BS ISO 4427-1:2019

BSI Standards Publication

Plastics piping systems for water supply and for drainage and sewerage under pressure — Polyethylene (PE)

Part 1: General

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National foreword

This British Standard is the UK implementation of ISO 4427-1:2019. It supersedes BS ISO 4427-1:2007+A1:2015, which is withdrawn.

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.

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ISO 4427-1

Second edition
2019-08

Plastics piping systems for water supply and for drainage and sewerage under pressure — Polyethylene (PE) —

Part 1: **General**

Systèmes de canalisations en plastique destinés à l'alimentation en eau et aux branchements et collecteurs d'assainissement sous pression — Polyéthylène (PE) —

Partie 1: Généralités

Reference number
ISO 4427-1:2019(E)

Contents

Page

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.

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).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, 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 www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 138, *Plastics pipes, fitting 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 4427-1:2007), which has been technically revised. It also incorporates Technical Corrigendum ISO 4427-1:2007/Cor 1:2008 and Amendment ISO 4427-1:2007/Amd 1:2015.

The main changes compared to the previous edition are:

— update of the normative references;

— technical consistency with ISO 4437-1 (see Reference [1] in the Bibliography).

A list of all parts in the ISO 4427 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The ISO 4427 series of standards are a set of system standards that specify the requirements for a piping system and its components when made from polyethylene (PE). The piping system is intended to be used in buried or above ground applications, for the conveyance of water for human consumption, raw water prior to treatment, drainage and sewerage under pressure, vacuum sewer systems, and water for other purposes.

In respect of potential adverse effects on the quality of water intended for human consumption caused by the products covered by the ISO 4427 series, it does not provide information on the restriction on the use of products.

NOTE Guidance for assessment of conformity can be found in Reference [2] in the Bibliography.

Plastics piping systems for water supply and for drainage and sewerage under pressure — Polyethylene (PE) —

Part 1: General

1 Scope

This document specifies the general aspects of polyethylene (PE) compounds for the manufacture of pressure pipes and fittings (mains and service pipes) for buried or above ground applications, intended for the conveyance of:

— water for human consumption;

— raw water prior to treatment;

— drainage and sewerage under pressure;

— vacuum sewer systems;

— water for other purposes.

This document also specifies the test parameters and requirements for the test methods referred to in this document.

In conjunction with other parts of the ISO 4427 series, this document is applicable to PE pipes and fittings, their joints and to joints with components made of PE and other materials, intended to be used under the following conditions:

a) a maximum allowable operating pressure (PFA) up to and including 25 bar[1)];

b) an operating temperature of 20 °C as the reference temperature.

NOTE 1 For other operating temperatures, guidance is given in Annex A.

The ISO 4427 series covers a range of maximum allowable operating pressures and gives requirements concerning colours.

NOTE 2 It is the responsibility of the purchaser or specifier to make the appropriate selections from these aspects, taking into account their particular requirements and installation practices or codes.

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 3, *Preferred numbers — Series of preferred numbers*

ISO 472, *Plastics — Vocabulary*

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

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

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 1167-1:2006, *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 1183-1, *Plastics — Methods for determining the density of non-cellular plastics — Part 1: Immersion method, liquid pycnometer method and titration method*

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

ISO 4427-2, *Plastics piping systems for water supply, and for drainage and sewerage under pressure — Polyethylene (PE) — Part2: Pipes*

ISO 4427-3, *Plastics piping systems for water supply, and for drainage and sewerage under pressure — Polyethylene (PE) — Part 3: Fittings*

ISO 6259-1, *Thermoplastics pipes — Determination of tensile properties — Part 1: General test method*

ISO 6259-3, *Thermoplastics pipes — Determination of tensile properties — Part 3: Polyolefin pipes*

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

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

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

ISO 11413, *Plastics pipes and fittings — Preparation of test piece assemblies between a polyethylene (PE) pipe and an electrofusion fitting*

ISO 11414, *Plastics pipes and fittings — Preparation of polyethylene (PE) pipe/pipe or pipe/fitting test piece assemblies by butt fusion*

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 13479, *Polyolefin pipes for the conveyance of fluids — Determination of resistance to crack propagation — Test method for slow crack growth on notched pipes*

ISO 13953, *Polyethylene (PE) pipes and fittings — Determination of the tensile strength and failure mode of test pieces from a butt-fused joint*

ISO 13954, *Plastics pipes and fittings — Peel decohesion test for polyethylene (PE) electrofusion assemblies of nominal outside diameter greater than or equal to 90 mm*

ISO 15512, *Plastics — Determination of water content*

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

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 3, ISO 472 and ISO 1043-1 and the following 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

3.1 Geometrical terms

3.1.1
nominal size
DN/OD
numerical designation of the size of a component related to the outside diameter

Note 1 to entry: It is a convenient round number approximately equal to the manufacturing dimension in millimetres (mm). It is not applicable to components designated by thread size.

3.1.2
nominal outside diameter
d_n
specified outside diameter assigned to a nominal size DN/OD

Note 1 to entry: Nominal outside diameter is expressed in millimetres.

3.1.3
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

3.1.4
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

3.1.5
minimum mean outside diameter
$d_{em,min}$
minimum value for the mean outside diameter as specified for a given nominal size

3.1.6
maximum mean outside diameter
$d_{em,max}$
maximum value for the mean outside diameter as specified for a given nominal size

3.1.7
out-of-roundness
ovality
difference between the maximum and the minimum outside diameters 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 parts of the ISO 4427 series, 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

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

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

3.1.11
maximum wall thickness at any point

e_{max}

maximum value for the wall thickness at any point around the circumference of a component, as specified

3.1.12
mean wall thickness

e_m

arithmetical mean of a number of measurements of the wall thickness, regularly spaced around the circumference and in the same cross-section of a component, including the measured minimum and the measured maximum values of the wall thickness in that cross-section

3.1.13
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 from ISO 4065 (see Bibliography [3]):

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

3.1.14
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

3.1.15
tolerance

permitted variation of the specified value of a quantity, expressed as the difference between the permitted maximum and the permitted minimum value

3.1.16
wall thickness tolerance
t_y
permitted difference between the wall thickness at any point, e, and the nominal wall thickness, e_n

Note 1 to entry: $e_n \le e \le e_n + t_y$.

3.2 Material terms

3.2.1
virgin material
compound in the form of granules that has not been subjected to use or processing other than that required for its manufacture and to which no reprocessed or recycled materials have been added

3.2.2
own reprocessed material
material prepared from clean, rejected and unused pipes, fittings, or valves, including trimmings from the production of pipes, fittings, or valves, that is 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

3.2.3
compound
homogenous extruded mixture of base polymer (PE) and additives, i.e. anti-oxidants, pigments, carbon black, UV-stabilizers, at a dosage level necessary for the processing and use of components conforming to the requirements of this document

3.2.4
base polymer
polymer produced by the material supplier for the manufacture of the compound according to this document.

3.2.5
fusion compatibility
ability of two similar or dissimilar polyethylene (PE) materials to be fused together to form a joint which conforms to the performance requirements of this document

3.3 Terms 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 when σ_{LPL} is below 10 MPa, or to the next lower value of the R20 series when σ_{LPL} is 10 MPa or greater

Note 1 to entry: The R10 series conforms to ISO 3 and the R20 series conforms to ISO 497[4].

3.3.3
design coefficient
C
coefficient with a value greater than 1 which takes into consideration service conditions as well as properties of the components of a piping system other than those represented in the lower confidence limit

3.3.4
design stress
σ_s
allowable stress for a given application at 20 °C, that is derived from the MRS by dividing it by the design coefficient *C*, i.e.

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

Note 1 to entry: It is expressed in Megapascals.

3.3.5
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).

3.4 Terms related to service conditions

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

Note 1 to entry: For plastic piping systems conveying water, it corresponds to the allowable operating pressure (PFA) in bar, which can be sustained with water at 20 °C with a design basis of 50 years, and based on the minimum design coefficient:

$$\text{PN} = \frac{20 \times \text{MRS}}{C \times (\text{SDR} - 1)}$$

Note 2 to entry: Research on long term performance prediction of PE water distribution systems shows a possible service life of at least 100 years, see Bibliography [5] and [6].

3.4.2
allowable operating pressure
PFA
maximum hydrostatic pressure that a component is capable of withstanding continuously in service

Note 1 to entry: See Annex A.

3.5 Terms related to joints

3.5.1
electrofusion joint
joint between a PE socket or saddle electrofusion fitting and pipe or fitting with spigot ends, made by heating the electrofusion fittings by the Joule effect of the heating element incorporated at their jointing surfaces, causing the material adjacent to them to melt and the pipe and fitting surfaces to fuse

3.5.2
butt fusion joint
joint made by heating the planed ends of matching surfaces by holding them against a flat heating plate until the PE material reaches fusion temperature, quickly removing the heating plate and pushing the two softened ends against one another

3.5.3
mechanical joint
joint made by assembling a PE pipe to another PE pipe, or any other element using a fitting that generally includes a compression part, to provide for pressure integrity, leaktightness and resistance to end loads

3.5.4
socket fusion joint
joint made by heating the socket ends of matching surfaces by holding them against a flat heating plate until the PE material reaches fusion temperature, quickly removing the heating plate and pushing the two softened ends against one another

4 Symbols and abbreviated terms

4.1 Symbols

For the purposes of this document, the following symbols apply.

C	design coefficient
d_e	outside diameter (at any point)
d_{em}	mean outside diameter
$d_{em,max}$	maximum mean outside diameter
$d_{em,min}$	minimum mean outside diameter
d_n	nominal outside diameter
E	wall thickness (at any point) of a fitting body
e	wall thickness (at any point) around the circumference of a component
e_m	mean wall thickness
e_{max}	maximum wall thickness (at any point)
e_{min}	minimum wall thickness (at any point)
e_n	nominal wall thickness
t_y	wall thickness tolerance
σ_s	design stress
σ_{LPL}	lower confidence limit of the predicted hydrostatic strength

NOTE Symbols d_e, e, e_{min} and e_{max} in this document are equivalent to d_{ey}, e_y, $e_{y,min}$ and $e_{y,max}$, respectively, used in ISO 11922-1 (see Bibliography [7]).

4.2 Abbreviated terms

For the purposes of this document, the following abbreviated terms apply.

DN/OD	nominal size, outside diameter related
LPL	lower predicted limit
MFR	melt mass-flow rate
MRS	minimum required strength
PE	polyethylene
PFA	allowable operating pressure
PN	nominal pressure
S	pipe series
SDR	standard dimension ratio

5 Material

5.1 Material of the component

The material described in this document is a compound, which shall be supplied in the form of granules, suitable for the production of pipes complying with ISO 4427-2 or fittings complying with ISO 4427-3.

NOTE Since PE 40 is not commonly used for pressure applications, it is the intention of ISO/TC 138/SC 2 to withdraw all references to this compound at the next revision of the ISO 4427 series (all parts).

5.2 Compound

5.2.1 Additives and pigments

The compound shall be made by the material producer by adding to the polyethylene base polymer only those additives and pigments (e.g. carbon black) necessary for the manufacture of pipes and fittings conforming to ISO 4427-2 or ISO 4427-3, as applicable, and for their fusibility, storage, and use.

All additives and pigments shall be uniformly dispersed.

The carbon black used in the production of black compound shall have an average (primary) particle size of 10 nm to 25 nm.

5.2.2 Colour

The colour of the compound shall be either black or blue.

NOTE 1 Compounds with other colours than black and blue are only intended for identification purposes, (stripes).

Blue compound shall only be used for products in contact with water intended for human consumption.

Yellow and orange compound is not allowed for products according to the ISO 4427 series (all parts).

NOTE 2 Yellow and orange colour are used for gas applications, in accordance with the ISO 4437 series (all parts).

5.3 Physical characteristics of the compound

5.3.1 Characteristics of the compound in the form of granules

In the form of granules, the compound which is used for the manufacture of pipes and fittings shall have characteristics conforming to the requirements given in Table 1.

Unless otherwise specified by the applicable test method, the test pieces shall be conditioned at (23 ± 2) °C before testing in accordance with Table 1.

Table 1 — Characteristics of PE compound in the form of granules

Characteristic	Requirements[a]	Test parameters		Test method
		Parameter	Value	
Compound density	≥930 kg/m^3	Test temperature	23 °C	ISO 1183-1 or ISO 1183-2
		Number of test pieces[b]	Shall conform to ISO 1183-1 or ISO 1183-2	
Carbon black content[c]	(2,0 to 2,5) % (by mass)	Shall conform to ISO 6964		ISO 6964
Carbon black dispersion[c]	Grade ≤ 3 Rating of dispersion A1, A2, A3, or B	Preparation of test pieces[d]	Free	ISO 18553
		Number of test pieces[b]	Shall conform to ISO 18553	
Pigment dispersion[e]	Grade ≤ 3 Rating of dispersion A1, A2, A3, or B	Preparation of test pieces[d]	Free	ISO 18553
		Number of test pieces[b]	Shall conform to ISO 18553	
Volatile content	≤350 mg/kg	Number of test pieces[b]	1	EN 12099
Water content[f]	≤300 mg/kg (Equivalent to <0,03 % by mass)	Number of test pieces[b]	1	ISO 15512
Oxidation induction time (Thermal stability)	≥20 min	Test temperature[g]	210 °C	ISO 11357-6
		Number of test pieces[b]	3	
		Test atmosphere	Oxygen	
Melt mass-flow rate (MFR) for PE 40	0,20 ≤ MFR ≤ 1,40 g/10 min[h] Maximum deviation of ±20 % of the nominated value	Loading mass	2,16 kg	ISO 1133-1
		Test temperature	190 °C	
		Time	10 min	
		Number of test pieces[b]	Shall conform to ISO 1133-1	
Melt mass-flow rate (MFR) for PE80 and PE 100	0,20 ≤ MFR ≤ 1,40 g/10 min[h,i] Maximum deviation of ±20 % of the nominated value	Loading mass	5 kg	ISO 1133-1
		Test temperature	190 °C	
		Time	10 min	
		Number of test pieces[b]	Shall conform to ISO 1133-1	

Table 1 *(continued)*

Characteristic	Requirements[a]	Test parameters		Test method
		Parameter	Value	

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

[b] The number of test pieces given indicates the number required to establish a value for the characteristic described in Table 1. The number of test pieces required for factory production control and process control should be listed in the manufacturer's quality plan. Guidance on assessment of conformity can be found in CEN/TS 12201-7[2].

[c] Only for black compound.

[d] In case of dispute, the test pieces shall be prepared by microtome method.

[e] Only applicable for non-black compound.

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

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

[h] Nominated value given by the compound manufacturer.

[i] Materials of nominated value 0,15 ≤ MFR < 0,20 can be introduced, in such case attention is drawn to the fusion compatibility (see 5.4). The lowest MFR value resulting from the maximum lower deviation of the nominated value should be not less than 0,15.

5.3.2 Characteristics of the compound in the form of pipe

In the form of pipe, the compound which is used for the manufacture of pipes and fittings shall have characteristics conforming to the requirements given in Table 2.

Unless otherwise specified by the applicable test method, the test pieces shall be conditioned at (23 ± 2) °C before testing in accordance with Table 2.

NOTE Information on resistance to rapid crack propagation is given in Annex B.

Table 2 — Characteristic of the PE compound in the form of pipe

Characteristic	Requirements[a]	Test parameters		Test method
Tensile strength for butt-fusion[b]	Test to failure: Ductile — Pass Brittle — Fail	Pipe diameter	110 mm	ISO 13953
		Pipe diameter ratio	SDR 11	
		Test temperature	23 °C	
		Number of samples[c]	According to ISO 13953	
Resistance to slow crack growth	No failure during test period	Pipe diameter	110 mm	ISO 13479
		Pipe diameter ratio	SDR 11	
		Test temperature	80 °C	
		Internal test pressure for: PE 80 PE 100	 8,0 bar 9,2 bar	
		Test period	500 h	
		Type of test	Water-in-water	
		Number of samples[c]	According to ISO 13479	
Effect on water quality	According to existing national regulations			
Resistance to weathering[d]	The weathered test pieces shall fulfil the requirements of the characteristics, a), b) and c) below:	Preconditioning: –Cumulative radiant exposure[e] –Number of samples[c]	≥3,5 GJ/m² Shall conform to ISO 16871	ISO 16871
a) Decohesion of an electrofusion joint	≤33,3 % brittle failure	Sample preparation dimension jointing	d_n 110 mm / SDR 11 ISO 11413 condition 1: 23 °C	ISO 13954
b) Elongation at break	According to ISO 4427-2:2019, Table 5			ISO 6259-1 and ISO 6259-3
c) Hydrostatic strength (1 000 h at 80 °C)	According to ISO 4427-2:2019, Table 3			ISO 1167-1:2006[f] and ISO 1167-2
Resistance to rapid crack propagation[g,h,i]	Arrest	Pipe diameter	250 mm	ISO 13477
		Pipe diameter ratio	SDR 11	
		Test temperature	0 °C	
		Test medium	Air	
		Internal test pressure for: PE 80 PE 100	 8,0 bar 10,0 bar	
		Number of samples[c]	Shall conform to ISO 13477	
	OR			

Table 2 *(continued)*

Characteristic	Requirements[a]	Test parameters		Test method
	Arrest	Pipe diameter	500 mm	ISO 13478
		Pipe diameter ratio	SDR 11	
		Test temperature	0 °C	
		Test medium	Air	
		Internal test pressure for: PE 80 PE 100	 20,0 bar 24,0 bar	
		Number of samples[c]	Shall conform to ISO 13478	

[a] Conformity to these requirements shall be proven by the compound manufacturer.

[b] Preparation of samples in accordance with ISO 11414, normal conditions at 23 °C.

[c] The number of samples given indicates 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. Guidance on assessment of conformity can be found in CEN/TS 12201-7[2].

[d] Only applicable for non-black compound.

[e] For outdoor storage for 1 year to be valid globally, a cumulative radiant exposure of 7 GJ/m2 is required.

[f] Measured dimensions according to clause 7.2 of ISO 1167-1:2006 are applicable.

[g] Applicable for compounds dedicated for pipes with wall thickness ≥32 mm.

[h] If the requirements are met, the material is qualified for the full range of pipe produced in accordance with the scope of ISO 4427-2.

[i] If the requirements are not met for a given PE material, the critical pressure p_c may be established and used to determine the PFA for a material relative to diameter.

PFA ≤ p_c, where p_c is determined in accordance with ISO 13478, or

PFA ≤ 3,6 $p_{c,S4}$ + 2,6, where p_c is determined in accordance with ISO 13477.

5.4 Fusion compatibility

5.4.1 The compounds conforming to Table 1 shall be fusible. This shall be demonstrated by the compound manufacturer for each compound of his own product range by checking that the requirement for the failure mode in a tensile test given in Table 2 is fulfilled for a butt fusion joint prepared by using the parameters specified in ISO 11414:2009, Annex A at an ambient temperature of (23 ± 2) °C from pipes both manufactured from that compound.

For 0,15 ≤ MFR < 0,20 compounds, fusion compatibility of pipes with diameter >200 mm and wall thickness >20 mm shall be investigated to confirm compatibility. If electrofusion is used, appropriate testing should be carried out to verify the fusion capability of such pipes.

5.4.2 The compounds conforming to Table 1 are considered fusible to each other. If requested, the compound manufacturer shall demonstrate this by checking that the requirement for the failure mode in a tensile test given in Table 2 is fulfilled for a butt fusion joint prepared by using the parameters as specified in ISO 11414:2009, Annex A at an ambient temperature of (23 ± 2) °C from two pipes manufactured from the compounds from his own range covered by this request.

NOTE This clause is not applicable to PE 40 materials. Pipes in these materials are joined using mechanical fittings.

5.5 Classification and designation

Compounds shall be designated by the type of PE material. The minimum required strength (MRS) shall conform to Table 3 when tested in the form of pipe.

Table 3 — Classification and designation of compounds

Designation	Minimum required strength (MRS) MPa	σ_s [a] MPa
PE 100	10,0	8,0
PE 80	8,0	6,3
PE 40[b]	4,0	3,2

[a] The design stress, σs, is derived from the MRS by application of the overall service (design) coefficient, C = 1,25.

NOTE A higher value for C can be used; for example, if C = 1,6, this gives a design stress of 5,0 MPa for PE 80 materials. A higher value for C can also be obtained by choosing a higher PN class.

[b] PE40 will be withdrawn from the next revision of the ISO 4427 series.

The compound shall be evaluated in accordance with ISO 9080 from pressure tests on pipes in accordance with ISO 1167-1 and ISO 1167-2 performed on pipes at least at three temperatures, where two of the temperatures are fixed to 20 °C and 80 °C and the third temperature is chosen between 30 °C and 70 °C, to find the σ_{LPL}. The MRS-value shall be derived from the σ_{LPL} and the compound shall be classified by the compound producer in accordance with ISO 12162.

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.

The conformity of the designation of the compound to the classification given in Table 3 shall be demonstrated by the compound producer.

Where fittings are manufactured from the same compound as pipes, then the material classification is the same.

For the classification of a compound intended only for the manufacture of fittings, test pieces in the form of extruded pipe made from the compound shall be used.

6 Effects on water quality

For compounds and components to be used in contact with water intended for human consumption, attention is drawn to potential restrictions on the use of products.

Annex A
(informative)

Pressure reduction coefficient

This annex is only given for the convenience of the reader. Whenever operating temperatures are higher than 20 °C, reference should always be made to ISO 13761 (see Bibliography [8]).

When a PE piping system is to be operated at a continuous constant temperature higher than 20 °C, a pressure reduction coefficient as given in Table A.1 may be applicable for PE 80 and PE 100. For reduction coefficients of PE 40, refer to ISO 13761[8].

Table A.1 — Pressure reduction coefficient for PE 80 and PE 100

Temperature[a,b] °C	**Coefficient**
20	1,00
30	0,85
40	0,73
50	b

NOTE If analysis according to ISO 9080 demonstrates that less reduction is applicable, higher factors and hence higher pressures may be applied.

a For other temperatures between each step, interpolation is permitted (see also ISO 13761[8]).

b For temperatures between 40 °C and 50 °C, see ISO 13761[7] and consult the compound manufacturer.

The continuous allowable operating pressure (PFA) is derived from the following formula:

$$PFA = f_T \times f_A \times PN$$

where

f_T is the coefficient according to Table A.1;

f_A is the derating factor related to the application (for the conveyance of water, the maximum value of $f_A = 1$);

PN is the nominal pressure.

Annex B
(informative)

Resistance to rapid crack propagation

B.1 General

Rapid crack propagation (RCP) is the generation of a low ductility crack running at high speed (approximately 300 m/s) along a pressurized pipeline. Propagation or arrest of the crack is dependent on the strain energy at the crack tip, which is influenced by the internal pressure of the fluid, which is in turn affected by the rate at which the fluid decompresses.

If a fracture occurs in a water pipeline, the fluid is not subject to the same compression and energy release as that of a pipeline containing air or a gas. Therefore, propagation of a fast-running crack is much less likely to occur in a water pipe. Indeed, full-scale (FS) and S4 RCP tests on water pipes have shown that propagation does not occur when the pipe is completely filled (see Bibliography [9]). However, tests on large-diameter pipe containing both water and air at low temperature (<3 °C) have shown that the crack can propagate along the top of the pipe within the air pocket, but that higher pressures are required to sustain this propagation than those of air alone (see Bibliography [9] and [10]). The pressure to sustain propagation increases as the entrapped volume of air is decreased, hence minimizing the volume of entrapped air reduces the risk. Thus it is concluded that the risk of this phenomenon occurring in a water pipe is extremely low and requires certain coincident conditions, i.e. initiation of a fast-running crack at the location of an air pocket in a large-diameter pipe operated at high pressure and in low-temperature conditions. Large diameter water supply pipelines are usually designed to eliminate any entrapped air, otherwise operational difficulties will be encountered.

In the development of European standards for polyethylene water pipe, it has been concluded that RCP only needs to be taken into account for pipe of wall thickness >32 mm. Testing has shown that most modern-day pipe compounds are resistant to RCP and have high resistance to slow crack growth, considerably reducing the risk of initiation.

B.2 Initiation

The initiation of RCP could be the result of impact damage, the growth of a crack through the wall or a crack developing from a poor fusion weld in certain coincident operating and environmental conditions.

The phenomenon of RCP has been reported in pipelines of different materials, including steel and, in a few examples, plastics pipeline systems manufactured from older generation material.

B.3 Parameters governing propagation/arrest

The parameters that govern RCP if a crack is initiated are:

a) internal pressure;

a) pipeline temperature;

b) rate of decompression of the conveyed fluid (see B.1); and

c) fracture toughness of the pipe material.

B.4 Test methods

The susceptibility of pipes in a particular material to RCP increases with increasing pipe diameter and wall thickness. It is assessed experimentally in order to allow the system to be designed to eliminate the risk. Standardized test methods have been published for PE pipes: ISO 13477 and ISO 13478.

These tests require extreme conditions to initiate fast-running cracks, i.e. creating sharp notches in test pipe and impacting with a sharp blade, and, in the case of the full-scale test, cooling of the initiation pipe to −70 °C.

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