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Butt-welding pipe fittings - Part 4: Wrought austenitic and austenitic-ferritic (duplex) stainless steels with specific inspection requirements

Formstücke zum Einschweißen - Teil 4: Austenitische und austenitischferritisch nichtrostende Stähle mit besonderen Prüfanforderungen

This draft European Standard is submitted to CEN members for enquiry. It has been drawn up by the Technical Committee ECISS/TC 29.

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

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Contents

Foreword

This document (prEN 10253-4) has been prepared by Technical Committee CEN/TC ECISS/TC 29 “Steel tubes and fittings for steel tubes”, the secretariat of which is held by UNI.

This document is currently submitted to the CEN Enquiry.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

For relationship with EU Directive(s), see informative annex ZA, which is an integral part of this document.

EN 10253 comprises a series of European Standards about *Butt-welding pipe fittings*, namely:

— *Part 1: Wrought carbon steel for general use and without specific inspection requirements*

— *Part 2: Wrought carbon and ferritic alloy steels with specific inspection requirements*

— *Part 3: Wrought austenitic and austenitic-ferritic (duplex) stainless steels without specific inspection requirements*

— *Part 4: Wrought austenitic and austenitic-ferritic (duplex) stainless steels with specific inspection requirements*

In writing this European Standard the competent committee recognized that there are two broad types of products commonly used for stainless steels, and decided to reflect these in the standard by differentiating between two parts.

Firstly the committee recognized the need to provide a basic type in which the minimum wall thickness of the fitting is guaranteed without formal reference to the pressure resistance. This type is considered in Part 3 and includes products not intended to be used in applications covered by the Pressure Equipment Directive (97/23/EC).

Secondly the application standards for the Pressure Equipment Directive will require that the fitting is designed to withstand a defined resistance to internal pressure. This approach imposes enhanced requirements that are considered in Part 4.

Annex A (informative) gives information about specific dimensions of fittings and Annex D (informative) indicates preferred inside diameters and wall thicknesses.

For fittings specified in accordance with this EN 10253-4, the resistance to internal pressure of the fitting may be determined by calculation. Annex B (informative) gives information about the calculation.

For some wall thickness series Annex C (informative) lists wall thickness values for the body of the fittings so that the fitting will, in general, withstand the same pressure as a straight pipe with the same nominal dimensions.

The selection of steel type and requirement level depend on many factors ; the properties of the fluid to be conveyed, the service conditions, the design code and any statutory requirements should all be taken into consideration. Therefore this standard gives no detailed guidelines for the application of different parts. It is the ultimate responsibility of the user to select the appropriate part for the intended application.

1 Scope

1.1 This Part of EN 10253 specifies the technical delivery requirements for seamless and welded butt-welding fittings (elbows, concentric and eccentric reducers, equal and reducing tees, caps) made of austenitic and austenitic-ferritic (duplex) stainless steel which are applied for pressure and corrosion resisting purposes at room temperature, at low temperature or at elevated temperatures.

It specifies:

— the type of fittings;

  — type A : Butt-welding fittings with reduced pressure factor;

  — type B : Butt-welding fittings for use at full service pressure;

— the steel grades;

— the mechanical properties;

— the dimensions and tolerances;

— the requirements for inspection and testing;

— the inspection documents;

— the marking;

— the handling and packaging.

1.2 Unless otherwise specified in this Part of EN 10253 the general technical delivery requirements in EN 10021 apply.

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.

EN 287-1, *Approval testing of welders – Fusion welding – Part 1 : Steels.*

EN 288-1*, Specification and qualification of welding procedures for metallic materials – Part 1: General rules for fusion welding.*

EN 288-3, *Specification and approval of welding procedures for metallic material – Part 3: Welding procedure tests for the arc welding of steels.*

EN 473, *Qualification and certification of NDT personnel – General principles.*

EN 910, *Destructive tests on weld in metallic materials – Bend test*

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 10002–1, *Metallic materials – Tensile testing – Part 1: Method of test (at ambient temperature).*

EN 10002–5, *Metallic materials – Tensile testing – Part 5: Method of test (at elevated temperatures).*

EN 10020, *Definitions and classification of grades of steel.*

EN 10021, *General technical delivery requirements for steel and iron products.*

EN 10027–1, *Designation systems for steel – Part 1: Steel names, principal symbols.*

EN 10027–2, *Designation systems for steel – Part 2: Numerical system.*

EN 10028-7, *Flat products made of steels for pressure purposes – Part 7: Stainless steels.*

EN 10045–1, *Metallic materials – Charpy impact test – Part 1: Method of test.*

EN 10052, *Vocabulary of heat treatment terms for ferrous products.*

EN 10079, *Definitions of steel products.*

EN 10088–1, *Stainless steels – Part 1: List of stainless steel.*

EN 10088-2, *Stainless steels – Part 2: Technical delivery conditions for sheet/plate and strip for general purposes.*

EN 10204, *Metallic products – Types of inspection documents.*

EN 10216-5, *Seamless steel tubes for pressure purposes –- Technical delivery conditions – Part 5 : Stainless steel tubes.*

EN 10217-7, *Welded steel tubes for pressure purposes – Technical delivery conditions – Part 7: Stainless steel tubes.*

EN 10234, *Metallic materials – Tube – Drift expanding test.*

EN 10266, *Steel tubes and fittings and structural hollow sections – Definitions and symbols for use in product standards.*

EN 10272, *Stainless steel bars for pressure purposes.*

EN 13445-3, *Unfired pressure vessels – Part 3: Design.*

EN 13480-3, *Metallic industrial piping – Part 3: Design and calculation.*

EN ISO 377, *Steel and steel products – Location of samples and test pieces for mechanical testing (ISO377:1999*).

EN ISO 1127, *Stainless steel tubes – Dimensions, tolerances and conventional masses per unit length.*

EN ISO 2566-1, *Steel - Conversion of elongation values – Part 1: Carbon and low alloy steels.*

EN ISO 3651-2, *Determination of resistance to intergranular corrosion – Stainless steels – Part 2: Ferritic, austenitic and austenitic-ferritic stainless steels – Corrosion test in media containing sulfuric acid.*

EN ISO 6708, *Pipework components – Definition and selection of DN (nominal size).*

ISO 3419, *Non-alloy and alloy steel butt-welding fittings.*

ISO 5251, *Stainless steel butt-welding fittings.*

ISO 14284, *Iron and steel products – Sampling and preparation of samples for the determination of the chemical composition.*

CR 10260, *Designation system for steel – Additional symbols.*

3 Terms and definitions

For the purpose of this European Standard, the relevant definitions in EN 10020, EN 10021, EN 10052, EN 10079 and EN ISO 377 apply, except as defined below.

3.1
type
for elbows and return bend, the type defines the bending radius of the piece

3.2
welded fitting

3.2.1
fittings made from welded tubes

3.2.2
fittings made from sheet/plate or strip where welding is a part of the fabrication

3.3
purchaser
person or organisation that orders products in accordance with this standard. The purchaser is not necessarily, but may be, a manufacturer of pressure equipment in accordance with the EU Directive listed in Annex ZA. Where a purchaser has responsibilities under this EU Directive, this standard will provide a presumption of conformity with the essential requirements of the Directive so identified in Annex ZA

3.4
employer
organisation for which a person works on a regular basis. The employer may be either the fitting manufacturer or supplier or a third party organisation providing a service, e.g. NDT

4 Symbols

For the purpose of this European Standard, the symbols of EN 10266 and the following apply:

DN, DN 1	Conventional dimension used in piping ; non measurable value (See EN ISO 6708) ;
D	Specified outside diameter for elbows, return ends, equal tees, caps and the major outside diameter for reducers and reducing tees, expressed in millimetres;
D1	Specified minor outside diameter for reducers and reducing tees, expressed in millimetres;
T	Specified wall thickness at the welding ends for elbows, return bends and equal tees or on the D end for reducers and reducing tees, expressed in millimetres;
T1	Specified wall thickness on the D_1 welding end of reducers and reducing tees, expressed in millimetres

ID	Internal diameter at the welding ends of elbows, return bends, equal tees and at the major welding end of reducers and reducing tees (ID = D -2T);
ID1	Internal diameter at the minor welding end of reducers and reducing tees ($ID_1 = D_1 – 2T_1$);
C	Centre to centre distance for return bends (C=2R), expressed in millimetres;
B	Back to face distance for return bends, expressed in millimetres;
F	Distance from the axis of the branch outlet to the face of the centre body of tees, expressed in millimetres;
G	Distance from the axis of the centre line to the face of the branch outlet of reducing tees, expressed in millimetres;
H	Height of the straight part of dished ends, expressed in millimetres
H	Face to centre distance for 45° elbows, expressed in millimetres
K_2	Total height for caps, expressed in millimetres;
L	Face to face distance for reducers, expressed in millimetres;
X	Tolerance on the form of fittings;
R	Bending radius of elbows and return bends, expressed in millimetres;
R_m	Tensile strength at room temperature, expressed in megapascals;
$R_{p0,2}$	Minimum 0,2 % proof strength at room temperature, expressed in megapascals;
$R_{p1,0}$	Minimum 1,0 % proof strength at room temperature, expressed in megapascals;
A	Percentage of elongation at rupture, with reference to gauge length of 5,65 $\sqrt{S_o}$;
HB	Brinell hardness;
W0	Welded from hot or cold rolled plate, sheet or strip 1 D, 2 D, 2 E, 2 B (Symbols of flat products according to EN 10088-2);
W 1	Welded from hot rolled plate, sheet or strip 1 D, descaled;
W2	Welded from cold rolled plate, sheet or strip 2 D, 2 E and 2 B, descaled.

5 Classification of grades and designation

5.1 Classification of grades

Steels covered in this European Standard are classified according to their structure into:

— austenitic steels;

— austenitic–ferritic (duplex) steels.

For more details see EN 10088 – 1.

5.2 Designation

For the fittings covered by this European Standard the designation shall consist of:

— the number of this European Standard (EN 10253-4)

plus either :

— the steel name in accordance with EN 10027-1 and CR 10260;

or :

— the steel number allocated in accordance with EN 10027-2.

6 Information to be supplied by the purchaser

6.1 Mandatory information

6.1.1 Designation of fittings

Fittings may be designated by their outside diameter D (and D_1) or by their inside diameter ID (and ID_1).

6.1.1.1 Elbows and return bends

Elbows and return bends are designated by the type, the angle and the diameter (D or ID).

Types of elbows designated by their outside diameter D are:

R ~ 1 D, R ~ 1,5 D and R ~ 2,5 D.

Types of elbows designated by their inside diameter ID are :

R ~ ID+ 100, R ~ 1,5 ID and R ~ 3 ID.

6.1.1.2 Reducers

The reducers are designated by the type (concentric or eccentric), the major diameter (D or ID) and the minor diameter (D_1 or ID_1).

6.1.1.3 Tees

The equal tees are designated by the diameter (D or ID).

The reducing tees are designated by the major diameter (D or ID), the minor diameter (D_1 or ID_1).

6.1.1.4 Caps

The caps are designated by the diameter (D or ID).

6.1.2 Information

The following information shall be supplied by the purchaser at the time of enquiry and order:

a) the quantity required (number of pieces);

b) designation of fittings (see 5.1.1) and the wall thickness T(T_1);

c) the designation of the steel grade according to this European Standard;

d) reference to this European Standard;

e) type of fitting, A or B.

6.2 Options

A number of options are specified in this European Standard and these are listed below. In the event that the purchaser does not indicate a wish to implement any of these options at the time of enquiry and order, the fittings shall be supplied in accordance with the basic specification (see 5.1).

1) steelmaking process (see 7.1);

2) method of manufacture of the fitting (see 7.2.);

3) starting product form and /or delivery condition (see 7.2.1);

4) heat treatment of the fittings (see 7.2.3.1);

5) product analysis (see 8.2.2);

6) verification of impact properties at room temperature (see 8.3.1);

7) agreed mechanical properties at room temperature for austenitic stainless steel fittings with wall thicknesses greater than 60 mm (see table 6);

8) verification of tensile properties at elevated temperature (see 8.3.2);

9) verification of impact properties at low temperature (see 8.3.3);

10) pickling (see 9.9);

11) shot blasting or bright annealing (see 9.9);

12) pickling and passivation (see 9.9);

13) specific dimensions of fittings according to Annex A (see 10.1.2);

14) fittings are ordered with tolerance class D 3 or D 4 (see table 8);

15) type of inspection document other than the standard document (see 11.2.1);

16) special test size units (see table 10);

17) verification of impact properties transverse to the weld (see 12.2.2.6);

18) liquid penetrant of weld and weld ends (see 13.9.2);

19) liquid penetrant of surfaces (see 13.9.2);

20) ultrasonic testing of strip or plates (see 13.9.2);

21) additional marking (see 14.1);

22) special packaging (see 15).

6.3 Examples of an order

6.3.1 Example 1

1000 elbows in accordance with this European Standard of type 3D with angle 90° and dimensions 60,3 X 2,9 not having an increased wall thickness of the body of the fitting and with a bending radius according to Annex A made of steel grade 1.4436.

1000 elbows – EN 10253-4 – A – type 3D – 90° – 60,3 X 2,9 – 1.4436 – option 13.

6.3.2 Example 2

2000 concentric reducers in accordance with this European Standard of form 2 with dimensions 219,1 X 6,3 – 139,7 X 4,0 with an increased wall thickness of the body of the fitting and with a length according to Annex A made of steel grade X2CrNi19-11.

2000 concentric reducers – EN 10253-4 – B – 219,1 X 6,3 – 139,7 X 4,0 – X2CrNi19-11 – option 13.

6.3.3 Example 3

3000 equal tees in accordance with this European Standard with dimension ID 40.0 x 2.0 made of steel grade 1.4301 with their surface pickled.

3000 equal tees – EN 10253-4 – A – ID 40.0 x 2.0 – 1.4301 – option 10

7 Resistance to internal pressure

7.1 General

The Pressure Equipment Directive (Dir. 97/23/EC – Annex I – subclause 2.2.2) imposes that the design for adequate strength be based on a calculation method.

The resistance to internal pressure of a fitting conforming to this European Standard shall be determined according to the relevant design rules laid down in e.g. EN 13480-3 or EN 13445-3.

The selection of the appropriate fitting (material, thickness) is the ultimate responsibility of the manufacturer of the pressure equipment.

7.2 Fittings of type A

Fittings of type A have the same wall thickness at the welding ends and on the body of the fitting. Their resistance to internal pressure is less than that of a pipe with the same specified diameter, wall thickness and of the same steel grade.

For elbows the wall thickness at the extrados may be 25 % less than the nominal wall thickness.

For reducers the wall thickness at the conical section shall be the specified wall thickness at the mayor end.

7.3 Fittings of type B

Fittings of type B have increased wall thickness at the body of the fitting. They will, in general, withstand the same pressure as a pipe with the same specified diameter, wall thickness and of the same steel grade.

Wall thickness requirements of this type of fittings are defined by the calculation procedures given in Annex B. For some preferred, specified wall thicknesses the resulting wall thicknesses at the body of the fitting are listed in the tables given in Annex C.

8 Manufacturing process

8.1 Steelmaking process

The steelmaking process is left at the discretion of the manufacturer.

Option 1: *The purchaser shall be informed about the steelmaking process used. The process shall be reported in the inspection document.*

8.2 Product making process for fittings and heat treatment

8.2.1 Product making process

The different allowed processes and the relevant starting product forms are listed in Table 1. The method of manufacturing is left at the discretion of the manufacturer.

The product making process shall be so applied that it will not produce injurious imperfections in the fittings.

Where tubes are used as starting material, following conditions shall apply:

— the choice of the tubes (seamless or welded) is left at the discretion of the manufacturer;

— when manufacturing fittings from tubes, tubes according to EN 10216-5 (seamless) and EN 10217–7 (welded) shall be used. Tubes marked "C1" and/or " C2" are not allowed.

Where plate/strip are used as starting material, the following conditions shall apply.

— when manufacturing fittings from plate / strip, plate / strip according to EN 10028-7 shall be used.

Where bars are used as starting material, the following conditions shall apply:

— when manufacturing fittings from bars, bars according to EN 10272 shall be used.

Table 1 — Product making process – Starting product forms [a]

Process	Hot deformation			Cold deformation		
	Bending [b]	Pressed in die [c]	Rolled, forged followed by machining	Bending [b]	Pressed in die [c]	Machining from round bars (DN < 50)
Elbows	1, 2, 4, 5	1, 2, 3, 4, 5	-	1, 2, 4, 5	1, 2, 3, 4, 5	-
Tees	-	1, 2, 3, 4, 5	4, 5	-	1, 2, 3, 4, 5	-
Reducers	-	1, 2, 3, 4, 5	4, 5	-	1, 2, 3, 4, 5	5
Caps	-	1, 2, 3, 4, 5	4, 5	-	1, 2, 3, 4, 5	5

[a] Starting material

1 Seamless pipe
2 Welded pipe (v= 1,0)
3 Plate and strip
4 Forging
5 Bar

[b] When producing elbows from welded pipe, the position of the weld is at the discretion of the manufacturer.

[c] For these processes welding with or without filler metal may be used. When filler metal is used it shall be compatible with the parent metal.

Option 2: *The method of manufacturing and/or details of the manufacturing process, e.g. welding operations or position of the weld before forming shall be as specified on the purchase order.*

Option 3: *The starting product form to be used and/or its delivery condition shall be as specified on the purchase order.*

8.2.2 Welding

When producing fittings from plate or strip, welding is considered being a part of the manufacturing of fittings, the following criteria's is valid:

— welding process/procedures shall be qualified in accordance with EN 288–3;

— welders and/or welding operators shall be qualified in accordance with EN 287-1 and/or EN 1418.

All welds carried out during the manufacture of the fitting shall be fusion weld type. All welds shall have complete penetration.

Local repair of weld seam which have been made with filler metal is permitted provided that the repair procedure/welders are qualified in accordance with the relevant part of the above mentioned standards.

If heat treatment is required, the repair welding shall be carried out in advance.

8.2.2.1 Finished joint requirement

As welded surfaces are permitted provided the surface imperfections permit proper interpretation of radiographic or other non-destructive examination.

A reduction in thickness due to the welding process is acceptable provided that the material of the joining surfaces shall not be reduced below minimum required thickness at any point.

Concavity due to the welding process on the root side of a single welded joint is permitted when the resulting thickness of the weld is at least equal to the minimum thickness of the thinner part of the parts being joined and the contour of the concavity is smooth.

The height of the reinforcement on each face of the weld shall not exceed the values specified in Table 2.

Table 2 — Height of reinforcement

Dimensions in millimetres

Base metal thickness (T)	Reinforcement
$T < 2,5$	1,0
$2,5 \leq T \leq 5,0$	1,5
$5,0 < T \leq 10,0$	2,0
$10,0 < T \leq 25,0$	2,5
$25,0 < T \leq 50,0$	3,5

8.2.3 Heat treatment

8.2.3.1 Cold forming

Fittings, produced from solution – annealed and quenched or stabilised materials using cold forming as manufacturing method, do not require heat treatment afterwards, if in the case of austenitic steels with required minimum values for elongation $A_5 \geq 30$ %, a 15 % level of cold deformation is not exceeded on the base material or if evidence is supplied that there is a minimum post cold-forming residual elongation A_5 of 15 %.

If heat treatment still will be demanded, this shall be agreed at the time of enquiry and order.

Option 4: *Heat treatment of the fittings shall be carried out.*

8.2.3.2 Hot forming

Fittings manufactured by hot forming shall be solution annealed.

9 Technical requirements

9.1 General

Fittings supplied and inspected in accordance with clauses 7, 11 and 12, shall comply with the requirements of this Part of EN 10253.

In addition to the requirements of this Part of EN 10253, the general technical delivery requirements specified in EN 10021 shall apply.

9.2 Chemical composition

9.2.1 Cast analysis

The cast analysis reported by the steel manufacturer shall apply and comply with the requirements of Table 3 for austenitic steels and of Table 4 for austenitic-ferritic steels.

9.2.2 Product analysis

Option 5: *A product analysis shall be supplied.*

Table 5 specifies the permissible deviations of the product analysis from the specified cast analysis given in Tables 3 and 4.

Table 3 — Chemical composition (cast analysis)[a] of austenitic stainless steels, in % by mass

Steel grade		C	Si	Mn	P	S	N	Cr	Cu	Mo	Nb	Ni	Ti	Others
Steel name	Steel number	max	max	max	max	max								
X2CrNi18-9	1.4307	0,030	1,00	2,00	0,045[b]	0,015[b]	≤ 0,11	17,50-19,50	_	_	_	8,00-10,00	_	_
X2CrNi19-11	1.4306	0,030	1,00	2,00	0,045[b]	0,015[b]	≤ 0,11	18,00-20,00	_	_	_	10,00-12,00	_	_
X2CrNiN18-10	1.4311	0,030	1,00	2,00	0,045[b]	0,015[b]	0,12-0,22	17,00-19,50	_	_	_	8,50-11,50	_	_
X5CrNi18-10	1.4301	0,07	1,00	2,00	0,045[b]	0,015[b]	≤ 0,11	17,00-19,50	_	_	_	8,00-10,50	_	_
X6CrNiTi18-10	1.4541	0,08	1,00	2,00	0,045[b]	0,015[b]	_	17,00-19,00	_	_	_	9,00-12,00	5xC-0,70	_
X6CrNiNb18-10	1.4550	0,08	1,00	2,00	0,045[b]	0,015[b]	_	17,00-19,00	_	_	10xC-1,00	9,00-12,00	_	_
X1CrNi25-21	1.4335	0,020	0,25	2,00	0,025	0,010	≤ 0,11	24,00-26,00	_	≤ 0,20	_	20,00-22,00	_	_
X2CrNiMo17-12-2	1.4404	0,030	1,00	2,00	0,045[b]	0,015[b]	≤ 0,11	16,50-18,50	_	2,00-2,50	_	10,00-13,00	_	_
X5CrNiMo17-12-2	1.4401	0,07	1,00	2,00	0,045[b]	0,015[b]	≤ 0,11	16,50-18,50	_	2,00-2,50	_	10,00-13,00	_	_
X6CrNiMoTi17-12-2	1.4571	0,08	1,00	2,00	0,045[b]	0,015[b]	_	16,50-18,50	_	2,00-2,50	_	10,50-13,50	5xC-0,70	_
X2CrNiMo17-12-3	1.4432	0,030	1,00	2,00	0,045[b]	0,015[b]	≤ 0,11	16,50-18,50	_	2,50-3,00	_	10,50-13,00	_	
X2CrNiMoN17-13-3	1.4429	0,030	1,00	2,00	0,045[b]	0,015[b]	0,12-0,22	16,50-18,50	_	2,50-3,00	_	11,00-14,00	_	_
X3CrNiMo17-13-3	1.4436	0,05	1,00	2,00	0,045[b]	0,015[b]	≤ 0,11	16,50-18,50	_	2,50-3,00	_	10,50-13,00	_	_
X2CrNiMo18-14-3	1.4435	0,030	1,00	2,00	0,045[b]	0,015[b]	≤ 0,11	17,00-19,00	_	2,50-3,00	_	12,50-15,00	_	_

"to be continued""

Table 3 *(end)*

Steel grade		C	Si	Mn	P	S	N	Cr	Cu	Mo	Nb	Ni	Ti	Others
Steel name	Steel number	max	max	max	max	max								
X2CrNiMoN17-13-5	1.4439	0,030	1,00	2,00	0,040[b]	0,015[b]	0,12-0,22	16,50-18,50	_	4,00-5,00	_	12,50-14,50	_	_
X2CrNiMo18-15-4	1.4438	0,030	1,00	2,00	0,040[b]	0,015[b]	≤ 0,11	17,50-19,50	_	3,00-4,00	_	13,00-16,00	_	_
X1NiCrMoCu31-27-4	1.4563	0,020	0,70	2,00	0,030	0,010	≤ 0,11	26,00-28,00	0,70-1,50	3,00-4,00	_	30,00-32,00	_	_
X1NiCrMoCu25-20-5	1.4539	0,020	0,70	2,00	0,030	0,010	≤ 0,15	19,00-21,00	1,20-2,00	4,00-5,00	_	24,00-26,00	_	_
X1CrNiMoCuN20-18-7	1.4547	0,020	0,70	1,00	0,030	0,010	0,18-0,25	19,50-20,50	0,50-1,00	6,00-7.00	_	17.50-18,50	_	_
X1NiCrMoCuN25-20-7	1.4529	0,020	0,50	1,00	0,030	0,010	0,15-0,25	19,00-21,00	0,50-1,50	6,00-7,00	_	24,00-26,00	_	_

[a] Elements not listed in this table shall not be intentionally added to the steel without the agreement of the purchaser except for finishing the cast. All appropriate precautions are to be taken to avoid the addition of such elements from scrap and other materials used in production which would impair mechanical properties and the suitability of the steel.

[b] For fittings welded without filler material the sum of sulphur and phosphorus shall be maximum 0,040 %.

Table 4 — Chemical composition (cast analysis)[a] of austenitic-ferritc stainless steels, in % by mass

Steel grade		C	Si	Mn	P	S	N	Cr	Cu	Mo	Ni	Others
Steel name	Steel number	max	max	max	max	max						
X2CrNiMoN22-5-3	1.4462	0,030	1,00	2,00	0,035	0,015	0,10-0,22	21,00-23,00	_	2,50-3,50	4,50-6,50	_
X2CrNiN23-4[b]	1.4362	0,030	1,00	2,00	0,035	0,015	0,05-0,20	22,00-24,00	0,10-0,60	0,10-0,60	3,50-5,50	_
X2CrNiMoN25-7-4[b]	1.4410	0,030	1,00	2,00	0,035	0,015	0,20-0,35	24,00-26,00	_	3,00-4,50	6,00- 8,00	_
X2CrNiMoCuWN25-7-4	1.4501	0,030	1,00	1,00	0,035	0,015	0,20-0,30	24,00-26,00	0,50-1,00	3,00-4,00	6,00-8,00	W 0,50- 1,00
X2CrNiMoCuN25-6-3	1.4507	0,030	0,70	2,00	0,035	0,015	0,15-0,30	24,00-26,00	1,00-2,50	2,70-4,00	5,50-7,50	_

[a] Elements not listed in this table shall not be intentionally added to the steel without the agreement of the purchaser except for finishing the cast. All appropriate precautions are to be taken to avoid the addition of such elements from scrap and other materials used in production which would impair mechanical properties and the suitability of the steel.

[b] Patented steel grade

Table 5 — Permissible deviations of the product analysis from specified limits on cast analysis given in Tables 3 and 4

Element	Limiting value for the cast analysis in accordance width Tables 3 and 4 % by mass	Permissible deviation of the product analysis [a] % by mass
Carbon	≤ 0,030	+ 0,005
	> 0,030 ≤ 0,08	± 0,01
Silicon	≤ 1,00	± 0,05
Manganese	≤ 1,00	+ 0,03
	> 1,00 ≤ 2,00	+0,04
Phosphorus	≤ 0,030	+ 0,003
	> 0,030 to ≤ 0,045	+ 0,005
Sulphur	≤ 0,015	+ 0,003
Nitrogen	≤ 0,35	± 0,01
Chromium	≥ 10,50 ≤ 15,00	± 0,15
	> 15,00 ≤ 20,00	± 0,20
	> 20,00 ≤ 28,00	± 0,25
Copper	≤ 1,00	± 0,07
	> 1,00 ≤ 2,50	± 0,10
Molybdenum	≤ 0,60	± 0,03
	> 0,60 ≤ 1,75	± 0,05
	> 1,75 ≤ 7,00	± 0,10
Niobium	≤ 1,00	± 0,05
Nickel	≤ 1,00	± 0,03
	>1,00 ≤ 5,00	± 0,07
	> 5,00 ≤ 10,00	± 0,10
	> 10,00 ≤ 20,00	± 0,15
	> 20,00 ≤ 32,00	± 0,20
Titanium	≤ 0,70	± 0,05
Tungsten	≤ 1,00	± 0,05

[a] If several product analyses are carried out on one cast, and the contents of an individual element determined lie outside the permissible range of the chemical composition specified for the cast analysis, then it is only allowed to exceed the permissible maximum value or to fall short of the permissible minimum value, but not both for one cast.

9.3 Mechanical properties

9.3.1 At room temperature

The mechanical properties at room temperature of the fittings of this European Standard shall conform to the requirements given in Tables 6 and 7 (see also 7.2.3.1).

Option 6: *Impact test shall be carried out at room temperature (see Tables 6 and 7). For fittings manufactured from welded tubes the location of the test pieces, from the weld or opposite to the weld, shall be agreed at the time of enquiry and order.*

Option 7: *(see Table 6).*

9.3.2 At elevated temperature

The minimum proof strength $R_{p0,2}$ and $R_{p1,0}$ values at elevated temperature are specified in the relevant standard for the starting material dependent on the delivery form being used.

Option 8: *Proof strength $R_{p0,2}$ or $R_{p1,0}$ shall be verified for austenitic steels in Table 6. Proof strength $R_{p0,2}$ shall be verified for austenitic-ferritic steels in Table 7. The temperature for tensile testing shall be agreed at the time of enquiry and order.*

9.3.3 At low temperature

Impact energy values at specified low temperature shall conform to the requirements in Tables 6 and 7.

Option 9*:* *Impact test at low temperature shall be carried out. For fittings manufactured from welded tubes the location of the test pieces, from the weld or opposite to the weld, shall be agreed at the time of enquiry and order.*

Table 6 — Mechanical properties for wall thicknesses up to 60 mm at room temperature and impact properties at – 196 °C of austenitic stainless steels in the solution annealed condition (+AT), heat treatment and information about resistance to intergranular corrosion

Steel grade		Hardness	Tensile properties at room temperature[b]					Impact properties[a]			Reference heat treatment conditions		Resistance to intergranular corrosion		Limit temp.
			Proof strength		Tensile strength[h]	Elongation[c]		Minimum average absorbed energy							
		HB	$R_{p0,2}$ MPa	$R_{p1,0}$ MPa	R_m MPa	A %		KV J			Solution temperature [d]	Cooling in [e]	[f]	Method of EN ISO 3651-2	°C[i]
		max	min	min		min		at RT		at-196 °C					
Steel name	Steel number														
						l	*t*	*l*	*t*	*t*					
X2CrNi18-9	1.4307	200	180	215	470-670	40	35	100	60	60	1000-1100	w, a	yes	A	350
X2CrNi19-11	1.4306	200	180	215	460-680	40	35	100	60	60	1000-1100	w, a	yes	A	350
X2CrNiN18-10	1.4311	210	270	305	550-760	35	30	100	60	60	1000-1100	w, a	yes	A	400
X5CrNi18-10	1.4301	200	195	230	500-700	40	35	100	60	60	1000-1100	w, a	yes[g]	A	300
X6CrNiTi18-10	1.4541	210	200	235	500-730	35	30	100	60	60	1020-1120	w, a	yes	A	400
X6CrNiNb18-10	1.4550	210	205	240	510-740	35	30	100	60	60	1020-1120	w, a	yes	A	400
X1CrNi25-21	1.4335	220	180	210	470-670	45	40	100	60	60	1030-1110	w, a	yes	A	400
X2CrNiMo17-12-2	1.4404	200	190	225	490-690	40	30	100	60	60	1020-1120	w, a	yes	A	400
X5CrNiMo17-12-2	1.4401	200	205	240	510-710	40	30	100	60	60	1020-1120	w, a	yes[g]	A	300
X6CrNiMoTi17-12-2	1.4571	210	210	245	500-730	35	30	100	60	60	1020-1120	w, a	yes	A	400
X2CrNiMo 17-12-3	1.4432	200	190	225	490-690	40	30	100	60	60	1020-1120	w, a	yes	A	400
X2CrNiMoN17-13-3	1.4429	220	295	330	580-800	35	30	100	60	60	1020-1120	w, a	yes	A	400
X3CrNiMo17-13-3	1.4436	200	205	240	510-710	40	30	100	60	60	1020-1120	w, a	yes[g]	A	300
X2CrNMo18-14-3	1.4435	200	190	225	490-690	40	30	100	60	60	1020-1120	w, a	yes	A	400
X2CrNiMoN17-13-5	1.4439	200	285	315	580-800	35	30	100	60	60	1100-1140	w, a	yes	C	400
X2CrNiMo18-15-4	1.4438	200	220	250	490-690	35	30	100	60	60	1100-1160	w, a	yes	C	400
X1CrMoCu31-27-4	1.4563	220	215	245	500-750	40	35	120	90	60	1100-1160	w, a	yes	C	400

"to be continued"

Table 6 *(end)*

Steel grade		Hardness	Tensile properties at room temperature[b]					Impact properties[a]			Reference heat treatment conditions		Resistance to intergranular corrosion		Limit temp.
			Proof strength		Tensile strength[h]	Elongation[c]		Minimum average absorbed energy							
		HB	$R_{p0,2}$ MPa	$R_{p1,0}$ MPa	R_m MPa	A %		KV J			Solution temperature d	Cooling in e	f	Method of EN ISO 3651-2	°C[i]
		max	min	min		min		min							
Steel name	Steel number							at RT		at-196 °C					
						l	*t*	*l*	*t*	*t*					
X1NiCrMoCu25-20-5	1.4539	220	220	250	520-720	35	30	120	90	60	1100-1150	w, a	yes	C	400
X1CrNiMoCuN20-18-7	1.4547	220	300	340	650-850	35	30	100	60	60	1180-1230	w, a	yes	C	400
X1NiCrMoCuN25-20-7	1.4529	220	300	340	600-800	40	40	120	90	60	1120-1180	w, a	yes	C	400

a For wall thicknesses greater than 60 mm the mechanical properties are subject to agreement at the time of enquiry and order. **Option 7:** *Agreed mechanical properties for wall thicknesses greater than 60 mm apply.*

b *l* = longitudinal ; *t* = transverse.

c See also 7.2.3.1.

d The maximum temperatures are for guidance only.

e w = water ; a = air ; cooling sufficiently rapid.

f When tested in accordance with EN ISO 3651-2 (Appropriate method, A or B or C, shall be as indicated) up to the limit temperatures indicated in the last column of table 8.

g In delivery condition. (Normally not fulfilled in the sensitized condition).

h For the delivery conditions W 0, W 1 and W 2 which do not include solution annealing, the upper R_m limit may be exceeded by 70 MPa .

i Up to these temperatures, the material should, within 100 000 h, not have changed so as to show susceptibility of intergranular corrosion, when tested in conformity with EN ISO 3651-2.

Table 7 — Mechanical properties for wall thicknesses up to 30 mm at room temperature and impact properties at - 40°C of austenitic-ferritic stainless steel in the solution annealed condition (+AT), heat treatment and information about resistance to intergranular corrosion

Steel grade		Hardness	Tensile properties at room temperature[a]				Impact properties[a]			Reference heat treatment conditions		Resistance to intergranular corrosion		Limit temp.
			Proof strength	Tensile strength	Elongation[b]		Minimum average absorbed energy							
		HB	$R_{p0,2}$	R_m	A		KV			Solution temperature [c]	Cooling in[d]	[e]	Method in EN ISO 3651-2	[f]
		max	MPa min	MPa	% min		J min							°C
							at RT		at -40 °C					
Steel name	Steel number				*l*	*t*	*l*	*t*	*t*					
X2CrNiMoN22-5-3	1.4462	290	450	700-920	25	20	120	90	40	1020-1100	w, a	yes	B	250
X2CrNiN23-4	1.4362	290	400	600-820	25	25	120	90	40	950-1050	w, a	yes	A	250
X2CrNiMoCuN25-6-3	1.4507	310	500	700-900	20	20	100	100	40	1080-1160	w	yes	B	250
X2CrNiMoN25-7-4	1.4410	310	550	800-1000	20	20	100	100	40	1040-1120	w	yes	B or C	250
X2CrNiMoCuWN 25-7-4	1.4501	310	550	800-1000	20	20	100	100	40	1080-1160	w	yes	B or C	250

a *l* = longitudinal ; *t* = transverse.

b See also 7.2.3.1.

c The maximum temperatures are for guidance only.

d w = water ; a = air ; cooling sufficiently rapid.

e When tested in accordance with EN ISO 3651-2 (Appropriate method, A or B or C, shall be as indicated) up to 250 °C.

f Up to these temperatures, the material should, within 100 000 h, not have changed so as to show susceptibility of intergranular corrosion, when tested in conformity with EN ISO 3651-2.

10 Appearance and internal soundness

10.1 Appearance

10.1.1 The fittings shall be free from internal and external surface defects that can be detected by visual inspection in accordance with this European Standard.

10.1.2 The internal and external surface finish of the fittings shall be typical of the manufacturing process and, where applicable, the heat-treated condition employed. Normally the finish and surface condition shall be such, that any surface imperfections or marks requiring dressing shall be identified.

10.1.3 It shall be permissible to dress, by grinding or machining, surface marks and imperfections provided that, the wall thickness of the fitting in the dressed area is not less than the specified minimum wall thickness.

10.1.4 All dressed areas shall blend smoothly into the contour of the fitting.

10.1.5 Any surface imperfection, which demonstrates to be deeper than 5 % of the nominal thickness or 3 mm whichever is the lesser, but not less than 0,3 mm, shall be dressed. This also applies to repairs of surface defects according to 9.1.6.

10.1.6 Fittings with surface imperfections which encroach on the minimum wall thickness shall be considered defects and shall not comply with this European Standard. For mechanical marks the acceptance limit is 1,5 mm.

10.1.7 If surface imperfections acceptable under 9.1.5 is not scattered and appears over a large area which is not acceptable as “workmanlike finish“, the fittings shall be rejected or alternatively subject to dressing as agreed between purchaser and manufacturer.

10.1.8 Repairs of the fitting parent metal shall only be carried out by grinding or machining.

10.1.9 The surface of the fittings shall be metallically clean by a method suitable to stainless steels (by pickling, or bright annealing or shot blasting).

Option 10: *Pickling shall be specified at the time of enquiry and order.*

Option 11: *Shot blasting or bright annealing shall be specified at the time of enquiry and order*.

Option 12: *Pickling and passivation shall be specified at the time of enquiry and order*.

10.2 Internal soundness

For the internal soundness, where appropriate, requirements together with the conditions for their verification shall be agreed at the time of enquiry and order.

The weld area shall be free from cracks, lack of fusion and lack of penetration.

11 Dimensions and tolerances

11.1 Dimensions

11.1.1 Diameter and wall thickness

Preferred outside diameters and wall thicknesses covered by this European Standard are given in EN ISO 1127.

Preferred inside diameters (and wall thicknesses) covered by this European Standard are listed in Annex D.

11.1.2 Specific dimensions of fittings

For reducers and tees it is not mandatory that the produced pieces correspond to the exact representation in the figures.

The specific dimensions:

— F for elbows 90°;

— C and B for elbows 180°;

— F and H for elbows 45°;

— L for reducers;

— F and G for tees;

— K_2, R, v for caps;

shall be agreed at the time of enquiry and order.

Option13: *The specific dimensions of fittings specified by their outside diameter shall be according to Annex A.*

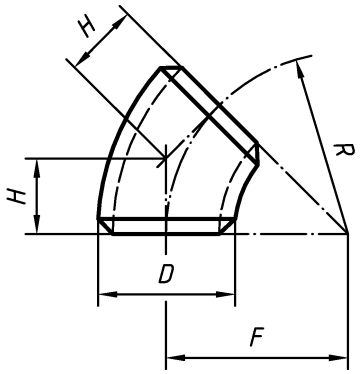


Figure 1 — 45°elbow

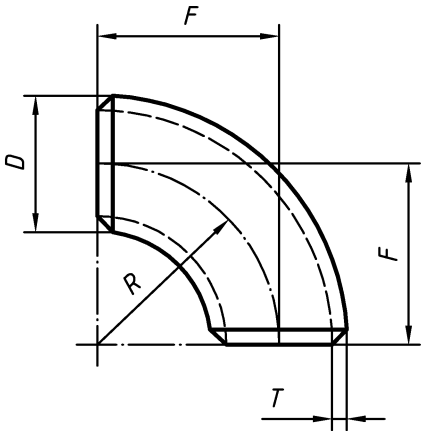


Figure 2 — 90° elbow

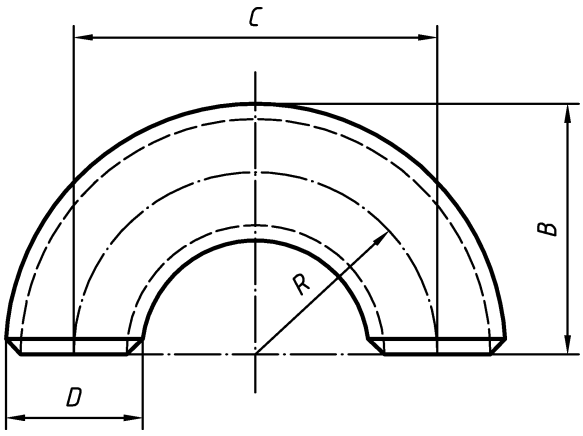


Figure 3 — Return bend

Elbows and return bends are produced according to Figures 1, 2 and 3 (45° - 90° - 180°). Specific dimensions are listed in Annex A.

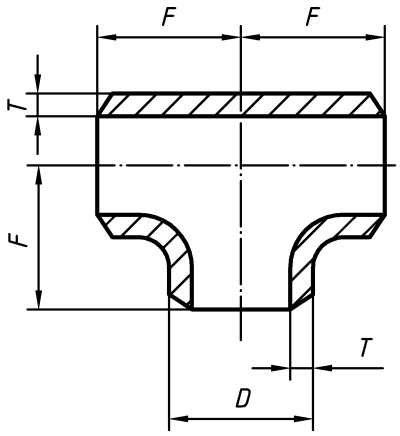


Figure 4 — Equal tee

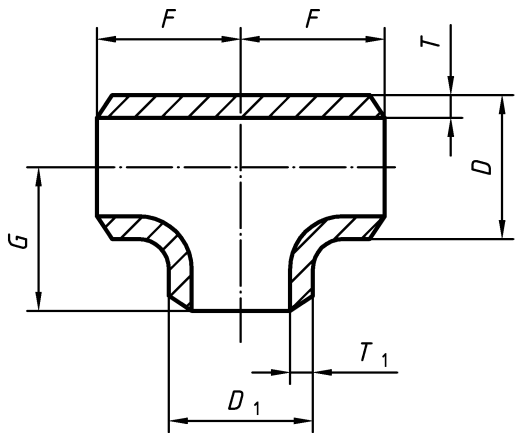


Figure 5 — Reducing tee

Equal tees are produced in accordance with Figure 4. Specific dimensions are listed in Annex A.

Reducing tees are produced in accordance with Figure 5. Specific dimensions are listed in Annex A.

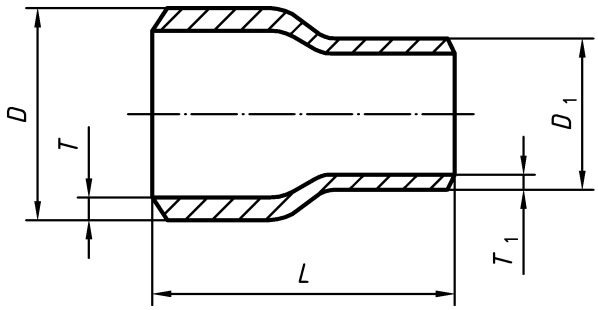


Figure 6 — Concentric reducer

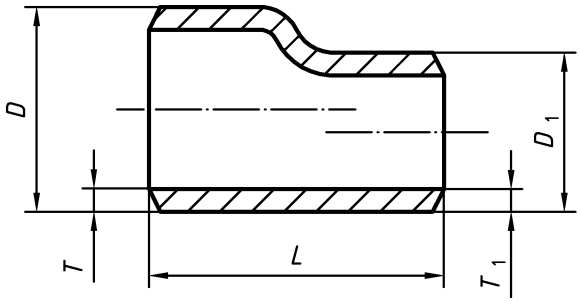
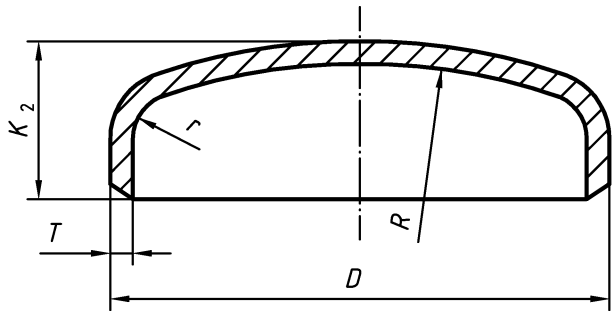


Figure 7 — Eccentric reducer

Concentric and eccentric reducers are produced in accordance respectively with Figures 6 and 7. Specific dimensions are listed in Annex A.



Key

R approximately equal to 0,8 D
r approximately equal to 0,15 D

Figure 8 — Cap

11.2 Dimensional tolerances

11.2.1 Tolerances on diameter

Tolerances on outside diameter shall be measured at the welding ends.

In order to guarantee the regular flow of the fluid through the fitting, the internal diameter in any section of the fitting (not applicable to caps) shall be above 80 % (for tees 70 %) of the internal diameter at the welding ends.

Internal diameter is calculated as follows :

Internal diameter = OD – 2 x nominal wall thickness

The outside diameter (OD) of fittings covered by this European Standard shall be within the tolerance limits given in Table 8.

Table 8 — Tolerances on outside diameter D

Tolerance on D	
EN Tolerance class	**Permissible deviation**
D2	± 1,0 % or ± 0,5 mm whichever is the greater
D3[a]	± 0,75 % or ± 0,3 mm whichever is the greater
D4[a]	± 0,5 % or ± 0,1 mm whichever is the greater
[a] **Option 14:** *The fittings may be ordered with tolerance classes D3 or D4.*	

11.2.2 Out of roundness

The out-of-roundness (0) shall be calculated using the following equation:

$$0 = \frac{D_{max} - D_{min}}{D} 100 \quad (1)$$

where

0 = out-of-roundness, in percentage;

D_{max} = maximum outside diameter D measured in the same plane, in millimetres;

D_{min}= minimum outside diameter measured in the same plane, in millimetres;

D = specified outside diameter, in millimetres.

For fittings of outside diameter $D \leq 406{,}4$ mm, out-of-roundness, shall be included in the limits of the diameter tolerances. Measurement shall be performed at the welding ends.

For fittings of outside diameter $D > 406{,}4$ mm and with D/T less than or equal to 100, out-of-roundness shall not exceed 2 %.

For fittings with a D/T ratio > 100 the values for out-of-roundness shall be agreed at the time of enquiry and order.

For elbows, the out–of–roundness on the body of the fitting shall not exceed 4 %.

11.2.3 Wall thickness tolerances

The wall thickness at the welding ends of fittings covered by this European Standard shall be within the tolerance limits given in Table 9. The minus tolerances apply also to the wall thickness at the body of the fitting.

Table 9 — Tolerances on wall thickness *T*

Outside diameter (OD)	Wall thickness (*T*)	Permissible deviation	
		Minus	Plus
OD ≤ 610	all	- 12,5 %	+ 15 %
OD > 610	≤ 10 mm	- 0,35 mm	+ 15 %
	> 10 mm	- 0,50 mm	+ 15 %

11.2.4 Tolerances on specific dimensions

For the dimensions specific to fittings, the tolerances are given in Table 10.

Table 10 — Tolerances on specific dimensions

Dimensions in millimetres

D	F- G – H – L	B	C	K_2
≤ 114,3	± 2	± 7	± 7	± 4
114,3 < D ≤ 219,1	± 2	± 7	± 7	± 7
219,1 < D ≤ 406,4	± 3	± 7	± 10	± 7
406,4 < D ≤ 762	± 3	± 10	± 10	± 7
762 < D ≤ 1219	± 5	± 10	± 10	± 10

11.2.5 Tolerances on the form of fittings

The tolerances on the form of every type of fitting (out–of–squareness, alignment) is following:

X = 1 % of the diameter at the point measured or 1 mm, whichever is the greater (see Figure 9).

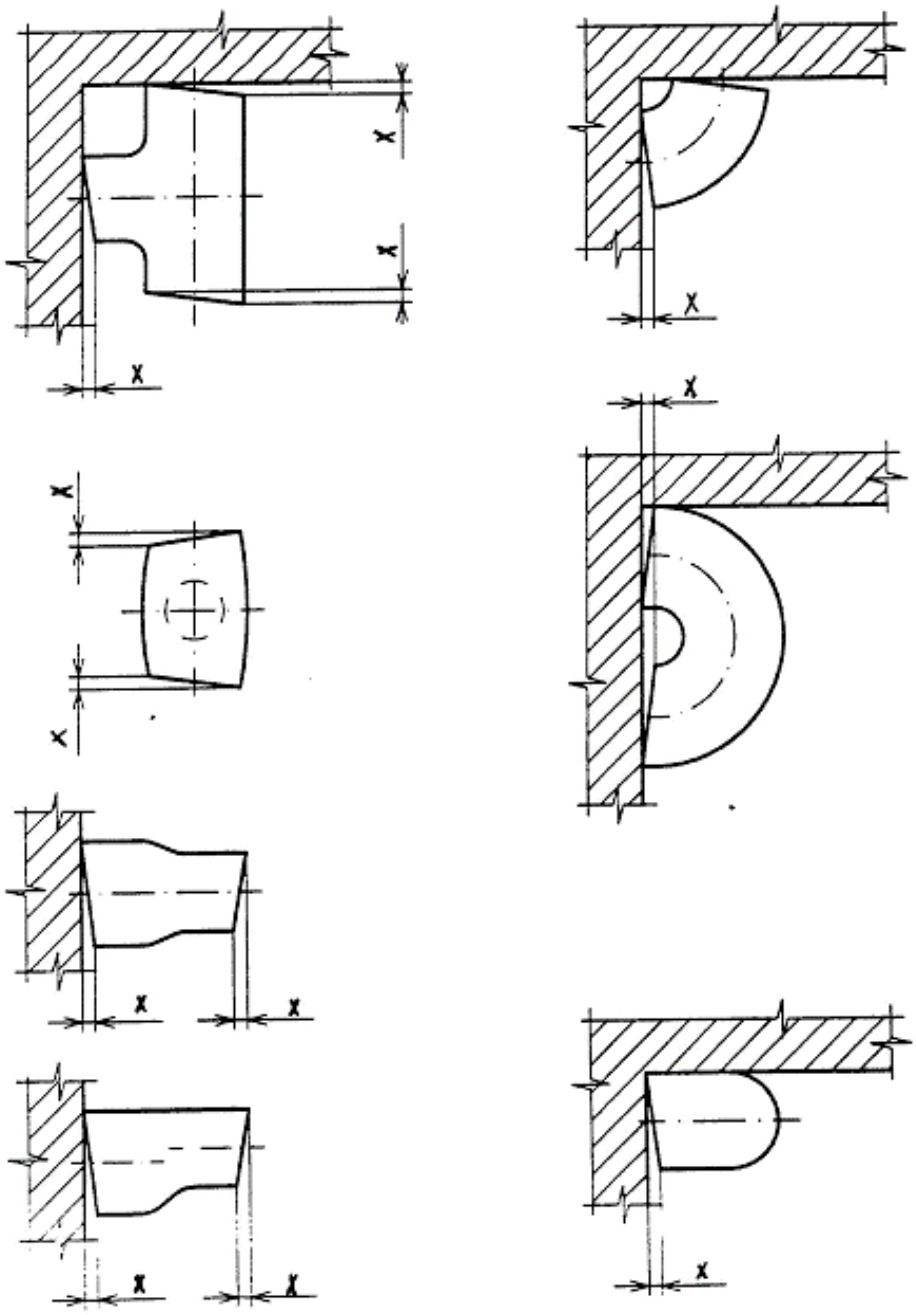


Figure 9 — Determination of the tolerance on the form of fittings

11.3 Performance of the end bevelling

Wall thickness T ≤ 3 mm: Fittings covered by this European Standard shall be delivered with square cut ends.

Wall thickness 3 mm < T < 22 mm: Fittings covered by this European Standard shall be delivered with bevelled ends with an angle of 30° - 0°/ + 5° and with a root face of 1,6 mm ± 0,8 mm.

Wall thickness ≥ 22 mm: Type of end bevelling shall be specified by the purchaser at the time of the enquiry and order.

For wall thickness above 3 mm, where machining of the welding ends is necessary, the wall thickness may be reduced by taper, slope of the taper shall be:

— Internal: 15° - 18°;

— External: 27° - 30°.

The ends shall be free from excessive burrs.

12 Inspection

12.1 Inspection documents

12.1.1 Types of inspection documents

Unless option 15 is specified, an inspection certificate 3.1.B, in accordance with EN 10204, shall be issued.

Option 15: *One of the inspection documents 3.1.C or 3.2 in accordance with EN 10204 shall be issued.*

If an inspection document 3.1.C or 3.2 is specified, the purchaser shall notify the manufacturer of the name and address of the organisation or person who is to carry out the inspection and produce inspection document. In case of inspection report 3.2 it shall be agreed which party shall issue the certificate.

12.1.2 Content of inspection documents

The content of the inspection document shall be in accordance with prEN 10168.

The inspection certificate or inspection report shall contain the following codes and/or information:

A – commercial transactions and parties involved;

B – description of products to which the inspection document applies;

C01-C03 – location of the samples and direction of the test pieces and testing temperature;

C10-C13 – tensile test;

C40-C43 – impact test if applicable;

C60-C69 – other tests (e.g. flattening);

C71-C92 – chemical composition on cast analysis (product analysis);

D01 – marking and identification, surface appearance, shape and dimensional properties;

D02-D99 – leak-tightness, NDT, material identification;

Z - validation.

12.2 Summary of inspection and testing

The fittings shall be inspected and tested as specified at the time of enquiry and order.

Inspection and testing to be carried out are summarised in Table 12.

13 Sampling

13.1 Frequency of tests

13.1.1 Test unit

A test unit shall consist of:

— same type;

— same specified dimensions;

— same manufacturing process;

— the same steel grade;

— same welding process (welded fittings);

— same cast;

— same heat treatment batch;

— same production lot.

If fittings fulfils above description but are heat treated in several batches depending on dimension or number of pieces, it may be regarded as one test unit provided that following conditions are obtained:

— temperature may be controlled within a range of 15 °C;

— cooling conditions are similar;

— furnace is equipped with recording devices so that complete records of heat treatment are available.

Test unit shall be as indicated in Table 11.

Table 11 — Test unit

Diameter (D) mm	**Max. number of pieces in a test unit**
D < 60,3	2500
60,3 ≥ D < 114,3	1000
114,3 ≥ D ≤ 219,1	500
219,1 < D ≤ 323,9	100
323,9 < D ≤ 610	50
610 < D ≤ 1219,0	25
1219 < D	10

Option 16: *The test unit size shall be as specified on the purchaser order.*

Table 12 — Summary of inspection and testing

Type of inspection and test		Frequency of testing	Reference to
Mandatory tests	Cast analysis of the starting material	One per cast	14.1
	Tensile test at room temperature	One per each sample of test unit	14.2.1
	Weld bend test (welded fittings)	One per each sample of test unit	3.4.2 & 14.4
	Dimensional testing	See 14.7	
	Visual inspection	See 14.8	
	NDT of the weld seam (100 %)	See 14.9.2	
	Material identification	See 14.10	
Optional tests	Product analysis	One per cast	9.2.2
	Tensile test on the weld at room temperature	One per each sample of test unit	14.3
	Tensile test at elevated temperature	One per each sample of test unit	14.2.2
	Impact test at room temperature	One per each sample of test unit	14.5
	Impact test at low temperature	One per each sample of test unit	9.3.3
	Intergranular corrosion test	One per each sample of test unit	14.6
	Liquid penetrant of weld and weld ends	Agreement	14.9.2
	Liquid penetrant of surfaces	Agreement	14.9.2
	Ultrasonic testing for detection of laminar imperfections	Agreement	14.9.2

13.2 Preparation of samples and test pieces

13.2.1 Samples for product analysis

Samples for product analysis shall be taken from the test piece or samples for mechanical testing of from the whole thickness of the fitting at same location as for the mechanical test samples, in accordance with ISO 14284.

13.2.2 Samples and test pieces for mechanical tests

The samples for the mechanical testing shall be taken and the corresponding test pieces prepared in accordance with the general conditions of EN ISO 377, as far as applicable. The test pieces may be taken from the fitting itself or from excess material, or shall be one which is produced from the same semi-finished product and has undergone the same heat treatment as the fitting.

13.2.3 Test piece for the tensile test on the base material

The test piece for the tensile test on the base material at room temperature shall consist of longitudinal segment, over length of the fitting or representative sample. The test shall be according to EN 10002–1.

13.2.4 Test piece for the tensile test on the weld

The test piece for the tensile test on the weld shall be taken transverse to the weld with the weld at the centre of the test piece.

13.2.5 Test piece for the weld bend test

The test pieces for the weld bend test at the root and face shall be taken and prepared in accordance with EN 910.

13.2.6 Test piece for the impact test

Three standard Charpy V-notch test pieces in accordance with EN 10045-1 shall be prepared. If the specified thickness is such that standard test pieces cannot be produced without flattening of the section, then test pieces of width less than 10 mm, but not less than 5 mm shall be prepared, the largest obtainable width shall be used.

The test pieces shall be taken transverse (where possible) to the fitting axis unless $D_{min,}$ as calculated by the following equation, is greater than the specified outside diameter, in which case longitudinal test pieces shall be used :

$$D_{min} = (T - 5) + [756{,}25/(T\text{-}5)]$$

where

T is the specified wall thickness, in millimetres.

It is the responsibility of the purchaser to specify the location of the impacting testing e.g. base material, HAZ, weld.

Option 17: *Impact test transverse to the weld in the HAZ or in the weld shall be specified.*

13.2.7 Test piece for the intergranular corrosion test

The test piece for the intergranular corrosion test shall be taken in accordance with the requirements of EN ISO 3651-2.

14 Test methods

14.1 Chemical analysis

The elements to be determined and reported shall be those in table 2 or 3 in accordance with the steel grade concerned.

14.2 Tensile test on the base material

14.2.1 At room temperature

The test shall be carried out at room temperature in accordance with EN 10002-1, and the following shall be determined:

— the tensile strength (R_m);

— the 0,2 % proof strength ($R_{p0,2}$) and where applicable, the 1,0 % proof strength ($R_{p1,0}$);

— the percentage elongation after fracture with a reference to a gauge length (L_0) of 5,65 $\sqrt{S_0}$; if a non proportional test piece is used, the percentage elongation value shall be converted to the value for a gauge length L_0 = 5,65 $\sqrt{S_0}$ using the conversion tables in EN ISO 2566–1.

For fittings with OD ≤ 100 mm hardness testing shall be performed on 10 % of the fittings, at least on 3 items. For these fittings tensile strength, proof strength and percentage elongation after fracture of the starting material shall be reported to the purchaser.

On cold formed fittings of OD < 100 mm which have not received additional heat treatment, tensile testing may be replaced by a ring expanding test in accordance with EN 10234. To equate to the minimum post cold forming residual elongation ''A'', an expansion rate of 20 % must be achieved and confirmed on at least 1 fitting per test unit.

14.2.2 At elevated temperature

The test shall be carried out in accordance with EN 10002-5 at the temperature agreed in the order, and the 0,2 % proof strength ($R_{p0,2}$) and, where applicable , the 1,0 % proof strength ($R_{p1,0}$) shall be determined.

14.3 Transverse tensile test on the weld

The test shall be carried out in accordance with EN 10002-1 at room temperature and the tensile strength (R_m) shall be determined.

14.4 Weld bend test

The test shall be carried out in accordance with EN 910 using a mandrel of a diameter of 3T. After testing the test piece shall show no cracks or flaws but slight premature failure at its edges shall not be regarded as a justification for rejection.

NOTE This test is only applicable for fittings made from sheet/plate or strip where welding is a part of the production.

14.5 Impact testing

14.5.1 The test shall be carried out in accordance with EN 10045-1 at the temperature agreed in the applicable option.

14.5.2 The mean value of the three test pieces shall meet the specified minimum average value given in Table 5 or 6 for the steel grade concerned. One individual value may be below the specified value, provided that it is not less than 70 % of that value.

14.5.3 If the width (W) of the test piece is less than 10 mm, the measured impact energy (KVp) shall be converted to impact energy (KVc) using the equation:

$$KVc = 10 \times KVp/W$$

where

KVc is the calculated impact energy, in joules;

KVp is the measured impact energy, in joules;

W is the width of the test piece.

The calculated impact energy KVc shall comply with the requirements given in 14.5.2.

14.5.4 If the requirement of 14.5.2 is not met, then an additional set of three test pieces may be taken at the discretion of the manufacturer from the same sample and tested. To consider the test unit as complying, after testing the second test, following conditions shall be satisfied:

— the average value of six test shall be equal to or greater than the specified minimum average value;

— not more than two of six individual values may be lower than the specified minimum average value;

— not more than one of six values may be lower than 70 % of the specified minimum average value.

14.5.5 The measured energy values and the resulting average value shall be reported.

14.6 Intergranular corrosion test

The intergranular corrosion test shall be carried out in accordance with EN ISO 3651-2.

14.7 Dimensional testing

The dimension of the fittings shall conform to the requirement stated in 11.1, 11.2, 11.3 and 11.4. It is the manufacturers responsibility to decide, frequency of testing.

14.8 Visual inspection

Fittings shall be visually examined and shall conform to the requirements stated in clause 10. It is the responsibility of the manufacturers to decide, frequency of inspection.

14.9 Non destructive testing

14.9.1 Personnel

Level 1 and 2 personnel and NDT operations shall be authorised by a level 3 individual and approved by the employer and certified in accordance with EN 473.

14.9.2 NDT of the weld

All weld seams on fittings shall be non-destructively tested either prior to or after forming.

The manufacturer shall demonstrate full traceability to each individual fitting.

Following methods of examination can be used :

— radiographic examination ;

— eddy current examination for fittings with wall thickness not greater than 6 mm ;

— ultrasonic examination.

Option 18: *Liquid penetrant examinations of welds and weld ends.*

Option 19: *Liquid penetrant examination of surfaces, extent shall be specified at the time of enquiry and order.*

Option 20: *Ultrasonic testing of strip or plates used for the manufacture of fittings, for the detection of laminar imperfections.*

14.10 Material identification

Each fitting shall be tested by an appropriate method to assure that the correct grade is being supplied.

14.11 Optional tests

These tests are carried out if agreed at the time of enquiry and order and in accordance with Table 11.

15 Marking

15.1 Marking to be applied

The marking shall include the following minimum information:

— the manufacturer's mark or trade mark;

— the number of this European Standard: EN 10253-4;

— "A" or "B" for the type of fitting;

— the steel name or number;

— the cast number or a code number which shows the correlation with the inspection document;

— outside diameter D;

— wall thickness T;

— the mark of the inspection representative ; it may be omitted if the relevant inspector can be identified in another way;

— the country of forming shall be mentioned in the inspection certificate (12.2.2) and/or marked on the fitting.

For reducing tees or reducers, the marking shall include D_1 and T_1.

Option 21: *Additional marking and methods of marking, as agreed upon the time of enquiry or order shall be applied.*

Methods of marking may be e.g.:

— ink jet marking;

— electrochemical etching;

— fibro-marking;

— laser marking.

16 Handling and packaging

The fittings are supplied in the manufacturers normal packaging and without any protective coating or end plugs.

Option 22: *Special packaging, coating or end plugs as agreed at the time of enquiry or order shall be applied.*

Annex A
(informative)

Specific dimensions of fittings

The specific dimensions of fittings listed below are based on ISO 5251 and ISO 3419.

Table A.1 — Below is specific dimensions for elbows with bending radius R~1 D, R~1,5 D and R~2,5 D listed

DN	D	R~ D			R~1,5 D			R~2,5 D
		F	C	B	F	C	B	F
	mm	mm	mm	mm	mm	mm	mm	mm
15	21,3				28	56	38	45
20	26,9				29	58	43	57
25	33,7				38	76	55	72
32	42,4				48	96	69	93
40	48,3				57	114	81	108
50	60,3	51	102	81	76	152	106	135
65	76,1	63	127	102	95	190	133	175
80	88,9	76	152	121	114	228	159	205
100	114,3	102	203	159	152	304	209	270
125	139,7	127	254	197	190	380	260	330
150	168,3	152	305	237	229	458	313	390
200	219,1	203	406	313	305	610	414	510
250	273,0	254	508	391	381	762	518	650
300	323,9	305	610	467	457	914	619	775
350	355,6	356	711	533	533	1066	711	850
400	406,4	406	813	610	610	1220	813	970
450	457,0	457	914	686	686	1372	914	1122
500	508,0	508	1016	762	762	1524	1016	1245
600	610,0	610	1220	914	914	1828	1219	1524
700	711,0				1067	2134	1422	1778
800	813,0				1219	2438	1625	2033
900	914,0				1372	2744	1829	2285
1000	1016,0				1524	3048	2032	2540

Table A.2 — Below is specific dimensions for tees, equal and reduced listed.

DN	D mm	DN1	D1 mm	F mm	G mm	DN	D mm	DN1	D1 mm	F mm	G mm
15	21,3	15	21,3	25	-	300	323,9	300	323,9	254	-
20	26,9	20	26,9	29	-			250	273		241
		15	21,3		29			200	219,1		229
25	33,7	25	33,7	38	-			150	168,3		219
		20	26,9		38	350	355,6	350	355,6	279	-
		15	21,3		38			300	323,9		270
32	42,4	32	42,4	48	-			250	273		257
		25	33,7		48			200	219,1		248
		20	26,9		48	400	406,4	400	406,4	305	-
		15	21,3		48			350	355,6		305
40	48,3	40	48,3	57	-			300	323,9		295
		32	42,4		57			250	273		283
		25	33,7		57	450	457	450	457	343	-
		20	26,9		57			400	406,4		330
50	60,3	50	60,3	64	-			350	355,6		330
		40	48,3		60			300	323,9		321
		32	42,4		57	500	508	500	508	381	-
		25	33,7		51			450	457		368
65	76,1	65	76,1	76	-			400	406,4		356
		50	60,3		70			350	355,6		356
		40	48,3		67	600	610	600	610	432	-
		32	42,4		64			500	508		432
80	88,9	80	88,9	86	-			450	457		419
		65	76,1		83			400	406,4		406
		50	60,3		76	700	711	700	711	521	-
		40	48,3		73	800	813	800	813	597	-
100	114,3	100	114,3	105	-	900	914	900	914	673	-
		80	88,9		98	1000	1016	1000	1016	749	-
		65	76,1		95						
		50	60,3		89						
125	139,7	125	139,7	124	-						
		100	114,3		117						
		80	88,9		111						
		65	76,1		108						
150	168,3	150	168,3	143	-						
		125	139,7		137						
		100	114,3		130						
		80	88,9		124						
200	219,1	200	219,1	178	-						
		150	168,3		168						
		125	139,7		162						
		100	114,3		156						
250	273	250	273	216	-						
		200	219,1		203						
		150	168,3		194						
		125	139,7		191						

Table A.3 — Below is specific dimensions for reducers, concentric and eccentric listed

DN	D mm	DN1	D1 mm	L mm	DN	D mm	DN1	D1 mm	L mm
20	26,9	15	21,3	38	450	457	400	406,4	381
25	33,7	20	26,9	51			350	355,6	
		15	21,3				300	323,9	
32	42,4	25	33,7	51	500	508	450	457	508
		20	26,9				400	406,4	
		15	21,3				350	355,6	
40	48,3	32	42,4	64	600	610	500	508	508
		25	33,7				450	457	
		20	26,9				400	406,4	
50	60,3	40	48,3	76	700	711	600	610	610
		32	42,4				500	508	
		25	33,7				450	457	
65	76,1	50	60,3	89	800	813	700	711	610
		40	48,3				600	610	
		32	42,4				500	508	
80	88,9	65	76,1	89	900	914	800	813	610
		50	60,3				700	711	
		40	48,3				600	610	
100	114,3	80	88,9	102	1000	1016	900	914	610
		65	76,1				800	813	
		50	60,3				700	711	
125	139,7	100	114,3	127					
		80	88,9						
		65	76,1						
150	168,3	125	139,7	140					
		100	114,3						
		80	88,9						
200	219,1	150	168,3	152					
		125	139,7						
		100	114,3						
250	273	200	219,1	178					
		150	168,3						
		125	139,7						
300	323,9	250	273	203					
		200	219,1						
		150	168,3						
350	355,6	300	323,9	330					
		250	273						
		200	219,1						
400	406,4	350	355,6	356					
		300	323,9						
		250	273						

Table A.4 — Below is specific dimensions for caps listed

DN	D mm	K_2 mm
15	21,3	25,0
20	26,9	25,0
25	33,7	38,0
32	42,4	38,0
40	48,3	38,0
50	60,3	38,0
65	76,1	38,0
80	88,9	51,0
100	114,3	64,0
125	139,7	76,0
150	168,3	89,0
200	219,1	102,0
250	273,0	127,0
300	323,9	152,0
350	355,6	165,0
400	406,4	178,0
450	457,0	203,0
500	508,0	229,0
600	610,0	267,0
700	711,0	267,0
800	813,0	267,0
900	914,0	267,0
1000	1016,0	305,0

Annex B
(informative)

Determination of wall thickness

B.1 General

Annex B defines wall thickness requirements of fittings. This is done by establishing appropriate calculation procedures in detail.

The wall thicknesses are established so that the fittings will, in general, withstand the same pressure as a straight pipe with the same dimensions (diameter, wall thickness, wall thickness tolerance) and material. Wall thickness tolerance of this corresponding pipe is assumed to be the same as the wall thickness tolerances at the welding ends of the fitting.

NOTE The calculation procedures are based on the design rules laid down in EN 13480-3:2002 and EN 13445-3:2002.

B.2 Symbols and units

For the purposes of annex B and C, the symbols given in Table B.1 shall apply in addition to those given in clause 4.

Table B.1 — Additional symbols for the purposes of annexes B and C

Symbol	Description
A_f	Stress loaded cross sectional area (calculation of tee)
A_p	Pressure loaded area (calculation of tee)
D_s	Outside diameter at the body of the run of a tee
D_b	Outside diameter at the body of the branch of a tee
l_s	Reinforcing length of run (calculation of tee)
l_b	Reinforcing length of branch (calculation of tee)
$L2_{min}$	Minimum length of cylindrical part at the large end of a reducer
$L4_{min}$	Minimum length of cylindrical part at the small end of a reducer
r	Bending radius of elbows and return bends referring to the internal diameter
r_c	Crotch radius of a tee
T_{min}	Minimum wall thickness at the welding ends for elbows, return bends and equal tees or on the D end for reducers and reducing tees
$T1_{min}$	Minimum wall thickness at the D1 welding end of reducers and reducing tees,
T_{ext}	Wall thickness at the extrados of an elbow (including tolerances)
T_{int}	Wall thickness at the intrados of an elbow (including tolerances)
$T_{min,ext}$	Minimum wall thickness at the extrados of an elbow
$T_{min,int}$	Minimum wall thickness at the intrados of an elbow
T_s	Wall thickness at the run of a tee

$T_{s,min}$	Minimum wall thickness at the run of a tee
T_b	Wall thickness at the branch of a tee
$T_{b,min}$	Minimum wall thickness at the branch of a tee
$T_{c.min}$	Minimum wall thickness at the crotch zone of a tee
$T_{co.min}$	Minimum wall thickness of a cone
T2	Wall thickness of the cylindrical part of a reducer at its large end
$T2_{min}$	Minimum wall thickness of the cylindrical part of a reducer at its large end
T3	Wall thickness of the conical part of a reducer
$T3_{min}$	Minimum wall thickness of the conical part of a reducer
T4	Wall thickness of the cylindrical part of a reducer at its small end
$T4_{min}$	Minimum wall thickness of the cylindrical part of a reducer at its small end
α	Semi angle of reducer
β, β_H, s, τ	Factors (calculation of reducer)

B.3 Minimal and nominal wall thickness

The design rules given in EN 13480-3 and EN 13445-3 are based on minimal required wall thicknesses. Therefore, in a first step these minimal wall thickness have to be derived from the nominal wall thickness of the fitting. Taking into account the negative tolerances given in Table 9 the minimal wall thickness are calculated:

$$T_{min} = \begin{cases} T \cdot (100 - 12{,}5)/100 & \text{if } D \le 610\,\text{mm} \\ T - 0{,}35\,\text{mm} & \text{if } D > 610\,\text{mm and } T \le 10\,\text{mm} \\ T - 0{,}5\,\text{mm} & \text{if } D > 610\,\text{mm and } T > 10\,\text{mm} \end{cases} \quad \text{(B.1)}$$

To obtain a wall thickness including wall thickness tolerances from a minimal wall thickness the following equation is used :

$$T = \begin{cases} T_{min} \cdot 100/(100 - 12{,}5) & \text{if } D \le 610\,\text{mm} \\ T_{min} + 0{,}35\,\text{mm} & \text{if } D > 610\,\text{mm and } T \le 9{,}65\,\text{mm} \\ T_{min} + 0{,}5\,\text{mm} & \text{if } D > 610\,\text{mm and } T > 9{,}65\,\text{mm} \end{cases} \quad \text{(B.2)}$$

If other tolerances are specified for the fitting, these values have to be used in above formulas.

B.4 Elbows

Wall thicknesses and other dimension of an elbow are illustrated in Figure B.1.

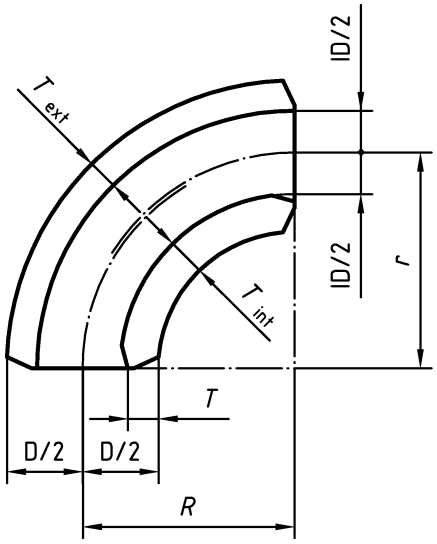


Figure B.1 — Elbow

The wall thickness at the intrados of an elbow shall be calculated :

$$T_{min,int} = T_{min} \cdot \left(\frac{D}{2 \cdot T_{min}} + \frac{r}{T_{min}} - \left(\frac{D}{2 \cdot T_{min}} + \frac{r}{T_{min}} - 1 \right) \cdot \sqrt{\frac{\left(\frac{r}{T_{min}} \right)^2 - \left(\frac{D}{2 \cdot T_{min}} \right)^2}{\left(\frac{r}{T_{min}} \right)^2 - \frac{D}{2 \cdot T_{min}} \cdot \left(\frac{D}{2 \cdot T_{min}} - 1 \right)}} \right) \qquad \text{(B.3)}$$

where

$$\frac{r}{T_{min}} = \sqrt{\frac{1}{2} \cdot \left\{ \left(\frac{D}{2 \cdot T_{min}} \right)^2 + \left(\frac{R}{T_{min}} \right)^2 \right\}} + \sqrt{\frac{1}{4} \cdot \left(\left(\frac{D}{2 \cdot T_{min}} \right)^2 + \left(\frac{R}{T_{min}} \right)^2 \right)^2 - \left(\frac{D}{2 \cdot T_{min}} \right) \cdot \left(\frac{D}{2 \cdot T_{min}} - 1 \right) \cdot \left(\frac{R}{T_{min}} \right)^2} \qquad \text{(B.4)}$$

The wall thickness at the extrados of an elbow shall be equal to the wall thickness of the corresponding pipe :

$$T_{min,ext} = T_{min} \qquad \text{(B.5)}$$

NOTE Setting T_{min}, ext = T_{min} ensures that the design requirements of EN 13480-3 and EN 13445-3 are met for all corrosion/erosion allowances.

NOTE Formulas (B.3) and (B.4) are given in EN 13480-3 :2002 as (B.4.1-3) and (B.4.1-4).

Example :

Wall thicknesses of an elbow 1D 711 x 7.1.

R = 711 mm

(B.1) : T_{min} = 7,1 mm – 0,35 mm = 6,75 mm

(B.4) : r / T_{min} = 105,66

(B.3) : $T_{min.int}$ = 10,07 mm

(B.5) : $T_{min,ext}$ = 6,75 mm

Wall thicknesses including tolerances are :

(B.2) : T_{int} = 10,07 mm + 0,5 mm = 10,57 mm,
T_{ext} = 6,75 + 0,35 mm = 7,1 mm

B.5 Tees

The wall thickness of tees cannot be calculated directly, but shall be assumed in a first step. This assumption shall then be verified by means of the method described. This method leads to a relationship between the pressure loaded area A_p and the stress loaded cross section area A_f shown in Figure B.2. Under certain circumstances, the calculation may need to be repeated using an improved assumption of the wall thickness.

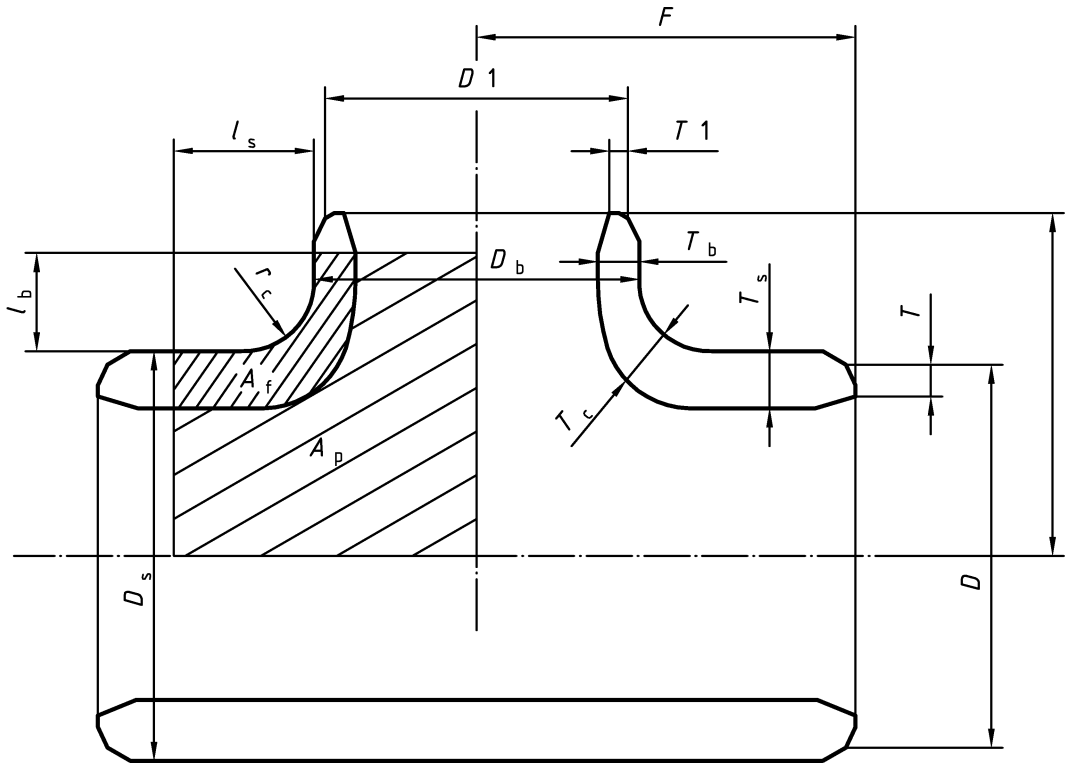


Figure B.2 — Dimensions and areas Ap and Af of a tee

For the tee the following condition shall apply:

$$\frac{A_p}{A_f} \le \max\left(\frac{D - 2\cdot T_{min}}{2\cdot T_{min}}, \frac{D1 - 2\cdot T1_{min}}{2\cdot T1_{min}}\right) \qquad \text{(B.5)}$$

The reinforcing lengths are calculated:

$$l_s = \min\left(\sqrt{(D_s - T_{s,min})\cdot T_{s,min}}, F - \frac{D_b}{2} - T_{min}\right) \qquad \text{(B.6)}$$

$$l_b = \min\left(\sqrt{(D_b - T_{b,min})\cdot T_{b,min}}, G - \frac{D_s}{2} - T1_{min}\right) \qquad \text{(B.7)}$$

Additionally, the wall thicknesses shall satisfy the condition

$$\frac{T_{b,\min}}{T_{s,\min}} \leq \begin{cases} 2 & \text{if} \quad \dfrac{\left(D_b - 2 \cdot T_{b,\min}\right)}{\left(D_s - 2 \cdot T_{s,\min}\right)} \leq 0{,}3 \\ 2{,}6 - 2 \cdot \dfrac{\left(D_b - 2 \cdot T_{b,\min}\right)}{\left(D_s - 2 \cdot T_{s,\min}\right)} & \text{if} \quad 0{,}3 < \dfrac{\left(D_b - 2 \cdot T_{b,\min}\right)}{\left(D_s - 2 \cdot T_{s,\min}\right)} < 0{,}8 \\ 1 & \text{if} \quad \dfrac{\left(D_b - 2 \cdot T_{b,\min}\right)}{\left(D_s - 2 \cdot T_{s,\min}\right)} \geq 0{,}8 \end{cases} \qquad \text{(B.8)}$$

NOTE Formula (B.5) is derived from (8.4.3-3) and (6.1-3) of EN 13480-3,
Formulas (B.6) and (A-7) are based on (8.4.1-2) and (8.4.3-1) of EN 13480-3,
Formula (B.8) is based on Figure 8.3.1-1 of EN 13480-3.

Example :

Wall thicknesses of a reducing tee 813 x 5.6 – 508 x 4.0
with the geometry D_s = D, D_b = D1, r_c = 95 mm and $T_{c,min}$ = ($T_{s,min}$ + $T_{b,min}$) / 2.

F = 597 mm, G = 533 mm.

Assumed wall thicknesses to be checked : T_s = 16,0 mm, T_b = 13,3 mm

(8-1) : T_{min} = 5,6 mm – 0,35 mm = 5,25 mm
$T1_{min}$ = 4,0 mm * (100 – 12,5) / 100 = 3,50 mm
$T_{s,min}$ = 16,0 mm – 0,5 mm = 15,5 mm,
$T_{b,min}$ = 13,3 mm * (100 – 12,5) / 100 = 11,64 mm

$T_{c,min}$ = (15,5 mm + 11,64 mm) / 2 = 13,57 mm

(8-6) : l_s = 111,18 mm

(8-7) : l_b = 76,01 mm

For the calculation of areas A_f and A_p see Figure B.3.

$$\alpha s = \operatorname{asin}\left(\max\left(\frac{rc - ls}{rc}, 0\right)\right) = 0°$$

$$\alpha b = \operatorname{asin}\left(\max\left(\frac{rc - lb}{rc}, 0\right)\right) = 11{,}53°$$

$$Tsc,min = \frac{45° - \alpha s}{45°} \cdot Ts.min + \frac{\alpha s}{45°} \cdot Tc.min = 15{,}5\,mm$$

$$Tbc,min = \frac{45° - \alpha b}{45°} \cdot Tb.min + \frac{\alpha b}{45°} \cdot Tc.min = 12{,}13\,mm$$

$$A_{fs} = \max\left(l_s - r_c, 0\right) \cdot T_{s,min} = 250{,}79\ mm^2$$

$$Afsc = \left(\left(rc + \frac{Tsc,min + Tc,min}{2}\right)^2 - rc^2\right) \cdot \pi \cdot \frac{45° - \alpha s}{360°} + Tsc,min^2 \cdot \frac{\tan(\alpha s)}{2} = 1167{,}46\,mm^2$$

$$Afbc = \left(\left(rc + \frac{Tbc,min + Tc,min}{2}\right)^2 - rc^2\right) \cdot \pi \cdot \frac{45° - \alpha b}{360°} + Tbc,min^2 \cdot \frac{\tan(\alpha b)}{2} = 776{,}35\,mm^2$$

$$A_{fb} = \max\left(l_b - r_c, 0\right) \cdot T_{s,min} = 0\ mm^2$$

$$A_f = A_{fs} + A_{fsc} + A_{Fbc} + A_{fb} = 2194.60\ mm^2$$

$$Apsc = rc^2 \cdot \left(\frac{1}{2} \cdot (1 - \sin(\alpha s))^2 - \pi \cdot \frac{45° - \alpha s}{360°} + \frac{1}{2} \cdot \sin(\alpha s) \cdot (\cos(\alpha s) - \sin(\alpha s))\right) = 968{,}39\,mm^2$$

$$A_{pbc} = r_c^2 \cdot \left(\frac{1}{2} \cdot (1 - \sin(\alpha_b))^2 - \pi \cdot \frac{45° - \alpha_b}{360°} + \frac{1}{2} \cdot \sin(\alpha_b) \cdot (\cos(\alpha_b) - \sin(\alpha_b)) \right) = 956{,}31\,mm^2$$

$$A_p = \left(\frac{D1}{2} + l_s \right) \left(\frac{D}{2} + l_b \right) - l_s \cdot l_b + A_{psc} + A_{psb} - A_f = 167482{,}31\,mm^2$$

$$\frac{A_p}{A_f} = 76{,}31$$

$$\max\left(\frac{D - 2 \cdot T_{min}}{2 \cdot T_{min}}, \frac{D1 - 2 \cdot T1_{min}}{2 \cdot T1_{min}} \right) = 76{,}43$$

Inequation (8-5) is satisfied (76.31 ≤ 76.43) and therefore the assumed wall thicknesses T_s and T_b are acceptable.

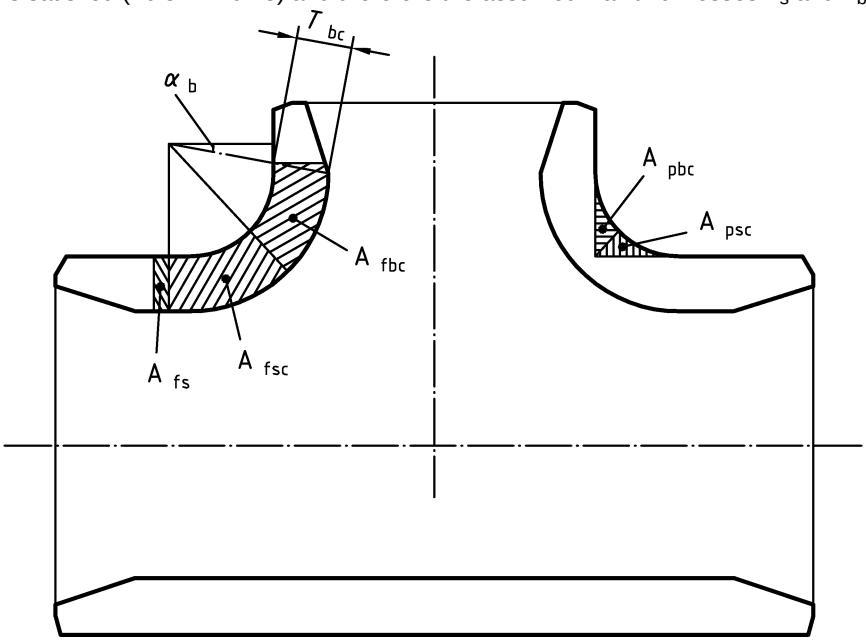


Figure B.3 — Additional dimensions and areas used in the calculation A_p and A_f of a tee

B.6 Reducers

In general the wall thickness of the conical part of the reducer can be calculated easily.

Though, for small ratios of wall thickness to diameter additional reinforcement at the ends of the cone and the cylindrical parts are necessary. These reinforcements cannot be calculated directly, but have to be determined by iteration.

Wall thicknesses and other dimension of a reducer are illustrated in Figure B.4, both for concentric and eccentric type.

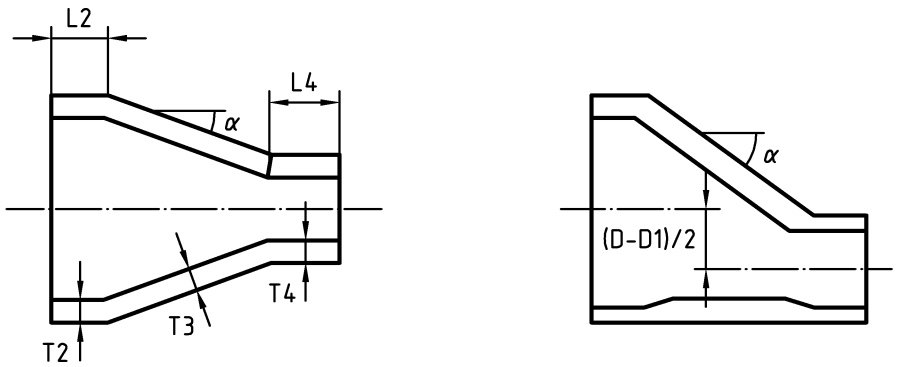


Figure B.4 — Wall thicknesses and dimensions of reducers

The wall thickness of a cone with the given half angle is calculated :

$$T_{co,min} = \frac{D}{\frac{1}{\min\left(\frac{T_{min}}{D - T_{min}}, \frac{T1_{min}}{D1 - T1_{min}}\right)} + 1} \cdot \frac{1}{\cos(\alpha)} \tag{B.9}$$

The reinforced wall thickness at the large end of the reducer is calculated:

$$T_{j,min} = \beta \cdot (D - T_{j,min}) \cdot \min\left(\frac{T_{min}}{D - T_{min}}, \frac{T1_{min}}{D1 - T1_{min}}\right) \tag{B.10}$$

with

$$\beta = \frac{1}{3} \cdot \sqrt{\frac{D - T_{j,min}}{T_{j,min}}} \cdot \frac{\tan(\alpha)}{1 + \frac{1}{\sqrt{\cos(\alpha)}}} - 0{,}15 \tag{B.11}$$

NOTE Formulas (B.11) and (B.10) cannot be evaluated directly but have to be solved by iteration.

The wall thickness of the conical part of a reducer shall be:

$$T3_{min} = \max(T_{co,min}, T_{j,min}) \tag{B.12}$$

The wall thickness of the cylindrical part at the large end of the reducer shall be:

$$T2_{min} = \max(T_{min}, T_{j,min}) \tag{B.13}$$

If the wall thickness at the cylindrical part at the large end of the reducer has to be reinforced, a minimal length of this part shall be assured:

$$L2_{min} = \begin{cases} 1.4 \cdot \sqrt{(D - T_{j,min}) \cdot T_{j,min}} & \text{if } T_{j,min} > T_{min} \\ 0 & \text{otherwise} \end{cases} \tag{B.14}$$

The wall thickness of the cylindrical part at the small end of the reducer shall be determined using the following formulas:

$$s = \frac{T3_{min}}{T4_{min}} \tag{B.15}$$

$$\tau = \begin{cases} s \cdot \sqrt{\frac{s}{\cos(\alpha)}} + \sqrt{\frac{1+s^2}{2}} & \text{if } s < 1 \\ 1 + \sqrt{s \cdot \left(\frac{1+s^2}{2 \cdot \cos(\alpha)} \right)} & \text{if } s \geq 1 \end{cases} \tag{B.16}$$

$$\beta_H = 0{,}4 \cdot \sqrt{\frac{D1 - T4_{min}}{T4_{min}}} \cdot \frac{\tan(\alpha)}{\tau} + 0{,}5 \tag{B.17}$$

If

$$\min\left(\frac{T_{min}}{D - T_{min}}, \frac{T1_{min}}{D1 - T1_{min}} \right) \leq \frac{T4_{min}}{(D1 - T4_{min}) \cdot \beta_H} \tag{B.18}$$

and

$$T4_{min} \geq T1_{min} \tag{B.19}$$

$T4_{min}$ is acceptable. If not, the calculation shall be repeated with a increased value of $T4_{min}$ In order to satisfy (B.18) it is also allowed to increase value of $T3_{min}$.

If the wall thickness at the cylindrical part at the small end of the reducer has to be reinforced, a minimal length of this part shall be assured :

$$L4_{min} = \begin{cases} \sqrt{(D1 - T4_{min}) \cdot T4_{min}} & \text{if } T4_{min} > T1_{min} \\ 0 & \text{otherwise} \end{cases} \tag{B.20}$$

NOTE Formula (B.9) to (B.18) are only applicable for semi angle α less equal 60° and ratios of D to T_{min} less equal 1000.

NOTE Formula (B.9) is derived from (8.6.4-2) and (6.1-3) from EN 13480-3.
Formula (B.10) is derived from (6.4.4-3) and (6.1-3) from EN 13480-3.
Formula (B.11) is given in EN 13480-3 as (6.4.4-4) in EN 13480-3.
Formula (B.14) is based on (6.4.4-1) and Figure 6.4.4-1 of EN 13480-3.
Formulas (B.15) to (B.17) are given in EN 13445-3 as (7.6-22) to (7.6-25).
Formula (B.18) is derived from (7.6-26) from EN 13445-3 and (6.1-3) form EN 13480-3.
Formula (B.20) is given in EN 13445-3 as (7.6-9).

Example:

Wall thicknesses of a concentric reducer 813 x 5,6 - 508 x 4.0
with an half angle α = 20°.

(8-1) : T_{min} = 5,6 mm – 0,35 mm = 5,25 mm
$T1_{min}$ = 4,0 mm * (100 – 12,5) / 100 = 3,50 mm

(8-9) : $T_{co,min}$ = 5,59 mm

Initial assumption : $T_{j,min}$ = 5,59 mm

(B.11), (B.10): β = 0,57, $T_{j,min}$ = 2,99 mm
β = 0,83, $T_{j,min}$ = 4,37 mm
β = 0,66, $T_{j,min}$ = 3,47 mm
β = 0,76, $T_{j,min}$ = 4,00 mm
β = 0,70, $T_{j,min}$ = 3,68 mm
β = 0,74, $T_{j,min}$ = 3,89 mm
β = 0,71, $T_{j,min}$ = 3,73 mm
β = 0,73, $T_{j,min}$ = 3,84 mm
β = 0,72, $T_{j,min}$ = 3,79 mm
β = 0,72, $T_{j,min}$ = 3,79 mm

(8-12): $T3_{min}$ = 5,59 mm

(8-13): $T2_{min}$ = 5,25 mm

(8-14): $L2_{min}$ = 0 mm

Initial assumption: $T4_{min}$ = 3,50 mm

(B.15) to (B.17): s = 1,60, τ = 2,74, β_H = 1,14,
checking (B.18): 0,00650 is not less equal 0,00608
next assumption: $T4_{min}$ = 3,70 mm
(B.15) to (B.17): s = 1,51, τ = 2,62, β_H = 1,15,
checking (B.18): 0,00650 is not less equal 0,00637
next assumption: $T4_{min}$ = 3,80 mm
(B.15) to (B.17): s = 1,47, τ = 2,57, β_H = 1,15,
checking (B.18): 0,00650 is less equal 0,00655
$T4_{min}$ = 3,80 mm is acceptable.

(8-20): $L4_{min}$ = 43,77 mm

(8-2): T2 = 5,25 mm + 0,35 mm = 5,60 mm
T3 = 5,59 mm + 0,35 mm = 5,94 mm
T4 = 3,80 mm * 100 / (100 – 12,5) = 4,34 mm

Annex C
(informative)

Wall thickness tables

C.1 General

This annex lists wall thicknesses at the body of the fitting of elbows, tees and reducers for 6 wall thickness series.

These wall thicknesses are calculated using the procedures given in annex B and tolerances listed in table 9. For the definition of symbols see section B.1 and the figures in annex B.

Fittings with nominal dimensions not listed in the tables of this annex or with other tolerances than given in table 9 may be designed in accordance with annex B.

C.2 Elbows

Table C.1 shows the wall thickness at the intrados of elbows of type 1 D, 1,5 D and 2,5 D whose bending radii are given annex A. The wall thickness at the extrados of the elbows shall be the same as at the welding ends.

Table C.1 — Wall thickness at the intrados of elbows

	1				2				3				4				5				6			
D	T	1D T_{int}	1,5D T_{int}	2,5D T_{int}	T	1D T_{int}	1,5D T_{int}	2,5D T_{int}	T	1D T_{int}	1,5D T_{int}	2,5D T_{int}	T	1D T_{int}	1,5D T_{int}	2,5D T_{int}	T	1D T_{int}	1,5D T_{int}	2,5D T_{int}	T	1D T_{int}	1,5D T_{int}	2,5D T_{int}
21,3	1,6	-	2,1	1,9	-	-	-	-	-	-	-	-	2,0	-	2,6	2,3	3,2	-	4,1	3,7	4,0	-	5,1	4,6
26,9	1,6	-	2,3	1,9	-	-	-	-	-	-	-	-	2,0	-	2,8	2,3	3,2	-	4,4	3,7	4,0	-	5,5	4,6
33,7	1,6	-	2,3	1,9	2,0	-	2,8	2,3	-	-	-	-	2,3	-	3,2	2,7	3,2	-	4,4	3,7	4,5	-	6,1	5,2
42,4	1,6	-	2,3	1,9	2,0	-	2,8	2,3	-	-	-	-	2,6	-	3,6	3,0	3,6	-	4,9	4,2	5,0	-	6,8	5,7
48,3	1,6	-	2,2	1,9	2,0	-	2,8	2,3	-	-	-	-	2,6	-	3,5	3,0	3,6	-	4,9	4,2	5,0	-	6,7	5,7
60,3	1,6	2,7	2,2	1,9	2,0	3,4	2,7	2,3	2,3	3,9	3,1	2,7	2,9	4,8	3,9	3,4	4,0	6,5	5,3	4,6	5,6	8,9	7,3	6,4
76,1	1,6	2,8	2,2	1,9	2,3	4,0	3,1	2,7	2,6	4,5	3,5	3,0	2,9	5,0	3,9	3,3	5,0	8,3	6,6	5,7	7,1	11,5	9,3	8,1
88,9	2,0	3,4	2,7	2,3	2,3	3,9	3,1	2,7	2,9	4,8	3,8	3,3	3,2	5,3	4,2	3,7	5,6	9,1	7,3	6,4	8,0	12,7	10,4	9,1
114,3	2,0	3,3	2,6	2,3	2,6	4,2	3,4	3,0	2,9	4,7	3,8	3,3	3,6	5,8	4,7	4,1	6,3	9,9	8,2	7,2	8,8	13,7	11,3	10,0
139,7	2,0	3,2	2,6	2,3	2,6	4,2	3,4	3,0	3,2	5,1	4,2	3,7	4,0	6,4	5,2	4,6	6,3	9,9	8,1	7,2	10,0	15,4	12,8	11,4
168,3	2,0	3,3	2,6	2,3	2,6	4,2	3,4	3,0	3,2	5,2	4,2	3,7	4,5	7,2	5,8	5,2	7,1	11,2	9,1	8,1	11,0	17,1	14,1	12,5
219,1	2,0	3,2	2,6	2,3	2,6	4,1	3,4	3,0	3,6	5,7	4,6	4,1	6,3	9,8	8,1	7,2	8,0	12,4	10,2	9,1	12,5	19,1	15,9	14,2
273,0	2,0	3,2	2,6	2,3	3,6	5,7	4,6	4,1	4,0	6,3	5,2	4,6	6,3	9,9	8,1	7,2	10,0	15,5	12,8	11,4	-	-	-	-
323,9	2,6	4,1	3,4	3,0	4,0	6,3	5,1	4,6	4,5	7,0	5,8	5,1	7,1	11,0	9,1	8,1	10,0	15,4	12,7	11,4	-	-	-	-
355,6	2,6	3,9	3,3	3,0	4,0	6,0	5,0	4,6	5,0	7,5	6,3	5,7	8,0	11,9	10,0	9,1	11,0	16,3	13,7	12,5	-	-	-	-
406,4	2,6	3,9	3,3	3,0	4,0	6,0	5,0	4,6	5,0	7,5	6,3	5,7	8,8	13,1	11,0	10,0	12,5	18,5	15,6	14,2	-	-	-	-
457,0	3,2	4,8	4,0	3,7	4,0	6,0	5,0	4,6	5,0	7,5	6,3	5,7	10,0	14,9	12,5	11,3	-	-	-	-	-	-	-	-
508,0	3,2	4,8	4,0	3,7	5,0	7,5	6,3	5,7	5,6	8,4	7,0	6,4	11,0	16,4	13,8	12,4	-	-	-	-	-	-	-	-
610,0	3,2	4,8	4,0	3,6	5,6	8,4	7,0	6,3	6,3	9,4	7,9	7,1	12,5	18,6	15,6	14,1	-	-	-	-	-	-	-	-
711,0	4,0	-	5,0	4,5	5,6	-	7,0	6,3	7,1	-	8,8	8,0	12,5	-	15,5	14,0	-	-	-	-	-	-	-	-
813,0	4,0	-	5,0	4,5	5,6	-	7,0	6,3	8,0	-	9,9	9,0	12,5	-	15,5	14,0	-	-	-	-	-	-	-	-
914,0	4,0	-	5,0	4,5	6,3	-	7,8	7,1	8,8	-	11,1	9,9	12,5	-	15,5	14,0	-	-	-	-	-	-	-	-
1016,0	4,0	-	5,0	4,5	6,3	-	7,8	7,1	10,0	-	12,6	11,4	12,5	-	15,5	14,0	-	-	-	-	-	-	-	-

C.3 Tees

Table C.2 shows the wall thickness at the body of equal tees and reducing tees. These data is applicable if one of the following two conditions apply :

1) The reinforcement is interior ($D_s = D$, $D_b = D1$) and
the crotch radius is less equal to 3/4 of the height of the branch ($r_c \leq 0.75 * (G - D/2)$) and
the wall thickness at the crotch zone is at least the mean of the wall thicknesses of run and branch ($T_{c,min} \geq (T_{s,min} + T_{b,min}) / 2$) and
dimensions F and G are as listed in annex A.

2) The reinforcement is at maximum half to the external ($D_c \leq D + (T_s-T)$, $D_b \leq D1 + (T_b-T1)$) and
the crotch radius is less equal to 1/2 of the height of the branch ($r_c \leq 0.5 * (G - D/2)$) and
the wall thickness at the crotch zone is at least the mean of the wall thicknesses of run and branch ($T_{c,min} \geq (T_{s,min} + T_{b,min}) / 2$) and
dimensions F and G are as listed in annex A.

In all other cases the wall thicknesses may be calculated in accordance with annex B.

Smaller wall thicknesses than listed in Table C.2 are acceptable provided that they are calculated in accordance with annex B, e.g. for smaller crotch radii or other ratios of the wall thicknesses of run to branch.

Table C.2 — Wall thickness of tees

		1				2				3				4				5				6			
D	D1	T	T1	T_s	T_b	T	T1	T_s	T_b	T	T1	T_s	T_b	T	T1	T_s	T_b	T	T1	T_s	T_b	T	T1	T_s	T_b
21,3	21,3	1,6	1,6	4,0	3,0	-	-	-	-	-	-	-	-	2,0	2,0	4,6	3,6	3,2	3,2	5,8	5,8	4,0	4,0	7,1	7,1
26,9	26,9	1,6	1,6	4,1	3,1	-	-	-	-	-	-	-	-	2,0	2,0	4,8	3,6	3,2	3,2	6,3	5,6	4,0	4,0	7,9	7,0
	21,3	1,6	1,6	3,8	2,9	-	-	-	-	-	-	-	-	2,0	2,0	4,4	3,3	3,2	3,2	6,2	4,6	4,0	4,0	7,2	5,4
33,7	33,7	1,6	1,6	4,6	3,4	2,0	2,0	5,3	4,0	-	-	-	-	2,3	2,3	5,8	4,4	3,2	3,2	7,3	5,5	4,5	4,5	9,6	7,2
	26,9	1,6	1,6	4,3	3,2	-	-	-	-	-	-	-	-	2,3	2,0	5,4	4,1	3,2	3,2	6,8	5,1	4,5	4,0	8,6	6,5
	21,3	1,6	1,6	4,1	3,1	-	-	-	-	-	-	-	-	2,3	2,0	5,1	3,9	3,2	3,2	6,4	4,8	4,5	4,0	8,1	6,1
42,4	42,4	1,6	1,6	5,0	3,7	2,0	2,0	5,7	4,3	-	-	-	-	2,6	2,6	6,8	5,1	3,6	3,6	8,5	6,4	5,0	5,0	10,7	8,1
	33,7	1,6	1,6	4,7	3,5	2,0	2,0	5,4	4,0	-	-	-	-	2,6	2,3	6,4	4,8	3,6	3,2	7,9	5,9	5,0	4,5	9,9	7,5
	26,9	1,6	1,6	4,5	3,4	-	-	-	-	-	-	-	-	2,6	2,0	6,0	4,5	3,6	3,2	7,5	5,6	5,0	4,0	9,3	7,0
	21,3	1,6	1,6	4,3	3,3	-	-	-	-	-	-	-	-	2,6	2,0	5,8	4,4	3,6	3,2	7,1	5,4	5,0	4,0	8,9	6,7
48,3	48,3	1,6	1,6	5,4	4,1	2,0	2,0	6,2	4,7	-	-	-	-	2,6	2,6	7,3	5,5	3,6	3,6	9,1	6,8	5,0	5,0	11,4	8,6
	42,4	1,6	1,6	5,2	3,9	2,0	2,0	6,0	4,5	-	-	-	-	2,6	2,6	7,1	5,3	3,6	3,6	8,7	6,6	5,0	5,0	10,9	8,2
	33,7	1,6	1,6	5,0	3,8	2,0	2,0	5,7	4,3	-	-	-	-	2,6	2,3	6,7	5,0	3,6	3,2	8,2	6,2	5,0	4,5	10,2	7,7
	26,9	1,6	1,6	4,9	3,7	-	-	-	-	-	-	-	-	2,6	2,0	6,4	4,8	3,6	3,2	7,9	5,9	5,0	4,0	9,7	7,3
60,3	60,3	1,6	1,6	5,4	4,0	2,0	2,0	6,2	4,6	2,3	2,3	6,8	5,1	2,9	2,9	7,9	5,9	4,0	4,0	9,8	7,4	5,6	5,6	12,4	9,3
	48,3	1,6	1,6	4,8	3,6	2,0	2,0	5,5	4,1	-	-	-	-	2,9	2,6	7,0	5,3	4,0	3,6	8,7	6,6	5,6	5,0	11,1	8,3
	42,4	1,6	1,6	4,4	3,3	2,0	2,0	5,1	3,8	-	-	-	-	2,9	2,6	6,5	4,9	4,0	3,6	8,1	6,1	5,6	5,0	10,3	7,7
	33,7	1,6	1,6	3,8	2,8	2,0	2,0	4,4	3,3	-	-	-	-	2,9	2,3	5,6	4,2	4,0	3,2	7,1	5,3	5,6	4,5	9,0	6,8
76,1	76,1	1,6	1,6	5,6	4,2	2,3	2,3	7,0	5,3	2,6	2,6	7,6	5,7	2,9	2,9	8,2	6,1	5,0	5,0	11,9	8,9	7,1	7,1	16,0	12,0
	60,3	1,6	1,6	4,8	3,6	2,3	2,0	6,1	4,6	2,6	2,3	6,6	5,0	2,9	2,9	7,1	5,4	5,0	4,0	10,4	7,8	7,1	5,6	13,3	10,0
	48,3	1,6	1,6	4,4	3,3	2,3	2,0	5,5	4,2	-	-	-	-	2,9	2,6	6,5	4,9	5,0	3,6	9,4	7,1	7,1	5,0	12,1	9,1
	42,4	1,6	1,6	4,1	3,1	2,3	2,0	5,1	3,9	-	-	-	-	2,9	2,6	6,0	4,5	5,0	3,6	8,8	6,6	7,1	5,0	11,4	8,5
88,9	88,9	2,0	2,0	6,6	5,0	2,3	2,3	7,2	5,4	2,9	2,9	8,4	6,3	3,2	3,2	9,0	6,7	5,6	5,6	13,2	9,9	8,0	8,0	18,3	13,7
	76,1	2,0	1,6	5,8	4,4	2,3	2,3	6,7	5,0	2,9	2,6	7,8	5,8	3,2	2,9	8,3	6,2	5,6	5,0	12,2	9,2	8,0	7,1	15,8	11,8
	60,3	2,0	1,6	5,3	4,0	2,3	2,0	5,8	4,4	2,9	2,3	6,8	5,1	3,2	2,9	7,2	5,4	5,6	4,0	10,7	8,0	8,0	5,6	13,9	10,4
	48,3	2,0	1,6	4,8	3,6	2,3	2,0	5,3	4,0	-	-	-	-	3,2	2,6	6,6	4,9	5,6	3,6	9,8	7,3	8,0	5,0	12,7	9,5
114,3	114,3	2,0	2,0	6,9	5,2	2,6	2,6	8,2	6,2	2,9	2,9	8,8	6,6	3,6	3,6	10,2	7,7	6,3	6,3	15,3	11,5	8,8	8,8	21,0	15,8
	88,9	2,0	2,0	6,0	4,5	2,6	2,3	7,2	5,4	2,9	2,9	7,7	5,8	3,6	3,2	8,9	6,7	6,3	5,6	13,1	9,9	8,8	8,0	16,7	12,6
	76,1	2,0	1,6	5,6	4,2	2,6	2,3	6,6	5,0	2,9	2,6	7,1	5,4	3,6	2,9	8,3	6,2	6,3	5,0	12,2	9,2	8,8	7,1	15,6	11,7
	60,3	2,0	1,6	4,9	3,7	2,6	2,0	5,9	4,4	2,9	2,3	6,3	4,8	3,6	2,9	7,3	5,5	6,3	4,0	10,9	8,2	8,8	5,6	14,0	10,5
139,7	139,7	2,0	2,0	7,2	5,4	2,6	2,6	8,6	6,4	3,2	3,2	9,8	7,4	4,0	4,0	11,4	8,6	6,3	6,3	15,8	11,8	10,0	10,0	24,8	18,6
	114,3	2,0	2,0	6,4	4,8	2,6	2,6	7,6	5,7	3,2	2,9	8,8	6,6	4,0	3,6	10,2	7,7	6,3	6,3	14,0	10,5	10,0	8,8	19,6	14,7
139,7	88,9	2,0	2,0	5,7	4,3	2,6	2,3	6,8	5,1	3,2	2,9	7,8	5,8	4,0	3,2	9,0	6,8	6,3	5,6	12,4	9,3	10,0	8,0	17,4	13,1
	76,1	2,0	1,6	5,3	4,0	2,6	2,3	6,3	4,7	3,2	2,6	7,2	5,4	4,0	2,9	8,4	6,3	6,3	5,0	11,6	8,7	10,0	7,1	16,3	12,2
168,3	168,3	2,0	2,0	7,5	5,6	2,6	2,6	8,8	6,6	3,2	3,2	10,1	7,6	4,5	4,5	12,8	9,6	7,1	7,1	18,2	13,7	11,0	11,0	28,8	21,6
	139,7	2,0	2,0	6,8	5,1	2,6	2,6	8,0	6,0	3,2	3,2	9,2	6,9	4,5	4,0	11,6	8,7	7,1	6,3	15,9	12,0	11,0	10,0	21,9	16,4
	114,3	2,0	2,0	6,0	4,5	2,6	2,6	7,2	5,4	3,2	2,9	8,2	6,2	4,5	3,6	10,4	7,8	7,1	6,3	14,4	10,8	11,0	8,8	19,8	14,8
	88,9	2,0	2,0	5,4	4,0	2,6	2,3	6,4	4,8	3,2	2,9	7,3	5,5	4,5	3,2	9,3	7,0	7,1	5,6	12,8	9,6	11,0	8,0	17,7	13,3
219,1	219,1	2,0	2,0	7,9	5,9	2,6	2,6	9,3	7,0	3,6	3,6	11,6	8,7	6,3	6,3	17,2	12,9	8,0	8,0	21,3	16,0	12,5	12,5	34,8	26,1
	168,3	2,0	2,0	6,9	5,2	2,6	2,6	8,1	6,1	3,6	3,2	10,1	7,6	6,3	4,5	14,1	10,6	8,0	7,1	17,6	13,2	12,5	11,0	24,3	18,3
	139,7	2,0	2,0	6,2	4,7	2,6	2,6	7,4	5,6	3,6	3,2	9,2	6,9	6,3	4,0	13,5	10,1	8,0	6,3	16,1	12,1	12,5	10,0	22,3	16,7
	114,3	2,0	2,0	5,6	4,2	2,6	2,6	6,7	5,0	3,6	2,9	8,3	6,3	6,3	3,6	12,3	9,3	8,0	6,3	14,7	11,0	12,5	8,8	20,4	15,3

"to be continued "

Table C.2 *(end)*

		1				2				3				4				5				6			
D	D1	T	T1	T_s	T_b	T	T1	T_s	T_b	T	T1	T_s	T_b	T	T1	T_s	T_b	T	T1	T_s	T_b	T	T1	T_s	T_b
273	273	2,0	2,0	8,4	6,3	3,6	3,6	12,2	9,2	4,0	4,0	13,1	9,9	6,3	6,3	17,9	13,5	10,0	10,0	27,7	20,8	-	-	-	-
	219,1	2,0	2,0	7,3	5,5	3,6	2,6	10,0	7,5	4,0	3,6	11,5	8,7	6,3	6,3	15,8	11,9	10,0	8,0	21,9	16,5	-	-	-	-
	168,3	2,0	2,0	6,4	4,8	3,6	2,6	9,4	7,1	4,0	3,2	10,1	7,6	6,3	4,5	13,9	10,4	10,0	7,1	19,4	14,6	-	-	-	-
	139,7	2,0	2,0	5,9	4,5	3,6	2,6	8,7	6,6	4,0	3,2	9,4	7,1	6,3	4,0	12,9	9,7	10,0	6,3	18,0	13,5	-	-	-	-
323,9	323,9	2,6	2,6	10,4	7,8	4,0	4,0	13,8	10,4	4,5	4,5	14,9	11,2	7,1	7,1	20,4	15,3	10,0	10,0	27,7	20,8	-	-	-	-
	273	2,6	2,0	8,8	6,6	4,0	3,6	12,4	9,3	4,5	4,0	13,5	10,1	7,1	6,3	18,4	13,8	10,0	10,0	23,5	17,7	-	-	-	-
	219,1	2,6	2,0	8,3	6,2	4,0	2,6	10,7	8,1	4,5	3,6	11,9	9,0	7,1	6,3	16,4	12,3	10,0	8,0	21,0	15,8	-	-	-	-
	168,3	2,6	2,0	7,2	5,4	4,0	2,6	9,7	7,3	4,5	3,2	10,5	7,9	7,1	4,5	14,5	10,9	10,0	7,1	18,6	13,9	-	-	-	-
355,6	355,6	2,6	2,6	10,8	8,1	4,0	4,0	14,2	10,7	5,0	5,0	16,5	12,4	8,0	8,0	22,9	17,2	11,0	11,0	30,5	22,9	-	-	-	-
	323,9	2,6	2,6	10,1	7,6	4,0	4,0	13,4	10,1	5,0	4,5	15,4	11,6	8,0	7,1	21,1	15,9	11,0	10,0	27,0	20,2	-	-	-	-
	273	2,6	2,0	9,1	6,8	4,0	3,6	12,1	9,1	5,0	4,0	14,1	10,6	8,0	6,3	19,5	14,7	11,0	10,0	24,5	18,4	-	-	-	-
	219,1	2,6	2,0	8,2	6,1	4,0	2,6	10,8	8,1	5,0	3,6	12,6	9,5	8,0	6,3	17,6	13,2	11,0	8,0	22,1	16,6	-	-	-	-
406,4	406,4	2,6	2,6	10,9	8,2	4,0	4,0	14,4	10,8	5,0	5,0	16,7	12,6	8,8	8,8	26,0	19,5	12,5	12,5	37,7	28,3	-	-	-	-
	355,6	2,6	2,6	10,4	7,8	4,0	4,0	13,7	10,3	5,0	5,0	15,9	11,9	8,8	8,0	23,4	17,6	12,5	11,0	30,0	22,5	-	-	-	-
	323,9	2,6	2,6	9,7	7,3	4,0	4,0	12,9	9,7	5,0	4,5	14,9	11,2	8,8	7,1	22,1	16,6	12,5	10,0	28,4	21,3	-	-	-	-
	273	2,6	2,0	8,8	6,6	4,0	3,6	11,7	8,8	5,0	4,0	13,6	10,2	8,8	6,3	20,2	15,1	12,5	10,0	26,0	19,5	-	-	-	-
457	457	2,6	2,6	11,4	8,5	4,0	4,0	15,0	11,3	5,0	5,0	17,4	13,1	8,8	8,8	26,4	19,8	12,5	12,5	37,2	27,9	-	-	-	-
	406,4	2,6	2,6	10,5	7,9	4,0	4,0	13,9	10,4	5,0	5,0	16,1	12,1	8,8	8,8	23,9	17,9	12,5	12,5	30,7	23,0	-	-	-	-
	355,6	2,6	2,6	10,0	7,5	4,0	4,0	13,2	9,9	5,0	5,0	15,3	11,5	8,8	8,0	22,6	16,9	12,5	11,0	29,0	21,7	-	-	-	-
	323,9	2,6	2,6	9,4	7,1	4,0	4,0	12,5	9,4	5,0	4,5	14,5	10,9	8,8	7,1	21,4	16,1	12,5	10,0	27,5	20,6	-	-	-	-
508	508	3,2	3,2	13,4	10,1	5,0	5,0	18,0	13,5	5,6	5,6	19,4	14,6	11,0	11,0	32,6	24,4	-	-	-	-	-	-	-	-
	457	3,2	2,6	11,7	8,8	5,0	4,0	15,6	11,7	5,6	5,0	18,1	13,6	11,0	8,8	26,7	20,0	-	-	-	-	-	-	-	-
	406,4	3,2	2,6	11,6	8,7	5,0	4,0	15,7	11,8	5,6	5,0	16,9	12,7	11,0	8,8	27,1	20,4	-	-	-	-	-	-	-	-
	355,6	3,2	2,6	11,1	8,3	5,0	4,0	14,9	11,2	5,6	5,0	16,1	12,1	11,0	8,0	25,7	19,3	-	-	-	-	-	-	-	-
610	610	3,2	3,2	13,7	10,3	5,6	5,6	19,8	14,9	6,3	6,3	21,5	16,1	12,5	12,5	41,4	31,1	-	-	-	-	-	-	-	-
	508	3,2	3,2	12,7	9,6	5,6	5,0	18,4	13,8	6,3	5,6	19,9	14,9	12,5	11,0	32,0	24,0	-	-	-	-	-	-	-	-
	457	3,2	2,6	11,9	8,9	5,6	4,0	16,7	12,5	6,3	5,0	18,6	14,0	12,5	8,8	28,8	21,6	-	-	-	-	-	-	-	-
	406,4	3,2	2,6	11,0	8,3	5,6	4,0	16,0	12,0	6,3	5,0	17,4	13,1	12,5	8,8	28,2	21,2	-	-	-	-	-	-	-	-
711	711	4,0	4,0	15,9	12,1	5,6	5,6	20,1	15,2	7,1	7,1	23,6	17,9	12,5	12,5	37,1	28,0	-	-	-	-	-	-	-	-
813	813	4,0	4,0	16,7	12,7	5,6	5,6	21,0	15,9	8,0	8,0	26,8	20,3	12,5	12,5	37,6	28,3	-	-	-	-	-	-	-	-
914	914	4,0	4,0	17,5	13,2	6,3	6,3	23,7	17,9	8,8	8,8	29,8	22,5	12,5	12,5	37,9	28,6	-	-	-	-	-	-	-	-
1016	1016	4,0	4,0	18,2	13,8	6,3	6,3	24,6	18,6	10,0	10,0	33,7	25,4	12,5	12,5	39,0	29,4	-	-	-	-	-	-	-	-

C.4 Reducers

Tables C.3 to C.8 show the wall thicknesses of concentric and eccentric reducers. The data is valid for reducers with semi angles α less equal then the maximum semi angle α_{max} listed in the tables. For larger semi angles wall thicknesses may be calculated in accordance with annex B,

For small ratios of wall thickness to diameter reinforcement at the ends of the cone and the cylindrical parts are necessary, In these cases the applicable minimal lengths of the cylindrical sections of the reducer are listed in the tables too.

Smaller wall thicknesses than listed in Tables C.3 to C.8 are acceptable provided that they are calculated in accordance with annex B. e.g. for smaller semi angles α.

Table C.3 — Wall thickness of reducers – Wall thickness serie 1

				Concentric						Eccentric					
D	D1	T	T1	α_{max}	$L2_{min}$	T2	T3	T4	$L4_{min}$	α_{max}	$L2_{min}$	T2	T3	T4	$L4_{min}$
26,9	21,3	1,6	1,6	8 °	-	1,6	1,7	1,6	-	15 °	-	1,6	1,7	1,6	-
33,7	26,9	1,6	1,6	7 °	-	1,6	1,7	1,6	-	13 °	-	1,6	1,7	1,6	-
	21,3	1,6	1,6	12 °	-	1,6	1,7	1,6	-	24 °	-	1,6	1,8	1,6	-
42,4	33,7	1,6	1,6	9 °	-	1,6	1,7	1,6	-	16 °	-	1,6	1,7	1,6	-
	26,9	1,6	1,6	15 °	-	1,6	1,7	1,6	-	30 °	-	1,6	1,9	1,6	-
	21,3	1,6	1,6	19 °	-	1,6	1,7	1,6	-	42 °	-	1,6	2,2	1,6	-
48,3	42,4	1,6	1,6	6 °	-	1,6	1,7	1,6	-	8 °	-	1,6	1,7	1,6	-
	33,7	1,6	1,6	10 °	-	1,6	1,7	1,6	-	19 °	-	1,6	1,7	1,6	-
	26,9	1,6	1,6	16 °	-	1,6	1,7	1,6	-	28 °	-	1,6	1,9	1,6	-
60,3	48,3	1,6	1,6	7 °	-	1,6	1,7	1,6	-	13 °	-	1,6	1,7	1,6	-
	42,4	1,6	1,6	11 °	-	1,6	1,7	1,6	-	20 °	-	1,6	1,8	1,6	-
	33,7	1,6	1,6	16 °	-	1,6	1,7	1,6	-	29 °	-	1,6	1,9	1,6	-
76,1	60,3	1,6	1,6	9 °	-	1,6	1,7	1,6	-	15 °	-	1,6	1,7	1,6	-
	48,3	1,6	1,6	15 °	-	1,6	1,7	1,6	-	27 °	-	1,6	1,8	1,6	-
	42,4	1,6	1,6	18 °	-	1,6	1,7	1,6	-	34 °	-	1,6	2,0	1,6	-
88,9	76,1	2,0	1,6	7 °	-	2,0	1,9	1,6	-	13 °	-	2,0	2,0	1,6	-
	60,3	2,0	1,6	16 °	-	2,0	2,1	1,6	-	30 °	-	2,0	2,4	1,6	-
	48,3	2,0	1,6	22 °	-	2,0	2,2	1,6	-	44 °	-	2,0	2,8	1,6	-
114,3	88,9	2,0	2,0	13 °	-	2,0	2,1	2,0	-	24 °	-	2,0	2,2	2,0	-
	76,1	2,0	1,6	18 °	-	2,0	2,2	1,6	-	37 °	-	2,0	2,6	1,8	10,6
	60,3	2,0	1,6	26 °	-	2,0	2,3	1,6	-	51 °	21,4	2,4	3,2	1,6	-
139,7	114,3	2,0	2,0	10 °	-	2,0	2,1	2,0	-	18 °	-	2,0	2,2	2,0	-
	88,9	2,0	2,0	20 °	-	2,0	2,2	2,0	-	35 °	-	2,0	2,5	2,0	-
	76,1	2,0	1,6	25 °	-	2,0	2,3	1,6	-	43 °	22,6	2,2	2,8	1,6	-
168,3	139,7	2,0	2,0	9 °	-	2,0	2,1	2,0	-	18 °	-	2,0	2,2	2,0	-
	114,3	2,0	2,0	19 °	-	2,0	2,2	2,0	-	34 °	-	2,0	2,5	2,0	-
	88,9	2,0	2,0	27 °	-	2,0	2,3	2,0	-	48 °	27,1	2,6	3,0	2,0	-
219,1	168,3	2,0	2,0	18 °	-	2,0	2,2	2,0	-	31 °	-	2,0	2,4	2,4	18,6
	139,7	2,0	2,0	27 °	-	2,0	2,3	2,0	-	45 °	31,4	2,7	2,9	2,4	16,8
	114,3	2,0	2,0	33 °	27,4	2,1	2,4	2,0	-	55 °	34,8	3,3	3,5	2,0	-

" to be continued"

Table C.3 *(end)*

				Concentric						Eccentric					
D	D1	T	T1	α_{max}	$L2_{min}$	T2	T3	T4	$L4_{min}$	α_{max}	$L2_{min}$	T2	T3	T4	$L4_{min}$
273,0	219,1	2,0	2,0	16 °	-	2,0	2,1	2,0	-	28 °	-	2,0	2,5	2,5	21,6
	168,3	2,0	2,0	30 °	30,6	2,1	2,4	2,0	-	48 °	37,6	3,1	3,1	2,6	19,1
	139,7	2,0	2,0	36 °	33,0	2,4	2,5	2,0	-	55 °	40,4	3,6	3,6	2,0	-
323,9	273,0	2,6	2,0	12 °	-	2,6	2,5	2,0	-	23 °	-	2,6	2,8	2,8	25,6
	219,1	2,6	2,0	24 °	-	2,6	2,9	2,3	20,9	44 °	44,1	3,6	3,7	3,5	25,5
	168,3	2,6	2,0	35 °	39,8	2,9	3,2	2,0	-	55 °	49,4	4,5	4,6	2,6	19,3
355,6	323,9	2,6	2,6	6 °	-	2,6	2,7	2,6	-	8 °	-	2,6	2,7	2,6	-
	273,0	2,6	2,0	14 °	-	2,6	2,7	2,1	22,0	25 °	-	2,6	2,9	2,9	26,1
355,6	219,1	2,6	2,0	22 °	-	2,6	2,9	2,0	-	37 °	43,5	3,2	3,3	2,8	22,9
406,4	355,6	2,6	2,6	8 °	-	2,6	2,7	2,6	-	15 °	-	2,6	2,7	2,7	28,5
	323,9	2,6	2,6	13 °	-	2,6	2,7	2,6	-	24 °	-	2,6	3,1	3,1	29,2
	273,0	2,6	2,0	21 °	-	2,6	2,8	2,3	23,1	36 °	47,0	3,2	3,3	3,3	27,6
457,0	406,4	3,2	2,6	7 °	-	3,2	3,0	2,6	-	11 °	-	3,2	3,0	2,6	-
	355,6	3,2	2,6	14 °	-	3,2	3,3	2,6	-	24 °	-	3,2	3,6	3,6	33,1
	323,9	3,2	2,6	18 °	-	3,2	3,4	2,7	27,2	31 °	51,1	3,4	3,8	3,8	32,3
508,0	457,0	3,2	3,2	4 °	-	3,2	3,3	3,2	-	8 °	-	3,2	3,3	3,2	-
	406,4	3,2	2,6	10 °	-	3,2	3,3	2,6	-	18 °	-	3,2	3,4	3,2	33,7
	355,6	3,2	2,6	17 °	-	3,2	3,4	2,6	-	27 °	-	3,2	3,6	3,5	32,7
610,0	508,0	3,2	3,2	10 °	-	3,2	3,3	3,2	-	17 °	-	3,2	3,5	3,5	38,9
	457,0	3,2	3,2	15 °	-	3,2	3,4	3,2	-	27 °	58,9	3,4	4,0	4,0	39,5
	406,4	3,2	2,6	21 °	-	3,2	3,5	3,0	32,1	35 °	65,5	4,2	4,2	4,1	37,8
711,0	610,0	4,0	3,2	10 °	-	4,0	3,7	3,2	-	19 °	-	4,0	4,2	4,4	48,0
	508,0	4,0	3,2	15 °	-	4,0	4,2	3,3	38,1	34 °	78,1	4,8	5,1	5,5	48,9
	457,0	4,0	3,2	20 °	-	4,0	4,3	3,4	36,6	40 °	83,8	5,5	5,5	5,3	45,7
813,0	711,0	4,0	4,0	10 °	-	4,0	4,1	4,0	-	19 °	-	4,0	4,8	4,8	55,5
	610,0	4,0	3,2	15 °	-	4,0	4,2	3,7	44,1	34 °	85,6	5,0	5,6	5,9	55,9
	508,0	4,0	3,2	20 °	-	4,0	4,3	3,4	38,7	45 °	96,8	6,3	6,3	5,6	49,6
914,0	813,0	4,0	4,0	10 °	-	4,0	4,1	4,0	-	19 °	-	4,0	5,0	5,0	60,7
	711,0	4,0	4,0	15 °	-	4,0	4,2	4,0	-	34 °	92,7	5,2	5,9	5,9	62,5
	610,0	4,0	3,2	20 °	-	4,0	4,3	3,9	45,3	45 °	104,9	6,6	6,6	6,4	58,0
1016,0	914,0	4,0	4,0	10 °	-	4,0	4,1	4,0	-	19 °	-	4,0	5,1	5,1	65,6
	813,0	4,0	4,0	15 °	-	4,0	4,2	4,1	55,0	34 °	99,6	5,4	6,3	6,3	68,8
	711,0	4,0	4,0	20 °	-	4,0	4,3	4,1	51,5	45 °	112,7	6,8	6,8	6,5	65,8

Table C.4 — Wall thickness of reducers – Wall thickness serie 2

				concentric						eccentric					
D	D1	T	T1	α_{max}	$L2_{min}$	T2	T3	T4	$L4_{min}$	α_{max}	$L2_{min}$	T2	T3	T4	$L4_{min}$
42,4	33,7	2,0	2,0	9 °	-	2,0	2,1	2,0	-	16 °	-	2,0	2,1	2,0	-
48,3	42,4	2,0	2,0	6 °	-	2,0	2,1	2,0	-	8 °	-	2,0	2,1	2,0	-
	33,7	2,0	2,0	10 °	-	2,0	2,1	2,0	-	19 °	-	2,0	2,2	2,0	-
60,3	48,3	2,0	2,0	7 °	-	2,0	2,1	2,0	-	13 °	-	2,0	2,1	2,0	-
	42,4	2,0	2,0	11 °	-	2,0	2,1	2,0	-	20 °	-	2,0	2,2	2,0	-
	33,7	2,0	2,0	16 °	-	2,0	2,1	2,0	-	29 °	-	2,0	2,3	2,0	-
76,1	60,3	2,3	2,0	9 °	-	2,3	2,4	2,0	-	15 °	-	2,3	2,4	2,0	-
	48,3	2,3	2,0	15 °	-	2,3	2,4	2,0	-	27 °	-	2,3	2,6	2,0	-
	42,4	2,3	2,0	18 °	-	2,3	2,5	2,0	-	34 °	-	2,3	2,8	2,0	-
88,9	76,1	2,3	2,3	7 °	-	2,3	2,4	2,3	-	13 °	-	2,3	2,4	2,3	-
	60,3	2,3	2,0	16 °	-	2,3	2,4	2,0	-	30 °	-	2,3	2,7	2,0	-
	48,3	2,3	2,0	22 °	-	2,3	2,5	2,0	-	44 °	-	2,3	3,2	2,0	-
114,3	88,9	2,6	2,3	13 °	-	2,6	2,7	2,3	-	24 °	-	2,6	2,9	2,3	-
	76,1	2,6	2,3	18 °	-	2,6	2,8	2,3	-	37 °	-	2,6	3,3	2,3	-
	60,3	2,6	2,0	26 °	-	2,6	2,9	2,0	-	51 °	23.2	2,9	4,2	2,0	-
139,7	114,3	2,6	2,6	10 °	-	2,6	2,7	2,6	-	18 °	-	2,6	2,8	2,6	-
	88,9	2,6	2,3	20 °	-	2,6	2,8	2,3	-	35 °	-	2,6	3,2	2,3	-
	76,1	2,6	2,3	25 °	-	2,6	2,9	2,3	-	43 °	-	2,6	3,6	2,3	-
168,3	139,7	2,6	2,6	9 °	-	2,6	2,7	2,6	-	18 °	-	2,6	2,8	2,6	-
	114,3	2,6	2,6	19 °	-	2,6	2,8	2,6	-	34 °	-	2,6	3,2	2,6	-
	88,9	2,6	2,3	27 °	-	2,6	3,0	2,3	-	48 °	29.4	3,1	3,9	2,3	-
219,1	168,3	2,6	2,6	18 °	-	2,6	2,8	2,6	-	31 °	-	2,6	3,1	2,9	20,2
219,1	139,7	2,6	2,6	27 °	-	2,6	3,0	2,6	-	45 °	34.1	3,2	3,7	2,8	18,1
	114,3	2,6	2,6	33 °	-	2,6	3,2	2,6	-	55 °	37.8	3,9	4,6	2,6	-
273,0	219,1	3,6	2,6	16 °	-	3,6	3,4	2,6	-	28 °	-	3,6	3,7	3,5	25,7
	168,3	3,6	2,6	30 °	-	3,6	4,2	2,7	19,7	48 °	45.3	4,5	5,4	3,6	22,7
	139,7	3,6	2,6	36 °	-	3,6	4,5	2,6	-	55 °	48.7	5,2	6,3	2,7	17,8
323,9	273,0	4,0	3,6	12 °	-	4,0	4,1	3,6	-	23 °	-	4,0	4,4	4,1	30,9
	219,1	4,0	2,6	24 °	-	4,0	4,3	3,0	23,8	44 °	49.9	4,6	5,4	4,4	28,6
	168,3	4,0	2,6	35 °	-	4,0	4,9	2,6	-	55 °	56.6	5,9	7,0	3,2	21,3
355,6	323,9	4,0	4,0	6 °	-	4,0	4,1	4,0	-	8 °	-	4,0	4,1	4,0	-
	273,0	4,0	3,6	14 °	-	4,0	4,2	3,6	-	25 °	-	4,0	4,5	3,9	30,2
	219,1	4,0	2,6	22 °	-	4,0	4,4	2,7	22,3	37 °	49.8	4,1	5,1	3,6	26,1
406,4	355,6	4,0	4,0	8 °	-	4,0	4,1	4,0	-	15 °	-	4,0	4,2	4,0	-
	323,9	4,0	4,0	13 °	-	4,0	4,2	4,0	-	24 °	-	4,0	4,4	4,2	34,0
	273,0	4,0	3,6	21 °	-	4,0	4,3	3,6	-	36 °	53.9	4,3	5,0	4,3	31,5
457,0	406,4	4,0	4,0	7 °	-	4,0	4,1	4,0	-	11 °	-	4,0	4,1	4,0	-
	355,6	4,0	4,0	14 °	-	4,0	4,2	4,0	-	24 °	-	4,0	4,4	4,2	35,8
	323,9	4,0	4,0	18 °	-	4,0	4,3	4,0	-	31 °	-	4,0	4,7	4,3	34,7
508,0	457,0	5,0	4,0	4 °	-	5,0	4,5	4,0	-	8 °	-	5,0	4,5	4,0	-
	406,4	5,0	4,0	10 °	-	5,0	5,1	4,0	-	18 °	-	5,0	5,3	4,4	39,3
	355,6	5,0	4,0	17 °	-	5,0	5,3	4,0	-	27 °	-	5,0	5,7	4,7	37,8
610,0	508,0	5,6	5,0	10 °	-	5,6	5,7	5,0	-	17 °	-	5,6	5,9	5,2	47,5
	457,0	5,6	4,0	15 °	-	5,6	5,6	4,0	-	27 °	-	5,6	6,0	5,7	47,3
	406,4	5,6	4,0	21 °	-	5,6	6,0	4,3	38,7	35 °	78.2	5,9	6,9	5,9	45,4
711,0	610,0	5,6	5,6	10 °	-	5,6	5,7	5,6	-	19 °	-	5,6	6,0	6,3	57,4
	508,0	5,6	5,0	15 °	-	5,6	5,8	5,0	-	34 °	87.7	6,0	6,7	7,1	55,5
	457,0	5,6	4,0	20 °	-	5,6	6,0	4,4	41,4	40 °	94.0	6,8	7,3	6,8	51,6
813,0	711,0	5,6	5,6	10 °	-	5,6	5,7	5,6	-	19 °	-	5,6	6,1	6,1	63,7
	610,0	5,6	5,6	15 °	-	5,6	5,8	5,6	-	34 °	96.1	6,2	7,1	7,7	63,8
	508,0	5,6	5,0	20 °	-	5,6	6,0	5,0	-	45 °	108.8	7,9	7,9	7,4	56,9
914,0	813,0	6,3	5,6	10 °	-	6,3	6,4	5,6	-	19 °	-	6,3	7,0	7,0	72,8
	711,0	6,3	5,6	15 °	-	6,3	6,6	5,6	-	34 °	108.3	7,0	8,3	8,3	74,6
	610,0	6,3	5,6	20 °	-	6,3	6,7	5,6	-	45 °	122.6	8,9	8,9	9,2	69,6
1016,0	914,0	6,3	6,3	10 °	-	6,3	6,4	6,3	-	19 °	-	6,3	7,2	7,2	78,9
	813,0	6,3	5,6	15 °	-	6,3	6,6	5,7	65,2	34 °	116.4	7,2	8,8	8,8	82,0
	711,0	6,3	5,6	20 °	-	6,3	6,7	5,6	-	45 °	131.7	9,2	9,2	9,2	78,7

Table C.5 — Wall thickness of reducers – Wall thickness serie 3

				concentric						eccentric					
D	D1	T	T1	α_{max}	$L2_{min}$	T2	T3	T4	$L4_{min}$	α_{max}	$L2_{min}$	T2	T3	T4	$L4_{min}$
76,1	60,3	2,6	2,3	9 °	-	2,6	2,7	2,3	-	15 °	-	2,6	2,7	2,3	-
88,9	76,1	2,9	2,6	7 °	-	2,9	3,0	2,6	-	13 °	-	2,9	3,0	2,6	-
	60,3	2,9	2,3	16 °	-	2,9	3,1	2,3	-	30 °	-	2,9	3,4	2,3	-
114,3	88,9	2,9	2,9	13 °	-	2,9	3,0	2,9	-	24 °	-	2,9	3,2	2,9	-
	76,1	2,9	2,6	18 °	-	2,9	3,1	2,6	-	37 °	-	2,9	3,7	2,6	-
	60,3	2,9	2,3	26 °	-	2,9	3,3	2,3	-	51 °	24,0	3,1	4,7	2,3	-
139,7	114,3	3,2	2,9	10 °	-	3,2	3,3	2,9	-	18 °	-	3,2	3,4	2,9	-
	88,9	3,2	2,9	20 °	-	3,2	3,5	2,9	-	35 °	-	3,2	4,0	2,9	-
	76,1	3,2	2,6	25 °	-	3,2	3,6	2,6	-	43 °	-	3,2	4,4	2,6	-
168,3	139,7	3,2	3,2	9 °	-	3,2	3,3	3,2	-	18 °	-	3,2	3,4	3,2	-
	114,3	3,2	2,9	19 °	-	3,2	3,4	2,9	-	34 °	-	3,2	3,9	2,9	-
	88,9	3,2	2,9	27 °	-	3,2	3,6	2,9	-	48 °	31,3	3,5	4,8	2,9	-
219,1	168,3	3,6	3,2	18 °	-	3,6	3,8	3,2	-	31 °	-	3,6	4,2	3,5	22,5
	139,7	3,6	3,2	27 °	-	3,6	4,1	3,2	-	45 °	37,8	3,9	5,1	3,3	19,9
	114,3	3,6	2,9	33 °	-	3,6	4,3	2,9	-	55 °	41,9	4,8	6,3	2,9	-
273,0	219,1	4,0	3,6	16 °	-	4,0	4,2	3,6	-	28 °	-	4,0	4,6	4,1	27,6
	168,3	4,0	3,2	30 °	-	4,0	4,7	3,2	-	48 °	46,8	4,8	6,0	3,8	23,3
	139,7	4,0	3,2	36 °	-	4,0	5,0	3,2	-	55 °	50,3	5,5	7,0	3,2	-
323,9	273,0	4,5	4,0	12 °	-	4,5	4,7	4,0	-	23 °	-	4,5	4,9	4,4	32,2
	219,1	4,5	3,6	24 °	-	4,5	5,0	3,6	-	44 °	52,4	5,0	6,3	4,8	30,0
	168,3	4,5	3,2	35 °	-	4,5	5,5	3,2	-	55 °	58,7	6,4	7,9	3,3	21,9
355,6	323,9	5,0	4,5	6 °	-	5,0	5,0	4,5	-	8 °	-	5,0	5,0	4,5	-
	273,0	5,0	4,0	14 °	-	5,0	5,2	4,0	-	25 °	-	5,0	5,6	4,5	32,5
	219,1	5,0	3,6	22 °	-	5,0	5,4	3,6	-	37 °	-	5,0	6,3	4,2	27,9
406,4	355,6	5,0	5,0	8 °	-	5,0	5,1	5,0	-	15 °	-	5,0	5,2	5,0	-
	323,9	5,0	4,5	13 °	-	5,0	5,2	4,5	-	24 °	-	5,0	5,5	4,8	36,7
	273,0	5,0	4,0	21 °	-	5,0	5,4	4,0	-	36 °	-	5,0	6,2	4,9	33,8
457,0	406,4	5,0	5,0	7 °	-	5,0	5,1	5,0	-	11 °	-	5,0	5,1	5,0	-
	355,6	5,0	5,0	14 °	-	5,0	5,2	5,0	-	24 °	-	5,0	5,5	5,0	-
	323,9	5,0	4,5	18 °	-	5,0	5,3	4,5	-	31 °	-	5,0	5,9	5,0	37,3
508,0	457,0	5,6	5,0	4 °	-	5,6	5,6	5,0	-	8 °	-	5,6	5,7	5,0	-
	406,4	5,6	5,0	10 °	-	5,6	5,7	5,0	-	18 °	-	5,6	5,9	5,0	-
	355,6	5,6	5,0	17 °	-	5,6	5,9	5,0	-	27 °	-	5,6	6,3	5,0	-
610,0	508,0	6,3	5,6	10 °	-	6,3	6,4	5,6	-	17 °	-	6,3	6,6	5,6	-
	457,0	6,3	5,0	15 °	-	6,3	6,6	5,0	-	27 °	-	6,3	7,1	6,4	50,0
	406,4	6,3	5,0	21 °	-	6,3	6,8	5,0	-	35 °	81,1	6,4	7,7	6,4	47,1
711,0	610,0	7,1	6,3	10 °	-	7,1	6,9	6,3	-	19 °	-	7,1	7,2	7,2	61,6
	508,0	7,1	5,6	15 °	-	7,1	7,4	5,6	-	34 °	-	7,1	8,5	8,3	60,1
	457,0	7,1	5,0	20 °	-	7,1	7,6	5,2	45,1	40 °	101,8	7,9	9,2	7,9	55,7
813,0	711,0	8,0	7,1	10 °	-	8,0	8,2	7,1	-	19 °	-	8,0	8,5	8,0	73,0
	610,0	8,0	6,3	15 °	-	8,0	8,0	6,3	-	34 °	-	8,0	9,3	9,8	71,7
	508,0	8,0	5,6	20 °	-	8,0	8,5	5,6	-	45 °	122,5	9,9	11,4	9,3	63,5
914,0	813,0	8,8	8,0	10 °	-	8,8	9,0	8,0	-	19 °	-	8,8	9,3	9,0	83,2
	711,0	8,8	7,1	15 °	-	8,8	9,1	7,1	-	34 °	-	8,8	10,8	10,8	84,7
	610,0	8,8	6,3	20 °	-	8,8	9,2	6,8	59,6	45 °	136,0	11,0	12,2	11,2	76,7
1016,0	914,0	10,0	8,8	10 °	-	10,0	9,9	8,8	-	19 °	-	10,0	10,3	10,1	93,6
	813,0	10,0	8,0	15 °	-	10,0	10,3	8,0	-	34 °	-	10,0	12,4	12,4	97,5
	711,0	10,0	7,1	20 °	-	10,0	10,8	7,6	71,4	45 °	153,6	12,5	14,2	12,6	91,7

Tableau C.6 — Wall thickness of reducers – Wall thickness serie 4

				concentric						eccentric					
D	D1	T	T1	α_{max}	$L2_{min}$	T2	T3	T4	$L4_{min}$	α_{max}	$L2_{min}$	T2	T3	T4	$L4_{min}$
26,9	21,3	2,0	2,0	8 °	-	2,0	2,1	2,0	-	15 °	-	2,0	2,1	2,0	-
33,7	26,9	2,3	2,0	7 °	-	2,3	2,4	2,0	-	13 °	-	2,3	2,4	2,0	-
	21,3	2,3	2,0	12 °	-	2,3	2,4	2,0	-	24 °	-	2,3	2,6	2,0	-
42,4	33,7	2,6	2,3	9 °	-	2,6	2,7	2,3	-	16 °	-	2,6	2,8	2,3	-
	26,9	2,6	2,0	15 °	-	2,6	2,7	2,0	-	30 °	-	2,6	3,1	2,0	-
	21,3	2,6	2,0	19 °	-	2,6	2,8	2,0	-	42 °	-	2,6	3,5	2,0	-
48,3	42,4	2,6	2,6	6 °	-	2,6	2,7	2,6	-	8 °	-	2,6	2,7	2,6	-
	33,7	2,6	2,3	10 °	-	2,6	2,7	2,3	-	19 °	-	2,6	2,8	2,3	-
	26,9	2,6	2,0	16 °	-	2,6	2,8	2,0	-	28 °	-	2,6	3,0	2,0	-
60,3	48,3	2,9	2,6	7 °	-	2,9	3,0	2,6	-	13 °	-	2,9	3,0	2,6	-
	42,4	2,9	2,6	11 °	-	2,9	3,0	2,6	-	20 °	-	2,9	3,1	2,6	-
60,3	33,7	2,9	2,3	16 °	-	2,9	3,1	2,3	-	29 °	-	2,9	3,4	2,3	-
76,1	60,3	2,9	2,9	9 °	-	2,9	3,0	2,9	-	15 °	-	2,9	3,1	2,9	-
	48,3	2,9	2,6	15 °	-	2,9	3,1	2,6	-	27 °	-	2,9	3,3	2,6	-
	42,4	2,9	2,6	18 °	-	2,9	3,1	2,6	-	34 °	-	2,9	3,5	2,6	-
88,9	76,1	3,2	2,9	7 °	-	3,2	3,3	2,9	-	13 °	-	3,2	3,3	2,9	-
	60,3	3,2	2,9	16 °	-	3,2	3,4	2,9	-	30 °	-	3,2	3,7	2,9	-
	48,3	3,2	2,6	22 °	-	3,2	3,5	2,6	-	44 °	-	3,2	4,5	2,6	-
114,3	88,9	3,6	3,2	13 °	-	3,6	3,7	3,2	-	24 °	-	3,6	4,0	3,2	-
	76,1	3,6	2,9	18 °	-	3,6	3,8	2,9	-	37 °	-	3,6	4,6	2,9	-
	60,3	3,6	2,9	26 °	-	3,6	4,1	2,9	-	51 °	-	3,6	5,8	2,9	-
139,7	114,3	4,0	3,6	10 °	-	4,0	4,1	3,6	-	18 °	-	4,0	4,3	3,6	-
	88,9	4,0	3,2	20 °	-	4,0	4,3	3,2	-	35 °	-	4,0	4,9	3,2	-
	76,1	4,0	2,9	25 °	-	4,0	4,5	2,9	-	43 °	-	4,0	5,5	2,9	-
168,3	139,7	4,5	4,0	9 °	-	4,5	4,6	4,0	-	18 °	-	4,5	4,8	4,0	-
	114,3	4,5	3,6	19 °	-	4,5	4,8	3,6	-	34 °	-	4,5	5,5	3,6	-
	88,9	4,5	3,2	27 °	-	4,5	5,1	3,2	-	48 °	-	4,5	6,8	3,2	-
219,1	168,3	6,3	4,5	18 °	-	6,3	6,2	4,5	-	31 °	-	6,3	6,9	4,9	26,5
	139,7	6,3	4,0	27 °	-	6,3	7,1	4,0	-	45 °	-	6,3	8,9	4,7	23,4
	114,3	6,3	3,6	33 °	-	6,3	7,6	3,6	-	55 °	49,9	6,8	11,0	3,6	-
273,0	219,1	6,3	6,3	16 °	-	6,3	6,6	6,3	-	28 °	-	6,3	7,2	6,3	-
	168,3	6,3	4,5	30 °	-	6,3	7,3	4,5	-	48 °	54,0	6,4	9,5	4,9	26,5
	139,7	6,3	4,0	36 °	-	6,3	7,8	4,0	-	55 °	58,0	7,4	11,0	4,0	-
323,9	273,0	7,1	6,3	12 °	-	7,1	7,3	6,3	-	23 °	-	7,1	7,8	6,3	-
	219,1	7,1	6,3	24 °	-	7,1	7,8	6,3	-	44 °	-	7,1	9,9	6,3	-
	168,3	7,1	4,5	35 °	-	7,1	8,7	4,5	-	55 °	67,7	8,5	12,4	4,5	-
355,6	323,9	8,0	7,1	6 °	-	8,0	7,9	7,1	-	8 °	-	8,0	7,9	7,1	-
	273,0	8,0	6,3	14 °	-	8,0	8,3	6,3	-	25 °	-	8,0	8,9	6,3	-
	219,1	8,0	6,3	22 °	-	8,0	8,7	6,3	-	37 °	-	8,0	10,1	6,3	-
406,4	355,6	8,8	8,0	8 °	-	8,8	8,9	8,0	-	15 °	-	8,8	9,2	8,0	-
	323,9	8,8	7,1	13 °	-	8,8	9,1	7,1	-	24 °	-	8,8	9,7	7,2	44,6
	273,0	8,8	6,3	21 °	-	8,8	9,5	6,3	-	36 °	-	8,8	10,9	7,0	40,4
457,0	406,4	10,0	8,8	7 °	-	10,0	10,0	8,8	-	11 °	-	10,0	10,1	8,8	-
	355,6	10,0	8,0	14 °	-	10,0	10,4	8,0	-	24 °	-	10,0	11,0	8,0	-
	323,9	10,0	7,1	18 °	-	10,0	10,6	7,1	-	31 °	-	10,0	11,7	7,9	46,8
508,0	457,0	11,0	10,0	4 °	-	11,0	11,1	10,0	-	8 °	-	11,0	11,2	10,0	-
	406,4	11,0	8,8	10 °	-	11,0	11,2	8,8	-	18 °	-	11,0	11,6	8,8	-
	355,6	11,0	8,0	17 °	-	11,0	11,6	8,0	-	27 °	-	11,0	12,4	8,0	-
610,0	508,0	12,5	11,0	10 °	-	12,5	12,7	11,0	-	17 °	-	12,5	13,1	11,0	-
	457,0	12,5	10,0	15 °	-	12,5	13,0	10,0	-	27 °	-	12,5	14,1	10,1	62,9
	406,4	12,5	8,8	21 °	-	12,5	13,4	8,8	-	35 °	-	12,5	15,3	9,8	58,4
711,0	610,0	12,5	12,5	10 °	-	12,5	12,7	12,5	-	19 °	-	12,5	13,2	12,5	-
	508,0	12,5	11,0	15 °	-	12,5	13,0	11,0	-	34 °	-	12,5	15,0	12,0	72,3
	457,0	12,5	10,0	20 °	-	12,5	13,3	10,0	-	40 °	-	12,5	16,2	11,2	66,2
813,0	711,0	12,5	12,5	10 °	-	12,5	12,7	12,5	-	19 °	-	12,5	13,2	12,5	-
	610,0	12,5	12,5	15 °	-	12,5	13,0	12,5	-	34 °	-	12,5	15,0	13,5	84,0
	508,0	12,5	11,0	20 °	-	12,5	13,3	11,0	-	45 °	141,2	13,2	17,5	12,0	72,3
914,0	813,0	12,5	12,5	10 °	-	12,5	12,7	12,5	-	19 °	-	12,5	13,2	12,5	-
	711,0	12,5	12,5	15 °	-	12,5	13,0	12,5	-	34 °	-	12,5	15,0	13,4	94,9
	610,0	12,5	12,5	20 °	-	12,5	13,3	12,5	-	45 °	153,0	13,8	17,5	14,0	85,6
1016,0	914,0	12,5	12,5	10 °	-	12,5	12,7	12,5	-	19 °	-	12,5	13,2	12,5	-
	813,0	12,5	12,5	15 °	-	12,5	13,0	12,5	-	34 °	-	12,5	15,0	14,4	105,4
	711,0	12,5	12,5	20 °	-	12,5	13,3	12,5	-	45 °	164,5	14,3	17,5	14,3	97,9

Table C.7 —C. Wall thickness of reducers – Wall thickness serie 5

				concentric						eccentric					
D	D1	T	T1	α_{max}	$L2_{min}$	T2	T3	T4	$L4_{min}$	α_{max}	$L2_{min}$	T2	T3	T4	$L4_{min}$
26,9	21,3	3,2	3,2	8 °	-	3,2	3,3	3,2	-	15 °	-	3,2	3,4	3,2	-
33,7	26,9	3,2	3,2	7 °	-	3,2	3,3	3,2	-	13 °	-	3,2	3,3	3,2	-
	21,3	3,2	3,2	12 °	-	3,2	3,3	3,2	-	24 °	-	3,2	3,6	3,2	-
42,4	33,7	3,6	3,2	9 °	-	3,6	3,7	3,2	-	16 °	-	3,6	3,8	3,2	-
	26,9	3,6	3,2	15 °	-	3,6	3,8	3,2	-	30 °	-	3,6	4,2	3,2	-
	21,3	3,6	3,2	19 °	-	3,6	3,9	3,2	-	42 °	-	3,6	4,9	3,2	-
48,3	42,4	3,6	3,6	6 °	-	3,6	3,7	3,6	-	8 °	-	3,6	3,7	3,6	-
	33,7	3,6	3,2	10 °	-	3,6	3,7	3,2	-	19 °	-	3,6	3,9	3,2	-
	26,9	3,6	3,2	16 °	-	3,6	3,8	3,2	-	28 °	-	3,6	4,1	3,2	-
60,3	48,3	4,0	3,6	7 °	-	4,0	4,1	3,6	-	13 °	-	4,0	4,2	3,6	-
	42,4	4,0	3,6	11 °	-	4,0	4,1	3,6	-	20 °	-	4,0	4,3	3,6	-
	33,7	4,0	3,2	16 °	-	4,0	4,2	3,2	-	29 °	-	4,0	4,6	3,2	-
76,1	60,3	5,0	4,0	9 °	-	5,0	5,1	4,0	-	15 °	-	5,0	5,2	4,0	-
	48,3	5,0	3,6	15 °	-	5,0	5,2	3,6	-	27 °	-	5,0	5,7	3,6	-
	42,4	5,0	3,6	18 °	-	5,0	5,3	3,6	-	34 °	-	5,0	6,1	3,6	-
88,9	76,1	5,6	5,0	7 °	-	5,6	5,7	5,0	-	13 °	-	5,6	5,8	5,0	-
	60,3	5,6	4,0	16 °	-	5,6	5,9	4,0	-	30 °	-	5,6	6,5	4,0	-
	48,3	5,6	3,6	22 °	-	5,6	6,1	3,6	-	44 °	-	5,6	7,8	3,6	-
114,3	88,9	6,3	5,6	13 °	-	6,3	6,5	5,6	-	24 °	-	6,3	6,9	5,6	-
	76,1	6,3	5,0	18 °	-	6,3	6,7	5,0	-	37 °	-	6,3	7,9	5,0	-
	60,3	6,3	4,0	26 °	-	6,3	7,1	4,0	-	51 °	-	6,3	10,1	4,0	-
139,7	114,3	6,3	6,3	10 °	-	6,3	6,4	6,3	-	18 °	-	6,3	6,7	6,3	-
	88,9	6,3	5,6	20 °	-	6,3	6,8	5,6	-	35 °	-	6,3	7,7	5,6	-
	76,1	6,3	5,0	25 °	-	6,3	7,0	5,0	-	43 °	-	6,3	8,7	5,0	-
168,3	139,7	7,1	6,3	9 °	-	7,1	7,2	6,3	-	18 °	-	7,1	7,5	6,3	-
	114,3	7,1	6,3	19 °	-	7,1	7,6	6,3	-	34 °	-	7,1	8,6	6,3	-
	88,9	7,1	5,6	27 °	-	7,1	8,0	5,6	-	48 °	-	7,1	10,7	5,6	-
219,1	168,3	8,0	7,1	18 °	-	8,0	8,5	7,1	-	31 °	-	8,0	9,4	7,1	-
	139,7	8,0	6,3	27 °	-	8,0	9,0	6,3	-	45 °	-	8,0	11,4	6,3	-
	114,3	8,0	6,3	33 °	-	8,0	9,6	6,3	-	55 °	-	8,0	14,0	6,3	-
273,0	219,1	10,0	8,0	16 °	-	10,0	10,4	8,0	-	28 °	-	10,0	11,3	8,0	-
	168,3	10,0	7,1	30 °	-	10,0	11,6	7,1	-	48 °	-	10,0	15,0	7,1	-
	139,7	10,0	6,3	36 °	-	10,0	12,4	6,3	-	55 °	-	10,0	17,5	6,3	-
323,9	273,0	10,0	10,0	12 °	-	10,0	10,3	10,0	-	23 °	-	10,0	10,9	10,0	-
	219,1	10,0	8,0	24 °	-	10,0	11,0	8,0	-	44 °	-	10,0	14,0	8,0	-
	168,3	10,0	7,1	35 °	-	10,0	12,3	7,1	-	55 °	75,3	10,5	17,5	7,1	-
355,6	323,9	11,0	10,0	6 °	-	11,0	11,1	10,0	-	8 °	-	11,0	11,1	10,0	-
	273,0	11,0	10,0	14 °	-	11,0	11,4	10,0	-	25 °	-	11,0	12,2	10,0	-
	219,1	11,0	8,0	22 °	-	11,0	11,9	8,0	-	37 °	-	11,0	13,8	8,0	-
406,4	355,6	12,5	11,0	8 °	-	12,5	12,7	11,0	-	15 °	-	12,5	13,0	11,0	-
	323,9	12,5	10,0	13 °	-	12,5	12,9	10,0	-	24 °	-	12,5	13,7	10,0	-
	273,0	12,5	10,0	21 °	-	12,5	13,4	10,0	-	36 °	-	12,5	15,5	10,0	-

Table C.8 — Wall thickness of reducers – Wall thickness serie 6

				concentric						eccentric					
D	D1	T	T1	α_{max}	$L2_{min}$	T2	T3	T4	$L4_{min}$	α_{max}	$L2_{min}$	T2	T3	T4	$L4_{min}$
26,9	21,3	4,0	4,0	8 °	-	4,0	4,1	4,0	-	15 °	-	4,0	4,2	4,0	-
33,7	26,9	4,5	4,0	7 °	-	4,5	4,6	4,0	-	13 °	-	4,5	4,7	4,0	-
	21,3	4,5	4,0	12 °	-	4,5	4,7	4,0	-	24 °	-	4,5	5,0	4,0	-
42,4	33,7	5,0	4,5	9 °	-	5,0	5,1	4,5	-	16 °	-	5,0	5,3	4,5	-
42,4	26,9	5,0	4,0	15 °	-	5,0	5,2	4,0	-	30 °	-	5,0	5,8	4,0	-
	21,3	5,0	4,0	19 °	-	5,0	5,3	4,0	-	42 °	-	5,0	6,8	4,0	-
48,3	42,4	5,0	5,0	6 °	-	5,0	5,1	5,0	-	8 °	-	5,0	5,1	5,0	-
	33,7	5,0	4,5	10 °	-	5,0	5,1	4,5	-	19 °	-	5,0	5,3	4,5	-
	26,9	5,0	4,0	16 °	-	5,0	5,3	4,0	-	28 °	-	5,0	5,7	4,0	-
60,3	48,3	5,6	5,0	7 °	-	5,6	5,7	5,0	-	13 °	-	5,6	5,8	5,0	-
	42,4	5,6	5,0	11 °	-	5,6	5,8	5,0	-	20 °	-	5,6	6,0	5,0	-
	33,7	5,6	4,5	16 °	-	5,6	5,9	4,5	-	29 °	-	5,6	6,5	4,5	-
76,1	60,3	7,1	5,6	9 °	-	7,1	7,2	5,6	-	15 °	-	7,1	7,4	5,6	-
	48,3	7,1	5,0	15 °	-	7,1	7,4	5,0	-	27 °	-	7,1	8,0	5,0	-
	42,4	7,1	5,0	18 °	-	7,1	7,5	5,0	-	34 °	-	7,1	8,6	5,0	-
88,9	76,1	8,0	7,1	7 °	-	8,0	8,1	7,1	-	13 °	-	8,0	8,3	7,1	-
	60,3	8,0	5,6	16 °	-	8,0	8,4	5,6	-	30 °	-	8,0	9,3	5,6	-
	48,3	8,0	5,0	22 °	-	8,0	8,7	5,0	-	44 °	-	8,0	11,2	5,0	-
114,3	88,9	8,8	8,0	13 °	-	8,8	9,1	8,0	-	24 °	-	8,8	9,7	8,0	-
	76,1	8,8	7,1	18 °	-	8,8	9,3	7,1	-	37 °	-	8,8	11,1	7,1	-
	60,3	8,8	5,6	26 °	-	8,8	9,8	5,6	-	51 °	-	8,8	14,0	5,6	-
139,7	114,3	10,0	8,8	10 °	-	10,0	10,2	8,8	-	18 °	-	10,0	10,6	8,8	-
	88,9	10,0	8,0	20 °	-	10,0	10,7	8,0	-	35 °	-	10,0	12,3	8,0	-
	76,1	10,0	7,1	25 °	-	10,0	11,1	7,1	-	43 °	-	10,0	13,7	7,1	-
168,3	139,7	11,0	10,0	9 °	-	11,0	11,2	10,0	-	18 °	-	11,0	11,6	10,0	-
	114,3	11,0	8,8	19 °	-	11,0	11,7	8,8	-	34 °	-	11,0	13,3	8,8	-
	88,9	11,0	8,0	27 °	-	11,0	12,4	8,0	-	48 °	-	11,0	16,5	8,0	-
219,1	168,3	12,5	11,0	18 °	-	12,5	13,2	11,0	-	31 °	-	12,5	14,6	11,0	-
	139,7	12,5	10,0	27 °	-	12,5	14,1	10,0	-	45 °	-	12,5	17,7	10,0	-
	114,3	12,5	8,8	33 °	-	12,5	15,0	8,8	-	55 °	-	12,5	21,8	8,8	-

Annex D
(informative)

Commonly used inside diameters and wall thicknesses

Table D.1 — commonly used diameters and wall thicknesses

ID	1	2	3	4	5	6	7	8	9	10
15,0	1,5									
16,0	1,5	2,0								
20,0	1,5	2,0								
21,0		2,0								
25,0	1,5									
26,0		2,0								
32,0	1,5									
34,0		2,0								
35,0	1,5									
40,0	1,5	2,0								
50,0	1,5	2,0								
51,0		2,0		3,0						
65,0		2,0								
75,0		2,0								
80,0		2,0	2,5	3,0						
100,0		2,0	2,5	3,0						
125,0		2,0	2,5	3,0						
150,0		2,0	2,5	3,0	4,0					
200,0		2,0	2,5	3,0	4,0	5,0				
250,0		2,0	2,5	3,0	4,0	5,0				
300,0		2,0	2,5	3,0	4,0	5,0	6,0			
350,0				3,0	4,0	5,0	6,0	8,0		
400,0				3,0	4,0	5,0	6,0	8,0		
450,0				3,0	4,0	5,0	6,0	8,0		
500,0				3,0	4,0	5,0	6,0	8,0		
600,0				3,0	4,0	5,0	6,0	8,0		
700,0					4,0	5,0	6,0	8,0	10,0	
800,0					4,0	5,0	6,0	8,0	10,0	
900,0					4,0	5,0	6,0	8,0	10,0	
1000,0						5,0	6,0	8,0	10,0	12,0

Annex ZA
(informative)

Clauses of this European Standard addressing essential requirements or other provisions of EU Directives

This European Standard has been prepared under a mandate given to CEN by the European Commission and supports essential requirements of EU Directive 97/23/EC.

Warning Other requirements and other EU Directives may be applicable to the product(s) falling within the scope of this European Standard.

The clauses of this European Standard are likely to support the essential requirements of section 4 of annex 1, “Essential safety requirements” of the Pressure Equipment Directive 97/23/EC.

Compliance with this European Standard provides one means of conforming to the specific essential requirements of the Directive concerned.