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Plastics piping systems for industrial applications — Polybutene (PB), polyethylene (PE), polyethylene of raised temperature resistance (PE-RT), crosslinked polyethylene (PE-X), polypropylene (PP) — Metric series for specifications for components and the system

Systèmes de canalisations en matières plastiques pour les applications industrielles — Polybutène (PB), polyéthylène (PE), polyéthylène de meilleure résistance à la température (PE-RT), polyéthylène réticulé (PE-X), polypropylène (PP) — Séries métriques pour les spécifications pour les composants et le système

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information.

The committee responsible for this document is Technical Committee ISO/TC 138, *Plastics piping systems*, Subcommittee SC 3, *Plastics pipes and fittings for industrial applications*.

This second edition cancels and replaces the first edition (ISO 15494:2003), which has been technically revised.

Introduction

This International Standard specifies the characteristics and requirements for a piping system and its components made from polybutene (PB), polyethylene (PE), polyethylene of raised temperature resistance (PE-RT), crosslinked polyethylene (PE-X), or polypropylene (PP), as applicable, intended to be used for industrial applications above ground or below ground by authorities, design engineers, certification bodies, inspection bodies, testing laboratories, manufacturers, and users.

At the date of publication of this International Standard, standards for piping systems of other plastics used for industrial applications are the following:

ISO 10931, *Plastics piping systems for industrial applications — Poly(vinylidene fluoride) (PVDF) — Specifications for components and the system*

ISO 15493, *Plastics piping systems for industrial applications — Acrylonitrile-butadiene-styrene (ABS), unplasticized poly(vinyl chloride) (PVC-U), chlorinated poly(vinyl chloride) (PVC-C) — Specifications for components and the system — Metric series*

Plastics piping systems for industrial applications — Polybutene (PB), polyethylene (PE), polyethylene of raised temperature resistance (PE-RT), crosslinked polyethylene (PE-X), polypropylene (PP) — Metric series for specifications for components and the system

1 Scope

This International Standard specifies the characteristics and requirements for components such as pipes, fittings, and valves made from one of the following materials intended to be used for thermoplastics piping systems in the field of industrial applications above and below ground:

— polybutene (PB);

— polyethylene (PE);

— polyethylene of raised temperature resistance (PE-RT);

— crosslinked polyethylene (PE-X);

— polypropylene (PP).

NOTE 1 Requirements for industrial valves are given in this International Standard and/or in other standards. Valves are to be used with components conforming to this International Standard provided that they conform additionally to the relevant requirements of this International Standard.

This International Standard is applicable to either PB, PE, PE-RT, PE-X, or PP pipes, fittings, valves, and their joints and to joints with components of other plastics and non-plastic materials, depending on their suitability, intended to be used for the conveyance of liquid and gaseous fluids as well as solid matter in fluids for industrial applications such as the following:

— chemical plants;

— industrial sewerage engineering;

— power engineering (cooling and general purpose water);

— mining;

— electroplating and pickling plants;

— semiconductor industry;

— agricultural production plants;

— fire fighting;

— water treatment;

— geothermal.

NOTE 2 Where relevant, national regulations (e.g. water treatment) are applicable.

Other application areas are permitted if the requirements of this International Standard and/or applicable national requirements are fulfilled.

National regulations in respect of fire behaviour and explosion risk are applicable.

The components have to withstand the mechanical, thermal, and chemical demands to be expected and have to be resistant to the fluids to be conveyed.

Characteristics and requirements which are applicable for all materials (PB, PE, PE-RT, PE-X, or PP) are covered by the relevant clauses of this International Standard. Those characteristics and requirements which are dependent on the material are given in the relevant normative annex for each material (see Table 1).

Table 1 — Material-specific annexes

Material	Annex
Polybutene (PB)	A
Polyethylene (PE)	B
Polyethylene of raised temperature resistance (PE-RT)	C
Crosslinked polyethylene (PE-X)	D
Polypropylene (PP)	E

Components conforming to any of the product standards listed in the bibliography or with national standards, as applicable, may be used with components conforming to this International Standard, provided that they conform to the requirements for joint dimensions and to the relevant requirements of this International Standard.

2 Normative references

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

ISO 7-1, *Pipe threads where pressure-tight joints are made on the threads — Part 1: Dimensions, tolerances and designation*

ISO 179-2, *Plastics — Determination of Charpy impact properties — Part 2: Instrumented impact test*

ISO 228-1, *Pipe threads where pressure-tight joints are not made on the threads — Part 1: Dimensions, tolerances and designation.*

ISO 472, *Plastics — Vocabulary*

ISO 1043-1, *Plastics — Symbols and abbreviated terms — Part 1: Basic polymers and their special characteristics*

ISO 1133-1, *Plastics — Determination of the melt mass-flow rate (MFR) and melt volume-flow rate (MVR) of thermoplastics — Part 1: Standard method*

ISO 1167-1, *Thermoplastics pipes, fittings and assemblies for the conveyance of fluids — Determination of the resistance to internal pressure — Part 1: General method*

ISO 1167-2, *Thermoplastics pipes, fittings and assemblies for the conveyance of fluids — Determination of the resistance to internal pressure — Part 2: Preparation of pipe test pieces*

ISO 1167-3, *Thermoplastics pipes, fittings and assemblies for the conveyance of fluids — Determination of the resistance to internal pressure — Part 3: Preparation of components*

ISO 1167-4, *Thermoplastics pipes, fittings and assemblies for the conveyance of fluids — Determination of the resistance to internal pressure — Part 4: Preparation of assemblies*

ISO 1183-1, *Plastics — Methods for determining the density of non-cellular plastics — Part 1: Immersion method, liquid pyknometer method and titration method*

ISO 1183-2, *Plastics — Methods for determining the density of non-cellular plastics — Part 2: Density gradient column method*

ISO 2505, *Thermoplastics pipes — Longitudinal reversion — Test method and parameters*

ISO 3126, *Plastics piping systems — Plastics components — Determination of dimensions*

ISO 4065, *Thermoplastics pipes — Universal wall thickness table*

ISO 4427-1:2007, *Plastics piping systems — Polyethylene (PE) pipes and fittings for water supply — Part 1: General*

ISO 4437-2, *Plastics piping systems for the supply of gaseous fuels - Polyethylene (PE) — Part 2: Pipes*

ISO 6964, *Polyolefin pipes and fittings — Determination of carbon black content by calcination and pyrolysis — Test method and basic specification*

ISO 9080:2012, *Plastics piping and ducting systems — Determination of the long-term hydrostatic strength of thermoplastics materials in pipe form by extrapolation*

ISO 10147, *Pipes and fittings made of crosslinked polyethylene (PE-X) — Estimation of the degree of crosslinking by determination of the gel content*

ISO 11357-6, *Plastics — Differential scanning calorimetry (DSC) — Part 6: Determination of oxidation induction time (isothermal OIT) and oxidation induction temperature (dynamic OIT)*

ISO 11922-1, *Thermoplastics pipes for the conveyance of fluids — Dimensions and tolerances — Part 1: Metric series*

ISO 12162, *Thermoplastics materials for pipes and fittings for pressure applications — Classification, designation and design coefficient*

ISO 13477, *Thermoplastics pipes for the conveyance of fluids — Determination of resistance to rapid crack propagation (RCP) — Small-scale steady-state test (S4 test)*

ISO 13478, *Thermoplastics pipes for the conveyance of fluids — Determination of resistance to rapid crack propagation (RCP) — Full-scale test (FST)*

ISO 13760, *Plastics pipes for the conveyance of fluids under pressure — Miner's rule — Calculation method for cumulative damage*

ISO 14531-1, *Plastics pipes and fittings — Crosslinked polyethylene (PE-X) pipe systems for the conveyance of gaseous fuels — Metric series — Specifications — Part 1: Pipes*

ISO 15512, *Plastics — Determination of water content*

ISO 15853, *Thermoplastics materials — Preparation of tubular test pieces for the determination of the hydrostatic strength of materials used for injection moulding.*

ISO 16135, *Industrial valves — Ball valves of thermoplastics materials*

ISO 16136, *Industrial valves — Butterfly valves of thermoplastics materials*

ISO 16137, *Industrial valves — Check valves of thermoplastics materials*

ISO 16138, *Industrial valves — Diaphragm valves of thermoplastics materials*

ISO 16139, *Industrial valves — Gate valves of thermoplastics materials*

ISO 16871, *Plastics piping and ducting systems — Plastics pipes and fittings — Method for exposure to direct (natural) weathering*

ISO 18553, *Method for the assessment of the degree of pigment or carbon black dispersion in polyolefin pipes, fittings and compounds*

ISO 21787, *Industrial valves — Globe valves of thermoplastics materials*

IEC 60529, *Degrees of protection provided by enclosures (IP-code)*

EN 712, *Thermoplastics piping systems — End-load bearing mechanical joints between pressure pipes and fittings — Test method for resistance to pull-out under constant longitudinal force*

EN 12099, *Plastics piping systems — Polyethylene piping materials and components — Determination of volatile content*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 472, ISO 1043-1, and the following apply.

3.1 Geometrical definitions

NOTE The symbols d_e and e correspond to d_{ey} and e_y, given in other International Standards such as ISO 11922-1.

3.1.1
nominal outside diameter
d_n
specified outside diameter assigned to a nominal size DN/OD

Note 1 to entry: The nominal inside diameter of a socket is equal to the nominal outside diameter of the corresponding pipe.

Note 2 to entry: It is expressed in millimetres.

3.1.2
outside diameter at any point
d_e
value of the measurement of the outside diameter through its cross-section at any point of the pipe, rounded to the next greater 0,1 mm

3.1.3
mean outside diameter
d_{em}
value of the measurement of the outer circumference of the pipe or spigot end of a fitting in any cross-section divided by π (= 3,142), rounded to the next greater 0,1 mm

3.1.4
mean inside diameter of a socket
arithmetical mean of two measured inside diameters perpendicular to each other

3.1.5
nominal size
DN/OD
numerical designation of the size of a component, other than a component designated by thread size, which is a convenient round number, approximately equal to the manufacturing dimension in millimetres (mm) and related to the outside diameter

3.1.6
nominal size of flange
DN
numerical designation of the size of a flange for reference purposes and related to the manufacturing dimension in millimetres

3.1.7
out-of-roundness
ovality
difference between the maximum and the minimum outside diameter in the same cross-section of a pipe or spigot

3.1.8
nominal wall thickness
e_n
numerical designation of the wall thickness of a component, which is a convenient round number, approximately equal to the manufacturing dimension in millimetres (mm)

Note 1 to entry: For thermoplastics components conforming to the different annexes of ISO 15494, the value of the nominal wall thickness, e_n, is identical to the specified minimum wall thickness at any point, e_{min}.

3.1.9
wall thickness at any point
e
wall thickness at any point around the circumference of a component rounded to the next greater 0,1 mm

3.1.10
minimum wall thickness at any point
e_{min}
minimum value for the wall thickness at any point around the circumference of a component, as specified

Note 1 to entry: The symbol for the wall thickness of the fittings and valves body at any point is E.

3.1.11
pipe series
S
dimensionless number for pipe designation conforming to ISO 4065

Note 1 to entry: The relationship between the pipe series, S, and the standard dimension ratio, SDR, is given by the following formula as specified in ISO 4065:

$$S = \frac{SDR - 1}{2}$$

Note 2 to entry: Flanges are designated on the basis of PN.

3.1.12
standard dimension ratio
SDR
numerical designation of a pipe series, which is a convenient round number, approximately equal to the dimension ratio of the nominal outside diameter, d_n, and the nominal wall thickness, e_n

3.2 Material definitions

3.2.1
melt mass-flow rate
MFR
value relating to the viscosity of the molten material at a specified temperature and load

Note 1 to entry: It is expressed in grams per 10 min (g/10 min).

3.2.2
virgin material
material in a form such as granules or powder that has not been subjected to use or processing other than that required for its manufacture and to which no reprocessable or recyclable materials have been added

3.2.3
own reprocessable material
material prepared from clean rejected unused pipes, fittings, or valves, including trimmings from the production of pipes, fittings, or valves, that will be reprocessed in a manufacturer's plant after having been previously processed by the same manufacturer in the production of components by, for example, injection-moulding or extrusion

Note 1 to entry: Only those thermoplastics parts of valves may be used which are made from material conforming to this International Standard.

3.3 Definitions related to material characteristics

3.3.1
lower confidence limit of the predicted hydrostatic strength
σ_{LPL}
quantity with the dimensions of stress, which represents the 97,5 % lower confidence limit of the predicted hydrostatic strength at a temperature, θ, and time, t

Note 1 to entry: It is expressed in megapascals.

3.3.2
minimum required strength
MRS
value of σ_{LPL} at 20 °C and 50 years, rounded down to the next smaller value of the R10 series or the R20 series

Note 1 to entry: The R10 series conforming to ISO 3 and the R20 series to ISO 497.

3.3.3
design stress
σ_S
allowable stress for a given application at 20 °C that is derived from the MRS by dividing it by the coefficient C

Note 1 to entry: Design stress can be calculated using the following formula:

$$\sigma_s = \frac{\text{MRS}}{C}$$

Note 2 to entry: It is expressed in megapascals.

3.3.4
design coefficient
C
coefficient with a value greater than one which takes into consideration service conditions as well as the properties of the components of a piping system other than those represented in the lower confidence limit

3.4 Definitions related to service conditions

3.4.1
nominal pressure
PN
numerical designation used for reference purposes related to the mechanical characteristics of the components of a piping system

Note 1 to entry: A pressure, in bar, with the numerical value of PN is identical with the pressure, PS, as defined by Reference [16] if both pressures are taken at 20 °C.

Note 2 to entry: For plastics piping systems conveying water, it corresponds to the maximum continuous operating pressure in bar, which can be sustained for water at 20 °C for 50 years, based on the following minimum design coefficient:

$$PN = \frac{10\sigma_s}{[S]} = \frac{20\sigma_s}{SDR-1}$$

where

σ_s is expressed in MPa;

PN is expressed in bar.

Note 3 to entry: 1 bar = 0,1 MPa = 10^5 Pa; 1 MPa= 1 N/mm^2.

3.4.2
hydrostatic stress
σ
stress induced in the wall of a pipe when an internal hydrostatic pressure is applied

Note 1 to entry: The hydrostatic stress is related to the applied internal hydrostatic pressure, in bar *p*, the wall thickness, *e*, at any point and the mean outside diameter, d_{em}, of a pipe and calculated using the following formula:

$$\sigma = p\frac{d_{em} - e_{min}}{20e_{min}}$$

Note 2 to entry: Formula is applicable for pipes only.

Note 3 to entry: It is expressed in megapascals.

3.4.3
long-term hydrostatic stress
σ_{LTHS}
quantity with the dimensions of stress, which represents the predicted mean strength at a temperature *T* and time *t*

Note 1 to entry: It is expressed in megapascals.

[SOURCE: ISO 9080:2012, 3.9]

4 Symbols and abbreviated terms

4.1 Symbols

C	design coefficient (design factor)
d_e	outside diameter (at any point)
d_{em}	mean outside diameter
d_n	nominal outside diameter
DN	nominal size of flange
e	wall thickness (at any point)
e_n	nominal wall thickness
l_0	free length

p internal hydrostatic pressure

p_S maximum allowable pressure

T temperature

t time

ρ material density

σ hydrostatic stress

σ_{LPL} lower confidence limit of the predicted hydrostatic strength

σ_{LTHS} long-term hydrostatic strength

σ_S design stress

4.2 Abbreviated terms

MFR melt mass-flow rate

MOP maximum operating pressure

MRS minimum required strength

OIT oxidation induction time

PB polybutene

PE polyethylene

PE-RT polyethylene of raised temperature resistance

PE-X crosslinked polyethylene

PP polypropylene

PP-H polypropylene homopolymer

PP-B polypropylene block-copolymer

PP-R polypropylene random-copolymer

PP-RCT polypropylene random-copolymer with modified crystallinity

PN nominal pressure

S pipe series S

SDR standard dimension ratio

TIR true impact rate

5 Material

5.1 General

The material from which the components are made shall either be PB, PE, PE-RT, PE-X, or PP, as applicable, to which are added those additives that are needed to facilitate the manufacture of pipes, fittings, and valves conforming to this International Standard.

If additives are used, they shall be uniformly dispersed.

The additives shall not be used separately or together in quantities sufficient to impair the fabrication or fusion characteristics of the component or to impair the chemical, physical, or mechanical characteristics as specified in this International Standard.

5.2 Hydrostatic strength properties

The material shall be evaluated according to ISO 9080 by analysis of pressure tests carried out in accordance with ISO 1167-1 and ISO 1167-2 to classify the material in accordance with ISO 12162.

Conformity of the relevant material to the reference curves given for PB (see Annex A), PE (see Annex B), PE-RT (see Annex C), PE-X (see Annex D), and PP (see Annex E) shall be proven according to the applicable Annex of this International Standard. At least 97,5 % of the data points shall be on or above the reference curves. For design, these reference curves shall be used as a basis.

The material shall be classified by the raw material producer.

NOTE In some cases, the component manufacturer can be regarded as the raw material producer.

Where fittings and valves are manufactured from the same material as pipes, the material classification shall be the same as for pipes.

For the classification of a material intended only for the manufacture of fittings and valves, the test piece shall be an injection-moulded or extruded test piece in form of a pipe where a test pressure is applied according to ISO 1167-1. The free length shall be $3d_n$, as defined in ISO 1167-2 or ISO 15853.

5.3 Material characteristics

The details of the material characteristics of PB, PE, PE-RT, PE-X, and PP mechanical and physical properties with requirements are given in the applicable Annex of this International Standard.

5.4 Reprocessable and recyclable material

The use of own reprocessable material obtained during the production and testing of components according to this International Standard is permitted in addition to virgin material, with the exception of PE-X.

Reprocessable material obtained from external sources and recyclable material shall not be used.

5.5 Materials for components not made from PB, PE, PE-RT, PE-X, or PP

5.5.1 General

All components shall conform to the relevant International Standard(s). Alternative standards may be applied in cases where suitable International Standard(s) do not exist. In all cases, fitness for purpose of the components shall be demonstrated.

Materials and constituent elements used in making the relevant component (including rubber, greases, and any metal parts as may be used) shall have comparable resistance to the external and internal environments as all other elements of the piping system according to this International Standard.

Materials other than PB, PE, PE-RT, PE-X, or PP in contact with components conforming to this International Standard shall not adversely affect the performance of the components or initiate stress cracking.

5.5.2 Metallic materials

All metal parts susceptible to corrosion shall be adequately protected.

When dissimilar metallic materials are used which can be in contact with moisture, steps shall be taken to avoid the possibility of galvanic corrosion.

5.5.3 Sealing materials

Sealing materials shall have no detrimental effects on the properties of the components, joints, and assemblies.

5.5.4 Other materials

Greases or lubricants shall not exude onto fusion areas and shall not affect the long-term performance of materials conforming to this International Standard.

6 General characteristics

6.1 Appearance

When viewed without magnification, the internal and external surfaces of the components shall be smooth, clean, and free from scoring, cavities, and other surface defects to an extent that would prevent conformity to this International Standard. The components shall not contain visible impurities.

Each end of a component shall be square to its axis and shall be deburred.

6.2 Colour

The colour of the components depends on the material used and shall be as given for PB, PE, PE-RT, PE-X, or PP in the applicable Annex of this International Standard.

NOTE Attention is drawn to the need to take account of any relevant legislation relating to the colour coding of piping in respect of its purpose or contents for the location in which the components are intended to be used.

6.3 Influence of UV radiation

Components for external above ground installations shall be adequately protected against UV radiation or the material shall be resistant to UV radiation for the intended application. For products which are usually stored outside in direct sunlight prior to installation, the effect of UV radiation shall be taken into account. To assess materials for resistance to UV radiation for storage purposes, pipe is subject to a cumulative radiant exposure of ≥3,5 GJ/m^2 in accordance with ISO 16871. Following this exposure, the pipe is assessed for any significant change in mechanical properties.

7 Geometrical characteristics

7.1 General

The measurement shall not be made less than 24 h after manufacture.

Dimensions shall be measured in accordance with ISO 3126 at (23 ± 2) °C after being conditioned for at least 4 h unless specified otherwise in the relevant material annex.

Indirect measurement during the stage of production is allowed at shorter time periods providing that evidence is shown of correlation.

The given figures are schematic sketches only, to indicate the relevant dimensions. They do not necessarily represent the manufactured component(s). The given dimensions shall be followed.

Dimensions not given shall be specified by the manufacturer.

7.2 Mean outside diameters, out-of-roundness (ovality), and tolerances

For components made from PB, PE, PE-RT, PE-X or PP, as applicable, the diameters, out-of-roundness (ovality) and related tolerances shall conform to the applicable annex of this International Standard.

The out-of-roundness (ovality) shall be measured at the point of manufacture.

7.3 Wall thicknesses and related tolerances

For components made from PB, PE, PE-RT, PE-X or PP, as applicable, the wall thicknesses and related tolerances shall conform to the applicable annex of this International Standard.

7.4 Angles

The permitted deviations from the nominal or declared angle for a nonlinear fitting shall be +/− 2° where the angle comprises the relevant change of axis of the flow through the fitting.

NOTE The preferred nominal angles for a nonlinear fitting are 45° or 90°.

7.5 Laying lengths

The laying lengths for fittings and valves shall be declared by the manufacturer.

The laying lengths are intended to assist in the design of moulds and are not intended to be used for quality control purposes. ISO 265-1 may be used as a guideline.

7.6 Threads

Threads used for jointing shall conform to ISO 7-1. Where a thread is used as a fastening thread for jointing an assembly (e.g. union nuts), a thread conforming to ISO 228-1 is preferred.

7.7 Mechanical fittings

Mechanical fittings such as adaptors, unions, compression fittings, and reducing bushes may be used provided that their joint dimensions are in accordance with the applicable dimensions of components conforming to this International Standard.

7.8 Joint dimensions of valves

The joint dimensions of valves shall conform to the relevant dimensions of pipes and fittings conforming to this International Standard.

8 Mechanical characteristics

8.1 Resistance to internal pressure of components

Components shall withstand the hydrostatic stress induced by internal hydrostatic pressure without bursting or leaking when tested in accordance with ISO 1167-1, ISO 1167-2, and ISO 1167-3 and the test conditions specified for PB, PE, PE-RT, PE-X, or PP in the applicable annex of this International Standard.

8.2 Calculation of the test pressure for components

8.2.1 Pipes

The hydrostatic test pressure, *p*, expressed in bar, shall be determined for pipes using Formula (1):

$$\sigma = p\frac{d_{em} - e_{min}}{20e_{min}} \qquad (1)$$

where

σ is the hydrostatic stress for PB, PE, PE-RT, PE-X, or PP conforming to the applicable Annex of this International Standard.

8.2.2 Fittings

The hydrostatic test pressure, *p*, expressed in bar, shall be determined for fittings using Formula (2). For S and SDR respectively, the value of the corresponding pipe shall be taken:

$$p = \frac{10\sigma}{[S]} = \frac{20\sigma}{SDR - 1} \qquad (2)$$

8.2.3 Valves

The hydrostatic test pressure, *p*, expressed in bar, is defined for valves in ISO 16135, ISO 16136, ISO 16137, ISO 16138, ISO 16139, or ISO 21787, as applicable, depending on the valve type.

8.2.4 Resistance to rapid crack propagation, RCP

For a pipeline systems carrying air or a compressible gas, for design purposes, the resistance of the material to the phenomenon known as rapid crack propagation shall be taken into account (see ISO 4427-1:2007, Annex B). The critical pressure *pc* is dependent on the material, pipe diameter, and operating temperature.

The critical pressure *pc* measured in accordance with ISO 13477 S4 test or ISO 13478 Full Scale Test shall be greater than 1,5 times the maximum operating pressure of the pipeline system.

Information provided by the pipe or material supplier should be taken into account when designing an industrial pipeline system for the transport of air or a compressible gas. Polyethylene (PE) pipe produced in accordance with ISO 4437-2 for natural gas applications is resistant to RCP for diameters up to 90 mm operated at 4 bar and temperature above 0 °C. Testing has shown that SDR11 pipe in some PE 100 materials can be operated up to 10 bar at 0 °C dependent on diameter. Crosslinked polyethylene (PE-X) pipe produced in accordance with ISO 14531-1 has been shown to be resistant to RCP at temperatures down to −50 °C.

9 Physical characteristics

The physical characteristics of components made from PB, PE, PE-RT, PE-X, or PP shall conform to the applicable annex of this International Standard.

10 Chemical characteristics

10.1 Effects on the component material(s)

Where fluids other than water are to be conveyed, the effect of the fluid on the component material should be considered.

NOTE 1 Guidance is given in ISO/TR 10358 or by the component manufacturer.

NOTE 2 If it is necessary to evaluate the chemical resistance of the pipe for a particular application, then the pipe can be classified in accordance with ISO 4433-1 and ISO 4433-2.

10.2 Effects on the fluids

Where fluids other than water are to be conveyed, the effect of the component material on the fluid should be considered.

11 Electrical characteristics

The electrical protection that shall be provided by the fusion process depends on the characteristics of the electricity power source.

NOTE The relevant component during the fusion process is part of an electrical system as defined in Reference [15] or Reference [13], respectively.

Protection against direct contacts with active parts (live conductors) is required in accordance with IEC 60529. This protection is a function of the work site conditions.

The surface finish of the terminal pins shall allow a minimum contact resistance.

12 Performance requirements

12.1 General

When components made from the same material conforming to this International Standard are jointed to each other, the pipes, fittings, valves, and the joints shall conform to the requirements of the applicable annex of this International Standard.

NOTE If test pressures defined for pipes are used for assemblies made from components of dissimilar materials (e.g. screwed joints, flanged joints), the resulting strain exceeds the strain occurring under service conditions. These strains unavoidably cause leakage. Therefore, in this International Standard, the time related strain behaviour of the assemblies is taken into account and the test pressures derived from the isochronous stress-strain-diagram are used.

12.2 Fusion compatibility

The manufacturer of components shall declare which components and materials conforming to this International Standard may be fused by using the same procedures (e.g. times, temperatures, fusion pressures) to conform to the requirements of this International Standard. If there is a need for deviation in fusion procedures, the manufacturer shall state this.

13 Classification of components

The classification of pipes shall be based on the pipe series, S, or the standard dimension ratio, SDR, or the nominal pressure, PN, as applicable.

The classification of fittings shall be based on the corresponding pipe together with the pipe series S or the standard dimension ratio, SDR, or the nominal pressure, PN, as applicable.

Valves shall be classified in accordance with the requirements of ISO 16135, ISO 16136, ISO 16137, ISO 16138, ISO 16139, or ISO 21787, as applicable, depending on the valve type.

14 Design and installation

For the design and installation of thermoplastic piping systems for industrial applications, see Annex F.

15 Declaration of conformity

The manufacturer shall declare conformity to this International Standard by marking the component in accordance with Clause 16 and, under request, issue a statement of conformity.

16 Marking

16.1 General

Marking elements shall be printed or formed directly on the component or be on a label in such a way that after storage, weathering and handling, and the installation, legibility is maintained.

NOTE The manufacturer is not responsible for marking of the component being illegible due to actions caused during installation and use such as painting, scratching, covering, or by use of detergents, etc. unless agreed upon or specified by the manufacturer.

Marking shall not initiate cracks or other types of defects which adversely influence the performance of the component.

If printing is used, the colouring of the printed information shall differ from the basic colouring of the component.

The size of the marking shall be such that the marking is legible without magnification.

16.2 Minimum required marking of pipes

The minimum required marking of pipes shall conform to Table 2.

Pipes shall be marked at intervals of maximum 1 m, at least once per pipe.

Table 2 — Minimum required marking of pipes

Aspects	Marking or symbol[c]
Number of the International Standard	ISO 15494
Manufacturer's name and/or trade mark	*Name or symbol*
Nominal outside diameter, d_n	e.g. 110
Nominal wall thickness, e_n, or pipe series, S, or standard dimension ratio, SDR, or nominal pressure, PN	e.g. 10,0 or e.g. S 5 or SDR 11 or e.g. PN 10
Material[a]	e.g. PP-H
Manufacturer's information	[b]

[a] If different types of a material are available, this shall be marked, e.g. PP-H or PP-R.

[b] For providing traceability, the following details shall be given:

— production period, year and month, in figures or in code;

— name or code for the production site if the manufacturer is producing at different sites.

[c] Information on abbreviations may be found in Reference [14] and/or in national rules.

16.3 Minimum required marking of fittings

The minimum required marking of fittings shall conform to Table 3, except for fittings with $d_n \leq 32$ mm, for which the minimum required marking shall be directly on the fitting, as follows:

— manufacturer's name and/or trade mark;

— nominal outside diameter(s);

— material;

— nominal wall thickness, e_n, or pipe series S or SDR or PN, as applicable.

Table 3 — Minimum required marking of fittings

Aspects	Marking or symbol[e]
Number of the standard[a]	ISO 15494
Manufacturer's name and/or trade mark	*Name or symbol*
Nominal outside diameter(s), d_n	e.g. 63-32-63
Nominal wall thickness, e_n, or pipe series, S, or standard dimension ratio, SDR, or nominal pressure, PN	e.g. 5,8 or e.g. S 5 or SDR 11 or e.g. PN 10
Nominal size DN[b]	e.g. DN 50
Material[c]	e.g. PP-H
Manufacturer's information	[d]

[a] This information may either be marked directly on the fitting or on a label attached to the fitting or on the packaging. If different types of a material are available, this shall be marked, e.g. PP-H or PP-R.

[b] Applicable to flanges only.

[c] If different types of material are available, this shall be marked directly on the fitting or on a label attached to the fitting or on the packaging.

[d] For providing traceability, the following details shall be given:

— production period, year and month, in figures or in code;

— name or code for the production site if the manufacturer is producing at different sites.

[e] Information on abbreviations may be found in Reference [14] and/or in national rules.

16.4 Minimum required marking of valves

Valves shall be marked in accordance with the requirements of ISO 16135, ISO 16136, ISO 16137, ISO 16138, ISO 16139, or ISO 21787, as applicable, depending on the valve type.

Annex A
(normative)

Specific characteristics and requirements for industrial piping systems made from polybutene (PB)

A.1 Material

A.1.1 Material for components

To prove conformance with the reference curves given in Figure A.1, the material shall be tested in accordance with 5.2 at 20 °C, 60 °C to 80 °C, and 95 °C as well as at various hydrostatic (hoop) stresses in such a way that at each temperature, at least three failure times fall in each of the following time intervals. Conformance with the reference lines should be demonstrated by plotting the individual experimental results on the graph. At least 97,5 % of them should lie on or above the following reference line:

— 10 h to 100 h;

— 100 h to 1 000 h;

— 1 000 h to 8 760 h;

— >8 760 h.

In tests lasting more than 8 760 h, any time which is reached at a certain stress and time at least on or above the relevant reference curve may be considered as failure time.

The values of the minimum required hydrostatic strength (see reference curves given in Figure A.1) in the temperature range of 10 °C to 110 °C are calculated using Formula (A.1) and Formula (A.2). The dotted lines of the reference curves apply if tests with longer testing times are carried out at 80 °C, 90 °C, 95 °C, and 110 °C, as applicable. The longer testing times shall be deduced from the extrapolation time limits given in ISO 9080:2012.

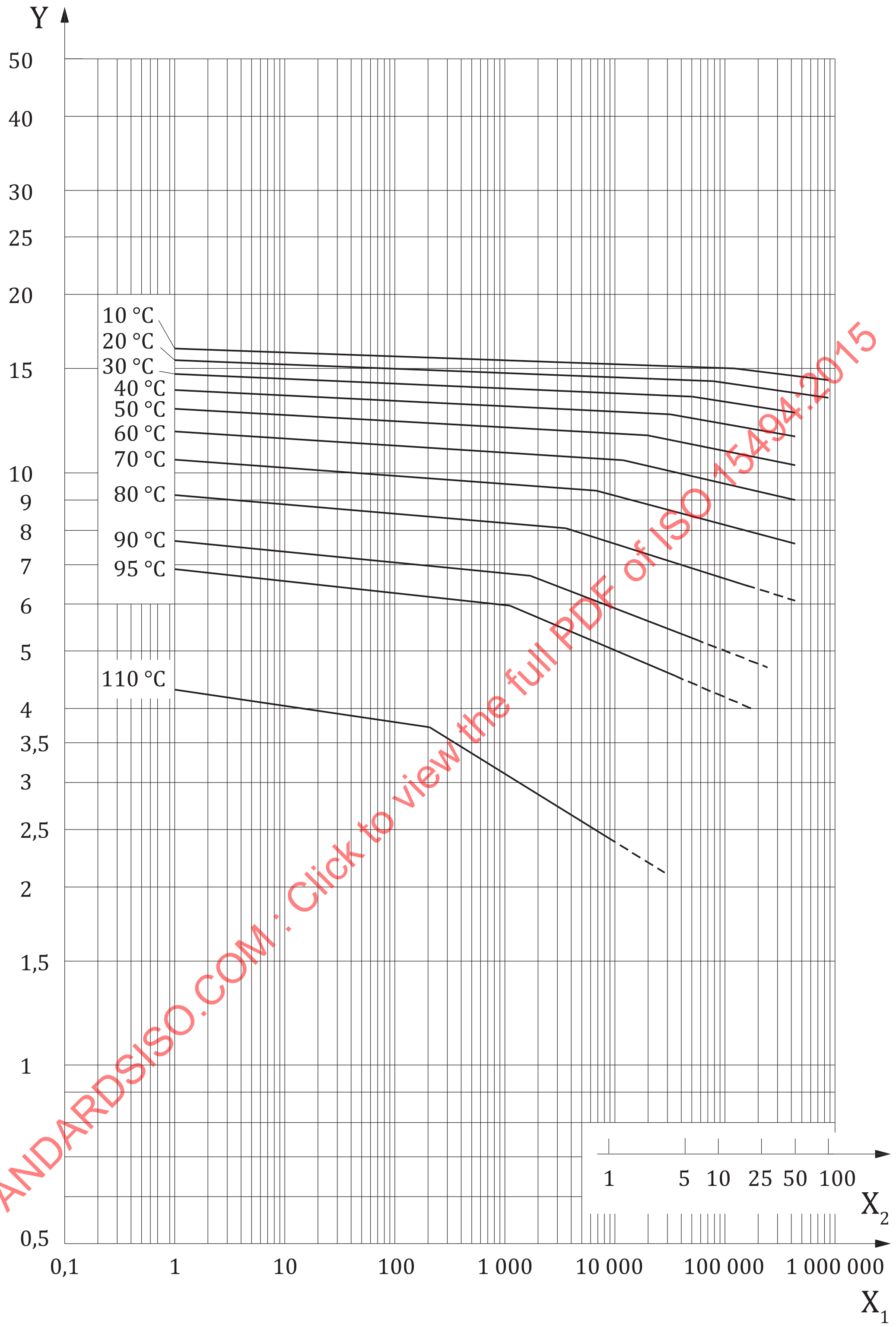
First branch (i.e. the left hand portion of the curves as shown in Figure A.1).

— PB: $$\log t = -430{,}866 - 125010{,}0 \frac{\log \sigma}{T} + 173892{,}7 \cdot \frac{1}{T} + 290{,}0569 \cdot \log \sigma \quad (A.1)$$

Second branch (i.e. the right hand portion of the curves as shown in Figure A.1).

— PB: $$\log t = -129{,}895 - 37262{,}7 \frac{\log \sigma}{T} + 52556{,}48 \cdot \frac{1}{T} + 88{,}56735 \cdot \log \sigma \quad (A.2)$$

NOTE The calculation for PB is based on ISO 12230.



Key

X_1 time to failure, in hours (h)

X_2 time to failure, in years

Y hoop stress, in megapascal (MPa)

Figure A.1 — Minimum required hydrostatic strength curves for PB

A.1.2 MRS-value

When evaluated in accordance with 5.2, PB shall have a minimum required strength, MRS, at least equal to 12,5 MPa.

A.1.3 Material characteristics

The material from which the components are manufactured shall conform to the requirements given in Table A.1.

Table A.1 — Material characteristics of PB

Characteristic	Requirements[a]	Test parameters		Test method
Pigment dispersion	≤Grade 3	Preparation of test pieces	Compression or microtome cut [b]	ISO 18553
Thermal stability tested by resistance to internal pressure at 110 °C	No failure during the test period	End caps	Type A according to ISO 1167-1	ISO 1167-1 ISO 1167-2
		Orientation	Free	
		Conditioning period	According to ISO 1167-1	
		Type of test	Water-in-air	
		Hydrostatic (hoop) stress	2,4 MPa	
		Test temperature	110 °C	
		Test period	8 760 h	

[a] Conformity to the requirements shall be declared by the raw material producer.

[b] In case of dispute, the compression method shall be used.

A.1.4 Crystallization

Due to the slow crystallization, crystalline transformation, and shrinkage which takes places after PB compounds are cooled from the melt, physical and mechanical testing in accordance with A.4.1 and measurement of dimensions shall be delayed after extrusion or moulding, according to recommendations obtained from the manufacturer or material supplier. Components manufactured from PB compounds shall be conditioned in accordance with the manufacturer's recommendations prior to measurement of dimensions.

A.2 General characteristics: Colour

Colour shall be agreed upon between manufacturer and purchaser.

A.3 Geometrical characteristics

A.3.1 Dimensions of pipes

A.3.1.1 Diameters and related tolerances

The mean outside diameter, d_{em}, and the related tolerances shall conform to Table A.2, appropriate to the tolerance grade, whereby the average value of the measurements of the outside diameter made at a distance of d_n and $0{,}1d_n$ from the end of the test pieces shall be within the tolerance range for d_{em} specified in Table A.2.

A.3.1.2 Out-of-roundness

The out-of-roundness for straight lengths shall conform to Table A.2 when measured at the point of manufacture. If other values for the out-of-roundness than those given in Table A.2 are necessary, they shall be agreed upon between manufacturer and purchaser.

For coiled pipes, the maximum out-of-roundness shall be specified by agreement between manufacturer and purchaser.

Table A.2 — Mean outside diameters, related tolerances and out-of-roundness of pipes

Dimensions in millimetres

Nominal outside diameter d_n	**Mean outside diameter** d_{em} min.	**Tolerance of outside diameter** Grade A[a]	**Out-of-roundness**[b] (straight pipes) Grade M[a] max.
12	12,0	+0,3	1,0
16	16,0	+0,3	1,0
20	20,0	+0,3	1,0
25	25,0	+0,3	1,0
32	32,0	+0,3	1,0
40	40,0	+0,4	1,0
50	50,0	+0,5	1,2
63	63,0	+0,6	1,5
75	75,0	+0,7	1,8
90	90,0	+0,9	2,2
110	110,0	+1,0	2,7
125	125,0	+1,2	3,0
140	140,0	+1,3	3,4
160	160,0	+1,5	3,9

[a] In accordance with ISO 11922-1.

[b] For straight pipes: Grade M (0,024d_n).

Tolerances of the outside diameter are rounded up to the next 0,1 mm.

A.3.1.3 Wall thicknesses and related tolerances

The wall thickness, *e*, and the related tolerances shall conform to Table A.3.

Components intended to be welded shall have a minimum wall thickness of 1,9 mm.

Table A.3 — Wall thicknesses and related tolerances

Dimensions in millimetres

Nominal outside diameter	Wall thickness, *e*, and related tolerances[c]											
	Pipe series S and standard dimension ratio, SDR											
	S 10 SDR 21		S 8 SDR 17		S 6,3 SDR 13,6		S 5 SDR 11		S 4 SDR 9		S 3,2 SDR 7,4	
d_n	e_n	a	e_n	a	e_n	a	e_n	a	e_n	a	e_n	a
12	1,3[b]	+0,3	1,3[b]	+0,3	1,3[b]	+0,3	1,3[b]	+0,3	1,4	+0,3	1,7	+0,3
16	1,3	+0,3	1,3	+0,3	1,3	+0,3	1,5	+0,3	1,8	+0,3	2,2	+0,4
20	1,3	+0,3	1,3	+0,3	1,5	+0,3	1,9	+0,3	2,3	+0,4	2,8	+0,4
25	1,3	+0,3	1,5	+0,3	1,9	+0,3	2,3	+0,4	2,8	+0,4	3,5	+0,5
32	1,6	+0,3	1,9	+0,3	2,4	+0,4	2,9	+0,4	3,6	+0,5	4,4	+0,6
40	1,9	+0,3	2,4	+0,4	3,0	+0,4	3,7	+0,5	4,5	+0,6	5,5	+0,7
50	2,4	+0,4	3,0	+0,4	3,7	+0,5	4,6	+0,6	5,6	+0,7	6,9	+0,8
63	3,0	+0,4	3,8	+0,5	4,7	+0,6	5,8	+0,7	7,1	+0,9	8,6	+1,0
75	3,6	+0,5	4,5	+0,6	5,6	+0,7	6,8	+0,8	8,4	+1,0	10,3	+1,2
90	4,3	+0,6	5,4	+0,7	6,7	+0,8	8,2	+1,0	10,1	+1,2	12,3	+1,4
110	5,3	+0,7	6,6	+0,8	8,1	+1,0	10,0	+1,1	12,3	+1,4	15,1	+1,7
125	6,0	+0,7	7,4	+0,9	9,2	+1,1	11,4	+1,3	14,0	+1,5	17,1	+1,9
140	6,7	+0,8	8,3	+1,0	10,3	+1,2	12,7	+1,4	15,7	+1,7	19,2	+2,1
160	7,7	+0,9	9,5	+1,1	11,8	+1,3	14,6	+1,6	17,9	+1,9	21,9	+2,3

a Tolerance of the wall thickness: $0{,}1e_n + 0{,}1$ mm, rounded up to the next 0,1 mm.

b For $d_n = 12$, a non-preferred wall thickness of 1,1 mm may be chosen.

c All dimensions correspond to ISO 4065.

A.3.2 Dimensions of fittings

A.3.2.1 General

This Annex is applicable for the following types of fittings:

— socket fusion fittings;

— electrofusion fittings;

— flange adaptors and loose backing flanges;

— mechanical fittings.

A.3.2.2 Socket fusion fittings

A.3.2.2.1 Types of socket fusion fittings

Socket fusion fittings (see Figure A.2) shall be classified in the following two types.

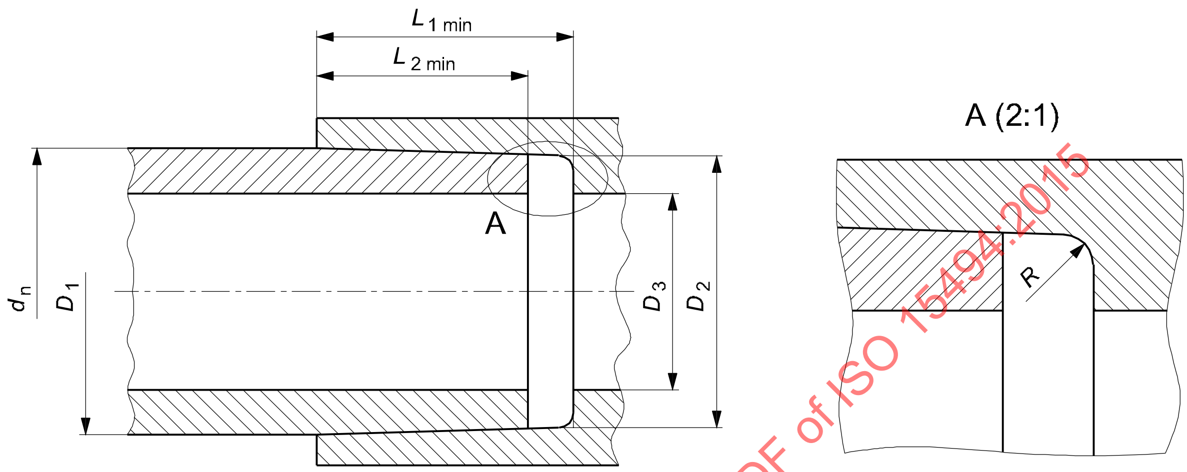
— **Type A**: Fittings intended to be used with pipes having dimensions as given in A.3.1 where no external machining of the pipe is required.

— **Type B**: Fittings intended to be used with pipes having dimensions as given in A.3.1 where machining of the outside surface of the pipe is necessary in accordance with the instructions of the manufacturer.

A.3.2.2.2 Diameters and lengths of sockets

The nominal diameter(s), d_n, of a socket fusion fitting shall correspond to, and be designated by, the nominal outside diameter(s) of the pipe(s) for which it is designed.

The diameters and lengths of sockets for socket fusion fittings of type A shall conform to Table A.4. For socket fusion fittings of type B, the diameters and lengths of sockets shall conform to Table A.5.



Key

$D1$ inside diameter of the socket mouth which comprises the mean diameter of the circle at the inner section of the extension of the socket with the plane of the socket mouth

D_2 mean inside diameter of the socket root which comprises the mean diameter of the circle in a plane parallel to the plane of the socket mouth and separated from it by a distance of L_{1min}

D_3 minimum diameter of the flow channel (bore) through the body of a fitting

L_{1min} minimum socket length which comprises the distance from the socket mouth to the shoulder

L_{2min} minimum insertion length which comprises the depth of the penetration of the heated pipe end into the socket

R minimum radius at socket root

Figure A.2 — Diameters and lengths of socket fusion fittings

Table A.4 — Diameters and lengths of sockets for socket fusion fittings of type A

Dimensions in millimetres

Nominal outside diameter of pipe	Mean outside diameter of pipe	Mean inside diameter				Out-of-roundness	Bore	Radius at socket root	Socket length	Penetration of pipe into socket
		Socket mouth		Socket root						
d_n	d_{em}	D_1		D_2			D_3[a]	R	L_1[b]	L_2[c]
	min.	min.		min.		max.	min.	max.	min.	min.
16	16,0	15,2	+0,3	15,1	+0,3	0,4	9,0	2,5	13,0	9,5
20	20,0	19,2	+0,3	19,0	+0,3	0,4	13,0	2,5	14,5	11,0
25	25,0	24,2	+0,3	23,9	+0,4	0,4	18,0	2,5	16,0	12,5
32	32,0	31,1	+0,4	30,9	+0,4	0,5	25,0	3,0	18,0	14,5
40	40,0	39,0	+0,4	38,8	+0,4	0,5	31,0	3,0	20,5	17,0
50	50,0	48,9	+0,5	48,7	+0,5	0,6	39,0	3,0	23,5	20,0

a Only applicable, if a shoulder exists.

b Length of the socket (rounded), d16 to d63: $L_{1min} = 0{,}3d_n + 8{,}5$ mm; d75 to 110: $L_{1min} = 0{,}2d_n + 15$ mm

c Penetration of pipe into socket, d16 to d63; $L_{2min} = L_{1min} - 3{,}5$ mm; d75 to d110; No formula available

Table A.4 *(continued)*

Nominal outside diameter of pipe	Mean outside diameter of pipe	Mean inside diameter				Out-of-round-ness	Bore	Radius at socket root	Socket length	Penetration of pipe into socket
		Socket mouth		Socket root						
d_n	d_{em}	D_1		D_2			D_3[a]	R	L_1[b]	L_2[c]
	min.	min.		min.		max.	min.	max.	min.	min.
63	63,0	61,9	+0,6	61,6	+0,5	0,6	49,0	4,0	27,5	24,0
75	75,0	74,3	+0,6	73,1	+0,6	1,0	59,0	4,0	30,0	26,0
90	90,0	89,3	+0,6	87,9	+0,6	1,0	69,0	4,0	33,0	29,0
110	110,0	109,4	+0,6	107,7	+0,6	1,0	85,0	4,0	37,0	32,5

a Only applicable, if a shoulder exists.

b Length of the socket (rounded), d16 to d63: $L_{1min} = 0{,}3d_n + 8{,}5$ mm; d75 to 110: $L_{1min} = 0{,}2d_n + 15$ mm

c Penetration of pipe into socket, d16 to d63; $L_{2min} = L_{1min} - 3{,}5$ mm; d75 to d110; No formula available

Table A.5 — Diameters and lengths of sockets for socket fusion fittings of type B

Dimensions in millimetres

Nominal outside diameter of pipe	Mean outside diameter of pipe		Mean inside diameter				Out-of-round-ness	Bore	Radius at socket root	Socket length	Penetration of pipe into socket
			Socket mouth		Socket root						
d_n	d_{em}		D_1		D_2			D_3[a]	R	L_1[b]	L_2[c]
	min.	max.	min.		min.		max.	min.	max.	min.	min.
16	15,8	16,0	15,2	+0,3	15,1	+0,3	0,4	11,0	2,5	13,0	9,5
20	19,8	20,0	19,2	+0,3	19,0	+0,3	0,4	13,0	2,5	14,5	11,0
25	24,8	25,0	24,2	+0,3	23,9	+0,4	0,4	18,0	2,5	16,0	12,5
32	31,8	32,0	31,1	+0,4	30,9	+0,4	0,5	25,0	3,0	18,0	14,5
40	39,8	40,0	39,0	+0,4	38,8	+0,4	0,5	31,0	3,0	20,5	17,0
50	49,8	50,0	48,9	+0,5	48,7	+0,5	0,6	39,0	3,0	23,5	20,0
63	62,7	63,0	61,9	+0,6	61,6	+0,5	0,6	49,0	4,0	27,5	24,0
75	74,7	75,0	73,7	+0,5	73,4	+0,5	1,0	58,0	4,0	31,0	27,5
90	89,7	90,0	88,6	+0,6	88,2	+0,6	1,0	69,0	4,0	35,5	32,0
110	109,6	110,0	108,4	+0,6	108,0	+0,6	1,0	85,0	4,0	41,5	38,0

a Only applicable if a shoulder exists.

b Length of the socket (rounded), $L_{1min} = 0{,}3d_n + 8{,}5$ min.

c Penetration of pipe into socket, $L_{2min} = L_{1min} - 3{,}5$ mm.

A.3.2.2.3 Other dimensions

Other dimensions of socket fusion fittings shall be specified by the manufacturer.

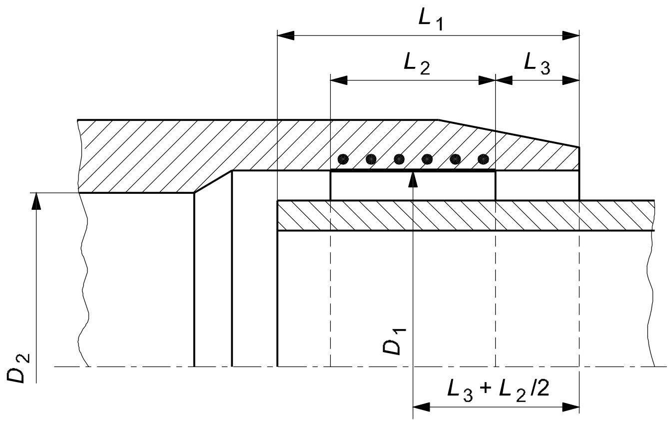
A.3.2.3 Electrofusion fittings

A.3.2.3.1 Dimensions of sockets of electrofusion fittings

The dimensions of sockets of electrofusion fittings (see Figure A.3) shall conform to Table A.6.

In the case of a fitting having sockets of different sizes (e.g. reduction), each socket shall conform to the requirements of the corresponding nominal diameter.

In case of using spigot end fittings, the outside tubular length of the fusion end shall allow the assembly with an electrofusion fitting.



Key

D_1 mean inside diameter in the fusion zone measured in a plane parallel to the plane of the mouth at a distance of $L_3 + 0{,}5L_2$ from that face

D_2 bore, which is the minimum diameter of the flow channel through the body of the fitting

L_1 depth of penetration of the pipe or male end of a spigot end fitting; in case of a coupling without stop, it is not greater than half the total length of the fitting

L_2 heated length within a socket as declared by the manufacturer, to be the nominal length of the fusion zone

L_3 distance between the mouth of the fitting and the start of the fusion zone as declared by the manufacturer to be the nominal unheated entrance length of the fitting ($L_3 \geq 5$ mm)

Figure A.3 — Dimensions of sockets of electrofusion fittings

Table A.6 — Dimensions of sockets of electrofusion fittings

Dimensions in millimetres

Nominal diameter of fitting d_n	Depth of penetration[a] L_1		Length of the fusion zone L_2
	min.	max.	min.
16	20	35	10
20	20	37	10
25	20	40	10
32	20	44	10
40	20	49	10
50	20	55	10
63	23	63	11
75	25	70	12
90	28	79	13
110	32	85	15
125	35	90	16
140	38	95	18
160	42	101	20

[a] The manufacturer shall declare the actual maximum and minimum values of D_1 and L_1 to determine suitability for clamping and joint assembly.

The mean inside diameter of the fitting in the middle of the fusion zone (see D_1 in Figure A.3) shall be not less than d_n.

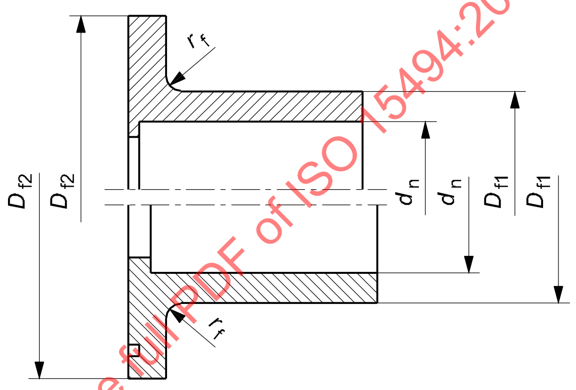
A.3.2.3.2 Other dimensions

Other dimensions of electrofusion fittings shall be specified by the manufacturer.

A.3.2.4 Flange adaptors and loose backing flanges

A.3.2.4.1 Dimensions of flange adaptors for socket fusion

The dimensions of flange adaptors for socket fusion (see Figure A.4) shall conform to Table A.7.



Key

D_{f1} outside diameter of flange adaptor

D_{f2} outer diameter of the chamfer on shoulder

r_f radius of chamfer on shoulder

Figure A.4 — Dimensions of flange adaptors for socket fusion

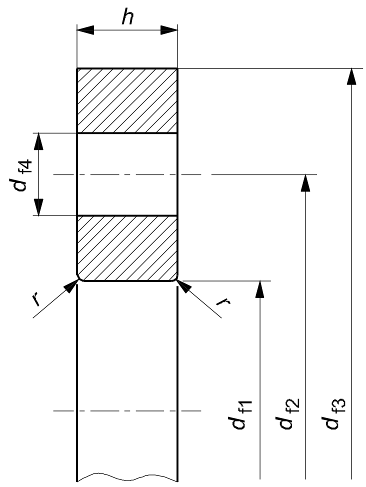
Table A.7 — Dimensions of flange adaptors for socket fusion

Dimensions in millimetres

Nominal outside diameter of the corresponding pipe d_n	Outside diameter of chamfer on shoulder D_{f1}	Outside diameter of flange adaptor D_{f2}	Radius of chamfer on shoulder r_f
16	22	40	3
20	27	45	3
25	33	58	3
32	41	68	3
40	50	78	3
50	61	88	3
63	76	102	4
75	90	122	4
90	108	138	4
110	131	158	4

A.3.2.4.2 Dimensions of loose backing flanges for use with flange adaptors for socket fusion

The dimensions of loose backing flanges for use with flange adaptors for socket fusion (see Figure A.5) shall conform to Table A.8.



Key

d_{f1} inside diameter of flange
d_{f2} pitch circle diameter of bolt holes
d_{f3} outside diameter of flange
d_{f4} diameter of bolt holes
r radius of flange
h thickness of backing ring

NOTE The thickness, h, of the loose backing flange is dependent on the material used.

Figure A.5 — Dimensions of loose backing flanges for use with flange adaptors for socket fusion

Table A.8 — Dimensions of loose backing flanges for use with flange adaptors for socket fusion

Dimensions in millimetres

Nominal outside diameter of the corresponding pipe d_n	Nominal size of flange DN	Inside diameter of flange d_{f1}	Pitch circle diameter of bolt holes d_{f2}	Outside diameter of flange d_{f3} min.	Diameter of bolt holes d_{f4}	Radius of flange r	Number of bolt holes N	Metric thread of bolt
16	10	23	60	90	14	3	4	M12
20	15	28	65	95	14	3	4	M12
25	20	34	75	105	14	3	4	M12
32	25	42	85	115	14	3	4	M12
40	32	51	100	140	18	3	4	M16
50	40	62	110	150	18	3	4	M16
63	50	78	125	165	18	3	4	M16
75	65	92	145	185	18	3	4	M16
90	80	110	160	200	18	3	8	M16
110	100	133	180	220	18	3	8	M16

A.4 Mechanical characteristics

A.4.1 Mechanical characteristics of pipes and fittings

When tested as specified in Table A.9 using the indicated parameters, the components shall withstand the hydrostatic stress without bursting or leaking under the test conditions given in Table A.10.

Table A.9 — Requirements for internal pressure testing

Characteristic	Requirements	Test parameters		Test method
		Hydrostatic (hoop) stress MPa	Time h	
Resistance to internal pressure at 20 °C	No failure during the test period	15,5	≥1	ISO 1167-1 ISO 1167-2 ISO 1167-3
Resistance to internal pressure at 95 °C		6,2	≥165	ISO 1167-1 ISO 1167-2 ISO 1167-3
Resistance to internal pressure at 95 °C		6,0	≥1 000	ISO 1167-1 ISO 1167-2 ISO 1167-3

Table A.10 — Test conditions for internal pressure testing

Test parameters	
End caps	Type A according to ISO 1167-1
Orientation	Free
Conditioning period	In accordance with ISO 1167-1
Type of test	Water-in-water or water-in-air[a]

[a] In case of dispute, water-in-water shall be used.

A.4.2 Mechanical characteristics of valves

The valves shall conform to the requirements of ISO 16135, ISO 16136, ISO 16137, ISO 16138, ISO 16139, or ISO 21787, as applicable, depending on the valve type.

A.5 Physical characteristics

A.5.1 Physical characteristics of pipes

When tested in accordance with the test methods as specified in Table A.11 using the indicated parameters, the pipe shall have physical characteristics conforming to the requirements given in Table A.11.

Table A.11 — Physical characteristics of pipes

Characteristic	Requirements	Test parameters		Test method
Melt mass-flow rate (MFR)	After processing maximum deviation of ±20 % of the value measured on the batch used to manufacture the pipe	Test temperature Loading mass Time Number of test pieces	190 °C 5 kg or 2,16 kg 10 min According to ISO 1133-1	ISO 1133-1
Thermal stability tested by resistance to internal pressure at 110 °C	No failure during the test period	End caps Orientation Conditioning period Type of test Hydrostatic (hoop) stress Test temperature Test period	Type A according to ISO 1167-1 Free According to ISO 1167-1 Water-in-air 2,4 MPa 110 °C 8 760 h	ISO 1167-1 ISO 1167-2
Longitudinal reversion[a] Wall thickness ≤16 mm	≤3 % Original appearance of pipe shall remain	Temperature Length of test piece Immersion time: Test method Number of test pieces	110 °C 200 mm 1 h Free Shall conform to ISO 2505	ISO 2505

[a] The choice of method A or method B is free. In case of dispute, method B shall be used.

A.5.2 Physical characteristics of fittings

When tested in accordance with the test method as specified in Table A.12 using the indicated parameters, the fitting shall have physical characteristics conforming to the requirements given in Table A.12.

Table A.12 — Physical characteristics of fittings

Characteristic	Requirements	Test parameters		Test method
Melt mass-flow rate (MFR)	After processing maximum deviation of ±30 % of the value measured on the batch used to manufacture the fitting	Test temperature Loading mass	190 °C 5 kg or 2,16 kg	ISO 1133-1

A.5.3 Physical characteristics of valves

In addition to the requirements of ISO 16135, ISO 16136, ISO 16137, ISO 16138, ISO 16139, or ISO 21787, as applicable, depending on the valve type, the physical characteristics of valves shall conform to A.5.2.

A.6 Fitness for purpose of the system

Fitness for purpose of the system shall be deemed to apply when test pieces assembled in accordance with 12.2 and tested using the test methods and indicated parameters as specified in Table A.13 conforming to the requirements given in Table A.13.

Table A.13 — General requirements for fitness for purpose of the system

Characteristic	Requirements	Test parameters		Test method
Hydrostatic strength at 95 °C	No failure during the test period	End caps	Type A according to ISO 1167-1	ISO 1167-1
		Orientation	Free	ISO 1167-4
		Test temperature	95 °C	
		Type of test	Water-in-water or water-in-air[a]	
		Hydrostatic (hoop) stress	6,0 MPa	
		Conditioning period	≥1 h	
		Test period	1 000 h	

[a] In case of dispute, water-in-water shall be used.

Annex B
(normative)

Specific characteristics and requirements for industrial piping systems made from polyethylene (PE)

B.1 Material

B.1.1 General

This Annex is applicable to the following types of polyethylene:

— polyethylene (PE 63);

— polyethylene (PE 80);

— polyethylene (PE 100).

NOTE PE 63 is an older generation material and is retained for special applications by some countries. This material is not recommended where stress cracking is of relevance, as the requirements are not specified. See Table B.3.

B.1.2 Material for components

The material shall be tested in accordance with 5.2 at 20 °C, 60 °C, and 80 °C, as well as at various hydrostatic (hoop) stresses in such a way that at each temperature, at least three failure times fall in each of the following time intervals:

— 10 h to 100 h;

— 100 h to 1 000 h;

— 1 000 h to 8 760 h;

— >8 760 h.

In tests lasting more than 8 760 h, any time which is reached at a certain stress and time at least on or above the relevant reference curve may be considered as failure time.

For PE 80 and PE 100, at 80 °C, there shall be no knee detected in the regression curve before 5 000 h.

The values of the minimum required hydrostatic strength [see reference curves given in Figure B.1 (PE 63), Figure B.2 (PE 80), and Figure B.3 (PE 100)] in the temperature range of 10 °C to 80 °C are calculated using Formula (B.1) to Formula (B.4):

NOTE Testing has shown that for many compounds, no knee is detected before 1 year at 80 °C.

First branch (i.e. the left hand portion of the curves as shown in Figure B.1, Figure B.2, and Figure B.3).

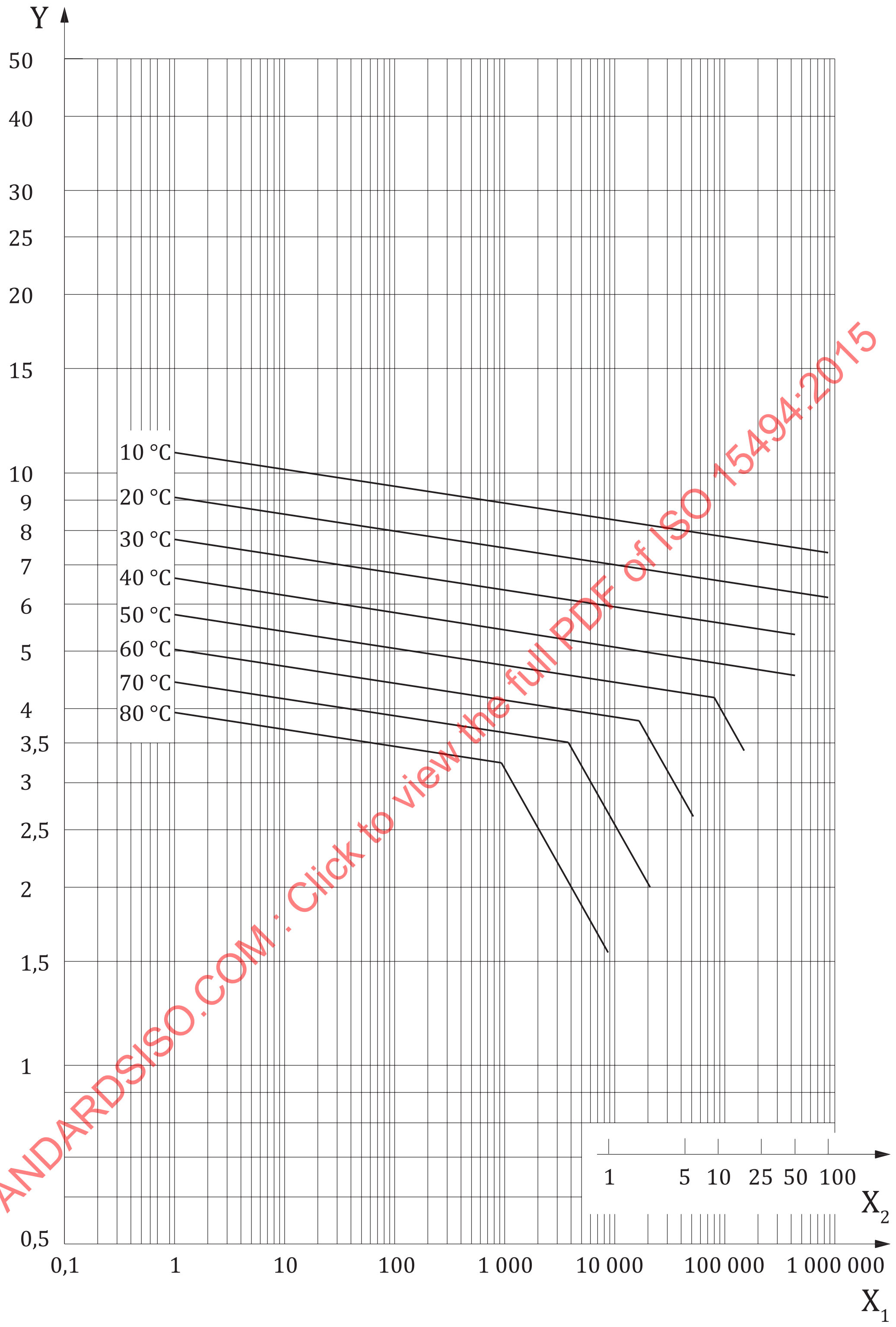
— PE 63: $$\log t = -41{,}4173 + 22008{,}5722 \cdot \frac{1}{T} - 35{,}0987 \cdot \log \sigma \qquad \text{(B.1)}$$

— PE 80: $$\log t = -42{,}5488 + 24074{,}8254 \cdot \frac{1}{T} - 37{,}5758 \cdot \log \sigma \qquad \text{(B.2)}$$

— PE 100: $\log t = -45{,}4008 + 28444{,}7345 \cdot \frac{1}{T} - 45{,}9891 \cdot \log \sigma$ (B.3)

Second branch (i.e. the right hand portion of the curves as shown in B.1).

— PE 63: $\log t = -19{,}8823 + 8619{,}357 \cdot \frac{1}{T} - 3{,}039 \cdot \log \sigma$ (B.4)



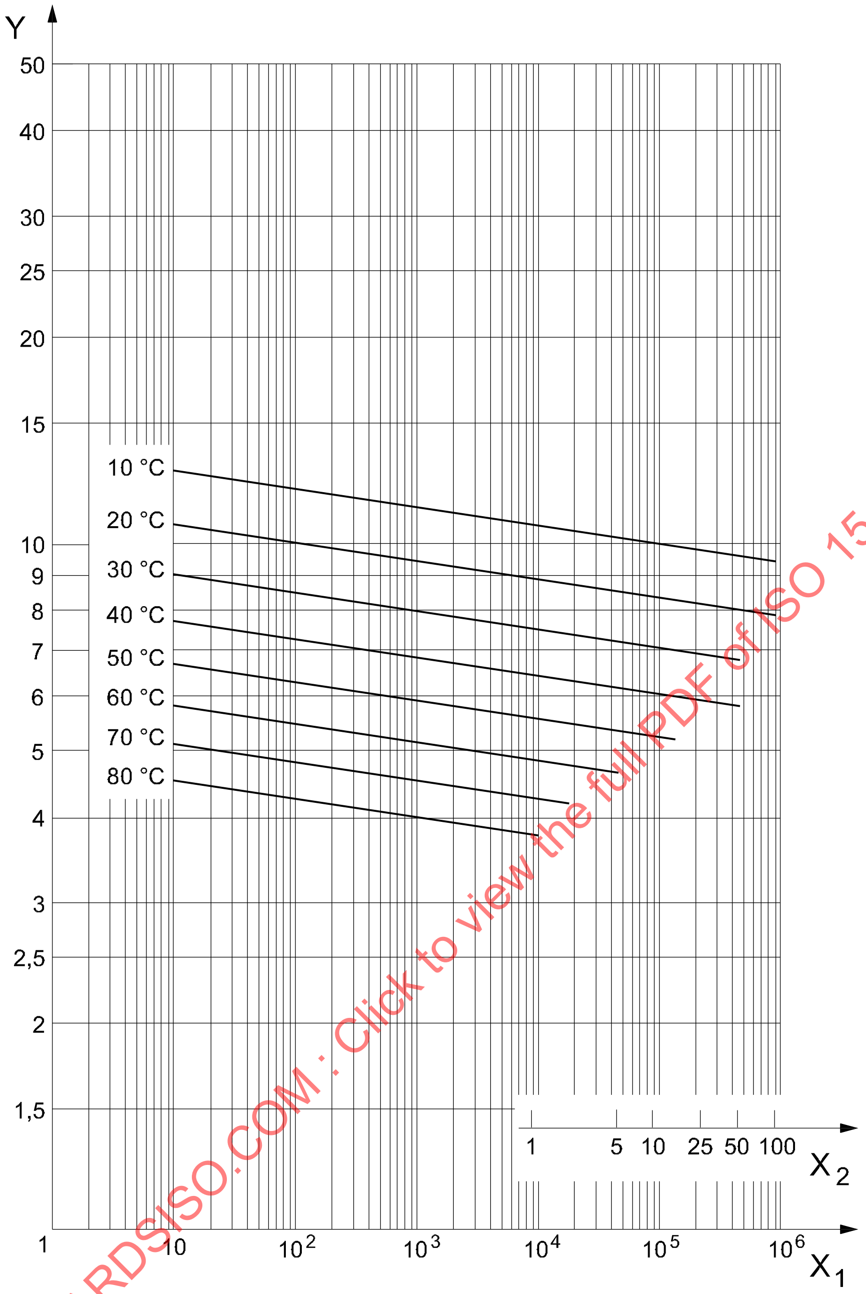
Key

X_1 time to failure, in hours (h)

X_2 time to failure, in years

Y hoop stress, in megapascal (MPa)

Figure B.1 — Minimum required hydrostatic strength curves for PE 63



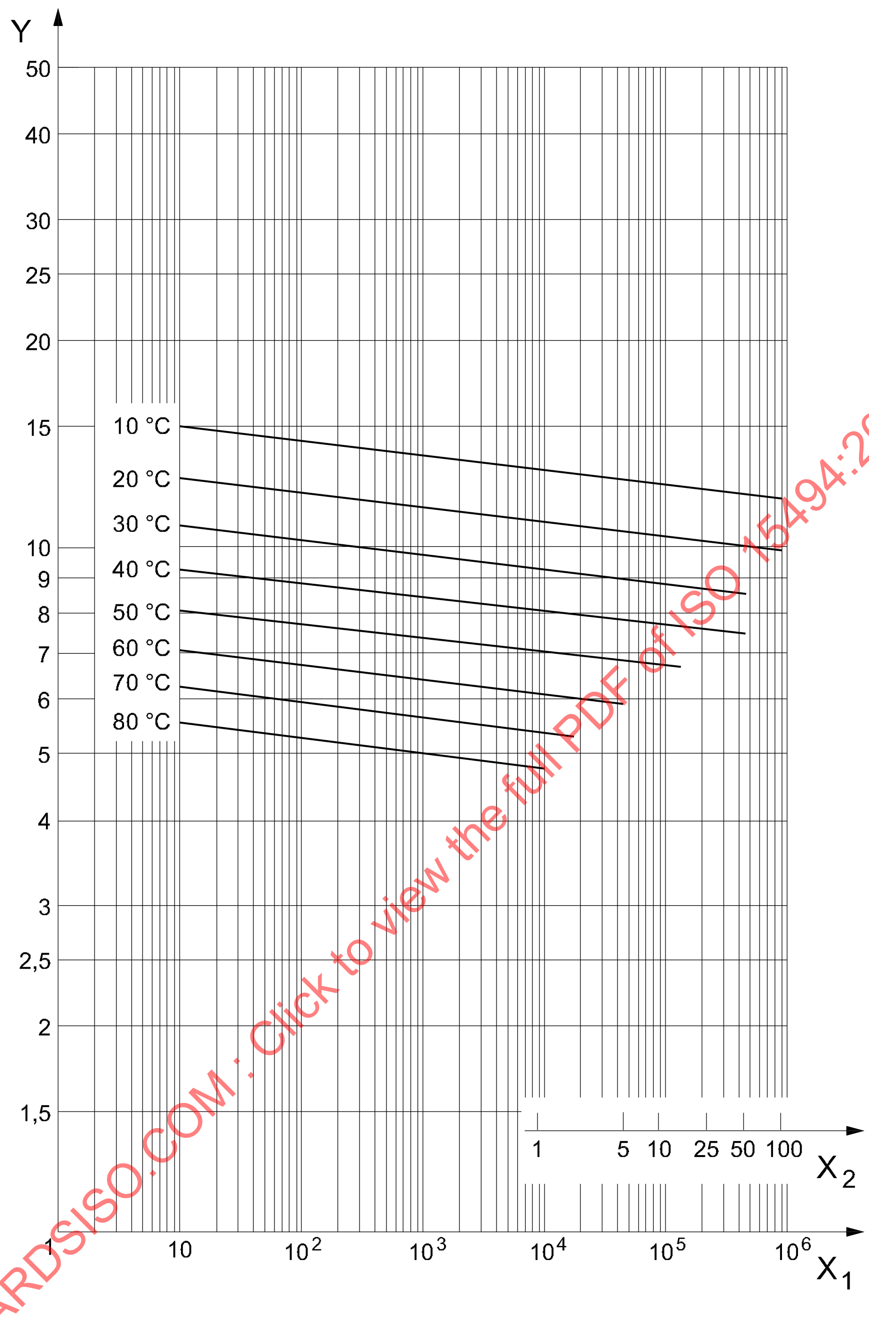
Key

X_1 time to failure, in hours (h)

X_2 time to failure, in years

Y hoop stress, in megapascal (MPa)

Figure B.2 — Minimum required hydrostatic strength curves for PE 80



Key

X_1 time to failure, in hours (h)

X_2 time to failure, in years

Y hoop stress, in megapascal (MPa)

Figure B.3 — Minimum required hydrostatic strength curves for PE 100

B.1.3 MRS-value

When evaluated in accordance with 5.2, the applicable PE-types shall have a minimum required strength, MRS, as given in Table B.1.

For PE 80 and PE 100, at 80 °C, there shall be no knee detected in the regression curve at t < 5 000 h.

NOTE Testing has shown that for many compounds, no knee is detected before 1 year at 80 °C.

Table B.1 — MRS-values of PE-types

PE-type	MRS-value
PE 63	≥6,3 MPa
PE 80	≥8,0 MPa
PE 100	≥10,0 MPa

B.1.4 Material characteristics

The material from which the components are manufactured shall conform to the requirements given in Table B.2 and Table B.3.

Table B.2 — Characteristics of the material in the form of granules

Characteristic	Requirements[a]	Test parameters		Test method
Compound density	≥ 930 kg/m^3 (base polymer)	Test temperature	23 °C	ISO 1183-1 or ISO 1183-2
Oxidation induction time (Thermal stability)[b]	OIT ≥ 20 min	Test temperature	200 °C	ISO 11357-6
Melt mass-flow rate (MFR)	(0,2 ≤ MFR ≤ 1,4) g/10 min Maximum deviation of ±20 % of the nominated value	Test temperature Loading mass	190 °C 5 kg	ISO 1133-1
Volatile content	≤ 350 mg/kg	Shall conform to EN 12099		EN 12099
Water content[f]	≤ 300 mg/kg (Equivalent to < 0,03 % by mass)	Shall conform to ISO 15512		ISO 15512
Carbon black content[c]	(2,0 to 2,5) % (by mass)	Shall conform to ISO 6964		ISO 6964
Pigment or carbon black dispersion[d]	≤ Grade 3 Rating of dispersion A1, A2, A3, or B	Preparation of test pieces	Compression or microtome cut[e]	ISO 18553

[a] Conformity to these requirements shall be declared by the raw material producer.

[b] Test may be carried out at 210 °C or 220 °C, provided that there is a clear correlation with the results at 200 °C. In case of dispute, the reference temperature shall be 200 °C.

[c] Only for black material.

[d] For black and non-black material.

[e] In case of dispute, the compression method shall be used.

[f] Only applicable if the measured volatile content is not in conformity to its specified requirement. In case of dispute, the requirement for water content shall be used. As an alternative method, ISO 760 may apply. The requirement applies to the compound producer at the stage of manufacturing and to the compound user at the stage of processing (if the water content exceeds the limit, drying is required prior to use).

Table B.3 — Characteristics of the material in the form of pipe

Characteristic	Requirements[a]	Test parameters		Test method
Resistance to rapid crack propagation[c,d] (Critical pressure, p_c) ($e \geq 15$ mm)	$p_c \geq 1{,}5 \times PN^{d,e}$ with $p_c = 3{,}6p_{c,S4} + 2{,}6$	Test temperature	0 °C	ISO 13477
Resistance to slow crack growth (d_n: 110 mm SDR 11)	No failure during the test period	Test temperature	80 °C	ISO 13479
		Internal test pressure: for PE 80	8,0 bar	
		PE 100	9,2 bar	
		Test period	500 h	
		Type of test	Water-in-water	
		Number of test pieces[b]	Shall conform to ISO 13479	

[a] Conformity to these requirements shall be proved by the compound producer.

[b] The numbers of test pieces given indicate the numbers required to establish a value for the characteristic described in the table. The numbers of test pieces required for factory production control and process control should be listed in the manufacturer's quality plan. For guidance, see Annex F.

[c] Only applicable for the conveyance of compressed gas in which case, PN is based on a C factor of 2.

[d] In this case, PN is based on a C factor of 2

[e] Full scale/S4 correlation factor is equal to 3,6 and is defined as the full scale/S4 critical absolute pressure ratio: $(p_{c,\text{full scale}} + 1) = 3{,}6(p_{c,s4} + 1)$. If the requirement is not met or S4 test equipment is not available, then (re)testing by using the full scale test shall be performed in accordance with ISO 13478. In this case, $p_c = p_{c,\text{full scale}}$.

B.1.5 Type of pipe

The following two types of pipe are covered:

— PE pipe (outside diameter d_n), including any identification;

— PE pipes with co-extruded layers on either or both the outside and/or inside of the pipe (total outside diameter d_n) where all PE layers shall have the same MRS rating.

B.2 General characteristics: Colour

Components made from PE should preferably be black using compound. Other colours shall be agreed upon between manufacturer and purchaser or in accordance with national regulations.

B.3 Geometrical characteristics

B.3.1 Dimensions of pipes

B.3.1.1 Diameters and related tolerances

The mean outside diameter, d_{em}, and the related tolerances shall conform to Table B.4, appropriate to the tolerance grade, whereby the average value of the measurements of the outside diameter made at a distance of d_n and $0{,}1d_n$, as well as from the end of the test pieces, shall be within the tolerance range for d_{em} as specified in Table B.4.

NOTE Pipes with tolerances of Grade A given in ISO 11922-1 are used for socket fusion and electrofusion joints where the peeling technique is used to prepare the pipe end for fusion. Pipes with tolerances of Grade B given in ISO 11922-1 are used for socket fusion joints where the peeling technique is not used.

B.3.1.2 Out-of-roundness

The out-of-roundness for straight lengths shall conform to Table B.4 when measured at the point of manufacture. If other values for the out-of-roundness than those given in Table B.4 are necessary, they shall be agreed upon between manufacturer and purchaser.

For coiled pipes, the maximum out-of-roundness shall be specified by agreement between manufacturer and purchaser.

Table B.4 — Mean outside diameters, related tolerances, and out-of-roundness of pipes

Dimensions in millimetres

Nominal outside diameter	Mean outside diameter	Tolerance of outside diameter		Out-of-roundness[b] (straight pipes)
d_n	d_{em}	Grade A[a]	Grade B[a]	Grade N[a]
	min.			max.
16	16,0	+0,3	+0,3	1,2
20	20,0	+0,3	+0,3	1,2
25	25,0	+0,3	+0,3	1,2
32	32,0	+0,3	+0,3	1,3
40	40,0	+0,4	+0,4[d]	1,4
50	50,0	+0,5	+0,4[d]	1,4
63	63,0	+0,6	+0,4	1,5
75	75,0	+0,7	+0,5	1,6
90	90,0	+0,9	+0,6	1,8
110	110,0	+1,0	+0,7	2,2
125	125,0	+1,2	+0,8	2,5
140	140,0	+1,3	+0,9	2,8
160	160,0	+1,5	+1,0	3,2
180	180,0	+1,7	+1,1	3,6
200	200,0	+1,8	+1,2	4,0
225	225,0	+2,1	+1,4	4,5
250	250,0	+2,3	+1,5	5,0
280	280,0	+2,6	+1,7	9,8
315	315,0	+2,9	+1,9	11,1
355	355,0	+3,2	+2,2	12,5
400	400,0	+3,6	+2,4	14,0
450	450,0	+4,1	+2,7	15,8[d]
500	500,0	+4,5	+3,0	17,5
560	560,0	+5,0	+3,4	19,6
630	630,0	+5,7	+3,8	22,1
710	710,0	+6,4	+4,0	24,9

a In accordance with ISO 11922-1:1997.

b For straight pipes, Grade N for: $d_n \leq 75$ mm ($0{,}008d_n + 1{,}0$ mm); 90 mm $\leq d_n \leq 250$ mm ($0{,}02d_n$); $d_n > 250$ mm ($0{,}035d_n$).

Tolerances of the outside diameter are rounded up to the next 0,1 mm.

c Tolerance calculated as $0{,}009d_{em}$ and do not conform to Grade A in ISO 11922-1.

d Not in accordance with ISO 11922-1.

Table B.4 *(continued)*

Nominal outside diameter d_n	Mean outside diameter d_{em} min.	Tolerance of outside diameter Grade A[a]	 Grade B[a]	Out-of-roundness[b] (straight pipes) Grade N[a] max.
800	800,0	+7,2	+4,0	28,0
900	900,0	+8,1	+4,0	31,5
1 000	1 000,0	+9,0	+4,0	35,0
1 200	1 200,0	+10,8[c]	-	42,0
1 400	1 400,0	+12,6[c]	-	49,0
1 600	1 600,0	+14,4[c]	-	56,0
1 800	1 800,0	+16,2[c]	-	63,0
2 000	2 000,0	+18,0[c]	-	70,0
2 250	2 250,0	+20,3[c]	-	-
2 500	2 500,0	+22,5[c]	-	-

[a] In accordance with ISO 11922-1:1997.

[b] For straight pipes, Grade N for: $d_n \leq 75$ mm ($0{,}008d_n + 1{,}0$ mm); 90 mm $\leq d_n \leq 250$ mm ($0{,}02d_n$); $d_n > 250$ mm ($0{,}035d_n$).
Tolerances of the outside diameter are rounded up to the next 0,1 mm.

[c] Tolerance calculated as $0{,}009d_{em}$ and do not conform to Grade A in ISO 11922-1.

[d] Not in accordance with ISO 11922-1.

B.3.1.3 Wall thicknesses and related tolerances

The wall thickness, *e*, and the related tolerances shall conform to Table B.5.

Table B.5 — Wall thicknesses and related tolerances

Dimensions in millimetres

Nominal outside diameter	Wall thickness, *e*, and related tolerances[b]															
	Pipe series S and standard dimension ratio, SDR															
	S 20 SDR 41		S 16 SDR 33		S 12,5 SDR 26		S 10 SDR 21		S 8 SDR 17		S 5 SDR 11		S 3,2 SDR 7,4		S 2,5 SDR 6	
d_n	e_n	[a]	e_n	[a]	e_n	[a]	e_n	[a]	e_n	[a]	e_n	[a]	e_n	[a]	E_n	[a]
16	-	-	-	-	-	-	-	-	-	-	1,8	+0,3	2,2	+0,4	2,7	+0,4
20	-	-	-	-	-	-	-	-	1,8	+0,3	1,9	+0,3	2,8	+0,4	3,4	+0,5
25	-	-	-	-	-	-	-	-	1,8	+0,3	2,3	+0,4	3,5	+0,5	4,2	+0,6
32	-	-	-	-	-	-	-	-	1,9	+0,3	2,9	+0,4	4,4	+0,6	5,4	+0,7
40	-	-	-	-	1,8	+0,3	2,0	+0,3	2,4	+0,4	3,7	+0,5	5,5	+0,7	6,7	+0,8
50	1,8	+0,3	1,8	+0,3	2,0	+0,3	2,4	+0,4	3,0	+0,4	4,6	+0,6	6,9	+0,8	8,3	+1,0
63	1,8	+0,3	2,0	+0,3	2,5	+0,4	3,0	+0,4	3,8	+0,5	5,8	+0,7	8,6	+1,0	10,5	+1,2
75	1,9	+0,3	2,3	+0,4	2,9	+0,4	3,6	+0,5	4,5	+0,6	6,8	+0,8	10,3	+1,2	12,5	+1,4
90	2,2	+0,4	2,8	+0,4	3,5	+0,5	4,3	+0,6	5,4	+0,7	8,2	+1,0	12,3	+1,4	15,0	+1,6
110	2,7	+0,4	3,4	+0,5	4,2	+ 0,6	5,3	+0,7	6,6	+0,8	10,0	+1,1	15,1	+1,7	18,3	+2,0
125	3,1	+0,5	3,9	+0,5	4,8	+0,6	6,0	+0,7	7,4	+0,9	11,4	+1,3	17,1	+1,9	20,8	+2,2

[a] Tolerance of the wall thickness: $0{,}1e + 0{,}1$ mm, rounded up to the next 0,1 mm.

[b] All dimensions correspond to ISO 4065.

Table B.5 *(continued)*

Nominal outside diameter	Wall thickness, *e*, and related tolerances[b]															
	Pipe series S and standard dimension ratio, SDR															
	S 20 SDR 41		S 16 SDR 33		S 12,5 SDR 26		S 10 SDR 21		S 8 SDR 17		S 5 SDR 11		S 3,2 SDR 7,4		S 2,5 SDR 6	
d_n	e_n	a	e_n	a	e_n	a	e_n	a	e_n	a	e_n	a	e_n	a	E_n	a
140	3,5	+0,5	4,3	+0,6	5,4	+0,7	6,7	+0,8	8,3	+1,0	12,7	+1,4	19,2	+2,1	23,3	+2,5
160	4,0	+0,5	4,9	+0,6	6,2	+0,8	7,7	+0,9	9,5	+1,1	14,6	+1,6	21,9	+2,3	26,6	+2,8
180	4,4	+0,6	5,5	+0,7	6,9	+0,8	8,6	+1,0	10,7	+1,2	16,4	+1,8	24,6	+2,6	29,9	+3,1
200	4,9	+0,6	6,2	+0,8	7,7	+0,9	9,6	+1,1	11,9	+1,3	18,2	+2,0	27,4	+2,9	33,2	+3,5
225	5,5	+0,7	6,9	+0,8	8,6	+1,0	10,8	+1,2	13,4	+1,5	20,5	+2,2	30,8	+3,2	37,4	+3,9
250	6,2	+0,8	7,7	+0,9	9,6	+1,1	11,9	+1,3	14,8	+1,6	22,7	+2,4	34,2	+3,6	41,5	+4,3
280	6,9	+0,8	8,6	+1,0	10,7	+1,2	13,4	+1,5	16,6	+1,8	25,4	+2,7	38,3	+4,0	46,5	+4,7
315	7,7	+0,9	9,7	+1,1	12,1	+1,4	15,0	+1,6	18,7	+2,0	28,6	+3,0	43,1	+4,5	52,3	+5,4
355	8,7	+0,9	10,9	+1,2	13,6	+1,5	16,9	+1,8	21,1	+2,3	32,2	+3,4	48,5	+5,0	59,0	+6,0
400	9,8	+1,1	12,3	+1,4	15,3	+1,7	19,1	+2,1	23,7	+2,5	36,3	+3,8	54,7	+5,6	-	-
450	11,0	+1,2	13,8	+1,5	17,2	+1,9	21,5	+2,3	26,7	+2,8	40,9	+4,2	61,5	+6,3	-	-
500	12,3	+1,4	15,3	+1,7	19,1	+2,1	23,9	+2,5	29,7	+3,1	45,4	+4,7	-	-	-	-
560	13,7	+1,5	17,2	+1,9	21,4	+2,3	26,7	+2,8	33,2	+3,5	50,8	+5,2	-	-	-	-
630	15,4	+1,7	19,3	+2,1	24,1	+2,6	30,0	+3,1	37,4	+3,9	57,2	+5,9	-	-	-	-
710	17,4	+1,9	21,8	+2,3	27,2	+2,9	33,9	+3,5	42,1	+4,4	64,5	+6,6	-	-	-	-
800	19,6	+2,1	24,5	+2,6	30,6	+3,2	38,1	+4,0	47,4	+4,9	72,6	+7,4	-	-	-	-
900	22,0	+2,3	27,6	+2,9	34,4	+3,6	42,9	+4,4	53,3	+5,5	81,7	+8,3	-	-	-	-
1 000	24,5	+2,6	30,6	+3,2	38,2	+4,0	47,7	+4,9	59,3	+6,1	90,8	+9,2	-	-	-	-
1 200	29,4	+3,1	36,7	+3,8	45,9	+4,7	57,2	+5,9	71,1	+7,3	-	-	-	-	-	-
1 400	34,3	+3,6	42,9	+4,4	53,5	+5,5	66,7	+6,8	83,0	+8,4	-	-	-	-	-	-
1 600	39,2	+4,1	49,0	+5,0	61,2	+6,3	76,2	+7,8	94,8	+9,6	-	-	-	-	-	-
1 800	44,0	+4,5	55,1	+5,6	68,8	+6,9	85,8	+8,7	106,6	+10,8	-	-	-	-	-	-
2 000	48,9	+4,9	61,2	+6,2	76,4	+7,7	95,3	+9,7	118,5	+12,0	-	-	-	-	-	-
2 250	55,0	+5,6	68,9	+7,0	86,0	+8,7	107,2	+10,9	-	-	-	-	-	-	-	-
2 500	61,2	+6,3	76,5	+7,8	95,5	+9,6	119,1	+12,1	-	-	-	-	-	-	-	-

a Tolerance of the wall thickness: 0,1e + 0,1 mm, rounded up to the next 0,1 mm.

b All dimensions correspond to ISO 4065.

B.3.2 Dimensions of fittings

B.3.2.1 General

This Annex is applicable for the following types of fittings:

— butt fusion fittings;

— socket fusion fittings;

— electrofusion fittings;

— flange adaptors and loose backing flanges;

— mechanical fittings.

B.3.2.2 Butt fusion fittings

B.3.2.2.1 Outside diameters

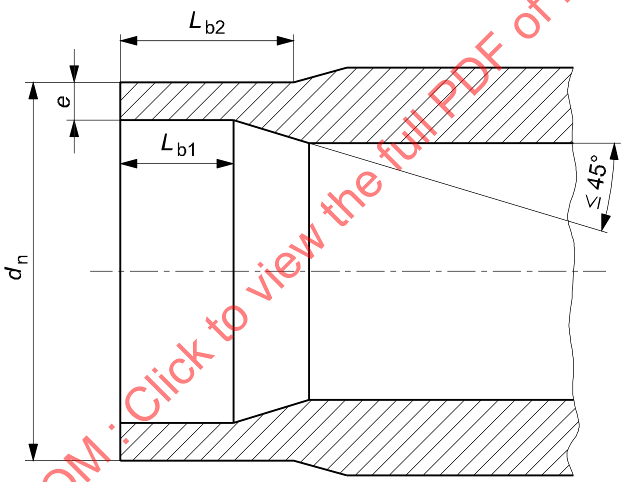
The mean outside diameter, d_{em}, of the spigot end (see Figure B.4) over the length, L_{b2} (see Table B.6) shall conform to B.3.1.1, except between the plane of the entrance face and the plane parallel to it, located at a distance not greater than 0,01d_n + 1 mm where a reduction of the outside diameter is permissible (e.g. for circumferential reversion).

B.3.2.2.2 Out-of-roundness

The out-of-roundness of the spigot end (see Figure B.4) over the length, L_{b2} (see Table B.6) shall conform to B.3.1.2.

B.3.2.2.3 Wall thickness of the spigot end

The wall thickness, e, of the spigot end (see Figure B.4) over the length, L_{b1}, (see Table B.6) shall conform to B.3.1.3 except between the plane of the entrance face and the plane parallel to it, located at a distance not greater than 0,01d_n + 1 mm where a thickness reduction is permissible (e.g. for chamfered edge).



Key

L_{b1} minimum inside tubular length of the fusion end, which comprises the initial depth of the spigot end which is necessary for butt fusion

L_{b2} minimum outside tubular length of the fusion end, which comprises the initial length of the fusion end

Figure B.4 — Dimensions of spigot end for butt fusion fittings

Table B.6 — Dimensions of spigot ends for butt fusion fittings

Dimensions in millimetres

Nominal outside diameter d_n	Inside tubular length L_{b1}[a] min.	Outside tubular length L_{b2}[a] min.
16	4	10
20	4	10

NOTE The minimum tubular lengths given in this table are too short for electrofusion joints. For this jointing method, a tubular length conforming to the depth of penetration according to Table B.9 is necessary.

[a] For bends, a reduction of the tubular length(s) is permissible.

Table B.6 *(continued)*

Nominal outside diameter d_n	Inside tubular length L_{b1}[a] min.	Outside tubular length L_{b2}[a] min.
25	4	10
32	5	10
40	5	10
50	5	12
63	6	12
75	6	12
90	7	12
110	8	12
125	8	15
140	9	15
160	9	20
180	10	20
200	11	20
225	12	25
250	13	25
280	14	30
315	15	30
355	16	30
400	18	30
450	20	35
500	20	35
560	20	40
630	20	40
710	20	40
800	20	50
900	20	50
1 000	20	60
1 200	20	60
1 400	20	70
1 600	20	70
1 800	-	-
2 000	-	-

NOTE The minimum tubular lengths given in this table are too short for electrofusion joints. For this jointing method, a tubular length conforming to the depth of penetration according to Table B.9 is necessary.

[a] For bends, a reduction of the tubular length(s) is permissible.

B.3.2.2.4 Wall thickness of fitting body

The wall thickness, *e*, of the fitting body shall be at least equal to the minimum wall thickness of the corresponding pipe (see B.3.1.3).

B.3.2.2.5 Other dimensions

Other dimensions of butt fusion fittings shall be specified by the manufacturer.

B.3.2.3 Socket fusion fittings

B.3.2.3.1 Types of socket fusion fittings

Socket fusion fittings (see Figure B.5) shall be classified into the following two types.

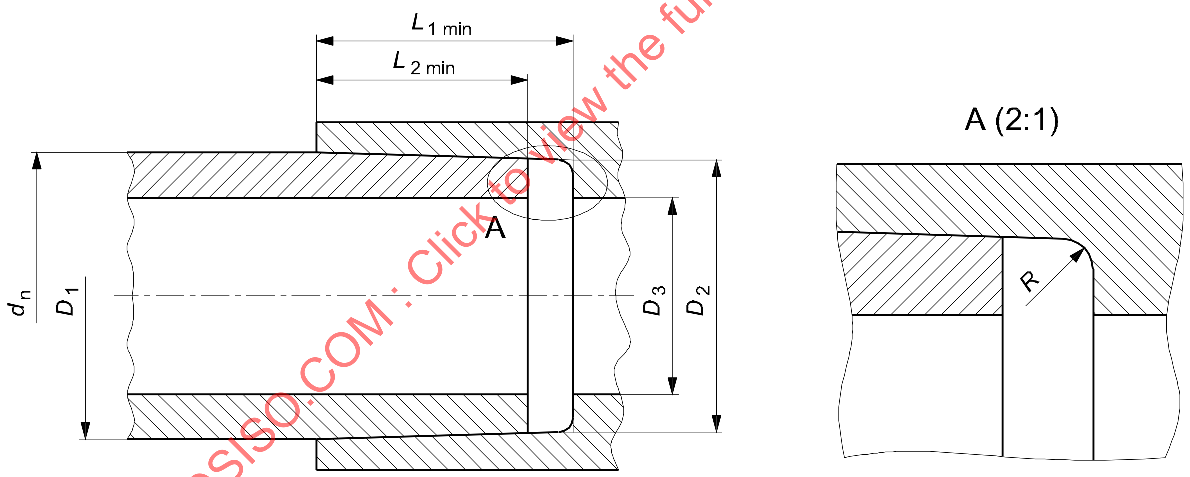
— **Type A**: Fittings intended to be used with pipes having dimensions as given in B.3.1 where no external machining of the pipe is required.

— **Type B**: Fittings intended to be used with pipes having dimensions as given in B.3.1 where machining of the outside surface of the pipe is necessary in accordance with the instructions of the manufacturer.

B.3.2.3.2 Diameters and lengths of sockets

The nominal diameter(s), d_n, of a socket fusion fitting shall correspond to, and be designated by, the nominal outside diameter(s) of the pipe(s) for which it is designed.

The diameters and lengths of sockets for socket fusion fittings of type A shall conform to Table B.7. For socket fusion fittings of type B, the diameters and lengths of sockets shall conform to Table B.8.



Key

D_1 inside diameter of the socket mouth which comprises the mean diameter of the circle at the inner section of the extension of the socket with the plane of the socket mouth

D_2 mean inside diameter of the socket root which comprises the mean diameter of the circle in a plane parallel to the plane of the socket mouth and separated from it by a distance of L_{1min}

D_3 minimum diameter of the flow channel (bore) through the body of a fitting

L_{1min} minimum socket length which comprises the distance from the socket mouth to the shoulder

L_{2min} minimum insertion length which comprises the depth of penetration of the heated pipe end into the socket;

R maximum radius at socket root

Figure B.5 — Diameters and lengths of socket fusion fittings

Table B.7 — Diameters and lengths of sockets for socket fusion fittings of type A

Dimensions in millimetres

Nominal outside diameter of pipe	Mean outside diameter of pipe	Mean inside diameter				Out-of-roundness	Bore	Radius at socket root	Socket length	Penetration of pipe into socket
		Socket mouth		Socket root						
d_n	d_{em}	D_1		D_2			D_3[a]	R	L_1[b]	L_2[c]
	min.	min.		min.		max.	min.	max.	min.	min.
16	16,0	15,2	+0,3	15,1	+0,3	0,4	9,0	2,5	13,0	9,5
20	20,0	19,2	+0,3	19,0	+0,3	0,4	13,0	2,5	14,5	11,0
25	25,0	24,2	+0,3	23,9	+0,4	0,4	18,0	2,5	16,0	12,5
32	32,0	31,1	+0,4	30,9	+0,4	0,5	25,0	3,0	18,0	14,5
40	40,0	39,0	+0,4	38,8	+0,4	0,5	31,0	3,0	20,5	17,0
50	50,0	48,9	+0,5	48,7	+0,5	0,6	39,0	3,0	23,5	20,0
63	63,0	61,9	+0,6	61,6	+0,5	0,6	49,0	4,0	27,5	24,0
75	75,0	74,3	+0,6	73,1	+0,6	1,0	59,0	4,0	30,0	26,0
90	90,0	89,3	+0,6	87,9	+0,6	1,0	69,0	4,0	33,0	29,0
110	110,0	109,4	+0,6	107,7	+0,6	1,0	85,0	4,0	37,0	32,5

[a] Only applicable if a shoulder exists.

[b] Length of the socket (rounded), d16 to d63: $L_{1min} = 0{,}3d_n + 8{,}5$ mm; d75 to d110: $L_{1min} = 0{,}2d_n + 15$ mm

[c] Penetration of pipe into socket, d16 to d63; $L_{2min} = L_{1min} - 3{,}5$ mm; d75 to d110; No formula available

Table B.8 — Diameters and lengths of sockets for socket fusion fittings of type B

Dimensions in millimetres

Nominal outside diameter of pipe	Mean outside diameter of pipe		Mean inside diameter				Out-of-roundness	Bore	Radius at socket root	Socket length	Penetration of pipe into socket
			Socket mouth		Socket root						
d_n	d_{em}		D_1		D_2			D_3[a]	R	L_1[b]	L_2[c]
	min.	max.	min.		min.		max.	min.	max.	min.	min.
16	15,8	16,0	15,2	+0,3	15,1	+0,3	0,4	11,0	2,5	13,0	9,5
20	19,8	20,0	19,2	+0,3	19,0	+0,3	0,4	13,0	2,5	14,5	11,0
25	24,8	25,0	24,2	+0,3	23,9	+0,4	0,4	18,0	2,5	16,0	12,5
32	31,8	32,0	31,1	+0,4	30,9	+0,4	0,5	25,0	3,0	18,0	14,5
40	39,8	40,0	39,0	+0,4	38,8	+0,4	0,5	31,0	3,0	20,5	17,0
50	49,8	50,0	48,9	+0,5	48,7	+0,5	0,6	39,0	3,0	23,5	20,0
63	62,7	63,0	61,9	+0,6	61,6	+0,5	0,6	49,0	4,0	27,5	24,0
75	74,7	75,0	73,7	+0,5	73,4	+0,5	1,0	58,0	4,0	31,0	27,5
90	89,7	90,0	88,6	+0,6	88,2	+0,6	1,0	69,0	4,0	35,5	32,0
110	109,6	110,0	108,4	+0,6	108,0	+0,6	1,0	85,0	4,0	41,5	38,0

[a] Only applicable if a shoulder exists.

[b] Length of the socket (rounded), $L_{1min} = 0{,}3d_n + 8{,}5$ mm.

[c] Penetration of pipe into socket, $L_{2min} = L_{1min} - 3{,}5$ mm.

B.3.2.3.3 Other dimensions

Other dimensions of socket fusion fittings shall be specified by the manufacturer.

B.3.2.4 Electrofusion fittings

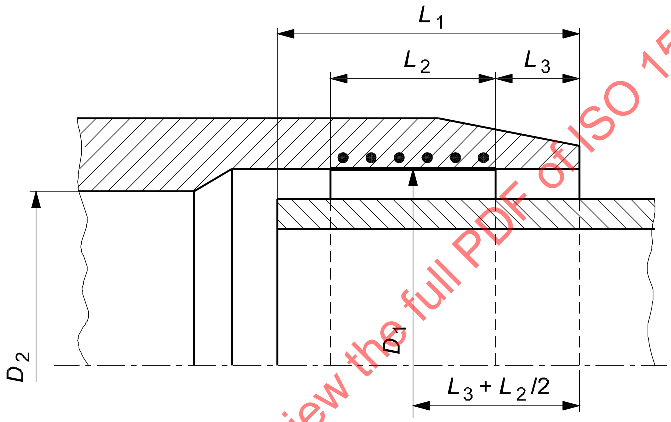
B.3.2.4.1 Dimensions of sockets of electrofusion fittings

The dimensions of sockets of electrofusion fittings (see Figure B.6) shall conform to Table B.9.

The mean inside diameter of the fitting in the middle of the fusion zone, D_1, shown in Figure B.6 shall not be less than d_n. The manufacturer shall declare the actual maximum and minimum values of D_1 and L_1 for determining suitability for clamping and joint assembly.

In the case of a fitting having sockets of different sizes (e.g. reduction), each socket shall conform to the requirements of the corresponding nominal diameter.

In case of using spigot end fittings, the outside tubular length of the fusion end shall allow the assembly with an electrofusion fitting.



Key

D_1 mean inside diameter in the fusion zone measured in a plane parallel to the plane of the mouth at a distance of $L_3 + 0{,}5L_2$ from that face

D_2 bore, which is the minimum diameter of the flow channel through the body of the fitting

L_1 depth of penetration of the pipe or male end of a spigot end fitting. In case of a coupling without stop, it is not greater than half the total length of the fitting

L_2 heated length within a socket as declared by the manufacturer, to be the nominal length of the fusion zone

L_3 distance between the mouth of the fitting and the start of the fusion zone as declared by the manufacturer to be the nominal unheated entrance length of the fitting ($L_3 \geq 5$ mm)

Figure B.6 — Dimensions of electrofusion socket fittings

Table B.9 — Dimensions of sockets of electrofusion fittings

Dimensions in millimetres

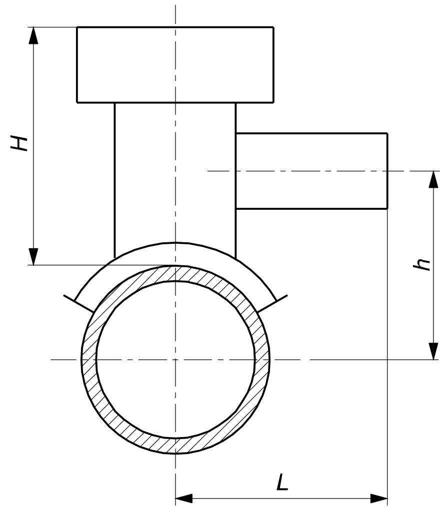
Nominal diameter of fitting d_n	Depth of penetration L_1		Length of the fusion zone L_2
	min.	max.	min.
16	20	41	10
20	20	41	10
25	20	41	10
32	20	44	10
40	20	49	10

Table B.9 *(continued)*

Nominal diameter of fitting d_n	Depth of penetration L_1		Length of the fusion zone L_2
	min.	max.	min.
50	20	55	10
63	23	63	11
75	25	70	12
90	28	79	13
110	32	82	15
125	35	87	16
140	38	92	18
160	42	98	20
180	46	105	21
200	50	112	23
225	55	120	26
250	73	129	33
280	81	139	35
315	89	150	39
355	99	164	42
400	110	179	47
450	122	195	51
500	135	212	56
560	147	235	61
630	161	255	67
710	177	280	74
800	193	300	82
900	198	305	83
1 000	208	315	83
1 200	213	320	96
1 400	218	325	96

B.3.2.4.2 Dimensions of electrofusion saddle fittings

The manufacturer shall specify the overall dimensions of the electrofusion saddle fitting (see Figure B.7) in a technical file. These dimensions shall include the maximum height of the saddle, H, and for tapping tees, the height of the service pipe, h.



Key

H height of the saddle which comprises the distance from the top of the main to the top of the tapping tee or saddle

h height of the service pipe which comprises the distance from the axis of the main pipe to the axis of the service pipe

L width of the tapping tee which comprises the distance between the axis of the pipe and the plane of the mouth of the service tee

Figure B.7 — Dimensions of electrofusion saddle fittings

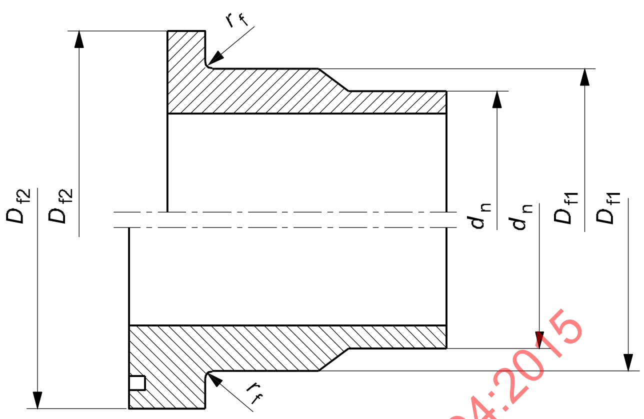
B.3.2.4.3 Other dimensions

Other dimensions of electrofusion fittings shall be specified by the manufacturer.

B.3.2.5 Flange adaptors and loose backing flanges

B.3.2.5.1 Dimensions of flange adaptors for butt fusion

The dimensions of flange adaptors for butt fusion (see Figure B.8) shall conform to Table B.10.



Key

D_{f1} outside diameter of chamfer on shoulder

D_{f2} outside diameter of flange adaptor

r_f radius of chamfer on shoulder

Figure B.8 — Dimensions of flange adaptors for butt fusion

Table B.10 — Dimensions of flange adaptors for butt fusion

Dimensions in millimetres

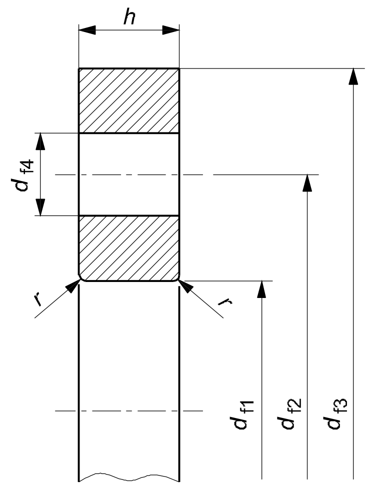
Nominal outside diameter of the corresponding pipe d_n	Outside diameter of chamfer on shoulder D_{f1}	Outside diameter of flange adaptor D_{f2}	Radius of chamfer on shoulder r_f
16	22	40	3
20	27	45	3
25	33	58	3
32	40	68	3
40	50	78	3
50	61	88	3
63	75	102	4
75	89	122	4
90	105	138	4
110	125	158	4
125	132	158	4
140	155	188	4
160	175	212	4
180	183	212	4
200	232	268	4
225	235	268	4
250	285	320	4
280	291	320	4
315	335	370	4
355	373	430	6

Table B.10 *(continued)*

Nominal outside diameter of the corresponding pipe d_n	Outside diameter of chamfer on shoulder D_{f1}	Outside diameter of flange adaptor D_{f2}	Radius of chamfer on shoulder r_f
400	427	482	6
450	514	585	6
500	530	585	6
560	615	685	6
630	642	685	6
710	737	800	8
800	840	905	8
900	944	1 005	8
1 000	1 047	1 110	8
1 200	1 245	1 330	8
1 400	1 450	1 540	8
1 600	1 650	1 760	10
1 800	1 860	1 960	10
2 000	2 070	2 170	10

B.3.2.5.2 Dimensions of loose backing flanges for use with flange adaptors for butt fusion

The dimensions of loose backing flanges for use with flange adaptors for butt fusion (see Figure B.9) shall conform to Table B.11.



Key

d_{f1} inside diameter of flange

d_{f2} pitch circle diameter of bolt holes

d_{f3} outside diameter of flange

d_{f4} diameter of bolt holes

r radius of flange

h thickness of backing flange

NOTE The thickness, h, of the loose backing flange is dependent on the material used.

Figure B.9 — Dimensions of loose backing flanges for use with flange adaptors for butt fusion

Table B.11 — Dimensions of loose backing flanges for use with flange adaptors for butt fusion

Dimensions in millimetres

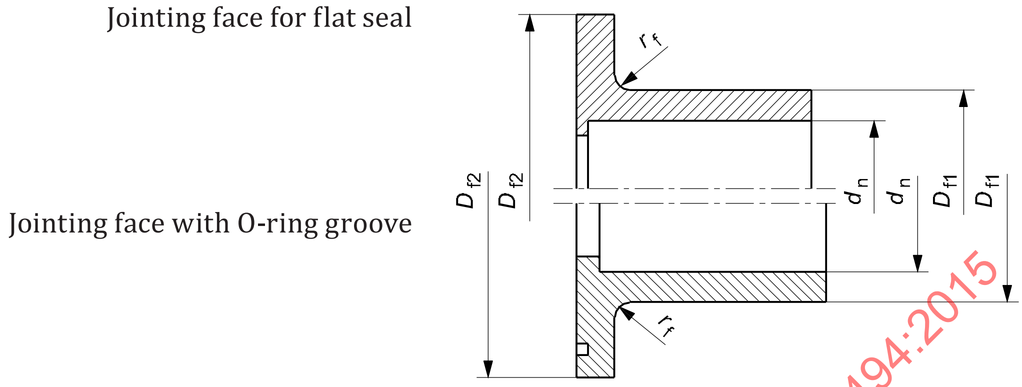
Nominal outside diameter of the corresponding pipe d_n	Nominal size of flange DN	Inside diameter of flange d_{f1}	Pitch circle diameter of bolt holes d_{f2}	Outside diameter of flange d_{f3} min.	Diameter of bolt holes d_{f4}	Radius of flange r	Number of bolt holes n	Metric thread of bolt
16	10	23	60	90	14	3	4	M12
20	15	28	65	95	14	3	4	M12
25	20	34	75	105	14	3	4	M12
32	25	42	85	115	14	3	4	M12
40	32	51	100	140	18	3	4	M16
50	40	62	110	150	18	3	4	M16
63	50	78	125	165	18	3	4	M16
75	65	92	145	185	18	3	4	M16
90	80	108	160	200	18	3	8	M16
110	100	128	180	220	18	3	8	M16

Table B.11 *(continued)*

Nominal outside diameter of the corresponding pipe d_n	Nominal size of flange DN	Inside diameter of flange d_{f1}	Pitch circle diameter of bolt holes d_{f2}	Outside diameter of flange d_{f3} min.	Diameter of bolt holes d_{f4}	Radius of flange r	Number of bolt holes n	Metric thread of bolt
125	100	135	180	220	18	3	8	M16
140	125	158	210	250	18	3	8	M16
160	150	178	240	285	22	3	8	M20
180	150	188	240	285	22	3	8	M20
200	200	235	295	340	22	3	8	M20
225	200	238	295	340	22	3	8	M20
250	250	288	350	395	22	3	12	M20
280	250	294	350	395	22	3	12	M20
315	300	338	400	445	22	3	12	M20
355	350	376	460	505	22	4	16	M20
400	400	430	515	565	26	4	16	M24
450	500	517	620	670	26	4	20	M24
500	500	533	620	670	26	4	20	M24
560	600	618	725	780	30	4	20	M27
630	600	645	725	780	30	4	20	M27
710	700	740	840	895	30	5	24	M27
800	800	843	950	1 015	33	5	24	M30
900	900	947	1 050	1 115	33	5	28	M30
1 000	1 000	1 050	1 160	1 230	36	5	28	M33
1 200	1 200	1 260	1 380	1 455	39	6	32	M36
1 400	1 400	1 470	1 590	1 675	42	7	36	M39
1 600	1 600	1 670	1 820	1 915	48	7	40	M45
1 800	1 800	1 875	2 020	2 115	48	7	44	M45
2 000	2 000	2 085	2 230	2 325	48	7	48	M45

B.3.2.5.3 Dimensions of flange adaptors for socket fusion

The dimensions of flange adaptors for socket fusion (see Figure B.10) shall conform to Table B.12.



Key

D_{f1} outside diameter of chamfer on shoulder

D_{f2} outside diameter of flange adaptor

r_f radius of chamfer on shoulder

Figure B.10 — Dimensions of flange adaptors for socket fusion

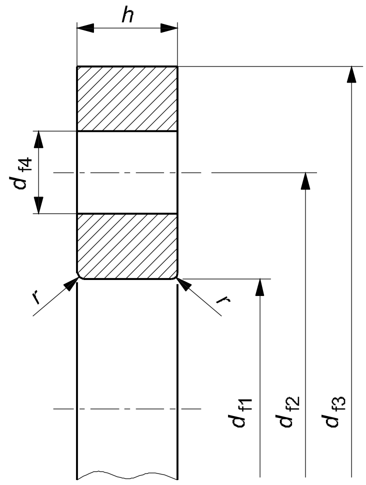
Table B.12 — Dimensions of flange adaptors for socket fusion

Dimensions in millimetres

Nominal outside diameter of the corresponding pipe d_n	**Outside diameter of chamfer on shoulder** D_{f1}	**Outside diameter of flange adaptor** D_{f2}	**Radius of chamfer on shoulder** r_f
16	22	40	3
20	27	45	3
25	33	58	3
32	41	68	3
40	50	78	3
50	61	88	3
63	76	102	4
75	90	122	4
90	108	138	4
110	131	158	4

B.3.2.5.4 Dimensions of loose backing flanges for use with flange adaptors for socket fusion

The dimensions of loose backing flanges for use with flange adaptors for socket fusion (see Figure B.11) shall conform to Table B.13.



Key

d_{f1} inside diameter of flange
d_{f2} pitch circle diameter of bolt holes
d_{f3} outside diameter of flange
d_{f4} diameter of bolt holes
r radius of flange
h thickness of backing flange

NOTE The thickness, h, of the loose backing flange is dependent on the material used.

Figure B.11 — Dimensions of loose backing flanges for use with flange adaptors for socket fusion

Table B.13 — Dimensions of loose backing flanges for use with flange adaptors for socket fusion

Dimensions in millimetres

Nominal outside diameter of the corresponding pipe d_n	Nominal size of flange DN	Inside diameter of flange d_{f1}	Pitch circle diameter of bolt holes d_{f2}	Outside diameter of flange d_{f3} min.	Diameter of bolt holes d_{f4}	Radius of flange r	Number of bolt holes n	Metric thread of bolt
16	10	23	60	90	14	3	4	M12
20	15	28	65	95	14	3	4	M12
25	20	34	75	105	14	3	4	M12
32	25	42	85	115	14	3	4	M12
40	32	51	100	140	18	3	4	M16
50	40	62	110	150	18	3	4	M16
63	50	78	125	165	18	3	4	M16
75	65	92	145	185	18	3	4	M16
90	80	110	160	200	18	3	8	M16
110	100	133	180	220	18	3	8	M16

B.4 Mechanical characteristics

B.4.1 Mechanical characteristics of pipes and fittings

B.4.1.1 General

When tested in accordance with the test methods as specified in Table B.14 using the indicated parameters in Table B.15, the pipe shall have mechanical characteristics conforming to the requirements given in Table B.14.

Table B.14 — Mechanical characteristics

Characteristic	Requirements	Test parameters			Test method
		Material	Hydrostatic (hoop) stress MPa	Time h	
Resistance to internal pressure at 20 °C	No failure during the test period	PE 63	8,0	≥100	ISO 1167-1
		PE 80	10,0		ISO 1167-2
		PE 100	12,0		
Resistance to internal pressure at 80 °C		PE 63	3,5	≥165[a]	ISO 1167-1
		PE 80	4,5		ISO 1167-2
		PE 100	5,4		
Resistance to internal pressure at 80 °C		PE 63	3,2	≥1 000	ISO 1167-1
		PE 80	4,0		ISO 1167-2
		PE 100	5,0		

[a] If a failure occurs before the required minimum time, B.4.1.2 shall be applied.

Table B.15 — Test conditions for internal pressure testing

Test parameters	
End caps	Type A according to ISO 1167-1
Orientation	Free
Conditioning period	In accordance with ISO 1167-1
Type of test	Water-in-water or water-in-air[a]
[a] In case of dispute, water-in-water shall be used.	

B.4.1.2 Retest in case of failure at 80 °C

A fracture in a brittle mode in less than 165 h shall constitute a failure, however, if a sample in the 165 h test fails in a ductile mode in less than 165 h, a retest shall be performed at a selected lower stress in order to achieve the minimum required time for the selected stress obtained from the line through the stress/time points given in Table B.16.

Table B.16 — Test parameters for retest of hydrostatic (hoop) stress at 80 °C

PE 63		PE 80		PE 100	
Stress MPa	Minimum test period h	Stress MPa	Minimum test period h	Stress MPa	Minimum test period h
3,5	165	4,5	165	5,4	165
3,4	295	4,4	233	5,3	256
3,3	538	4,3	331	5,2	399
3,2	1 000	4,2	474	5,1	629
-	-	4,1	685	5,0	1 000
-	-	4,0	1 000	-	-

B.4.2 Mechanical characteristics of valves

The valves shall conform to the requirements of ISO 16135, ISO 16136, ISO 16137, ISO 16138, ISO 16139, or ISO 21787, as applicable, depending on the valve type.

B.5 Physical characteristics

B.5.1 Physical characteristics of pipes

When tested in accordance with the test methods as specified in Table B.17, using the indicated parameters, the pipe shall have physical characteristics conforming to the requirements given in Table B.17.

Table B.17 — Physical characteristics of pipes

Characteristic	Requirements	Test parameters		Test method
Oxidation induction time (Thermal stability)	≥20 min	Test temperature	200 °C[a,b]	ISO 11357-6
		Test environment	Oxygen	
		Specimen weight	15 ± 2 mg	
[a] Test may be carried out as an indirect test at 210 °C or 220 °C provided that clear correlation has been established with the results at 200 °C. In case of dispute, the reference temperature shall be 200 °C.				
[b] Samples shall be taken from the outer and inner pipe surfaces.				

Table B.17 *(continued)*

Characteristic	Requirements	Test parameters		Test method
Melt mass-flow rate (MFR)	Change of MFR by processing ±20 %	Test temperature Loading mass	190 °C 5 kg	ISO 1133-1
Longitudinal reversion Wall thickness ≤16 mm	≤3 % original appearance of the pipe shall remain	Test temperature Length of test piece Immersion time Number of test pieces[a]	110 °C 200 mm 1 h Free	ISO 2505

[a] Test may be carried out as an indirect test at 210 °C or 220 °C provided that clear correlation has been established with the results at 200 °C. In case of dispute, the reference temperature shall be 200 °C.

[b] Samples shall be taken from the outer and inner pipe surfaces.

B.5.2 Physical characteristics of fittings

When tested in accordance with the test method as specified in Table B.18 using the indicated parameters, the fitting shall have physical characteristics conforming to the requirements given in Table B.18.

Table B.18 — Physical characteristics of fittings

Characteristic	Requirements	Test parameters		Test method
Oxidation induction time (Thermal stability)	≥20 min	Test temperature Number of test pieces[a] Test environment Specimen weight	200 °C[c] 3 Oxygen 15 mg ± 2 mg	ISO 11357-6
Melt mass-flow rate (MFR)	When processing the material into a fitting, the MFR value specified by the raw material producer may deviate at maximum ±20 % compared with the raw material[b]	Test temperature Load Test period Number of test pieces	190 °C 5 kg 10 min Shall conform to ISO 1133-1	ISO 1133-1

[a] The number of test pieces given indicate the quantity required to establish a value for the characteristic described in this table. The number of test pieces required for factory production control and process control should be listed in the manufacturer's quality plan.

[b] Value as measured on the fitting relative to the value measured on the compound used.

[c] Test may be carried out as an indirect test at 210 °C or 220 °C provided that there is clear correlation of the results to those at 200 °C. In cases of dispute, the reference temperature shall be 200 °C.

B.5.3 Physical characteristics of valves

In addition to the requirements of ISO 16135, ISO 16136, ISO 16137, ISO 16138, ISO 16139, or ISO 21787, as applicable, depending on the valve type, the physical characteristics of valves shall conform to B.5.2.

B.6 Fitness for purpose of the system

Fitness for purpose of the system shall be deemed to apply when test pieces assembled in accordance with 12.2 and tested using the test methods and indicated parameters as specified in Table B.19 conforming to the requirements given in Table B.19

Table B.19 — General requirements for fitness for purpose of the system

Characteristic	Requirements	Test parameters		Test method
Hydrostatic strength at 20 °C	No failure during the test period	End caps	Type A according to ISO 1167-1	ISO 1167-1 ISO 1167-4
		Orientation	Free	
		Test temperature	20 °C	
		Type of test	Water-in-water or water-in-air[a]	
For fusion and mechanical joints		Hydrostatic (hoop) stress:		
		PE 63		
		PE 80	1,2 PN[b]	
		PE 100		
		Conditioning period	In accordance with ISO 1167-1	
		Test period	≥1 000 h	

[a] In case of dispute, water-in-water applies.

[b] PN of the system.

Annex C
(normative)

Specific characteristics and requirements for industrial piping systems made from polyethylene of raised temperature resistance (PE-RT)

C.1 Material

C.1.1 General

This Annex is applicable to the following types of polyethylene of raised temperature resistance:

— polyethylene of raised temperature resistance (PE-RT) Type I;

— polyethylene of raised temperature resistance (PE-RT) Type II.

C.1.2 Material for components

The material shall be tested in accordance with 5.2 at 20 °C, 60 °C to 80 °C, and 95 °C, as well as at various hydrostatic (hoop) stresses, in such a way that at each temperature, at least three failure times fall in each of the following time intervals:

— 10 h to 100 h;

— 100 h to 1 000 h;

— 1 000 h to 8 760 h;

— >8 760 h.

In tests lasting more than 8 760 h, any time which is reached at a certain stress and time at least on or above the relevant reference curve may be considered as failure time.

The values of the minimum required hydrostatic strength [see reference curves given in Figure C.1 (PE-RT) Type I in the temperature range of 10°C to 95°C and Figure C.2 (PE-RT) Type II in the temperature range of 10 °C to 110 °C] are calculated using Formula (C.1) to Formula (C.3). The dotted lines of the reference curves apply if tests with longer testing times are carried out at 80 °C, 90 °C, 95 °C, and 110 °C, as applicable. The longer testing times shall be deduced from the extrapolation time limits given in ISO 9080:2012.

NOTE 1 The reference curve for (PE-RT) Type I for 110 °C has been determined separately using water inside and air outside the test specimen and has not been derived from the values of Formula (C.1).

NOTE 2 The calculation for PE-RT is based on ISO 24033.

For PE-RT Type I, first branch (i.e. the left-hand portion of the lines shown in Figure C.1):

$$\log t = -190{,}481 - \frac{58219{,}035 \log \sigma}{T} + \frac{78763{,}07}{T} + 119{,}877 \log \sigma \quad \text{(C.1)}$$

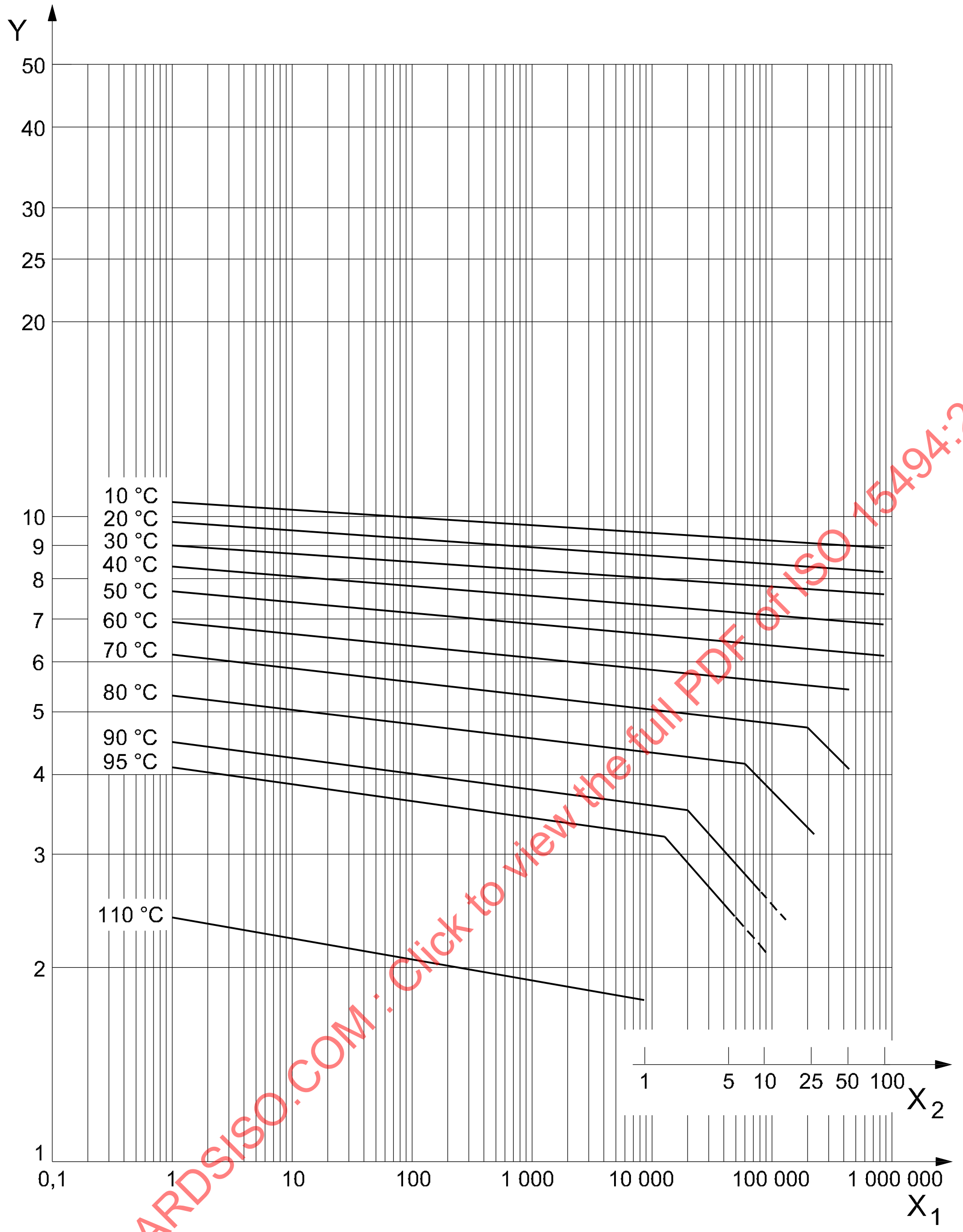
For PE-RT Type I, second branch (i.e. the right-hand portion of the lines shown in Figure C.1):

$$\log t = -23{,}7954 - \frac{1723{,}318 \log \sigma}{T} + \frac{11150{,}56}{T} \quad \text{(C.2)}$$

For PE-RT Type II, there is only one branch as shown in Figure C.2:

$$\log t = -219 - \frac{62600{,}752 \log \sigma}{T} + \frac{90635{,}353}{T} + 126{,}387 \log \sigma \quad \text{(C.3)}$$

NOTE 3 The reference curves for PE-RT Type II in Figure C.2 in the temperature range of 10 °C to 110 °C are derived from Formula (C.3).



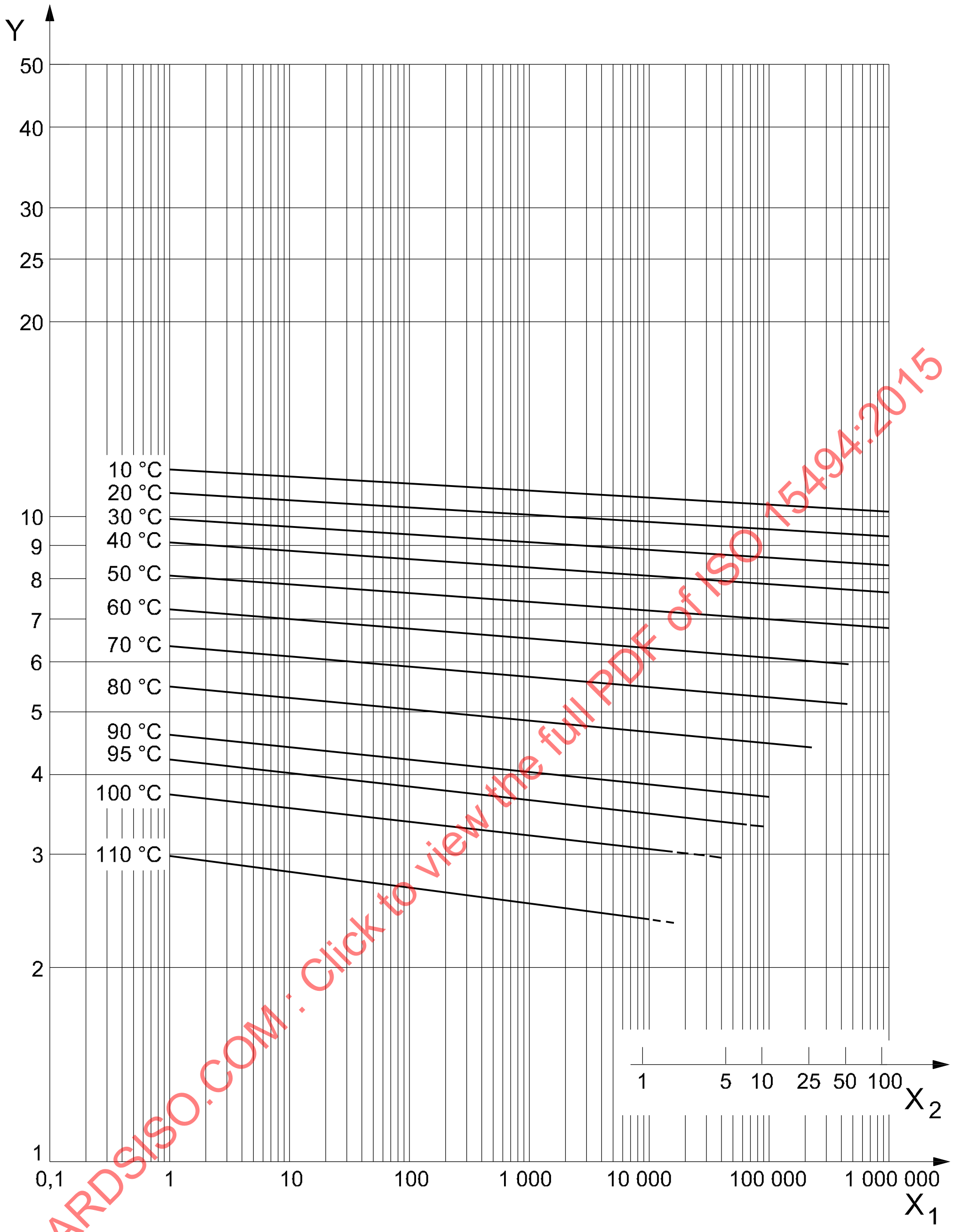
Key

X_1 time to failure, in hours (h)

X_2 time to failure, in years

Y hoop stress, in megapascal (MPa)

Figure C.1 — Minimum required hydrostatic strength curves for PE-RT Type I



Key

X_1 time to failure, in hours (h)

X_2 time to failure, in years

Y hoop stress, in megapascal (MPa)

Figure C.2 — Minimum required hydrostatic strength curves for PE-RT Type II

C.1.3 MRS-value

When evaluated in accordance with 5.2, PE-RT shall have a minimum required strength, MRS, at least equal to 8,0 MPa.

C.1.4 Material characteristics

The material from which the components are manufactured shall conform to the requirements given in Table C.1

Table C.1 — Material characteristics of PE-RT

Characteristic	Requirements[a]	Test parameters		Test method
Melt mass-flow rate (MFR)	Type I ≤ 2,5 g/10 min	Test temperature	190 °C	ISO 1133-1
	Type II ≤ 2,0 g/10 min	Loading mass	5 kg	
Pigment dispersion	≤Grade 3	Preparation of test pieces	Compression or microtome cut[b]	ISO 18553
Thermal stability tested by resistance to internal pressure at 110 °C[c]	No failure during the test period	End caps	Type A according to ISO 1167-1	ISO 1167-1 ISO 1167-2
		Orientation	Free	
		Conditioning period	According to ISO 1167-1	
		Type of test	Water-in-air	
		Hydrostatic (hoop) stress	Type I 1,9 MPa Type II 2,3 MPa	
		Test temperature Test period	110 °C 8 760 h	

a Conformity to these requirements shall be declared by the raw material producer.

b In case of dispute, the compression method shall be used.

c Carried out as type test only (see Table C.4). Results from evaluation according to ISO 9080:2012 shall be taken into account.

C.1.5 Coextruded pipe

PE-RT pipes with co-extruded layers on either or both the outside and/or inside of the pipe (total outside diameter, d_n) where all PE-RT layers shall be of the same type or MRS.

C.2 General characteristics: Colour

Non pigmented pipes can be used provided that UV protection is not needed. Other colours shall be agreed upon between manufacturer and purchaser.

C.3 Geometrical characteristics

Diameters up to and including a 1 000 mm are applicable for PE-RT pipes and fittings. The dimensions of PE pipes and fittings are applicable, see B.3.

C.4 Mechanical characteristics

C.4.1 Mechanical characteristics of pipes and fittings

When tested as specified in Table C.2 using the indicated parameters, the components shall withstand the hydrostatic stress without bursting or leaking under the test conditions given in Table C.3.

Table C.2 — Requirements for internal pressure testing

Characteristic	Requirements	Test parameters			Test method[a]
		Hydrostatic (hoop) stress MPa		Time h	
		Type I	Type II		
Resistance to internal pressure at 20 °C	No failure during the test period	9,9	10,8	≥1	ISO 1167-1 ISO 1167-2 ISO 1167-3
Resistance to internal pressure at 95 °C		3,6	3,7	≥165	ISO 1167-1 ISO 1167-2 ISO 1167-3
Resistance to internal pressure at 95 °C		3,4	3,6	≥1 000	ISO 1167-1 ISO 1167-2 ISO 1167-3

[a] Fittings shall be prepared in accordance with ISO 1167-3 and tested in accordance with ISO 1167-2.

Table C.3 — Test conditions for internal pressure testing

Test parameters	
End caps	Type A according to ISO 1167-1
Orientation	Free
Conditioning period	In accordance with 1167-1
Type of test	Water inside and outside the test specimen or water inside-air outside the test specimen[a]

[a] In case of dispute, water inside and outside the test specimen shall be used.

C.5 Physical characteristics

C.5.1 Physical characteristics of pipes

When tested in accordance with the test methods as specified in Table C.4 using the indicated parameters, the pipe shall have physical characteristics conforming to the requirements given in Table C.4.

Table C.4 — Physical characteristics of pipes

Characteristic	Requirements	Test parameters		Test method
Melt mass-flow rate (MFR)	30 % maximum difference compared to material	Test temperature Loading mass	190 °C 5 kg	ISO 1133-1
Longitudinal reversion	≤2 %	Temperature Duration of exposure: $e \leq 8$ mm $8 \text{ mm} < e \leq 16$ mm Number of test pieces	110 °C 1 h 2 h 3	ISO 2505

Table C.4 *(continued)*

Characteristic	Requirements	Test parameters		Test method
Thermal stability tested by resistance to internal pressure at 110 °C	No failure during the test period	End caps	Type A according to ISO 1167-1	ISO 1167-1 ISO 1167-2
		Orientation	Not specified	
		Type of test	Water-in-air	
		Hydrostatic (hoop) stress	Type I 1,9 MPa Type II 2,3 MPa	
		Test temperature	110 °C	
		Test period	8 760 h	

C.5.2 Physical characteristics of fittings

When tested in accordance with the test method as specified in Table C.5 using the indicated parameters, the fitting shall have physical characteristics conforming to the requirements given in Table C.5.

Table C.5 — Physical characteristics of fittings

Characteristic	Requirements	Test parameters		Test method
Melt mass-flow rate (MFR)	30 % maximum difference compared to material	Test temperature	190 °C	ISO 1133-1
		Loading mass	5 kg	

C.6 Fitness for purpose of the system

Fitness for purpose of the system shall be deemed to apply when test pieces are assembled in accordance with 12.2 and tested using the test methods and indicated parameters as specified in Table C.6 conforming to the requirements given in Table C.6.

Table C.6 — General requirements for fitness for purpose of the system

Characteristic	Requirements	Test parameters		Test method
Hydrostatic strength at 95 °C	No failure during the test period	End caps Orientation Test temperature Type of test	Type A according to ISO 1167-1 Free 95 °C Water inside and outside the test specimen or water inside-air outside the test specimen[a]	ISO 1167-1 ISO 1167-4
		Hydrostatic (hoop) stress	Type I 3,4 MPa Type II 3,6 MPa	
		Conditioning period	In accordance with ISO 1167-1	
		Test period	≥1 000 h	

[a] In case of dispute, water inside and outside the test specimen shall be used.

Annex D
(normative)

Specific characteristics and requirements for industrial piping systems made from crosslinked polyethylene (PE-X)

D.1 Material

D.1.1 Material for components

To prove conformance with the reference curves given in Figure D.1, the material shall be tested in accordance with 5.2 at 20 °C, 60 °C to 80 °C and 95 °C as well as at various hydrostatic (hoop) stresses in such a way that at each temperature, at least three failure times fall in each of the following time intervals:

— 10 h to 100 h;

— 100 h to 1 000 h;

— 1 000 h to 8 760 h;

— >8 760 h.

In tests lasting more than 8 760 h, any time which is reached at a certain stress and time at least on or above the relevant reference curve may be considered as failure time.

The values of the minimum required hydrostatic strength (see reference curves given in Figure D.1) in the temperature range of 10 °C to 95 °C are calculated using Formula (D.1). The dotted lines of the reference curves apply if tests with longer testing times are carried out at 80 °C, 90 °C, and 95 °C, as applicable. The longer testing times shall be deduced from the extrapolation time limits given in ISO 9080:2012.

$$\log t = -105{,}8618 - \frac{18506{,}15\log\sigma}{T} + \frac{57895{,}49}{T} - 24{,}997\log\sigma \qquad \text{(D.1)}$$

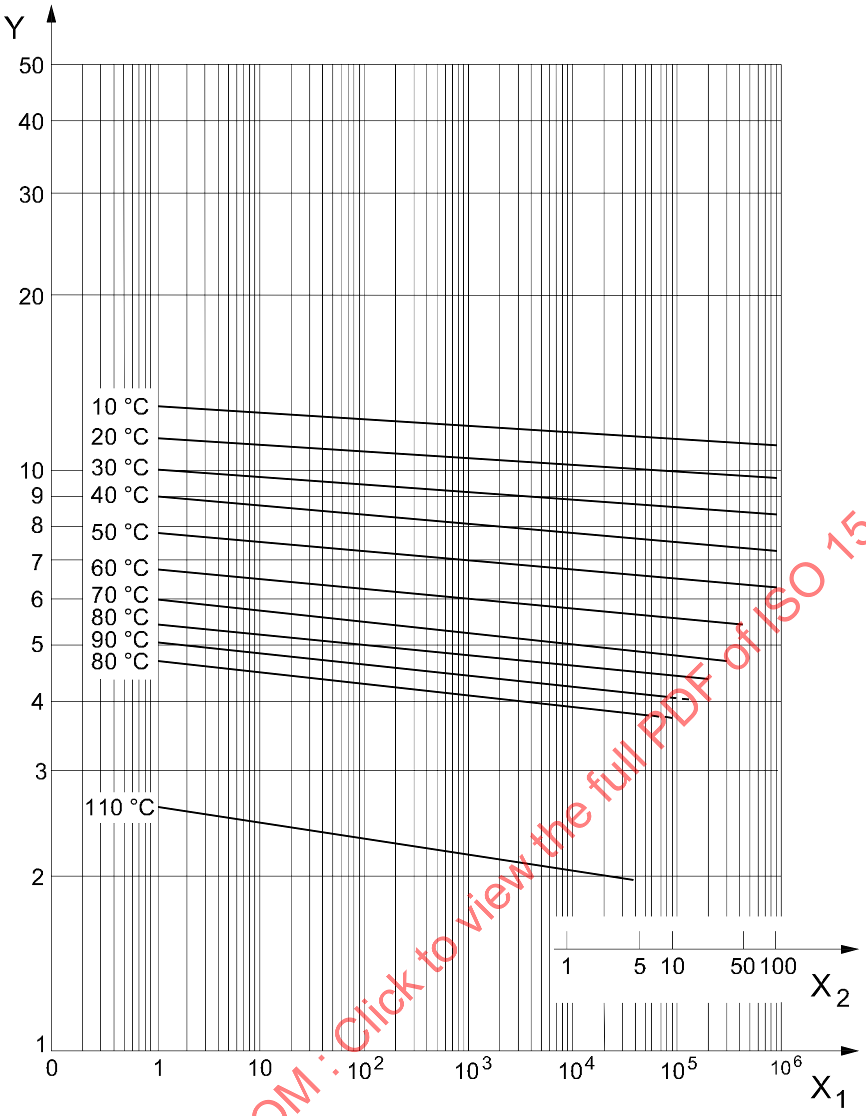
NOTE The calculation for PE-X is based on ISO 10146.

D.1.1.1 MRS-value

Alternatively, PE-X in the form of pipe shall be classified in accordance with ISO 12162. The MRS classification and material designation given in Table D.1 shall apply. Classification, testing, and evaluation shall be undertaken in accordance with ISO 1167-1, ISO 1167-2, ISO 12162, and ISO 9080:2012.

Table D.1 — Classification of PE-X

Designation	σLPL (20 °C, 50 y, 97,5 %)	MRS MPa
PE-X 100	$10{,}00 \le \sigma_{LPL} < 12{,}5$	10,0



Key

X_1 time to failure, in hours (h)

X_2 time to failure, in years

Y hoop stress, in megapascal (MPa)

Figure D.1 — Minimum required hydrostatic strength curves for PE-X

D.1.2 Material characteristics

The material from which the components are manufactured shall conform to the requirements given in Table D.2.

Table D.2 — Material characteristics of PE-X

Characteristic	Requirements[a]	Test parameters		Test method
Crosslinking PE-Xa – peroxide PE-Xb – silane PE-Xc - electron beam	 >70 % >65 % >60 %	Shall conform to ISO 10147		ISO 10147
Pigment dispersion	≤Grade 3	Preparation of test pieces	Compression or microtome cut[b]	ISO 18553
Thermal stability tested by resistance to internal pressure at 110 °C	No failure during the test period	End caps Orientation Conditioning period Type of test Hydrostatic (hoop) stress Test temperature Test period	Type a) according to ISO 1167-1 Free According to ISO 1167-1 Water-in-air 2,5 MPa 110 °C 8 760 h	ISO 1167-1 ISO 1167-2
Slow crack growth[c]	>5 000 h	110 mm SDR 11 pipe Pressure: PE-X[d] PE-X 100	 8,0 bar 9,2 bar	ISO 13479
RCP arrest temperature[e,f]	<50 C	Pipe size Stress level PE-X[d] PE-X 100	>90 mm 6,4 MPa 8,0 MPa	ISO 13477

a Conformity to these requirements shall be declared by the raw material producer.

b To be carried out on compounds. In case of dispute, the compression method shall be used.

c Carried out as type test only. Results from evaluation according to ISO 9080:2012 shall be taken into account.

d Materials conforming to the reference line in accordance with D.1.1.

e RCP evaluation of pipes intended for pipes of diameter <90 mm is unnecessary.

f Alternate temperature limits of −20 °C or −35 °C may be used to qualify material for minimum operating temperatures higher than -50 °C.

D.2 General characteristics: Colour

Non pigmented pipes can be used provided that UV protection is not needed. Other colours shall be agreed upon between manufacturer and purchaser.

D.3 Geometrical characteristics

D.3.1 Dimensions of pipes

D.3.1.1 Diameters and related tolerances

The mean outside diameter, d_{em}, and the related tolerances shall conform to Table D.3, appropriate to the tolerance grade, whereby the average value of the measurements of the outside diameter made at a distance of d_n and $0{,}1d_n$, as well as from the end of the test pieces, shall be within the tolerance range for d_{em} specified in Table D.3.

D.3.1.2 Out-of-roundness

The out-of-roundness for straight lengths shall conform to Table D.3 when measured at the point of manufacture. If other values for the out-of-roundness than those given in Table D.3 are necessary, they shall be agreed upon between manufacturer and purchaser.

For coiled pipes, the maximum out-of-roundness shall be specified by agreement between manufacturer and purchaser.

Table D.3 — Mean outside diameters, related tolerances and out-of-roundness of pipes

Dimensions in millimetres

Nominal outside diameter d_n	Mean outside diameter d_{em} min.	Tolerance of outside diameter Grade A[a]	Out-of-roundness[b] (straight pipes) Grade M[a] max.
12	12,0	+0,3	1,0
16	16,0	+0,3	1,0
20	20,0	+0,3	1,0
25	25,0	+0,3	1,0
32	32,0	+0,3	1,0
40	40,0	+0,4	1,0
50	50,0	+0,5	1,2
63	63,0	+0,6	1,5
75	75,0	+0,7	1,8
90	90,0	+0,9	2,2
110	110,0	+1,0	2,7
125	125,0	+1,2	3,0
140	140,0	+1,3	3,4
160	160,0	+1,5	3,9
180	180,0	+1,7	
200	200,0	+1,8	
225	225,0	+2,1	
250	250,0	+2,3	
280	280,0	+2,6	
315	315,0	+2,9	
355	355,0	+3,2	
400	400,0	+3,6	
450	450,0	+4,1	
500	500,0	+4,5	
560	560,0	+5,0	
630	630,0	+5,7	

a In accordance with ISO 11922-1. Tolerances of the outside diameter are rounded up to the next 0,1 mm

b For straight pipes: Grade M ($0{,}024d_n$).

D.3.1.3 Wall thicknesses and related tolerances

The wall thickness, *e*, and the related tolerances shall conform to Table D.4.

Components intended to be welded shall have a minimum wall thickness of 1,9 mm.

Table D.4 — Wall thicknesses and related tolerances

Dimensions in millimetres

Nominal outside diameter	Wall thickness, *e*, and related tolerances[c]											
	Pipe series S and standard dimension ratio, SDR											
	S 10 SDR 21		S 8 SDR 17		S 6,3 SDR 13,6		S 5 SDR 11		S 4 SDR 9		S 3,2 SDR 7,4	
d_n	e_n	a	e_n	a	e_n	a	e_n	a	e_n	a	e_n	a
12	1,3[b]	+0,3	1,3[b]	+0,3	1,3[b]	+0,3	1,3[b]	+0,3	1,4	+0,3	1,7	+0,3
16	1,3	+0,3	1,3	+0,3	1,3	+0,3	1,5	+0,3	1,8	+0,3	2,2	+0,4
20	1,3	+0,3	1,3	+0,3	1,5	+0,3	1,9	+0,3	2,3	+0,4	2,8	+0,4
25	1,3	+0,3	1,5	+0,3	1,9	+0,3	2,3	+0,4	2,8	+0,4	3,5	+0,5
32	1,6	+0,3	1,9	+0,3	2,4	+0,4	2,9	+0,4	3,6	+0,5	4,4	+0,6
40	1,9	+0,3	2,4	+0,4	3,0	+0,5	3,7	+0,5	4,5	+0,6	5,5	+0,7
50	2,4	+0,4	3,0	+0,5	3,7	+0,5	4,6	+0,6	5,6	+0,7	6,9	+0,8
63	3,0	+0,5	3,8	+0,5	4,7	+0,6	5,8	+0,7	7,1	+0,9	8,6	+1,0
75	3,6	+0,5	4,5	+0,6	5,6	+0,7	6,8	+0,8	8,4	+1,0	10,3	+1,2
90	4,3	+0,6	5,4	+0,7	6,7	+0,8	8,2	+1,0	10,1	+1,2	12,3	+1,4
110	5,3	+0,7	6,6	+0,8	8,1	+1,0	10,0	+1,2	12,3	+1,4	15,1	+1,7
125	6,0	+0,8	7,4	+0,9	9,2	+1,1	11,4	+1,3	14,0	+1,6	17,1	+1,9
140	6,7	+0,8	8,3	+1,0	10,3	+1,2	12,7	+1,4	15,7	+1,7	19,2	+2,1
160	7,7	+0,9	9,5	+1,1	11,8	+1,3	14,6	+1,6	17,9	+1,9	21,9	+2,3
180	8,6	+1,0	10,7	+1,2	13,3	+1,5	16,4	+1,8	20,1	+2,2	24,6	+2,6
200	9,6	+1,1	11,9	+1,3	14,7	+1,6	18,2	+2,0	22,4	+2,4	27,4	+2,9
225	10,8	+1,2	13,4	+1,5	16,6	+1,8	20,5	+2,2	25,2	+2,7	30,8	+3,2
250	11,9	+1,3	14,8	+1,6	18,4	+2,0	22,7	+2,4	27,9	+2,9	34,2	+3,6
280	13,4	+1,5	16,6	+1,8	20,6	+2,2	25,4	+2,7	31,3	+3,2	38,3	+4,0
315	15,0	+1,6	18,7	+2,0	23,2	+2,5	28,6	+3,0	35,2	+3,7	43,1	+4,5
355	16,9	+1,9	21,1	+2,3	26,1	+2,8	32,2	+3,4	39,7	+4,1	48,5	5,0
400	19,1	+2,1	23,7	+2,5	29,4	+3,1	36,3	+3,8	44,7	+4,6	54,7	+5,6
450	21,5	+2,3	26,7	+2,8	33,1	+3,5	40,9	+4,2	50,3	+5,2		
500	23,9	+2,5	29,7	+3,1	36,8	+3,8	45,4	+4,7	55,8	+5,7	-	-
560	26,7	+2,8	33,2	+3,5	41,2	+4,2	-	-	62,5	+6,4	-	-
630	30,0	+3,1	37,4	+3,9	46,3	+4,8	-	-	70,3	+7,2	-	-

a Tolerance of the wall thickness: 0,1*e* + 0,1 mm, rounded up to the next 0,1 mm.

b For d_n = 12, a non-preferred wall thickness of 1,1 mm may be chosen.

c All dimensions correspond to ISO 4065.

D.3.2 Dimensions of fittings

D.3.2.1 General

This Annex is applicable for the following types of fittings:

— electrofusion fittings;

— flange adaptors and loose backing flanges;

— mechanical fittings.

D.3.2.2 Electrofusion fittings

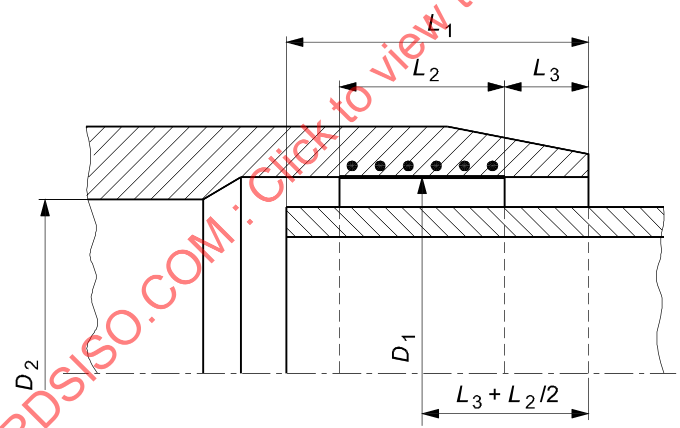
D.3.2.2.1 Dimensions of sockets of electrofusion fittings

The dimensions of sockets of electrofusion fittings (see Figure D.2) shall conform to Table D.5.

In the case of a fitting having sockets of different sizes (e.g. reduction), each socket shall conform to the requirements of the corresponding nominal diameter.

The mean inside diameter of the fitting in the middle of the fusion zone, D_1, shown in Figure D.2 shall not be less than d_n. The manufacturer shall declare the actual maximum and minimum values of D_1 and L_1 for determining suitability for clamping and joint assembly.

In case of using spigot end fittings, the outside tubular length of the fusion end shall allow the assembly with an electrofusion fitting.



Key

D_1 mean inside diameter in the fusion zone measured in a plane parallel to the plane of the mouth at a distance of L_3 + 0,5L_2 from that face

D_2 bore, which is the minimum diameter of the flow channel through the body of the fitting

L_1 depth of penetration of the pipe or male end of a spigot end fitting. In case of a coupling without stop, it is not greater than half the total length of the fitting

L_2 heated length within a socket as declared by the manufacturer, to be the nominal length of the fusion zone

L_3 distance between the mouth of the fitting and the start of the fusion zone as declared by the manufacturer to be the nominal unheated entrance length of the fitting ($L_3 \geq 5$ mm)

Figure D.2 — Dimensions of sockets of electrofusion fittings

Table D.5 — Dimensions of sockets of electrofusion fittings

Dimensions in millimetres

Nominal diameter of fitting d_n	Depth of penetration L_1		Length of the fusion zone L_2
	min.	max.	min.
16	20	35	10
20	20	37	10
25	20	40	10
32	20	44	10
40	20	49	10
50	20	55	10
63	23	63	11
75	25	70	12
90	28	79	13
110	32	85	15
125	35	90	16
140	38	95	18
160	42	101	20

D.3.2.2.2 Other dimensions

Other dimensions of electrofusion fittings shall be specified by the manufacturer.

D.3.2.3 Flange adaptors and loose backing flanges

Dimensions and tolerances of flange adaptors for electrofusion shall be specified by the manufacturer.

Dimensions of loose backing flanges shall be according to known national and International Standards for flanges.

D.4 Mechanical characteristics

D.4.1 Mechanical characteristics of pipes and fittings

When tested as specified in Table D.6, using the indicated parameters, the components shall withstand the hydrostatic stress without bursting or leaking under the test conditions given in Table D.7.

Table D.6 — Requirements for internal pressure testing

Characteristic	Requirements	Test parameters		Test method[a]
		Hydrostatic (hoop) stress MPa	Time H	
Resistance to internal pressure at 20 °C	No failure during test period	12,0[b] PE-X 100: 12,5	≥1	ISO 1167-1 ISO 1167-2 ISO 1167-3
Resistance to internal pressure at 95 °C		4,6[b] PE-X 100: 4,8	≥165	ISO 1167-1 ISO 1167-2 ISO 1167-3
Resistance to internal pressure at 95 °C		4,4[b] PE-X 100: 4,7	≥1 000	ISO 1167-1 ISO 1167-2 ISO 1167-3

[a] Fittings shall be prepared in accordance with ISO 1167-3 and tested in accordance with ISO 1167-1.

[b] For materials complying with the reference curves.

Table D.7 — Test conditions for internal pressure testing

Test parameters	
End caps	Type A according to ISO 1167-1
Orientation	Free
Conditioning period	In accordance with ISO 1167-1
Type of test	Water-in-water or water-in-air[a]

[a] In case of dispute, water-in-water shall be used.

D.4.2 Mechanical characteristics of valves

The valves shall conform to the requirements of ISO 16135, ISO 16136, ISO 16137, ISO 16138, ISO 16139, or ISO 21787, as applicable, depending on the valve type.

D.5 Physical characteristics

D.5.1 Physical characteristics of pipes

When tested in accordance with the test methods specified in Table D.8, using the indicated parameters, the pipe shall have physical characteristics conforming to the requirements given in Table D.8.

Table D.8 — Physical characteristics of pipes

Characteristic	Requirements	Test parameters	Test method
Crosslinking		Shall conform to ISO 10147	ISO 10147
— peroxide PE-Xa	≥70 %[b]		
— silane PE-Xb	≥65 %[b]		
— electron beam PE-Xc	≥60 %[b]		

[a] The choice of method A or method B is free. In case of dispute, method B shall be used.

[b] Minimum requirement tested on pipe before delivery

Table D.8 *(continued)*

Characteristic	Requirements	Test parameters		Test method
Longitudinal reversion[a] Wall thickness ≤ 16 mm	≤3 % Original appearance of pipe shall remain	Temperature Length of test piece Immersion time: Test method Number of test pieces	110 °C 200 mm 1 h Free Shall conform to ISO 2505	ISO 2505
Thermal stability tested by resistance to internal pressure at 110 °C	No failure during the test period	End caps Orientation Conditioning period Type of test Hydrostatic (hoop) stress Test temperature Test period	Type A according to ISO 1167-1 Free According to ISO 1167-2 Water-in-air 2,5 MPa 110 °C 8 760 h	ISO 1167-1 ISO 1167-2

[a] The choice of method A or method B is free. In case of dispute, method B shall be used.

[b] Minimum requirement tested on pipe before delivery

D.5.2 Physical characteristics of fittings

When tested in accordance with the test method specified in Table D.8, using the indicated parameters, the fitting shall have physical characteristics conforming to the requirements given in Table D.8.

Table D.9 — Physical characteristics of fittings

Characteristic	Requirements	Test parameters	Test method
Crosslinking		Shall conform to ISO 10147	ISO 10147
— peroxide PE-Xa	≥70 %[a]		
— silane PE-Xb	≥65 %[a]		
— electron beam PE-Xc	≥60 %[a]		

[a] Minimum requirement tested on fittings before delivery.

D.5.3 Physical characteristics of valves

In addition to the requirements of ISO 16135, ISO 16136, ISO 16137, ISO 16138, ISO 16139, or ISO 21787, as applicable, depending on the valve type, the physical characteristics of valves shall conform to D.5.2.

D.6 Fitness for purpose of the system

Fitness for purpose of the system shall be deemed to apply when test pieces assembled in accordance with 12.2 and tested using the test methods and indicated parameters as specified in Table D.9 conforming to the requirements given in Table D.10.

Table D.10 — General requirements for fitness for purpose of the system

Characteristic	Requirements	Test parameters		Test method
Hydrostatic strength at 95 °C	No failure during the test period	End caps	Type A according to ISO 1167-1	ISO 1167-1
		Orientation	Free	ISO 1167-4
		Test temperature	95 °C	
		Type of test	Water-in-water or water-in-air[a]	
		Conditioning period	According to ISO 1167-1	
		Hydrostatic (hoop) stress	4,4 MPa PE-X 100 4,7 MPa	
		Test period	≥1 000 h	
Pull-out test[b]	No failure during the test period	Pull out force	1,5 × *F* in N	EN 712
		Test temperature	23 °C	
		Test period	1 h	

[a] In case of dispute, water-in-water shall be used.

[b] The force, *F*, shall be calculated using the following formula: $F = \frac{\pi}{4} \times d_n^2 \times PN$

Annex E
(normative)

Specific characteristics and requirements for industrial piping systems made from polypropylene (PP)

E.1 Material

E.1.1 General

This Annex is applicable to the following types of polypropylene:

— polypropylene homopolymer (PP-H);

— polypropylene block-copolymer (PP-B);

— polypropylene random-copolymer (PP-R);

— polypropylene random-copolymer with modified crystallinity (PP-RCT).

E.1.2 Material for components

The material shall be tested in accordance with 5.2 at 20 °C, 60 °C to 82 °C, and 95 °C, as well as at various hydrostatic (hoop) stresses, in such a way that at each temperature, at least three failure times fall in each of the following time intervals:

— 10 h to 100 h;

— 100 h to 1 000 h;

— 1 000 h to 8 760 h;

— >8 760 h.

In tests lasting more than 8 760 h, any time which is reached at a certain stress and time at least on or above the relevant reference curve may be considered as failure time.

The values of the minimum required hydrostatic strength [see reference curves given in Figure E.1 (PP-H), Figure E.2 (PP-B), Figure E.3 (PP-R), and Figure E.4 (PP-RCT) in the temperature range of 10 °C to 95 °C are calculated using the following Formula (E.1) to Formula (E.8). The dotted lines of the reference curves apply if tests with longer testing times are carried out at 80 °C, 90 °C, 95 °C, and 110 °C, as applicable. The longer testing times shall be deduced from the extrapolation time limits given in ISO 9080:2012

NOTE 1 The reference curve for 110 °C has been determined separately by testing using water-in-air and has not been derived from the values of Formula (E.1) to Formula (E.6).

First branch (i.e. the left hand portion of the curves as shown in Figure E.1, Figure E.2, and Figure E.3).

— PP-H: $$\log t = -46{,}364 - 9601{,}1 \cdot \frac{\log \sigma}{T} + 20381{,}5 \cdot \frac{1}{T} + 15{,}24 \cdot \log \sigma \qquad \text{(E.1)}$$

— PP-B: $$\log t = -56{,}086 - 10157{,}8 \cdot \frac{\log \sigma}{T} + 23971{,}7 \cdot \frac{1}{T} + 13{,}32 \cdot \log \sigma \qquad \text{(E.2)}$$

— PP-R: $\log t = -55{,}725 - 9484{,}1 \cdot \frac{\log \sigma}{T} + 25502{,}2 \cdot \frac{1}{T} + 6{,}39 \cdot \log \sigma$ (E.3)

— PP-RCT: (only one branch)

$$\log t = -119{,}546 - 23738{,}797 \cdot \frac{\log \sigma}{T} + 52176{,}686 \cdot \frac{1}{T} + 31{,}279 \cdot \log \sigma \quad \text{(E.4)}$$

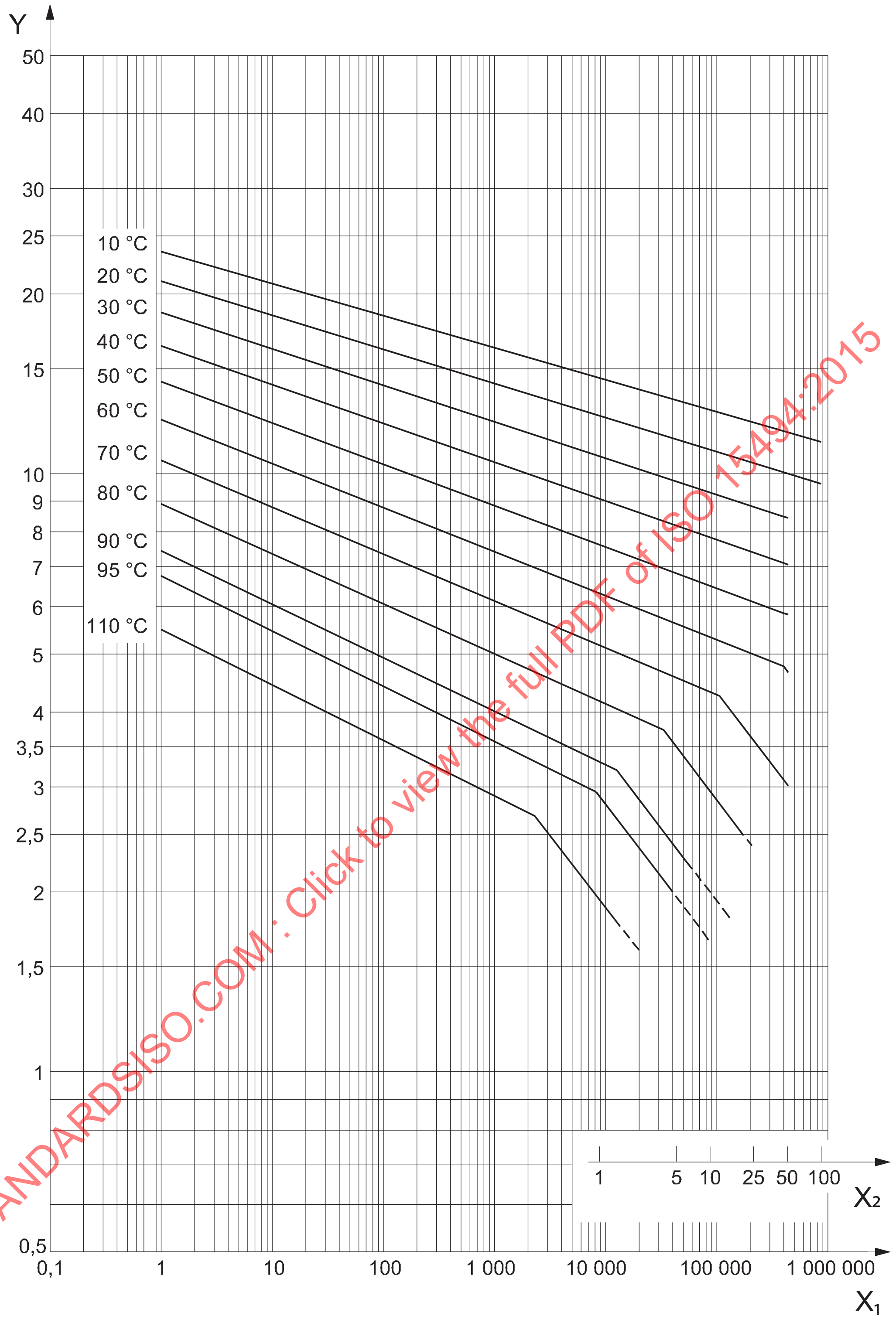
Second branch (i.e. the right hand portion of the curves as shown in Figure E.1, Figure E.2, and Figure E.3).

— PP-H: $\log t = -18{,}387 + 8918{,}5 \cdot \frac{1}{T} - 4{,}1 \cdot \log \sigma$ (E.5)

— PP-B: $\log t = -13{,}699 + 6970{,}3 \cdot \frac{1}{T} - 3{,}82 \cdot \log \sigma$ (E.6)

— PP-R: $\log t = -19{,}98 + 9507{,}0 \cdot \frac{1}{T} - 4{,}11 \cdot \log \sigma$ (E.7)

NOTE 2 The calculation for PP is based on ISO 3213.



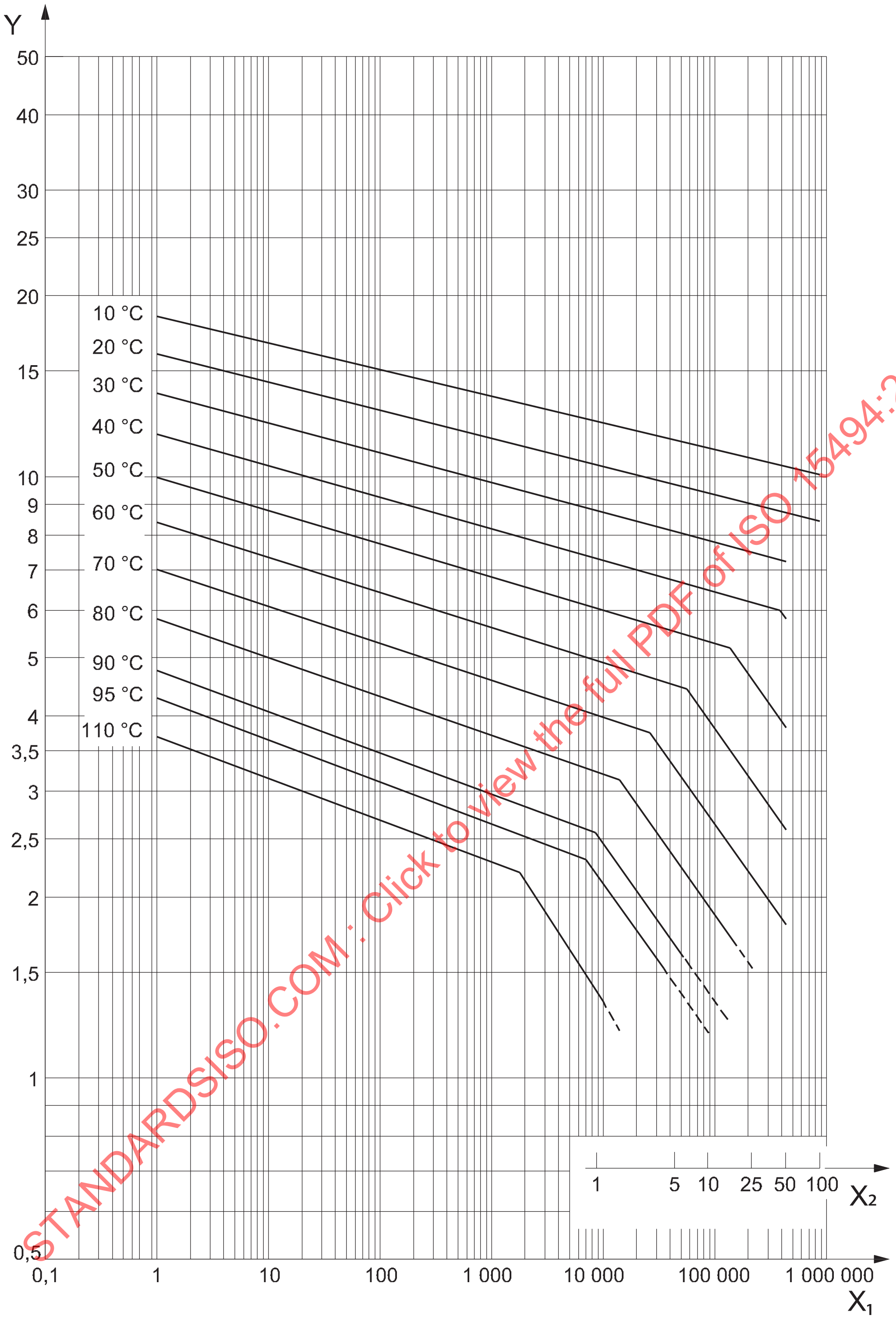
Key

X1 time to failure, in hours (h)

X2 time to failure, in years

Y hoop stress, in megapascal (MPa)

Figure E.1 — Minimum required hydrostatic strength curves for PP-H



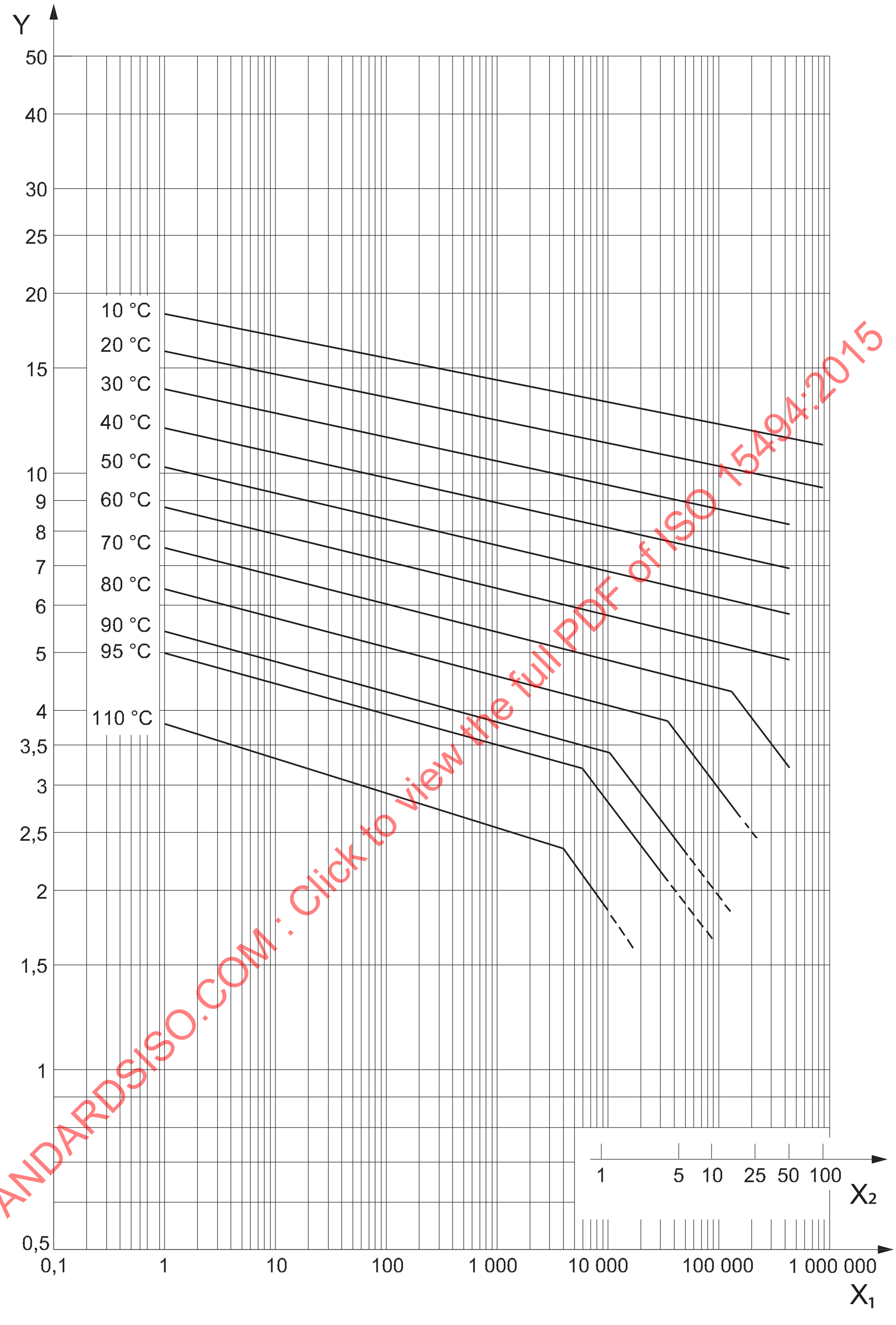
Key

X_1 time to failure, in hours (h)

X_2 time to failure, in years

Y hoop stress, in megapascal (MPa)

Figure E.2 — Minimum required hydrostatic strength curves for PP-B



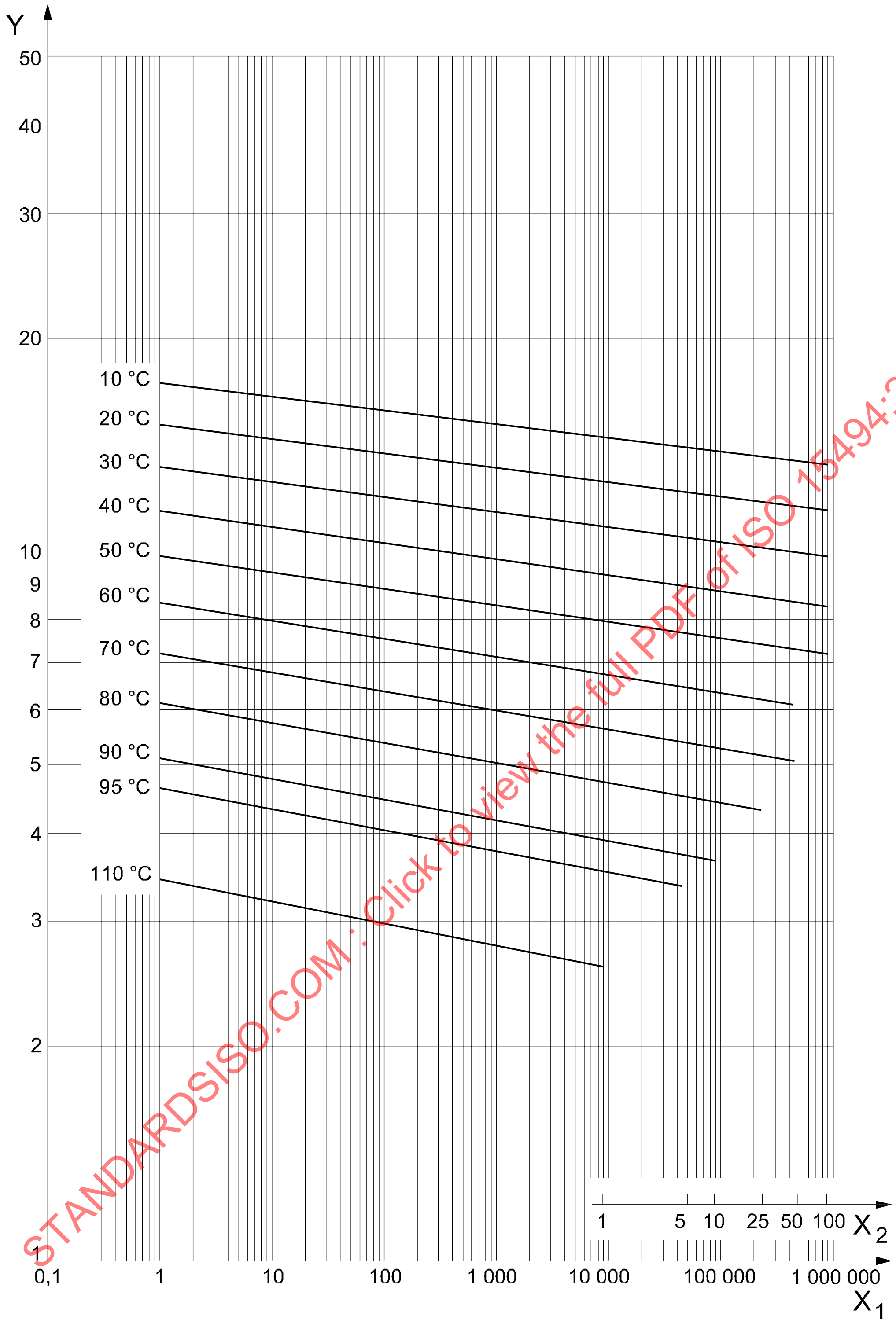
Key

X_1 time to failure, in hours (h)

X_2 time to failure, in years

Y hoop stress, in megapascal (MPa)

Figure E.3 — Minimum required hydrostatic strength curves for PP-R



Key

X_1 time to failure, in hours (h)

X_2 time to failure, in years

Y hoop stress, in megapascal (MPa)

Figure E.4 — Minimum required hydrostatic strength curves for PP-RCT

E.1.3 MRS-value

When evaluated in accordance with 5.2, the applicable PP-types shall have a minimum required strength, MRS, as given in Table E.1.

Table E.1 — MRS-values of PP-types

PP-type	MRS-value
PP-H	≥10,0 MPa
PP-B	≥8,0 MPa
PP-R	≥8,0 MPa
PP-RCT	≥11,2 MPa

E.1.4 Material characteristics

The material from which the components are manufactured shall conform to the requirements given in Table E.2.

Table E.2 — Material characteristics of PP

Characteristic	Requirements[a]	Test parameters			Test method
Pigment dispersion	≤Grade 3	Preparation of test pieces		Compression or microtome cut[b]	ISO 13949
Charpy impact resistance	PP-H ≥ 7 kJ/m^2	Test temperature		23 °C	ISO 179-2
	PP-B ≥ 25 kJ/m^2	Test pieces		Notched	Test method:
	PP-R ≥ 25 kJ/m^2				ISO 179/1eA
	PP-RCT ≥ 15 kJ/m^2				
Melt mass-flow rate (MFR)[d]	(0,18 ≤ MFR ≤ 0,5) g/10 min	Test temperature		230 °C	ISO 1133-1
		Loading mass		2,16 kg	
		Number of test pieces		3	
		or[e]			
	(0,28 ≤ MFR ≤ 1,1) g/10 min	Test temperature		190 °C	
		Loading mass		5 kg	
		Number of test pieces		3	
Thermal stability tested by resistance to internal pressure at 110 °C[c]	No failure during the test period	Material	Hydro-static (hoop) stress MPa	Time h	ISO 1167-1 ISO 1167-2
		PP-H	1,9	≥8 760	
		PP-B	1,4		
		PP-R	1,9		
		PP-RCT	2,6		

[a] Conformity to these requirements shall be declared by the raw material producer.

[b] In case of dispute, the compression method shall be used.

[c] Test conditions are given in Table E.14.

[d] In case of dispute, the test method agreed upon in the customer product specification with the raw material producer shall be used.

[e] Alternative test method.

E.2 General characteristics: Colour

Components made from PP should preferably be grey (RAL 7032). Other colours shall be agreed upon between manufacturer and purchaser.

NOTE RAL-colour cards are obtainable from national standards institutes.

For colouring of grey components, titanium dioxide TiO_2 (rutile type) is recommended.

E.3 Geometrical characteristics

E.3.1 Dimensions of pipes

E.3.1.1 Diameters and related tolerances

The mean outside diameter, d_{em}, and the related tolerances shall conform to Table E.3, appropriate to the tolerance grade, whereby the average value of the measurements of the outside diameter made at a distance of d_n and $0{,}1d_n$ as well as from the end of the test pieces shall be within the tolerance range for d_{em} specified in Table E.3.

NOTE Pipes with tolerances of Grade A given in ISO 11922-1 are used for socket fusion and electrofusion joints where the peeling technique is used to prepare the pipe end for fusion. Pipes with tolerances of Grade B given in ISO 11922-1 are used for socket fusion joints where the peeling technique is not used.

E.3.1.2 Out-of-roundness

The out-of-roundness for straight lengths shall conform to Table E.3 when measured at the point of manufacture. If other values for the out-of-roundness than those given in Table E.3 are necessary, they shall be agreed upon between manufacturer and purchaser.

For coiled pipes, the maximum out-of-roundness shall be specified by agreement between manufacturer and purchaser.

Table E.3 — Mean outside diameters, related tolerances, and out-of-roundness of pipes

Dimensions in millimetres

Nominal outside diameter d_n	Mean outside diameter d_{em} min.	Tolerance of outside diameter		Out-of-roundness[b] (straight pipes)
		Grade A[a]	Grade B[a]	Grade N[a] max.
12	12,0	+0,3	+0,3	1,2
16	16,0	+0,3	+0,3	1,2
20	20,0	+0,3	+0,3	1,2
25	25,0	+0,3	+0,3	1,2
32	32,0	+0,3	+0,3	1,3
40	40,0	+0,4	+0,4[c]	1,4
50	50,0	+0,5	+0,4[c]	1,4
63	63,0	+0,6	+0,4	1,5
75	75,0	+0,7	+0,5	1,6

[a] In accordance with ISO 11922-1. Tolerances of the outside diameter are rounded up to the next 0,1 mm.

[b] For straight pipes, Grade N for: $d_n \leq 75$ mm ($0{,}008d_n + 1{,}0$ mm); 90 mm $\leq d_n \leq 250$ mm ($0{,}02d_n$); $d_n > 250$ mm ($0{,}035d_n$).

[c] Not in accordance with ISO 11922-1.

