 The following is not taken into account or covered by the procedure:

— bending stiffness of bolts;

— creep of flanges and bolts except through nominal design stress and thermal expansion factors;

— external torsion moments and external shear loads.

P.3 Application of EN 1591

P.3.1 Calculations

The minimum tightening load for the required tightening of bolts shall be calculated by successive iterations.

Internal loads due to initial tightening shall be calculated for each condition (initial tightening, proof test condition and operating conditions) and combined with external loads.

Safety factors shall be those defined by EN 13480-3:2002, Clause 5. However for seating condition, factor for strength test condition shall apply.

P.3.2 Gasket coefficients

The recommended gaskets for industrial piping are given in Table P.1.

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NOTE 1 For more information the gasket manufacturer should be contacted.

NOTE 2 Legend of tables:

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— NA: not applicable;

— ND: not defined.

Gasket reference: Example: 1-09-101-1:

— 1-09 = see Table P.2;

— 101-1 = joint origin (manufacturer or other).

P.3.2.1 Gasket maximum allowable stress Q_{smax}.

The coefficients determined according to EN 13555 are given in Table P.2 to Table P.29 (room temperature and operating temperature).

In these tables:

— P is the test pressure in the sample;

— S_{ai} is the gasket pressure.

P.3.2.2 Minimum stress Q_{minL} to be applied at room temperature (seating condition) in order to fulfil the requirements regarding leak tightness class for the fluid under consideration.

The values determined according to EN 13555 (Helium tightness test at room temperature) are given in Table P.2 to Table P.29.

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NOTE In Tables P.3 to P.29, Q_{minL} is given in MPa.

P.3.2.3 Minimum stress Q_{sminL} to be applied at room temperature (operating conditions) in order to fulfil the requirements regarding leak tightness class for the fluid under consideration.

The values determined according to EN 13555 (Helium tightness test at room temperature) are given in Table P.2 to Table P.29.

NOTE In Tables P.3 to P.29, Q_{sminL} is given in MPa.

P.3.2.4 Modulus of elasticity

E_{G} is the modulus of elasticity when compression is released and for a maximal stress equal to Q_0.

P.3.2.5 Creep/relaxation parameter

The parameter P_{QR} is given in Table P.2 to Table P.29. This parameter is used instead of the previous creep factor called g_{c} where permitted by the next revision of EN 1591-1.

P.3.3 Tightening

The initial tightening shall be greater than the minimum tightening required at room temperature to comply to the requirements of the tightness class for the fluid and pressure considered.

However this tightening shall not lead to a gasket stress greater than the allowable value at room temperature.

In addition, calculations shall take into account the tolerances on tightening due to tightening procedure and the used equipment.

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Table P.1 – Recommended gaskets for industrial piping

Gasket type	EN 1514 c (PN flanges)	EN 12560 (CLASS Flanges)	Chemical compatibility	Maximum temperature	Maximum internal fluid pressure (bar)	PN max (EN 1514)	CLASS max (EN 12560)	Surface finish (Ra)
Fibre	1514-1	12560-1	All fluids (to be used carefully for steam: risk of hydrolysis)	250 °C	50	63	900	3,2 µm to 12,5 µm
Graphite	1514-1	12560-1	Risk of oxidation	350 °C (in oxidant environment) 550 °C with inhibitor or non oxidant environment	50	63	900	3,2 µm to 12,5 µm
PTFE	1514-1	12560-1	All fluids	Pure PTFE: 120 °C Modified PTFE 225 °C	50	63	900	3,2 µm to 12,5 µm
Spiral wound gasket	1514-2	12560-2	Depending on insert, spiral and ring materials (risk of oxidation with graphite insert)	> 600 °C (vermiculite insert) 600 °C (graphite insert) 250 °C (PTFE insert)	400	100 (with internal ring	900 (without internal ring) 2500 (with internal ring)	12,5 µm for P < 12 bar 6,4 µm for P > 20 bar 3,2 µm for hard conditions 1,6 µm for vacuum
Kammprofil	1514-6	12560-6	Depending on internal and covering materials (risk of oxidation with graphite covering)	600 °C (may be limited to 260 °C, by a PTFE covering for example)	400	100	2500	3,2 µm to 6,4 µm 1,6 µm for vacuum
Metal jacketed	1514-4 (Metal jacketed) 1514-7 (Covered metal jacketed)	12560-4 (Metal jacketed) 12560-7 (Covered metal jacketed)	Most of industrial fluids	Depending on covering	> 400	100	2500	0,8 µm to 3,2 µm (not covered) 1,6 µm to 12,5 µm (covered)
Solid metal	1514-4	12560-5 (RTJ) 12560-4 (Flat metallic gaskets)	Depending on material	High	500	100	2500	1,6 µm
Ring joint			Depending on material	Depending on material	> 400			1,6 µm
Expanded graphite			All fluids	600 °C	500			1,6 to 6,4 µm

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Table P.2 – Gasket type code

Classification from EN 1514	Gasket type	Gasket family (ENV 1591-2)	ENV 1591-2 Table	Table of this European Standard
EN 1514-1	Modified PTFE	Non metallic flat gasket	1	P.5 and P.6
EN 1514-1	Non-asbestos fibre (aramid/glass)	Non metallic flat gasket	1	P.3
EN 1514-1	Expanded graphite with perforated metal insertion	Non metallic flat gasket	1	P.4
EN 1514-2	Standard spiral wound gasket with external ring	Spiral wound gasket	3	P.9
EN 1514-2	Standard spiral wound gasket with internal and external rings	Spiral wound gasket	3	P.8
EN 1514-2	Low stress spiral wound gasket with internal and external rings	Spiral wound gasket	3	P.7
EN 1514-4	Metal jacketed with graphite filler and stainless steel shell	Metal jacketed gasket	6	P.12
EN 1514-4	Corrugated inlaid gasket (graphite/stainless steel)	Non metallic flat gasket	7	P.11
EN 1514-6	Kammprofile gasket for use with steel flanges (graphite/stainless steel)	Grooved steel gasket with soft layers on both sides	2	P.10
EN 1514-7	Covered metal jacketed (graphite/graphite/stainless steel)	Covered metal jacketed gasket	5	P.13
EN 1514-1	Expanded graphite with metallic sheets laminated in thin layers withstanding high stresses	Flat gasket with metal insertion	1	P.14, P.27
EN 1514-1	Modified PTFE sheet material	Non metallic flat gasket	1	P.15, P.17, P.23
EN 1514-1	Non-asbestos fibre with binder $e_G \geq 1$ mm	Non metallic flat gasket	1	P.16, P.18, P.19, P.22
EN 1514-1	Expanded graphite with adhesive perforated metal insertion	Flat gasket with metal insertion	1	P.20
EN 1514-2	PTFE Standard spiral wound gasket with inner and outer support ring	Spiral wound gasket	3	P.24
EN 1514-3	PTFE envelope gasket	PTFE envelope gasket	1	P.28
EN 1514-4	Metal jacketed gasket with graphite	Metal jacketed gasket	6	P.26
EN 1514-4	Corrugated gasket with graphite	Corrugated gasket	7	P.29
EN 1514-4	Expanded graphite with metallic sheets laminated in thin layers withstanding high stresses	Flat gasket with metal insertion	1	P.14, P.27
EN 1514-6	Kammprofile gasket with bonded graphite layers	Grooved steel gasket with soft layers on both sides	2	P.21
EN 1514-7	Covered metal jacketed gasket with graphite (outer ring)	Covered metal jacketed gasket	5	P.25

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Table P.3 – Gasket 1-09-101-1 – Non-asbestos fibre (aramid/glass) $e_G \geq 1$ mm

Gasket coefficients from mechanical tests

Coefficient	Temperature	Values
Q_{smax}	Room	150 MPa
	200 °C	60 MPa
	250 °C	50 MPa
g_C (for a simulated stiffness of 500 kN/mm)	Room	Initial load: 150 MPa Average for g_c: 0,72
	200 °C	Initial load: 60 MPa Average for g_c: 0,29
	250 °C	Initial load: 50 MPa Average for g_c: 0,28
P_{QR} (for a simulated stiffness of 500 kN/mm)	Room	Initial load: 150 MPa Average for P_{QR}: 0,985
	200 °C	Initial load: 60 MPa Average for P_{QR}: 0,805
	250 °C	Initial load: 50 MPa Average for P_{QR}: 0,775

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Q_0	E_G		
	Room	**200 °C**	**250 °C**
20 MPa	979 MPa	4 898 MPa	3 731 MPa
30 MPa	1 414 MPa		
40 MPa	2 153 MPa	4 990 MPa	4 159 MPa
50 MPa	2 972 MPa		
60 MPa	4 182 MPa	6 023 MPa	4 024 MPa
80 MPa	8 412 MPa		
100 MPa	15 159 MPa		
120 MPa	26 392 MPa		
140 MPa	40 379 MPa		

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Table P.3 (*concluded*)

Class of tightness from tightness tests

P = 10 bar – “Simplified test” values		
Tighness Class	Q_{minL}	S_{a1}=320 MPa
		$Q_{sminL,Sa1}$
High tightness	15,5	10
Very high tightness	60	10

P = 40 bar – Average of “full tests” values							
Tighness Class	Q_{minL}	S_{a1} = 20 MPa	S_{a2} = 40 MPa	S_{a3} = 60 MPa	S_{a4} = 80 MPa	S_{a5} = 105 MPa	S_{a6} = 160 MPa
		$Q_{sminL,Sa1}$	$Q_{sminL,Sa2}$	$Q_{sminL,Sa3}$	$Q_{sminL,Sa4}$	$Q_{sminL,Sa5}$	$Q_{sminL,Sa6}$
Normal	11,6	10	10	10	10	10	10
High tightness	34,5	NA	10	10	10	10	10
Very high tightness	81	NA	NA	NA	40	33	17

P = 80 bar – Average of “full test” and “simplified test” values							
Tighness Class	Q_{minL}	S_{a1}= 20 MPa	S_{a2} = 40 MPa	S_{a3}= 60 MPa	S_{a4}= 80 MPa	S_{a5}= 105 MPa	S_{a6}= 160 MPa
		$Q_{sminL,Sa1}$	$Q_{sminL,Sa2}$	$Q_{sminL,Sa3}$	$Q_{sminL,Sa4}$	$Q_{sminL,Sa5}$	$Q_{sminL,Sa6}$
Normal	10	10	10	10	10	10	10
High tightness	43	NA	10	10	10	10	10
Very high tightness	95	NA	NA	NA	NA	38	19,4

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