INTERNATIONAL STANDARD

ISO 15876-2

Second edition
2017-01

Plastics piping systems for hot and cold water installations — Polybutene (PB) —

Part 2: Pipes

Systèmes de canalisations en plastique pour les installations d'eau chaude et froide — Polybutène (PB) —

Partie 2: Tubes

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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 World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

ISO 15876-2 was prepared by the European Committee Standardization (CEN) Technical Committee CEN/TC 155, *Plastics piping systems and ducting systems*, in collaboration with ISO Technical Committee ISO/TC 138, *Plastics pipes, fittings and valves for the transport of fluids*, Subcommittee SC 2, *Plastics pipes and fittings for water supplies*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This second edition cancels and replaces the first edition (ISO 15876-2:2003), which has been technically revised with the following changes:

— introduction of polybutene random copolymer (PB-R) and renaming existing polybutene (PB) into polybutene homopolymer (PB-H);

— revision of specifications for conditioning of samples.

It also incorporates the Amendment ISO 15876-2:2003/Amd 1:2007.

A list of all parts in the ISO 15876 series can be found on the ISO website.

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Introduction

The System Standard ISO 15876, of which this document is Part 2, specifies the requirements for a piping system when made from polybutene (PB). The piping system is intended to be used for hot and cold water installations.

In respect of potential adverse effects on the quality of water intended for human consumption, caused by the product covered by ISO 15876 (all parts):

— ISO 15876 (all parts) provides no information as to whether the product may be used without restriction in any of the Member States of the EU or EFTA;

— it should be noted that, while awaiting the adoption of verifiable European criteria, existing national regulations concerning the use and/or the characteristics of this product remain in force.

Requirements and test methods for material and components, other than pipes, are specified in ISO 15876-1 and ISO 15876-3. Characteristics for fitness for purpose (mainly for joints) are covered in ISO 15876-5. ISO/TS 15876-7 gives guidance for the assessment of conformity.

This document specifies the characteristics of pipes.

At the date of publication of this standard, System Standards for piping systems of other plastics materials used for the same application include ISO 15874, ISO 15875, ISO 15876, ISO 15877, ISO 21003 and ISO 22391.

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Plastics piping systems for hot and cold water installations — Polybutene (PB) —

Part 2: Pipes

1 Scope

This document specifies the characteristics of pipes for polybutene-1 (PB-1) piping systems intended to be used for hot and cold water installations within buildings for the conveyance of water whether or not intended for human consumption (domestic systems), and for heating systems, under design pressures and temperatures appropriate to the class of application (see ISO 15876-1).

The designation polybutene is used together with the abbreviation PB throughout this document.

This document covers a range of service conditions (application classes), design pressures and pipe dimension classes. For values of T_D, T_{max} and T_{mal} in excess of those in ISO 15876-1, this document does not apply.

NOTE 1 It is the responsibility of the purchaser or specifier to make the appropriate selections from these aspects, taking into account their particular requirements and any relevant national regulations and installation practices or codes.

It also specifies the test parameters for the test methods referred to in this document.

In conjunction with the other parts of ISO 15876, this document is applicable to PB pipes, their joints and to joints with components of PB, other plastics and non-plastics materials intended to be used for hot and cold water installations.

It is applicable to pipes with or without (a) barrier layer(s).

NOTE 2 In the case of plastics pipes provided with a thin barrier layer, e.g. to prevent or greatly diminish the diffusion of gases and the transmission of light into or through the pipe wall, the design stress requirements are totally met by the base polymer (PB).

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2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

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

ISO 7686, *Plastics pipes and fittings — Determination of opacity*

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

ISO 15876-1:2003, *Plastics piping systems for hot and cold water installations — Polybutene (PB) — Part 1: General*

ISO 15876-3, *Plastics piping systems for hot and cold water installations — Polybutene (PB) — Part 3: Fittings*

ISO 15876-5, *Plastics piping systems for hot and cold water installations — Polybutene (PB) —Part 5: Fitness for purpose of the system*

3 Terms and definitions, symbols and abbreviated terms

For the purposes of this document, the terms and definitions, symbols and abbreviated terms given in ISO 15876-1 apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

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4 Pipe material

4.1 General

The pipe material from which the pipe is made shall comply with ISO 15876-1.

After extrusion or moulding, PB undergoes a crystalline phase transition (usually called ageing) before it develops its final properties. The minimum required transition time depends on temperature and product characteristics. The same final material performance is obtained once completion of crystalline phase transition is achieved, irrespective of transition conditions. For quality control purposes, therefore, test specimens shall be taken immediately after processing and be conditioned in accordance with recommendations obtained from the compound supplier prior to testing.

The crystalline phase transition is dependent on time and temperature. For guidance a minimum time of five days for PB-H and one day for PB-R should be allowed at 23 °C, unless accelerated ageing is performed.

NOTE The crystalline phase transition can be considerably accelerated upon applying higher hydrostatic pressure of approx. 1 kbar to 2 kbar. Accelerated ageing at higher pressure can be accepted if test results can be proven reproducible and equal to those obtained at atmospheric pressure.

Because of the slow crystallization, transformation and shrinkage which takes places after PB-H and PB-R plastics are cooled from the melt, physical testing should be delayed after extrusion or moulding until this morphological transition is complete.

4.2 Evaluation of σ_{LPL}-curves

The pipe material shall be evaluated in accordance with ISO 9080 or equivalent where internal pressure tests are made in accordance with ISO 1167-1 and ISO 1167-2 to find the σ_{LPL}-values. The σ_{LPL}-value thus determined shall at least be as high as the corresponding values of the reference curves given in Figure 1 or Figure 2.

NOTE One equivalent way of evaluation is to calculate the σ_{LPL}-value for each temperature (e.g. 20 °C, 60 °C to 70 °C and 95 °C) individually.

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The reference curves in Figure 1 in the temperature range of 10 °C to 110 °C for PB-H and in Figure 2 in the temperature range of 10 °C to 95 °C for PB-R are derived from the following formulae:

First branch (i.e. the left-hand portion of the lines as shown in Figure 1 and Figure 2)

for PB-H:

$$\log t = -430,866 - \frac{125\,010 \cdot \lg \sigma}{T} + \frac{173\,892,7}{T} + 290,056\,9 \cdot \log \sigma \qquad (1)$$

for PB-R:

$$\log t = -367,8019 - \frac{104\,096,6 \cdot \lg \sigma}{T} + \frac{145\,940,231}{T} + 245,536 \cdot \log \sigma \qquad (2)$$

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

for PB-H:

$$\log t = -129,895 - \frac{37\,262,7 \cdot \lg \sigma}{T} + \frac{52\,556,48}{T} + 88,567\,35 \cdot \log \sigma \qquad (3)$$

To demonstrate conformance to the reference lines, pipe samples shall be tested at following temperatures and at various hoop stresses such that, at each of the temperatures given, at least three failure times fall in each of the following time intervals:

— temperatures 20 °C; 60 °C to 70 °C; 95 °C;

— time intervals 10 h to 100 h, 100 h to 1 000 h, 1 000 h to 8 760 h and above 8 760 h.

In tests lasting more than 8 760 h, once failure is reached at a stress and time at least on or above the reference line, any time after that may be considered as the failure time. Testing should be carried out in accordance with ISO 1167-1 and ISO 1167-2.

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 reference line.

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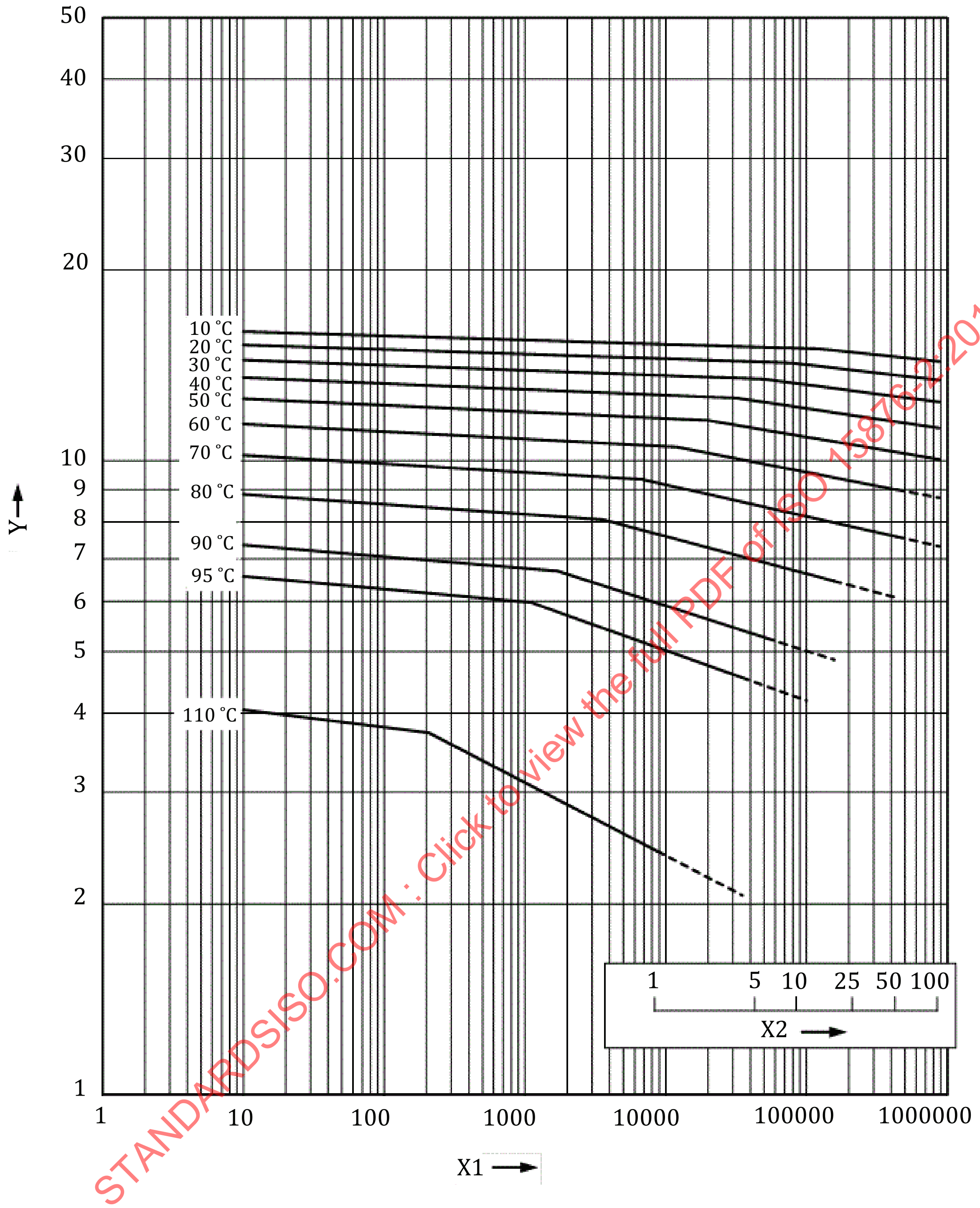

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Key

X1 time, t_1, to fracture, in hours

X2 time, t_2, to fracture, in years

Y hoop stress, σ, in megapascal

Figure 1 — Reference curves for expected strength of polybutene homopolymer (PB-H)

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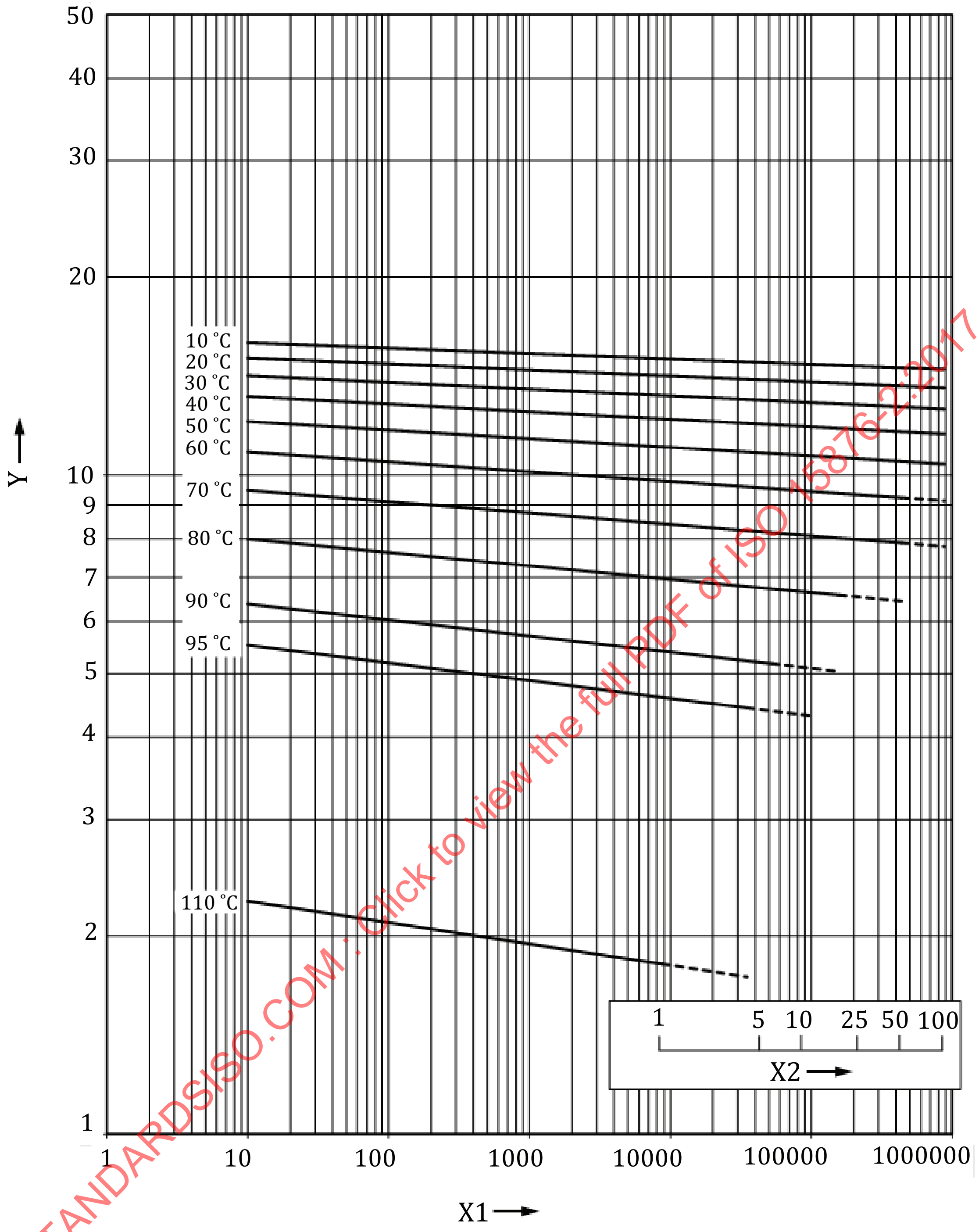

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Key

X1 time, t_1, to fracture, in hours

X2 time, t_2, to fracture, in years

Y hoop stress, σ, in megapascal

Figure 2 — Reference curves for expected strength of polybutene random copolymer (PB-R)

4.3 Influence on water intended for human consumption

The material shall conform to ISO 15876-1.

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5 General characteristics

5.1 Appearance

When viewed without magnification, the internal and external surfaces of pipes shall be smooth, clean and free from scoring, cavities, and other surface defects to an extent that would prevent conformity to this document. The material shall not contain visible impurities. Slight variations in the appearance of the colour shall be permitted. The ends of the pipe shall be cut cleanly and square to the axis of the pipe.

5.2 Opacity

Polybutene pipes that are declared to be opaque shall not transmit more than 0,2 % of visible light, when tested in accordance with ISO 7686.

6 Geometrical characteristics

6.1 General

Dimensions shall be measured in accordance with ISO 3126.

The maximum calculated pipe value, $S_{calc,max}$, for the applicable class of service condition and design pressure, p_D, is given in Table 1 and Table 2 for PB-H and PB-R, respectively.

Table 1 — $S_{calc,max}$-values for PB-H

Design pressure p_D bar	Application			
	Class 1	Class 2	Class 4	Class 5
	$S_{calc,max}$ -values[a]			
4	10,9[b]	10,9[b]	10,9[b]	10,9[b]
6	9,5	8,4	9,1	7,2
8	7,1	6,3	6,8	5,4
10	5,7	5,0	5,4	4,3

[a] The values are rounded down to the first place of decimals.

[b] The 20 °C, 10 bar, 50 years, cold water requirement, being higher, determines this value (see ISO 15876-1).

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Table 2 — $S_{calc,max}$-values for PB-R

Design pressure p_D bar	Application			
	Class 1	Class 2	Class 4	Class 5
	$S_{calc,max}$ -values[a]			
4	10,9 [b]	10,9 [b]	10,8	10,3
6	8,6	8,5	7,2	6,8
8	6,4	6,4	5,4	5,1
10	5,1	5,0	4,3	4,1

[a] The values are rounded down to the first place of decimals.

[b] The 20 °C, 10 bar, 50 years, cold water requirement, being higher, determines this value (see ISO 15876-1).

NOTE The derivation of $S_{calc,max}$ is provided in Annex A. The method described takes account of the properties of PB under the service conditions of different classes given in ISO 15876-1.

The values of outside diameter and/or wall thickness apply to the polybutene pipe and are exclusive of additional outside layers. For pipes with barrier layers, the values of outside diameter and wall thickness may apply to the finished product, including the barrier layer, provided that the thickness of the outside barrier layer, including any adhesive layer, is ≤0,4 mm and the design calculation using the values of outside diameter and wall thickness of base pipe (PB) meet the $S_{calc,max}$ values according to Table 1 or Table 2.

The manufacturer shall state the dimensions and tolerances of the base pipe in his documentation when different from Tables 3 to 7.

Pipes with non-circular cross section are permitted if they conform to the requirements of this document.

6.2 Dimensions of pipes

6.2.1 Outside diameters

For the applicable pipe dimension class, the mean outside diameter, d_{em}, of a pipe shall conform to Table 3, Table 4, Table 5 or Table 6, as applicable.

6.2.2 Wall thicknesses and their tolerances

For any particular class of service condition, design pressure and nominal size, the minimum wall thickness, e_{min}, shall be chosen in such a way that the corresponding S series or S_{calc}-value is equal to or less than the values of $S_{calc,max}$ given in Table 1 or Table 2, respectively.

For the applicable pipe dimension class, the wall thickness of the base pipe or finished pipe (see 6.1), shall conform to Table 3, Table 4, Table 5 or Table 6, as applicable, in relation to the pipe series S and S_{calc}-values, respectively. However, pipes intended to be joined together by fusion shall have a minimum wall thickness of 1,9 mm.

The tolerance on the wall thickness, e, shall conform to Table 7.

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Table 3 — Pipe dimensions for dimension class A (sizes conform to ISO 4065 and are applicable for all classes of service conditions)

Dimensions in millimetres

Nominal size DN/OD	Nominal outside diameter d_n	Mean outside diameter $d_{em,min}$	Mean outside diameter $d_{em,max}$	Pipe series S 10	S 8	S 6,3	S 5	S 4	S 3,2
				Wall thicknesses e_{min} and e_n					
12	12	12,0	12,3	1,3[a]	1,3[a]	1,3[a]	1,3[a]	1,4	1,7
16	16	16,0	16,3	1,3	1,3	1,3	1,5	1,8	2,2
20	20	20,0	20,3	1,3	1,3	1,5	1,9	2,3	2,8
25	25	25,0	25,3	1,3	1,5	1,9	2,3	2,8	3,5
32	32	32,0	32,3	1,6	1,9	2,4	2,9	3,6	4,4
40	40	40,0	40,4	1,9	2,4	3,0	3,7	4,5	5,5
50	50	50,0	50,5	2,4	3,0	3,7	4,6	5,6	6,9
63	63	63,0	63,6	3,0	3,8	4,7	5,8	7,1	8,6
75	75	75,0	75,7	3,6	4,5	5,6	6,8	8,4	10,3
90	90	90,0	90,9	4,3	5,4	6,7	8,2	10,1	12,3
110	110	110,0	111,0	5,3	6,6	8,1	10,0	12,3	15,1
125	125	125,0	126,2	6,0	7,4	9,2	11,4	14,0	17,1
140	140	140,0	141,3	6,7	8,3	10,3	12,7	15,7	19,2
160	160	160,0	161,5	7,7	9,5	11,8	14,6	17,9	21,9

[a] non-preferred wall thickness of 1,1 mm is permitted for dimension d_n = 12.

Table 4 — Pipe dimensions for dimension class B1 (sizes based on copper pipe sizes and applicable for all classes of service conditions)

Dimensions in millimetres

Nominal size DN/OD	Nominal outside diameter d_n	Mean outside diameter $d_{em,min}$	Mean outside diameter $d_{em,max}$	Pipe series S 10	S 8	S 6,3	S 5	S 4	S 3,2
				Wall thicknesses e_{min} and e_n					
10	10	9,9	10,2	1,3	1,3	1,3	1,3	1,3	1,4
12	12	11,9	12,2	1,3	1,3	1,3	1,3	1,3	1,6
15	15	14,9	15,2	1,3	1,3	1,3	1,3	1,7	2,0
18	18	17,9	18,2	1,3	1,3	1,3	1,6	2,0	2,4
22	22	21,9	22,2	1,3	1,3	1,6	2,0	2,4	3,0
28	28	27,9	28,2	1,3	1,6	2,0	2,5	3,1	3,8
35	35	34,9	35,4	1,7	2,0	2,6	3,2	3,9	4,8

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Table 5 — Pipe dimensions for dimension class B2 (sizes based on copper pipe sizes and applicable for all classes of service conditions)

Dimensions in millimetres

Nominal size DN/OD	Nominal outside diameter	Mean outside diameter		Wall thicknesses e_{min} and e_n	S_{calc}
	d_n	$d_{em,min}$	$d_{em,max}$		
14,7	14,7	14,63	14,74	1,6	4,1
21	21	20,98	21,09	2,05	4,6
27,4	27,4	27,33	27,44	2,6	4,8
34	34	34,08	34,19	3,15	4,9

Table 6 — Pipe dimensions for dimension class C (non-preferred pipe sizes used for example for heating systems)

Dimensions in millimetres

Nominal size DN/OD	Nominal outside diameter	Mean outside diameter		Wall thicknesses	S_{calc}
	d_n	$d_{em,min}$	$d_{em,max}$	e_{min} and e_n	
12	12	12,0	12,3	2,0	2,5
14	14	14,0	14,3	2,0	3,0
15	15	15,0	15,3	2,0	3,2
16	16	16,0	16,3	2,0	3,5
17	17	17,0	17,3	2,0	3,8
18	18	18,0	18,3	2,0	4,0
20	20	20,0	20,3	2,0	4,5

Table 7 — Tolerance on wall thicknesses

Dimensions in millimetres

Minimum wall thickness e_{min}		Tolerance[a] x	Minimum wall thickness e_{min}		Tolerance[a] x
>	≤		>	≤	
1,0	2,0	0,3	11,0	12,0	1,3
2,0	3,0	0,4	12,0	13,0	1,4
3,0	4,0	0,5	13,0	14,0	1,5
4,0	5,0	0,6	14,0	15,0	1,6
5,0	6,0	0,7	15,0	16,0	1,7
6,0	7,0	0,8	16,0	17,0	1,8
7,0	8,0	0,9	17,0	18,0	1,9
8,0	9,0	1,0	18,0	19,0	2,0
9,0	10,0	1,1	19,0	20,0	2,1
10,0	11,0	1,2	20,0	21,0	2,2
			21,0	22,0	2,3

[a] The tolerance is expressed in the form $^{+x}_{0}$ mm, where “x” is the value of the tolerance given. The level of the tolerances conforms to Grade V in ISO 11922-1.

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7 Mechanical characteristics

When tested in accordance with the test methods as specified in Table 8 using the indicated parameters, the pipe shall withstand the hydrostatic (hoop) stress without bursting. In the case of pipes with (a) barrier layer(s), the test shall be carried out on test pieces produced without the barrier layer(s).

Prior to the delivery, the pipes shall meet the mechanical characteristics.

Table 8 — Mechanical characteristics of pipes

Characteristic	Requirement	Test parameters for the individual tests				Test method
		Hydrostatic (hoop) stress MPa	**Test temp.** °C	**Test period** h	**Number of test pieces**	
Resistance to internal pressure	No failure during the test period					ISO 1167-1/ ISO 1167-2
	PB-H	15,5	20	1 [a]	3	
		15,2	20	22	3	
		6,5	95	22	3	
		6,2	95	165	3	
		6,0	95	1 000	3	
	PB-R	15,3	20	1[a]	3	
		15,0	20	22	3	
		5,5	95	22	3	
		5,2	95	165	3	
		5,0	95	1 000	3	
		Test parameters for all tests				
		Sampling procedure		[b]		
		Type of end cap		Type a)		
		Orientation of test piece		Not specified		
		Type of test		Water-in-water		

[a] In case of dispute, tests shall be done at 20 °C/22 h.

[b] The sampling procedure is not specified. For guidance, see ISO/TS 15876-7.

8 Physical and chemical characteristics

When tested in accordance with the test methods as specified in Table 9 using the indicated parameters, the pipe shall conform to the requirements given in this table.

Prior to the delivery, the pipes shall meet the physical and chemical characteristics.

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Table 9 — Physical and chemical characteristics of pipes

Characteristic	Requirement	Test parameters		Test method
		Parameter	Value	
Longitudinal reversion	≤2 %	Temperature Duration of exposure for: $e_n \leq 8$ mm 8 mm < $e_n \leq 16$ mm Number of test pieces	110 °C 1 h 2 h 3	Method B of ISO 2505 (oven test)
Thermal stability by hydrostatic pressure testing	No bursting during the test period	Sampling procedure End cap Orientation Type of test Hydrostatic (hoop) stress PB-H PB-R Test temperature Test period Number of test pieces	[a] Type a) Free Water-in-air 2,4 Mpa 1,8 MPa[b] 110 °C 8 760 h 1	ISO 1167-1/ ISO 1167-2
Melt flow rate MFR/ MVR (pipe)[c]	30 % maximum difference compared to compound	Load Test temperature Number of test pieces	2,16 kg or 5 kg[d] 190 °C 3	ISO 1133-1

[a] The sampling procedure is free. For guidance, see ISO 15876-7.

[b] PB-R samples shall be conditioned at 95 °C/96 h prior to thermal stability testing.

[c] Samples for measuring MFR/MVR (melt mass-flow rate / melt volume-flow rate) of pellets and pipe shall be taken from the same compound and the same batch of material. It is not allowed to compare pipe or fittings prepared from a blend of batches with MFR/MVR measured on individual components.

[d] In case of dispute, 2,16 kg load shall be used.

9 Performance requirements

When pipes conforming to this document are jointed to each other or to components conforming to ISO 15876-3, the pipes and the joints shall conform to ISO 15876-5.

10 Marking

10.1 General requirements

Marking details shall be printed or formed directly on the pipe no less than once per metre in such a way that after storage, handling and installation (e.g. in accordance with CEN/TR 12108[11]), legibility is maintained.

NOTE The manufacturer is not responsible for marking being illegible, due to actions such as painting, scratching, covering of the components or by use of detergent, etc. on the components unless agreed or specified by the manufacturer.

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

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

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

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10.2 Minimum required marking

The minimum required marking of the pipe is specified in Table 10.

Table 10 — Minimum required marking

Aspects	Marking or symbol
Number of this document	e.g. ISO 15876
Manufacturer's name and/or trade mark	Name or code
Nominal outside diameter and nominal wall thickness	e.g. 32 × 2,9
Pipe dimensions class	e.g. A
Material	PB-H or PB-R
Application class combined with design pressure	e.g. Class 2/10 bar
Opacity[a]	e.g. opaque
Manufacturer's information	[b]

[a] If declared by the manufacturer.

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

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

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

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Annex A
(normative)

Derivation of $S_{calc,max}$

A.1 General

This Annex details the principles regarding the calculation of $S_{calc,max}$-values and, hence, of minimum wall thicknesses, e_{min}, of pipes relative to the classes of service conditions (application classes) given in ISO 15876-1 and the applicable design pressure, p_D.

A.2 Design stress

The design stress, σ_D, for a particular class of service conditions (application class) is calculated from Formula (1) or Formula (2) and Formula (3) (see 4.2) using Miner's rule in accordance with ISO 13760 and taking into account the applicable class requirements given in of ISO 15876-1:2003, Table 1 and the service coefficients given in Table A.1.

Table A.1 — Overall service (design) coefficients

Temperature °C	Overall service (design) coefficient C	
	PB-H	PB-R
T_D	1,5	1,5
T_{max}	1,3	1,3
T_{mal}	1,0	1,0
T_{cold}	1,25	1,25

The resulting design stress, σ_D, has been calculated relative to each class and is given in Table A.2.

Table A.2 — Design stress

Application class	Design stress[a] σ_D MPa	
	PB-H	PB-R
1	5,72	5,16
2	5,04	5,12
4	5,46	4,33
5	4,30	4,13
20 °C for 50 y	10,91	10,92

[a] Values given are rounded down to the second place of decimals (i.e. the nearest 0,01 MPa).

A.3 Derivation of maximum value of S_{calc} ($S_{calc,max}$)

$S_{calc,max}$ is the smaller value of

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