BRITISH STANDARD

BS EN ISO 22391-2:2009

Plastics piping systems for hot and cold water installations — Polyethylene of raised temperature resistance (PE-RT)

Part 2: Pipes (ISO 22391-2:2009)

ICS 23.040.20; 91.140.60; 93.025

BSI British Standards

National foreword

This British Standard is the UK implementation of EN ISO 22391-2:2009.

The UK participation in its preparation was entrusted to Technical Committee PRI/88/2, Plastics piping for pressure applications.

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

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

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

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Systèmes de canalisations en plastique pour les installations d'eau chaude et froide - Polyéthylène de meilleure résistance à la température (PE-RT) - Partie 2: Tubes (ISO 22391-2:2009)

Kunststoff-Rohrleitungssysteme für die Warm- und Kaltwasserinstallation - Polyethylen erhöhter Temperaturbeständigkeit (PE-RT) - Teil 2: Rohre (ISO 22391-2:2009)

This European Standard was approved by CEN on 4 November 2009.

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Foreword

This document (EN ISO 22391-2:2009) has been prepared by Technical Committee ISO/TC 138 "Plastics pipes, fittings and valves for the transport of fluids" in collaboration with Technical Committee CEN/TC 155 “Plastics piping systems and ducting systems” the secretariat of which is held by NEN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by June 2010, and conflicting national standards shall be withdrawn at the latest by June 2010.

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Endorsement notice

The text of ISO 22391-2:2009 has been approved by CEN as a EN ISO 22391-2:2009 without any modification.

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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ISO 22391-2 was prepared by 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*.

This second edition cancels and replaces the first edition (ISO 22391-2:2007), which is extended from only dealing with PE-RT material (referred to as Type I) to cover PE-RT materials Type I and Type II.

ISO 22391 consists of the following parts[1)], under the general title *Plastics piping systems for hot and cold water installations — Polyethylene of raised temperature resistance (PE-RT)*:

— *Part 1: General*

— *Part 2: Pipes*

— *Part 3: Fittings*

— *Part 5: Fitness for purpose of the system*

1) This System Standard does not incorporate a Part 4: Ancillary equipment or a Part 6: Guidance for installation. For ancillary equipment, separate standards can apply. Guidance for installation of plastics piping systems made from different materials, intended to be used for hot and cold water installations, is covered by ENV 12108.

Introduction

The System Standard, of which this is Part 2, specifies the requirements for a piping system and its components when made from polyethylene of raised temperature resistance (PE-RT). 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 products covered by ISO 22391, the following are relevant.

a) This part of ISO 22391 provides no information as to whether the products can be used without restriction.

b) Existing national regulations concerning the use and/or characteristics of the products remain in force.

This part of ISO 22391 specifies the characteristics of pipes. At the date of publication of this part of ISO 22391, System Standards Series for piping systems of other plastics materials used for the same application are the following:

ISO 15874 (all parts), *Plastics piping systems for hot and cold water installations — Polypropylene (PP)*

ISO 15875 (all parts), *Plastics piping systems for hot and cold water installations — Crosslinked polyethylene (PE-X)*

ISO 15876 (all parts), *Plastics piping systems for hot and cold water installations — Polybutylene (PB)*

ISO 15877 (all parts), *Plastics piping systems for hot and cold water installations — Chlorinated poly(vinyl chloride) (PVC-C)*

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INTERNATIONAL STANDARD **ISO 22391-2:2009(E)**

Plastics piping systems for hot and cold water installations — Polyethylene of raised temperature resistance (PE-RT) —

Part 2: Pipes

1 Scope

This part of ISO 22391 specifies the characteristics of pipe made of

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

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

intended to be used for hot and cold water installations within buildings for the conveyance of water, whether or not the water is intended for human consumption (domestic systems) and for heating systems, under the design pressures and temperatures appropriate to the class of application according to ISO 22391-1.

This part of ISO 22391 covers a range of service conditions (classes of application), design pressures and pipe dimension classes, and also specifies test parameters and test methods. In conjunction with the other parts of ISO 22391, it is applicable to PE-RT pipes, fittings, their joints, and to joints having components of PE-RT, as well as of other plastics and non-plastics materials, respectively, used for hot and cold water installations.

It is applicable to pipes with or without a barrier layer or layers.

It is not applicable to values of design temperature, maximum design temperature or malfunction temperature in excess of those specified in ISO 22391-1.

NOTE 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.

2 Normative references

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

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

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

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

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

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

ISO 22391-1:2009, *Plastics piping systems for hot and cold water installations — Polyethylene of raised temperature resistance (PE-RT) — Part 1: General*

ISO 22391-3, *Plastics piping systems for hot and cold water installations — Polyethylene of raised temperature resistance (PE-RT) — Part 3: Fittings*

ISO 22391-5, *Plastics piping systems for hot and cold water installations — Polyethylene of raised temperature resistance (PE-RT) — Part 5: Fitness for purpose of the system*

3 Terms, definitions, symbols and abbreviated terms

For the purposes of this document, the terms, definitions, symbols and abbreviated terms given in ISO 22391-1 apply.

4 Material

4.1 Pipe material

The material from which the pipe is made shall be polyethylene of raised temperature resistance (PE-RT).

4.2 Evaluation of σ_{LPL} values

The pipe material shall be evaluated in accordance with ISO 9080 or equivalent, with internal pressure tests being carried out in accordance with ISO 1167-1 and ISO 1167-2, in order to determine the σ_{LPL} values. The σ_{LPL} value thus determined shall be at least as high as the corresponding values of the reference curves given in Figure 1 or Figure 2 (taken from ISO 24033:2009) over the complete range of times.

NOTE 1 One equivalent way of evaluation is to calculate the σ_{LPL} value for each temperature (for example 20 °C, 60 °C and 95 °C), individually.

NOTE 2 The reference curves for PE-RT Type I in Figure 1 in the temperature range of 10 °C to 95 °C are derived from Equations (1) and (2).

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

$$\lg t = -190{,}481 - \frac{58\,219{,}035 \lg \sigma}{T} + \frac{78\,763{,}07}{T} + 119{,}877 \lg \sigma \quad (1)$$

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

$$\lg t = -23{,}795\,4 - \frac{1723{,}318 \lg \sigma}{T} + \frac{11\,150{,}56}{T} \quad (2)$$

The 110 °C values have been determined separately using water inside and air outside the test specimen and have not been derived from Equations (1) and (2).

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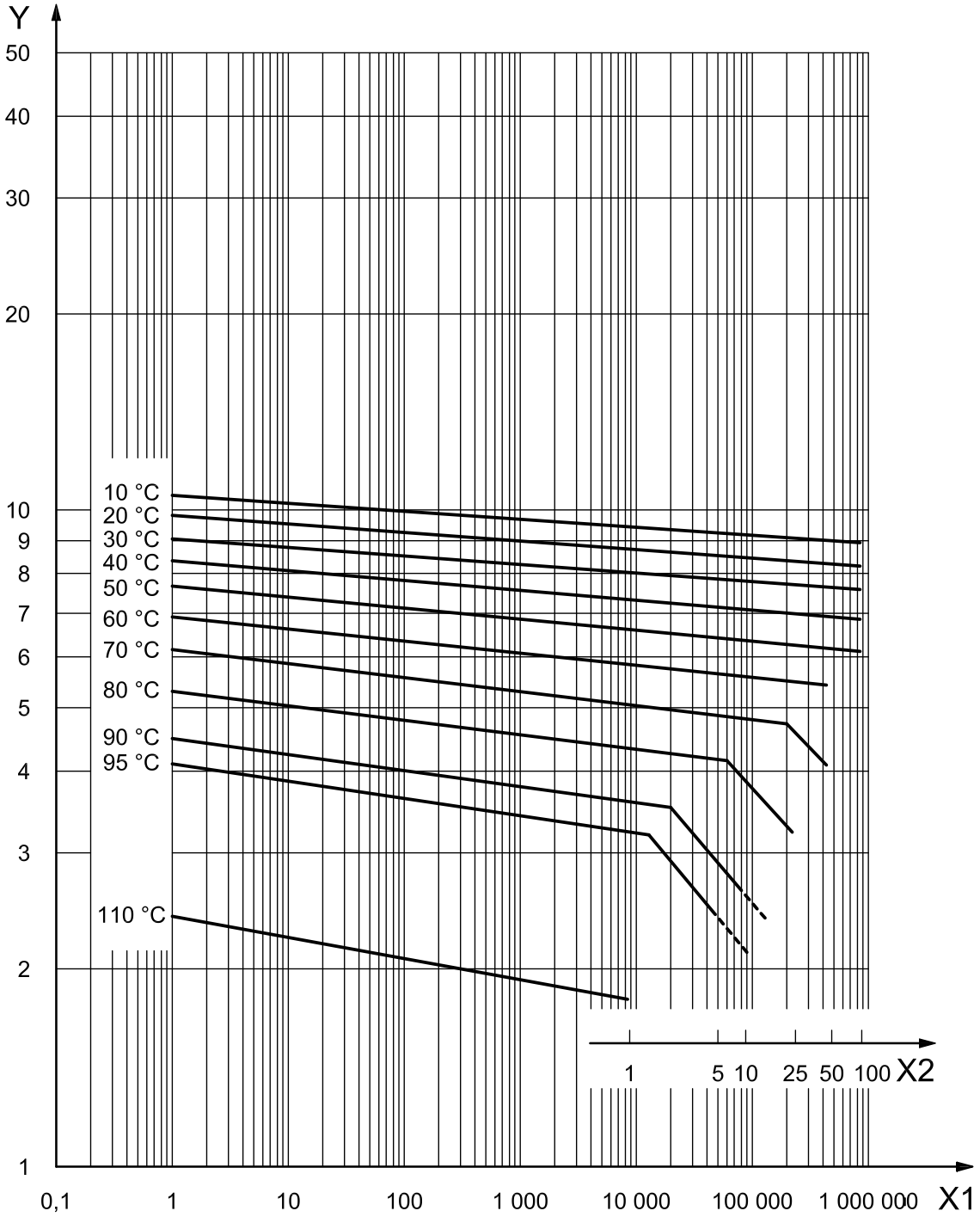
NOTE 3 The reference curves for PE-RT Type II in Figure 2 in the temperature range of 10 °C to 110 °C are derived from Equation (3):

$$\lg t = -219 - \frac{62\,600{,}752\,\lg\sigma}{T} + \frac{90\,635{,}353}{T} + 126{,}387\,\lg\sigma \qquad (3)$$



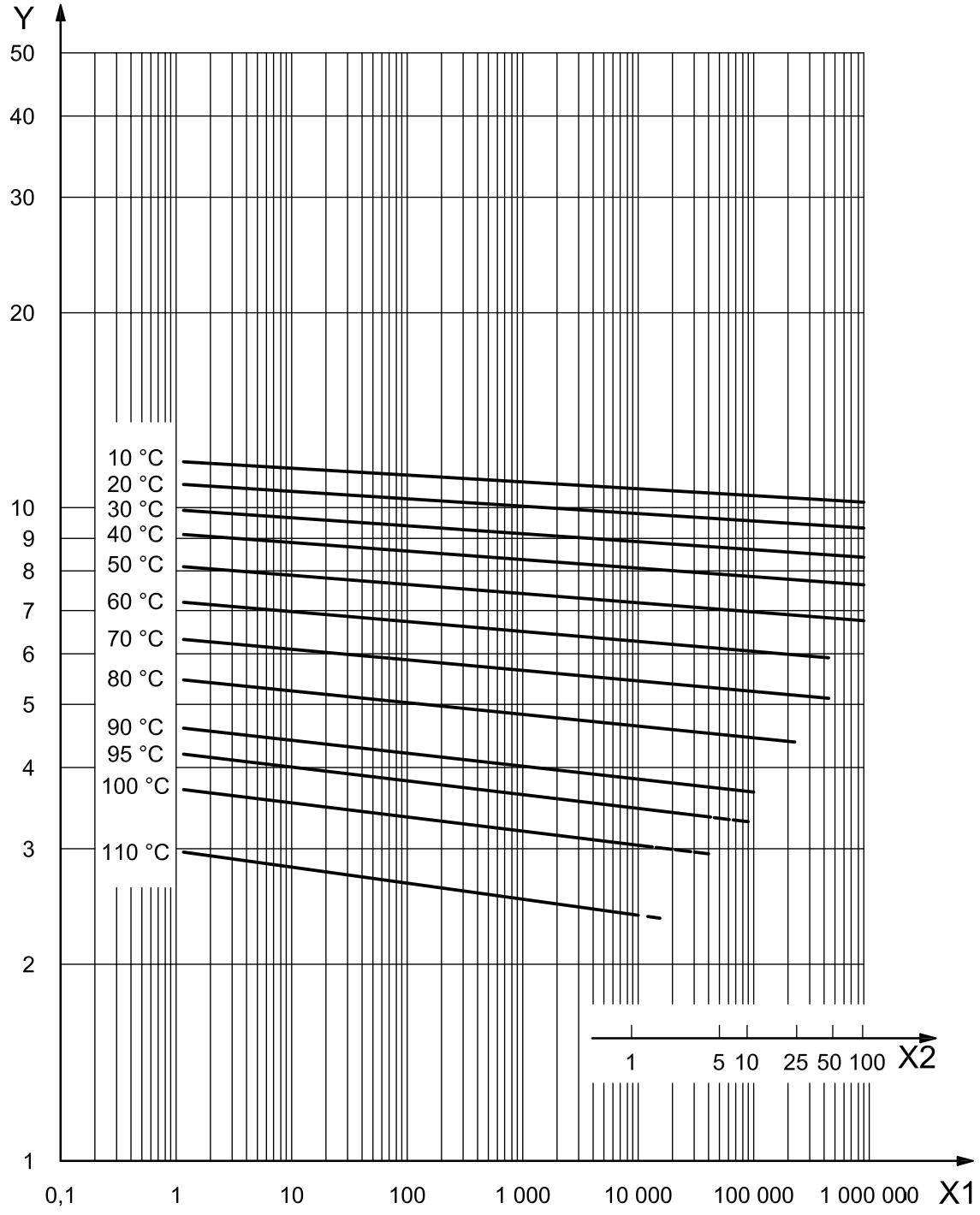
Key

X1 time, t, to fracture, expressed in hours

X2 time, t, to fracture, expressed in years

Y hoop stress, σ, expressed in megapascal

Figure 1 — Expected strength of PE-RT Type I pipes



Key

X1 time, t, to fracture, expressed in hours

X2 time, t, to fracture, expressed in years

Y hoop stress, σ, expressed in megapascal

Figure 2 — Expected strength of PE-RT Type II pipes

In order to demonstrate conformance to the reference lines, pipe samples should be tested in accordance with ISO 1167-1 and ISO 1167-2 at the following temperatures and at various hoop stresses such that, at each of the temperatures, 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 over.

In tests lasting more than 8 760 h without failure, any test time after 8 760 h may be considered as the failure time.

Conformance to 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.

For PE-RT Type II these experimental results shall not give any brittle failures indicating the presence of a knee at any temperature up to 110 °C before 8 760 h.

4.3 Influence on water intended for human consumption

The material shall be in accordance with ISO 22391-1.

5 General characteristics

5.1 Appearance

When viewed without magnification, the internal and external surfaces of pipes shall be smooth, clean and free from an extent of scoring, cavities and other surface defects that would prevent conformance with this part of ISO 22391. 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

PE-RT 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

6.1.1 The dimensions shall be measured in accordance with ISO 3126.

6.1.2 The maximum calculated pipe value, $S_{\text{calc, max}}$, for the applicable class of service condition and design pressure, p_{D}, shall be in accordance with Table 1 for PE-RT Type I and Table 2 for PE-RT Type II.

NOTE The derivation of $S_{\text{calc, max}}$ is provided by Annex A, where the method described takes account of the properties of PE-RT under the service conditions for the classes given in ISO 22391-1:2009, Table 1.

6.1.3 The values of outside diameter and/or wall thickness apply to the PE-RT pipe and, for design calculation purposes, are exclusive of any barrier layer thickness.

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Table 1 — $S_{calc,\ max}$ values for PE-RT Type I

p_D bar[c]	Application class			
	1	2	4	5
	$S_{calc,\ max}$ values[a]			
4	6,7[b]	6,7[b]	6,7[b]	6,0
6	5,5	4,5	5,4	4,0
8	4,1	3,4	4,1	3,0
10	3,3	2,7	3,3	2,4

[a] The values are rounded to the first decimal place.

[b] The 20 °C, 10 bar, 50 years, cold water requirement, being higher, determines this value (see ISO 22391-1:2009, Clause 4).

[c] 1 bar = 0,1 MPa = 10^5 Pa; 1 MPa = 1 N/mm^2.

Table 2 — $S_{calc,\ max}$ values for PE-RT Type II

p_D bar[c]	Application class			
	1	2	4	5
	$S_{calc,\ max}$ values[a]			
4	7,5[b]	7,5[b]	7,5[b]	7,2
6	5,9	5,6	5,6	4,8
8	4,4	4,2	4,2	3,6
10	3,5	3,4	3,4	2,9

[a] The values are rounded to the first decimal place.

[b] The 20 °C, 10 bar, 50 years, cold water requirement, being higher, determines this value (see ISO 22391-1:2009, Clause 4).

[c] 1 bar = 0,1 MPa = 10^5 Pa; 1 MPa = 1 N/mm^2.

6.2 General dimensions of pipe

6.2.1 Outside diameters

For the corresponding pipe dimension class, the mean outside diameter, d_{em}, of a pipe shall be in accordance with Tables 3, 4, 5 or 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 such that the corresponding S series or S_{calc} value is less than or equal to the values of $S_{calc,\ max}$ given in Table 1 or 2, respectively.

For the corresponding pipe dimension class, the wall thicknesses, e_{min} and e_n, shall be in accordance with Tables 3, 4, 5 or 6, as applicable, in respect of pipe series S or S_{calc} values. 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 be in accordance with Table 7.

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**Table 3 — Pipe dimensions for dimension class A
(sizes in accordance with ISO 4065 and applicable for all classes of service condition)**

Dimensions in millimetres

Nominal size DN/OD	Nominal outside diameter	Mean outside diameter		Pipe series			
				S 5	S 4	S 3,2	S 2,5
				Wall thicknesses			
	d_n	$d_{em,\,min}$	$d_{em,\,max}$	e_{min} and e_n			
12	12	12,0	12,3	1,3[a]	1,4	1,7	2,0
16	16	16,0	16,3	1,5	1,8	2,2	2,7
20	20	20,0	20,3	1,9	2,3	2,8	3,4
25	25	25,0	25,3	2,3	2,8	3,5	4,2
32	32	32,0	32,3	2,9	3,6	4,4	5,4
40	40	40,0	40,4	3,7	4,5	5,5	6,7
50	50	50,0	50,5	4,6	5,6	6,9	8,3
63	63	63,0	63,6	5,8	7,1	8,6	10,5
75	75	75,0	75,7	6,8	8,4	10,3	12,5
90	90	90,0	90,9	8,2	10,1	12,3	15,0
110	110	110,0	111,0	10,0	12,3	15,1	18,3
125	125	125,0	126,2	11,4	14,0	17,1	20,8
140	140	140,0	141,3	12,7	15,7	19,2	23,3
160	160	160,0	161,5	14,6	17,9	21,9	26,6

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

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

Dimensions in millimetres

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

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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 condition)**

Dimensions in millimetres

Nominal size DN/OD	Nominal outside diameter d_n	Mean outside diameter		Wall thicknesses	
		$d_{em,\,min}$	$d_{em,\,max}$	e_{min} and e_n	S_{calc}
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 d_n	Mean outside diameter		Wall thicknesses	
		$d_{em,\,min}$	$d_{em,\,max}$	e_{min} and e_n	S_{calc}
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 — Tolerances on wall thicknesses

Dimensions in millimetres

Minimum wall thickness e_{min}		Tolerance[a] x
>	⩽	
1,0	2,0	0,3
2,0	3,0	0,4
3,0	4,0	0,5
4,0	5,0	0,6
5,0	6,0	0,7
6,0	7,0	0,8
7,0	8,0	0,9
8,0	9,0	1,0
9,0	10,0	1,1
10,0	11,0	1,2

Minimum wall thickness e_{min}		Tolerance[a] x
>	⩽	
11,0	12,0	1,3
12,0	13,0	1,4
13,0	14,0	1,5
14,0	15,0	1,6
15,0	16,0	1,7
16,0	17,0	1,8
17,0	18,0	1,9
18,0	19,0	2,0
19,0	20,0	2,1
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 ISO 11922-1, Grade V.

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7 Mechanical characteristics

The pipe shall be tested using the test methods and test parameters specified in Table 8 or Table 9. The pipe shall withstand the hydrostatic (hoop) stress without bursting. In the case of pipes with a barrier layer or layers, testing shall be carried out on test pieces without the barrier layer(s).

Table 8 — Mechanical characteristics of PE-RT Type I pipes

Characteristic	Requirement	Test parameters				Test methods
		For individual tests				
Resistance to internal pressure	No failure during the test period	**Hydrostatic (hoop) stress** MPa	**Test temperature** °C	**Test period** h	**Number of test pieces**	ISO 1167-1 and ISO 1167-2
		9,9	20	1	3	
		3,8	95	22	3	
		3,6	95	165	3	
		3,4	95	1 000	3	
		For all tests				
		Sampling procedure		Not specified		
		Type of end cap		Type a)		
		Orientation of test piece		Not specified		
		Type of test		Water-in-water		

Table 9 — Mechanical characteristics of PE-RT Type II pipes

Characteristic	Requirement	Test parameters				Test methods
		For individual tests				
Resistance to internal pressure	No failure during the test period	**Hydrostatic (hoop) stress** MPa	**Test temperature** °C	**Test period** h	**Number of test pieces**	ISO 1167-1 and ISO 1167-2
		10,8	20	1	3	
		3,9	95	22	3	
		3,7	95	165	3	
		3,6	95	1 000	3	
		For all tests				
		Sampling procedure		Not specified		
		Type of end cap		Type a)		
		Orientation of test piece		Not specified		
		Type of test		Water-in-water		

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8 Physical and chemical characteristics

The pipe shall be tested using the test method and test parameters, and conforming to the requirements, specified in Table 10.

Table 10 — Physical and chemical characteristics of pipes

Characteristic	Requirement	Test parameters		Test methods
		Parameter	Value	
Longitudinal reversion	⩽ 2 %	Temperature	110 °C	ISO 2505
		Duration of exposure:		
		$e_n \leqslant 8$ mm	1 h	
		8 mm < $e_n \leqslant 16$ mm	2 h	
		$e_n > 16$ mm	4 h	
		Number of test pieces	3	
Thermal stability by hydrostatic pressure testing	No bursting during test period	Sampling procedure	Not specified	ISO 1167-1 and ISO 1167-2
		End cap	Type a)	
		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	
		Number of test pieces	1	
Melt mass flow rate (MFR)	30 % maximum difference compared to compound	Mass	5 kg	ISO 1133-1
		Test temperature	190 °C	
		Test period	10 min	
		Number of test pieces	3	

9 System performance requirements

Pipes conforming to this part of ISO 22391 and fittings conforming to ISO 22391-3 jointed together shall be in accordance with ISO 22391-5.

10 Marking

10.1 General requirements

10.1.1 Marking details shall be printed or formed directly on the pipe not less than once per metre in such a manner that, after storage, handling and installation (e.g. in accordance with ENV 12108), legibility is maintained.

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

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

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

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

10.2 Minimum required marking

The minimum required marking of pipes conforming to ISO 22391 shall be in accordance with Table 11.

Table 11 — Minimum required marking

Aspect	Marking or symbol
Identification of conformity	ISO 22391
Manufacturer's name and/or trade mark	Name or code
Nominal outside diameter and nominal wall thickness	e.g. $32 \times 4{,}4$
Pipe dimension class	e.g. A
Material	PE-RT Type I or II
Application class combined with design pressure	e.g. Class 1/10 bar
Opacity[a]	e.g. opaque
Manufacturer's information	[b]
NOTE Attention is drawn to the possible need to include CE marking when required for legislative purposes.	
[a] If declared by the manufacturer.	
[b] To provide 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.	

Annex A
(informative)

Derivation of the maximum calculated pipe value $S_{calc,\ max}$

A.1 General

This annex gives the principles for the calculation of the maximum calculated pipe value, $S_{calc,\ max}$ values, hence the determination of minimum wall thickness, e_{min}, of pipes, relative to the classes of service conditions (application class) in accordance with ISO 22391-1:2009, Table 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 using Equations (1) and (2), using Miner's rule in accordance with ISO 13760, and taking into account the applicable class requirements given in ISO 22391-1:2009, 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
T_D	1,5
T_{max}	1,3
T_{mal}	1,0
T_{cold}	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	**Design stress**[a] σ_D MPa
	PE-RT Type I	**PE-RT Type II**
1	3,29	3,53
2	2,68	3,37
4	3,25	3,38
5	2,38	2,88
20 °C for 50 years	6,68	7,47

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

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

The derivation of the maximum value of S_{calc}, $S_{calc,\,max}$ is the smaller of the values obtained from Equations (A.1) and (A.2):

$$\frac{\sigma_{DP}}{p_D} \tag{A.1}$$

where

σ_{DP} is the design stress of the pipe material taken from Table A.2, in megapascal (MPa);

p_D is the design pressure of 4 bar, 6 bar, 8 bar or 10 bar, as applicable, expressed in megapascal (MPa);

$$\frac{\sigma_{cold}}{p_D} \tag{A.2}$$

where

σ_{cold} is the design stress at 20 °C relative to a service life of 50 years (MPa);

p_D is the design pressure of 10 bar, expressed in megapascal (MPa).

The values of $S_{calc,\,max}$ relative to each class of service condition (see ISO 22391-1) are given in Table 1.

A.4 Use of $S_{calc,\,max}$ to determine wall thickness

The S series and S_{calc} values shall be chosen for each application class and design pressure from Tables 3, 4, 5 or 6, as applicable, in such a way that S or S_{calc} is not greater than $S_{calc,\,max}$ given in Table 1 for PE-RT Type I and Table 2 for PE-RT Type II.

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Bibliography

[1] ISO 4065, *Thermoplastics pipes — Universal wall thickness table*

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

[3] ISO 24033:2009, *Polyethylene of raised temperature resistance (PE-RT) pipes — Effect of time and temperature on the expected strength*

[4] ENV 12108, *Plastics piping systems — Guidance for the installation inside buildings of pressure piping systems for hot and cold water intended for human consumption*

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