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**EN 10253-2:2007**

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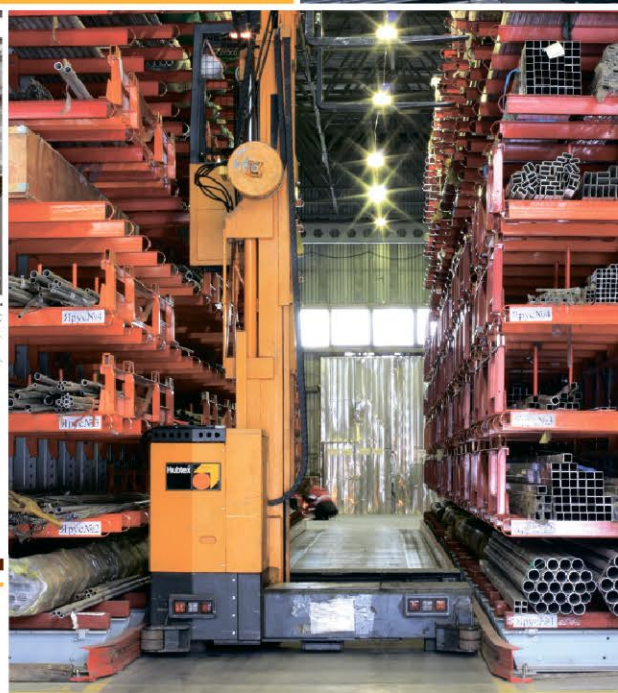
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СОВРЕМЕННЫХ И АВТОМАТИЗИРОВАННЫХ  
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## ТОНН

НЕСНИЖАЕМЫЙ  
СКЛАДСКОЙ ОСТАТОК

**Щелково**, +7 (495) 775-55-22  
ул. Заводская, д. 14Б, пом.17

**Челябинск**, +7 (351) 242-01-02  
пр-т Победы, д. 158, офис 407

**Санкт-Петербург**, +7 (812) 454-21-54  
пр-т Обуховской обороны, д. 112, литера И, БЦ "ВАНТ", офис 235

**Воронеж**, +7 (473) 300-38-88  
ул. Солнечная, 10Б, БК "Крепезж", офис 210

**Краснодар**, +7 (861) 205-00-10  
Ростовское шоссе, д. 14/2, офис 306

**Самара**, +7 (846) 300-44-54  
Заводское шоссе, д. 111, офис 452

**Нижний Новгород**, +7 (831) 260-12-22  
ул. Варварская, д. 32, литера Д, офис 301

**Пятигорск**, +7 (8793) 31-78-22  
Черкесское шоссе, д. 11



**BRITISH STANDARD**

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**BS EN  
10253-2:2007**

# Butt-welding pipe fittings —

## Part 2: Non alloy and ferritic alloy steels with specific inspection requirements

The European Standard EN 10253-2:2007 has the status of a  
British Standard

ICS 23.040.40

## National foreword

This British Standard is the UK implementation of EN 10253-2:2007. Together with BS EN 10253-1:1999 it supersedes BS 1965-1:1963, which is withdrawn. It partially supersedes BS 1640-1:1962, and BS 1640-3:1968, which will be withdrawn upon publication of BS EN 10253-3 and BS EN 10253-4.

The UK participation in its preparation was entrusted to Technical Committee ISE/19, Pipe fittings (other than cast iron).

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

**Compliance with a British Standard cannot confer immunity from legal obligations.**

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Management Centre: rue de Stassart, 36 B-1050 Brussels

## EN 10253-2:2007 (E)

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## EN 10253-2:2007 (E)

### Foreword

This document (EN 10253-2:2007) has been prepared by Technical Committee ECISS/TC 29 "Steel tubes and fittings for steel tubes", the secretariat of which is held by UNI/UNSIDER.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by May 2008, and conflicting national standards shall be withdrawn at the latest by May 2008.

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 (97/23/EC).

For relationship with EU Directive, 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 : Non alloy 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, and decided to reflect these in the standard by differentiating between two parts.

EN 10253-1 describes fittings without formal reference to the pressure resistance, which are not intended to be used in applications covered by the Pressure Equipment Directive (97/23/EC).

EN 10253-2 defines two types of fittings : Type A fittings have the same wall thickness at the welding ends and at the body of the fitting than a pipe having the same specified wall thickness. Their resistance to internal pressure is, in general, less than that of a straight pipe with the same dimensions. Type B fittings showing increased wall thickness at the body of the fitting are designed to resist the same internal pressure as a straight pipe with same dimensions. These two types of fittings are intended to be used in applications covered by the EU Directive 97/23/EC. According to this Directive and further interpretation guidelines (e.g. guideline 7/19), seamless fittings are considered as materials whereas welded fittings are considered as components. Therefore, in some areas of this European Standard, provisions for seamless and welded fittings are different.

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.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.



## 1 Scope

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 carbon and alloy steel which are intended for pressure purposes at room temperature, at low temperature or at elevated temperatures, and for the transmission and distribution of fluids and gases.

It specifies:

- type of fittings ;
  - type A : Butt-welding fittings with reduced pressure factor ;
  - type B : Butt-welding fittings for use at full service pressure ;
- steel grades ;
- mechanical properties ;
- dimensions and tolerances ;
- requirements for inspection and testing ;
- inspection documents ;
- marking ;
- protection and packaging.

**NOTE** In the case of a harmonised supporting standard for materials, presumption of conformity to the ESRs is limited to technical data of materials in the standard and does not presume adequacy of the material to a specific item of equipment. Consequently it is essential that the technical data stated in the material standard be assessed against the design requirements of this specific item of equipment to verify that the ESRs of the PED are satisfied.

## 2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

EN 910, *Destructive tests on welds in metallic materials — Bend tests*

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 testing at elevated temperature*

EN 10020:2000, *Definition and classification of grades of steel*

EN 10021:2006, *General technical delivery conditions for steel products*

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EN 10027-1, *Designation systems for steels — Part 1: Steel names*

EN 10027-2, *Designation systems for steels — Part 2: Numerical system*

EN 10028-2, *Flat products made of steels for pressure purposes — Part 2: Non-alloy and alloy steels with specified elevated temperature properties*

EN 10028-3, *Flat products made of steels for pressure purposes — Part 3: Weldable fine grain steels, normalized*

EN 10028-4, *Flat products made of steels for pressure purposes — Part 4: Nickel alloy steels with specified low temperature properties*

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

EN 10052:1993, *Vocabulary of heat treatment terms for ferrous products*

EN 10168, *Steel products — Inspection documents — List of information and description*

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

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

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

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

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

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

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

EN 10246-10, *Non-destructive testing of steel tubes — Part 10: Radiographic testing of the weld seam of automatic fusion arc welded steel tubes for the detection of imperfections*

EN 10246-11, *Non-destructive testing of steel tubes — Part 11: Liquid penetrant testing of seamless and welded steel tubes for the detection of surface imperfections*

EN 10246-12, *Non-destructive testing of steel tubes — Part 12: Magnetic particle inspection of seamless and welded ferromagnetic steel tubes for the detection of surface imperfections*

EN 10266:2003, *Steel tubes, fittings and structural hollow sections — Symbols and definitions of terms for use in product standards*

EN 10273, *Hot rolled weldable steel bars for pressure purposes with specified elevated temperature properties*

EN 13480-3:2002, *Metallic industrial piping — Part 3: Design and calculation*

EN ISO 377:1997, *Steel and steel products — Location and preparation of samples and test pieces for mechanical testing (ISO 377:1997)*

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EN ISO 2566-1, *Steel — Conversion of elongation values — Part 1: Carbon and low alloy steels (ISO 2566-1:1984)*.

EN ISO 3166-1, *Codes for the representation of names of countries and their subdivisions — Part 1: Country codes (ISO 3166-1:2006)*

EN ISO 6708, *Pipe work components — Definition and selection of DN (nominal size) (ISO 6708:1995)*

EN ISO 14284, *Steel and iron — Sampling and preparation of samples for the determination of chemical composition (ISO 14284:1996)*

EN ISO 15614-1, *Specification and qualification of welding procedures for metallic materials - Welding procedure test — Part 1: Arc and gas welding of steels and arc welding of nickel and nickel alloys (ISO 15614-1:2004)*

ISO 1027, *Radiographic image quality indicators for non-destructive testing — Principles and identification*

### **3 Terms and definitions**

For the purposes of this document, the relevant definitions in EN 10020:2000, EN 10021:2006, EN 10052:1993 and EN ISO 377:1997 apply, except as defined below.

#### **3.1**

##### **carbon steel grade**

in this part of EN 10253, the following grades :

P235TR2 - P265TR2 - P235GH - P265GH - P355N - P355NH - P355NL1 - P215NL - P265NL

#### **3.2**

##### **employer**

organisation for which a person works on a regular basis

NOTE The employer may be either the fitting manufacturer or supplier or a third party organisation providing a service, e.g. NDT.

#### **3.3**

##### **model**

for elbows and return bends, the model defines the bending radius of the piece

#### **3.4**

##### **purchaser**

person or organisation that orders products in accordance with this European Standard

NOTE 1 The purchaser is not necessarily, but may be, a manufacturer of pressure equipment in accordance with the EU Directive listed in Annex ZA.

NOTE 2 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.

#### **3.5**

##### **weld during manufacture**

weld made for obtaining a fitting

NOTE This term does not include the tube welds when a tube is used as starting material.

**EN 10253-2:2007 (E)****3.6****seamless fitting**

fitting manufactured without welding from starting material which is not welded

**3.7****welded fitting****3.7.1**

fitting made from welded tubes

**3.7.2**

fitting made from sheet/plate or strip where welding is a part of the manufacturing process

## 4 Symbols

For the purposes of this document, the symbols defined in EN 10266:2003 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 ;
$D_1$	Specified minor outside diameter for reducers and reducing tees, expressed in millimetres ;
$T$	Specified wall thickness at the welding ends for elbows, return bends, equal tees and bends or on the $D$ end for reducers and reducing tees, expressed in millimetres ;
$T_1$	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 ( $ID = D - 2T$ ) ;
$ID_1$	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 ( $C \approx 2R$ ), 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 ;
$k$	Total height for caps, expressed in millimetres ;
$L$	Face to face distance for reducers, expressed in millimetres ;
$X$	Tolerance on the form of fittings ;
$r$	Inside knuckle radius of cap ;
$R$	Bending radius of elbows and return bends, expressed in millimetres ;
$R1$	Inside spherical radius of cap ;
$P$	Tolerance on the form of elbows ;
$W$	Distance from the extrados to the centre of a 90° elbow at the welding ends ;

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$Z$	Distance from the extrados to the centre of a 45° elbow at the welding ends ;
$R_m$	Tensile strength at room temperature, expressed in megapascals ;
$R_{p0,2}$	Minimum 0,2 % proof strength at room temperature, expressed in megapascals ;
$A$	Percentage of elongation at rupture, with reference to gauge length of $5,65 \sqrt{S_0}$ .

## 5 Designations

### 5.1 Designation of steel grades

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

— number of this European Standard (EN 10253-2) ;

plus either :

— steel name in accordance with EN 10027-1 ;

or

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

### 5.2 Designation of fittings

Elbows and return bends are designated by the model (2D, 3D or 5D), the angle, the outside diameter  $D$ .

Reducers are designated by the model (concentric or eccentric), the major diameter  $D$ , the minor diameter  $D_1$ .

Equal tees are designated by the outside diameter  $D$ .

Reducing tees are designated by the major diameter  $D$ , the minor diameter  $D_1$ .

Caps are designated by the outside diameter  $D$ .

## 6 Information to be supplied by the purchaser

### 6.1 Mandatory information

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

- quantity required (number of pieces) ;
- reference to this European Standard ;
- type of fitting, A or B ;
- designation of fittings (see 5.2) and the wall thickness  $T(T_1)$  ;
- designation of the steel grade (see 5.1) ;

## 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 6.1).

- 1) Steelmaking process (see 8.1) ;
- 2) method of manufacture of the fitting (see 8.2) ;
- 3) starting product form and /or delivery condition (see 8.2.1) ;
- 4) information about the product-making process (see 8.2.1) ;
- 5) type of heat treatment (see 8.2.3) ;
- 6) other grades as specified on the purchase order (see 9.2.1) ;
- 7) product analysis (see 9.2.2) ;
- 8) verification of the proof strength at elevated temperature (see 9.3) ;
- 9) tolerance to be applied to the outside diameter (see 11.2.1.1) ;
- 10) special ID tolerances for pigging (see 11.2.1.2) ;
- 11) plus tolerances on the body of the fitting (see 11.2.2) ;
- 12) end finishing (see 11.3) ;
- 13) inspection document 3.2 (see 12.2.1) ;
- 14) mechanical properties determined on the finished product (see 9.2) ;
- 15) hardness testing of each fitting (see Table 20) ;
- 16) impact testing for grades listed in footnote <sup>e</sup> of Table 20 (see Table 20) ;
- 17) registration records of the heat treatment temperatures (see 13.1.1) ;
- 18) size of the test unit per Table 21 (see 13.1.1) ;
- 19) size of the test unit per Table 22 (see 13.1.1) ;
- 20) special test unit size (see 13.1.1) ;
- 21) impact test of the heat affected zone (see 13.2.6) ;
- 22) NDT of welds after forming (see 14.9.2.1) ;
- 23) NDT of welds mandatory after forming (see 14.9.2.1) ;

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- 24) NDT of the starting material for the detection of laminar imperfections (see 14.9.4) ;
- 25) method of marking to be applied (see 15.2) ;
- 26) special provisions concerning marking (see 15.2) ;
- 27) protection to be applied (see Clause 16).

### 6.3 Examples of an order

#### 6.3.1 Example 1

1 000 elbows in accordance with this European Standard, of type A (not having an increased wall thickness for the body of the fitting) and model 3D, with angle 90°, having an outside diameter 114, and a wall thickness 6,3, made of steel grade P265GH.

**1000 elbows - EN 10253-2 - Type A – Model 3D - 90° - 114,3 X 6,3 - P265GH**

#### 6.3.2 Example 2

500 reducing tees in accordance with this European Standard of type B (having an increased wall thickness for the body of the fitting), with dimensions 114,3 X 6,3 - 88,9 X 4,0 and made of steel grade P265GH.

**500 reducing tees - EN 10253-2 – Type B - 114, 3X6,3 - 88,9 X 4,0 - P265GH**

## 7 Resistance to internal pressure

### 7.1 General

The Pressure Equipment Directive (EU Directive 97/23/EC — Annex I — subclause 2.2.2) imposes that the design for adequate strength shall be based on a calculation method or, with restrictions, on an experimental 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.

The selection of the appropriate fitting (material, thickness) is the ultimate responsibility of the manufacturer of the pressure equipment (See Annex ZA for presumption of conformity of the material to the ESR's of Directive 97/23/EC).

For fittings of type A in carbon steel grades, when the manufacturer is able to guarantee that the minimum yield strength of the delivered products is higher than the specified minimum yield strength, the wall thickness may be reduced such as the product of the reduced thickness times the minimum product yield strength shall at least equal the product of the specified wall thickness times the specified minimum yield strength of the specified grade. For such products the mechanical properties shall be determined on the finished product and they shall be clearly identified on the inspection documents and by specific marking. See 12.2 for relevant documents, 12.3 for testing and Clause 15 for relevant information on marking.

### 7.2 Fittings of type A

Type A fitting have the same wall thickness at the welding ends and at the body of the fitting than a pipe having the same specified wall thickness. 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. The determination of the reducing pressure factor is given in Annex A and tables of pressure factors are given in Annex B.

For reducers the wall thickness at the conical section shall be the specified wall thickness at the major 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 than a pipe having the same specified diameter, wall thickness and the same steel grade.

Wall thickness requirements for this type of fittings are defined by the calculation procedures given in Annex A. 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 and shall be reported. The steels shall be fully killed.

**Option 1 :** *The steelmaking process shall be as specified on the purchase order.*

### 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. Differing starting materials and production routes are associated with variations in the types of controls applied. The method of manufacturing is left at the discretion of the manufacturer. When choosing the method the manufacturer shall take suitable precautions to prevent the occurrence of ageing problems in the final product form.

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

- unless otherwise specified, the choice of the tubes (seamless or welded) is left at the discretion of the manufacturer ;
- when manufacturing fittings from welded tubes, only tubes according to EN 10217, Parts 1 to 6 shall be used. Tubes marked "C1" and/or " C2" are not allowed ;
- helical SAW tubes are not permitted ;
- after forming, repair of the pipe weld seam is only permitted for weld seams made with filler metal. These repairs shall be carried out as described in 8.2.2.

Where plate/strip are used as starting material for welded fittings, the following condition shall apply :

- only plate / strip according to EN 10028-2 to -4 shall be used.

Where bars are used as starting material for welded or machined fittings, the following condition shall apply :

- only bars according to EN 10273 shall be used.

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Table 1 — Product making process – Starting product forms <sup>a</sup>

Process	Hot deformation			Cold deformation		Machining from round bars (DN < 50) <sup>d</sup>
	Bending <sup>b</sup>	Pressed in die <sup>c</sup>	Rolled, forged followed by machining	Bending <sup>b</sup>	Pressed in die <sup>c</sup>	
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

<sup>a</sup> Starting material :

- 1 seamless pipe ;
- 2 welded pipe ;
- 3 plate and strip ;
- 4 forging ;
- 5 bar.

<sup>b</sup> When producing elbows from welded pipe, the position of the weld is at the discretion of the manufacturer.

<sup>c</sup> For these processes welding with or without filler metal may be used (see 8.2.2.1). When filler metal is used it shall be compatible with the parent metal.

<sup>d</sup> The method of manufacture shall be reported.

**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.*

**Option 4 :** *The method of manufacture shall be reported.*

## 8.2.2 Welding as part of the manufacturing process of the fitting

### 8.2.2.1 General

When producing fittings from plate or strip, welding is considered being a part of the manufacturing of fittings, and :

- welding process/procedures shall be qualified in accordance with EN ISO 15614-1 ;
- welders and/or welding operators shall be qualified in accordance with EN 287-1 and/or EN 1418.

For pressure equipment in categories II, III, and IV, (of Directive 97/23 EC) the operating procedures and the personnel shall be approved by a competent third-party.

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 and the repaired area is heat treated and non destructively tested in the same way as the original weld.

All joints welded with filler metal shall be finished in accordance with the requirements in 8.2.2.1 and 8.2.2.2.

When taking into account the conditions specified for the manufacture of fittings and for the testing of the welds, a weld efficiency factor of 1,0 can be used in design calculations.

### 8.2.2.2 Alignment tolerances

Alignments of sections at edges to be butt-welded shall be such that the maximum offset does not cause the effective wall thickness to be less than the specified minimum and is not greater than :

$$t / 20 + 1 \text{ mm}$$

where:

$t$  is the nominal wall thickness of the thinner section to be joined.

### 8.2.2.3 Finished joint requirement

As welded surfaces are permitted provided the surface imperfections permit proper interpretation of radiographic or other non-destructive examination. If there is a question regarding the surface condition of the weld when interpreting the radiographic film, the film shall be compared to the actual weld surface for determination of acceptability.

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

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.

To assure that the weld grooves are completely filled the reinforcement on each face of the weld is permitted provided that it does not exceed the values specified in Table 2.

**Table 2 — Height of reinforcement**

Dimensions in millimetres

Base metal thickness ( $T$ )	Reinforcement
$T < 5$	1,0
$5 \leq T \leq 10$	0,2t
$10 < T \leq 25$	3,0
$25 < T \leq 50$	3,0 inside 5,0 outside
$50 < T$	5,0 inside 6,0 outside

The finished joint criteria for the fittings made from welded pipe without filler metal shall be governed by the standard defining the starting material.

### 8.2.3 Heat treatment condition

The fittings shall be delivered in one of the final heat-treated conditions given in Table 3. Recommended heat treatment temperatures are given in Annex D.

In case of hot deformation fittings in carbon steel grades (see Clause 3) and steel grade 16Mo3 may be delivered without heat treatment if hot deformation produces a technically equivalent metallurgical structure with the corresponding mechanical characteristics.

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This condition is regarded as satisfied when the final forming operation is completed at a temperature between 750 °C and 980 °C.

When welding is part of the manufacturing process of the fitting, the final heat treatment shall be carried out after welding.

**Option 5 :** *The heat treatment to be applied shall be as specified on the purchase order.*

**Table 3 — Steel grades — Heat treatment conditions**

Steel grade	Heat treatment condition <sup>a</sup>
P235TR2	N
P265TR2	N
P235GH	N
P265GH	N
16Mo3	N
10CrMo5-5	NT <sup>b</sup>
13CrMo4-5	NT <sup>b</sup>
10CrMo9-10	NT <sup>b</sup>
X11CrMo5	I or NT
X11CrMo9-1	I or NT
X10CrMoVNb9-1	NT <sup>b</sup>
P355N	N
P355NH	N
P355NL1	N
P215NL	N
P265NL	N
12Ni14	NT or QT
X10Ni9	NT or QT
L290NB	N
L360NB	N
L360QB	QT
L415NB	N
L415QB	QT
L450QB	QT

N = Normalized or normalized formed ; NT = Normalized and tempered.  
 QT = Quenched and tempered ; I = Isothermal annealing.

<sup>a</sup> These heat treatments are identical to those described in the corresponding tube standards.

<sup>b</sup> For these steel grades it may be necessary in the case of wall thickness T above 25 mm or T/D > 0,15 to apply quenching and tempering in order to achieve the intended structure and material properties. The decision shall be left to the discretion of the manufacturer but shall be stated to the customer at the time of enquiry and order. Steel tubes treated in such a way shall be designated by the steel name supplemented by the symbol "+QT".

## 9 Technical requirements

### 9.1 General

Fittings supplied and inspected in accordance with Clauses 8, 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.

The requirements for the base material of the seamless fittings are left at the discretion of the manufacturer provided the requirements defined in Clauses 8 and 9 are fulfilled.

### 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 4.

**Option 6 :** *Other grades, as specified on the purchase order, may be agreed.*

#### 9.2.2 Product analysis

**Option 7 :** *A product analysis shall be supplied.*

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

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Table 4 — Chemical composition (cast analysis), in % by mass <sup>a</sup>

Steel name	Steel number	C	Si	Mn	P	S	Al tot	Cr	Cu	Mo	Nb	Ni	Ti	V	Others
P235TR2	1.0255	0,16	0,35	1,20	0,025	0,020	≥ 0,020 <sup>c</sup>	0,30 <sup>b</sup>	0,30 <sup>b</sup>	0,08 <sup>b</sup>	0,01 <sup>b</sup>	0,30 <sup>b</sup>	0,04 <sup>b</sup>	0,02 <sup>b</sup>	Cr+Cu+Mo+Ni ≤ 0,70
P265TR2	1.0259	0,20	0,40	1,40	0,025	0,020	≥ 0,020 <sup>c</sup>	0,30 <sup>b</sup>	0,30 <sup>b</sup>	0,08 <sup>b</sup>	0,01 <sup>b</sup>	0,30 <sup>b</sup>	0,04 <sup>b</sup>	0,02 <sup>b</sup>	«
P235GH	1.0345	0,16	0,35	1,20	0,025	0,020	≥ 0,020 <sup>c</sup>	0,30	0,30	0,08	0,01 <sup>b</sup>	0,30	0,04 <sup>b</sup>	0,02 <sup>b</sup>	«
P265GH	1.0425	0,20	0,40	1,40	0,025	0,020	≥ 0,020 <sup>c</sup>	0,30	0,30	0,08	0,01 <sup>b</sup>	0,30	0,04 <sup>b</sup>	0,02 <sup>b</sup>	«
16Mo3	1.5415	0,12-0,20 <sup>d</sup>	0,35	0,40-0,90	0,025	0,020	≤ 0,040	0,30	0,30	0,25-0,35	-	0,30	-	-	-
10CrMo5-5	1.7338	0,15	0,50-1,00	0,30-0,60	0,025	0,020	≤ 0,040	1,00-1,50	0,30	0,45-0,65	-	0,30	-	-	-
13CrMo4-5	1.7335	0,10-0,17 <sup>d</sup>	0,35	0,40-0,70	0,025	0,020	≤ 0,040	0,70-1,15	0,30	0,40-0,60	-	0,30	-	-	-
10CrMo9-10	1.7380	0,08-0,14	0,50	0,30-0,70	0,025	0,020	≤ 0,040	2,00-2,50	0,30	0,90-1,10	-	0,30	-	-	-
X11CrMo5	1.7362	0,08-0,15	0,15-0,50	0,30-0,60	0,025	0,020	≤ 0,040	4,00-6,00	0,30	0,45-0,65	-	-	-	-	-
X11CrMo9-1	1.7386	0,08-0,15	0,25-1,00	0,30-0,60	0,025	0,020	≤ 0,040	8,00-10,00	0,30	0,90-1,10	-	-	-	-	-
X10CrMoV Nb9-1	1.4903	0,08-0,12	0,20-0,50	0,30-0,60	0,020	0,010	≤ 0,040	8,00-9,50	0,30	0,85-1,05	0,06-0,10	0,40	-	0,18-0,25	N : 0,030-0,070
P355N P355 NH	1.0562 1.0565	0,20	0,50	0,90-1,70	0,025	0,020	≥ 0,020 <sup>c</sup>	0,30 <sup>b</sup>	0,30 <sup>e</sup>	0,08 <sup>e</sup>	0,05	0,50	0,04	0,10	N ≤ 0,02 Nb+Ti+V ≤ 0,12
P355NL1	1.0566	0,18	0,50	0,90-1,70	0,025	0,020	≥ 0,020 <sup>c</sup>	0,30 <sup>b</sup>	0,30 <sup>e</sup>	0,08 <sup>e</sup>	0,05	0,50	0,04	0,10	N ≤ 0,02 Nb+Ti+V ≤ 0,12
P215NL	1.0451	0,15	0,35	0,40-1,20	0,025	0,020	≥ 0,020 <sup>c</sup>	0,30	0,30	0,08	0,10	0,30	0,04	0,02	-
P265NL	1.0453	0,20	0,40	0,60-1,40	0,025	0,020	≥ 0,020 <sup>c</sup>	0,30	0,30	0,08	0,10	0,30	0,04	0,02	-
12Ni14	1.5637	0,15	0,15-0,35	0,30-0,80	0,025	0,010	-	-	0,30	-	-	3,25-3,75	-	0,05	-
X10Ni9	1.5682	0,13	0,15-0,35	0,30-0,80	0,020	0,010	-	-	0,30	0,10	-	8,50-9,50	-	0,05	-
L290NB	1.0484	0,17	0,40	1,20	0,025	0,020	0,015-0,060	0,30	0,25	0,10 <sup>f</sup>	0,05	0,30	0,04	0,05	N ≤ 0,012 CEV ≤ 0,42
L360NB	1.0582	0,20	0,45	1,60	0,025	0,020	0,015-0,060	0,30	0,25	0,10 <sup>f</sup>	0,05	0,30	0,04	0,15	N ≤ 0,012 V+Nb+Ti ≤ 0,15 CEV ≤ 0,45
L360QB	1.8948	0,16	0,45	1,40	0,025	0,020	0,015-0,060	0,30	0,25	0,10 <sup>f</sup>	0,05	0,30	0,04	0,05	N ≤ 0,012 CEV ≤ 0,42
L415NB	1.8972	0,21	0,45	1,60	0,025	0,020	0,015-0,060	0,30	0,25	0,10 <sup>f</sup>	0,05	0,30	0,04	0,15	N ≤ 0,012 V+Nb+Ti ≤ 0,15
L415QB	1.8947	0,16	0,45	1,60	0,025	0,020	0,015-0,060	0,30	0,25	0,10 <sup>f</sup>	0,05	0,30	0,04	0,08	N ≤ 0,012 V+Nb+Ti ≤ 0,15 CEV ≤ 0,43
L450QB	1.8952	0,16	0,45	1,60	0,025	0,020	0,015-0,060	0,30	0,25	0,10 <sup>f</sup>	0,05	0,30	0,06	0,09	N ≤ 0,012 V+Nb+Ti ≤ 0,15 CEV ≤ 0,45

Elements not included in this table shall not be intentionally added to the steel without the agreement of the purchaser, except for elements which may be added for finishing the cast. All appropriate measures shall be taken to prevent the addition of undesirable elements from scrap or other materials used in the steelmaking process.

<sup>a</sup> For elements where only one value is indicated without further information, this value shall be regarded as a maximum.

<sup>b</sup> The content of these elements need not be reported unless intentionally added to the cast.

<sup>c</sup> This requirement is not applicable provided the steel contains a sufficient amount of other nitrogen binding elements which shall be reported.

<sup>d</sup> For wall thicknesses greater than 30 mm, the carbon content may be increased by 0,02% for cast and product analysis.

<sup>e</sup> The sum of the percentage by mass of the three elements chromium, copper and molybdenum shall not exceed 0,45 %.

<sup>f</sup> Al / N ≤ 2.

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

Element	Limiting value for the cast analysis in accordance with Table 4 % by mass	Permissible deviation of the product analysis % by mass
C	≤ 0,21	± 0,02
Si	≤ 0,40	± 0,05
	> 0,40 to ≤ 1,00	± 0,06
Mn	≤ 1,00	± 0,05
	> 1,00 to ≤ 1,70	± 0,10
P	≤ 0,025	+ 0,005
S	≤ 0,010	+ 0,003
	> 0,010 ≤ 0,020	+ 0,005
Al	≤ 0,060	± 0,005
Cr	≤ 1,00	± 0,05
	> 1,00 to ≤ 10,00	± 0,10
Cu	≤ 0,30	± 0,05
Mo	≤ 0,35	± 0,03
	> 0,35 to ≤ 1,10	± 0,04
N	≤ 0,012	± 0,01
Nb	≤ 0,10	± 0,005
Ni	≤ 0,35	± 0,05
	> 0,35 to ≤ 9,50	± 0,07
Ti	≤ 0,060	+ 0,010
V	≤ 0,10	+ 0,01
	> 0,10 to ≤ 0,25	± 0,03

<sup>a</sup> 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

### 9.3 Mechanical properties

The mechanical properties of the finished product shall conform to the requirements given in Tables 6 to 9. For the impact properties in the weld (where applicable), the values of the relevant grade in the transverse direction shall apply.

**Option 8 :** For the grades listed in Table 7, the proof strength at elevated temperature shall be verified. The test temperature shall be specified at the time of enquiry and order.

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Table 6 — Mechanical properties

Steel grade		Upper yield strength or proof strength ReH or R <sub>p0.2</sub> min. for wall thicknesses T in mm N/mm <sup>2</sup>				Tensile strength R <sub>m</sub> for wall thicknesses T in mm N/mm <sup>2</sup>			Elongation A min. %	
Name	Number	T ≤ 16	16 < T ≤ 40	40 < T ≤ 60	60 < T ≤ 100	T ≤ 16	16 < T ≤ 60	60 < T ≤ 100	Longitudinal	Transverse
P235TR2	1.0255	235	225	215	-	360-500	360-500	-	25	23
P265TR2	1.0259	265	255	245	-	410-570	410-570	-	21	19
P235GH	1.0345	235	225	215	-	360-500	360-500	-	25	23
P265GH	1.0425	265	255	245	-	410-570	410-570	-	23	21
16Mo3	1.5415	280	270	260	-	450-600	450-600	-	22	20
10CrMo5-5	1.7338	275	275	265	-	410-560	410-560	-	22	20
13CrMo4-5	1.7335	290	290	280	-	440-590	440-590	-	22	20
10CrMo9-10	1.7380	280	280	270	-	480-630	480-630	-	22	20
X11CrMo5+I	1.7362	175	175	175	175	430-580	430-580	430-580	22	20
X11CrMo5+NT1	1.7362	280	280	280	280	480-640	480-640	480-640	20	18
X11CrMo5+NT2	1.7362	390	390	390	390	570-740	570-740	570-740	18	16
X11CrMo9-1+ I	1.7386	210	210	210	-	460-640	460-640	-	20	18
X11CrMo9-1+NT	1.7386	390	390	390	-	590-740	590-740	-	18	16
X10CrMoV Nb9-1	1.4903	450	450	450	450	630-830	630-830	630-830	19	17
P355N P355NH	1.0562 1.0562	355	345	325	305	490-650	490-630	450-590	22	20
P355NL1	1.0566	355	345	325	305	490-650	490-630	450-590	22	20
P215NL	1.0451	215 <sup>a</sup>	-	-	-	360-480	360-480	-	25	23
P265NL	1.0453	265	265 <sup>b</sup>	-	-	410-570	410-570	-	24	22
12Ni14	1.5637	345	345	-	-	440-590	440-590	-	22	20
X10Ni9	1.5682	510	510	-	-	690-840	690-840	-	20	18
L290NB	1.0484	290-440	290-440	-	-	≥ 415	-	-	23	21
L360NB	1.0582	360-510	360-510	-	-	≥ 460	-	-	22	20
L360QB	1.8948	360-510	360-510	-	-	≥ 460	-	-	22	20
L415NB	1.8972	415-565	415-565	-	-	≥ 520	≥ 520	-	20	18
L415QB	1.8947	415-565	415-565	-	-	≥ 520	≥ 520	-	20	18
L450QB	1.8952	450-570	450-570	-	-	≥ 535	≥ 535	-	20	18

<sup>a</sup> For wall thicknesses equal to or smaller than 10 mm.  
<sup>b</sup> For wall thicknesses equal to or smaller than 25 mm.



Table 7 — Minimum proof strength  $R_{p0,2}$  at elevated temperature

Grade	Minimum proof strength $R_{p0,2}$ N/mm <sup>2</sup> at temperature of (°C)										
	100	150	200	250	300	350	400	450	500	550	600
P235GH	198	187	170	150	132	120	112	108	-	-	-
P265GH	226	213	192	171	154	141	134	128	-	-	-
16Mo3	243	237	224	205	173	159	156	150	146	-	-
10CrMo5-5	240	228	219	208	165	156	148	144	143	-	-
13CrMo4-5	264	253	245	236	192	182	174	168	166	-	-
10CrMo9-10	249	241	234	224	219	212	207	193	180	-	-
X11CrMo5+I	156	150	148	147	145	142	137	129	116	-	-
X11CrMo5+NT1	245	237	230	223	216	206	196	181	167	-	-
X11CrMo5+NT2	366	350	334	332	309	299	289	280	265	-	-
X11CrMo9-1+I	187	186	178	177	175	171	164	153	142	120	-
X11CrMo9-1+NT	363	348	334	330	326	322	316	311	290	235	-
X10CrMoV Nb9-1	410	395	380	370	360	350	340	320	300	270	215
P355NH	$T \leq 16$	304	284	255	235	216	196	167	-	-	-
	$16 < T \leq 40$	294	275	255	235	216	196	167	-	-	-
	$40 < T \leq 60$	284	265	245	226	206	186	157	-	-	-
	$60 < T \leq 100$	265	245	226	206	186	167	137	-	-	-

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Table 8 — Minimum tensile strength values at elevated temperature for grade P355NH

Temperature in °C	Rm for wall thickness T in mm			
	T ≤ 30	30 < T ≤ 50	50 < T ≤ 80	80 < T ≤ 100
100	440	420	400	390
150	430	410	390	380
200	410	390	370	360
250	410	390	370	360
300	410	390	370	360
350	400	380	360	350
400	390	370	350	340

Table 9 — Impact properties

Grade	Minimum average absorbed energy KV, in J											
	longitudinal direction						transverse direction					
	at a temperature of (°C)											
	-50	-40	-20	-10	0	20	-50	-40	-20	-10	0	20
P235TR2	-	-	-	-	40	-	-	-	-	27	-	-
P265TR2	-	-	-	-	40	-	-	-	-	27	-	-
P235GH	-	-	-	-	40	-	-	-	-	27	-	-
P265GH	-	-	-	-	40	-	-	-	-	27	-	-
16Mo3	-	-	-	-	-	40	-	-	-	-	-	27
10CrMo5-5	-	-	-	-	-	40	-	-	-	-	-	27
13CrMo4-5	-	-	-	-	-	40	-	-	-	-	-	27
10CrMo9-10	-	-	-	-	-	40	-	-	-	-	-	27
X11CrMo5	-	-	-	-	-	40	-	-	-	-	-	27
X11CrMo9-1	-	-	-	-	-	40	-	-	-	-	-	27
X10CrMoVNb9-1	-	-	-	-	-	40	-	-	-	-	-	27
P355N P355NH	-	-	40	43	47	55	-	-	27	31	35	39
P355NL1	-	40	53	60	65	70	-	27	35	39	43	47
P215NL	-	40	45	-	-	55	-	-	-	-	-	-
P265NL	-	40	45	-	-	50	-	27	30	-	-	35
12Ni14 <sup>a</sup>	T ≤ 25	55	55	60	-	65	35	40	45	45	45	45
	25 < T ≤ 40	50	50	55	-	65	30	35	40	40	45	45
X10Ni9 <sup>a</sup>	70	70	70	-	-	70	50	50	50	50	50	50
L290NB	-	-	-	-	60	-	-	-	-	-	40	-
L360NB	-	-	-	-	60	-	-	-	-	-	40	-
L360QB	-	-	-	-	60	-	-	-	-	-	40	-
L415NB	-	-	-	-	60	-	-	-	-	-	40	-
L415QB	-	-	-	-	60	-	-	-	-	-	40	-
L450QB	-	-	-	-	60	-	-	-	-	-	40	-

<sup>a</sup> For lower temperatures, the applicable values are those of the corresponding grade in EN 10216-4.

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### 9.4 Weldability

Fittings covered by this European Standard are weldable ; however account should be taken of the fact that the behaviour of the steel during and after welding is dependent not only on the steel, but also essentially on the conditions of preparing and carrying out the welding.

## 10 Appearance and internal soundness

**10.1** The fittings shall be free from surface defects as can be established by visual inspection in accordance with this European Standard.

**10.2** The fittings shall have a finish and internal and external surface condition typical of the manufacturing process and, where applicable, the heat treated condition. The finish and surface condition shall permit surface imperfections or marks requiring dressing to be identified.

**10.3** It shall be permissible to dress by grinding or machining surface marks or imperfections provided that the wall thickness of the fitting after dressing does not fall below the minimum permitted wall thickness.

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

**10.5** Surface imperfections which encroach on the minimum wall thickness shall be considered defects and shall be deemed not to comply with this European Standard.

**10.6** The manufacturer shall explore by grinding a sufficient number of surface marks and imperfections identified during visual inspection to provide assurance that these have been evaluated to ensure compliance with 10.7.

**10.7** The manufacturer shall, subject to the limitations given in 10.8 and 10.10, dress surface marks and imperfections found by exploration in accordance with 10.6 to be deeper than 5 % of the specified wall thickness or 3 mm, whichever is the lesser, but not less than 0,5 mm.

**10.8** If surface imperfections acceptable under 10.7 are not scattered and appear over a large area in excess of what is considered to be an acceptable surface condition then fittings shall be rejected or alternatively subjected to dressing as agreed between purchaser and manufacturer.

**10.9** Repairs to fittings shall only be carried out by grinding or machining, and hammering is not permitted. Welding as a mean of repair may be only be carried out in specific instances agreed between manufacturer and purchaser.

**10.10** Score marks (linear mechanical scratches) shall not have a depth greater than 1,6 mm or 12,5 % of the nominal wall thickness, whichever is the smaller, provided that the bottom of the marks are rounded and not sharp. Excessive numbers of score marks, even within these limits, may constitute an unacceptable condition, and is dependent upon agreement between manufacturer and purchaser.

Sharp bottom scores shall be considered as defects and treated in accordance with 10.7.

**10.11** Localised or generalised scale up to 0,8 mm thick is permissible provided the scale is tightly adherent to the fitting and does not readily flake off.

## 11 Dimensions and tolerances

### 11.1 Dimensions

#### 11.1.1 General

For reducers and tees it is not mandatory that the produced pieces correspond to the exact representation in the figures. Only the dimensions given in the relevant tables shall be respected.

#### 11.1.2 Elbows

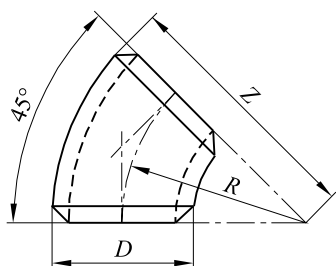


Figure 1 — 45° elbow

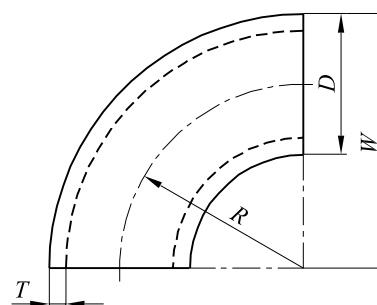


Figure 2 — 90° elbow

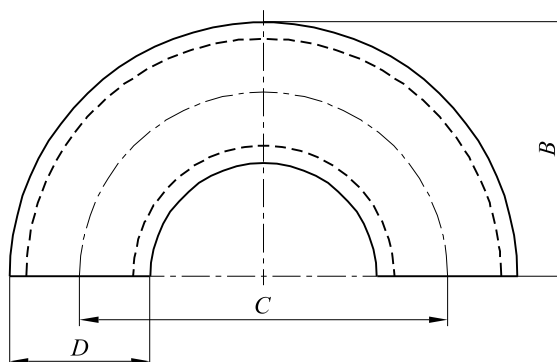


Figure 3 — Return bend

Elbows and return bends are produced according to Figures 1, 2 and 3 (45° - 90° - 180°). Specific dimensions are listed in Tables 10, 11 and 12.

The values given for  $W$  and  $Z$  in addition to those for  $R$  have been calculated from the values of  $R$  and shall be used to verify conformance of the elbow because measurement of  $R$  is not possible in practice.

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Table 10 — Elbows model 2D — Dimensions

Dimensions in millimetres

<i>DN</i>	<i>D</i>	<i>R</i>	<i>C</i>	<i>B - W</i>
15	21,3	25	50	36
20	26,9	25	50	39
25	33,7	25	50	42
32	42,4	32	64	53
40	48,3	38	76	62
50	60,3	51	102	81
65	76,1	63	127	102
80	88,9	76	152	121
100	114,3	102	203	159
125	139,7	127	254	197
150	168,3	152	305	237
200	219,1	203	406	313
250	273	254	508	391
300	323,9	305	610	467
350	355,6	356	711	533
400	406,4	406	813	610
450	457	457	914	686
500	508	508	1 016	762
550	559	559	1 118	838
600	610	610	1 220	914
650	660	660	1 320	990
700	711	711	1 422	1 066
750	762	762	1 524	1 143
800	813	813	1 626	1 220
850	864	864	1 728	1 296
900	914	914	1 828	1 371
1 000	1 016	1 016	2 032	1 524
1 050	1 067	1 067	2 134	1 600
1 100	1 118	1 118	2 236	1 677
1 150	1 166	1 166	2 332	1 749
1 200	1 219	1 219	2 438	1 830

Table 11 — Elbows model 3D — Dimensions

Dimensions in millimetres

<i>DN</i>	<i>D</i>	<i>R</i>	<i>C</i>	<i>B - W - Z</i>
15	21,3	38	76	49
20	26,9	38	76	51
25	33,7	38	76	56
	38	45	90	64
32	42,4	48	96	69
40	48,3	57	114	82
	51	63	126	88
	57	72	144	100
50	60,3	76	152	106
	70	92	184	127
65	76,1	95	190	133
80	88,9	114	228	159
	101,6	133	267	184
	108	142,5	285	196
100	114,3	152	304	210
	133	181	362	247
125	139,7	190	380	260
	159	216	432	295
150	168,3	229	457	313
	193,7	270	540	367
200	219,1	305	610	414
	244,5	340	680	462
250	273	381	762	518
300	323,9	457	914	619
350	355,6	533	1 066	711
400	406,4	610	1 220	813
450	457	686	1 372	914
500	508	762	1 524	1 016
550	559	838	1 676	1 118
600	610	914	1 828	1 219
650	660	990	1 980	1 320
700	711	1 067	2 134	1 422
750	762	1 143	2 286	1 524
800	813	1 219	2 438	1 626
850	864	1 296	2 592	1 728
900	914	1 372	2 744	1 829
1 000	1 016	1 524	3 048	2 032
1 050	1 067	1 600	3 201	2 134
1 100	1 118	1 677	3 354	2 236
1 150	1 168	1 752	3 504	2 336
1 200	1 219	1 829	3 658	2 438

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Table 12 — Elbows model 5D — Dimensions

Dimensions in millimetres

<i>DN</i>	<i>D</i>	<i>R</i>	<i>C</i>	<i>B - W - Z</i>
15	21,3	42,5	85	53
20	26,9	57,5	115	71
25	33,7	72,5	145	89
	38	82,5	165	101
32	42,4	92,5	185	114
40	48,3	109,5	219	134
	51	122,5	245	149
	57	130	260	158
50	60,3	137,5	275	168
	70	160	320	195
65	76,1	175	350	213
80	88,9	207,5	415	252
	101,6	235	470	286
	108	253	506	306
100	114,3	270	540	327
	133	311,5	623	378
125	139,7	330	660	400
	159	375	750	454
150	168,3	390	780	474
200	219,1	515	1030	624
	244,5	580	1160	702
250	273	650	1300	786
300	323,9	770	1540	932
350	355,6	850	1700	1 028
400	406,4	970	1940	1 173
450	457	1 122	2 244	1 350
500	508	1 245	2 490	1 500
550	559	1 398	2 796	1 677
600	610	1 525	3 050	1 830
650	660	1 650	3 300	1 980
700	711	1 778	3 556	2 133
750	762	1 905	3 810	2 286
800	813	2 033	4 066	2 439
850	864	2 155	4 310	2 587
900	914	2 285	4 570	2 742
1 000	1 016	2 540	5 080	3 048
1 050	1 067	2 665	5 335	3 201
1 100	1 118	2 790	5 580	3 354
1 150	1 168	2 915	5 830	3 504
1 200	1 219	3 050	6 100	3 657



## 11.1.3 Tees

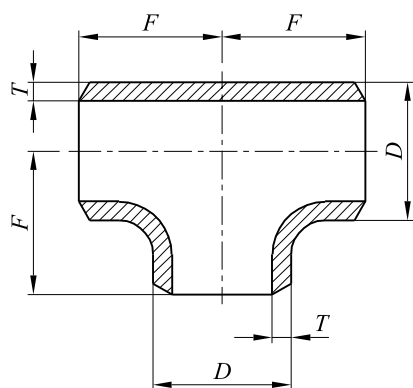


Figure 4 — Equal tee

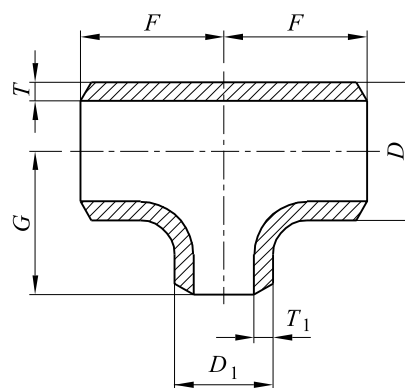


Figure 5 — Reducing tee

Equal tees are produced in accordance with Figure 4. Specific dimensions are listed in Table 13.

Reducing tees are produced in accordance with Figure 5. Specific dimensions are listed in Table 14.

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Table 13 — Equal Tees — Dimensions

Dimensions in millimetres

<i>DN</i>	<i>D</i>	<i>F</i>
15	21,3	25
20	26,9	29
25	33,7	38
32	42,4	48
40	48,3	57
50	60,3	64
65	76,1	76
80	88,9	86
90	101,6	95
100	114,3	105
125	139,7	124
150	168,3	143
200	219,1	178
250	273	216
300	323,9	254
350	355,6	279
400	406,4	305
450	457	343
500	508	381
550	559	419
600	610	432
650	660	495
700	711	521
750	762	559
800	813	597
850	864	635
900	914	673
1 000	1 016	749
1 050	1 067	762 <sup>a</sup>
1 100	1 118	813 <sup>a</sup>
1 150	1 166	851 <sup>a</sup>
1 200	1 219	889 <sup>a</sup>

<sup>a</sup> For these dimensions, the length of the outlet branch is not equal to the length of the run F. The applicable values for the length of the outlet branch are respectively : 711 for *DN* 1050, 762 for *DN* 1100, 800 for *DN* 1150 and 838 for *DN* 1200.

Table 14 — Reducing Tees — Dimensions

Dimensions in millimetres

Side <i>D</i>		Side <i>D</i> <sub>1</sub>			
<i>DN</i>	<i>D</i>	<i>DN</i> <sub>1</sub>	<i>D</i> <sub>1</sub>	<i>F</i>	<i>G</i>
20	26,9	15	21,3	29	29
25	33,7	15	21,3	38	38
		20	26,9		
32	42,4	15	21,3	48	48
		20	26,9		
		25	33,7		
40	48,3	15	21,3	57	57
		20	26,9		
		25	33,7		
		32	42,4		
50	60,3	20	26,9	64	44
		25	33,7		51
		32	42,4		57
		40	48,3		60
65	76,1	25	33,7	76	57
		32	42,4		64
		40	48,3		67
		50	60,3		70
80	88,9	32	42,4	86	70
		40	48,4		73
		50	60,3		76
		65	76,1		83
100	114,3	40	48,3	105	86
		50	60,3		89
		65	76,1		95
		80	88,9		98
125	139,7	50	60,3	124	105
		65	76,1		108
		80	88,9		111
		100	114,3		117
150	168,3	65	76,1	143	121
		80	88,9		124
		100	114,3		130
		125	139,7		137
200	219,1	100	114,3	178	156
		125	139,7		162
		150	168,3		168
250	273,1	100	114,3	216	184
		125	139,7		191
		150	168,3		194
		200	219,1		203
300	323,9	150	168,3	254	219
		200	219,1		229
		250	273		241

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Table 14 (continued)

Side D		Side D <sub>1</sub>		F	G
DN	D	DN <sub>1</sub>	D <sub>1</sub>		
350	355,6	150	168,3	279	238
		200	219,1		248
		250	273		257
		300	323,9		270
400	406,4	150	168,3	305	264
		200	219,1		273
		250	273		283
		300	323,9		295
		350	355,6		305
450	457	200	219,1	343	298
		250	273		308
		300	323,9		321
		350	355,6		330
		400	406,4		330
500	508	250	273	381	333
		300	323,9		346
		400	406,4		356
		450	457,0		368
550	559	250	273	419	359
		300	323,9		371
		400	406,4		381
		500	508,0		406
600	610	250	273	432	384
		300	323,9		397
		400	406,4		406
		500	508,0		432
650	660	300	323,9	495	422
		350	355,6		432
		400	406,4		432
		500	508		457
700	711	300	323,9	521	448
		400	406,4		457
		500	508,0		483
		600	610,0		508
750	762	400	406,4	559	483
		500	508,0		508
		600	610,0		533
800	813	400	406,4	602	508
		500	508,0		533
		600	610,0		559
		700	711,0		572
850	864	400	406,4	635	533
		500	508,0		559
		600	610,0		584
		700	711,0		597

Table 14 (continued)

Side $D$		Side $D_1$		$F$	$G$
$DN$	$D$	$DN_1$	$D_1$		
900	914	400	406,4	673	559
		500	508,0		584
		600	610,0		610
		700	711,0		622
		800	813,0		648
1 000	1 016	600	610,0	749	660
		700	711,0		673
		800	813,0		711
		900	914,0		737
1 050	1 067	600	610,0	762	660
		700	711,0		698
		800	813,0		711
		900	914,0		711
1 100	1 118	600	610,0	813	698
		700	711,0		698
		800	813,0		711
		900	914		724
1 200	1 219	700	711,0	889	762
		800	813,0		787
		900	914,0		787
		1 000	1 016,0		813

## 11.1.4 Reducers

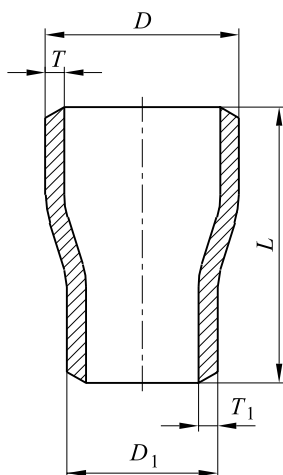


Figure 6 — Concentric reducer

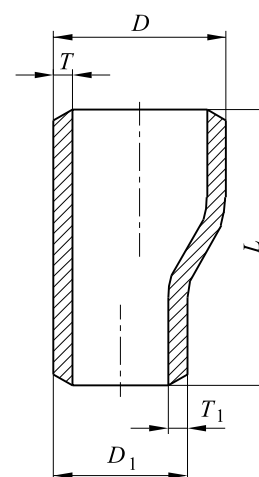


Figure 7 — Eccentric reducer

Concentric and eccentric reducers are produced in accordance respectively with Figures 6 and 7. Specific dimensions are listed in Table 15.

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Table 15 — Reducers — Dimensions

Dimensions in millimetres

Side <i>D</i>		Side <i>D</i> <sub>1</sub>		Length <i>L</i>
<i>DN</i>	<i>D</i>	<i>DN</i> <sub>1</sub>	<i>D</i> <sub>1</sub>	
20	26,9	15	21,3	38
25	33,7	20	26,9	51
		15	21,3	51
32	42,4	25	33,7	51
		20	26,9	51
		15	21,3	51
40	48,3	32	42,4	64
		25	33,7	64
		20	26,9	64
50	60,3	40	48,3	76
		32	42,4	76
		25	33,7	76
		20	26,9	76
65	76,1	50	60,3	89
		40	48,3	89
		32	42,4	89
		25	33,7	89
80	88,9	65	76,1	89
		50	60,3	89
		40	48,3	89
		32	42,4	89
100	114,3	80	88,9	102
		65	76,1	102
		50	60,3	102
		40	48,3	102
125	139,7	100	114,3	127
		80	88,9	127
		65	76,1	127
		50	60,3	127
150	168,3	125	139,7	140
		100	114,3	140
		80	88,9	140
		65	76,1	140
200	219,1	150	168,3	152
		125	139,7	152
		100	114,3	152
		80	88,9	152

Table 15 (continued)

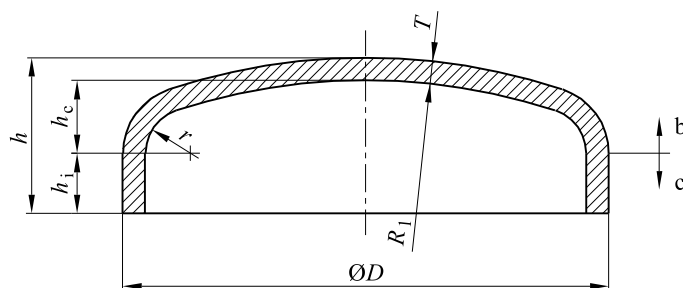
Side <i>D</i>		Side <i>D</i> <sub>1</sub>		Length <i>L</i>
<i>DN</i>	<i>D</i>	<i>DN</i> <sub>1</sub>	<i>D</i> <sub>1</sub>	
250	273	200	219,1	178
		150	168,3	178
		125	139,7	178
		100	114,3	178
300	323,9	250	273	203
		200	219,1	203
		150	168,3	203
		125	139,7	203
350	355,6	300	323,9	330
		250	273	330
		200	219,1	330
		150	168,3	330
400	406,4	350	355,6	356
		300	323,9	356
		250	273	356
		200	219,1	356
450	457	400	406,4	381
		350	355,6	381
		300	323,9	381
		250	273	381
500	508	450	457	508
		400	406,4	508
		350	355,6	508
		300	323,9	508
550	559	500	508	508
		450	457	508
		400	406,4	508
		350	355,6	508
600	610	550	559	508
		500	508	508
		450	457	508
		400	406,4	508
700	711	600	610	610
		500	508	610
		450	457	610
800	813	700	711	610
		600	610	610
		550	559	610
		500	508	610

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Table 15 (continued)

Side $D$		Side $D_1$		Length $L$
$DN$	$D$	$DN_1$	$D_1$	
900	914	800	813	610
		700	711	610
		600	610	610
1 000	1 016	900	914	610
		800	813	610
		700	711	610
1 200	1 219	1 000	1 016	711
		900	914	711
		800	813	711

## 11.1.5 Caps



## Key

$R_1$  approximately equal to  $0,8 D$

$r$  approximately equal to  $0,15 D$

Figure 8 — Cap

NOTE Some of the listed dimensions don't comply with all technical regulations, e.g. according to EN 13480-3 (see B.5). Nevertheless they are standard on the market. In these cases, it is essential that the dimensions be agreed.



Table 16 — Caps — Dimensions

Dimensions in millimetres

<i>DN</i>	<i>D</i>	<i>k</i>
15	21,3	25
20	26,9	25
25	33,7	25
32	42,4	38
40	48,3	38
50	60,3	38
65	76,1	38
80	88,9	51
	101,6	64
100	114,3	64
125	139,7	76
150	168,3	89
200	219,1	102
250	273,1	127
300	323,9	152
350	355,6	165
400	406,4	178
450	457	203
500	508	229
550	559	254
600	610	267
650	660	267
700	711	267 for T ≤ 25
		290
750	762	267 for T ≤ 20
		310
800	813	267 for T ≤ 17,5
		330
850	864	267 for T ≤ 14
		350
900	914	267 for T ≤ 10
		370
1 000	1 016	305 for T ≤ 14,2
		420
1 050	1 067	305 for T ≤ 13
		405
1 100	1 118	343 for T ≤ 12
		390
1 150	1 166	343 for T ≤ 11
		375
1 200	1 219	343 for T ≤ 10
		360

**11.1.6 Preferred diameters and wall thicknesses**

Preferred diameters and wall thicknesses have been selected to match with tube dimensions described in EN 10220 and are listed in Table 17.

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NOTE Dimensions which are different from those in Table 17 may be agreed.

Table 17 — Preferred diameter and wall thicknesses

Diameter			Wall thickness series							
DN	D	D	1	2	3	4	5	6	7	8
15	21,3			2,0	2,6	3,2	4,0		5	7,1
		25		2,0	2,3					
20	26,9			2,3	2,6	3,2	4,0	4,5	5,6	8,0
		31,8		2,6						
25	33,7			2,6	3,2	4,0	4,5	5,6	6,3	8,8
		38		2,6						
32	42,4			2,6	3,6	4,0	5,0	6,3	8,0	10,0
40	48,3			2,6	3,6	4,0	5,0	6,3	8,0	10,0
		51		2,6						
		57		2,9						
50	60,3			2,9	3,6	4,0	5,6	7,1	8,8	11,0
		63,5		2,9						
		70		2,9						
		73		2,9	3,6	4,5	7,1			14,2
65	76,1			2,9	3,6	5,6	7,1	8,0	10,0	14,2
		82,5		3,2						
80	88,9			3,2	4,0	5,6	8,0	8,8	11,0	16,0
		101,6		3,6	4,0	5,6	8,0			
		108		3,6						
100	114,3			3,6	4,5	6,3	8,8	11,0	14,2	17,5
		127		4,0						
		133		4,0						
125	139,7			4,0	5,0	6,3	10,0	12,5	16,0	20,0
		141,3		4,0	5,4	6,3	10,0		16,0	20,0
		152,4		4,5						
		159		4,5						
		165,1		4,5	5,4					
150	168,3		4,0	4,5	5,6	7,1	11,0	14,2	17,5	22,2
		177,8		5,0						
		193,7		5,6	6,3	7,1				
200	219,1		4,5	6,3	7,1	8,0	12,5	16,0	17,5	22,2
		244,5		6,3						

Table 17 (continued)

Diameter			Wall thickness series							
DN	D	D	1	2	3	4	5	6	7	8
250	273		5	6,3	8,8	10,0	12,5	16,0	22,2	30,0
300	323,9		5,6	7,1	8,8	10,0	12,5	17,5	25,0	32,0
350	355,6		5,6	8,0	10,0	12,5	16,0	20,0	28,0	36,0
400	406,4		6,3	8,8	10,0	12,5	17,5	22,2	30,0	40,0
450	457		6,3	10,0	11,0	12,5	17,5	22,2	32,0	45,0
500	508		6,3	10,0	11,0	12,5	17,5	25,0	36,0	50,0
550		559	6,3	10,0		12,5	20,0	28,0		
600	610		6,3	10,0	12,5	17,5	25,0	30,0	45,0	60,0
650	660			10,0	12,5	17,5				
700	711		7,1	10,0	12,5	25,0				
750		762		10,0	12,5	25,0				
800	813		8,0	10,0	12,5	25,0				
850		864		10,0	12,5	25,0				
900	914		10,0	12,5	20,0	25,0				
1 000	1 016		10,0	12,5	20,0	25,0				
1 050		1 067	10,0	12,5	20,0	25,0				
1 100		1 118	10,0	12,5	20,0	25,0				
1 150		1 168	10,0	12,5	20,0	25,0				
1 200	1 219		10,0	12,5	20,0	25,0				

## 11.2 Dimensional tolerances

### 11.2.1 Inside diameter (ID-ID1)

**11.2.1.1** The relevant diameters shall be measured at the welding ends of the fittings. The tolerance is as follows :

$\pm 1\%$  or  $\pm 0,5$  mm, whichever is the greater, but maximum  $\pm 5$  mm

**Option 9 :** *The tolerance on diameter shall apply to the outside diameter instead of the inside diameter.*

**11.2.1.2** 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 *ID* at the welding ends.

**Option 10 :** *Special tolerances may be agreed when pigging shall be applied.*

**EN 10253-2:2007 (E)****11.2.1.3** Tolerances for ovality are following:

At the welding ends:

- $D \leq 273,0$  Included in the diameter tolerance ;
- $273,0 < D \leq 610$  2 % ;
- $D > 610$  1 % ;

On the body for elbows and return bends : 4 %.

The ovality shall be calculated as follows :

$$Ov = 100 (D_{max} - D_{min}) / D \text{ in } \%$$

Where:

$D_{max}$  is the bigger diameter in one section, expressed in millimetres ;

$D_{min}$  is the smaller diameter in the same section, expressed in millimetres ;

$D$  is the specified diameter, expressed in millimetres.

**11.2.2 Wall thickness tolerances at the welding ends**

Wall thickness tolerances are indicated in Table 18. For fittings type B, the minus tolerances on  $T$  apply also for the other values of the wall thickness as defined in Annex A.

**Table 18 — Wall thickness tolerances at the welding ends**

$D$ mm	$T$ mm	Wall thickness tolerance	
		Minus	Plus
$\leq 610$	$\leq 4$	- 12,5 %	+ 20 %
	$> 4$		
$> 610$	Seamless	- 12,5 %	+ 20 %
	Welded		
	$\leq 10$	- 0,35 mm	+ 20 %
	$> 10$	- 0,5 mm	

The minus tolerances apply also for the body of the fitting.

**Option 11** : Plus tolerances on the body of the fitting shall be as specified on the purchase order.

### 11.2.3 Tolerances on specific dimensions

For the dimensions specific to fittings, the tolerances are given in Table 19.

**Table 19 — Tolerances on specific dimensions and form**

Dimensions in millimetres					
<i>D</i>	<i>F-G-L-W</i>	<i>B-Z</i>	<i>C</i>	<i>h</i>	<i>P</i>
$\leq 114,3$	$\pm 2$	$\pm 7$	$\pm 7$	$\pm 4$	2
$114,3 < D \leq 219,1$	$\pm 2$	$\pm 7$	$\pm 7$	$\pm 7$	4
$219,1 < D \leq 406,4$	$\pm 3$	$\pm 7$	$\pm 10$	$\pm 7$	6
$406,4 < D \leq 762$	$\pm 3$	$\pm 10$	$\pm 10$	$\pm 7$	7
$762 < D$	$\pm 5$	$\pm 12$	$\pm 10$	$\pm 10$	9

### 11.2.4 Tolerances on the form of fittings

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

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

For P, the tolerance is given in Table 19.

All tolerances on the form shall be verified with the fitting remaining in the same position.

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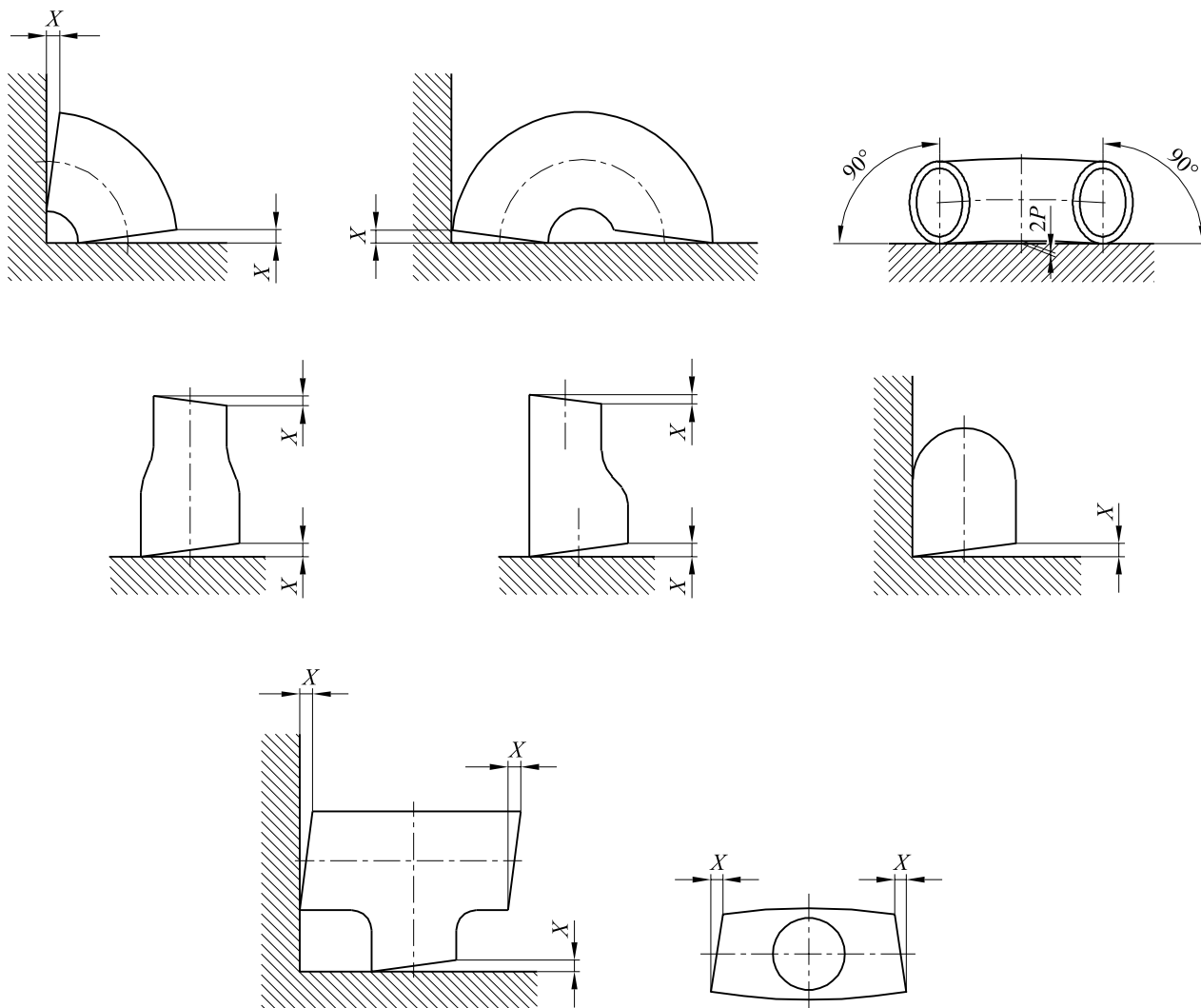


Figure 9 — Determination of the tolerance on the form of fittings

### 11.2.5 Corrugation

Corrugation (see Figure 10) is permitted within following limits:

a) for elbows and return bends :

- $hm$  not exceeding 3 %  $D$  or 25 mm, whichever is lesser ;
- $LE \geq 15 \cdot hm$ .

b) for tees and reducers :

- $hm$  not exceeding 3 %  $D$  or 25 mm, whichever is lesser ;
- $LE \geq 5 \cdot hm$  ;
- there shall be no sharp edges associated with the corrugation.

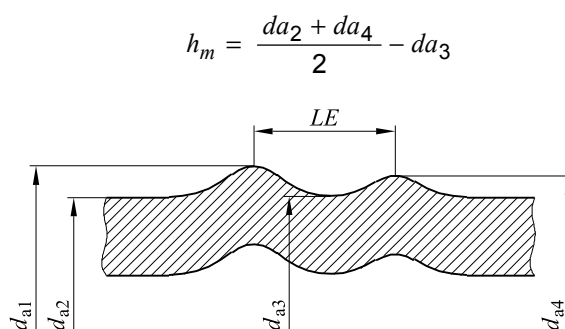


Figure 10 — Determination of corrugation

### 11.3 End finishing

At the manufacturer's option, for specified wall thicknesses below 3 mm, the ends may be square cut or slightly chamfered. For wall thicknesses between 3 mm and 22 mm, the ends shall be bevelled with an angle of  $30^\circ - 0 + 5^\circ$  with a root face of  $1,6 \text{ mm} \pm 0,8 \text{ mm}$ .

For wall thicknesses above 22 mm the type of bevel shall be agreed.

For wall thicknesses above 3 mm, where machining at the welding ends is necessary, the wall thickness may be reduced by taper boring, the taper being not larger than:

- external :  $30^\circ$  ;
- internal :  $18^\circ$ .

The fitting ends shall be free from harmful burrs.

**Option 12:** *The end finishing shall be as specified.*

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### 12 Inspection

#### 12.1 Type of inspection

Conformity to the requirements of the order, for fittings in accordance with this Part of EN 10253, shall be checked by specific inspection.

When an inspection document 3.1 is specified, the manufacturer shall state in the confirmation of the order whether he is operating according to a "quality assurance system", certified by a competent body established within the community, and having undergone a specific assessment for materials and processes relevant to manufacture of fittings, including, if applicable, welding procedure approvals, welder/weld operator approval and NDT operator approval.

NOTE See Directive 97/23/EC Annex I section 4.3 third paragraph.

#### 12.2 Inspection documents

##### 12.2.1 Type of inspection documents

Unless Option 13 is specified an inspection certificate 3.1 in accordance with EN 10204 shall be issued.

**Option 13** : *An inspection document 3.2 in accordance with EN 10204 shall be issued.*

If an inspection document 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 to produce the inspection document.

For welded fittings and fittings machined from bars, the manufacturer shall join to the inspection document the relevant inspection document concerning the starting material (welded tube or plate/strip or bar).

##### 12.2.2 Content of inspection documents

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

In all types of inspection documents a statement on the conformity of the products delivered with the requirements of this standard and the order shall be included.

The inspection document 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-C02 – location of the test sample where applicable ;

C10-C13 – tensile test where applicable ;

C40-C43 – impact test where applicable ;

C50 – bend test where applicable ;

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



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

D02-D99 – non destructive inspection where applicable ;

Z - authentication.

When welding is part of the manufacturing process, the inspection document shall also contain :

- reference to welding procedure approval ;
- reference to welder and or welding operator approval ;
- reference to non-destructive testing operators approval ;
- information on the forming process and the applied heat treatment.

When fittings are produced from welded tubes, the inspection document shall also contain :

- Information on the forming process and the applied heat treatment.

When fittings are marked “Y” (see 7.1), the inspection document shall also contain :

- reduced wall thickness used instead of the specified one ;
- attested minimum yield strength.

In addition, for inspection document 3.1, the manufacturer shall state the references to the certificate (see 12.1) of the appropriate “quality assurance system”, if applicable.

### 12.3 Summary of inspection and testing

Inspection and testing to be carried out are summarised in Table 20. Unless option 14 is specified, the tensile test may be waived for carbon steels provided the four following conditions are simultaneously fulfilled:

- manufacturer does not attest a higher yield strength than the specified minimum (see 7.1) ;
- tensile test results used to determine compliance with the standard are the results of the starting material as reported by the material manufacturer ;
- producer can demonstrate that the fittings are in the equivalent metallurgical condition as that of the starting material as a result of the heating or heat treatment carried out during manufacture ;
- thardness results (see Table 20) are in compliance with the criteria defined in this standard.

If the tensile test is waived the manufacturer shall join the relevant inspection documents concerning the starting material (tube, plate/strip or bar).

**Option 14 :** *The mechanical properties shall be determined on the finished product in accordance with Table 20.*

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Table 20 — Inspections and tests

Type of inspection and testing	Conditions for realisation	Number of tests
Cast analysis (14.1)	Base material	1 per cast
Mandatory tests		
Tensile test at room temperature (14.2.1)	$D \geq 114,3$ mm	1 per test unit
Tensile test transverse to the weld (14.3)	Welded fittings <sup>a</sup> with $D \geq 219,1$ mm	1 per test unit
Hardness test (14.4)	$D < 114,3$ mm $D \geq 114,3$ mm <sup>b</sup>	10 per test unit 10 per test unit
Impact test (14.6) <sup>c</sup>	$D \geq 114,3$ mm	1 per test unit
Impact test transverse to the weld (14.6)	Welded fittings <sup>a</sup> with $D \geq 219,1$ mm	1 per test unit
Bend test transverse to the weld (14.5)	Welded fittings <sup>a</sup>	1 per test unit
Material identification (14.10)	Alloy steels	Each fitting
Dimensional inspection (14.7)		Manufacturer's procedure
Visual inspection (14.8)		Each fitting
NDT of the weld (14.9.2)	Welded fittings	Each fitting
NDT of the tee (14.9.3)	Cold formed tees	Each fitting
Optional tests		
Product analysis (14.1)		1 per cast
Tensile test at elevated temperature (14.2.2)		1 per cast
Hardness test (14.4) <sup>d</sup>		Each fitting
Impact test (14.6) <sup>e</sup>	$D \geq 114,3$ mm	1 per test unit
Impact test of the heat affected zone (14.6)	To be agreed	To be agreed
NDT of the starting material for laminar imperfections (14.9.4)	To be agreed	To be agreed
<sup>a</sup> In this table welded fittings are fittings for which a weld is made during the manufacture of the fitting. <sup>b</sup> To be carried out when the tube results are used for the inspection document. <sup>c</sup> The test is not mandatory for grades P235GH, P265GH, 16Mo3, 10CrMo5-5, 13CrMo4-5, 10 CrMo9-10, X11CrMo5, X11CrMo9-1, X10CrMoVNb9-1. <sup>d</sup> <b>Option 15</b> : Each fitting shall be hardness tested according to 14.4. <sup>e</sup> <b>Option 16</b> : This option applies only for grades P235GH, P265GH, 16Mo3, 10CrMo5-5, 13CrMo4-5, 10 CrMo9-10, X11CrMo5, X11CrMo9-1, X10CrMoVNb9-1.		

## 13 Sampling

### 13.1 Frequency of tests

#### 13.1.1 Test unit

A test unit shall consist of fittings of the same type, same specified dimension, same manufacturing process (for welded fittings, same welding process), from the same cast and the same heat treatment.

**NOTE** If the fitting dimensions are so large or the test unit so numerous that the furnace capacity leads to multiple heat treatment, it may be regarded as one test unit provided that the temperature can be guaranteed in a range of  $\pm 15$  °C and that the cooling conditions are similar.

**Option 17 :** *The registration records of the temperatures shall be transmitted to the purchaser.*

The purchaser may indicate in his enquiry and order that the test unit size shall be limited ; in this case he shall select one of the following options and following conditions apply :

For test unit size determination, equal or reducing tees as well as concentric or eccentric reducers with the same large diameter  $D$  and different reducing ratios are considered the same type.

**Option 18 :** *The test unit size shall be as indicated in Table 21.*

**Table 21**

Diameter mm	Maximum number of pieces in a test unit
$D < 114,3$	500
$114,3 \leq D \leq 219,1$	200
$219,1 < D \leq 323,9$	100
$323,9 < D \leq 610$	50
$610 < D \leq 1219$	25
$1219 < D$	10

**Option 19 :** *The test unit size shall be as indicated in Table 22.*

**Table 22**

Diameter mm	Maximum number of pieces in a test unit
$D < 114,3$	200
$114,3 \leq D \leq 219,1$	100
$219,1 < D \leq 323,9$	50
$323,9 < D \leq 610$	25
$610 < D \leq 1219$	10
$1219 < D$	10

**Option 20:** *The test unit size shall be as specified on the purchase order.*

### 13.1.2 Number of sample fittings per test unit

One sample fitting shall be taken from each test unit.

## 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 or from the whole thickness of the fitting at same location as for the mechanical test samples, in accordance with EN ISO 14284.

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### 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 an over length of the fitting or from an accompanying test piece 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 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 from the fitting 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. Where test pieces of least 5 mm width cannot be obtained, the fittings shall not be subjected to impact testing ; in this case, the impact test results on the starting material shall be used and reported.

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 :

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

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

## 14 Test methods

### 14.1 Chemical analysis

The chemical composition shall be determined by the manufacturer of the starting material.

The elements to be determined and reported shall be those in Table 4 in accordance with the steel grade concerned.

## 14.2 Tensile test on the base material

### 14.2.1 At room temperature

Unless the starting material characteristics are used, the test shall be carried out for fittings with  $D \geq 114,3$  mm 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.

### 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 ( $R_{p0,2}$ ) 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 Hardness test

The test is carried out for fittings with  $D < 114,3$  mm. It shall also be carried out for fittings with  $D \geq 114,3$  mm under the conditions in 12.3.

The test pieces shall be selected at random in the test unit provided they are representative of the test unit.

One measurement shall be carried out on the external wall of the fitting in accordance with EN ISO 6506-1 or with any other suitable method where the results can be converted to Brinell hardness numbers.

The measured hardness values shall be converted into tensile strength values in accordance with EN ISO 2566-1 to determine compliance.

## 14.5 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.

## 14.6 Impact testing

**14.6.1** The test shall be carried out for fittings with  $D \geq 114,3$  mm in accordance with EN 10045-1. The test temperature shall be the lowest specified in Table 9 for the relevant grade.

**14.6.2** 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.

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**14.6.3** If the width ( $W$ ) of the test piece is less than 10 mm, the measured impact energy ( $KV_p$ ) shall be converted to impact energy ( $KV_c$ ) using the equation :

$$KV_c = 10 \times KV_p / W$$

where:

$KV_c$  is the calculated impact energy, in joules ;

$KV_p$  is the measured impact energy, in joules ;

$W$  is the width of the test piece.

The calculated impact energy  $KV_c$  shall comply with the requirements given in 14.6.2.

**14.6.4** If the requirement of 14.6.2 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 :

- 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.

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

## 14.7 Dimensional testing

The fittings shall be checked at a frequency fixed by the manufacturer in order to verify statistically that the dimensions conform to the requirements in Clause 11.

For elbows, the dimension  $R$  cannot be measured directly. Conformity with the requirements is verified by measurements of  $W$  and  $Z$ , for which relevant tolerances are given in Table 19.

## 14.8 Visual inspection

The fittings shall be submitted individually to a visual inspection in order to detect the imperfections on external and internal surfaces.

The fittings are inspected after final deformation without being protected with any coating.

The requirements in Clause 10 shall be complied with.

## 14.9 Non destructive testing

### 14.9.1 Personnel

All NDT activities shall be carried out by qualified and competent level 1, 2 and/or 3 personnel authorised to operate by the employer.

The qualification shall comply with EN 10256 or an equal specification.

It is recommended that the level 3 personnel be certified in accordance with EN 473 or, at least, an equivalent to it.

The operating authorisation issued by the employer shall be in accordance with a written procedure.

NDT operations shall be authorised by level 3 NDT individual approved by the employer.

For pressure equipment in categories III and IV (of Directive 97/23-EC) the personnel shall be approved by a recognised third-party organisation.

NOTE The definition of level 1, 2 and 3 can be found in appropriate standards, e.g. EN 473 and EN 10256

#### 14.9.2 NDT of the weld

**14.9.2.1** The NDT of welds in grades P235GH, P265GH, P355GH, 16 Mo3, 10CrMo5-5 and 13CrMo4-5 may be performed either prior or after forming and heat treatment. If fittings in such grades are produced from welded tubes not marked with C2, no additional NDT of the weld is necessary.

For all other grades, the NDT of welds shall be performed after forming and heat treatment.

**Option 22** : *If NDT of the weld of fittings in grades P235, P265, P355, 16 Mo3, 10CrMo5-5 and 13CrMo4-5 is performed prior to forming and heat treatment, 10 % of the welds shall be tested after forming and heat treatment again. If one or more fitting among the 10 % has to be rejected for defect in the weld, then NDT of 100 % of the fittings shall be carried out.*

**Option 23** : *The NDT of welds in grades P235, P265, P355, 16 Mo3, 10CrMo5-5 and 13CrMo4-5 shall be performed after forming and heat treatment.*

**14.9.2.2** Except as mentioned in 14.9.2.3 and 14.9.2.4, all welds shall be radiographically examined throughout their entire length in accordance with EN 10246-10 to image quality R1, with the conditions given in 1) to 3) below :

- 1) sensitivity requirements, given in Table 23 established on the base material, shall be verified by use of the ISO wire penetrometer according to ISO 1027 or, if so agreed, by use of an equivalent hole penetrometer ;
- 2) only X-Ray radiation, using fine-grain, high-contrast direct film with lead screen, or gamma-ray, shall be used unless precluded by the thickness of the weld ; in such cases, other methods may be agreed ;
- 3) density of the radiograph shall not be less than 2,0 and shall be chosen so that the density through the thickest portion of the weld seam is not less than 1,5 and that maximum contrast for the type of film used is achieved.

**Table 23 — Sensitivity requirements for the radiographic inspection, image quality R1**

Wall thickness mm		Visibility required	
above	up to	of the hole with a diameter mm	of the wire with a diameter mm
4,5	10	0,40	0,16
10	16	0,50	0,20
16	25	0,63	0,25
25	32	0,80	0,32
32	40	1,00	0,40

The acceptance limits for the radiographic inspection of the weld seam shall be as given in a) to f) below :

- a) cracks, incomplete penetration and lack of fusion are not acceptable ;
- b) individual circular slag inclusions and gas pockets up to 3,0 mm or T/3 in diameter, whichever is the smaller, are acceptable ;

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The sum of the diameters of all such permitted individual imperfections in any 150 mm or  $12T$  of weld length, whichever is the smaller, shall not exceed 6,0 mm or  $0,5T$ , whichever is the smaller, where the separation between individual inclusions is less than  $4T$  ;

- c) individual elongated slag inclusions up to 12,0 mm or  $1T$  in length, whichever is the smaller, or up to 1,6 mm in width, are acceptable. The maximum accumulated length of such permitted individual imperfections in any 150 mm or  $12T$  of weld length, whichever is the smaller, shall not exceed 12,0 mm, where the separation between individual inclusions is less than  $4T$  ;
- d) individual undercuts of any length having a maximum depth of 0,4 mm are acceptable.

Individual undercuts of a maximum length of  $T/2$  having a maximum depth of 0,8 mm and not exceeding 10 % of the specified wall thickness are acceptable provided that there are not more than two such undercuts in any 300 mm of the weld length, and that all such undercuts are dressed out ;

- e) undercuts exceeding the above limits shall be repaired or the suspect area shall be cropped off or the fitting shall be rejected ;
- f) undercuts on the inside and outside weld of any length and depth which are coincident in the longitudinal direction on the same side of the weld are not acceptable.

**14.9.2.3** Instead of radiographic examination and with the agreement of the purchaser, welds made by the fitting manufacturer, may be ultrasonically tested throughout their entire length in accordance with EN 10246-9 with acceptance level U2.

**14.9.2.4** For fittings made from welded tubes, instead of radiographic examination, ultrasonic testing in accordance with EN 10246-8 with acceptance level U3 or EN 10246-9 with acceptance level U3 is permitted.

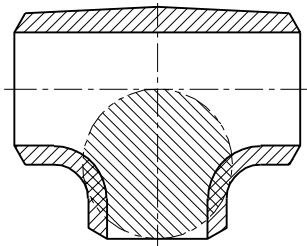
**14.9.3 NDT of cold formed tees**

Each cold formed tee shall be liquid penetrant or magnetic particle inspected in accordance with EN 10246-11 or EN 10246-12. This examination shall be carried out after final heat treatment.

Only the side wall areas of the tees shall be examined. This area is defined by a circle which covers the area from the weld bevel of the branch outlet to the centre of the body of run (see Figure 11). Internal and external surfaces shall be examined when size permits accessibility.

No cracks shall be permitted. Other imperfections shall be treated in accordance with 10.5 to 10.9. After removal of any imperfections the tee shall be re-examined by the original method.

If the manufacturer can demonstrate by testing history (relevant to the particular fitting size) that the results are consistent with the definition of a test unit, then the manufacturer can agree a percentage test with the purchaser provided always that a minimum of 10 % of any test unit is tested ; in the event of a single crack being found on this sample, then 100 % testing is carried out.



**Figure 11 — Area of cold formed tee to be examined**



#### 14.9.4 Detection of laminar imperfections

**Option 24** : *The starting material shall be ultrasonically tested for the detection of laminar imperfections.*

#### 14.10 Material identification

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

### 15 Marking

#### 15.1 Marking to be applied

The marking shall include the following minimum information:

- manufacturer's mark or logo ;
- country of manufacture or the ISO code (in accordance with EN ISO 3166-1) representing it ;

**NOTE** When individual manufacturing/production operations are performed at different locations, country of manufacture means country where the forming operation is performed.

- letters "EN2" used as reference to this standard ;
- letter "B" for fittings of type B ;
- steel name or steel number (see 5.1) ;
- letter W (for welded fittings or fittings made from welded tubes) ;
- letter "Y" when increased yield strength is used (see 7.1) ;
- cast number or a code number which permits the correlation with the inspection document ;
- mark of the inspection representative (for third party when applicable) ;
- outside diameter  $D$  ;
- wall thickness  $T$  ;
- category conformity indicator C1 or C2, if applicable (see 8.2.2.1 and 14.9.1).

At the manufacturer's discretion, for fittings of type A, the letter "A" is marked after the letters "EN2".

For the meaning of deformation, see Table 1. A code number may be used for correspondence between the fitting and the inspection document. For reducing tees or reducers, the marking of dimensions shall include  $D_1$  and  $T_1$  (in addition to  $D$  and  $T$ ) in the following order :  $D \times T/D_1 \times T_1$ .

For the outside diameter, the value to be marked may be rounded, i.e. 42 instead of 42,4 or 89 instead of 88,9.

Additional markings may be added at the manufacturer's discretion.

For fittings with  $D < 88,9$  mm, markings may be omitted in the following order when the shape or size of the product does not permit the inclusion of all required markings :

- outside diameter ;

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— wall thickness.

In this case the full marking shall be reported on the packaging or the attached tag.

### 15.2 Methods

The marking shall be die stamped. As far as possible the die stamping should not be applied in the weld area.

**Option 25** : *Cold die stamping shall not be used ; the method of marking shall be as specified on the purchase order.*

**Option 26** : *Any requirements for additional markings or for special locations shall be as specified on the purchase order.*

## 16 Protection and packaging

At the manufacturer's discretion the fittings are delivered without protection or with the normal manufacturer's mill protection.

For  $D \leq 60,3$  the fittings are delivered packaged.

**Option 27** : *The protection shall be as specified on the purchase order.*

## Annex A (informative)

### Determination of pressure factors and wall thickness

#### A.1 General

Annex A defines pressure factors for fittings of type A and wall thickness requirements of fittings of type B. This is done by laying down appropriate calculation procedures in detail.

The pressure factor of a fitting of type A gives the percentage of internal pressure which may, in general, be applied to the fitting relative to the pressure which may be applied to a straight pipe with the same dimensions (diameter, wall thickness, wall thickness tolerance) and material. The wall thickness tolerance of this pipe is assumed to be the same as the wall thickness tolerances at the welding ends of the fitting.

The wall thicknesses of fittings type B are laid down so that the fittings will, in general, withstand the same internal pressure as a straight pipe with the same dimensions (diameter, wall thickness, wall thickness tolerance) and material. Wall thickness tolerance of this corresponding straight 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. Most of the formulas may be applied in case of time-independent and time-dependent loads. Where the formulas are valid only for time-independent loads appropriate notes are made in Annex A.

#### A.2 Symbols and units

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

**Table A.1 — Additional symbols for the purposes of Annexes A, B and C**

Symbol	Description
$A_f$	Stress loaded cross sectional area (calculation of tees)
$A_{fs}, A_{fsc}, A_{fbc}, A_{fb}$	Partial Areas of $A_f$ (calculation of tees)
$A_p$	Pressure loaded area (calculation of tees)
$A_{pbc}, A_{psc}$	Areas used in the determination of $A_p$ (calculation of tees)
$c_0$	Corrosion or erosion allowance
$D_b$	Outside diameter at the body of the branch of tees type B
$D_s$	Outside diameter at the body of the run of tees type B
$L_2$	Length at the major end of reducers
$L'_2$	Length of cylindrical part at the major end of reducers
$L_{2,min}$	Minimum length at the major end of reducers
$L'_{2,min}$	Minimum length of cylindrical part at the major end of reducers
$L_4$	Length at the minor end of reducers

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Table A.1 (continued)

Symbol	Description
$L_{4,min}$	Minimum length at the minor end of reducers
$l_b$	Reinforcing length of branch (calculation of tees)
$l'_b$	Modified reinforcing length of branch (calculation of tees)
$l_s$	Reinforcing length of run (calculation of tees)
$l'_s$	Modified reinforcing length of run (calculation of tees)
$R$	Bending radius of elbows and return bends relating to the internal diameter
$r_c$	Crotch radius of tees
$T_{1,min}$	Minimum wall thickness at the minor welding end of reducers and at the welding end of the branch of reducing tees ( $D_1$ ) Minimum wall thickness of the branch of reducing tees type A Minimum wall thickness of the cylindrical part at the minor end of reducers type A
$T_{1,X}$	Wall thickness of a straight pipe with the same resistance to pressure as a fitting type A (equivalent wall thickness) with the diameter $D_1$ (minor end of a reducer)
$T_2$	Wall thickness of the cylindrical part of reducers type B at their major end
$T_{2,min}$	Minimum wall thickness of the cylindrical part of reducers type B at their major end
$T^*_{2,min}$	Minimum wall thickness of a cylindrical part with modified length of reducers type B at their major end
$T_3$	Wall thickness of the conical part of reducers type B
$T_{3,min}$	Minimum wall thickness of the conical part of reducers type B
$T_4$	Wall thickness of the cylindrical part of reducers type B at their minor end
$T_{4,min}$	Minimum wall thickness of the cylindrical part of reducers type B at their minor end
$T^*_{4,min}$	Minimum wall thickness of a cylindrical part with modified length of reducers type B at their minor end
$T_b$	Wall thickness on the branch of tees type B
$T_{b,min}$	Minimum wall thickness on the branch of tees type B
$T_{bc,min}$	Intermediate result (calculation of tees)
$T_c$	Wall thickness of caps type B
$T_{c,min}$	Minimum wall thickness of caps type B Minimum wall thickness on the crotch zone of tees
$T_{co,min}$	Intermediate result (calculation of reducers type B)
$T_{ext}$	Wall thickness on the extrados of elbows type B
$T_{ext,min}$	Minimum wall thickness on the extrados of elbows type B
$T_{int}$	Wall thickness on the intrados of elbows type B
$T_{int,min}$	Minimum wall thickness on the intrados of elbows type B
$T_{j,min}$	Intermediate result (calculation of reducers type B)
$T_{kn y,min}$	Intermediate result (calculation of caps type B)

Table A.1 (continued)

Symbol	Description
$T_{\min}$	Minimum wall thickness at the welding ends of elbows, return bends, caps and equal tees, at the welding ends of the run of reducing tees or at the major welding end of reducers  Minimum wall thickness at the body of elbows, return bends, equal tees and caps of type A  Minimum wall thickness of the run of reducing tees type A  Minimum wall thickness of the cylindrical part at the major end of reducers type A and of the conical part of reducers type A
$T_s$	Wall thickness at the run of tees type B
$T_{s,\min}$	Minimum wall thickness at the run of tees type B  Intermediate result (calculation of caps type B)
$T_{sc,\min}$	Intermediate result (calculation of tees)
$T_X$	Wall thickness of a straight pipe with the same pressure resistance as a fitting of type A (equivalent wall thickness)
$T_{X,23}, T_{X,3},$ $T_{X,34}, T_{X,4}, T_{L2},$ $T_{L2}, T_{L4}, T_{L4},$	Intermediate results (calculation of reducers type A)
$T_{X,s}, T_{X,ky}$	Intermediate results (calculation of caps type A)
$T_{a,\min}$	Minimum wall thickness at the body of elbows type B (between intrados and the crown)
$X$	Pressure factor : ratio of the pressure a fitting of type A will resist to the pressure a straight pipe (with same dimensions and material) will resist
$\alpha$	Semi angle of reducer  Angle at the perimeter of elbows (for the evaluation of the wall thickness at the body of the elbow)
$\alpha_b, \alpha_s$	Angle (intermediate result in the calculation of tees)
$\beta, \beta_{0,06}, \beta_{0,1},$ $\beta_{0,2}, N, W, Y, Z$	Factors (calculation of caps)
$\beta, \beta_H, s, \tau$	Factors (calculation of reducers)

### A.3 Minimal and nominal wall thickness

The design rules given in EN 13480-3:2002 are based on minimal required wall thicknesses. Therefore, in a first step, these minimal wall thicknesses have to be derived from the nominal wall thickness of the fitting. Taking into account the negative tolerances given in Table 18 and the corrosion or erosion allowance  $c_0$  the minimal wall thickness is calculated :

$$T_{\min} = \begin{cases} T \cdot (100 - 12.5) / 100 - c_0 & \text{if } D \leq 610 \text{ mm or fitting is seamless} \\ T - 0,35 \text{ mm} - c_0 & \text{if } D > 610 \text{ mm and } T \leq 10 \text{ mm and fitting is welded (A-1)} \\ T - 0,5 \text{ mm} - c_0 & \text{if } D > 610 \text{ mm and } T > 10 \text{ mm and fitting is welded} \end{cases}$$

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To obtain a wall thickness including wall thickness tolerances and corrosion or erosion allowance from a minimal wall thickness the following equation is used:

$$T = \begin{cases} (T_{\min} + c_0) \cdot 100 / (100 - 12.5) & \text{if } D \leq 610 \text{ mm or fitting is seamless} \\ T_{\min} + c_0 + 0, < 35 \text{ mm} & \text{if } D > 610 \text{ mm and } T_{\min} + c_0 \leq 9,65 \text{ mm and fitting is welded} \\ T_{\min} + c_0 + 0,5 \text{ mm} & \text{if } D > 610 \text{ mm and } T_{\min} + c_0 > 9,65 \text{ mm and fitting is welded} \end{cases} \quad (\text{A-2})$$

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

For fittings of type B the corrosion or erosion allowance  $c_0$  shall be 0.

NOTE In general,  $c_0 = 0$  has the consequence that elbows, tees and reducers will withstand at least the same pressure as the corresponding straight pipe for all corrosion or erosion allowances.

**A.4 Pressure factors of fittings of type A****A.4.1 Pressure factor**

In general, fittings of type A will not withstand the same internal pressure as a straight pipe with the same dimensions (diameter, wall thickness, wall thickness tolerance) and material. To support the designer of a piping system a pressure factor  $X$  is calculated. This pressure factor  $X$  gives the ratio of the pressure the fitting will resist to the pressure the pipe will resist :

$$X = \frac{\text{pressure resistance of fitting}}{\text{pressure resistance of pipe}} \cdot 100 \% \quad (\text{A-3})$$

In many cases the design formulas for fittings are based on the wall thickness of a straight pipe. Therefore, in a first step, the wall thickness  $T_X$  of a pipe with the same outside diameter, which will resist to the same pressure as the given fitting, (equivalent wall thickness) will be determined. The pressure factor  $X$  is calculated afterwards:

$$X = \frac{\frac{T_X}{D} \cdot 1 - \frac{T_{\min}}{D}}{\frac{T_{\min}}{D} \cdot 1 - \frac{T_X}{D}} \cdot 100 \% \quad (\text{A-4})$$

NOTE Formula (A-4) is derived from (6.1-1) from EN 13480-3:2002.

For fittings with two different ends (reducers and reducing tees) the pressure factor shall be calculated:

$$X = \frac{\frac{T_X}{D} \cdot 1 - \min\left(\frac{T_{\min}}{D}, \frac{T_{1,\min}}{D_1}\right)}{\min\left(\frac{T_{\min}}{D}, \frac{T_{1,\min}}{D_1}\right) \cdot 1 - \frac{T_X}{D}} \cdot 100 \% \quad (\text{A-5})$$

### A.4.2 Elbows

For elbows, the equivalent wall thickness is given by :

$$T_x = \frac{4 \cdot R - 2 \cdot D + 2 \cdot T_{\min}}{4 \cdot R - D} \cdot T_{\min} \quad (\text{A-6})$$

NOTE Formula (A-6) is derived from (B.4.1-11) from EN 13480-3:2002 by setting  $B = e_f/e$  and solving the equation for  $e$ .

#### EXAMPLE

Pressure factor of an elbow (welded) model 2D - 711 x 7.1, corrosion or erosion allowance 1 mm :

Table 10 :  $R = 711 \text{ mm}$

(A-1) :  $T_{\min} = 7,1 \text{ mm} - 0,35 \text{ mm} - 1 \text{ mm} = 5,75 \text{ mm}$

(A-6) :  $T_x = 3,864 \text{ mm}$

(A-4) :  $X = 67,0 \%$

### A.4.3 Tees

The calculation procedure for tees is based on the design rules in EN 13480-3:2002. It includes the determination of the stress loaded cross sectional area  $A_f$  and the pressure loaded cross sectional area  $A_p$ , which are shown in Figure A.1.

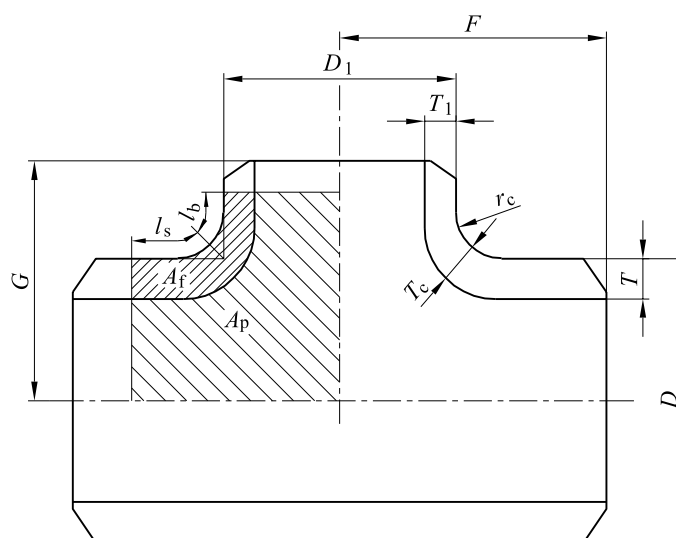


Figure A.1 — Tee type A

With these areas  $A_p$  and  $A_f$  the wall thickness of a pipe with the same resistance to internal pressure as the tee is given by :

$$T_x = \frac{D}{2 \cdot \left( \frac{A_p}{A_f} + 1 \right)} \quad (\text{A-7})$$

The reinforcing lengths are calculated :

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$$l_s = \min\left(\sqrt{(D - T_{\min}) \cdot T_{\min}}, F - \frac{D_1}{2} - \left(1 - \frac{\pi}{4}\right) \cdot r_c\right) \quad (\text{A-8})$$

$$l_b = \min\left(\sqrt{(D_1 - T_{1,\min}) \cdot T_{1,\min}}, G - \frac{D}{2} - \left(1 - \frac{\pi}{4}\right) \cdot r_c\right) \quad (\text{A-9})$$

At the transition of run and branch (crotch zone) the inside and outside surfaces shall merge smoothly.

NOTE 1 Formula (A-7) is only applicable if  $T_{1,\min}$  is less equal  $T_{\min}$ .

NOTE 2 Formula (A-7) is derived from (8.4.3-3) and (6.1-1) from EN 13480-3:2002, Formulas (A-8) and (A-9) are based on (8.4.1-2) and (8.4.3-1) from EN 13480-3:2002. The requirement  $T_{1,\min} \leq T_{\min}$  is more restrictive than the stipulation in EN 13480-3:2002, Figure 8.3.1-1.

NOTE 3 In EN 13480-3:2002 the design is limited to  $D1 - 2 T_{1,\min} \leq 0,8 (D - 2 \cdot T_{\min})$  for materials others than austenitic steels. For applications within the creep range it is limited to  $D1 - 2 T_{1,\min} \leq 0,7 (D - 2 \cdot T_{\min})$  and the pressure factor is multiplied by 0,9.

EXAMPLE :

Pressure factor of a reducing tee 813 x 8 – 508 x 6.3,

$c_0 = 0$  mm,  $r_c = 95$  mm and  $T_{c,\min} = (T_{s,\min} + T_{b,\min}) / 2$  :

Table 14 :  $F = 597$  mm,  $G = 533$  mm.

$$(\text{A-1}) : \quad T_{\min} = 8 \text{ mm} - 0,35 \text{ mm} - 0 \text{ mm} = 7,650 \text{ mm}$$

$$T_{1,\min} = 6,3 \text{ mm} (100 - 12.5) / 100 - 0 \text{ mm} = 5,513 \text{ mm}$$

$$T_{c,\min} = (7,65 \text{ mm} + 5,513 \text{ mm}) / 2 = 6,581 \text{ mm}$$

$$(\text{A-8}) : \quad l_s = 78,49 \text{ mm}$$

$$(\text{A-9}) : \quad l_b = 52,63 \text{ mm}$$



For the calculation of areas  $A_f$  and  $A_p$  see Figure A.2.

$$\alpha_s = 45^\circ \cdot \max\left(1 - \frac{l_s}{\frac{\pi}{4} \cdot r_c}, 0\right) = 0,00^\circ$$

$$\alpha_b = 45^\circ \cdot \max\left(1 - \frac{l_b}{\frac{\pi}{4} \cdot r_c}, 0\right) = 13,26^\circ$$

$$l'_s = r_c - r_c \cdot \sin(\alpha_s) + \max\left(l_s - r_c \cdot \frac{\pi}{4}, 0\right) = 98,88 \text{ mm}$$

$$l'_b = r_c - r_c \cdot \sin(\alpha_b) + \max\left(l_b - r_c \cdot \frac{\pi}{4}, 0\right) = 73,21 \text{ mm}$$

$$T_{sc,min} = \frac{45^\circ - \alpha_s}{45^\circ} \cdot T_{min} + \frac{\alpha_s}{45^\circ} \cdot T_{c,min} = 7,650 \text{ mm}$$

$$T_{bc,min} = \frac{45^\circ - \alpha_b}{45^\circ} \cdot T_{1,min} + \frac{\alpha_b}{45^\circ} \cdot T_{c,min} = 5,827 \text{ mm}$$

$$A_{fs} = \max(l'_s - r_c, 0) \cdot T_{min} = 29,7 \text{ mm}^2$$

$$A_{fsc} = \left( \left( r_c + \frac{T_{sc,min} + T_{c,min}}{2} \right)^2 - r_c^2 \right) \cdot \pi \cdot \frac{45^\circ - \alpha_s}{360^\circ} + T_{sc,min}^2 \cdot \frac{\tan(\alpha_s)}{2} = 550,8 \text{ mm}^2$$

$$A_{fbc} = \left( \left( r_c + \frac{T_{bc,min} + T_{c,min}}{2} \right)^2 - r_c^2 \right) \cdot \pi \cdot \frac{45^\circ - \alpha_b}{360^\circ} + T_{bc,min}^2 \cdot \frac{\tan(\alpha_b)}{2} = 341,2 \text{ mm}^2$$

$$A_{fb} = \max(l'_b - r_c, 0) \cdot T_{1,min} = 0,0 \text{ mm}^2$$

$$A_f = A_{fs} + A_{fsc} + A_{fbc} + A_{fb} = 921,7 \text{ mm}^2$$

$$A_{psc} = r_c^2 \cdot \left( \frac{1}{2} \cdot (1 - \sin(\alpha_s))^2 - \pi \cdot \frac{45^\circ - \alpha_s}{360^\circ} + \frac{1}{2} \cdot \sin(\alpha_s) \cdot (\cos(\alpha_s) - \sin(\alpha_s)) \right) = 968 \text{ mm}^2$$

$$A_{pbc} = r_c^2 \cdot \left( \frac{1}{2} \cdot (1 - \sin(\alpha_b))^2 - \pi \cdot \frac{45^\circ - \alpha_b}{360^\circ} + \frac{1}{2} \cdot \sin(\alpha_b) \cdot (\cos(\alpha_b) - \sin(\alpha_b)) \right) = 950 \text{ mm}^2$$

$$A_p = \left( \frac{D1}{2} + l'_s \right) \cdot \left( \frac{D}{2} + l'_b \right) - l'_s \cdot l'_b + A_{psc} + A_{psb} - A_f = 163038 \text{ mm}^2$$

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$$\frac{A_p}{A_f} = 176,89$$

(A-7) : TX = 2,285 mm

(A-5) : X = 29,7 %

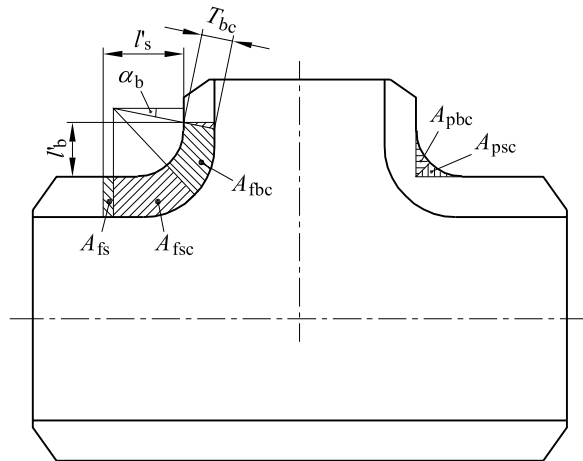


Figure A.2 — Additional dimensions and areas used in the calculation  $A_p$  and  $A_f$  of a tee

#### A.4.4 Reducers

For the determination of the pressure resistance of reducers several aspects have to be taken into consideration. The calculations are based on the following preconditions:

- wall thickness in the conical section is at least the wall thickness at the major end of the reducer ;
- reducer has cylindrical sections on both ends of the reducer. In some cases minimal lengths of these sections are required ;
- at the transition of cylindrical sections and conical sections the inside and outside surfaces shall merge smoothly ;
- transition between the cylindrical sections and the conical section at the major end may be curved. In this case the distance between the knuckle and the end of the reducer shall be at least :

$$L'_{2,\min} = 0,5 \cdot \sqrt{(D - T_{L2}) \cdot T_{L2}} \quad (\text{A-10})$$

- transition between the cylindrical sections and the conical section at the minor end may be curved too. The wall thickness of the knuckle shall be the same as of the conical section.

Figure A.3 shows wall thicknesses, minimal lengths at the ends and the semi angle for both concentric and eccentric reducers.

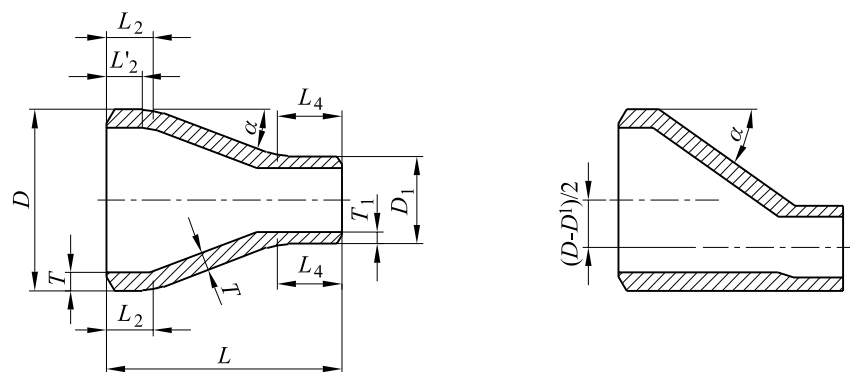


Figure A.3 — Concentric and eccentric reducer type A

The design of a reducer comprises the determination of the wall thickness at the cylindrical sections, the wall thickness at the conical section and the wall thicknesses at the transitions between cylindrical and conical sections. Therefore, first the equivalent wall thickness at different sections of the reducer has to be calculated. In the next step the overall equivalent wall thickness of the reducer is determined.

$$T_{X,23} = T_{\min} \cdot \frac{D}{\beta \cdot (D - T_{\min}) + T_{\min}} \quad (\text{A-11})$$

$$T_{X,3} = T_{\min} \cdot \cos(\alpha) \cdot \frac{D}{D - 2 \cdot T_{\min} - \sqrt{\frac{(D - T_{\min}) \cdot T_{\min}}{\cos(\alpha)} \cdot \sin(\alpha)} + T_{\min} \cdot \cos(\alpha)} \quad (\text{A-12})$$

$$T_{X,34} = T_{\min} \cdot \frac{D}{\beta_H \cdot (D_1 - T_{1,\min}) \cdot \frac{T_{\min}}{T_{1,\min}} + T_{\min}} \quad (\text{A-13})$$

$$T_{X,4} = T_{1,\min} \cdot \frac{D}{D_1} \quad (\text{A-14})$$

$$T_X = \min(T_{X,23}, T_{X,3}, T_{X,34}, T_{X,4}) \quad (\text{A-15})$$

$$T_{1,X} = T_X \cdot \frac{D_1}{D} \quad (\text{A-16})$$

with the factors  $\beta$  and  $\beta_H$ :

$$\beta = \max \left( \frac{1}{3} \cdot \sqrt{\frac{D - T_{\min}}{T_{\min}}} \cdot \frac{\tan(\alpha)}{1 + \frac{1}{\sqrt{\cos(\alpha)}}} - 0,15, 1 \right) \quad (\text{A-17})$$

$$s = \frac{T_{\min}}{T_{1,\min}} \quad (\text{A-18})$$

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$$\tau = \begin{cases} s \cdot \sqrt{\frac{s}{\cos(\alpha)}} + \sqrt{\frac{1+s^2}{2}} & \text{if } s < 1 \\ 1 + \sqrt{s \cdot \frac{1+s^2}{2 \cdot \cos(\alpha)}} & \text{if } s \geq 1 \end{cases} \quad (\text{A-19})$$

$$\beta_H = 0,4 \cdot \sqrt{\frac{D_1 - T_{1,\min}}{T_{1,\min}}} \cdot \frac{\tan(\alpha)}{\tau} + 0,5 \quad (\text{A-20})$$

Afterwards, the minimal lengths at the ends have to be calculated. In a first step, the wall thicknesses  $T_{L2}$  and  $T_{L4}$  are determined. These wall thicknesses are required at the cylindrical sections so that the reducer is able to resist the pressure expressed by the pressure factor  $X$ . The following equations have to be solved by iteration :

$$T'_{L2} = \beta \cdot T_X \cdot \frac{D}{D + (\beta - 1) \cdot T_X} \quad (\text{A-21})$$

$$T_{L2} = \max(T_X, T'_{L2}) \quad (\text{A-22})$$

$$T'_{L4} = \beta_H \cdot T_{1,X} \cdot \frac{D}{D + (\beta_H - 1) \cdot T_X} \quad (\text{A-23})$$

$$T_{L4} = \max(T_{1,X}, T'_{L4}) \quad (\text{A-24})$$

with the factors  $\beta$  and  $\beta_H$  :

$$\beta = \frac{1}{3} \cdot \sqrt{\frac{D - T'_{L2}}{T'_{L2}}} \cdot \frac{\tan(\alpha)}{1 + \frac{1}{\sqrt{\cos(\alpha)}}} - 0,15 \quad (\text{A-25})$$

$$s = \frac{T_{\min}}{T'_{L4}} \quad (\text{A-26})$$

$$\tau = \begin{cases} s \cdot \sqrt{\frac{s}{\cos(\alpha)}} + \sqrt{\frac{1+s^2}{2}} & \text{if } s < 1 \\ 1 + \sqrt{s \cdot \frac{1+s^2}{2 \cdot \cos(\alpha)}} & \text{if } s \geq 1 \end{cases} \quad (\text{A-27})$$

$$\beta_H = 0,4 \cdot \sqrt{\frac{D_1 - T'_{L4}}{T'_{L4}}} \cdot \frac{\tan(\alpha)}{\tau} + 0,5 \quad (\text{A-28})$$

With these wall thicknesses the minimal lengths are calculated :

$$L_{2,\min} = \frac{T_{L2} - T_X}{T_{\min} - T_X} \cdot 1,4 \cdot \sqrt{(D - T_{L2}) \cdot T_{L2}} \quad (\text{A-29})$$

$$L_{4,\min} = \frac{T_{L4} - T_{1,X}}{T_{1,\min} - T_{1,X}} \cdot \sqrt{(D_1 - T_{L4}) \cdot T_{L4}} \quad (\text{A-30})$$

The length  $L_{2,\min}$  is applicable only if  $T_X$  is less than  $T_{\min}$ ,  $L_{4,\min}$  is applicable if  $T_{1,X}$  is less than  $T_{1,\min}$ . If the reducer is located between pipes with minimal wall thicknesses larger than  $T_{L2}$  and  $T_{L4}$ , respectively, the minimal lengths do not apply, too.

NOTE 1 Formula (A-12) to (A-28) are applicable only for semi angle  $\alpha$  less equal  $75^\circ$  and ratios of  $T_{\min} \cos(\alpha)$  to  $D$  not smaller than 0,001.

NOTE 2 The calculation of reducers is based on the following sections/equations in EN 13480-3:2002:

Formula (A-10) is based on the stipulations in 6.4.7.2 ;

Formula (A-11) takes into account 6.4.6.3 a) and 6.4.6.3 g) ;

Formula (A-12) takes into account 6.4.6.3 b) and 6.4.6.3e) ;

Formula (A-13) takes into account 6.4.8.3 ;

Formula (A-14) takes into account the pressure resistance of the cylindrical part at the minor end ;

Formulas (A-17) and (A-25) are based on (6.4.6-1) ;

Formulas (A-18) and (A-26) are given as (6.4.8-1) ;

Formulas (A-19) and (A-27) are based on (6.4.8-2) and (6.4.8-3) ;

Formulas (A-20) and (A-28) are given as (6.4.8-4) ;

Formula (A-21) is derived from (6.4.6-2) and (6.1-1) ;

Formula (A-23) is derived from (6.4.8-6) and (6.1-1).

The calculation of the minimal length at the ends of the reducers (A-29) and (A-30) takes into account that the wall thickness near the junction may be increased and the wall thickness further away may be reduced provided that the cross-sectional area remains constant (see last paragraph of 6.4.6.2 and last paragraph of 6.4.8.2 of in EN 13480-3:2002) and that the reducer will be located between pipes with minimal wall thicknesses of at least  $T_X$  and  $T_{1,X}$ .

No additional calculation of the wall thickness of the knuckle at the major end is required. The formulas in EN 13480-3:2002 (6.4.7-1) to (6.4.7-4) give wall thicknesses which are not larger than for junctions without a knuckle.

The rules for a knuckle at the minor end differs from the stipulations in EN 13480-3:2002.

#### EXAMPLE

Pressure factor of a concentric reducer 323,9 x 7,1 – 168,3 x 4,5,

$c_0 = 0$  mm, semi angle  $\alpha = 35^\circ$  :

Table 15 :  $L = 203$  mm.

$$(A-1) : \quad T_{\min} = 7,1 \text{ mm } (100 - 12,5) / 100 - 0 \text{ mm} = 6,213 \text{ mm}$$

$$T_{1,\min} = 4,5 \text{ mm } (100 - 12,5) / 100 - 0 \text{ mm} = 3,938 \text{ mm}$$

$$(A-17) : \quad \beta = 1,000$$

$$(A-18) : \quad s = 1,578$$

$$(A-19) : \quad \tau = 2,833$$

$$(A-20) : \quad \beta_H = 1,139$$

$$(A-11) : \quad T_{X,23} = 6,213 \text{ mm}$$

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$$(A-12) : T_{X,3} = 5,715 \text{ mm}$$

$$(A-13) : T_{X,34} = 6,674 \text{ mm}$$

$$(A-14) : T_{X,4} = 7,578 \text{ mm}$$

$$(A-15) : T_X = 5,715 \text{ mm}$$

$$(A-16) : T_{1,X} = 2,970 \text{ mm}$$

$$(A-5) : X = 91,9 \%$$

The calculation of the minimal lengths at the ends of the cylinders :

Result of solving (A-21) and (A-25) by iteration :  $T_{L2}^* = 4,499 \text{ mm}$ ,  $\beta = 0,784$

Result of solving (A-23) with (A-26), (A-27) and (A-28) by iteration :  $T_{L4}^* = 3,261 \text{ mm}$ ,  $s = 1,905$ ,  $\tau = 3,320$ ,  $\beta_H = 1,100$

$$(A-22) : T_{L2} = 5,715 \text{ mm}$$

$$(A-24) : T_{L4} = 3,261 \text{ mm}$$

$$(A-29) : L_{2,\min} = 0,00 \text{ mm (no specific length required)}$$

$$(A-10) : L'_{2,\min} = 21,32 \text{ mm}$$

$$(A-30) : L_{4,\min} = 6,99 \text{ mm}$$

**A.4.5 Caps**

The design of a cap comprises the determination of the wall thickness of the ellipsoidal end, the wall thickness of the knuckle and the wall thickness of the cylindrical part. Therefore, first the equivalent wall thickness at different sections of the cap has to be calculated. In the next step the overall equivalent wall thickness of the cap is determined :

$$T_{X,s} = T_{\min} \cdot \frac{D}{R1 + 1,5 \cdot T_{\min}} \quad (A-31)$$

$$T_{X,ky} = T_{\min} \cdot \frac{D}{2 \cdot \beta \cdot (0,75 \cdot R1 + 0,2 \cdot (D - 2 \cdot T_{\min})) + T_{\min}} \quad (A-32)$$

$$T_X = \min(T_{X,s}, T_{X,ky}, T_{\min}) \quad (A-33)$$

The factors  $\beta$  is calculated :

$$Y = \min\left(\frac{T_{\min}}{R1}, 0,04\right) \quad (A-34)$$

$$Z = \log\left(\frac{1}{Y}\right) \quad (A-35)$$

$$W = \frac{r}{D - 2 \cdot T_{\min}} \quad (A-36)$$

$$N = 1,006 - \frac{1}{6,2 + (90 \cdot Y)^4} \quad (\text{A-37})$$

$$\beta_{0,06} = (-0,3635 \cdot Z^3 + 2,2124 \cdot Z^2 - 3,2937 \cdot Z + 1,8873) \cdot N \quad (\text{A-38})$$

$$\beta_{0,1} = (-0,1833 \cdot Z^3 + 1,0383 \cdot Z^2 - 1,2943 \cdot Z + 0,837) \cdot N \quad (\text{A-39})$$

$$\beta_{0,2} = 0,5 \quad (\text{A-40})$$

$$\beta = \begin{cases} 25 \cdot ((0,1 - W) \cdot \beta_{0,06} + (W - 0,06) \cdot \beta_{0,1}) & \text{if } 0,06 \leq W \leq 0,1 \\ 10 \cdot ((0,2 - W) \cdot \beta_{0,1} + (W - 0,1) \cdot \beta_{0,2}) & \text{if } 0,1 < W \leq 0,2 \end{cases} \quad (\text{A-41})$$

The heights of the curved and cylindrical parts of the cap shall be :

$$h_i = 0,255 \cdot D - 0,635 \cdot T$$

$$h_c \geq 3 \cdot T$$

NOTE 1 Formulas (A-31) to (A-41) are applicable provided that the following conditions are simultaneously fulfilled :

$$r \geq 0,06 (D - 2 T_{\min})$$

$$r \geq 3 T_{\min}$$

$$0,004 (D - 2 T_{\min}) < T_{\min} \leq 0,08 (D - 2 T_{\min})$$

$$R1 \leq D$$

NOTE 2 The calculation of caps is based on the following formulas in EN 13480-3:2002:

Formula (A-31) is derived from (7.1.3-1) and (6.1-1) ;

Formula (A-32) is derived from (7.1.3-2) and (6.1-1) ;

Formula (A-34) is given as (7.1.5-1) ;

Formula (A-35) is given as (7.1.5-2) ;

Formula (A-36) is given as (7.1.5-3) ;

Formula (A-37) is given as (7.1.5-4) ;

Formula (A-38) is given as (7.1.5-6) ;

Formula (A-39) is given as (7.1.5-5) ;

Formula (A-40) is read from Figure 7.1.5-1 ;

Formula (A-41) is given as (7.1.5-8) and (7.1.5-7).

#### EXAMPLE

Pressure factor of a seamless cap 1219x10,

$$c_0 = 0 \text{ mm}, r = 0,15 \cdot D, R1 = 0,8 \cdot D :$$

$$r = 0,15 \cdot 1219 = 183 \text{ mm}$$

$$R1 = 0,8 \cdot 1219 = 975 \text{ mm}$$

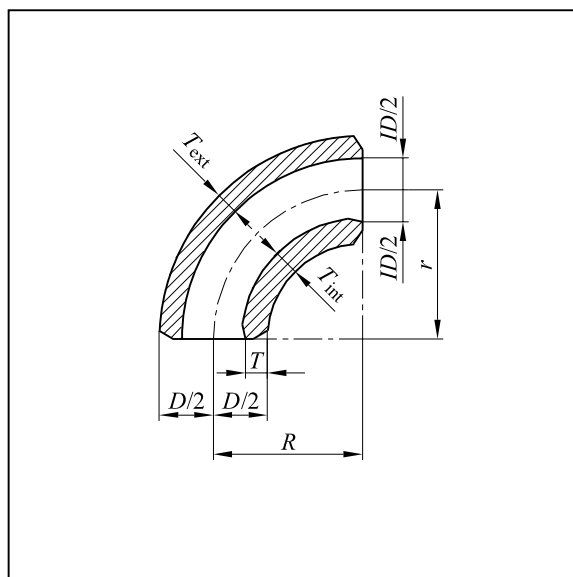
$$(\text{A-1}) : T_{\min} = 10 \text{ mm} \cdot (100 - 12,5) / 100 - 0 \text{ mm} = 8,75 \text{ mm}$$

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(A-31) :	$T_{X,s} = 10,792 \text{ mm}$
(A-34) :	$Y = 0,00897$
(A-35) :	$Z = 2,047$
(A-36) :	$W = 0,152$
(A-37) :	$N = 0,855$
(A-38) :	$\beta_{0,06} = 1,110$
(A-39) :	$\beta_{0,1} = 0,826$
(A-41) :	$\beta = 0,656$
(A-32) :	$T_{X, kn y} = 8,311 \text{ mm}$
(A-33) :	$T_X = 8,311 \text{ mm}$
(A-4) :	$X = 94,9 \%$

**A.5 Wall thicknesses of fittings of type B****A.5.1 Elbows**

Wall thicknesses and other dimension of an elbow type B are illustrated in Figure A.4.



**Figure A.4 — Elbow type B**

The wall thickness on the intrados of the elbow shall be calculated:



$$T_{\text{int,min}} = T_{\text{min}} \cdot \left( \frac{D}{2 \cdot T_{\text{min}}} + \frac{r}{T_{\text{min}}} - \left( \frac{D}{2 \cdot T_{\text{min}}} + \frac{r}{T_{\text{min}}} - 1 \right) \cdot \sqrt{\frac{\left( \frac{r}{T_{\text{min}}} \right)^2 - \left( \frac{D}{2 \cdot T_{\text{min}}} \right)^2}{\left( \frac{r}{T_{\text{min}}} \right)^2 - 2 \cdot \frac{D}{T_{\text{min}}} \cdot \left( \frac{D}{2 \cdot T_{\text{min}}} - 1 \right)}} \right) \quad (\text{A-42})$$

where:

$$\frac{r}{T_{\text{min}}} = \sqrt{\frac{1}{2} \cdot \left\{ \left( \frac{D}{2 \cdot T_{\text{min}}} \right)^2 + \left( \frac{R}{T_{\text{min}}} \right)^2 \right\}} + \sqrt{\frac{1}{4} \cdot \left( \left( \frac{D}{2 \cdot T_{\text{min}}} \right)^2 + \left( \frac{R}{T_{\text{min}}} \right)^2 \right)^2 - 2 \cdot \frac{D}{T_{\text{min}}} \cdot \left( \frac{D}{2 \cdot T_{\text{min}}} - 1 \right) \cdot \left( \frac{R}{T_{\text{min}}} \right)^2} \quad (\text{A-43})$$

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

$$T_{\text{ext,min}} = T_{\text{min}} \quad (\text{A-44})$$

Between intrados ( $\alpha = 0^\circ$ ) and crown ( $\alpha = 90^\circ$ ) of the elbow the wall thickness shall be :

$$T_{\alpha,\text{min}} = T_{\text{min}} + (T_{\text{int,min}} - T_{\text{min}}) \cdot \cos(\alpha) \quad (\text{A-45})$$

Between the crown of the elbow ( $\alpha = 90^\circ$ ) and extrados ( $\alpha = 180^\circ$ ) the wall thickness shall be  $T_{\text{min}}$ .

NOTE 1 Setting  $T_{\text{ext,min}} = T_{\text{min}}$  ensures that the design requirements of EN 13480-3 are met for all corrosion or erosion allowances.

NOTE 2 Formulas (A-42) and (A-43) are given in EN 13480-3:2002 as (B.4.1-3) and (B.4.1-4).

#### EXAMPLE

Wall thicknesses of an elbow (welded) model 2D - 711 x 7,1.

$R = 711$  mm

$$(\text{A-1}) : T_{\text{min}} = 7,1 \text{ mm} - 0,35 \text{ mm} = 6,75 \text{ mm}$$

$$(\text{A-43}) : r / T_{\text{min}} = 105,66$$

$$(\text{A-42}) : T_{\text{int,min}} = 10,067 \text{ mm}$$

$$(\text{A-44}) : T_{\text{int,min}} = 6,75 \text{ mm}$$

Wall thicknesses including tolerances are :

$$(\text{A-2}) : T_{\text{int}} = 10,07 \text{ mm} + 0,5 \text{ mm} = 10,57 \text{ mm},$$

$$T_{\text{ext}} = 6,75 + 0,35 \text{ mm} = 7,1 \text{ mm}$$

#### A.5.2 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 described method. This method leads to a relation between the pressure loaded

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area  $A_p$  and the stress loaded cross section area  $A_f$  shown in Figure A.5. Under certain circumstances, the calculation may need to be repeated using an improved assumption of the wall thickness.

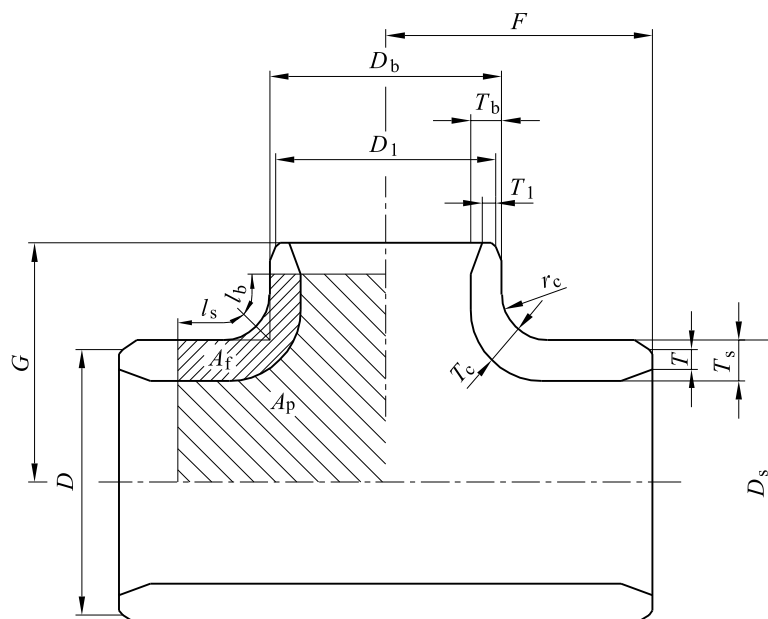


Figure A.5 — Dimensions and areas  $A_p$  and  $A_f$  of a tee

For the tee the following condition shall apply :

$$\frac{A_p}{A_f} \leq \max\left(\frac{D - 2 \cdot T_{s,\min}}{2 \cdot T_{s,\min}}, \frac{D_1 - 2 \cdot T_{1,\min}}{2 \cdot T_{1,\min}}\right) \quad (\text{A-46})$$

The reinforcing lengths are calculated :

$$l_s = \min\left(\sqrt{(D_s - T_{s,\min}) \cdot T_{s,\min}}, F - \frac{D_b}{2} - \left(1 - \frac{\pi}{4}\right) \cdot r_c - T_{s,\min}\right) \quad (\text{A-47})$$

$$l_b = \min\left(\sqrt{(D_b - T_{b,\min}) \cdot T_{b,\min}}, G - \frac{D_s}{2} - \left(1 - \frac{\pi}{4}\right) \cdot r_c - T_{1,\min}\right) \quad (\text{A-48})$$

The wall thickness  $T_{s,\min}$  and  $T_{b,\min}$  apply to the whole perimeter of the run and the branch, respectively. At the transitions between the run and the branch (crotch zone) the inside and outside surfaces shall merge smoothly.

The minimum wall thickness at the branch  $T_{b,\min}$  shall not be larger than the minimum wall thickness at the run  $T_{s,\min}$ .

NOTE 1 Formula (A-46) is derived from (8.4.3-3) and (6.1-1) from EN 13480-3:2002,

formulas (A-47) and (A-48) are based on (8.4.1-2) and (8.4.3-1) from EN 13480-3:2002.

The requirement  $T_{b,\min} \leq T_{s,\min}$  is more restrictive than the stipulations in EN 13480-3:2002, Figure 8.3.1-1.

NOTE 2 The subtraction of  $T_{s,\min}$  and  $T_{1,\min}$  in (A-47) and (A-48), respectively, approximately considers the taper borings at the ends.

NOTE 3 In EN 13480-3:2002 the design is limited to  $D_b - 2 \cdot T_{b,\min} \leq 0,8 (D_s - 2 \cdot T_{s,\min})$  for materials others than austenitic steels. For applications within the creep range it is limited to  $D_b - 2 \cdot T_{b,\min} \leq 0,7 (D_s - 2 \cdot T_{b,\min})$  and the design stress is multiplied by 0,9.

## EXAMPLE

Wall thicknesses of a reducing tee (welded) 813 x 8,0 – 508 x 6,3

with the geometry  $D_s = D$ ,  $D_b = D_1$ ,  $r_c = 95$  mm and  $T_{c,\min} = (T_{s,\min} + T_{b,\min}) / 2$ .

Table 14 :  $F = 597$  mm,  $G = 533$  mm.

Assumed wall thicknesses to be checked :  $T_s = 19,0$  mm,  $T_b = 15,5$  mm

$$\begin{aligned} \text{(A-1)} : \quad T_{\min} &= 8 \text{ mm} - 0,35 \text{ mm} - 0 \text{ mm} = 7,650 \text{ mm} \\ T_{1,\min} &= 6,3 \text{ mm} \cdot (100 - 12,5) / 100 - 0 \text{ mm} = 5,513 \text{ mm} \\ T_{s,\min} &= 19,0 \text{ mm} - 0,5 \text{ mm} = 18,5 \text{ mm}, \\ T_{b,\min} &= 15,5 \text{ mm} (100 - 12,5) / 100 = 13,563 \text{ mm} \\ T_{c,\min} &= (18,5 \text{ mm} + 13,563 \text{ mm}) / 2 = 16,031 \text{ mm} \end{aligned}$$

$$\text{(A-47)} : \quad l_s = 121,24 \text{ mm}$$

$$\text{(A-48)} : \quad l_b = 81,89 \text{ mm}$$

For the calculation of areas  $A_f$  and  $A_p$  see Figure A.2.

$$\alpha_s = 45^\circ \cdot \max \left( 1 - \frac{l_s}{\frac{\pi}{4} \cdot r_c}, 0 \right) = 0,00^\circ$$

$$\alpha_b = 45^\circ \cdot \max \left( 1 - \frac{l_b}{\frac{\pi}{4} \cdot r_c}, 0 \right) = 0,00^\circ$$

$$l'_s = r_c - r_c \cdot \sin(\alpha_s) + \max \left( l_s - r_c \cdot \frac{\pi}{4}, 0 \right) = 141,62 \text{ mm}$$

$$l'_b = r_c - r_c \cdot \sin(\alpha_b) + \max \left( l_b - r_c \cdot \frac{\pi}{4}, 0 \right) = 102,28 \text{ mm}$$

$$T_{sc,\min} = \frac{45^\circ - \alpha_s}{45^\circ} \cdot T_{s,\min} + \frac{\alpha_s}{45^\circ} \cdot T_{c,\min} = 18,500 \text{ mm}$$

$$T_{bc,\min} = \frac{45^\circ - \alpha_b}{45^\circ} \cdot T_{b,\min} + \frac{\alpha_b}{45^\circ} \cdot T_{c,\min} = 13,563 \text{ mm}$$

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$$A_{fs} = \max(l'_s - r_c, 0) \cdot T_{s,\min} = 862,5 \text{ mm}^2$$

$$A_{fsc} = \left( \left( r_c + \frac{T_{sc,\min} + T_{c,\min}}{2} \right)^2 - r_c^2 \right) \cdot \pi \cdot \frac{45^\circ - \alpha_s}{360^\circ} + T_{sc,\min}^2 \cdot \frac{\tan(\alpha_s)}{2} = 1405,3 \text{ mm}^2$$

$$A_{fbc} = \left( \left( r_c + \frac{T_{bc,\min} + T_{c,\min}}{2} \right)^2 - r_c^2 \right) \cdot \pi \cdot \frac{45^\circ - \alpha_b}{360^\circ} + T_{bc,\min}^2 \cdot \frac{\tan(\alpha_b)}{2} = 1190,0 \text{ mm}^2$$

$$A_{fb} = \max(l'_b - r_c, 0) \cdot T_{b,\min} = 98,7 \text{ mm}^2$$

$$A_f = A_{fs} + A_{fsc} + A_{fbc} + A_{fb} = 3556,5 \text{ mm}^2$$

$$A_{psc} = r_c^2 \cdot \left( \frac{1}{2} \cdot (1 - \sin(\alpha_s))^2 - \pi \cdot \frac{45^\circ - \alpha_s}{360^\circ} + \frac{1}{2} \cdot \sin(\alpha_s) \cdot (\cos(\alpha_s) - \sin(\alpha_s)) \right) = 968 \text{ mm}^2$$

$$A_{pbc} = r_c^2 \cdot \left( \frac{1}{2} \cdot (1 - \sin(\alpha_b))^2 - \pi \cdot \frac{45^\circ - \alpha_b}{360^\circ} + \frac{1}{2} \cdot \sin(\alpha_b) \cdot (\cos(\alpha_b) - \sin(\alpha_b)) \right) = 968 \text{ mm}^2$$

$$A_p = \left( \frac{D_b}{2} + l'_s \right) \cdot \left( \frac{D_s}{2} + l'_b \right) - l'_s \cdot l'_b + A_{psc} + A_{psb} - A_f = 185179 \text{ mm}^2$$

$$\frac{A_p}{A_f} = 52,07$$

$$\max \left( \frac{D - 2 \cdot T_{\min}}{2 \cdot T_{\min}}, \frac{D_1 - 2 \cdot T_{1,\min}}{2 \cdot T_{1,\min}} \right) = 52,14$$

Inequation (A-46) is satisfied ( $52,07 \leq 52,14$ ) and therefore the assumed wall thicknesses  $T_s$  and  $T_b$  are acceptable.

### A.5.3 Reducers

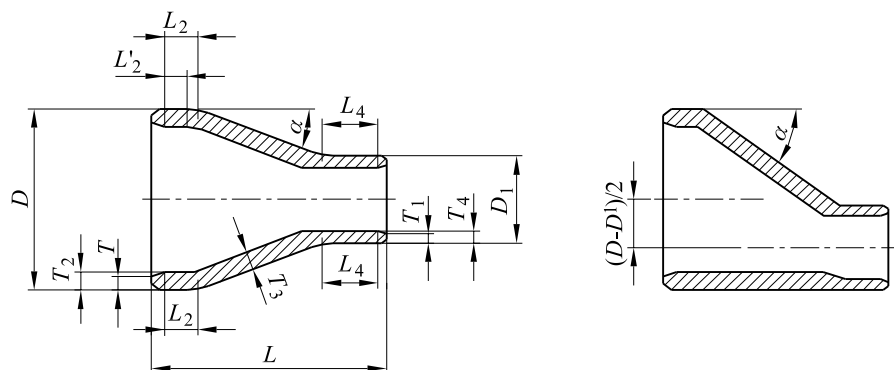
For the design of reducers several aspects have to be taken into account. The calculations are based on the following preconditions:

- reducer has cylindrical sections on both ends of the reducer. In some cases minimal lengths of these sections are required ;
- at the transition of cylindrical sections and the conical sections the inside and outside surfaces shall merge smoothly ;
- transition between the cylindrical sections and the conical section at the major end may be curved. In this case the wall thickness of the knuckle shall be at least  $T_2$  and the distance between the knuckle and the end of the reducer shall be at least :

$$L'_{2,\min} = 0,5 \cdot \sqrt{(D - T_{2,\min}) \cdot T_{2,\min}} \quad (\text{A-49})$$

- transition between the cylindrical sections and the conical section at the minor end may be curved too. The wall thickness of the knuckle shall be at least the maximum of  $T_{3,\min}$  and  $T_{4,\min}$ .

Wall thicknesses and other dimension of a reducer are illustrated in Figure A.6, both for concentric and eccentric type.



**Figure A.6 - Wall thicknesses and dimensions of reducers type B**

NOTE 1 The lengths  $L_2$ ,  $L'_2$  and  $L_4$  are not measured from the ends of the reducer, but from the location where the wall thickness reaches  $T_{2,\min}$  or  $T_{4,\min}$ , respectively.

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

$$T_{j,\min} = \frac{\beta \cdot D \cdot \min\left(\frac{T_{\min}}{D - T_{\min}}, \frac{T_{1,\min}}{D_1 - T_{1,\min}}\right)}{1 + \beta \cdot \min\left(\frac{T_{\min}}{D - T_{\min}}, \frac{T_{1,\min}}{D_1 - T_{1,\min}}\right)} \quad (\text{A-50})$$

with

$$\beta = \frac{1}{3} \cdot \sqrt{\frac{D - T_{j,\min}}{T_{j,\min}}} \cdot \frac{\tan(\alpha)}{1 + \frac{1}{\sqrt{\cos(\alpha)}}} - 0,15 \quad (\text{A-51})$$

NOTE 2 Formulas (A-50) and (A-51) cannot be evaluated directly but are solved by iteration.

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

$$T_{2,\min} = \max(T_{\min}, T_{j,\min}) \quad (\text{A-52})$$

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

$$T_{co,min} = \frac{\left( \sqrt{\frac{D - T_{2,min}}{\cos(\alpha)} \cdot \sin^2(\alpha) + 4 \cdot \left( \frac{1}{\min\left(\frac{T_{min}}{D - T_{min}}, \frac{T_{1,min}}{D_1 - T_{1,min}}\right)} - 1\right) \cdot \cos(\alpha) \cdot (D - 2 \cdot T_{2,min}) - \sqrt{\frac{D - T_{2,min}}{\cos(\alpha)} \cdot \sin(\alpha)}} \right)^2}{4 \cdot \cos^2(\alpha) \cdot \left( \frac{1}{\min\left(\frac{T_{min}}{D - T_{min}}, \frac{T_{1,min}}{D_1 - T_{1,min}}\right)} - 1\right)^2} \quad (A-53)$$

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

$$T_{3,min} = \max(T_{co,min}, T_{j,min}) \quad (A-54)$$

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

$$s = \frac{T_{3,min}}{T_{4,min}} \quad (A-55)$$

$$\tau = \begin{cases} s \cdot \sqrt{\frac{s}{\cos(\alpha)} + \sqrt{\frac{1+s^2}{2}}} & \text{if } s < 1 \\ 1 + \sqrt{s \cdot \frac{1+s^2}{2 \cdot \cos(\alpha)}} & \text{if } s \geq 1 \end{cases} \quad (A-56)$$

$$\beta_H = 0,4 \cdot \sqrt{\frac{D_1 - T_{4,min}}{T_{4,min}}} \cdot \frac{\tan(\alpha)}{\tau} + 0,5 \quad (A-57)$$

If

$$\min\left(\frac{T_{min}}{D - T_{min}}, \frac{T_{1,min}}{D_1 - T_{1,min}}\right) \leq \frac{T_{4,min}}{(D_1 - T_{4,min}) \cdot \beta_H} \quad (A-58)$$

and

$$T_{4,min} \geq T_{1,min} \quad (A-59)$$

$T_{4,min}$  is acceptable. If not, the calculation shall be repeated with a larger value of  $T_{4,min}$ . In order to satisfy (A-58) it is also allowed to increase value of  $T_{3,min}$ .

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

$$L_{2,\min} = \begin{cases} 1,4 \cdot \sqrt{(D - T_{2,\min}) \cdot T_{2,\min}} & \text{if } T_{2,\min} > T_{\min} \\ 0 & \text{if } T_{2,\min} \leq T_{\min} \end{cases} \quad (\text{A-60})$$

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

$$L_{4,\min} = \begin{cases} \sqrt{(D_1 - T_{4,\min}) \cdot T_{4,\min}} & \text{if } T_{4,\min} > T_{1,\min} \\ 0 & \text{if } T_{4,\min} \leq T_{1,\min} \end{cases} \quad (\text{A-61})$$

If smaller lengths for  $L_2$  and/or  $L_4$  than calculated above are desired it is possible to increase the wall thickness and reduce the lengths :

$$T'_{2,\min} = \frac{T_{2,\min} \cdot L_{2,\min} - T_{\min} \cdot (L_{2,\min} - L_2)}{L_2} \quad (\text{A-62})$$

$$T'_{4,\min} = \frac{T_{4,\min} \cdot L_{4,\min} - T_{1,\min} \cdot (L_{4,\min} - L_4)}{L_4} \quad (\text{A-63})$$

NOTE 1 Formulas (A-50) to (A-59) are applicable only for semi angle  $\alpha$  less equal  $75^\circ$  and ratios of  $T_{3,\min} \cos(\alpha)$  to  $D$  not smaller than 0,001.

NOTE 2 The design of reducers is based on the following sections/formulas in EN 13480-3:2002:

Formula (A-49) is based on the stipulations in 6.4.7.2 ;

Formula (A-50) is derived from (6.4.6-2) and (6.1-1) ;

Formula (A-51) is given as (6.4.6-1) ;

Formula (A-52) is based on the stipulations in 6.4.6.2 ;

Formula (A-53) is derived from (6.4.4-3) and (6.1-1) using (6.4.4-4), (6.4.4-5), (6.4.4-6), (6.4.4-7) and (6.4.5-2), setting  $r = 0$  and solving for  $e_{\text{con}}$  ;

Formula (A-54) is based on the stipulations in 6.4.6.2 ;

Formula (A-55) is given in EN 13480-3 as (6.4.8-1) ;

Formula (A-56) is based on (6.4.8-2) and (6.4.8-3) ;

Formula (A-57) is given in EN 13480-3 as (6.4.8-4) ;

Formula (A-58) is derived from (6.4.8-5) and (6.1-1) ;

Formula (A-59) is based on the stipulations in 6.4.8.1 b) ;

Formula (A-60) is based on (6.4.5-1) and the provisions in 6.4.6.2 ;

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Formula (A-61) is based on the stipulations in 6.4.8.1 a) ;

Formula (A-62) is based on the stipulations in 6.4.6.2 ;

Formula (A-63) is based on the stipulations in 6.4.8.2.

No additional calculation of the wall thickness of the knuckle at the major end is required. The formulas in EN 13480-3:2002 (6.4.7-1) to (6.4.7-4) give wall thicknesses which are not larger than for junctions without a knuckle.

The rules for a knuckle at the minor end differs from the stipulations in EN 13480-3:2002.

**EXAMPLE**

Design of an eccentric reducer of type B 323,9 x 7,1 – 168,3 x 4,5,

$c_0 = 0$  mm, semi angle  $\alpha = 55^\circ$  :

Table 15 :  $L = 203$  mm.

$$(A-1) : T_{\min} = 7,1 \text{ mm} \cdot (100 - 12,5) / 100 - 0 \text{ mm} = 6,213 \text{ mm}$$

$$T_{1,\min} = 4,5 \text{ mm} \cdot (100 - 12,5) / 100 - 0 \text{ mm} = 3,938 \text{ mm}$$

Result of solving (A-50) and (A-51) by iteration :  $T_{j,\min} = 7,385$  mm,  $\beta = 1,193$

$$(A-52) : T_{2,\min} = 7,385 \text{ mm}$$

$$(A-53) : T_{\text{co},\min} = 8,768 \text{ mm}$$

$$(A-54) : T_{3,\min} = 8,768 \text{ mm}$$

Result of solving (A-55) to (A-59) by iteration :  $T_{4,\min} = 4,454$  mm,  $s = 1,969$ ,  $\tau = 3,893$ ,  $\beta_H = 1,390$

$$(A-60) : L_{2,\min} = 67,69 \text{ mm}$$

$$(A-61) : L_{4,\min} = 27,01 \text{ mm}$$

$$(A-49) : L'_{2,\min} = 24,17 \text{ mm}$$

$$(A-2) : T_2 = (7,385 \text{ mm} + 0 \text{ mm}) / (100 - 12,5) \cdot 100 = 8,44 \text{ mm}$$

$$T_3 = (8,768 \text{ mm} + 0 \text{ mm}) / (100 - 12,5) \cdot 100 = 10,02 \text{ mm}$$

$$T_4 = (4,45 \text{ mm} + 0 \text{ mm}) / (100 - 12,5) \cdot 100 = 5,09 \text{ mm}$$

The results of the design are :

$$T_2 = 8,44 \text{ mm}, L_2 = 67,7 \text{ mm}, L'_2 \geq 24,2 \text{ mm}, T_3 = 10,02 \text{ mm}, T_4 = 5,09 \text{ mm}, L_4 \geq 27,0 \text{ mm}$$

The length  $L_2$  and  $L_4$  are quite long compared to the total length of the reducer  $L$ . Therefore, an alternative design with lengths  $L_2 = 30$  mm and  $L_4 = 20$  is made :

$$(A-62) : T'_{2,\min} = 8,858 \text{ mm}$$

$$(A-63) : T'_{4,\min} = 4,635 \text{ mm}$$



$$(A-2) : T_2 = (8,86 \text{ mm} + 0 \text{ mm}) / (100 - 12,5) \cdot 100 = 10,12 \text{ mm}$$

$$T_4 = (4,64 \text{ mm} + 0 \text{ mm}) / (100 - 12,5) \cdot 100 = 5,30 \text{ mm}$$

The results of the alternative design are :

$$T_2 = 10,12 \text{ mm}, L_2 \geq 30 \text{ mm}, L'_2 \geq 24,2 \text{ mm}, T_3 = 10,02 \text{ mm}, T_4 = 5,29 \text{ mm}, L_4 \geq 20 \text{ mm}$$

#### A.5.4 Caps

The design of an ellipsoidal end comprises the determination of the wall thickness of the ellipsoidal end and the wall thickness of the knuckle. For the wall thickness of a cap the wall thickness requirements of the cylindrical part have also to be taken into consideration too :

$$T_{s,\min} = T_{\min} \cdot \frac{R1}{D - 1,5 \cdot T_{\min}} \quad (A-64)$$

$$T_{\text{kn y},\min} = T_{\min} \frac{\beta \cdot (0,75 \cdot R1 + 0,2 D)}{0,5 \cdot D - (0,5 - 0,4 \cdot \beta) \cdot T_{\min}} \quad (A-65)$$

$$T_{c,\min} = \max(T_{s,\min}, T_{\text{kn y},\min}, T_{\min}) \quad (A-66)$$

The factor  $\beta$  is calculated :

$$Y = \min\left(\frac{T_{\text{kn y},\min}}{R1}, 0,04\right) \quad (A-67)$$

$$Z = \log\left(\frac{1}{Y}\right) \quad (A-68)$$

$$W = \frac{r}{D - 2 \cdot T_{\text{kn y},\min}} \quad (A-69)$$

$$N = 1,006 - \frac{1}{6,2 + (90 \cdot Y)^4} \quad (A-70)$$

$$\beta_{0,06} = (-0,3635 \cdot Z^3 + 2,2124 \cdot Z^2 - 3,2937 \cdot Z + 1,8873) \cdot N \quad (A-71)$$

$$\beta_{0,1} = (-0,1833 \cdot Z^3 + 1,0383 \cdot Z^2 - 1,2943 \cdot Z + 0,837) \cdot N \quad (A-72)$$

$$\beta_{0,2} = 0,5 \quad (A-73)$$

$$\beta = \begin{cases} 25 \cdot ((0,1 - W) \cdot \beta_{0,06} + (W - 0,06) \cdot \beta_{0,1}) & \text{if } 0,06 \leq W \leq 0,1 \\ 10 \cdot ((0,2 - W) \cdot \beta_{0,1} + (W - 0,1) \cdot \beta_{0,2}) & \text{if } 0,1 < W \leq 0,2 \end{cases} \quad (A-74)$$

NOTE 1 Formula (A-65) with  $\beta$  from formulas (A-67) to (A-74) cannot be evaluated directly but are solved by iteration.

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NOTE 2 Formulas (A-64) to (A-74) are applicable provided that the following conditions are simultaneously fulfilled :

$$r \geq 0,06 \cdot (D - 2 \cdot T_{c,\min})$$

$$r \geq 3 \cdot T_{c,\min}$$

$$0,004 \cdot (D - 2 \cdot T_{c,\min}) < T_{c,\min} \leq 0,08 \cdot (D - 2 \cdot T_{c,\min})$$

$$R1 \leq D$$

NOTE 3 The calculation of caps is based on the following formulas in EN 13480-3:2002:

Formula (A-64) is derived from (7.1.3-1) and (6.1-1) ;

Formula (A-65) is derived from (7.1.3-2) and (6.1-1) ;

Formula (A-67) is given as (7.1.5-1) ;

Formula (A-68) is given as (7.1.5-2) ;

Formula (A-69) is given as (7.1.5-3) ;

Formula (A-70) is given as (7.1.5-4) ;

Formula (A-71) is given as (7.1.5-6) ;

Formula (A-72) is given as (7.1.5-5) ;

Formula (A-73) is read from figure 7.1.5-1 ;

Formula (A-74) is given as (7.1.5-8) and (7.1.5-7).

**EXAMPLE**

Wall thickness of a seamless cap 1219x10,

$$c_0 = 0 \text{ mm}, r = 0,15 \cdot D, R1 = 0,8 \cdot D :$$

$$r = 0,15 \cdot 1219 = 183 \text{ mm}$$

$$R1 = 0,8 \cdot 1219 = 975 \text{ mm}$$

$$(A-1) : T_{\min} = 10 \text{ mm} \cdot (100 - 12,5) / 100 - 0 \text{ mm} = 8,75 \text{ mm}$$

$$(A-64) : T_{s,\min} = 7,076 \text{ mm}$$

Result of solving (A-65) with (A-67) to (A-74) by iteration :

$$T_{\text{kn y},\min} = 9,149, Y = 0,00938, Z = 2,028, W = 0,152, N = 0,857, \beta_{0,06} = 1,092, \beta_{0,1} = 0,817, \beta = 0,651$$

$$(A-66) : T_{c,\min} = 9,149 \text{ mm}$$

$$(A-2) : T_c = 10,46 \text{ mm}$$

## Annex B (informative)

### Pressure factor tables for Fittings of type A

#### B.1 General

This annex lists pressure factors of elbows, tees, reducers and caps for the 8 wall thickness series listed in Table 17.

These pressure factors are calculated using the procedures given in Annex A and tolerances listed in Table 18. For fittings with diameters larger than 610 mm, where seamless and welded fittings have different wall thickness tolerances, the smaller of the two pressure factors is listed. For the corrosion allowance 0 mm is used.

NOTE 1 In general, welded elbows, tees and reducers with diameters larger than 610 mm have larger pressure factors than the seamless fittings.

NOTE 2 In general, corrosion allowances larger than 0 mm lead to smaller pressure factors.

For the definition of symbols see A.1 and the figures in Annex A.

The pressure factor of fittings with nominal dimensions not listed in the tables of this annex, with a corrosion allowance larger than 0 mm or with other tolerances (e.g. welded fitting with diameter larger than 610 mm) may be calculated in accordance with Annex A.

#### B.2 Elbows

Table B.1 shows the pressure factors of elbows of model 2D, 3D and 5D (indicated in second line of table) whose bending radii are given in Table 10, Table 11 and Table 12, respectively.

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Table B.1 — Pressure factors of elbows type A

Model	1			2			3			4			5			6			7			8												
	T	2D	3D	5D	T	2D	3D	5D	T	2D	3D	5D	T	2D	3D	5D	T	2D	3D	5D	T	2D	3D	5D										
15	21,3	-	-	-	2	75	85	87	2,6	76	85	87	3,2	77	86	88	4	79	87	88	-	-	-	-	5	80	88	89	7,1	84	90	91		
20	26,9	-	-	-	2,3	67	80	87	2,6	67	80	88	3,2	68	81	88	4	69	82	88	4,5	70	82	89	5,6	72	83	89	8	77	86	91		
25	33,7	-	-	-	2,6	54	74	87	3,2	55	74	88	4	57	75	88	4,5	58	75	88	5,6	60	77	89	6,3	61	77	89	8,8	66	80	90		
32	42,4	-	-	-	2,6	54	73	87	3,6	55	74	88	4	56	74	88	5	58	75	88	6,3	60	76	89	8	62	78	89	10	65	79	90		
40	48,3	-	-	-	2,6	56	74	88	3,6	57	75	88	4	58	75	88	5	59	76	88	6,3	61	77	89	8	63	78	89	10	65	79	90		
50	60,3	-	-	-	2,9	60	76	88	3,6	61	76	88	4	61	77	88	5,6	62	77	88	7,1	64	78	89	8,8	65	79	89	11	67	80	90		
65	76,1	-	-	-	2,9	58	76	88	3,6	59	76	88	5,6	60	77	88	7,1	61	77	88	8	62	77	89	10	63	78	89	14,2	67	80	90		
80	88,9	-	-	-	3,2	60	76	88	4	60	76	88	5,6	61	77	88	8	63	78	89	8,8	63	78	89	11	65	79	89	16	68	80	90		
100	114,3	-	-	-	3,6	62	77	88	4,5	62	77	88	6,3	63	78	88	8,8	64	78	89	11	65	79	89	14,2	67	80	89	17,5	68	80	90		
125	139,7	-	-	-	4	63	78	88	5	63	78	88	6,3	64	78	88	10	65	79	89	12,5	66	79	89	16	67	80	89	20	68	81	89		
150	168,3	4	62	78	88	4,5	62	78	88	5,6	63	78	88	7,1	63	78	88	11	64	79	88	14,2	65	79	88	17,5	66	80	89	22,2	67	80	89	
200	219,1	4,5	63	78	88	6,3	64	78	88	7,1	64	78	88	8	64	78	88	12,5	65	79	88	16	66	79	88	17,5	66	80	89	22,2	67	80	89	
250	273	5	64	78	88	6,3	64	78	88	8,8	64	78	88	10	64	79	88	12,5	65	79	88	16	65	79	88	22,2	66	80	89	30	68	80	89	
300	323,9	5,6	64	78	88	7,1	64	78	88	8,8	65	79	88	10	65	79	88	12,5	65	79	88	17,5	66	79	88	25	67	80	89	32	68	80	89	
350	355,6	5,6	67	80	88	8	67	80	88	10	67	80	88	12,5	68	80	88	16	68	80	88	20	68	81	88	28	69	81	89	36	70	82	89	
400	406,4	6,3	67	80	88	8,8	67	80	88	10	67	80	88	12,5	67	80	88	17,5	68	80	88	22,2	68	81	88	30	69	81	89	40	70	82	89	
450	457	6,3	67	80	88	10	67	80	88	11	67	80	88	12,5	67	80	88	17,5	68	80	89	22,2	68	81	89	32	69	81	89	45	70	82	89	
500	508	6,3	67	80	88	10	67	80	88	11	67	80	88	12,5	67	80	88	17,5	68	80	89	25	68	81	89	36	69	81	89	50	70	82	89	
600	610	6,3	67	80	89	10	67	80	89	12,5	67	80	89	17,5	67	80	89	25	68	80	89	30	68	81	89	45	69	81	89	60	70	82	90	
700	711	7,1	67	80	89	10	67	80	89	12,5	67	80	89	25	68	80	89	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
800	813	8	67	80	88	10	67	80	89	12,5	67	80	89	25	67	80	89	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
900	914	10	67	80	89	12,5	67	80	89	20	67	80	89	25	67	80	89	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1 000	1 016	10	67	80	88	12,5	67	80	89	20	67	80	89	25	67	80	89	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1 200	1 219	10	66	80	88	12,5	67	80	89	20	67	80	89	25	67	80	89	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

### B.3 Tees

Table B.2 shows the pressure factors of equal tees and reducing tees.

The data listed is applicable if the following conditions apply:

- crotch radius is less equal to 3/4 of the height of the branch ( $r_c \leq 0,75 \cdot (G - D/2)$ ) and
- wall thickness at the crotch zone is at least the mean of the wall thicknesses of run and branch ( $T_{c,min} \geq (T_{min} + T_{1,min}) / 2$ ) and
- dimensions  $F$  and  $G$  are as listed in Table 13 or 14.

In all other cases the pressure factor may be calculated in accordance with Annex A.

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Table B.2 — Pressure factors of tees type A

DN	D	DN <sub>1</sub>	D <sub>1</sub>	1			2			3			4			5			6			7			8		
				T	T <sub>1</sub>	X	T	T <sub>1</sub>	X	T	T <sub>1</sub>	X	T	T <sub>1</sub>	X	T	T <sub>1</sub>	X	T	T <sub>1</sub>	X	T	T <sub>1</sub>	X	T	T <sub>1</sub>	X
15	21,3	15	21,3	-	2	42	2,6	2,6	45	3,2	3,2	48	4	4	51	-	-	-	5	5	53	7,1	7,1	57			
				-	2,3	43	2,6	2,6	44	3,2	3,2	47	4	4	50	4,5	4,5	51	5,6	5,6	54	8	8	58			
20	26,9	15	21,3	-	2,3	44	2,6	2,6	50	3,2	3,2	53	4	4	57	-	-	-	5,6	5,6	57	8	8	61			
				-	2,6	41	3,2	3,2	43	4	4	46	4,5	4,5	47	5,6	5,6	50	6,3	6,3	52	8,8	8,8	56			
25	33,7	20	26,9	-	2,6	42	3,2	2,6	42	4	3,2	45	4	4	49	5,6	4,5	49	6,3	5,6	54	8,8	8,8	59			
				-	2,6	43	3,2	2,6	47	4	3,2	50	4,5	4,5	55	-	-	-	6,3	5	56	8,8	7,1	61			
32	42,4	32	42,4	-	2,6	38	3,6	3,6	42	4	4	43	5	5	46	6,3	6,3	49	8	8	52	10	10	54			
				-	2,6	42	3,6	3,2	43	4	4	48	5	4,5	48	6,3	5,6	51	8	6,3	51	10	8,8	56			
20	26,9	20	26,9	-	2,6	43	3,6	2,6	43	4	3,2	47	5	4	50	6,3	4,5	50	8	5,6	52	10	8	59			
				-	2,6	44	3,6	2,6	47	4	3,2	51	5	4	54	-	-	-	8	5	55	10	7,1	61			
40	48,3	40	48,3	-	2,6	35	3,6	3,6	39	4	4	40	5	5	43	6,3	6,3	46	8	8	49	10	10	52			
				-	2,6	38	3,6	3,6	42	4	4	43	5	5	46	6,3	6,3	49	8	8	52	10	10	55			
25	33,7	25	33,7	-	2,6	42	3,6	3,2	43	4	4	48	5	4,5	48	6,3	5,6	51	8	6,3	50	10	8,8	57			
				-	2,6	42	3,6	2,6	42	4	3,2	46	5	4	49	6,3	4,5	49	8	5,6	52	10	8	59			
15	21,3	15	21,3	-	2,6	42	3,6	2,6	46	4	3,2	50	5	4	53	-	-	-	8	5	54	10	7,1	60			
				-	2,9	36	3,6	3,6	39	4	4	40	5,6	5,6	44	7,1	7,1	47	8,8	8,8	50	11	11	53			
40	48,3	40	48,3	-	2,9	39	3,6	3,6	45	4	4	47	5,6	5	48	7,1	6,3	51	8,8	8	55	11	10	58			
				-	2,9	43	3,6	3,6	49	4	4	51	5,6	5	53	7,1	6,3	56	8,8	8	60	11	10	64			
25	33,7	25	33,7	-	2,9	51	3,6	3,2	54	4	4	60	5,6	4,5	59	7,1	5,6	62	8,8	6,3	62	11	8,8	69			
				-	2,9	58	3,6	2,6	59	4	3,2	63	5,6	4	66	7,1	4,5	66	8,8	5,6	70	11	8	78			
20	26,9	20	26,9	-	2,9	34	3,6	3,6	37	5,6	5,6	43	7,1	7,1	46	8	8	47	10	10	50	14,2	14,2	55			
				-	2,9	41	3,6	3,6	44	4	4	46	7,1	5,6	47	8	7,1	52	10	8,8	55	14,2	11	57			
40	48,3	40	48,3	-	2,9	44	3,6	3,6	50	5,6	4	48	7,1	5	51	8	6,3	55	10	8	59	14,2	10	60			
				-	2,9	48	3,6	3,6	55	5,6	4	52	7,1	5	55	8	6,3	60	10	8	64	14,2	10	66			
25	33,7	25	33,7	-	2,9	57	3,6	3,2	60	5,6	4	61	7,1	4,5	62	8	5,6	67	10	6,3	67	14,2	8,8	73			
				-	2,9	60	3,6	3,2	60	5,6	4	61	7,1	4,5	62	8	5,6	67	10	6,3	67	14,2	8,8	73			

Table B.2 (continued)

DN	D	DN <sub>1</sub>	D <sub>1</sub>	1		2		3		4		5		6		7		8							
				T	X	T	X	T <sub>1</sub>	X	T	X	T <sub>1</sub>	X	T	X	T <sub>1</sub>	X	T	X	T <sub>1</sub>	X				
80	88,9	80	88,9	-	-	3,2	3,2	4	4	37	5,6	5,6	8	8	8,8	8,8	11	11	16	16					
				-	-	3,2	2,9	4	3,6	38	5,6	5,6	8	7,1	8,8	8	8	8,8	8	11	10	16	14,2		
				-	-	3,2	2,9	4	3,6	45	5,6	4	45	5,6	49	8	5,6	8,8	7,1	11	8,8	57	16	11	58
				-	-	3,2	2,6	4	3,6	52	5,6	4	51	8	5	53	8,8	6,3	58	11	8	62	16	10	63
				-	-	3,2	2,6	4	3,6	56	5,6	4	55	8	5	58	8,8	6,3	63	11	8	67	16	10	68
100	114,3	100	114,3	-	-	3,6	3,6	4,5	4,5	36	6,3	6,3	10	8,8	11	11	48	14,2	17,5	17,5					
				-	-	3,6	3,2	4	4,0	40	6,3	5,6	45	8	8	8,8	50	11	14,2	11	52	17,5	16	60	
				-	-	3,6	2,9	4	3,6	42	6,3	5,6	49	8,8	7,1	52	11	8	52	14,2	10	55	17,5	14,2	62
				-	-	3,6	2,9	4	3,6	49	6,3	4	49	8,8	5,6	54	11	7,1	57	14,2	8,8	60	17,5	11	63
				-	-	3,6	2,6	4	3,6	55	6,3	4	55	8,8	5	58	11	6,3	61	14,2	8	65	17,5	10	69
125	139,7	125	139,7	-	-	4	4	5	5	36	6,3	6,3	10	10	12,5	12,5	47	16	20	20					
				-	-	4	3,6	5	4,5	38	6,3	6,3	44	10	8,8	47	12,5	11	50	20	17,5	57			
				-	-	4	3,2	5	4	42	6,3	5,6	48	10	8	52	12,5	8,8	52	16	11	55	20	16	63
				-	-	4	2,9	5	3,6	44	6,3	5,6	53	10	7,1	54	12,5	8	55	16	10	58	20	14,2	65
				-	-	4	2,9	5	3,6	50	6,3	4	51	10	5,6	56	12,5	7,1	60	16	8,8	63	20	11	66
150	168,3	150	168,3	4	4	4,5	4,5	5,6	5,6	36	7,1	7,1	11	11	14,2	14,2	47	17,5	22,2	22,2					
				-	-	4,5	4	5,6	5	38	7,1	6,3	40	11	10	47	14,2	12,5	50	22,2	20	56			
				-	-	4,5	3,6	5,6	4,5	41	7,1	6,3	46	11	8,8	50	14,2	11	53	17,5	14,2	57	22,2	17,5	60
				-	-	4,5	3,2	4	4,5	45	7,1	5,6	51	11	8	55	14,2	8,8	56	17,5	11	59	22,2	16	66
				-	-	4,5	2,9	4	4,5	44	7,1	5,6	55	11	7,1	57	14,2	8	59	17,5	10	62	22,2	14,2	68
200	219,1	200	219,1	4,5	4,5	6,3	6,3	7,1	7,1	36	8	8	12,5	12,5	16	16	46	17,5	22,2	22,2					
				4,5	4	6,3	4,5	37	8	7,1	41	12,5	11	47	16	14,2	51	17,5	17,5	57	22,2	22,2	49		
				-	-	6,3	4	37	7,1	5,6	37	8	6,3	44	12,5	10	51	16	12,5	54	22,2	20	63		
				-	-	6,3	3,6	40	7,1	4,5	43	8	6,3	50	12,5	8,8	54	11	57	17,5	14,2	63			
				-	-	6,3	3,6	40	7,1	4,5	43	8	6,3	50	12,5	8,8	54	11	57	17,5	14,2	63			

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Table B.2 (continued)

DN	D	DN <sub>1</sub>	D <sub>1</sub>	1		2		3		4		5		6		7		8							
				T	X	T	X	T	X	T	X	T	X	T	X	T	X	T	X	T	X				
250	273	250	273	5	30	6,3	6,3	32	36	8,8	8,8	10	10	12,5	12,5	16	16	22,2	22,2	30	30	48			
				5	4,5	6,3	6,3	38	37	8,8	7,1	8	8	12,5	12,5	16	16	22,2	17,5	30	30	22,2	55		
				5	4	6,3	4,5	37	40	8,8	5,6	10	7,1	11	11	12,5	12,5	16	14,2	22,2	17,5	30	30	22,2	59
				-	-	6,3	4	40	40	8,8	5	10	6,3	10	10	12,5	12,5	16	12,5	22,2	16	30	30	20	63
				-	-	6,3	3,6	43	47	8,8	4,5	10	6,3	10	10	12,5	8,8	16	11	22,2	14,2	30	30	17,5	67
300	323,9	300	323,9	5,6	29	7,1	7,1	32	34	8,8	8,8	10	10	12,5	12,5	17,5	17,5	25	25	32	32	47			
				5,6	5	7,1	6,3	33	33	8,8	8,8	10	10	12,5	12,5	16	16	25	22,2	32	32	30	53		
				5,6	4,5	7,1	6,3	39	39	8,8	7,1	10	8	11	11	12,5	12,5	16	16	25	17,5	32	32	22,2	53
				5,6	4	7,1	4,5	39	42	8,8	5,6	10	7,1	10	10	12,5	11	14,2	14,2	25	17,5	32	32	22,2	62
				5,6	28	8	8	32	10	10	35	12,5	12,5	16	16	16	16	20	20	28	28	36	36	47	
350	355,6	300	323,9	5,6	30	8	7,1	33	35	10	8,8	12,5	10	16	12,5	20	17,5	28	25	36	32	51			
				5,6	5	8	6,3	34	34	10	8,8	12,5	10	16	12,5	16	16	28	22,2	36	36	30	53		
				5,6	4,5	8	6,3	39	10	7,1	40	12,5	8	11	11	12,5	16	16	28	17,5	36	36	22,2	54	
				5,6	4	8	4,5	40	10	5,6	43	12,5	7,1	10	10	12,5	11	14,2	14,2	28	17,5	36	36	22,2	63
				6,3	28	8,8	8,8	32	10	10	34	12,5	12,5	16	16	17,5	17,5	22,2	22,2	30	30	40	40	45	
400	406,4	350	355,6	6,3	29	8,8	8	33	33	10	10	12,5	12,5	16	16	20	20	30	28	40	40	50			
				6,3	5,6	8,8	7,1	33	10	8,8	36	12,5	10	10	12,5	12,5	16	16	30	25	40	40	32	51	
				6,3	5	8,8	6,3	35	10	8,8	41	12,5	10	10	12,5	12,5	16	16	30	22,2	40	40	30	55	
				6,3	4,5	8,8	6,3	40	10	7,1	42	12,5	8	10	10	12,5	12,5	16	16	30	17,5	40	40	22,2	57
				6,3	4	8,8	4,5	42	10	5,6	45	12,5	7,1	10	10	12,5	11	14,2	14,2	30	17,5	40	40	22,2	65
450	457	400	406,4	6,3	27	10	10	32	11	11	11	12,5	12,5	16	16	22,2	22,2	32	32	45	45	45			
				6,3	30	10	8,8	33	11	10	34	12,5	12,5	16	16	17,5	17,5	22,2	22,2	32	30	47	45	49	
				6,3	5,6	10	8	33	11	10	37	12,5	12,5	16	16	17,5	16	20	20	32	28	50	45	36	52
				6,3	5,6	10	7,1	34	11	8,8	37	12,5	10	10	10	12,5	12,5	16	16	32	25	51	45	32	52
				6,3	5	10	6,3	36	11	8,8	42	12,5	10	10	10	12,5	12,5	16	16	32	22,2	53	45	30	57
6,3	4,5	10	6,3	42	11	7,1	43	12,5	8	10	10	12,5	12,5	16	16	32	17,5	56	45	22,2	59				



Table B.2 (continued)

DN	D	DN <sub>1</sub>	D <sub>1</sub>	1		2		3		4		5		6		7		8								
				T	X	T	X	T	X	T	X	T	X	T	X	T	X	T	X							
500	508	500	508	6,3	6,3	26	10	10	31	11	11	32	12,5	34	17,5	38	25	25	42	36	36	44	50	50	45	
		450	457	6,3	6,3	28	10	10	34	11	11	35	12,5	36	17,5	41	25	22,2	43	36	32	47	50	45	49	
		400	406,4	6,3	6,3	31	10	8,8	34	11	10	36	12,5	40	17,5	44	25	22,2	46	36	30	48	50	40	50	
		300	323,9	6,3	5,6	33	10	7,1	35	11	8,8	39	12,5	40	17,5	42	25	17,5	47	36	25	52	50	32	54	
		250	273	6,3	5	35	10	6,3	38	11	8,8	43	12,5	45	17,5	48	25	16	50	36	22,2	55	50	30	58	
600	610	600	610	6,3	6,3	25	10	10	30	12,5	12,5	32	17,5	36	25	25	30	30	40	45	45	41	60	60	42	
		500	508	6,3	6,3	28	10	10	33	12,5	11	33	17,5	39	25	17,5	45	30	25	43	45	36	48	60	50	49
		400	406,4	6,3	6,3	33	10	8,8	36	12,5	10	37	17,5	42	25	17,5	44	30	22,2	47	45	30	50	60	40	53
		300	323,9	6,3	5,6	36	10	7,1	38	12,5	8,8	40	17,5	42	25	12,5	47	30	17,5	49	45	25	54	60	32	57
		250	273	6,3	5	38	10	6,3	40	12,5	8,8	45	17,5	46	25	12,5	50	30	16	53	45	22,2	57	60	30	61
700	711	700	711	7,1	7,1	24	10	10	28	12,5	12,5	30	25	25	38	-	-	-	-	-	-	-	-	-	-	
		600	610	7,1	6,3	25	10	10	30	12,5	12,5	33	25	17,5	43	-	-	-	-	-	-	-	-	-	-	
		500	508	7,1	6,3	28	10	10	34	12,5	11	35	25	12,5	50	-	-	-	-	-	-	-	-	-	-	-
		400	406,4	7,1	6,3	33	10	8,8	37	12,5	10	39	25	12,5	47	-	-	-	-	-	-	-	-	-	-	-
		300	323,9	7,1	5,6	36	10	7,1	39	12,5	8,8	42	25	10	51	-	-	-	-	-	-	-	-	-	-	-
800	813	800	813	8	8	24	10	10	26	12,5	12,5	29	25	25	37	-	-	-	-	-	-	-	-	-	-	
		700	711	8	7,1	25	10	10	29	12,5	12,5	32	25	25	40	-	-	-	-	-	-	-	-	-	-	
		600	610	8	6,3	26	10	10	32	12,5	12,5	34	25	17,5	39	-	-	-	-	-	-	-	-	-	-	
		500	508	8	6,3	29	10	10	36	12,5	11	36	25	12,5	46	-	-	-	-	-	-	-	-	-	-	
		400	406,4	8	6,3	34	10	8,8	39	12,5	10	40	25	12,5	43	-	-	-	-	-	-	-	-	-	-	
900	914	900	914	10	10	25	12,5	12,5	27	20	20	33	25	25	35	-	-	-	-	-	-	-	-	-	-	
		800	813	10	8	27	12,5	10	29	20	12,5	39	25	25	38	-	-	-	-	-	-	-	-	-	-	
		700	711	10	7,1	27	12,5	10	29	20	12,5	38	25	25	42	-	-	-	-	-	-	-	-	-	-	
		600	610	10	6,3	28	12,5	10	32	20	12,5	36	25	17,5	38	-	-	-	-	-	-	-	-	-	-	
		500	508	10	6,3	30	12,5	10	36	20	11	37	25	12,5	43	-	-	-	-	-	-	-	-	-	-	
400	406,4	10	6,3	36	12,5	8,8	40	20	10	42	25	12,5	45	-	-	-	-	-	-	-	-	-	-	-		

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Table B.2 (continued)

DN	D	DN <sub>1</sub>	D <sub>1</sub>	1			2			3			4			5			6			7			8		
				T	T <sub>1</sub>	X	T	T <sub>1</sub>	X	T	T <sub>1</sub>	X	T	T <sub>1</sub>	X	T	T <sub>1</sub>	X	T	T <sub>1</sub>	X	T	T <sub>1</sub>	X	T	T <sub>1</sub>	X
1000	1016	1000	1016	10	10	24	12,5	12,5	26	20	20	31	25	25	34	-	-	-	-	-	-	-	-	-	-	-	-
		900	914	10	10	26	12,5	12,5	28	20	20	34	25	25	36	-	-	-	-	-	-	-	-	-	-	-	-
		800	813	10	8	25	12,5	10	27	20	12,5	37	25	25	40	-	-	-	-	-	-	-	-	-	-	-	-
		700	711	10	7,1	26	12,5	10	30	20	12,5	36	25	25	44	-	-	-	-	-	-	-	-	-	-	-	-
		600	610	10	6,3	27	12,5	10	33	20	12,5	35	25	17,5	39	-	-	-	-	-	-	-	-	-	-	-	-
		1200	1219	10	10	23	12,5	12,5	25	20	20	30	25	25	33	-	-	-	-	-	-	-	-	-	-	-	-
1200	1016	1000	1016	10	10	26	12,5	12,5	29	20	20	34	25	25	37	-	-	-	-	-	-	-	-	-	-	-	
		900	914	10	10	28	12,5	12,5	31	20	20	37	25	25	40	-	-	-	-	-	-	-	-	-	-	-	
		800	813	10	8	27	12,5	10	29	20	12,5	33	25	25	43	-	-	-	-	-	-	-	-	-	-	-	-
		700	711	10	7,1	28	12,5	10	32	20	12,5	34	25	25	47	-	-	-	-	-	-	-	-	-	-	-	-

## B.4 Reducers

Table B.3 and Table B.4 show the pressure factors of concentric and eccentric reducers, respectively.

The data listed is applicable if all of the following conditions apply :

- semi angle of the reducer is not larger than the values listed in Table B.3 and B.4 ;
- wall thickness of the conical part is at least the wall thickness at the major end ;
- each of the lengths  $L_2$  and  $L_4$  at the ends of the reducer is at least 10 % of the total length  $L$  listed in Table 15 ;
- at the transitions between the cylindrical sections and the conical sections the inside and outside surfaces shall merge smoothly ;
- length  $L'_2$  between a knuckle and the major end of a reducer is at least ;

$$L'_2 \geq 0.5 \cdot \sqrt{(D - T) \cdot T} \quad (\text{B-1})$$

or, alternatively, at least  $L_{2,\min}$  given by formula (A-10).

- transition between the cylindrical sections and the conical section at the minor end may be curved too. The wall thickness of the knuckle shall be the same as the wall thickness of the conical part.

In all other cases the pressure factor may be calculated in accordance with Annex A.

If the pressure factor is shown in brackets the lengths required at the ends of the reducer are larger than 10 % of the total length  $L$  listed in Table 15. In this case the pressure factor is applicable only if the lengths  $L_2$  and  $L_4$  are at least  $L_{2,\min}$  and  $L_{4,\min}$  given by formulas (A-29) and (A-30) or if the reducer is situated between tubes with wall thicknesses of  $T$  and  $T_1$ , respectively.

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Table B.3 — Pressure factors of concentric reducers type A

DN	D	DN <sub>1</sub>	D <sub>1</sub>	α <sub>max</sub>	1			2			3			4			5			6			7			8		
					T	T <sub>1</sub>	X	T	T <sub>1</sub>	X	T	T <sub>1</sub>	X	T	T <sub>1</sub>	X	T	T <sub>1</sub>	X	T	T <sub>1</sub>	X	T	T <sub>1</sub>	X	T	T <sub>1</sub>	X
20	26,9	15	21,3	8	-	-	2,3	2	100	2,6	2,6	100	3,2	3,2	100	4	4	100	-	-	-	5,6	5	100	8	7,1	100	
25	33,7	20	26,9	7	-	-	2,6	2,3	100	3,2	2,6	100	4	3,2	100	4,5	4	100	5,6	4,5	100	6,3	5,6	100	8,8	8	100	
32	42,4	15	21,3	12	-	-	2,6	2	100	3,2	2,6	100	4	3,2	100	4,5	4	100	-	-	-	6,3	5	100	8,8	7,1	100	
		25	33,7	9	-	-	2,6	2,6	100	3,6	3,2	100	4	4	100	5	4,5	100	6,3	5,6	100	8	6,3	100	10	8,8	100	
		20	26,9	15	-	-	2,6	2,3	100	3,6	2,6	100	4	3,2	100	5	4	100	6,3	4,5	100	8	5,6	100	10	8	100	
		15	21,3	19	-	-	2,6	2	100	3,6	2,6	100	4	3,2	100	5	4	100	-	-	-	8	5	100	10	7,1	100	
40	48,3	32	42,4	6	-	-	2,6	2,6	100	3,6	3,6	100	4	4	100	5	5	100	6,3	6,3	100	8	8	100	10	10	100	
		25	33,7	10	-	-	2,6	2,6	100	3,6	3,2	100	4	4	100	5	4,5	100	6,3	5,6	100	8	6,3	100	10	8,8	100	
		20	26,9	16	-	-	2,6	2,3	100	3,6	2,6	100	4	3,2	100	5	4	100	6,3	4,5	100	8	5,6	100	10	8	100	
50	60,3	40	48,3	7	-	-	2,9	2,6	100	3,6	3,6	100	4	4	100	5,6	5	100	7,1	6,3	100	8,8	8	100	11	10	100	
		32	42,4	11	-	-	2,9	2,6	100	3,6	3,6	100	4	4	100	5,6	5	100	7,1	6,3	100	8,8	8	100	11	10	100	
		25	33,7	16	-	-	2,9	2,6	100	3,6	3,2	100	4	4	100	5,6	4,5	100	7,1	5,6	100	8,8	6,3	100	11	8,8	100	
		20	26,9	21	-	-	2,9	2,3	100	3,6	2,6	100	4	3,2	100	5,6	4	100	7,1	4,5	100	8,8	5,6	100	11	8	100	
65	76,1	50	60,3	9	-	-	2,9	2,9	100	3,6	3,6	100	5,6	4	100	7,1	5,6	100	8	7,1	100	10	8,8	100	14,2	11	100	
		40	48,3	15	-	-	2,9	2,6	100	3,6	3,6	100	5,6	4	100	7,1	5	100	8	6,3	100	10	8	100	14,2	10	100	
		32	42,4	18	-	-	2,9	2,6	100	3,6	3,6	100	5,6	4	100	7,1	5	100	8	6,3	100	10	8	100	14,2	10	100	
		25	33,7	23	-	-	2,9	2,6	100	3,6	3,2	100	5,6	4	100	7,1	4,5	100	8	5,6	100	10	6,3	100	14,2	8,8	100	
80	88,9	65	76,1	7	-	-	3,2	2,9	100	4	3,6	100	5,6	5,6	100	8	7,1	100	8,8	8	100	11	10	100	16	14,2	100	
		50	60,3	16	-	-	3,2	2,9	100	4	3,6	100	5,6	4	100	8	5,6	100	8,8	7,1	100	11	8,8	100	16	11	100	
		40	48,3	22	-	-	3,2	2,6	100	4	3,6	100	5,6	4	100	8	5	100	8,8	6,3	100	11	8	100	16	10	100	
		32	42,4	26	-	-	3,2	2,6	100	4	3,6	100	5,6	4	100	8	5	100	8,8	6,3	100	11	8	100	16	10	100	
100	114,3	80	88,9	13	-	-	3,6	3,2	100	4,5	4	100	6,3	5,6	100	8,8	8	100	11	8,8	100	14,2	11	100	17,5	16	100	
		65	76,1	18	-	-	3,6	2,9	100	4,5	3,6	100	6,3	5,6	100	8,8	7,1	100	11	8	100	14,2	10	100	17,5	14,2	100	
		50	60,3	26	-	-	3,6	2,9	100	4,5	3,6	100	6,3	4	100	8,8	5,6	100	11	7,1	100	14,2	8,8	100	17,5	11	100	
		40	48,3	31	-	-	3,6	2,6	97	4,5	3,6	99	6,3	4	100	8,8	5	100	11	6,3	100	14,2	8	100	17,5	10	100	

Table B.3 (continued)

DN	D	DN <sub>1</sub>	D <sub>1</sub>	α <sub>max</sub>	1			2			3			4			5			6			7			8				
					T	T <sub>1</sub>	X	T	T <sub>1</sub>	X	T	T <sub>1</sub>	X	T	T <sub>1</sub>	X	T	T <sub>1</sub>	X	T	T <sub>1</sub>	X	T	T <sub>1</sub>	X	T	T <sub>1</sub>	X		
125	139,7	100	114,3	10	-	-	4	3,6	100	5	4,5	100	6,3	6,3	100	10	8,8	100	12,5	11	100	12,5	11	100	16	14,2	100	20	17,5	100
		80	88,9	20	-	-	4	3,2	100	5	4	100	6,3	5,6	100	10	8	100	12,5	8,8	100	16	11	100	16	11	100	20	16	100
		65	76,1	25	-	-	4	2,9	100	5	3,6	100	6,3	5,6	100	10	7,1	100	12,5	8	100	16	10	100	16	10	100	20	14,2	100
		50	60,3	30	-	-	4	2,9	97	5	3,6	99	6,3	4	100	10	5,6	100	12,5	7,1	100	16	8,8	100	16	8,8	100	20	11	100
150	168,3	125	139,7	9	-	-	4,5	4	100	5,6	5	100	7,1	6,3	100	11	10	100	14,2	12,5	100	14,2	12,5	100	17,5	16	100	22,2	20	100
		100	114,3	19	-	-	4,5	3,6	100	5,6	4,5	100	7,1	6,3	100	11	8,8	100	14,2	11	100	14,2	11	100	17,5	14,2	100	22,2	17,5	100
		80	88,9	27	-	-	4,5	3,2	98	5,6	4	100	7,1	5,6	100	11	8	100	14,2	8,8	100	14,2	8,8	100	17,5	11	100	22,2	16	100
		65	76,1	31	-	-	4,5	2,9	96	5,6	3,6	98	7,1	5,6	100	11	7,1	100	14,2	8	100	14,2	8	100	17,5	10	100	22,2	14,2	100
200	219,1	150	168,3	18	4,5	4	6,3	4,5	100	7,1	5,6	100	8	7,1	100	12,5	11	100	16	14,2	100	16	14,2	100	17,5	17,5	100	22,2	22,2	100
		125	139,7	27	-	-	6,3	4	99	7,1	5	100	8	6,3	100	12,5	10	100	16	12,5	100	16	12,5	100	17,5	16	100	22,2	20	100
		100	114,3	33	-	-	6,3	3,6	95	7,1	4,5	96	8	6,3	97	12,5	8,8	100	16	11	100	16	11	100	17,5	14,2	100	22,2	17,5	100
		80	88,9	39	-	-	6,3	3,2	90	7,1	4	91	8	5,6	92	12,5	8	99	16	8,8	100	16	8,8	100	17,5	11	100	22,2	16	100
250	273	200	219,1	16	5	4,5	6,3	6,3	100	8,8	7,1	100	10	8	100	12,5	12,5	100	16	16	100	16	16	100	22,2	17,5	100	30	22,2	100
		150	168,3	30	5	4	6,3	4,5	95	8,8	5,6	98	10	7,1	99	12,5	11	100	16	14,2	100	16	14,2	100	22,2	17,5	100	30	22,2	100
		125	139,7	36	-	-	6,3	4	91	8,8	5	94	10	6,3	95	12,5	10	98	16	12,5	100	16	12,5	100	22,2	16	100	30	20	100
		100	114,3	40	-	-	6,3	3,6	87	8,8	4,5	90	10	6,3	91	12,5	8,8	94	16	11	98	16	11	98	22,2	14,2	100	30	17,5	100
300	323,9	250	273	12	5,6	5	7,1	6,3	100	8,8	8,8	100	10	10	100	12,5	12,5	100	17,5	16	100	17,5	16	100	25	22,2	100	32	30	100
		200	219,1	24	5,6	4,5	7,1	6,3	99	8,8	7,1	100	10	8	100	12,5	12,5	100	17,5	16	100	17,5	16	100	25	17,5	100	32	22,2	100
		150	168,3	35	5,6	4	7,1	4,5	91	8,8	5,6	93	10	7,1	94	12,5	11	96	17,5	14,2	100	17,5	14,2	100	25	17,5	100	32	22,2	100
		125	139,7	40	-	-	7,1	4	87	8,8	5	88	10	6,3	90	12,5	10	92	17,5	12,5	97	17,5	12,5	97	25	16	100	32	20	100
350	355,6	300	323,9	6	5,6	5,6	8	7,1	100	10	8,8	100	12,5	10	100	16	12,5	100	20	17,5	100	20	17,5	100	28	25	100	36	32	100
		250	273	14	5,6	5	8	6,3	100	10	8,8	100	12,5	10	100	16	12,5	100	20	16	100	20	16	100	28	22,2	100	36	30	100
		200	219,1	22	5,6	4,5	8	6,3	100	10	7,1	100	12,5	8	100	16	12,5	100	20	16	100	20	16	100	28	17,5	100	36	22,2	100
		150	168,3	29	5,6	4	8	4,5	96	8	5,6	98	12,5	7,1	99	16	11	100	20	14,2	100	20	14,2	100	28	17,5	100	36	22,2	100

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Table B.3 (continued)

DN	D	DN <sub>1</sub>	D <sub>1</sub>	α <sub>max</sub>	1			2			3			4			5			6			7			8		
					T	T <sub>1</sub>	X	T	T <sub>1</sub>	X	T	T <sub>1</sub>	X	T	T <sub>1</sub>	X	T	T <sub>1</sub>	X	T	T <sub>1</sub>	X	T	T <sub>1</sub>	X	T	T <sub>1</sub>	X
400	406,4	350	355,6	8	6,3	5,6	100	8,8	8	100	10	10	100	12,5	12,5	100	17,5	16	100	22,2	20	100	30	28	100	40	36	100
		300	323,9	13	6,3	5,6	100	8,8	7,1	100	10	8,8	100	12,5	10	100	17,5	12,5	100	22,2	17,5	100	30	25	100	40	32	100
		250	273	21	6,3	5	99	8,8	6,3	100	10	8,8	100	12,5	10	100	17,5	12,5	100	22,2	16	100	30	22,2	100	40	30	100
		200	219,1	28	6,3	4,5	95	8,8	6,3	96	10	7,1	97	12,5	8	99	17,5	12,5	100	22,2	16	100	30	17,5	100	40	22,2	100
450	457	400	406,4	7	6,3	6,3	100	10	8,8	100	11	10	100	12,5	12,5	100	17,5	17,5	100	22,2	22,2	100	32	30	100	45	40	100
		350	355,6	14	6,3	5,6	100	10	8	100	11	10	100	12,5	12,5	100	17,5	16	100	22,2	20	100	32	28	100	45	36	100
		300	323,9	18	6,3	5,6	99	10	7,1	100	11	8,8	100	12,5	10	100	17,5	12,5	100	22,2	17,5	100	32	25	100	45	32	100
		250	273	25	6,3	5	96	10	6,3	98	11	8,8	99	12,5	10	100	17,5	12,5	100	22,2	16	100	32	22,2	100	45	30	100
500	508	450	457	4	6,3	6,3	100	10	10	100	11	11	100	12,5	12,5	100	17,5	17,5	100	25	22,2	100	36	32	100	50	45	100
		400	406,4	10	6,3	6,3	100	10	8,8	100	11	10	100	12,5	12,5	100	17,5	17,5	100	25	22,2	100	36	30	100	50	40	100
		350	355,6	17	6,3	5,6	99	10	8	100	11	10	100	12,5	12,5	100	17,5	16	100	25	20	100	36	28	100	50	36	100
		300	323,9	20	6,3	5,6	98	10	7,1	100	11	8,8	100	12,5	10	100	17,5	12,5	100	25	17,5	100	36	25	100	50	32	100
600	610	500	508	10	6,3	6,3	100	10	10	100	12,5	11	100	17,5	12,5	100	25	17,5	100	30	25	100	45	36	100	60	50	100
		450	457	15	6,3	6,3	100	10	10	100	12,5	11	100	17,5	12,5	100	25	17,5	100	30	22,2	100	45	32	100	60	45	100
		400	406,4	21	6,3	6,3	97	10	8,8	99	12,5	10	100	17,5	12,5	100	25	17,5	100	30	22,2	100	45	30	100	60	40	100
		600	610	10	7,1	6,3	100	10	10	100	12,5	12,5	100	25	17,5	100	-	-	-	-	-	-	-	-	-	-	-	-
700	711	500	508	15	7,1	6,3	99	10	10	100	12,5	11	100	25	12,5	100	-	-	-	-	-	-	-	-	-	-	-	-
		400	406,4	25	7,1	6,3	95	10	8,8	96	12,5	10	97	25	12,5	100	-	-	-	-	-	-	-	-	-	-	-	-
		700	711	10	8	7,1	100	10	10	100	12,5	12,5	100	25	25	100	-	-	-	-	-	-	-	-	-	-	-	-
		600	610	15	8	6,3	99	10	10	100	12,5	12,5	100	25	17,5	100	-	-	-	-	-	-	-	-	-	-	-	-
800	813	500	508	20	8	6,3	98	10	10	98	12,5	11	99	25	12,5	100	-	-	-	-	-	-	-	-	-	-	-	-
		800	813	10	10	8	100	12,5	10	100	20	12,5	100	25	25	100	-	-	-	-	-	-	-	-	-	-	-	
		700	711	15	10	7,1	100	12,5	10	100	20	12,5	100	25	25	100	-	-	-	-	-	-	-	-	-	-	-	
		600	610	20	10	6,3	94	12,5	10	99	20	12,5	100	25	17,5	100	-	-	-	-	-	-	-	-	-	-	-	
900	914	800	813	10	10	8	100	12,5	10	100	20	12,5	100	25	25	100	-	-	-	-	-	-	-	-	-	-	-	
		700	711	15	10	7,1	100	12,5	10	100	20	12,5	100	25	25	100	-	-	-	-	-	-	-	-	-	-		
		600	610	20	10	6,3	94	12,5	10	99	20	12,5	100	25	17,5	100	-	-	-	-	-	-	-	-	-	-		

Table B.3 (continued)

DN	D	DN <sub>1</sub>	D <sub>1</sub>	α <sub>max</sub>	1			2			3			4			5			6			7			8										
					T	T <sub>1</sub>	X	T	T <sub>1</sub>	X	T	T <sub>1</sub>	X	T	T <sub>1</sub>	X	T	T <sub>1</sub>	X	T	T <sub>1</sub>	X	T	T <sub>1</sub>	X	T	T <sub>1</sub>	X								
1 000	1 016	900	914	10	10	100	12,5	12,5	100	20	20	100	25	25	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
		800	813	15	8	(99)	12,5	10	100	20	20	100	25	25	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
		700	711	20	10	(90)	12,5	10	98	20	20	100	25	25	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
1 200	1 219	1 000	1 016	11	10	100	12,5	12,5	100	20	20	100	25	25	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
		900	914	16	10	99	12,5	12,5	99	20	20	100	25	25	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		800	813	20	10	97	12,5	10	98	20	20	100	25	25	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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Table B.4 — Pressure factors of eccentric reducers type A

DN	D	DN <sub>1</sub>	D <sub>1</sub>	α <sub>max</sub>	1			2			3			4			5			6			7			8		
					T	T <sub>1</sub>	X	T	T <sub>1</sub>	X	T	T <sub>1</sub>	X	T	T <sub>1</sub>	X	T	T <sub>1</sub>	X	T	T <sub>1</sub>	X	T	T <sub>1</sub>	X	T	T <sub>1</sub>	X
20	26,9	15	21,3	15	-	-	2,3	2	100	2,6	2,6	100	3,2	3,2	100	4	4	100	-	-	-	5,6	5	100	8	7,1	100	
25	33,7	20	26,9	13	-	-	2,6	2,3	100	3,2	2,6	100	4	3,2	100	4,5	4	100	5,6	4,5	100	6,3	5,6	100	8,8	8	100	
		15	21,3	24	-	-	2,6	2	100	3,2	2,6	100	4	3,2	100	4,5	4	100	-	-	-	6,3	5	100	8,8	7,1	100	
32	42,4	25	33,7	16	-	-	2,6	2,6	100	3,6	3,2	100	4	4	100	5	4,5	100	6,3	5,6	100	8	6,3	100	10	8,8	100	
		20	26,9	30	-	-	2,6	2,3	100	3,6	2,6	100	4	3,2	100	5	4	100	6,3	4,5	100	8	5,6	100	10	8	100	
		15	21,3	42	-	-	2,6	2	97	3,6	2,6	100	4	3,2	100	5	4	100	-	-	-	8	5	100	10	7,1	100	
40	48,3	32	42,4	8	-	-	2,6	2,6	100	3,6	3,6	100	4	4	100	5	5	100	6,3	6,3	100	8	8	100	10	10	100	
		25	33,7	19	-	-	2,6	2,6	100	3,6	3,2	100	4	4	100	5	4,5	100	6,3	5,6	100	8	6,3	100	10	8,8	100	
		20	26,9	28	-	-	2,6	2,3	100	3,6	2,6	100	4	3,2	100	5	4	100	6,3	4,5	100	8	5,6	100	10	8	100	
50	60,3	40	48,3	13	-	-	2,9	2,6	100	3,6	3,6	100	4	4	100	5,6	5	100	7,1	6,3	100	8,8	8	100	11	10	100	
		32	42,4	20	-	-	2,9	2,6	100	3,6	3,6	100	4	4	100	5,6	5	100	7,1	6,3	100	8,8	8	100	11	10	100	
		25	33,7	29	-	-	2,9	2,6	100	3,6	3,2	100	4	4	100	5,6	4,5	100	7,1	5,6	100	8,8	6,3	100	11	8,8	100	
65	76,1	20	26,9	36	-	-	2,9	2,3	98	3,6	2,6	100	4	3,2	100	5,6	4	100	7,1	4,5	100	8,8	5,6	100	11	8	100	
		50	60,3	15	-	-	2,9	2,9	100	3,6	3,6	100	5,6	4	100	7,1	5,6	100	8	7,1	100	10	8,8	100	14,2	11	100	
		40	48,3	27	-	-	2,9	2,6	100	3,6	3,6	100	5,6	4	100	7,1	5	100	8	6,3	100	10	8	100	14,2	10	100	
		32	42,4	34	-	-	2,9	2,6	97	3,6	3,6	99	5,6	4	100	7,1	5	100	8	6,3	100	10	8	100	14,2	10	100	
		25	33,7	42	-	-	2,9	2,6	90	3,6	3,2	93	5,6	4	100	7,1	4,5	100	8	5,6	100	10	6,3	100	14,2	8,8	100	
80	88,9	65	76,1	13	-	-	3,2	2,9	100	4	3,6	100	5,6	5,6	100	8	7,1	100	8,8	8	100	11	10	100	16	14,2	100	
		50	60,3	30	-	-	3,2	2,9	99	4	3,6	100	5,6	4	100	8	5,6	100	8,8	7,1	100	11	8,8	100	16	11	100	
		40	48,3	44	-	-	3,2	2,6	87	4	3,6	90	5,6	4	96	8	5	100	8,8	6,3	100	11	8	100	16	10	100	
		32	42,4	50	-	-	3,2	2,6	80	4	3,6	83	5,6	4	90	8	5	100	8,8	6,3	100	11	8	100	16	10	100	
100	114,3	80	88,9	24	-	-	3,6	3,2	100	4,5	4	100	6,3	5,6	100	8,8	8	100	11	8,8	100	14,2	11	100	17,5	16	100	
		65	76,1	37	-	-	3,6	2,9	93	4,5	3,6	95	6,3	5,6	100	8,8	7,1	100	11	8	100	14,2	10	100	17,5	14,2	100	
		50	60,3	51	-	-	3,6	2,9	78	4,5	3,6	80	6,3	4	86	8,8	5,6	94	11	7,1	100	14,2	8,8	100	17,5	11	100	
		40	48,3	60	-	-	3,6	2,6	(65)	4,5	3,6	(68)	6,3	4	74	8,8	5	83	11	6,3	93	14,2	8	100	17,5	10	100	



Table B.4 (continued)

DN	D	DN <sub>1</sub>	D <sub>1</sub>	α <sub>max</sub>	1			2			3			4			5			6			7			8		
					T	T <sub>1</sub>	X	T	T <sub>1</sub>	X	T	T <sub>1</sub>	X	T	T <sub>1</sub>	X	T	T <sub>1</sub>	X	T	T <sub>1</sub>	X	T	T <sub>1</sub>	X	T	T <sub>1</sub>	X
125	139,7	100	114,3	18	-	-	-	4	3,6	100	5	4,5	100	6,3	6,3	100	10	8,8	100	12,5	11	100	16	14,2	100	20	17,5	100
		80	88,9	35	-	-	-	4	3,2	93	5	4	95	6,3	5,6	98	10	8	100	12,5	8,8	100	16	11	100	20	16	100
		65	76,1	43	-	-	-	4	2,9	86	5	3,6	88	6,3	5,6	91	10	7,1	100	12,5	8	100	16	10	100	20	14,2	100
		50	60,3	51	-	-	-	4	2,9	77	5	3,6	79	6,3	4	82	10	5,6	92	12,5	7,1	99	16	8,8	100	20	11	100
150	168,3	125	139,7	18	-	-	-	4,5	4	100	5,6	5	100	7,1	6,3	100	11	10	100	14,2	12,5	100	17,5	16	100	22,2	20	100
		100	114,3	34	-	-	-	4,5	3,6	94	5,6	4,5	95	7,1	6,3	98	11	8,8	100	14,2	11	100	17,5	14,2	100	22,2	17,5	100
		80	88,9	48	-	-	-	4,5	3,2	80	5,6	4	82	7,1	5,6	85	11	8	93	14,2	8,8	100	17,5	11	100	22,2	16	100
		65	76,1	52	-	-	-	4,5	2,9	(75)	5,6	3,6	77	7,1	5,6	80	11	7,1	88	14,2	8	96	17,5	10	100	22,2	14,2	100
200	219,1	150	168,3	31	4,5	4	(93)	6,3	4,5	(90)	7,1	5,6	(95)	8	7,1	98	12,5	11	100	16	14,2	100	17,5	17,5	100	22,2	22,2	100
		125	139,7	45	-	-	-	6,3	4	(74)	7,1	5	(84)	8	6,3	(86)	12,5	10	93	16	12,5	99	17,5	16	100	22,2	20	100
		100	114,3	55	-	-	-	6,3	3,6	(71)	7,1	4,5	(72)	8	6,3	74	12,5	8,8	81	16	11	88	17,5	14,2	91	22,2	17,5	100
		80	88,9	60	-	-	-	6,3	3,2	(84)	7,1	4	(65)	8	5,6	(67)	12,5	8	74	16	8,8	81	17,5	11	84	22,2	16	96
250	273	200	219,1	28	5	4,5	(92)	6,3	6,3	97	8,8	7,1	(97)	10	8	100	12,5	12,5	100	16	16	100	22,2	17,5	100	30	22,2	100
		150	168,3	48	5	4	(76)	6,3	4,5	(75)	8,8	5,6	(76)	10	7,1	(83)	12,5	11	86	16	14,2	91	22,2	17,5	99	30	22,2	100
		125	139,7	55	-	-	-	6,3	4	(69)	8,8	5	(72)	10	6,3	74	12,5	10	77	16	12,5	82	22,2	16	91	30	20	100
		100	114,3	60	-	-	-	6,3	3,6	(62)	8,8	4,5	(65)	10	6,3	(67)	12,5	8,8	(70)	16	11	75	22,2	14,2	85	30	17,5	100
300	323,9	250	273	23	5,6	5	(95)	7,1	6,3	(99)	8,8	8,8	100	10	10	100	12,5	12,5	100	17,5	16	100	25	22,2	100	32	30	100
		200	219,1	44	5,6	4,5	(72)	7,1	6,3	(83)	8,8	7,1	(84)	10	8	(86)	12,5	12,5	88	17,5	16	93	25	17,5	100	32	22,2	100
		150	168,3	55	5,6	4	(66)	7,1	4,5	(69)	8,8	5,6	(71)	10	7,1	(72)	12,5	11	75	17,5	14,2	80	25	17,5	90	32	22,2	100
		125	139,7	60	-	-	-	7,1	4	(61)	8,8	5	(63)	10	6,3	(65)	12,5	10	(67)	17,5	12,5	73	25	16	83	32	20	94
350	355,6	300	323,9	8	5,6	5,6	100	8	7,1	100	10	8,8	100	12,5	10	100	16	12,5	100	20	17,5	100	28	25	100	36	32	100
		250	273	25	5,6	5	97	8	6,3	(97)	10	8,8	100	12,5	10	100	16	12,5	100	20	16	100	28	22,2	100	36	30	100
		200	219,1	37	5,6	4,5	88	8	6,3	90	10	7,1	92	12,5	8	94	16	12,5	97	20	16	100	28	17,5	100	36	22,2	100
		150	168,3	47	5,6	4	(77)	8	4,5	79	10	5,6	81	12,5	7,1	84	16	11	87	20	14,2	91	28	17,5	99	36	22,2	100

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Table B.4 (continued)

DN	D	DN <sub>1</sub>	D <sub>1</sub>	α <sub>max</sub>	1			2			3			4			5			6			7			8		
					T	T <sub>1</sub>	X	T	T <sub>1</sub>	X	T	T <sub>1</sub>	X	T	T <sub>1</sub>	X	T	T <sub>1</sub>	X	T	T <sub>1</sub>	X	T	T <sub>1</sub>	X	T	T <sub>1</sub>	X
400	406,4	350	355,6	15	6,3	5,6	100	8,8	8	100	10	10	100	12,5	12,5	100	17,5	16	100	22,2	20	100	30	28	100	40	36	100
		300	323,9	24	6,3	5,6	(96)	8,8	7,1	(96)	10	8,8	99	12,5	10	100	17,5	12,5	100	22,2	17,5	100	30	25	100	40	32	100
		250	273	36	6,3	5	82	8,8	6,3	(83)	10	8,8	91	12,5	10	93	17,5	12,5	97	22,2	16	100	30	22,2	100	40	30	100
		200	219,1	46	6,3	4,5	(78)	8,8	6,3	80	10	7,1	81	12,5	8	83	17,5	12,5	87	22,2	16	91	30	17,5	98	40	22,2	100
450	457	400	406,4	11	6,3	6,3	100	10	8,8	100	11	10	100	12,5	12,5	100	17,5	17,5	100	22,2	22,2	100	32	30	100	45	40	100
		350	355,6	24	6,3	5,6	(96)	10	8	(98)	11	10	99	12,5	12,5	100	17,5	16	100	22,2	20	100	32	28	100	45	36	100
		300	323,9	31	6,3	5,6	(91)	10	7,1	(85)	11	8,8	(95)	12,5	10	96	17,5	12,5	99	22,2	17,5	100	32	25	100	45	32	100
		250	273	41	6,3	5	(83)	10	6,3	(79)	11	8,8	86	12,5	10	88	17,5	12,5	91	22,2	16	94	32	22,2	100	45	30	100
500	508	450	457	8	6,3	6,3	100	10	10	100	11	11	100	12,5	12,5	100	17,5	17,5	100	25	22,2	100	36	32	100	50	45	100
		400	406,4	18	6,3	6,3	99	10	8,8	100	11	10	100	12,5	12,5	100	17,5	17,5	100	25	22,2	100	36	30	100	50	40	100
		350	355,6	27	6,3	5,6	94	10	8	96	11	10	97	12,5	12,5	98	17,5	16	100	25	20	100	36	28	100	50	36	100
		300	323,9	32	6,3	5,6	91	10	7,1	93	11	8,8	94	12,5	10	95	17,5	12,5	97	25	17,5	100	36	25	100	50	32	100
600	610	500	508	17	6,3	6,3	99	10	10	100	12,5	11	100	17,5	12,5	100	25	17,5	100	30	25	100	45	36	100	60	50	100
		450	457	27	6,3	6,3	94	10	10	96	12,5	11	97	17,5	12,5	(98)	25	17,5	100	30	22,2	100	45	32	100	60	45	100
		400	406,4	35	6,3	6,3	88	10	8,8	90	12,5	10	(91)	17,5	12,5	(93)	25	17,5	97	30	22,2	99	45	30	100	60	40	100
		700	711	19	7,1	6,3	88	10	10	99	12,5	12,5	100	25	17,5	100	-	-	-	-	-	-	-	-	-	-	-	-
800	813	500	508	34	7,1	6,3	71	10	10	(89)	12,5	11	(85)	25	12,5	(97)	-	-	-	-	-	-	-	-	-	-	-	-
		400	406,4	45	7,1	6,3	(67)	10	8,8	(79)	12,5	10	(80)	25	12,5	(86)	-	-	-	-	-	-	-	-	-	-	-	-
		700	711	19	8	7,1	(86)	10	10	99	12,5	12,5	99	25	25	100	-	-	-	-	-	-	-	-	-	-	-	-
		600	610	34	8	6,3	62	10	10	(80)	12,5	12,5	(86)	25	17,5	(87)	-	-	-	-	-	-	-	-	-	-	-	-
900	914	500	508	45	8	6,3	(60)	10	10	(76)	12,5	11	(78)	25	12,5	(80)	-	-	-	-	-	-	-	-	-	-	-	-
		800	813	19	10	8	(87)	12,5	10	(93)	20	12,5	100	25	25	100	-	-	-	-	-	-	-	-	-	-	-	-
		700	711	34	10	7,1	(62)	12,5	10	(68)	20	12,5	(79)	25	25	(94)	-	-	-	-	-	-	-	-	-	-	-	-
		600	610	45	10	6,3	(52)	12,5	10	(62)	20	12,5	(67)	25	17,5	(74)	-	-	-	-	-	-	-	-	-	-	-	-

Table B.4 (continued)

DN	D	DN <sub>1</sub>	D <sub>1</sub>	α <sub>max</sub>	1			2			3			4			5			6			7			8											
					T	T <sub>1</sub>	X	T	T <sub>1</sub>	X	T	T <sub>1</sub>	X	T	T <sub>1</sub>	X	T	T <sub>1</sub>	X	T	T <sub>1</sub>	X	T	T <sub>1</sub>	X	T	T <sub>1</sub>	X									
1000	1016	900	914	19	10	10	(93)	12,5	12,5	(99)	20	20	100	25	25	100	25	25	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
		800	813	34	10	8	(58)	12,5	10	(63)	20	12,5	(76)	25	25	(93)	25	25	(93)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
		700	711	45	10	7,1	(49)	12,5	10	(59)	20	12,5	(63)	25	25	(82)	25	25	(82)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
1200	1219	1000	1016	30	10	10	(70)	12,5	12,5	(76)	20	20	(89)	25	25	(95)	25	25	(95)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
		900	914	41	10	10	(62)	12,5	12,5	(67)	20	20	(80)	25	25	(85)	25	25	(85)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		800	813	49	10	8	(49)	12,5	10	(54)	20	12,5	(56)	25	25	(76)	25	25	(76)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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## B.5 Caps

Table B.5 shows pressure factors of caps.

The calculation was done for an inside knuckle radius  $r = 0,15 D$  and an inside spherical radius  $R1 = 0,8 D$ . Smaller inside knuckle radii ( $r < 0,15 D$ ) or larger inside spherical radii ( $R1 > 0,8 D$ ) of the ellipsoidal end may result in lower pressure factors, especially for small ratios of wall thickness to diameter with pressure factors less than 100 %.

For some dimensions no pressure factors are listed. In these cases the dimensions of the cap are outside the range of validity of the calculation procedures given in Annex A ; the usability has to be checked for each case.

Table B.5 — Pressure factors of caps type A

DN	D	1		2		3		4		5		6		7		8	
		T	X	T	X	T	X	T	X	T	X	T	X	T	X	T	X
15	21,3		-	2	-	2,6	-	3,2	-	4	-		-	5	-	7,1	-
20	26,9		-	2,3	-	2,6	-	3,2	-	4	-	4,5	-	5,6	-	8	-
25	33,7		-	2,6	-	3,2	-	4	-	4,5	-	5,6	-	6,3	-	8,8	-
32	42,4		-	2,6	-	3,6	-	4	-	5	-	6,3	-	8	-	10	-
40	48,3		-	2,6	100	3,6	-	4	-	5	-	6,3	-	8	-	10	-
50	60,3		-	2,9	100	3,6	-	4	-	5,6	-	7,1	-	8,8	-	11	-
65	76,1		-	2,9	100	3,6	100	5,6	-	7,1	-	8	-	10	-	14,2	-
80	88,9		-	3,2	100	4	100	5,6	-	8	-	8,8	-	11	-	16	-
100	114,3		-	3,6	100	4,5	100	6,3	100	8,8	-	11	-	14,2	-	17,5	-
125	139,7		-	4	100	5	100	6,3	100	10	-	12,5	-	16	-	20	-
150	168,3	4	100	4,5	100	5,6	100	7,1	100	11	-	14,2	-	17,5	-	22,2	-
200	219,1	4,5	100	6,3	100	7,1	100	8	100	12,5	100	16	-	17,5	-	22,2	-
250	273	5	100	6,3	100	8,8	100	10	100	12,5	100	16	-	22,2	-	30	-
300	323,9	5,6	100	7,1	100	8,8	100	10	100	12,5	100	17,5	100	25	-	32	-
350	355,6	5,6	100	8	100	10	100	12,5	100	16	100	20	100	28	-	36	-
400	406,4	6,3	100	8,8	100	10	100	12,5	100	17,5	100	22,2	100	30	-	40	-
450	457	6,3	100	10	100	11	100	12,5	100	17,5	100	22,2	100	32	-	45	-
500	508	6,3	100	10	100	11	100	12,5	100	17,5	100	25	100	36	-	50	-
600	610	6,3	98	10	100	12,5	100	17,5	100	25	100	30	100	45	-	60	-
700	711	7,1	97	10	100	12,5	100	25	100	-	-	-	-	-	-	-	-
800	813	8	97	10	100	12,5	100	25	100	-	-	-	-	-	-	-	-
900	914	10	99	12,5	100	20	100	25	100	-	-	-	-	-	-	-	-
1000	1016	10	97	12,5	100	20	100	25	100	-	-	-	-	-	-	-	-
1200	1219	10	94	12,5	98	20	100	25	100	-	-	-	-	-	-	-	-

## Annex C (informative)

### Wall thickness tables for Fittings of type B

#### C.1 General

This annex lists wall thicknesses at the body of the fitting of elbows, tees, reducers and caps for the wall thickness series listed in Table 17 and with the tolerances given in Table 18.

These wall thicknesses are calculated using the procedures given in Annex A. For fittings with diameters larger than 610 mm, where seamless and welded fittings have different wall thickness tolerances, the larger of the resulting wall thicknesses is listed. For the corrosion allowance 0 mm is used.

NOTE In general, corrosion allowances larger than 0 mm lead to smaller wall thicknesses at the body of elbows, tees and reducers.

For the definition of symbols see A.2 and the figures in Annex A.

Fittings with dimensions not listed in the tables of this annex, with a corrosion allowance larger than 0 mm or with other tolerances shall be designed in accordance with Annex A. Smaller wall thicknesses than listed in the tables are acceptable provided that they are calculated in accordance with Annex A, e.g. for welded elbows with diameters larger than 610 mm.

#### C.2 Elbows

Table C.1 shows the wall thickness on the intrados of elbows of model 2D, 3D and 5D (indicated in second line of table) whose bending radii are given in Table 10, Table 11 and Table 12, respectively.

The wall thickness on the extrados of the elbows shall be the same as at the welding ends.

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Table C.1 — Wall thickness on the intrados of elbows type B

Model	1			2			3			4			5			6			7			8													
	<i>D<sub>N</sub></i>	<i>T</i>	<i>D</i>	2D	3D	5D	<i>T</i>	<i>T<sub>int</sub></i>	<i>T<sub>int</sub></i>	2D	3D	5D	<i>T</i>	<i>T<sub>int</sub></i>	<i>T<sub>int</sub></i>	2D	3D	5D	<i>T</i>	<i>T<sub>int</sub></i>	<i>T<sub>int</sub></i>	2D	3D	5D	<i>T</i>	<i>T<sub>int</sub></i>	<i>T<sub>int</sub></i>	2D	3D	5D	<i>T</i>	<i>T<sub>int</sub></i>	<i>T<sub>int</sub></i>		
15	213	-	-	2	2,7	2,4	2,4	2,4	3,1	3,1	3,1	3,2	4,3	3,8	3,7	4	5,3	4,7	4,7	-	-	-	5	6,5	5,9	5,8	7,1	9,0	8,3	8,1					
20	269	-	-	2,3	3,5	2,9	2,7	2,6	3,9	3,3	3,0	3,2	4,8	4,0	3,7	4	5,9	5,0	4,6	4,5	6,5	5,6	5,2	5,6	8,0	6,9	6,4	8	11,0	9,8	9,1				
25	33,7	-	-	2,6	4,7	3,6	3,0	3,2	5,7	4,4	3,7	4	6,9	5,4	4,6	4,5	7,7	6,1	5,2	5,6	9,2	7,5	6,4	6,3	10,2	8,4	7,2	8,8	13,5	11,4	10,0				
32	42,4	-	-	2,6	4,7	3,6	3,0	3,6	6,4	4,9	4,2	4	7,0	5,5	4,6	5	8,5	6,8	5,8	6,3	10,4	8,4	7,2	8	12,8	10,6	9,1	10	15,4	13,1	11,4				
40	48,3	-	-	2,6	4,6	3,5	3,0	3,6	6,2	4,9	4,1	4	6,8	5,4	4,6	5	8,4	6,7	5,7	6,3	10,3	8,4	7,2	8	12,7	10,5	9,1	10	15,4	13,0	11,3				
50	60,3	-	-	2,9	4,8	3,9	3,3	3,6	5,9	4,8	4,1	4	6,5	5,3	4,6	5,6	8,9	7,3	6,4	7,1	11,1	9,2	8,1	8,8	13,5	11,4	10,0	11	16,5	14,1	12,5				
65	76,1	-	-	2,9	5,0	3,9	3,3	3,6	6,1	4,8	4,1	5,6	9,2	7,4	6,4	7,1	11,5	9,3	8,1	8	12,8	10,5	9,1	10	15,7	13,0	11,4	14,2	21,5	18,2	16,1				
80	88,9	-	-	3,2	5,3	4,2	3,7	4	6,6	5,3	4,6	5,6	9,1	7,3	6,4	8	12,7	10,4	9,1	8,8	13,9	11,4	10,0	11	17,0	14,2	12,5	16	23,9	20,4	18,1				
100	114,3	-	-	3,6	5,8	4,7	4,1	4,5	7,2	5,9	5,1	6,3	9,9	8,2	7,2	8,8	13,7	11,3	10,0	11	16,9	14,1	12,5	14,2	21,4	18,1	16,1	17,5	25,9	22,1	19,8				
125	139,7	-	-	4	6,4	5,2	4,6	5	7,9	6,5	5,7	6,3	9,9	8,1	7,2	10	15,4	12,8	11,4	12,5	19,0	15,9	14,2	16	24,0	20,3	18,1	20	29,5	25,2	22,6				
150	166,3	4	6,4	4,5	7,2	5,8	5,2	5,6	8,9	7,2	6,4	7,1	11,2	9,1	8,1	11	17,1	14,1	12,5	14,2	21,7	18,1	16,1	17,5	26,5	22,2	19,9	22,2	33,0	28,0	25,1				
200	219,1	4,5	7,1	5,8	9,8	8,1	7,2	7,1	11,1	9,1	8,1	8	12,4	10,2	9,1	12,5	19,1	15,9	14,2	16	24,3	20,3	18,1	17,5	26,4	22,1	19,8	22,2	33,1	28,0	25,1				
250	273	5	7,9	6,4	5,7	6,3	9,9	8,1	7,2	8,8	13,7	11,2	10,0	10	15,5	12,8	11,4	12,5	19,2	15,9	14,2	16	24,4	20,3	18,1	22,2	33,4	28,0	25,1	30	44,4	37,7	33,9		
300	323,9	5,6	8,7	7,2	6,4	7,1	11,0	9,1	8,1	8,8	13,6	11,2	10,0	10	15,4	12,7	11,4	12,5	19,2	15,9	14,2	16	23,5	19,9	18,1	25	37,4	31,5	28,3	32	47,3	40,1	36,1		
350	355,6	5,6	8,4	7,0	6,4	8	11,9	10,0	9,1	10	14,8	12,5	11,4	12,5	18,5	15,6	14,2	17,5	25,7	21,8	19,8	20	29,2	24,8	22,6	28	40,4	34,6	31,6	36	51,5	44,4	40,6		
400	406,4	6,3	9,4	7,9	7,2	8,8	13,1	11,0	10,0	10	14,9	12,5	11,4	12,5	18,5	15,6	14,2	17,5	25,7	21,8	19,8	22,2	32,5	27,6	25,1	30	43,5	37,1	33,9	40	57,3	49,3	45,1		
450	457	6,3	9,4	7,9	7,2	10	14,9	12,5	11,3	11	16,3	13,7	12,4	12,5	18,5	15,6	14,1	17,5	25,8	21,8	19,8	22,2	32,5	27,6	25,0	32	46,4	39,6	36,0	45	64,4	55,5	50,6		
500	508	6,3	9,4	7,9	7,2	10	14,9	12,5	11,3	11	16,4	13,8	12,4	12,5	18,6	15,6	14,1	17,5	25,8	21,8	19,8	25	36,6	31,1	28,2	36	52,2	44,6	40,5	50	71,6	61,6	56,2		
600	610	6,3	9,4	7,9	7,1	10	14,9	12,5	11,3	12,5	18,6	15,6	14,1	17,5	25,9	21,8	19,7	25	36,8	31,1	28,1	30	43,9	37,3	33,7	45	65,1	55,7	50,5	60	85,9	74,0	67,3		
700	711	7,1	10,6	8,9	8,0	10	14,9	12,6	11,4	12,5	18,6	15,6	14,1	25	36,9	31,1	28,1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
800	813	8	12,0	10,0	9,0	10	15,0	12,6	11,4	12,5	18,6	15,6	14,1	25	37,0	31,2	28,1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
900	914	10	15,0	12,6	11,4	12,5	18,7	15,6	14,1	20	29,7	25,0	22,5	25	37,0	31,2	28,1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1000	1016	10	15,0	12,6	11,4	12,5	18,7	15,6	14,1	20	29,7	25,0	22,5	25	37,1	31,2	28,1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1200	1219	10	15,0	12,6	11,4	12,5	18,7	15,6	14,1	20	29,8	25,0	22,5	25	37,2	31,2	28,1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

### C.3 Tees

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

- 1) reinforcement is interior ( $D_s = D, D_b = D_1$ ) 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 Table 13 and 14 ;
- 2) reinforcement is at maximum half to the external ( $D_s \leq D + (T_{s,min} - T), D_b \leq D_1 + (T_{b,min} - T_1)$ ) and the crotch radius is less equal to 1/2 of the height of the branch ( $r_c \leq 0.5 (G - D_s/2)$ ) 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 Table 13 and 14.

In all other cases, e.g. when the reinforcement is completely to the external, the wall thicknesses shall be calculated in accordance with Annex A.

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

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Table C.2 — Wall thickness of tees type B

DN	D	DN <sub>1</sub>	D <sub>h</sub>	1			2			3			4			5			6			7			8							
				T	T <sub>1</sub>	T <sub>s</sub>	T <sub>b</sub>	T	T <sub>1</sub>	T <sub>s</sub>	T <sub>b</sub>	T	T <sub>1</sub>	T <sub>s</sub>	T <sub>b</sub>	T	T <sub>1</sub>	T <sub>s</sub>	T <sub>b</sub>	T	T <sub>1</sub>	T <sub>s</sub>	T <sub>b</sub>	T	T <sub>1</sub>	T <sub>s</sub>	T <sub>b</sub>	T	T <sub>1</sub>	T <sub>s</sub>	T <sub>b</sub>	
15	21,3	15	21,3	-	2	2	4,2	3,2	2,6	2,6	2,6	5,2	3,9	3,2	3,2	6,1	4,6	4	4	7,4	5,6	-	-	5	5	9,1	6,9	7,1	7,1	12,8	9,6	
20	26,9	20	26,9	-	2,3	2,3	4,8	3,6	2,6	2,6	2,6	5,3	4,0	3,2	3,2	6,3	4,7	4	4	7,7	5,8	4,5	4,5	5,6	5,6	10,7	8,1	8	8	15,2	11,4	
25	33,7	25	33,7	-	2,3	2	4,4	3,3	2,6	2,6	2,6	4,8	3,6	3,2	3,2	5,7	4,3	4	4	6,7	5,1	-	-	5,6	5	8,9	6,7	8	7,1	12,4	9,3	
32	42,4	32	42,4	-	2,6	2,6	5,7	4,3	3,2	3,2	3,2	6,7	5,0	4	4	7,9	5,9	4,5	4,5	8,7	6,5	5,6	5,6	6,3	6,3	11,8	8,8	8,8	8,8	16,4	12,3	
40	48,3	40	48,3	-	2,6	2,3	5,2	3,9	3,2	3,2	6,1	4,6	4	3,2	3,2	7,2	5,4	4,5	4	7,9	5,9	5,6	4,5	4,5	6,3	5,6	10,3	7,7	8,8	8	13,8	10,3
50	60,3	50	60,3	-	2,6	2	4,8	3,6	3,2	3,2	6,1	4,6	4	3,2	3,2	6,7	5,0	4,5	4	7,3	5,5	-	-	6,3	5	9,5	7,1	8,8	7,1	12,3	9,2	
		25	33,7	-	2,6	2,6	5,5	4,1	3,6	3,2	7,0	5,3	4	4	4	7,6	5,7	5	4,5	9,0	6,8	6,3	5,6	6,3	6,3	12,9	9,7	10	8,8	15,7	11,8	
		20	26,9	-	2,6	2,3	5,1	3,8	3,6	3,6	6,5	4,9	4	3,2	3,2	7,1	5,3	5	4	8,4	6,3	6,3	4,5	4,5	6,3	4,5	10,0	7,5	8	8	14,3	10,8
		15	21,3	-	2,6	2	4,8	3,6	3,6	3,6	6,1	4,6	4	3,2	3,2	6,6	5,0	5	4	7,9	5,9	-	-	8	5	11,3	8,5	10	7,1	13,5	10,1	
		40	48,3	-	2,6	2,6	6,3	4,7	3,6	3,6	8,0	6,0	4	4	4	8,7	6,6	5	5	10,3	7,8	6,3	6,3	12,3	9,3	8	15,0	11,2	10	10	18,3	13,7
		32	42,4	-	2,6	2,6	6,0	4,5	3,6	3,6	7,7	5,8	4	4	4	8,3	6,2	5	5	9,8	7,4	6,3	6,3	11,7	8,8	8	14,1	10,6	10	10	16,8	12,6
		25	33,7	-	2,6	2,6	5,5	4,2	3,6	3,2	7,1	5,3	4	4	4	7,7	5,8	5	4,5	9,1	6,8	6,3	5,6	10,8	8,1	8	13,0	9,8	10	8,8	15,4	11,6
		20	26,9	-	2,6	2,3	5,2	3,9	3,6	3,6	6,6	5,0	4	3,2	3,2	7,2	5,4	5	4	8,5	6,4	6,3	4,5	10,1	7,6	8	12,2	9,1	10	8	14,5	10,9
		15	21,3	-	2,6	2	4,9	3,7	3,6	3,6	6,3	4,7	4	3,2	3,2	6,8	5,1	5	4	8,0	6,0	-	-	8	5	11,5	8,7	10	7,1	13,7	10,3	
		50	60,3	-	2,9	2,9	6,9	5,2	3,6	3,6	8,2	6,1	4	4	4	8,8	6,6	5,6	5,6	11,4	8,6	7,1	7,1	13,9	10,5	8,8	17,0	12,8	11	11	21,3	16,0
		40	48,3	-	2,9	2,6	6,2	4,6	3,6	3,6	7,3	5,5	4	4	4	7,9	5,9	5,6	5	10,2	7,7	7,1	6,3	12,2	9,2	8,8	14,5	10,9	11	10	17,6	13,2
		32	42,4	-	2,9	2,6	5,8	4,3	3,6	3,6	6,8	5,1	4	4	4	7,4	5,5	5,6	5	9,5	7,2	7,1	6,3	11,5	8,6	8,8	13,7	10,3	11	10	16,5	12,4
		25	33,7	-	2,9	2,6	5,1	3,8	3,6	3,2	6,0	4,5	4	4	4	6,5	4,9	5,6	4,5	8,5	6,4	7,1	5,6	10,3	7,7	8,8	12,3	9,2	11	8,8	14,9	11,2
		20	26,9	-	2,9	2,3	4,5	3,4	3,6	3,6	5,3	4,0	4	3,2	3,2	5,8	4,4	5,6	4	7,7	5,8	7,1	4,5	9,4	7,1	8,8	11,3	8,5	11	8	13,8	10,4



Table C.2 (continued)

DN	D	DN <sub>1</sub>	D <sub>h</sub>	1			2			3			4			5			6			7			8										
				T	T <sub>1</sub>	T <sub>s</sub>	T <sub>b</sub>	T	T <sub>1</sub>	T <sub>s</sub>	T <sub>b</sub>	T	T <sub>1</sub>	T <sub>s</sub>	T <sub>b</sub>	T	T <sub>1</sub>	T <sub>s</sub>	T <sub>b</sub>	T	T <sub>1</sub>	T <sub>s</sub>	T <sub>b</sub>	T	T <sub>1</sub>	T <sub>s</sub>	T <sub>b</sub>								
65	76,1	65	76,1	-	-	-	-	2,9	2,9	7,2	5,4	6,3	8,4	6,3	5,6	5,6	5,6	8,9	7,1	7,1	14,4	10,8	8	8	16,1	12,1	10	10	20,1	15,1	14,2	28,7	21,5		
				-	-	-	-	2,9	2,9	6,3	4,8	3,6	3,6	4	9,6	7,2	7,1	5,6	12,5	9,4	8	8	13,8	10,4	8	8	16,6	12,5	14,2	11	22,7	17,0			
				-	-	-	-	2,9	2,6	5,7	4,3	3,6	3,6	6,7	5,1	5,6	4	9,4	7,1	5	11,4	8,5	8	8	12,5	9,4	10	8	15,0	11,3	14,2	10	20,1	15,1	
				-	-	-	-	2,9	2,6	5,4	4,0	3,6	3,6	6,3	4,8	5,6	4	8,9	6,7	5	10,7	8,0	8	8	11,8	8,8	10	8	14,2	10,7	14,2	10	19,0	14,3	
				-	-	-	-	2,9	2,6	4,8	3,6	3,6	3,2	5,6	4,2	5,6	4	8,0	6,0	4,5	9,7	7,3	8	8	10,8	8,1	10	6,3	13,0	9,8	14,2	8,8	17,5	13,2	
80	88,9	80	88,9	-	-	-	-	3,2	3,2	7,9	6,0	4	9,4	7,0	5,6	5,6	9,1	8	8	16,5	12,4	8,8	8,8	18,1	13,6	11	11	22,6	17,0	16	33,2	24,9			
				-	-	-	-	3,2	2,9	7,3	5,5	4	3,6	8,7	6,5	5,6	5,6	11,2	8,4	8	7,1	14,7	11,1	8,8	8	15,9	11,9	11	10	19,4	14,6	16	28,4	21,3	
				-	-	-	-	3,2	2,9	6,5	4,9	4	3,6	7,7	5,8	5,6	4	9,9	7,5	8	5,6	13,1	9,8	8,8	7,1	14,2	10,7	11	8,8	17,1	12,8	16	11	23,9	17,9
				-	-	-	-	3,2	2,6	5,9	4,4	4	3,6	7,0	5,3	5,6	4	9,0	6,8	8	5	11,9	9,0	8,8	6,3	12,9	9,7	11	8	15,6	11,7	16	10	21,4	16,0
				-	-	-	-	3,2	2,6	5,6	4,2	4	3,6	6,6	5,0	5,6	4	8,5	6,4	8	5	11,3	8,5	8,8	6,3	12,2	9,2	11	8	14,8	11,1	16	10	20,3	15,2
100	114,3	100	114,3	-	-	-	-	3,6	3,6	9,0	6,8	4,5	10,7	8,0	6,3	6,3	13,9	10,4	8,8	8,8	18,8	14,1	11	11	23,6	17,7	14,2	14,2	30,6	23,0	17,5	38,0	28,5		
				-	-	-	-	3,6	3,2	7,9	6,0	4,5	4	9,4	7,1	6,3	5,6	12,2	9,1	8,8	8	15,8	11,9	11	8,8	19,0	14,2	14,2	11	23,9	18,0	17,5	16	29,3	22,0
				-	-	-	-	3,6	2,9	7,4	5,6	4,5	3,6	8,8	6,6	6,3	5,6	11,3	8,5	8,8	7,1	14,7	11,0	11	8	17,6	13,2	14,2	10	21,9	16,4	17,5	14,2	26,1	19,6
				-	-	-	-	3,6	2,9	6,6	5,0	4,5	3,6	7,9	5,9	6,3	4	10,2	7,7	8,8	5,6	13,2	9,9	11	7,1	15,9	12,0	14,2	8,8	19,8	14,9	17,5	11	23,8	17,8
				-	-	-	-	3,6	2,6	6,1	4,6	4,5	3,6	7,2	5,4	6,3	4	9,4	7,0	8,8	5	12,2	9,2	11	6,3	14,6	11,0	14,2	8	18,2	13,7	17,5	10	21,8	16,4
125	139,7	125	139,7	-	-	-	-	4	4	10,2	7,6	5	12,0	9,0	6,3	6,3	14,3	10,8	10	10	22,0	16,5	12,5	12,5	27,6	20,7	16	16	35,6	26,7	20	44,9	33,7		
				-	-	-	-	4	3,6	9,1	6,9	5	4,5	10,8	8,1	6,3	6,3	12,9	9,7	10	8,8	18,6	14,0	12,5	11	22,4	16,8	16	14,2	28,8	21,6	20	17,5	36,1	27,1
				-	-	-	-	4	3,2	8,1	6,1	5	4	9,6	7,2	6,3	5,6	11,5	8,6	10	8	16,5	12,4	12,5	8,8	19,8	14,9	16	11	24,6	18,4	20	16	29,6	22,2
				-	-	-	-	4	2,9	7,6	5,7	5	3,6	9,0	6,8	6,3	5,6	10,7	8,1	10	7,1	15,4	11,6	12,5	8	18,5	13,9	16	10	23,0	17,2	20	14,2	27,7	20,8
				-	-	-	-	4	2,9	6,9	5,2	5	3,6	8,2	6,2	6,3	4	9,9	7,4	10	5,6	14,2	10,6	12,5	7,1	16,9	12,7	16	8,8	20,9	15,7	20	11	25,4	19,0
150	168,3	150	168,3	4	4	10,5	7,9	4,5	4,5	11,5	8,6	5,6	5,6	13,5	10,2	7,1	7,1	16,5	12,4	11	11	25,2	18,9	14,2	14,2	32,9	24,7	17,5	17,5	40,8	30,6	22,2	52,4	39,3	
				-	-	-	-	4,5	4	10,4	7,8	5,6	5	12,3	9,2	7,1	6,3	14,7	11,1	11	10	21,0	15,7	14,2	12,5	26,7	20,0	17,5	16	32,9	24,7	22,2	20	42,0	31,5
				-	-	-	-	4,5	3,6	9,4	7,1	5,6	4,5	11,1	8,4	7,1	6,3	13,4	10,0	11	8,8	19,0	14,3	14,2	11	23,6	17,7	17,5	14,2	28,1	21,1	22,2	17,5	35,4	26,5
				-	-	-	-	4,5	3,2	8,4	6,3	5,6	4	10,0	7,5	7,1	5,6	12,0	9,0	11	8	17,0	12,8	14,2	8,8	21,1	15,9	17,5	11	25,3	19,0	22,2	16	31,0	23,2
				-	-	-	-	4,5	2,9	7,9	5,9	5,6	3,6	9,4	7,0	7,1	5,6	11,3	8,5	11	7,1	16,0	12,0	14,2	8	19,8	14,9	17,5	10	23,8	17,9	22,2	14,2	29,2	21,9

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Table C.2 (continued)

DN	D	DN <sub>1</sub>	D <sub>h</sub>	1			2			3			4			5			6			7			8												
				T	T <sub>1</sub>	T <sub>s</sub>	T <sub>b</sub>	T	T <sub>1</sub>	T <sub>s</sub>	T <sub>b</sub>	T	T <sub>1</sub>	T <sub>s</sub>	T <sub>b</sub>	T	T <sub>1</sub>	T <sub>s</sub>	T <sub>b</sub>	T	T <sub>1</sub>	T <sub>s</sub>	T <sub>b</sub>	T	T <sub>1</sub>	T <sub>s</sub>	T <sub>b</sub>										
200	219,1	200	219,1	4,5	4,5	12,1	9,1	6,3	6,3	15,7	11,8	7,1	7,1	17,4	13,1	8	8	19,4	14,5	12,5	12,5	30,2	22,6	16	16	39,0	29,2	17,5	17,5	42,8	32,1	22,2	22,2	55,0	41,2		
				4,5	4	10,6	7,9	6,3	4,5	12,9	9,7	7,1	5,6	14,9	11,2	8	7,1	16,3	12,3	12,5	11	23,5	17,7	16	14,2	28,9	21,7	17,5	17,5	31,5	23,6	22,2	22,2	40,0	30,0		
				-	-	-	-	6,3	4	12,4	9,3	7,1	5	13,7	10,3	8	6,3	15,0	11,2	12,5	10	21,5	16,2	16	12,5	26,5	19,9	17,5	16	28,7	21,5	22,2	20	34,9	26,2		
				-	-	-	-	6,3	3,6	11,4	8,6	7,1	4,5	12,5	9,4	8	6,3	13,7	10,3	12,5	8,8	19,7	14,8	16	11	24,3	18,3	17,5	14,2	26,4	19,8	22,2	17,5	32,2	24,2		
250	273	250	273	5	5	13,7	10,3	6,3	6,3	16,3	12,2	8,8	8,8	21,9	16,5	10	10	24,8	18,6	12,5	12,5	31,0	23,3	16	16	40,1	30,1	22,2	22,2	56,5	42,4	30	30	77,8	58,4		
				5	4,5	12,2	9,2	6,3	6,3	14,5	10,9	8,8	7,1	18,7	14,1	10	8	20,8	15,6	12,5	12,5	25,1	18,9	16	16	30,8	23,1	22,2	17,5	42,5	31,9	30	22,2	54,4	40,8		
				5	4	10,8	8,1	6,3	4,5	12,8	9,6	8,8	5,6	16,5	12,4	10	7,1	18,3	13,7	12,5	11	22,2	16,6	16	14,2	27,3	20,5	22,2	17,5	35,9	27,0	30	22,2	46,8	35,1		
				-	-	-	-	6,3	4	11,9	8,9	8,8	5	15,3	11,5	10	6,3	16,9	12,7	12,5	10	20,4	15,3	16	12,5	25,1	18,8	16	12,5	25,1	18,8	22,2	16	33,1	24,8	30	20
300	323,9	300	323,9	-	-	-	-	6,3	3,6	10,9	8,2	8,8	4,5	14,1	10,6	10	6,3	15,6	11,7	12,5	8,8	18,8	14,1	16	11	23,2	17,4	22,2	14,2	30,7	23,1	30	17,5	40,0	30,0		
				5,6	5,6	15,5	11,7	7,1	7,1	18,6	13,9	8,8	8,8	22,4	16,8	10	10	25,2	18,9	12,5	12,5	31,3	23,5	17,5	17,5	44,2	33,2	25	25	64,3	48,2	32	32	83,6	62,7		
				5,6	5	14,2	10,6	7,1	6,3	16,9	12,7	8,8	8,8	19,9	14,9	10	10	22,1	16,6	12,5	12,5	26,5	19,9	17,5	16	35,8	26,8	25	22,2	51,7	38,8	32	30	66,5	49,9		
				5,6	4,5	12,7	9,5	7,1	6,3	15,1	11,4	8,8	7,1	17,8	13,4	10	8	19,8	14,8	12,5	12,5	23,9	18,0	17,5	16	31,6	23,7	25	17,5	42,8	32,1	32	22,2	54,3	40,7		
350	355,6	300	323,9	5,6	4	11,2	8,4	7,1	4,5	13,4	10,1	8,8	5,6	15,8	11,9	10	7,1	17,5	13,2	12,5	11	21,3	16,0	17,5	14,2	28,2	21,2	25	17,5	38,2	28,7	32	22,2	47,2	35,4		
				5,6	5,6	15,9	11,9	8	8	20,8	15,6	10	10	25,3	19,0	12,5	12,5	31,3	23,5	16	16	40,2	30,1	20	20	50,6	38,0	28	28	72,0	54,0	36	36	94,1	70,6		
				5,6	5,6	15,1	11,3	8	7,1	19,3	14,5	10	8,8	22,7	17,1	12,5	10	25,2	18,9	16	12,5	30,7	23,1	20	17,5	43,0	32,3	28	25	62,3	46,7	36	32	80,7	60,5		
				5,6	5	13,8	10,3	8	6,3	18,0	13,5	10	8,8	21,4	16,1	12,5	10	25,7	19,3	16	12,5	31,6	23,7	20	16	38,1	28,6	28	22,2	52,7	39,6	36	30	68,1	51,1		
	219,1	200	219,1	5,6	4,5	12,4	9,3	8	6,3	16,3	12,2	10	7,1	19,3	14,5	12,5	8	23,1	17,3	16	12,5	28,4	21,3	20	16	34,4	25,8	28	17,5	45,8	34,4	36	22,2	57,0	42,8		
				5,6	4	11,0	8,3	8	4,5	14,5	10,9	10	5,6	17,2	12,9	12,5	7,1	20,5	15,4	16	11	25,4	19,1	20	14,2	30,7	23,1	28	17,5	41,1	30,8	36	22,2	51,1	38,3		

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Table C.2 (continued)

DN	D	DN <sub>1</sub>	D <sub>1</sub>	1			2			3			4			5			6			7			8											
				T	T <sub>1</sub>	T <sub>s</sub>	T <sub>b</sub>	T	T <sub>1</sub>	T <sub>s</sub>	T <sub>b</sub>	T	T <sub>1</sub>	T <sub>s</sub>	T <sub>b</sub>	T	T <sub>1</sub>	T <sub>s</sub>	T <sub>b</sub>	T	T <sub>1</sub>	T <sub>s</sub>	T <sub>b</sub>	T	T <sub>1</sub>	T <sub>s</sub>	T <sub>b</sub>									
400	406,4	400	406,4	6,3	6,3	17,8	13,3	8,8	8,8	23,6	17,7	10	10	26,7	20,1	12,5	12,5	33,2	24,9	17,5	17,5	47,0	35,3	22,2	22,2	60,3	45,2	30	30	83,0	62,3	40	40	114	85,1	
		350	355,6	6,3	5,6	16,7	12,5	8,8	8	21,4	16,1	10	10	23,6	17,7	12,5	12,5	28,1	21,1	17,5	16	38,7	29,1	22,2	20	49,5	37,1	30	28	67,5	50,7	40	36	91,6	68,7	
		300	323,9	6,3	5,6	15,8	11,9	8,8	7,1	20,4	15,3	10	8,8	8,8	22,4	16,8	12,5	10	26,8	20,1	17,5	12,5	32,3	24,2	22,2	17,5	44,2	33,2	30	25	60,9	45,7	40	32	82,3	61,7
		250	273	6,3	5	14,5	10,9	8,8	6,3	18,7	14,0	10	8,8	8,8	20,6	15,5	12,5	10	24,7	18,6	17,5	12,5	32,7	24,6	22,2	16	40,0	30,0	30	22,2	51,8	38,9	40	30	69,5	52,2
		200	219,1	6,3	4,5	13,1	9,9	8,8	6,3	16,9	12,7	10	7,1	7,1	18,6	14,0	12,5	8	22,3	16,7	17,5	12,5	29,6	22,2	22,2	16	36,3	27,3	30	17,5	47,1	35,3	40	22,2	60,2	45,2
450	457	450	457	6,3	6,3	18,3	13,7	10	10	26,8	20,1	11	11	29,4	22,1	12,5	12,5	33,3	25,0	17,5	17,5	46,8	35,1	22,2	22,2	59,9	45,0	32	32	88,2	66,2	45	45	128	95,7	
		400	406,4	6,3	6,3	17,1	12,9	10	8,8	24,1	18,1	11	10	26,3	19,7	12,5	12,5	29,2	21,9	17,5	17,5	39,7	29,8	22,2	22,2	50,7	38,0	32	30	74,3	55,7	45	40	107	80,1	
		350	355,6	6,3	5,6	16,1	12,1	10	8	22,8	17,1	11	10	24,5	18,4	12,5	12,5	27,1	20,4	17,5	16	35,8	26,8	22,2	20	43,6	32,7	32	28	63,0	47,3	45	36	90,1	67,6	
		300	323,9	6,3	5,6	15,3	11,5	10	7,1	21,7	16,3	11	8,8	8,8	23,3	17,5	12,5	10	25,9	19,4	17,5	12,5	34,2	25,7	22,2	17,5	41,8	31,4	32	25	57,8	43,4	45	32	82,4	61,8
		250	273	6,3	5	14,1	10,6	10	6,3	20,0	15,0	11	8,8	8,8	21,6	16,2	12,5	10	24,0	18,0	17,5	12,5	31,7	23,8	22,2	16	38,8	29,1	32	22,2	53,0	39,7	45	30	71,7	53,8
500	508	500	508	6,3	6,3	18,8	14,1	10	10	27,2	20,4	11	11	29,5	22,2	12,5	12,5	33,4	25,1	17,5	17,5	46,7	35,0	25	25	67,6	50,7	36	36	99,4	74,6	50	50	142	107	
		450	457	6,3	6,3	17,7	13,3	10	10	25,0	18,8	11	11	26,9	20,2	12,5	12,5	29,9	22,5	17,5	17,5	40,3	30,2	25	22,2	57,5	43,1	36	32	84,2	63,1	50	45	121	90,6	
		400	406,4	6,3	6,3	16,6	12,5	10	8,8	23,5	17,6	11	10	25,4	19,1	12,5	12,5	28,3	21,2	17,5	17,5	37,3	28,0	25	22,2	50,7	38,0	36	30	73,9	55,5	50	40	105	78,3	
		300	323,9	6,3	5,6	14,9	11,2	10	7,1	21,1	15,8	11	8,8	8,8	22,7	17,0	12,5	10	25,1	18,9	17,5	12,5	33,2	24,9	25	17,5	44,9	33,7	36	25	61,2	45,9	50	32	84,0	63,0
		250	273	6,3	5	13,7	10,3	10	6,3	19,5	14,6	11	8,8	8,8	21,0	15,8	12,5	10	23,4	17,5	17,5	12,5	30,9	23,2	25	16	41,9	31,4	36	22,2	57,1	42,9	50	30	75,6	56,7
600	610	600	610	6,3	6,3	19,4	14,6	10	10	29,4	22,1	12,5	12,5	36,5	27,4	17,5	17,5	51,5	38,7	25	25	74,9	56,2	30	30	90,9	68,2	45	45	142	106	60	60	192	144	
		500	508	6,3	6,3	17,8	13,3	10	10	25,1	18,8	12,5	11	8,8	8,8	22,3	17,5	23,4	17,5	17,5	12,5	46,9	35,2	30	25	67,6	50,7	45	36	99,1	74,4	60	50	141	106	
		400	406,4	6,3	6,3	15,8	11,9	10	8,8	22,3	16,8	12,5	10	8,8	8,8	20,1	17,5	23,4	17,5	17,5	12,5	47,6	35,7	30	22,2	55,5	41,6	45	30	81,7	61,3	60	40	111	82,6	
		300	323,9	6,3	5,6	14,3	10,7	10	7,1	20,2	15,2	12,5	8,8	8,8	23,9	18,0	17,5	10	31,6	23,7	25	12,5	40,6	30,5	30	17,5	50,1	37,6	45	25	70,8	53,1	60	32	92,0	69,0
		250	273	6,3	5	13,2	9,9	10	6,3	18,7	14,0	12,5	8,8	8,8	22,4	16,8	17,5	10	29,6	22,2	25	12,5	40,1	30,1	30	16	47,0	35,2	45	22,2	66,6	49,9	60	30	85,2	63,9

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Table C.2 (continued)

DN	D	DN <sub>1</sub>	D <sub>1</sub>	1			2			3			4			5			6			7			8													
				T	T <sub>1</sub>	T <sub>s</sub>	T <sub>b</sub>	T	T <sub>1</sub>	T <sub>s</sub>	T <sub>b</sub>	T	T <sub>1</sub>	T <sub>s</sub>	T <sub>b</sub>	T	T <sub>1</sub>	T <sub>s</sub>	T <sub>b</sub>	T	T <sub>1</sub>	T <sub>s</sub>	T <sub>b</sub>	T	T <sub>1</sub>	T <sub>s</sub>	T <sub>b</sub>	T	T <sub>1</sub>	T <sub>s</sub>	T <sub>b</sub>							
700	711	700	711	7,1	7,1	22,2	16,7	10	10	28,7	21,6	12,5	12,5	34,9	26,2	25	25	69,7	52,4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-				
		600	610	7,1	6,3	20,5	15,8	10	10	26,5	21,4	12,5	12,5	31,3	25,2	25	17,5	46,3	34,7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-				
		500	508	7,1	6,3	18,6	14,9	10	10	24,1	19,4	12,5	11	28,4	22,9	25	12,5	37,3	28,0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
		400	406,4	7,1	6,3	16,6	13,3	10	8,8	21,5	17,4	12,5	10	25,7	20,8	25	12,5	40,7	30,5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
800	813	300	323,9	7,1	5,6	15,1	12,0	10	7,1	19,5	15,8	12,5	8,8	23,2	18,7	25	10	36,8	27,6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
		800	813	8	8	25,2	18,9	10	10	29,7	22,3	12,5	12,5	35,5	26,6	25	25	68,9	51,8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
		700	711	8	7,1	23,3	17,5	10	10	27,5	20,7	12,5	12,5	32,5	24,4	25	25	57,1	42,9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
		600	610	8	6,3	21,6	16,8	10	10	25,5	20,6	12,5	12,5	30,1	24,3	25	17,5	49,5	37,2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
900	914	500	508	8	6,3	19,7	15,8	10	10	23,2	18,8	12,5	11	27,5	22,1	25	12,5	40,1	30,1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
		400	406,4	8	6,3	17,6	14,2	10	8,8	20,9	16,9	12,5	10	24,9	20,1	25	12,5	44,3	33,2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
		900	914	10	10	30,6	23,0	12,5	12,5	36,1	27,1	20	20	55,0	41,2	25	25	68,3	51,3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
		800	813	10	8	26,5	19,9	12,5	10	31,3	23,5	20	12,5	36,9	27,7	25	25	58,6	43,9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
		700	711	10	7,1	24,9	18,7	12,5	10	31,5	23,6	20	12,5	38,1	28,6	25	25	55,0	41,3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
		600	610	10	6,3	23,7	17,8	12,5	10	29,2	23,5	20	12,5	40,0	30,0	25	17,5	50,7	39,7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
		500	508	10	6,3	22,6	18,2	12,5	10	26,7	21,5	20	11	38,6	28,9	25	12,5	42,9	32,2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		400	406,4	10	6,3	20,3	16,4	12,5	8,8	24,1	19,5	20	10	35,6	29,4	25	12,5	43,1	35,7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	

Table C.2 (continued)

DN	D	DN <sub>1</sub>	D <sub>1</sub>	1			2			3			4			5			6			7			8									
				T	T <sub>1</sub>	T <sub>s</sub>	T <sub>b</sub>	T	T <sub>1</sub>	T <sub>s</sub>	T <sub>b</sub>	T	T <sub>1</sub>	T <sub>s</sub>	T <sub>b</sub>	T	T <sub>1</sub>	T <sub>s</sub>	T <sub>b</sub>	T	T <sub>1</sub>	T <sub>s</sub>	T <sub>b</sub>	T	T <sub>1</sub>	T <sub>s</sub>	T <sub>b</sub>	T	T <sub>1</sub>	T <sub>s</sub>	T <sub>b</sub>			
1000	1016	1000	1016	10	10	31,5	23,6	12,5	12,5	37,1	27,9	20	20	55,0	41,3	25	25	68,3	51,2	-	-	-	-	-	-	-	-	-	-	-	-	-		
		900	914	10	10	29,8	22,4	12,5	12,5	35,2	26,4	20	20	50,0	37,5	25	25	59,8	44,9	-	-	-	-	-	-	-	-	-	-	-	-	-		
		800	813	10	8	27,9	21,0	12,5	10	33,0	24,7	20	12,5	39,0	29,2	25	25	56,5	42,4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
		700	711	10	7,1	25,9	19,4	12,5	10	30,6	22,9	20	12,5	40,3	30,2	25	25	53,4	40,1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
		600	610	10	6,3	24,1	18,7	12,5	10	28,5	22,9	20	12,5	41	31,8	25	17,5	49,4	40,8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
1200	1219	1200	1219	10	10	32,4	24,3	12,5	12,5	38,2	28,7	20	20	56,7	42,5	25	25	70,6	52,9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
		1000	1016	10	10	29,5	22,1	12,5	12,5	34,8	26,1	20	20	50,5	37,9	25	25	60,5	45,4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		900	914	10	10	27,8	20,9	12,5	12,5	32,8	24,6	20	20	48,2	36,2	25	25	57,8	43,3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		800	813	10	8	26,4	19,8	12,5	10	31,1	23,4	20	12,5	42,6	32,0	25	25	54,3	40,7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		700	711	10	7,1	24,6	18,5	12,5	10	29,1	21,8	20	12,5	42,4	31,8	25	25	51,4	38,5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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## C.4 Reducers

Tables C.3 to C.6 show the wall thicknesses of concentric and eccentric reducers of type B.

The data listed is applicable if all of the following conditions apply:

- semi angle of the reducer is not larger than the values listed in Tables C.3 to C.6 ;
- each of the lengths  $L_2$  and  $L_4$  at the ends of the reducer is at least 10 % of the total length  $L$  listed in Table 15 ;
- at the transitions between the cylindrical sections and the conical sections the inside and outside surfaces shall merge smoothly ;
- the length  $L'_2$  between a knuckle and the major end of a reducer is at least :

$$L'_2 \geq 0,5 \cdot \sqrt{(D - T_2) \cdot T_2} \quad (\text{C-1})$$

or, alternatively, at least  $L'_{2,\min}$  given by formula (A-49). The wall thickness of such a knuckle shall be at least  $T_2$  ;

- transition between the cylindrical sections and the conical section at the minor end may be curved too. The wall thickness of the knuckle shall be at least the maximum of  $T_{3,\min}$  and  $T_{4,\min}$ .

If a wall thickness is shown in brackets the length required at the end of the reducer is larger than 10 % of the total length  $L$  listed in Table 15. In this case the length shall be at least  $L_{2,\min}$  or  $L_{4,\min}$  given by (A-60) or (A-61) or the wall thickness shall be increased in accordance with (A-62) or (A-63).

Smaller wall thicknesses than listed in Tables C.3 to C.6 are acceptable provided that they are calculated in accordance with Annex A. e.g. for smaller semi angles  $\alpha$ .

NOTE For the calculation of the wall thickness tolerances of  $T$ ,  $T_2$  and  $T_3$  the diameter  $D$  should be used. For the calculation of the wall thickness tolerance of  $T_1$  and  $T_4$  the diameter  $D_1$  should be used.

Table C.3 — Wall thickness of concentric reducers type B – wall thickness series 1 to 4

DN	D	DN <sub>1</sub>	D <sub>1</sub>	α <sub>max</sub>	1				2				3				4											
					T	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>				
20	26,9	15	21,3	8	-	-	-	-	-	2,3	2	2,3	2,3	2,0	2,6	2,6	2,6	2,6	2,6	2,6	2,6	2,6	2,6	3,2	3,2	3,2	3,1	3,2
					-	-	-	-	-	2,6	2,3	2,6	2,6	2,3	3,2	3,2	3,1	3,1	3,1	3,1	3,1	3,1	3,1	3,1	3,1	4	4	4,0
25	33,7	15	21,3	12	-	-	-	-	-	2,6	2	2,6	2,5	2,0	3,2	3,2	3,2	3,2	3,2	3,2	3,2	3,2	3,2	4	4	4,0	3,8	3,2
					-	-	-	-	-	2,6	2,6	2,6	2,6	2,6	3,6	3,6	3,5	3,5	3,5	3,5	3,5	3,5	3,5	3,5	3,5	4	4	4,0
32	42,4	20	26,9	15	-	-	-	-	-	2,6	2,3	2,6	2,6	2,3	3,6	3,6	3,6	3,6	3,6	3,6	3,6	3,6	4	4	4,0	3,8	3,2	
					-	-	-	-	-	2,6	2,6	2,6	2,6	2,6	3,6	3,6	3,5	3,5	3,5	3,5	3,5	3,5	3,5	3,5	3,5	4	4	4,0
40	48,3	32	42,4	6	-	-	-	-	-	2,6	2	2,6	2,6	2,0	3,6	3,6	3,6	3,6	3,6	3,6	3,6	3,6	4	4	4,0	3,8	3,2	
					-	-	-	-	-	2,6	2,6	2,6	2,6	2,6	3,6	3,6	3,6	3,6	3,6	3,6	3,6	3,6	3,6	3,6	4	4	4,0	3,9
50	60,3	20	26,9	16	-	-	-	-	-	2,6	2,3	2,6	2,6	2,3	3,6	3,6	3,6	3,6	3,6	3,6	3,6	3,6	4	4	4,0	3,9	3,2	
					-	-	-	-	-	2,9	2,6	2,9	2,9	2,6	3,6	3,6	3,6	3,6	3,6	3,6	3,6	3,6	3,6	3,6	4	4	4,0	4,0
65	76,1	32	42,4	11	-	-	-	-	-	2,9	2,6	2,9	2,9	2,6	3,6	3,6	3,6	3,6	3,6	3,6	3,6	3,6	4	4	4,0	3,9	4,0	
					-	-	-	-	-	2,9	2,6	2,9	2,9	2,6	3,6	3,6	3,6	3,6	3,6	3,6	3,6	3,6	3,6	3,6	4	4	4,0	4,0
80	88,9	25	33,7	23	-	-	-	-	-	2,9	2,6	2,9	3,0	2,6	3,6	3,6	3,6	3,6	3,6	3,6	3,6	3,6	4	4	4,0	5,6	4,0	
					-	-	-	-	-	3,2	2,9	3,2	3,2	2,9	4	4	4,0	4,0	4,0	4,0	4,0	4,0	4,0	4,0	5,6	5,6	5,6	5,5
100	114,3	50	60,3	16	-	-	-	-	-	3,2	2,9	3,2	3,2	2,9	4	4	4	4	4	4	4	4	5,6	4	5,6	5,5	4,0	
					-	-	-	-	-	3,2	2,9	3,2	3,3	2,6	4	4	4,0	4,0	4,0	4,0	4,0	4,0	4,0	4,0	5,6	5,6	5,6	5,5
80	88,9	65	76,1	7	-	-	-	-	-	3,6	3,2	3,6	3,6	3,2	4,5	4,5	4,5	4,5	4,5	4,5	4,5	4,5	6,3	4	6,3	6,3	6,2	5,6
					-	-	-	-	-	3,6	2,9	3,6	3,6	2,9	4,5	4,5	4,5	4,5	4,5	4,5	4,5	4,5	4,5	4,5	6,3	5,6	6,3	6,2
50	60,3	50	60,3	26	-	-	-	-	-	3,6	2,9	3,6	3,7	2,9	4,5	4,5	4,5	4,5	4,5	4,5	4,5	4,5	6,3	4	6,3	6,3	6,2	4,0
					-	-	-	-	-	3,6	2,6	3,6	3,6	2,6	4,5	4,5	4,5	4,5	4,5	4,5	4,5	4,5	4,5	4,5	6,3	4	6,3	6,3
40	48,3	40	48,3	31	-	-	-	-	-	3,6	2,6	3,6	3,8	2,6	4,5	4,5	4,5	4,5	4,5	4,5	4,5	4,5	6,3	4	6,3	6,3	6,2	4,0
					-	-	-	-	-	3,6	2,6	3,6	3,8	2,6	4,5	4,5	4,5	4,5	4,5	4,5	4,5	4,5	4,5	4,5	6,3	4	6,3	6,3

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Table C.3 (continued)

DN	D	DN <sub>1</sub>	D <sub>1</sub>	α <sub>max</sub>	1				2				3				4									
					T	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>		
125	139,7	100	114,3	10	-	-	-	-	-	4	3,6	4,0	4,0	3,6	5	4,5	5,0	5,0	4,5	6,3	6,3	6,3	6,3	6,3		
		80	88,9	20	-	-	-	-	-	4	3,2	4,0	4,1	3,2	5	4	5,0	5,0	4,0	6,3	5,6	6,3	6,3	6,3	5,6	
		65	76,1	25	-	-	-	-	-	4	2,9	4,0	4,1	2,9	5	3,6	5,0	5,1	3,6	6,3	5,6	6,3	6,3	6,3	5,6	5,6
		50	60,3	30	-	-	-	-	-	4	2,9	4,0	4,3	2,9	5	3,6	5,0	5,2	3,6	6,3	4	6,3	6,3	6,5	6,5	4,0
150	168,3	125	139,7	9	-	-	-	-	-	4,5	4	4,5	4,5	4,0	5,6	5	5,6	5,6	5,0	7,1	6,3	7,1	7,0	7,0	6,3	
		100	114,3	19	-	-	-	-	-	4,5	3,6	4,5	4,6	3,6	5,6	4,5	5,6	5,6	4,5	7,1	6,3	7,1	7,1	7,1	6,3	
		80	88,9	27	-	-	-	-	-	4,5	3,2	4,5	4,7	3,2	5,6	4	5,6	5,8	4,0	7,1	5,6	7,1	7,2	7,2	5,6	
		65	76,1	31	-	-	-	-	-	4,5	2,9	4,5	4,8	2,9	5,6	3,6	5,6	5,9	3,6	7,1	5,6	7,1	7,4	7,4	5,6	
200	219,1	150	168,3	18	4,5	4,5	4,6	4,0	4,0	6,3	4,5	6,3	5,9	4,5	7,1	5,6	7,1	7,1	5,6	8	7,1	8,0	8,0	8,0	7,1	
		125	139,7	27	-	-	-	-	-	6,3	4	6,3	6,5	4,0	7,1	5	7,1	7,3	5,0	8	6,3	8,0	8,2	8,2	6,3	
		100	114,3	33	-	-	-	-	-	6,3	3,6	6,3	6,8	3,6	7,1	4,5	7,1	7,6	4,5	8	6,3	8,0	8,5	8,5	6,3	
		80	88,9	39	-	-	-	-	-	6,3	3,2	6,3	7,1	3,2	7,1	4	7,1	8,0	4,0	8	5,6	8,0	8,9	8,9	5,6	
250	273	200	219,1	16	5	4,5	5,0	5,1	4,5	6,3	6,3	6,3	6,3	6,3	8,8	7,1	8,8	8,8	7,1	10	8	10,0	9,9	9,9	8,0	
		150	168,3	30	5	4	5,0	5,4	4,0	6,3	4,5	6,3	6,7	4,5	8,8	5,6	8,8	9,2	5,6	10	7,1	10,0	10,4	10,4	7,1	
		125	139,7	36	-	-	-	-	-	6,3	4	6,3	7,1	4,0	8,8	5	8,8	9,6	5,0	10	6,3	10,0	10,8	10,8	6,3	
		100	114,3	40	-	-	-	-	-	6,3	3,6	6,3	7,3	3,6	8,8	4,5	8,8	10,0	4,5	10	6,3	10,0	11,2	11,2	6,3	
300	323,9	250	273	12	5,6	5,6	5,6	5,0	5,0	7,1	6,3	7,1	7,1	6,3	8,8	8,8	8,8	8,7	8,8	10	10	10,0	9,9	10,0	10,0	
		200	219,1	24	5,6	4,5	5,6	5,8	4,5	7,1	6,3	7,1	7,3	6,3	8,8	7,1	8,8	9,0	7,1	10	8	10,0	10,2	10,2	8,0	
		150	168,3	35	5,6	4	5,6	6,3	4,0	7,1	4,5	7,1	7,9	4,5	8,8	5,6	8,8	9,7	5,6	10	7,1	10,0	10,9	10,9	7,1	
		125	139,7	40	-	-	-	-	-	7,1	4	7,1	8,3	4,0	8,8	5	8,8	10,1	5,0	10	6,3	10,0	11,4	11,4	6,3	



Table C.3 (continued)

DN	D	DN <sub>1</sub>	D <sub>1</sub>	α <sub>max</sub>	1				2				3				4								
					T	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	
350	355,6	300	323,9	6	5,6	5,6	5,6	5,6	5,6	8	7,1	8,0	7,8	7,1	10	8,8	10,0	9,6	8,8	12,5	10	12,5	10,8	10,0	
		250	273	14	5,6	5	5,6	5,7	5,0	8	6,3	8,0	8,0	6,3	10	8,8	10,0	9,9	8,8	12,5	10	12,5	12,4	10,0	
	200	219,1	22	5,6	4,5	5,6	5,8	4,5	8	6,3	8,0	8,2	6,3	10	7,1	10,0	10,1	7,1	12,5	8	12,5	12,6	8,0		
	150	168,3	29	5,6	4	5,6	6,0	4,0	8	4,5	8,0	8,5	4,5	10	5,6	10,0	10,5	5,6	12,5	7,1	12,5	13,0	7,1		
400	406,4	350	355,6	8	6,3	5,6	6,3	6,3	5,6	8,8	8	8,8	8,8	8,0	10	10	10,0	9,9	10,0	12,5	12,5	12,5	12,4	12,5	
		300	323,9	13	6,3	5,6	6,3	6,3	5,6	8,8	7,1	8,8	8,8	7,1	10	8,8	10,0	10,0	8,8	12,5	10	12,5	12,4	10,0	
	250	273	21	6,3	5	6,3	6,5	5,0	8,8	6,3	8,8	9,0	6,3	10	8,8	10,0	10,2	8,8	12,5	10	12,5	12,6	10,0		
	200	219,1	28	6,3	4,5	6,3	6,7	4,5	8,8	6,3	8,8	9,3	6,3	10	7,1	10,0	10,5	7,1	12,5	8	12,5	13,0	8,0		
450	457	400	406,4	7	6,3	6,3	6,3	6,3	6,3	10	8,8	10,0	9,8	8,8	11	10	11,0	10,9	10,0	12,5	12,5	12,5	12,4	12,5	
		350	355,6	14	6,3	5,6	6,3	6,4	5,6	10	8	10,0	10,0	8,0	11	10	11,0	11,0	10,0	12,5	12,5	12,5	12,4	12,5	
	300	323,9	18	6,3	5,6	6,3	6,4	5,6	10	7,1	10,0	10,1	7,1	11	8,8	11,0	11,1	8,8	12,5	10	12,5	12,5	10,0		
	250	273	25	6,3	5	6,3	6,6	5,0	10	6,3	10,0	10,4	6,3	11	8,8	11,0	11,4	8,8	12,5	10	12,5	12,8	10,0		
500	508	450	457	4	6,3	6,3	6,3	6,3	6,3	10	10	10,0	10,0	10,0	11	11	11,0	11,0	11,0	12,5	12,5	12,5	12,4	12,5	
		400	406,4	10	6,3	6,3	6,3	6,3	6,3	10	8,8	10,0	10,0	8,8	11	10	11,0	10,9	10,0	12,5	12,5	12,5	12,4	12,5	
	350	355,6	17	6,3	5,6	6,3	6,4	5,6	10	8	10,0	10,1	8,0	11	10	11,0	11,1	10,0	12,5	12,5	12,5	12,5	12,5		
	300	323,9	20	6,3	5,6	6,3	6,5	5,6	10	7,1	10,0	10,2	7,1	11	8,8	11,0	11,2	8,8	12,5	10	12,5	12,6	10,0		
600	610	500	508	10	6,3	6,3	6,3	6,3	6,3	10	10	10,0	10,0	10,0	12,5	11	12,5	12,4	11,0	17,5	12,5	17,5	14,8	12,5	
		450	457	15	6,3	6,3	6,3	6,4	6,3	10	10	10,0	10,1	10,0	12,5	11	12,5	12,5	11,0	17,5	12,5	17,5	16,6	12,5	
	400	406,4	21	6,3	6,3	6,3	6,6	6,3	10	8,8	10,0	10,3	8,8	12,5	10	12,5	12,8	10,0	17,5	12,5	17,5	17,6	12,5		
	300	323,9	20	6,3	5,6	6,3	6,5	5,6	10	7,1	10,0	10,0	10,0	10,0	11	12,5	12,5	12,5	12,5	25	17,5	25,0	19,9	17,5	
700	711	600	610	10	7,1	6,3	7,1	7,1	6,3	10	10	10,0	10,0	10,0	12,5	12,5	12,5	12,5	12,5	25	25	25,0	25,0	17,1	12,5
		500	508	15	7,1	6,3	7,1	7,2	6,3	10	10	10,0	10,2	10,0	12,5	11	12,5	12,6	11,0	25	12,5	25,0	17,1	12,5	
	400	406,4	25	7,1	6,3	7,1	7,5	6,3	10	8,8	10,0	10,6	8,8	12,5	10	12,5	13,0	10,0	25	12,5	25,0	22,1	12,5		
	300	323,9	20	7,1	6,3	7,1	7,1	7,1	10	10	10,0	10,0	10,0	10,0	11	12,5	12,5	12,5	12,5	25	25	25,0	24,7	25,0	
800	813	700	711	10	8	7,1	8,0	7,1	7,1	10	10	10,0	10,0	10,0	12,5	12,5	12,5	12,5	12,5	25	25	25,0	25,0	25,0	
		600	610	15	8	6,3	8,0	8,1	6,3	10	10	10,0	10,2	10,0	12,5	12,5	12,5	12,6	12,5	25	17,5	25,0	23,1	17,5	
	500	508	20	8	6,3	8,0	8,3	6,3	10	10	10,0	10,4	10,0	12,5	11	12,5	12,8	11,0	25	12,5	25,0	20,0	12,5		
	400	406,4	25	8	6,3	8,0	8,3	6,3	10	10	10,0	10,4	10,0	12,5	11	12,5	12,8	11,0	25	12,5	25,0	20,0	12,5		

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Table C.3 (continued)

DN	D	DN <sub>1</sub>	D <sub>1</sub>	α <sub>max</sub>	1				2				3				4								
					T	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	
900	914	800	813	10	10	8	10,0	10,0	9,0	8,0	12,5	10	12,5	11,3	10,0	20	12,5	20,0	13,9	12,5	25	25	25,0	24,7	25,0
						7,1	10,0	10,0	9,2	7,1	12,5	10	12,5	12,6	10,0	20	12,5	20,0	16,0	12,5	25	25	25,0	24,8	25,0
						6,3	10,0	10,0	9,7	6,9	12,5	10	12,5	12,8	10,0	20	12,5	20,0	19,0	12,5	25	17,5	25	25,0	25,1
1000	1016	900	914	10	10	10	10,0	10,0	10,0	10,0	12,5	12,5	12,5	12,5	12,5	20	20	20,0	19,9	20,0	25	25	25,0	24,8	25,0
						8	10,0	10,0	10,1	8,0	12,5	10	12,5	12,6	10,0	20	12,5	20,0	15,6	12,5	25	25	25,0	24,9	25,0
						7,1	10,0	10,0	10,5	(7,9)	12,5	10	12,5	12,9	10,0	20	12,5	20,0	18,1	12,5	25	25	25,0	25,2	25,0
1200	1219	1000	1016	11	10	10	10,0	10,0	10,2	10,0	12,5	12,5	12,5	12,5	12,5	20	20	20,0	19,9	20,0	25	25	25,0	24,8	25,0
						10	10,0	10,0	10,3	10,0	12,5	12,5	12,7	12,5	20	20	20,0	20,1	20,0	25	25	25,0	25,1	25,0	
						8	10,0	10,0	10,5	8,0	12,5	10	12,5	12,9	10,0	20	12,5	20,0	19,1	12,5	25	25	25,0	25,4	25,0

Table C.4 — Wall thickness of concentric reducers type B – wall thickness series 5 to 8

DN	D	DN <sub>1</sub>	D <sub>1</sub>	α <sub>max</sub>	5				6				7				8							
					T	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>
20	26,9	15	21,3	8	4	4	4,0	3,8	4,0	-	-	-	-	5,6	5	5,6	5,2	5,0	8	7,1	8,0	7,2	7,1	
																								4,5
25	33,7	15	21,3	12	4,5	4	4,5	4,3	4,0	-	-	-	-	6,3	5	6,3	5,8	5,0	8,8	7,1	8,8	7,7	7,1	
																								4,5
32	42,4	25	33,7	9	5	4,5	5,0	4,8	4,5	6,3	5,6	6,3	6,0	5,6	8	6,3	8,0	7,4	6,3	10	8,8	10,0	9,1	8,8
40	48,3	15	21,3	19	5	4	5,0	4,7	4,0	-	-	-	-	8	5	8,0	7,0	5,0	10	7,1	10,0	8,4	7,1	
																								5
50	60,3	25	33,7	10	5	4,5	5,0	4,8	4,5	6,3	5,6	6,3	6,0	5,6	8	6,3	8,0	7,5	6,3	10	8,8	10,0	9,2	8,8
65	76,1	40	48,3	7	5,6	5	5,6	5,5	5,0	7,1	6,3	7,1	6,9	6,3	8,8	8	8,8	8,4	8,0	11	10	11,0	10,4	10,0
80	88,9	25	33,7	16	5,6	4,5	5,6	5,4	4,5	7,1	5,6	7,1	6,7	5,6	8,8	6,3	8,8	8,1	6,3	11	8,8	11,0	9,9	8,8
100	114,3	50	60,3	9	7,1	5,6	7,1	6,8	5,6	8	7,1	8,0	7,7	7,1	10	8,8	10,0	9,5	8,8	14,2	11	14,2	12,8	11,0
100	114,3	32	42,4	18	7,1	5	7,1	6,8	5,0	8	6,3	8,0	7,5	6,3	10	8	10,0	9,2	8,0	14,2	10	14,2	12,5	10,0
100	114,3	65	76,1	7	8	7,1	8,0	7,8	7,1	8,8	8	8,8	8,6	8,0	11	10	11,0	10,6	10,0	16	14,2	16,0	15,2	14,2
100	114,3	40	48,3	22	8	5	8,0	7,6	5,0	8,8	6,3	8,8	8,3	6,3	11	8	11,0	10,2	8,0	16	10	16,0	14,0	10,0
100	114,3	80	88,9	13	8,8	8	8,8	8,5	8,0	11	8,8	11,0	10,5	8,8	14,2	11	14,2	13,3	11,0	17,5	16	17,5	16,2	16,0
100	114,3	50	60,3	26	8,8	5,6	8,8	8,6	5,6	11	7,1	11,0	10,5	7,1	14,2	8,8	14,2	13,1	8,8	17,5	11	17,5	15,6	11,0

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Table C.4 (continued)

DN	D	DN <sub>1</sub>	D <sub>1</sub>	α <sub>max</sub>	5				6				7				8						
					T	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>
125	139,7	100	114,3	10	8,8	10,0	9,7	8,8	12,5	11	12,5	12,0	11,0	16	14,2	16,0	15,3	14,2	20	17,5	20,0	18,8	17,5
		80	88,9	20	8	10,0	9,7	8,0	12,5	8,8	12,5	11,9	8,8	16	11	16,0	14,9	11,0	20	16	20,0	18,2	16,0
		65	76,1	25	7,1	10,0	9,7	7,1	12,5	8	12,5	11,9	8,0	16	10	16,0	14,9	10,0	20	14,2	20,0	18,0	14,2
		50	60,3	30	5,6	10,0	9,9	5,6	12,5	7,1	12,5	12,1	7,1	16	8,8	16,0	14,9	8,8	20	11	20,0	18,0	11,0
150	168,3	125	139,7	9	10	11,0	10,7	10,0	14,2	12,5	14,2	13,7	12,5	17,5	16	17,5	16,8	16,0	22,2	20	22,2	21,1	20,0
		100	114,3	19	8,8	11,0	10,7	8,8	14,2	11	14,2	13,6	11,0	17,5	14,2	17,5	16,4	14,2	22,2	17,5	22,2	20,4	17,5
		80	88,9	27	8	11,0	10,9	8,0	14,2	8,8	14,2	13,7	8,8	17,5	11	17,5	16,5	11,0	22,2	16	22,2	20,2	16,0
		65	76,1	31	7,1	11,0	11,0	7,1	14,2	8	14,2	13,8	8,0	17,5	10	17,5	16,6	10,0	22,2	14,2	22,2	20,2	14,2
200	219,1	150	168,3	18	12,5	12,5	12,2	11,0	16	14,2	16,0	15,4	14,2	17,5	17,5	17,5	16,8	17,5	22,2	22,2	22,2	20,9	22,2
		125	139,7	27	12,5	12,5	12,5	10,0	16	12,5	16,0	15,6	12,5	17,5	16	17,5	16,9	16,0	22,2	20	22,2	20,9	20,0
		100	114,3	33	12,5	12,5	12,8	8,8	16	11	16,0	16,0	11,0	17,5	14,2	17,5	17,3	14,2	22,2	17,5	22,2	21,2	17,5
		80	88,9	39	12,5	12,5	13,3	8,0	16	8,8	16,0	16,5	8,8	17,5	11	17,5	17,8	11,0	22,2	16	22,2	21,7	16,0
250	273	200	219,1	16	12,5	12,5	12,3	12,5	16	16	16,0	15,6	16,0	22,2	17,5	22,2	20,8	17,5	30	22,2	30,0	25,6	22,2
		150	168,3	30	12,5	12,5	12,8	11,0	16	14,2	16,0	16,1	14,2	22,2	17,5	22,2	21,6	17,5	30	22,2	30,0	28,1	22,2
		125	139,7	36	12,5	12,5	13,3	10,0	16	12,5	16,0	16,6	12,5	22,2	16	22,2	22,1	16,0	30	20	30,0	28,5	20,0
		100	114,3	40	12,5	12,5	13,7	8,8	16	11	16,0	17,1	11,0	22,2	14,2	22,2	22,6	14,2	30	17,5	30,0	28,9	17,5
300	323,9	250	273	12	12,5	12,5	12,3	12,5	17,5	16	17,5	17,1	16,0	25	22,2	25,0	24,1	22,2	32	30	32,0	30,5	30,0
		200	219,1	24	12,5	12,5	12,6	12,5	17,5	16	17,5	17,3	16,0	25	17,5	25,0	24,1	17,5	32	22,2	32,0	30,2	22,2
		150	168,3	35	12,5	12,5	13,4	11,0	17,5	14,2	17,5	18,2	14,2	25	17,5	25,0	25,0	17,5	32	22,2	32,0	30,9	22,2
		125	139,7	40	12,5	12,5	13,9	10,0	17,5	12,5	17,5	18,8	12,5	25	16	25,0	25,6	16,0	32	20	32,0	31,5	20,0

Table C.4 (continued)

DN	D	DN <sub>1</sub>	D <sub>1</sub>	α <sub>max</sub>	5				6				7				8						
					T	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>
350	355,6	300	323,9	6	16	12,5	16,0	13,4	12,5	17,5	20,0	18,8	17,5	28	25	28,0	26,7	25,0	36	32	36,0	34,0	32,0
		250	273	14	16	12,5	16,0	15,7	12,5	16	20,0	19,5	16,0	28	22,2	28,0	26,9	22,2	36	30	36,0	34,1	30,0
		200	219,1	22	16	12,5	16,0	15,9	12,5	16	20,0	19,6	16,0	28	17,5	28,0	26,9	17,5	36	22,2	36,0	33,8	22,2
		150	168,3	29	16	11	16,0	16,3	11,0	20	14,2	20,0	20,1	14,2	28	17,5	28,0	27,3	17,5	36	22,2	36,0	34,1
400	406,4	350	355,6	8	17,5	16	17,5	17,2	16,0	22,2	22,2	21,7	20,0	30	28	30,0	29,2	28,0	40	36	40,0	38,6	36,0
		300	323,9	13	17,5	12,5	17,5	15,3	12,5	22,2	22,2	21,4	17,5	30	25	30,0	28,9	25,0	40	32	40,0	38,0	32,0
		250	273	21	17,5	12,5	17,5	17,4	12,5	22,2	22,2	21,8	16,0	30	22,2	30,0	28,9	22,2	40	30	40,0	37,7	30,0
		200	219,1	28	17,5	12,5	17,5	17,8	12,5	22,2	22,2	22,2	16,0	30	17,5	30,0	29,3	17,5	40	22,2	40,0	37,9	22,2
450	457	400	406,4	7	17,5	17,5	17,5	17,3	17,5	22,2	22,2	21,8	22,2	32	30	32,0	31,2	30,0	45	40	45,0	43,5	40,0
		350	355,6	14	17,5	16	17,5	17,2	16,0	22,2	22,2	21,7	20,0	32	28	32,0	30,9	28,0	45	36	45,0	42,7	36,0
		300	323,9	18	17,5	12,5	17,5	17,3	12,5	22,2	22,2	21,8	17,5	32	25	32,0	30,8	25,0	45	32	45,0	42,4	32,0
		250	273	25	17,5	12,5	17,5	17,7	12,5	22,2	22,2	22,2	16,0	32	22,2	32,0	31,1	22,2	45	30	45,0	42,4	30,0
500	508	450	457	4	17,5	17,5	17,5	17,4	17,5	25	25,0	24,4	22,2	36	32	36,0	35,0	32,0	50	45	50,0	49,0	45,0
		400	406,4	10	17,5	17,5	17,5	17,3	17,5	25	25,0	24,5	22,2	36	30	36,0	34,9	30,0	50	40	50,0	47,9	40,0
		350	355,6	17	17,5	16	17,5	17,4	16,0	25	25,0	24,5	20,0	36	28	36,0	34,7	28,0	50	36	50,0	47,2	36,0
		300	323,9	20	17,5	12,5	17,5	17,5	12,5	25	17,5	25,0	24,6	17,5	36	25	36,0	34,7	25,0	50	32	50,0	47,1
600	610	500	508	10	25	17,5	25,0	20,5	17,5	30	30,0	29,3	25,0	45	36	45,0	41,6	36,0	60	50	60,0	57,4	50,0
		450	457	15	25	17,5	25,0	22,9	17,5	30	30,0	28,9	22,2	45	32	45,0	40,8	32,0	60	45	60,0	56,8	45,0
		400	406,4	21	25	17,5	25,0	24,8	17,5	30	30,0	29,6	22,2	45	30	45,0	43,3	30,0	60	40	60,0	56,5	40,0

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Table C.5 — Wall thickness of eccentric reducers type B — wall thickness series 1 to 4

DN	D	DN <sub>1</sub>	D <sub>1</sub>	α <sub>max</sub>	1				2				3				4									
					T	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>		
20	26,9	15	21,3	15	-	2,3	2	2,3	2,2	2,0	2,6	2,6	2,5	2,6	3,2	3,2	2,6	2,6	2,6	2,6	2,6	3,2	3,2	3,2	3,0	3,2
25	33,7	20	26,9	13	-	2,6	2,3	2,6	2,5	2,3	3,2	3,2	3,1	3,2	4	4	2,6	2,6	2,6	2,6	2,6	4	4	4	3,8	3,2
32	42,4	15	21,3	24	-	2,6	2	2,6	2,6	2,0	3,2	3,2	3,1	3,2	4	4	2,6	2,6	2,6	2,6	2,6	4	4	4	3,7	3,2
32	42,4	25	33,7	16	-	2,6	2,6	2,6	2,6	2,6	3,6	3,6	3,5	3,6	4	4	3,2	3,6	3,6	3,5	3,2	4	4	4	3,8	4,0
32	42,4	20	26,9	30	-	2,6	2,3	2,6	2,6	2,3	3,6	3,6	3,5	3,6	4	4	2,6	3,6	3,6	3,5	2,6	4	4	4	3,9	3,2
32	42,4	15	21,3	42	-	2,6	2	2,6	2,8	2,0	3,6	3,6	3,7	3,6	4	4	2,6	3,6	3,6	3,7	2,6	4	4	4	4,1	3,2
40	48,3	32	42,4	8	-	2,6	2,6	2,6	2,6	2,6	3,6	3,6	3,5	3,6	4	4	3,6	3,6	3,6	3,5	3,6	4	4	4	3,9	4,0
40	48,3	25	33,7	19	-	2,6	2,6	2,6	2,6	2,6	3,6	3,6	3,5	3,6	4	4	3,2	3,6	3,6	3,5	3,2	4	4	4	3,9	4,0
40	48,3	20	26,9	28	-	2,6	2,3	2,6	2,7	2,3	3,6	3,6	3,6	3,6	4	4	2,6	3,6	3,6	3,6	2,6	4	4	4	3,9	3,2
50	60,3	40	48,3	13	-	2,9	2,6	2,9	2,9	2,6	3,6	3,6	3,5	3,6	4	4	3,6	3,6	3,6	3,5	3,6	4	4	4	3,9	4,0
50	60,3	32	42,4	20	-	2,9	2,6	2,9	2,9	2,6	3,6	3,6	3,5	3,6	4	4	3,6	3,6	3,6	3,5	3,6	4	4	4	3,9	4,0
50	60,3	25	33,7	29	-	2,9	2,6	2,9	3,0	2,6	3,6	3,6	3,6	3,6	4	4	3,2	3,6	3,6	3,6	3,2	4	4	4	4,0	4,0
50	60,3	20	26,9	36	-	2,9	2,3	2,9	3,1	2,3	3,6	3,6	3,8	3,6	4	4	2,6	3,6	3,6	3,8	2,6	4	4	4	4,1	3,2
65	76,1	50	60,3	15	-	2,9	2,9	2,9	2,9	2,9	3,6	3,6	3,6	3,6	5,6	5,6	3,6	3,6	3,6	3,6	3,6	5,6	5,6	5,6	4,8	4,0
65	76,1	40	48,3	27	-	2,9	2,6	2,9	3,0	2,6	3,6	3,6	3,7	3,6	5,6	5,6	3,6	3,6	3,6	3,7	3,6	5,6	5,6	5,6	5,5	4,0
65	76,1	32	42,4	34	-	2,9	2,6	2,9	3,1	2,6	3,6	3,6	3,8	3,6	5,6	5,6	3,6	3,6	3,6	3,8	3,6	5,6	5,6	5,6	5,6	4,0
65	76,1	25	33,7	42	-	2,9	2,6	2,9	3,3	2,6	3,6	3,6	4,0	3,6	5,6	5,6	3,2	3,6	4,0	4,0	3,2	5,6	5,6	5,6	5,9	4,0
80	88,9	65	76,1	13	-	3,2	2,9	3,2	3,2	2,9	4	4	4,0	3,6	5,6	5,6	3,6	4,0	4,0	4,0	3,6	5,6	5,6	5,6	5,5	5,6
80	88,9	50	60,3	30	-	3,2	2,9	3,2	3,4	2,9	4	4	4,1	3,6	5,6	5,6	3,6	4,0	4,1	4,1	3,6	5,6	5,6	5,6	5,6	4,0
80	88,9	40	48,3	44	-	3,2	2,6	3,2	3,8	2,6	4	4	4,6	3,6	5,6	5,6	3,6	4,0	4,6	4,6	3,6	5,6	5,6	5,6	6,1	4,0
80	88,9	32	42,4	50	-	3,2	2,6	3,2	4,0	2,6	4	4	4,9	3,6	5,6	5,6	3,6	4,0	4,9	4,9	3,6	5,6	5,6	5,6	6,5	4,0

Table C.5 (continued)

DN	D	DN <sub>1</sub>	D <sub>1</sub>	α <sub>max</sub>	1				2				3				4							
					T	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>
100	114,3	80	88,9	24	-	-	-	-	3,6	3,2	3,6	3,7	3,2	3,2	4,5	4	4,5	4,6	4,0	6,3	5,6	6,3	6,3	5,6
		65	76,1	37	-	-	-	-	3,6	2,9	3,6	4,0	2,9	2,9	4,5	3,6	4,5	4,9	3,6	6,3	5,6	6,3	6,3	5,6
		50	60,3	51	-	-	-	-	3,6	2,9	3,6	4,7	2,9	2,9	4,5	3,6	4,5	5,7	3,6	6,3	4	6,3	7,5	4,0
		40	48,3	60	-	-	-	-	3,6	2,6	(4,2)	5,3	2,6	2,6	4,5	3,6	(4,9)	6,4	3,6	6,3	4	6,3	8,4	4,0
125	139,7	100	114,3	18	-	-	-	-	4	3,6	4,0	4,0	3,6	3,6	5	4,5	5,0	5,0	4,5	6,3	6,3	6,3	6,3	6,3
		80	88,9	35	-	-	-	-	4	3,2	4,0	4,4	3,2	3,2	5	4	5,0	5,4	4,0	6,3	5,6	6,3	6,7	5,6
		65	76,1	43	-	-	-	-	4	2,9	4,0	4,7	2,9	2,9	5	3,6	5,0	5,8	3,6	6,3	5,6	6,3	7,1	5,6
		50	60,3	51	-	-	-	-	4	2,9	4,0	5,2	2,9	2,9	5	3,6	5,0	6,4	3,6	6,3	4	6,3	7,8	4,0
150	168,3	125	139,7	18	-	-	-	-	4,5	4	4,5	4,5	4,0	4,0	5,6	5	5,6	5,6	5,0	7,1	6,3	7,1	7,0	6,3
		100	114,3	34	-	-	-	-	4,5	3,6	4,5	4,9	3,6	3,6	5,6	4,5	5,6	6,0	4,5	7,1	6,3	7,1	7,5	6,3
		80	88,9	48	-	-	-	-	4,5	3,2	4,5	5,7	3,2	3,2	5,6	4	5,6	6,9	4,0	7,1	5,6	7,1	8,5	5,6
		65	76,1	52	-	-	-	-	4,5	2,9	(4,7)	6,0	2,9	2,9	5,6	3,6	5,6	7,3	3,6	7,1	5,6	7,1	8,9	5,6
200	219,1	150	168,3	31	4,5	4	4,5	4,9	(4,2)	6,3	4,5	6,3	6,2	(5,1)	7,1	5,6	7,1	7,5	(5,9)	8	7,1	8,0	8,4	7,1
		125	139,7	45	-	-	-	-	6,3	4	6,3	7,6	(5,1)	(5,1)	7,1	5	7,1	8,5	(5,6)	8	6,3	8,0	9,4	6,3
		100	114,3	55	-	-	-	-	6,3	3,6	(6,8)	8,7	(4,2)	(4,2)	7,1	4,5	(7,4)	9,7	4,5	8	6,3	8,0	10,7	6,3
		80	88,9	60	-	-	-	-	6,3	3,2	(7,6)	9,4	3,2	3,2	7,1	4	(8,2)	10,4	4,0	8	5,6	(8,8)	11,5	5,6
250	273	200	219,1	28	5	4,5	5,0	5,3	(4,8)	6,3	6,3	6,7	6,3	6,3	8,8	7,1	8,8	9,1	(7,3)	10	8	10,0	10,3	8,0
		150	168,3	48	5	4	(5,5)	6,5	(4,7)	6,3	4,5	(6,4)	8,0	(5,5)	8,8	5,6	8,8	10,9	(6,8)	10	7,1	10,0	12,2	(7,5)
		125	139,7	55	-	-	-	-	6,3	4	(7,4)	8,9	(4,4)	(4,4)	8,8	5	(9,1)	12,0	(5,4)	10	6,3	10,0	13,4	6,3
		100	114,3	60	-	-	-	-	6,3	3,6	(8,2)	9,7	3,6	3,6	8,8	4,5	(10,2)	12,9	4,5	10	6,3	(11,0)	14,4	6,3
300	323,9	250	273	23	5,6	5	5,6	5,8	(5,3)	7,1	6,3	7,1	7,3	6,3	8,8	8,8	8,8	9,0	8,8	10	10	10,0	10,2	10,0
		200	219,1	44	5,6	4,5	(5,8)	6,9	(5,8)	7,1	6,3	7,1	8,7	(6,8)	8,8	7,1	8,8	10,5	(7,9)	10	8	10,0	11,8	(8,6)
		150	168,3	55	5,6	4	(7,3)	8,1	(4,4)	7,1	4,5	(8,5)	10,1	(5,1)	8,8	5,6	(9,7)	12,2	(5,9)	10	7,1	(10,5)	13,7	7,1
		125	139,7	60	-	-	-	-	7,1	4	(9,4)	11,0	4,0	4,0	8,8	5	(10,8)	13,2	5,0	10	6,3	(11,7)	14,8	6,3

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Table C.5 (continued)

DN	D	DN <sub>1</sub>	D <sub>1</sub>	α <sub>max</sub>	1				2				3				4								
					T	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	
350	355,6	300	323,9	8	5,6	5,6	5,6	5,6	5,6	8	7,1	8,0	7,8	7,1	10	8,8	10,0	9,6	8,8	12,5	10	12,5	10,8	10,0	
		250	273	25	5,6	5	5,6	5,9	5,0	8	6,3	8,0	8,3	(6,4)	10	8,8	10,0	10,3	8,8	12,5	10	12,5	12,7	10,0	
		200	219,1	37	5,6	4,5	5,6	6,5	4,7	8	6,3	8,0	9,0	6,3	6,3	10	7,1	10,0	11,1	7,1	12,5	8	12,5	13,7	(8,1)
		150	168,3	47	5,6	4	(6,4)	7,2	4,0	8	4,5	8,0	10,1	4,5	4,5	10	5,6	10,0	12,4	5,6	12,5	7,1	12,5	15,1	7,1
400	406,4	350	355,6	15	6,3	5,6	6,3	6,4	5,6	8,8	8	8,8	8,8	8,0	10	10	10,0	10,0	10,0	12,5	12,5	12,5	12,4	12,5	
		300	323,9	24	6,3	5,6	6,3	6,6	(5,8)	8,8	7,1	8,8	9,1	(7,4)	10	8,8	10,0	10,3	8,8	12,5	10	12,5	12,7	10,0	
		250	273	36	6,3	5	6,3	7,2	(5,9)	8,8	6,3	8,8	9,9	(7,4)	10	8,8	10,0	11,1	8,8	12,5	10	12,5	13,7	10,0	
		200	219,1	46	6,3	4,5	(7,1)	8,0	5,0	8,8	6,3	8,8	11,0	6,3	6,3	10	7,1	10,0	12,4	7,1	12,5	8	12,5	15,1	8,0
450	457	400	406,4	11	6,3	6,3	6,3	6,3	6,3	10	8,8	10,0	9,9	8,8	11	10	11,0	10,9	10,0	12,5	12,5	12,5	12,4	12,5	
		350	355,6	24	6,3	5,6	6,3	6,6	(5,8)	10	8	10,0	10,3	(8,1)	11	10	11,0	11,3	10,0	12,5	12,5	12,5	12,8	12,5	
		300	323,9	31	6,3	5,6	6,3	6,9	(6,0)	10	7,1	10,0	10,8	(8,2)	11	8,8	11,0	11,8	8,8	12,5	10	12,5	13,3	10,0	
		250	273	41	6,3	5	(6,6)	7,6	5,6	10	6,3	10,0	11,8	(7,6)	11	8,8	11,0	12,8	8,8	12,5	10	12,5	14,5	10,0	
500	508	450	457	8	6,3	6,3	6,3	6,3	6,3	10	10	10,0	10,0	10,0	11	11	11,0	10,9	11,0	12,5	12,5	12,5	12,4	12,5	
		400	406,4	18	6,3	6,3	6,3	6,5	6,3	10	8,8	10,0	10,1	8,8	11	10	11,0	11,1	10,0	12,5	12,5	12,5	12,6	12,5	
		350	355,6	27	6,3	5,6	6,3	6,7	5,6	10	8	10,0	10,5	8,0	8,0	11	10	11,0	11,5	10,0	12,5	12,5	12,5	13,0	12,5
		300	323,9	32	6,3	5,6	6,3	7,0	5,6	10	7,1	10,0	10,9	7,4	7,4	11	8,8	11,0	11,9	8,8	12,5	10	12,5	13,5	10,0
600	610	500	508	17	6,3	6,3	6,3	6,4	6,3	10	10	10,0	10,1	10,0	12,5	11	12,5	12,6	11,0	17,5	12,5	17,5	14,9	12,5	
		450	457	27	6,3	6,3	6,3	6,8	6,5	10	10	10,0	10,6	10,0	10,0	12,5	11	12,5	13,1	11,0	17,5	12,5	17,5	17,3	(12,8)
		400	406,4	35	6,3	6,3	(6,4)	7,2	6,6	10	8,8	10,0	11,3	(8,9)	12,5	10	12,5	13,9	(10,3)	17,5	12,5	17,5	19,1	(13,0)	
		600	610	19	7,1	6,3	7,1	7,3	(7,3)	10	10	10,0	10,3	10,0	10,0	12,5	12,5	12,5	12,7	12,5	25	17,5	25,0	20,2	17,5
700	711	500	508	34	7,1	6,3	7,1	8,1	8,5	10	10	10,0	11,3	(10,8)	12,5	11	12,5	13,9	(12,5)	25	12,5	25,0	18,7	(15,0)	
		400	406,4	45	7,1	6,3	(9,1)	9,1	7,5	10	8,8	(11,4)	12,6	9,4	12,5	10	(13,1)	15,6	10,7	25	12,5	25,0	25,9	(14,8)	



Table C.5 (continued)

DN	D	1				2				3				4									
		T	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>		
800	813	19	711	7,1	8,0	8,2	(8,2)	10	10,0	10,4	10,0	10,0	10,0	12,5	12,5	12,5	12,5	12,5	25	25	25,0	25,0	25,0
			610	6,3	8,0	9,1	(10,3)	10	10,0	11,4	(12,0)	12,5	12,5	12,5	14,0	(14,0)	25	17,5	25,0	25,1	(20,3)		
			508	6,3	(10,3)	10,3	(9,8)	10	(11,9)	12,7	(11,3)	12,5	11	(13,7)	15,7	(13,0)	25	12,5	25,0	24,1	(16,7)		
900	914	19	813	8	10,0	9,2	(9,6)	12,5	12,5	11,6	(11,1)	20	12,5	20,0	14,2	(13,1)	25	25	25,0	25,1	25,0		
			711	7,1	10,0	10,4	(12,2)	12,5	10	12,5	14,0	(14,4)	20	12,5	20,0	17,7	(17,0)	25	25	25,0	27,1	25,0	
			610	6,3	(12,0)	12,1	(11,8)	12,5	10	(14,3)	15,8	(14,9)	20	12,5	20,0	23,1	(18,3)	25	17,5	25,0	30,2	(22,8)	
1000	1016	19	914	10	10,0	10,4	(10,8)	12,5	12,5	12,8	12,5	12,5	20	20	20,0	20,2	20,0	25	25	25,0	25,1	25,0	
			813	8	10,0	11,4	(14,2)	12,5	10	12,5	14,1	(16,0)	20	12,5	20,0	17,3	(18,2)	25	25	25,0	27,3	25,0	
			711	7,1	(12,9)	12,9	(13,9)	12,5	10	(14,9)	15,9	(15,6)	20	12,5	20,0	22,2	(19,7)	25	25	25,0	30,4	25,0	
1200	1219	30	1016	10	10,0	11,1	(15,0)	12,5	12,5	13,7	(16,9)	20	20	20,0	21,6	(21,9)	25	25	25,0	26,7	(25,5)		
			914	10	(12,6)	12,6	(15,9)	12,5	12,5	(14,6)	15,2	(18,2)	20	20	20,0	23,9	(23,2)	25	25	25,0	29,4	(26,9)	
			813	8	(15,0)	15,0	(14,0)	12,5	10	(17,3)	17,3	(16,5)	20	12,5	(22,4)	24,8	(21,5)	25	25	(26,9)	32,5	(25,8)	

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Table C.6 — Wall thickness of eccentric reducers type B – wall thickness series 5 to 8

DN	D	DN <sub>1</sub>	D <sub>1</sub>	C <sub>max</sub>	5				6				7				8						
					T	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>
20	26,9	15	21,3	15	4	4	4,0	3,7	4,0	-	-	-	5,6	5	5,6	5,0	5,0	5,0	8	7,1	8,0	6,5	7,1
		25	33,7	13	4,5	4	4,5	4,2	4,0	5,6	4,5	5,6	5,2	6,3	5,6	6,3	5,7	5,6	8,8	8	8,8	7,6	8,0
32	42,4	15	21,3	24	4,5	4	4,5	4,1	4,0	-	-	-	6,3	5	6,3	5,5	5,0	8,8	7,1	8,8	6,9	7,1	
		25	33,7	16	5	4,5	5,0	4,7	4,5	6,3	5,6	6,3	5,8	8	6,3	8,0	7,1	6,3	10	8,8	10,0	8,6	8,8
40	48,3	20	26,9	30	5	4	5,0	4,7	4,0	6,3	4,5	6,3	5,6	8	5,6	8,0	6,8	5,6	10	8	10,0	7,8	8,0
		15	21,3	42	5	4	5,0	4,8	4,0	-	-	-	8	5	8,0	6,6	5,0	10	7,1	10,0	7,4	7,1	
50	60,3	32	42,4	8	5	5	5,0	4,9	5,0	6,3	6,3	6,1	6,3	8	8	8,0	7,6	8,0	10	10	10,0	9,3	10,0
		25	33,7	19	5	4,5	5,0	4,7	4,5	6,3	5,6	6,3	5,8	8	6,3	8,0	7,2	6,3	10	8,8	10,0	8,6	8,8
65	76,1	20	26,9	28	5	4	5,0	4,8	4,0	6,3	4,5	6,3	5,8	8	5,6	8,0	7,0	5,6	10	8	10,0	8,3	8,0
		40	48,3	13	5,6	5	5,6	5,4	5,0	7,1	6,3	7,1	6,7	8,8	8	8,8	8,2	8,0	11	10	11,0	10,0	10,0
80	88,9	32	42,4	20	5,6	5	5,6	5,3	5,0	7,1	6,3	7,1	6,6	8,8	8	8,8	8,0	8,0	11	10	11,0	9,7	10,0
		25	33,7	29	5,6	4,5	5,6	5,4	4,5	7,1	5,6	7,1	6,6	8,8	6,3	8,8	7,9	6,3	11	8,8	11,0	9,4	8,8
80	88,9	40	48,3	36	5,6	4	5,6	5,5	4,0	7,1	4,5	7,1	6,7	8,8	5,6	8,8	7,9	5,6	11	8	11,0	9,3	8,0
		50	60,3	15	7,1	5,6	7,1	6,7	5,6	8	7,1	8,0	7,6	10	8,8	10,0	9,3	8,8	14,2	11	14,2	12,4	11,0
80	88,9	40	48,3	27	7,1	5	7,1	6,8	5,0	8	6,3	8,0	7,5	10	8	10,0	9,1	8,0	14,2	10	14,2	12,1	10,0
		32	42,4	34	7,1	5	7,1	6,9	5,0	8	6,3	8,0	7,7	10	8	10,0	9,2	8,0	14,2	10	14,2	11,9	10,0
80	88,9	25	33,7	42	7,1	4,5	7,1	7,2	4,5	8	5,6	8,0	7,9	10	6,3	10,0	9,3	6,3	14,2	8,8	14,2	11,8	8,8
		65	76,1	13	8	7,1	8,0	7,7	7,1	8,8	8	8,8	8,4	8,0	11	10	11,0	10,4	10,0	16	14,2	16,0	14,6
80	88,9	50	60,3	30	8	5,6	8,0	7,7	5,6	8,8	7,1	8,8	8,4	11	8,8	11,0	10,2	8,8	16	11	16,0	13,7	11,0
		40	48,3	44	8	5	8,0	8,2	5,0	8,8	6,3	8,8	8,9	6,3	11	8	11,0	10,5	8,0	16	10	16,0	13,4
80	88,9	32	42,4	50	8	5	8,0	8,6	5,0	8,8	6,3	8,8	9,2	11	8	11,0	10,8	8,0	16	10	16,0	13,4	10,0

Table C.6 (continued)

DN	D	DN <sub>1</sub>	D <sub>1</sub>	C <sub>max</sub>	5				6				7				8							
					T	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>
100	114,3	80	88,9	24	8,8	8	8,8	8,5	8,0	11	8,8	11,0	10,4	8,8	14,2	11	14,2	13,0	11,0	17,5	16	17,5	15,6	16,0
					8,8	7,1	8,8	8,9	7,1	11	8	11,0	10,8	8,0	14,2	10	14,2	13,2	10,0	17,5	14,2	17,5	15,5	14,2
					8,8	5,6	8,8	9,8	5,6	11	7,1	11,0	11,7	7,1	14,2	8,8	14,2	13,9	8,8	17,5	11	17,5	15,8	11,0
					8,8	5	8,8	10,8	5,0	11	6,3	11,0	12,5	6,3	14,2	8	14,2	14,5	8,0	17,5	10	17,5	16,0	10,0
125	139,7	100	114,3	18	10	8,8	10,0	9,7	8,8	12,5	11	12,5	11,9	11,0	16	14,2	16,0	14,9	14,2	20	17,5	20,0	18,3	17,5
					10	8	10,0	10,1	8,0	12,5	8,8	12,5	12,3	8,8	16	11	16,0	15,1	11,0	20	16	20,0	18,0	16,0
					10	7,1	10,0	10,6	7,1	12,5	8	12,5	12,8	8,0	16	10	16,0	15,5	10,0	20	14,2	20,0	18,2	14,2
					10	5,6	10,0	11,4	5,6	12,5	7,1	12,5	13,5	7,1	16	8,8	16,0	16,1	8,8	20	11	20,0	18,6	11,0
150	168,3	125	139,7	18	11	10	11,0	10,7	10,0	14,2	12,5	14,2	13,6	12,5	17,5	16	17,5	16,5	16,0	22,2	20	22,2	20,4	20,0
					11	8,8	11,0	11,2	8,8	14,2	11	14,2	14,0	11,0	17,5	14,2	17,5	16,7	14,2	22,2	17,5	22,2	20,3	17,5
					11	8	11,0	12,3	8,0	14,2	8,8	14,2	15,2	8,8	17,5	11	17,5	17,8	11,0	22,2	16	22,2	21,0	16,0
					11	7,1	11,0	12,8	7,1	14,2	8	14,2	15,7	8,0	17,5	10	17,5	18,2	10,0	22,2	14,2	22,2	21,4	14,2
200	219,1	150	168,3	31	12,5	11	12,5	12,7	11,0	16	14,2	16,0	15,8	14,2	17,5	17,5	17,5	17,1	17,5	22,2	22,2	22,2	21,1	22,2
					12,5	10	12,5	13,9	10,0	16	12,5	16,0	17,2	12,5	17,5	16	17,5	18,5	16,0	22,2	20	22,2	22,3	20,0
					12,5	8,8	12,5	15,5	8,8	16	11	16,0	18,8	11,0	17,5	14,2	17,5	20,1	14,2	22,2	17,5	22,2	23,8	17,5
					12,5	8	12,5	16,5	8,0	16	8,8	16,0	19,8	8,8	17,5	11	17,5	21,1	11,0	22,2	16	22,2	24,7	16,0
250	273	200	219,1	28	12,5	12,5	12,5	12,7	12,5	16	16	16,0	16,0	16,0	22,2	17,5	22,2	21,1	17,5	30	22,2	30,0	25,6	22,2
					12,5	11	12,5	14,8	11,0	16	14,2	16,0	18,3	14,2	22,2	17,5	22,2	23,9	17,5	30	22,2	30,0	30,0	22,2
					12,5	10	12,5	16,1	10,0	16	12,5	16,0	19,7	12,5	22,2	16	22,2	25,4	16,0	30	20	30,0	31,3	20,0
					12,5	8,8	12,5	17,3	8,8	16	11	16,0	21,0	11,0	22,2	14,2	22,2	26,6	14,2	30	17,5	30,0	32,3	17,5
300	323,9	250	273	23	12,5	12,5	12,5	12,6	12,5	17,5	16	17,5	17,3	16,0	25	22,2	25,0	24,1	22,2	32	30	32,0	30,1	30,0
					12,5	12,5	12,5	14,5	12,5	17,5	16	17,5	19,5	16,0	25	17,5	25,0	26,3	17,5	32	22,2	32,0	32,1	22,2
					12,5	11	12,5	16,6	11,0	17,5	14,2	17,5	21,9	14,2	25	17,5	25,0	28,9	17,5	32	22,2	32,0	34,6	22,2
					12,5	10	12,5	17,8	10,0	17,5	12,5	17,5	23,4	12,5	25	16	25,0	30,5	16,0	32	20	32,0	35,9	20,0

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Table C.6 (continued)

DN	D	DN <sub>1</sub>	D <sub>1</sub>	C <sub>max</sub>	5				6				7				8							
					T	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>
350	355,6	300	323,9	8	16	12,5	16,0	13,4	12,5	20	17,5	20,0	18,7	17,5	28	25	28,0	26,6	25,0	36	32	36,0	33,7	32,0
		250	273	25	16	12,5	16,0	16,0	12,5	20	16	20,0	19,8	16,0	28	22,2	28,0	27,0	22,2	36	30	36,0	33,9	30,0
		200	219,1	37	16	12,5	16,0	17,1	12,5	20	16	20,0	21,0	16,0	28	17,5	28,0	28,2	17,5	36	22,2	36,0	34,8	22,2
		150	168,3	47	16	11	16,0	18,8	11,0	20	14,2	20,0	22,7	14,2	28	17,5	28,0	30,1	17,5	36	22,2	36,0	36,6	22,2
400	406,4	350	355,6	15	17,5	16	17,5	17,2	16,0	22,2	20	22,2	21,6	20,0	30	28	30,0	28,8	28,0	40	36	40,0	37,9	36,0
		300	323,9	24	17,5	12,5	17,5	15,7	12,5	22,2	17,5	22,2	21,7	17,5	30	25	30,0	29,0	25,0	40	32	40,0	37,7	32,0
		250	273	36	17,5	12,5	17,5	18,7	12,5	22,2	16	22,2	23,2	16,0	30	22,2	30,0	30,3	22,2	40	30	40,0	38,7	30,0
		200	219,1	46	17,5	12,5	17,5	20,4	12,5	22,2	16	22,2	25,1	16,0	30	17,5	30,0	32,3	17,5	40	22,2	40,0	40,7	22,2
450	457	400	406,4	11	17,5	17,5	17,5	17,2	17,5	22,2	22,2	22,2	21,7	22,2	32	30	32,0	31,0	30,0	45	40	45,0	42,9	40,0
		350	355,6	24	17,5	16	17,5	17,6	16,0	22,2	20	22,2	22,1	20,0	32	28	32,0	31,1	28,0	45	36	45,0	42,4	36,0
		300	323,9	31	17,5	12,5	17,5	18,2	12,5	22,2	17,5	22,2	22,7	17,5	32	25	32,0	31,7	25,0	45	32	45,0	42,9	32,0
		250	273	41	17,5	12,5	17,5	19,7	12,5	22,2	16	22,2	24,3	16,0	32	22,2	32,0	33,5	22,2	45	30	45,0	44,5	30,0
500	508	450	457	8	17,5	17,5	17,5	17,3	17,5	25	22,2	25,0	24,2	22,2	36	32	36,0	34,6	32,0	50	45	50,0	48,2	45,0
		400	406,4	18	17,5	17,5	17,5	17,4	17,5	25	22,2	25,0	24,5	22,2	36	30	36,0	34,7	30,0	50	40	50,0	47,1	40,0
		350	355,6	27	17,5	16	17,5	18,0	16,0	25	20	25,0	25,1	20,0	36	28	36,0	35,2	28,0	50	36	50,0	47,3	36,0
		300	323,9	32	17,5	12,5	17,5	18,5	12,5	25	17,5	25,0	25,7	17,5	36	25	36,0	35,8	25,0	50	32	50,0	47,8	32,0
600	610	500	508	17	25	17,5	25,0	20,6	17,5	30	25	30,0	29,4	25,0	45	36	45,0	41,4	36,0	60	50	60,0	56,6	50,0
		450	457	27	25	17,5	25,0	23,7	17,5	30	22,2	30,0	29,7	22,2	45	32	45,0	41,4	32,0	60	45	60,0	56,7	45,0
		400	406,4	35	25	17,5	25,0	26,6	17,5	30	22,2	30,0	31,4	22,2	45	30	45,0	45,2	30,0	60	40	60,0	57,9	40,0

## C.5 Caps

Table C.7 shows wall thicknesses at the body of caps of type B.

The calculation was done for an inside knuckle radius  $r = 0,15 D$  and an inside spherical radius  $R1 = 0,8 D$ . Smaller inside knuckle radii ( $r < 0,15 D$ ) or larger inside spherical radii ( $R1 > 0,8 D$ ) of the ellipsoidal end may result in larger wall thicknesses, especially for small ratios of wall thickness to diameter showing increased wall thicknesses at the body of the cap.

For caps with an inside knuckle radius  $r < 0,15 D$  or with an inside spherical radius  $R > 0,8 D$  the wall thickness at the body of the cap shall be calculated in accordance with Annex A.

For some dimensions no wall thicknesses at the body of the cap are listed. In these cases the dimensions of the cap are outside the range of validity of the calculation procedures given in Annex A.

Smaller wall thicknesses than listed in Table C.7 are acceptable provided that they are calculated in accordance with Annex A.

**Table C.7 — Wall thickness of caps**

DN	D	1		2		3		4		5		6		7		8	
		T	T <sub>c</sub>	T	T <sub>c</sub>	T	T <sub>c</sub>	T	T <sub>c</sub>	T	T <sub>c</sub>	T	T <sub>c</sub>	T	T <sub>c</sub>	T	T <sub>c</sub>
15	21,3	-	-	2	-	2,6	-	3,2	-	4	-	-	-	5	-	7,1	-
20	26,9	-	-	2,3	-	2,6	-	3,2	-	4	-	4,5	-	5,6	-	8	-
25	33,7	-	-	2,6	-	3,2	-	4	-	4,5	-	5,6	-	6,3	-	8,8	-
32	42,4	-	-	2,6	-	3,6	-	4	-	5	-	6,3	-	8	-	10	-
40	48,3	-	-	2,6	2,6	3,6	-	4	-	5	-	6,3	-	8	-	10	-
50	60,3	-	-	2,9	2,9	3,6	-	4	-	5,6	-	7,1	-	8,8	-	11	-
65	76,1	-	-	2,9	2,9	3,6	3,6	5,6	-	7,1	-	8	-	10	-	14,2	-
80	88,9	-	-	3,2	3,2	4	4,0	5,6	-	8	-	8,8	-	11	-	16	-
100	114,3	-	-	3,6	3,6	4,5	4,5	6,3	6,3	8,8	-	11	-	14,2	-	17,5	-
125	139,7	-	-	4	4,0	5	5,0	6,3	6,3	10	-	12,5	-	16	-	20	-
150	168,3	4	4,0	4,5	4,5	5,6	5,6	7,1	7,1	11	-	14,2	-	17,5	-	22,2	-
200	219,1	4,5	4,5	6,3	6,3	7,1	7,1	8	8,0	12,5	12,5	16	-	17,5	-	22,2	-
250	273	5	5,0	6,3	6,3	8,8	8,8	10	10,0	12,5	12,5	16	-	22,2	-	30	-
300	323,9	5,6	5,6	7,1	7,1	8,8	8,8	10	10,0	12,5	12,5	17,5	17,5	25	-	32	-
350	355,6	5,6	5,6	8	8,0	10	10,0	12,5	12,5	16	16,0	20	20,0	28	-	36	-
400	406,4	6,3	6,3	8,8	8,8	10	10,0	12,5	12,5	17,5	17,5	22,2	22,2	30	-	40	-
450	457	6,3	6,3	10	10,0	11	11,0	12,5	12,5	17,5	17,5	22,2	22,2	32	-	45	-
500	508	6,3	6,3	10	10,0	11	11,0	12,5	12,5	17,5	17,5	25	25,0	36	-	50	-
600	610	6,3	6,4	10	10,0	12,5	12,5	17,5	17,5	25	25,0	30	30,0	45	-	60	-
700	711	7,1	7,3	10	10,0	12,5	12,5	25	25,0	-	-	-	-	-	-	-	-
800	813	8	8,2	10	10,0	12,5	12,5	25	25,0	-	-	-	-	-	-	-	-
900	914	10	10,1	12,5	12,5	20	20,0	25	25,0	-	-	-	-	-	-	-	-
1 000	1 016	10	10,3	12,5	12,5	20	20,0	25	25,0	-	-	-	-	-	-	-	-
1 200	1 219	10	10,5	12,5	12,8	20	20,0	25	25,0	-	-	-	-	-	-	-	-

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## Annex D (informative)

### Recommended heat treatment temperatures

Table D.1

Steel grade	Reference heat treatment	Austenitizing temperature	Cooling medium	Tempering temperature	Cooling medium
P235TR2	N	880-940	air		
P265TR2	N	880-940	air		
P235GH	N	880-940	air		
P265GH	N	880-940	air		
16Mo3	N	890-950	air		
10CrMo5-5	NT	900-960	air	650-750	air
13CrMo4-5	NT	900-960	air	660-730	air
10CrMo9-10	NT	900-960	air	680-750	air
X11CrMo5	I	890-950	furnace atmosphere		
X11CrMo5	NT1	930-980	air	710-770	air
X11CrMo5	NT2	930-980	air	710-750	air
X11CrMo9-1	I	950-980	furnace atmosphere		
X11CrMo9-1	NT	890-950	air	720-800	air
X10CrMoVNb9-1	NT	1040-1090	air	730-830	air
P355N	N	-	-		
P355NH	N	-	-		
P355NL1	N	-	-		
P215NL	N	900-940			
P265NL	N	880-940			
12Ni14	QT	820-880	water or oil	580-660	air
X10Ni9	QT	770-820	water or oil	540-660	air

## Annex ZA (informative)

### Relationship between this European Standard and the Essential Requirements of EU Directive 97/23/EC

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association to provide a means of conforming to Essential Requirements of the New Approach Directive 97/23/EC.

Once this standard is cited in the Official Journal of the European Union under that Directive and has been implemented as a national standard in at least one Member State, compliance with the clauses of this standard given in the four divisions of Table ZA-1 confers, within the limits of the scope of this standard, a presumption of conformity with the corresponding Essential Requirements of that Directive and associated EFTA regulations.

**Table ZA-1 — Correspondence between this European Standard and Directive 97/23/EC**

**Table ZA-1 a) - Seamless fittings (except fittings machined from bars)**

Clauses/sub clauses of this EN	Pressure Equipment Directive 97/23/EC Annex I	Content
9.3	Annex I, 4.1a	Appropriate material properties
8.1 and 9.2 Table 4 and Table 7	Annex I, 4.1c	Ageing
8.2 and 10	Annex I, 4.1d	Suitable for the processing procedures
12	Annex I, 4.3	Documentation

**Table ZA-1 b) - Fittings produced from welded pipe**

Clauses/sub-clauses of this EN	Pressure Equipment Directive 97/23/EC Annex I	Content
8.2.1	3.1.1	Forming
8.2.1	3.1.2	Welding
8.2.1, 14.9.1	3.1.3	NDT personnel
8.2.3	3.1.4	Heat treatment
8.2.1, 9.3	Annex I, 4.1a	Appropriate material properties
8.1 and 9.2 Table 4 and Table 7	Annex I, 4.1c	Ageing
8.2 and 10	Annex I, 4.1d	Suitable for the processing procedures
12	Annex I, 4.3	Documentation

## EN 10253-2:2007 (E)

Table ZA-1 c) - Fittings where welding is part of the production process

Clauses/sub-clauses of this EN	Pressure Equipment Directive 97/23/EC Annex I	Content
8.2.1	3.1.1	Forming
8.2.2	3.1.2	Welding
14.9.1	3.1.3	NDT personnel
8.2.3	3.1.4	Heat treatment
8.2.1, 9.3	Annex I, 4.1a	Appropriate material properties
8.1 and 9.2 Table 4 and Table 7	Annex I, 4.1c	Ageing
8.2 and 10	Annex I, 4.1d	Suitable for the processing procedures
12	Annex I, 4.3	Documentation

Table ZA-1 d) - Fittings machined from bars

Clauses/sub-clauses of this EN	Pressure Equipment Directive 97/23/EC Annex I	Content
8.2.1, 9.3	Annex I, 4.1a	Appropriate material properties
8.1 and 9.2 Table 4 and Table 7	Annex I, 4.1c	Ageing
8.2 and 10	Annex I, 4.1d	Suitable for the processing procedures
12	Annex I, 4.3	Documentation

**WARNING — Other requirements and other EU Directives may be applicable to the product(s) falling within the scope of this standard.**



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- [3] EN 10208-2, *Steel pipes for pipelines for combustible fluids — Technical delivery conditions — Part 2: Pipes of requirement class B*
- [4] EN 10246-8, *Non-destructive testing of steel tubes — Part 8: Automatic ultrasonic testing of the weld seam of electric welded steel tubes for the detection of longitudinal imperfections*
- [5] EN 10246-9, *Non-destructive testing of steel tubes — Part 9: Automatic ultrasonic testing of the weld seam of submerged arc welded steel tubes for the detection of longitudinal and/or transverse imperfections*
- [6] EN 10220, *Seamless and welded steel tubes — Dimensions and masses per unit length*
- [7] EN 10256, *Non-destructive testing of steel tubes — Qualification and competence of level 1 and 2 non-destructive testing personnel*
- [8] EN ISO 6506-1, *Metallic materials — Brinell hardness test - Part 1: Test method (ISO 6506-1:2005)*

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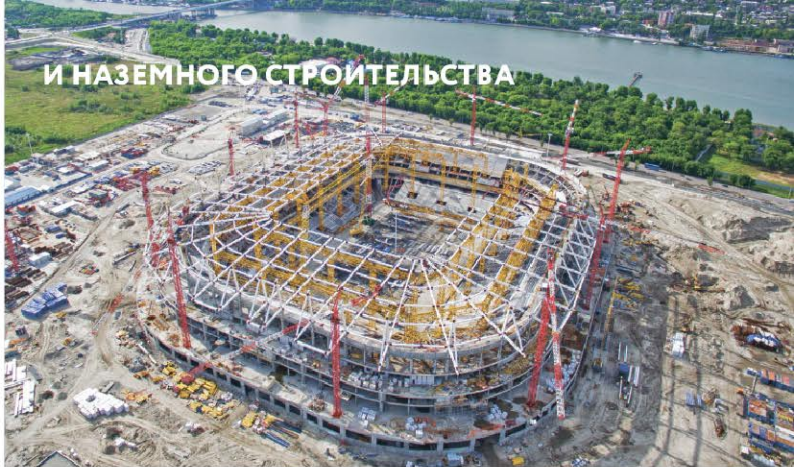
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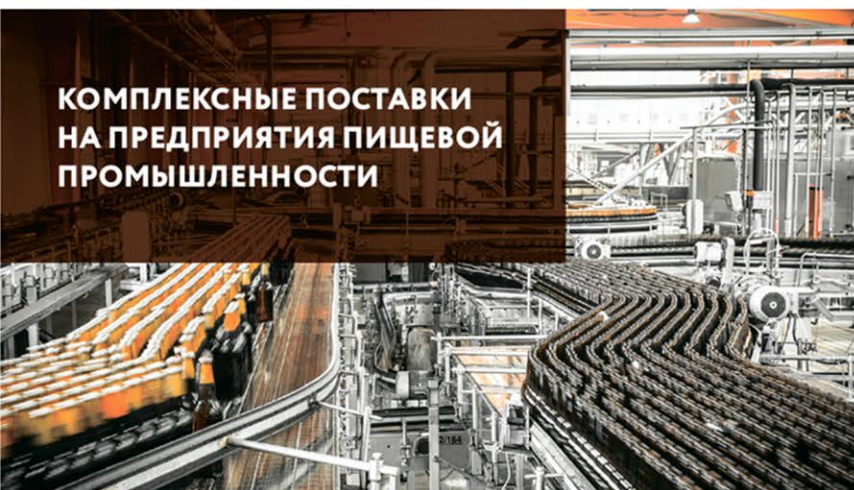
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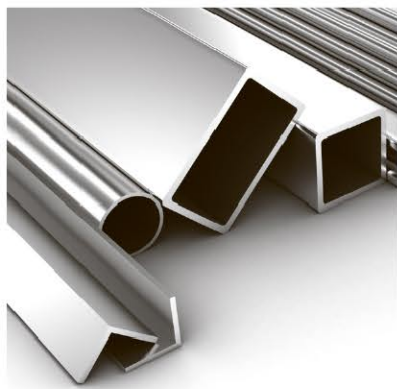
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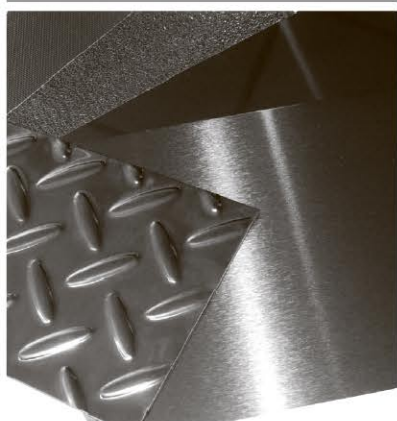
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