International Standard

ISO 4437-2

Second edition
2024-02

Plastics piping systems for the supply of gaseous fuels — Polyethylene (PE) —

Part 2: Pipes

Systèmes de canalisations en plastique pour la distribution de combustibles gazeux — Polyéthylène (PE) —

Partie 2: Tubes

Reference number
ISO 4437-2:2024(en)

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Published in Switzerland

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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 document 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).

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This document was prepared by Technical Committee ISO/TC 138, *Plastics pipes, fittings and valves for the transport of fluids*, Subcommittee SC 4, *Plastics pipes and fittings for the supply of gaseous fuels*.

This second edition cancels and replaces the first edition (ISO 4437-2:2014), which has been technically revised.

The main changes are as follows:

— PE 100-RC type materials with enhanced resistance to slow crack growth (SCG) have been added;

— requirements for the compound for identification stripes have been updated;

— the nominal outside diameter range of the pipe has been increased to 800 mm;

— the PE 80 20 °C/100 h control point has been changed to 10 MPa with a note to advise that 9 MPa is applicable if the ISO 9080 data set for a material indicates that a lower value is applicable;

— test methods have been updated and new methods have been added for PE 100-RC materials.

A list of all parts in the ISO 4437 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 4437 series specifies the requirements for a piping system and its components made from polyethylene (PE) compounds, which is intended to be used for the supply of gaseous fuels.

This document covers the characteristics of pipes.

Requirements and test methods for materials and components, other than pipes, are specified in ISO 4437-1, ISO 4437-3 and ISO 4437-4.

Characteristics for fitness for purpose of the system are covered in ISO 4437-5.

Recommended practice for design, handling and installation is given in ISO/TS 10839.

Plastics piping systems for the supply of gaseous fuels — Polyethylene (PE) —

Part 2: Pipes

1 Scope

This document specifies the characteristics of pipes made from polyethylene (PE) for piping systems in the field of the supply of gaseous fuels.

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

In conjunction with ISO 4437-1, ISO 4437-3, ISO 4437-4 and ISO 4437-5, this document is applicable to PE pipes, fittings and valves, their joints, and joints with components of PE and other materials intended to be used under the following conditions:

a) a maximum operating pressure (MOP), up to and including 10 bar[1)], at a reference temperature of 20 °C for design purposes;

b) an operating temperature between −20 °C and 40 °C.

For operating temperatures between 20 °C and 40 °C, derating coefficients are defined in ISO 4437-5.

The ISO 4437 series covers a range of MOPs and gives requirements concerning colours.

This document is applicable to three types of pipes:

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

— PE pipes with co-extruded layers on either or both the outside and/or inside of the pipe (total outside diameter, d_n) as specified in Annex A, where all PE layers have the same MRS rating;

— PE pipes (outside diameter, d_n) with a peelable and contiguous thermoplastics additional layer on the outside of the pipe ("coated pipe") as specified in Annex B.

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 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 1167-1:2006, *Thermoplastics pipes, fittings and assemblies for the conveyance of fluids — Determination of the resistance to internal pressure — Part 1: General method*

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

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 4437-1, *Plastics piping systems for the supply of gaseous fuels — Polyethylene (PE) — Part 1: General*

ISO 4437-5, *Plastics piping systems for the supply of gaseous fuels — Polyethylene (PE) — Part 5: Fitness for purpose of the system*

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 9969, *Thermoplastics pipes — Determination of ring stiffness*

ISO 11922-1:2018, *Thermoplastics pipes for the conveyance of fluids — Dimensions and tolerances — Part 1: Metric series*

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

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 13968, *Plastics piping and ducting systems — Thermoplastics pipes — Determination of ring flexibility*

ISO 18488, *Polyethylene (PE) materials for piping systems — Determination of Strain Hardening Modulus in relation to slow crack growth — Test method*

ISO 18489, *Polyethylene (PE) materials for piping systems — Determination of resistance to slow crack growth under cyclic loading — Cracked Round Bar test method*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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

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

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

3.1 Terms related to geometry

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* (3.1.1)

Note 1 to entry: Nominal outside diameter is expressed in millimetres (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
minimum mean outside diameter
$d_{em,min}$
minimum value for the *mean outside diameter* (3.1.3) as specified for a given *nominal size* (3.1.1)

3.1.5
maximum mean outside diameter
$d_{em,max}$
maximum value for the *mean outside diameter* (3.1.3) as specified for a given *nominal size* (3.1.1)

3.1.6
out-of-roundness
ovality
difference between the maximum and the minimum outside diameters in the same cross-section of a pipe or spigot

3.1.7
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 ISO 4437 series, the value of the nominal wall thickness, e_n, is identical to the specified *minimum wall thickness at any point* (3.1.9).

3.1.8
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 a fitting and valve body at any point is E.

3.1.9
minimum wall thickness at any point
e_{min}
minimum value for the *wall thickness at any point* (3.1.8) around the circumference of a component

3.1.10
tolerance
permitted variation of the specified value of a quantity, expressed as the difference between the permitted maximum and the permitted minimum value

3.1.11
wall thickness tolerance
T_y
permitted difference between the *wall thickness at any point* (3.1.8) and the *nominal wall thickness* (3.1.7)

Note 1 to entry: $e_n \leq e \leq e_n + T_y$.

3.1.12
standard dimension ratio
SDR
numerical designation of a *pipe series* (3.1.13), which is a convenient round number, approximately equal to the dimension ratio of the *nominal outside diameter* (3.1.2) and the *nominal wall thickness* (3.1.7)

3.1.13
pipe series
S
number for pipe designation

Note 1 to entry: The relationship between the pipe series, *S*, and the *standard dimension ratio (SDR)* (3.1.12) is given by the following formula, as specified in ISO 4065.

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

3.2 Terms related to material

3.2.1
compound
homogenous extruded mixture of *base polymer* (3.2.4) (polyethylene) and additives (i.e. anti-oxidants, pigments, carbon black, UV-stabilizers and others) at a dosage level necessary for the processing and use of components

3.2.2
virgin material
compound (3.2.1) in a form such as granules that has not been subjected to use or processing other than that required for its manufacture and to which no reworked or recyclable materials have been added

3.2.3
reworked material
plastics material from rejected unused products or trimmings capable of being reclaimed that have been manufactured and retained within plants owned and operated by the same legal entity

3.2.4
base polymer
polymer produced by the material supplier for the manufacture of the *compound* (3.2.1)

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 temperature θ and time t

Note 1 to entry: It is expressed in megapascals (MPa).

3.3.2
minimum required strength
MRS
value of the *lower confidence limit of the predicted hydrostatic strength* (3.3.1) at 20 °C and 50 years, rounded down to the next smaller value of the R10 series or R20 series

Note 1 to entry: Only *compounds* (3.2.1) with an MRS of 8 MPa or 10 MPa are specified in this document.

Note 2 to entry: The R10 series and the R20 series conform to ISO 3.

Note 3 to entry: It is expressed in megapascals (MPa).

[SOURCE: ISO 12162:2009, 3.3, modified — Note 1 to entry has been removed and replaced with new Notes 1 to 3 to entry.]

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
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 minutes (g/10 min).

3.4 Terms related to service conditions

3.4.1
gaseous fuel
fuel which is in gaseous state at a temperature of 15 °C at atmospheric pressure

Note 1 to entry: There are proposals to inject gases from renewable sources in natural gas networks, e.g. hydrogen (H_2). This is the subject of ongoing research.

3.4.2
maximum operating pressure
MOP
maximum effective pressure of the fluid in the piping system which is allowed in continuous use

Note 1 to entry: It is expressed in bar. It takes into account the physical and the mechanical characteristics of the components of a piping system. It is calculated using the following formula:

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

Note 2 to entry: Research on long-term performance prediction of polyethylene gas distribution systems shows a possible service life of at least 100 years; see References [14], [15] and [16].

3.4.3
reference temperature
temperature for which the piping system is designed

Note 1 to entry: It is used as the base for further calculation when designing a piping system or parts of a piping system for operating temperatures different from the reference temperature (see ISO 4437-5).

3.5 Terms related to joints

3.5.1
fusion compatibility
ability of two similar or dissimilar polyethylene *compounds* (3.2.1) to be fused together to form a joint

3.5.2
squeeze-off
restriction of the gas flow to an acceptable rate through mechanical compression of the pipe

Note 1 to entry: See Annex C.

4 Symbols and abbreviated terms

4.1 Symbols

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

C	design coefficient
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) around the circumference of a component
e_{min}	minimum wall thickness (at any point)
e_n	nominal wall thickness
$<G_p>$	strain hardening modulus
p_c	critical pressure
$p_{c,full\text{-}scale}$	critical pressure obtained in full-scale test
$p_{c,s4}$	critical pressure obtained in S4-test
S	pipe series
T_y	wall thickness tolerance
t	time
θ	temperature
σ_{LPL}	lower confidence limit of the predicted hydrostatic strength

4.2 Abbreviated terms

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

ANPT	accelerated notched pipe test
CRB	cracked round bar (test)
DN/OD	nominal size, outside diameter-related
LPL	lower predicted limit
MFR	melt mass-flow rate
MOP	maximum operating pressure
MRS	minimum required strength
NPT	notched pipe test
PE	polyethylene

RC	raised crack resistance
RCP	rapid crack propagation
SCG	slow crack growth
SDR	standard dimension ratio
SHT	strain hardening test

5 Material

5.1 Compound for pipes

The PE compound from which the pipes are made shall conform to ISO 4437-1.

The pipes shall be made from virgin material or reworked material from the same PE compound from the manufacturer's own plant, or a mixture of both. Reworked material from the base pipe of peelable layer pipe (coated pipe) and reworked material from pipes with identification stripes may be used.

For co-extruded layers, see Annex A. A coextruded pipe made of a combination of PE 100 and PE 100-RC layers shall be regarded as PE 100 and marked accordingly.

Reworked material from co-extruded pipes or from pipes reworked with the peelable layer attached shall not be used.

5.2 Compound for identification stripes

The stripe compound (see 6.2) shall be manufactured from a PE base polymer in accordance with ISO 4437-1, which is used for a pipe compound for which fusion compatibility has been proven.

The compound used for identification stripes in the form of a pipe shall conform to the decohesion test requirement of resistance to weathering as described in ISO 4437-1:2024, Table 2.

The OIT of the stripe compound shall be ≥ 10 min at 210 °C, measured by the compound supplier in accordance with ISO 11357-6 (table footnote [b] of Table 6 applies).

5.3 External reworked and recycled material

Reworked material obtained from external sources and recycled material shall not be used.

6 General characteristics

6.1 Appearance

When viewed without magnification, the internal and external surfaces of pipes shall be smooth and clean and shall have no scoring, cavities and other surface defects to an extent that would prevent conformity to this document.

The ends of the pipe shall be cut cleanly and square to the axis of the pipe.

6.2 Colour

Pipes shall be black (PE 80, PE 100 and PE 100-RC), yellow (PE 80) or orange (PE 100 and PE 100-RC). In addition, black PE 80 pipes may be identified by yellow stripes and black PE 100 and PE 100-RC pipes may be identified by yellow or orange stripes, according to national preference.

The outer co-extruded layer of co-extruded pipes (see Annex A) or the outer peelable layer of peelable-layer pipes (see Annex B) shall be either black, yellow or orange. In addition, identification stripes may be used according to national preference.

7 Geometrical characteristics

7.1 Measurement of dimensions

The dimensions of the pipe shall be measured in accordance with ISO 3126 and rounded to the next 0,1 mm. In case of dispute, the measurement shall be made at least 24 h after manufacture and after being conditioned for at least 4 h at (23 ± 2) °C.

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

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

The mean outside diameters of the pipe, d_{em}, shall conform to Table 1.

For straight pipes, the maximum out-of-roundness shall conform to Table 1. For coiled pipes, the maximum out-of-roundness shall be specified by agreement between the manufacturer and the end user.

Care should be taken that packaging and storage does not lead to an increased out-of-roundness and flattening of the pipe. Additional information is given in ISO/TS 10839.

Table 1 — Mean outside diameters and out-of-roundness

Dimensions in millimetres

Nominal size DN/OD	Nominal outside diameter d_n	Mean outside diameter		Maximum out-of-roundness for straight pipes[b]
		$d_{em,min}$	$d_{em,max}$[a]	
16	16	16,0	16,3	1,2
20	20	20,0	20,3	1,2
25	25	25,0	25,3	1,2
32	32	32,0	32,3	1,3
40	40	40,0	40,4	1,4
50	50	50,0	50,4	1,4
63	63	63,0	63,4	1,5
75	75	75,0	75,5	1,6
90	90	90,0	90,6	1,8
110	110	110,0	110,7	2,2
125	125	125,0	125,8	2,5
140	140	140,0	140,9	2,8
160	160	160,0	161,0	3,2
180	180	180,0	181,1	3,6
200	200	200,0	201,2	4,0
225	225	225,0	226,4	4,5
250	250	250,0	251,5	5,0
280	280	280,0	281,7	9,8
315	315	315,0	316,9	11,1

[a] In accordance with ISO 11922-1:2018, except for d_n 50. Grade B for sizes ≤ 630, except for d_n 40 and grade A for sizes ≥ 710 and for d_n 40.

[b] Measurement of out-of-roundness shall be made at the point of manufacturing.

Table 1 *(continued)*

Nominal size DN/OD	Nominal outside diameter d_n	Mean outside diameter		Maximum out-of-roundness for straight pipes[b]
		$d_{em,min}$	$d_{em,max}$[a]	
355	355	355,0	357,2	12,5
400	400	400,0	402,4	14,0
450	450	450,0	452,7	15,6
500	500	500,0	503,0	17,5
560	560	560,0	563,4	19,6
630	630	630,0	633,8	22,1
710	710	710,0	716,4	24,9
800	800	800,0	807,2	28,0

[a] In accordance with ISO 11922-1:2018, except for d_n 50. Grade B for sizes ≤ 630, except for d_n 40 and grade A for sizes ≥ 710 and for d_n 40.

[b] Measurement of out-of-roundness shall be made at the point of manufacturing.

7.3 Wall thicknesses and related tolerances

7.3.1 Minimum wall thicknesses

The use of any standard dimension ratio (SDR) derived from the pipe series, *S*, in accordance with ISO 4065 is permitted.

The minimum wall thickness, e_{min}, of pipes shall conform to Table 2. The minimum wall thickness, e_{min}, of pipes with an SDR not given in Table 2 shall be agreed upon between the manufacturer and the end-user.

Table 2 — Minimum wall thicknesses

Dimensions in millimetres

Nominal outside diameter d_n	Minimum wall thickness e_{min}[a]						
	SDR 9	SDR 11[b]	SDR 13,6	SDR 17[b]	SDR 17,6	SDR 21	SDR 26
16	3,0	2,3[c]	—	—	—	—	—
20	3,0	2,3[c]	—	—	—	—	—
25	3,0	2,3[c]	2,3[c]	—	—	—	—
32	3,6	3,0	2,4[c]	2,3[c]	2,3[c]	—	—
40	4,5	3,7	3,0	2,4[c]	2,3[c]	2,3[c]	—
50	5,6	4,6	3,7	3,0	2,9[c]	2,4[c]	2,3[c]
63	7,1	5,8	4,7	3,8	3,6	3,0	2,5[c]
75	8,4	6,8	5,6	4,5	4,3	3,6	2,9[c]
90	10,1	8,2	6,7	5,4	5,2	4,3	3,5
110	12,3	10,0	8,1	6,6	6,3	5,3	4,2
125	14,0	11,4	9,2	7,4	7,1	6,0	4,8
140	15,7	12,7	10,3	8,3	8,0	6,7	5,4
160	17,9	14,6	11,8	9,5	9,1	7,7	6,2
180	20,1	16,4	13,3	10,7	10,3	8,6	6,9

[a] $e_{min} = e_n$.

[b] Preferred series.

[c] Minimum wall thickness values greater than the limits of 2,3 mm, 2,4 mm, 2,5 mm and 2,9 mm can be imposed for practical reasons in accordance with national requirements. See the manufacturer's technical files or national specifications for advice.

Table 2 *(continued)*

Nominal outside diameter d_n	Minimum wall thickness e_{min}[a]						
	SDR 9	SDR 11[b]	SDR 13,6	SDR 17[b]	SDR 17,6	SDR 21	SDR 26
200	22,4	18,2	14,7	11,9	11,4	9,6	7,7
225	25,2	20,5	16,6	13,4	12,8	10,8	8,6
250	27,9	22,7	18,4	14,8	14,2	11,9	9,6
280	31,3	25,4	20,6	16,6	15,9	13,4	10,7
315	35,2	28,6	23,2	18,7	17,9	15,0	12,1
355	39,7	32,2	26,1	21,1	20,2	16,9	13,6
400	44,7	36,4	29,4	23,7	22,8	19,1	15,3
450	50,3	40,9	33,1	26,7	25,6	21,5	17,2
500	55,8	45,5	36,8	29,7	28,4	23,9	19,1
560	62,5	50,9	41,2	33,2	31,9	26,7	21,4
630	70,3	57,3	46,3	37,4	35,8	30,0	24,1
710	79,3	64,5	52,2	42,1	—	33,9	27,2
800	89,3	72,6	58,8	47,4	—	38,1	30,6

[a] $e_{min} = e_n$.

[b] Preferred series.

[c] Minimum wall thickness values greater than the limits of 2,3 mm, 2,4 mm, 2,5 mm and 2,9 mm can be imposed for practical reasons in accordance with national requirements. See the manufacturer's technical files or national specifications for advice.

7.3.2 Tolerance on the wall thicknesses

The tolerance on the wall thickness at any point shall conform to Table 3, which is derived from ISO 11922-1:2018, grade V.

Table 3 — Tolerance on wall thicknesses

Dimensions in millimetres

Nominal wall thickness e_n [a]		Plus tolerance	Nominal wall thickness e_n [a]		Plus tolerance
>	≤	T_y [b]	>	≤	T_y [b]
—	2,0	0,3	40,0	41,0	4,2
2,0	3,0	0,4	41,0	42,0	4,3
3,0	4,0	0,5	42,0	43,0	4,4
4,0	5,0	0,6	43,0	44,0	4,5
5,0	6,0	0,7	44,0	45,0	4,6
6,0	7,0	0,8	45,0	46,0	4,7
7,0	8,0	0,9	46,0	47,0	4,8
8,0	9,0	1,0	47,0	48,0	4,9
9,0	10,0	1,1	48,0	49,0	5,0
10,0	11,0	1,2	49,0	50,0	5,1
11,0	12,0	1,3	50,0	51,0	5,2
12,0	13,0	1,4	51,0	52,0	5,3
13,0	14,0	1,5	52,0	53,0	5,4
14,0	15,0	1,6	53,0	54,0	5,5
15,0	16,0	1,7	54,0	55,0	5,6
16,0	17,0	1,8	55,0	56,0	5,7
17,0	18,0	1,9	56,0	57,0	5,8
18,0	19,0	2,0	57,0	58,0	5,9
19,0	20,0	2,1	58,0	59,0	6,0
20,0	21,0	2,2	59,0	60,0	6,1
21,0	22,0	2,3	60,0	61,0	6,2
22,0	23,0	2,4	61,0	62,0	6,3
23,0	24,0	2,5	62,0	63,0	6,4
24,0	25,0	2,6	63,0	64,0	6,5
25,0	26,0	2,7	64,0	65,0	6,6
26,0	27,0	2,8	65,0	66,0	6,7
27,0	28,0	2,9	66,0	67,0	6,8
28,0	29,0	3,0	67,0	68,0	6,9
29,0	30,0	3,1	68,0	69,0	7,0
30,0	31,0	3,2	69,0	70,0	7,1
31,0	32,0	3,3	70,0	71,0	7,2
32,0	33,0	3,4	71,0	72,0	7,3
33,0	34,0	3,5	72,0	73,0	7,4
34,0	35,0	3,6	73,0	74,0	7,5
35,0	36,0	3,7			
36,0	37,0	3,8			
37,0	38,0	3,9			
38,0	39,0	4,0			
39,0	40,0	4,1			

[a] $e_{min} = e_n$.

[b] The tolerance is expressed in the form $^{+T_y}_{-0}$ mm.

7.4 Circumferential reversion of pipes with d_n equal to or greater than 250 mm

The circumferential reversion of pipes with d_n equal to or greater than 250 mm shall be determined at least 48 h after manufacture. The pipe shall be conditioned in water at 80 °C in accordance with ISO 1167-1. The pipe test pieces shall be 3 d_n in length. With the test piece at (23 ± 2) °C, circumferential measurement shall be made to establish d_{em} made at distance of 0,1 d_n and 1,0 d_n, respectively, from the end of the test piece. The difference between these d_{em} measurements shall not be greater than the d_{em} tolerance range specified in Table 1.

7.5 Coiled pipe

During production, the pipe shall be coiled such that localized deformation (e.g. buckling and kinking) is prevented.

The internal diameter of the coil shall not be less than 18 d_n.

7.6 Lengths

The length of pipes is to be supplied by agreement between the purchaser and the manufacturer.

8 Mechanical characteristics

8.1 Conditioning

Unless otherwise specified by the applicable test method, the test pieces shall be conditioned at (23 ± 2) °C before testing in accordance with Table 4.

8.2 Requirements

When tested in accordance with the test methods as specified in Table 4 using the indicated parameters, the pipe shall have mechanical characteristics conforming to the requirements given in Table 4. The requirements for co-extruded pipe given in Annex A and for peelable pipe given in Annex B shall be followed. If requested by the end user, a pipe that will be subject to squeeze-off shall be tested in accordance with Annex C.

Table 4 — Mechanical characteristics

Characteristic	Requirement	Test parameters		Test method
		Parameter	Value	
Hydrostatic strength (20 °C, 100 h) [o]	No failure during the test period of any test piece	End caps	Type A [a] of ISO 1167-1:2006	ISO 1167-1:2006 and ISO 1167-2
		Orientation	Free	
		Conditioning time at test temperature	Shall conform to ISO 1167-1:2006	
		Number of test pieces [b]	3	
		Type of test	Water internal and water external to the test piece ("water-in-water") [p]	
		Circumferential (hoop) stress for: PE 80 PE 100 and PE 100-RC	 10,0 MPa [s] 12,0 MPa	
		Test period	≥ 100 h	
		Test temperature	20 °C	

Table 4 *(continued)*

Characteristic	Requirement	Test parameters		Test method
		Parameter	Value	
Hydrostatic strength (80 °C, 165 h) [o]	No failure during the test period of any test piece	End caps	Type A [a] of ISO 1167-1:2006	ISO 1167-1:2006 and ISO 1167-2
		Orientation	Free	
		Conditioning time at test temperature	Shall conform to ISO 1167-1:2006	
		Number of test pieces [b]	3	
		Type of test	Water internal and water external to the test piece ("water-in-water") [p]	
		Circumferential (hoop) stress for: PE 80 PE 100 and PE 100-RC	 4,5 MPa 5,4 MPa	
		Test period	≥ 165 h [c]	
		Test temperature	80 °C	
Hydrostatic strength (80 °C, 1 000 h) [o]	No failure during the test period of any test piece	End caps	Type A [a] of ISO 1167-1:2006	ISO 1167-1:2006 and ISO 1167-2
		Orientation	Free	
		Conditioning time at test temperature	Shall conform to ISO 1167-1:2006	
		Number of test pieces [b]	3	
		Type of test	Water internal and water external to the test piece ("water-in-water") [p]	
		Circumferential (hoop) stress for: PE 80 PE 100 and PE 100-RC	 4,0 MPa 5,0 MPa	
		Test period	≥ 1 000 h	
		Test temperature	80 °C	
Elongation at break	≥ 350 % [d, e]	Thickness	$e \leq 5$ mm	ISO 6259-1 and ISO 6259-3
		Test piece shape	Type 2	
		Speed of test	100 mm/min	
		Number of test pieces [b]	Shall conform to ISO 6259-1	
Elongation at break	≥ 350 % [d, e]	Thickness	5 mm < $e \leq$ 12 mm	ISO 6259-1 and ISO 6259-3
		Test piece shape	Type 1 [f]	
		Speed of test	50 mm/min	
		Number of test pieces [b]	Shall conform to ISO 6259-1	
Elongation at break	≥ 350 % [d, e]	Thickness	$e >$ 12 mm	ISO 6259-1 and ISO 6259-3
		Test piece shape	Type 1 [f]	
		Speed of test	25 mm/min	
		Number of test pieces [b]	Shall conform to ISO 6259-1	
		Or		
		Test piece shape	Type 3 [f]	
		Speed of test	10 mm/min	
		Number of test pieces [b]	Shall conform to ISO 6259-1	

Table 4 *(continued)*

Characteristic	Requirement	Test parameters		Test method
		Parameter	Value	
Resistance to SCG for PE 80 and PE 100 Notched pipe test (NPT) [q]	No failure during the test period	Thickness	e > 5 mm	ISO 13479
		Test temperature	80 °C	
		Internal test pressure for: PE 80, SDR 11 PE 100, SDR 11	 8,0 bar [g] 9,2 bar [g]	
		Test period	≥ 500 h	
		Type of test	Water internal and water external to the test piece ("water-in-water")	
		Number of test pieces [b]	Shall conform to ISO 13479	
Resistance to SCG for PE 100-RC Accelerated notched pipe test (ANPT) [h]	No failure during the test period	Pipe dimension	d_n: 110 mm SDR 11	ISO 13479
		Test temperature	80 °C	
		Internal test pressure for: PE 100-RC, SDR 11	 9,2 bar	
		Test period	≥ 300 h [j]	
		Type of test	Water internal and detergent solution external to the test piece [k] ("water-in-liquid")	
		Number of test pieces [b]	Shall conform to ISO 13479	
Resistance to SCG for PE 100-RC Strain-hardening test (SHT) [h]	$<G_p>$ ≥ 50,0 MPa	Test sample	Compression moulded sheet made from regrind from pipe [i]	ISO 18488
		Test temperature	80 °C	
		Thickness	300 µm	
		Test speed	Shall conform to ISO 18488	
		Number of test pieces [b]	Shall conform to ISO 18488	
Resistance to SCG for PE 100-RC Cracked round bar (CRB) test [h]	≥ 1,5 × 10^6 cycles	Test sample	Machined from pipe [r]	ISO 18489
		Pipe wall thickness	e > 16 mm	
		Test temperature	23 °C	
		Type of test	In air	
		Diameter of test piece	14 mm	
		Reference stress level	12,5 MPa	
		Waveform/frequency	Sinusoid/10 Hz	
		Number of test pieces [l]	4	
Resistance to rapid crack propagation (RCP) Critical pressure, p_c [m]	p_c ≥ 1,5 MOP with $p_c = 3{,}6\ p_{c,s4} + 2{,}6$ [n]	Test temperature	0 °C	ISO 13477
		Pressurizing fluid	air	
		Number of test pieces [b]	Shall conform to ISO 13477	

Table 4 *(continued)*

Characteristic	Requirement	Test parameters		Test method
		Parameter	Value	

[a] Type B end caps may be used for batch release tests for diameters ≥ 500 mm.

[b] The number of test pieces given indicates the number 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 1555-7.[11]

[c] Only brittle failures shall be taken into account. If a ductile failure occurs before 165 h, the test may be repeated at a lower stress. The stress and the associated test period shall be selected from Table 5 or from a line based on the stress/time points given in Table 5.

[d] Where the rupture takes place outside the gauge marks, the test is accepted if the value conforms to the requirements.

[e] The test can be terminated when the requirement is met, without necessarily carrying out the test up to the rupture of the test piece.

[f] Where practical, machine or die cut type 2 test pieces may be used for pipe wall thickness equal to or less than 25 mm.

[g] For other SDR classes, values are given in ISO 13479:2022, Annex B.

[h] These tests are specifically for PE 100-RC materials. The SHT is intended to be used for size group 1, the ANPT for size group 2, and the CRB test for size group 3, 4 or 5 (see CEN/TS 1555-7).[11] As nonylphenol ethoxylate is currently unavailable in certain markets, the SHT may be used for size group 2 as alternative test until a requirement using a new detergent for ANPT has been defined.

[i] The sample for the SHT shall be taken across the pipe wall or the whole pipe in case of small diameter. The outer surface shall be scraped to remove any contamination present.

[j] This requirement correlates to a test on 110 mm diameter SDR 11 PE 100-RC pipe in accordance with ISO 13479, at a pressure level of 9,2 bar at 80 °C, water-in-water, with no failure in a test period of 8 760 h.[17] The ANPT test has been developed based on testing 110 mm SDR 11 pipe (see ISO 13479:2022, Annex D).[18][19] Research is ongoing to define requirements for other pipe diameters and SDR ratios in this test.

[k] Nonylphenol ethoxylate (CAS Registry Number® 9016-45-9) with a trade name of Arkopal® N100 is used for this test with a concentration for testing using 2 % (mass fraction) aqueous solution. This detergent will be replaced by lauramine oxide CAS Registry Number® 85408-49-7), which is commercially available as Dehyton® PL. The requirement for the ANPT using lauramine oxide is under development at the time of publication of this document.

[l] At least four samples shall be machined axially and evenly distributed around the circumference of the pipe.

[m] Rapid crack propagation testing is only required when the wall thickness of the pipe is greater than the wall thickness of the pipe used in the rapid crack propagation PE compound test (see ISO 4437-1:2024, Table 2). Rapid crack propagation testing is required at sub-zero temperatures for applications at such temperatures.

[n] If the requirement is not met or S4 test equipment not available, then (re)testing by using the full-scale test shall be performed in accordance with ISO 13478. In this case: $p_c = p_{c,\text{full-scale}}$.

[o] Test pressure shall be calculated using the measured pipe dimensions. However, for BRT testing nominal dimensions may be used. In case of dispute, measured dimensions shall be used.

[p] For pipes ≥ 630 mm diameter, the test may be carried out water-in-air.

[q] This test is not performed on PE 100-RC pipes.

[r] The sample for the CRB test shall be taken as close as possible to the inner wall needed for sample preparation and axially along the pipe.

[s] If the predicted value at (20 °C, 100 h) in accordance with ISO 9080 for a PE 80 material is less than 10 MPa, the control point stress value 9,0 MPa at (20 °C, 100 h) can be used.

NOTE 1 Chemical Abstracts Service (CAS) Registry Number® is a trademark of the American Chemical Society (ACS). This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the product named. Equivalent products can be used if they can be shown to lead to the same results.

NOTE 2 Arkopal® N100 is an example of a suitable product available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of this product.

NOTE 3 Dehyton® PL is an example of a suitable product available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of this product.

Table 5 — Test parameters for the retest of the hydrostatic strength at 80 °C

PE 80		PE 100 and PE 100-RC	
Stress MPa	**Test period** h	**Stress** MPa	**Test period** h
4,5	165	5,4	165
4,4	233	5,3	256
4,3	331	5,2	399
4,2	474	5,1	629
4,1	685	5,0	1 000
4,0	1 000	—	—

9 Physical characteristics

9.1 Conditioning

Unless otherwise specified by the applicable test method, the test pieces shall be conditioned at (23 ± 2) °C before testing in accordance with Table 6.

9.2 Requirements

When tested in accordance with the test methods as specified in Table 6 using the indicated parameters, the pipe shall have physical characteristics conforming to the requirements given in Table 6.

Table 6 — Physical characteristics

Characteristic	Requirement	Test parameters		Test method
		Parameter	Value	
Oxidation induction time (OIT) (thermal stability)	≥ 10 min	Test temperature	210 °C [b]	ISO 11357-6
		Test atmosphere	Oxygen	
		Specimen mass	(15 ± 2) mg	
		Number of test pieces [a, c]	4	
Melt mass-flow rate (MFR)	After processing maximum deviation of ±20 % of the value measured on the batch used to manufacture the pipe [d]	Loading mass	5 kg	ISO 1133-1
		Test temperature	190 °C	
		Time	10 min	
		Number of test pieces [a]	Shall conform to ISO 1133-1	
Longitudinal reversion (For pipes ≤ 16 mm wall thickness)	≤ 3,0 % original appearance of the pipe shall remain	Test temperature	110 °C	ISO 2505
		Length of test piece	200 mm	
		Immersion time	1 h	
		Test method	Free	
		Number of test pieces [a]	Shall conform to ISO 2505	

[a] The number of test pieces given indicates the number required to establish a value for the characteristic described in the table. The number of test pieces required for factory production control and process control should be listed in the manufacturer's quality plan. Guidance for assessment of conformity can be found in CEN/TS 1555-7.[11]

[b] Alternatively the test may be carried out at 200 °C with a minimum requirement of ≥ 20 min. In case of dispute, testing at 210 °C is applicable. The sample thickness is free and not in accordance with ISO 11357-6.

[c] Two samples shall be taken from the outer and inner pipe surfaces.

[d] The value given by the material supplier can be used, but in case of dispute the measurement on granules shall be carried out by the pipe manufacturer.

10 Performance requirements

When pipes conforming to this document are assembled to each other or to components conforming to other parts of the ISO 4437 series, the joints shall conform to ISO 4437-5.

11 Marking

11.1 General

11.1.1 The marking elements shall be printed or formed directly on the pipe in such a way that after storage, weathering, handling and installation, legibility is maintained during the use of the pipe.

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

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

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

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

11.1.5 In case of pipe made from own reworked material, the use of appropriate marking can be subject to agreement between the manufacturer and the end user.

11.2 Minimum required marking

The minimum required marking shall conform to Table 7.

Table 7 — Minimum required marking

Aspects	Mark or symbol
Reference to the ISO 4437 series Manufacturer's name and/or trademark	ISO 4437 Name or symbol
For pipes $d_n \leq 32$ mm: — Nominal outside diameter × nominal wall thickness ($d_n \times e_n$)	 e.g. 32 × 3,0
For pipes $d_n > 32$ mm: — Nominal outside diameter, d_n — SDR	 e.g. 200 e.g. SDR 11
Type of pipe, if applicable Designation Manufacturer's information [a] Intended use [b]	e.g. co-extruded or peelable layer e.g. PE 100, PE 100-RC GAS
[a] For providing traceability, the following details shall be given: — the production period, year and month, in figures or in code; — name or code for the production site, if the manufacturer is producing in different sites; — materials used by name or code. [b] Information on abbreviated terms can be found in national rules. NOTE ISO 12176-4 and ISO 12176-5 provide coded information about traceability.	

The frequency of the marking shall not be less than once per metre.

The length of coiled pipe is permitted to be indicated on the coil. The remaining length of pipe on drums is permitted to be indicated on the pipe. Co-extruded and peelable pipes shall be marked accordingly including any specific instructions related to these types of pipes.

Annex A
(normative)

Pipes with co-extruded layers

A.1 General

This annex specifies the additional geometrical, mechanical and physical properties of PE pipes with co-extruded layer(s), intended to be used for the supply of gaseous fuels. Additional marking requirements are given. The outside diameter, d_e, is specified as the total outside diameter, including the co-extruded black or coloured layer(s) at the outside of the pipe. The wall thickness, e_n, is defined as the total wall thickness including all layers, on either or both the outside and/or inside of the pipe.

NOTE Other types of layered pipes are covered by other International Standards, e.g. ISO 17484-1 or ISO 18225.

A.2 Material

The PE compounds used for the layer(s) of the pipe shall be in accordance with ISO 4437-1 and shall be of the same MRS rating (see ISO 4437-1:2024, Table 3). Reworked material from co-extruded pipes shall not be used for components in accordance with the ISO 4437 series.

A.3 Geometrical characteristics

The geometrical characteristics of the pipe, inclusive of the co-extruded layer(s), shall be in accordance with Clause 7. The manufacturer shall declare the thickness of each layer and tolerance in the technical file.

A.4 Mechanical characteristics

The mechanical characteristics of the pipe, inclusive of the co-extruded layer(s) shall be in accordance with Clause 8.

In addition, the requirements for RCP and slow crack growth resistance in accordance with Table 4 shall be fulfilled by the manufactured pipe, and the first sentence of footnote [m] does not apply. The RCP test is to be performed on the maximum wall thickness of the manufacturer's range.

For pipe with all PE 100-RC layers, the SHT shall be performed on a sample made from compression moulded sheets taken from regrind of each of the layer. When layer thickness is less than 1,0 mm, the test may be carried out on a mixture of this and the adjacent layer.

A.5 Physical characteristics

The physical characteristics shall be in accordance with Clause 9. The requirements for thermal stability and for melt mass flow rate shall apply to the individual layers. Heat reversion shall be applicable to the pipe, inclusive of the co-extruded layer(s).

A.6 Marking

The marking of pipes with co-extruded layer(s) shall be in accordance with Clause 11.