



**International
Standard**

ISO 4437-1

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

**Part 1:
General**

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

Partie 1: Généralités

**Second edition
2024-02**

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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.

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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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, 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 4437-1:2014), 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;
- [Annex A](#) has been added, discussing the performance of PE 100-RC type materials with enhanced resistance to slow crack growth (SCG) and giving additional information for installation techniques;
- test methods have been updated and new test 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 materials and the general aspects of the plastics piping system.

Requirements and test methods for components of the piping system are specified in ISO 4437-2, 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.

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

Part 1: General

1 Scope

This document specifies materials and the general aspects of polyethylene (PE) 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 4437-2, 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 bar¹⁾, 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.

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 472, *Plastics — Vocabulary*

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

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

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

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

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

1) 1 bar = 0,1 MPa = 10⁵ Pa; 1 MPa = 1 N/mm².

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- ISO 1183-2, *Plastics — Methods for determining the density of non-cellular plastics — Part 2: Density gradient column method*
- ISO 4437-2:2024, *Plastics piping systems for the supply of gaseous fuels — Polyethylene (PE) — Part 2: Pipes*
- ISO 4437-3:2024, *Plastics piping systems for the supply of gaseous fuels — Polyethylene (PE) — Part 3: Fittings*
- ISO 4437-4, *Plastics piping systems for the supply of gaseous fuels — Polyethylene (PE) — Part 4: Valves*
- 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 11413:2019, *Plastics pipes and fittings — Preparation of test piece assemblies between a polyethylene (PE) pipe and an electrofusion fitting*
- ISO 11414:2009, *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 13479:2022, *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 16770, *Plastics — Determination of environmental stress cracking (ESC) of polyethylene — Full-notch creep test (FNCT)*
- ISO 16871, *Plastics piping and ducting systems — Plastics pipes and fittings — Method for exposure to direct (natural) weathering*
- 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*
- ISO 18553, *Method for the assessment of the degree of pigment or carbon black dispersion in polyolefin pipes, fittings and compounds*

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

3 Terms and definitions

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

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

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* (3.1.5).

3.1.4

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 .

3.1.5

minimum wall thickness at any point

e_{\min}

minimum value for the *wall thickness at any point* (3.1.4) around the circumference of a component

3.1.6

standard dimension ratio

SDR

numerical designation of a *pipe series* (3.1.7), 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* (3.1.3)

3.1.7**pipe series***S*

number for pipe designation

Note 1 to entry: The relationship between the pipe series, *S*, and the *standard dimension ratio*, *SDR* (3.1.6) 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* (3.2.2) (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**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, that 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 the 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 of the predicted hydrostatic strength* (3.3.1)

**3.3.4
design stress**

σ_s
allowable stress for a given application at 20 °C that is derived from the *minimum required strength*, *MRS* (3.3.2), by dividing it by the *design coefficient*, *C* (3.3.3)

Note 1 to entry: This is demonstrated in the following formula:

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

Note 2 to entry: It is expressed in megapascals (MPa).

**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 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 (H₂). 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).

**3.4.4
manufactured gas
synthetic gas**

gas which has been treated and can contain components that are not typical of natural gas

Note 1 to entry: Manufactured (synthetic) gases can contain substantial amounts of chemical species that are not typical of natural gases or common species found in atypical proportions as in the case of wet and sour gases.

Note 2 to entry: Manufactured gases fall into two distinct categories, as follows:

- a) those that are intended as synthetic or substitute natural gases, and that closely match true natural gases in both composition and properties;

- b) those that, whether or not intended to replace or enhance natural gas in service, do not closely match natural gases in composition.

Case b) includes gases such as town gas, coke oven gas (undiluted), and LPG/air mixtures. None of which is compositionally similar to a true natural gas (even though, in the latter case, it can be operationally interchangeable with natural gas).

[SOURCE: ISO 14532:2014, 2.1.1.4]

3.5 Terms related to joints

3.5.1

butt fusion joint

joint made by heating the planed ends of pipes or *spigot end fittings* (3.5.6), the surfaces of which are fused together by holding them against a flat heating plate until the polyethylene material reaches fusion temperature, removing the heating plate quickly and pushing the two softened ends against one another

3.5.2

fusion compatibility

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

3.5.3

electrofusion joint

joint between a polyethylene *electrofusion socket fitting* (3.5.4) or *electrofusion saddle fitting* (3.5.5) and a pipe or *spigot end fitting* (3.5.6), made by heating the electrofusion fitting 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

3.5.4

electrofusion socket fitting

polyethylene (PE) fitting which contains one or more integrated heating elements that are capable of transforming electrical energy into heat to realize a fusion joint with a spigot end or a pipe

3.5.5

electrofusion saddle fitting

polyethylene (PE) fitting which contains one or more integrated heating elements that are capable of transforming electrical energy into heat to realize a fusion joint onto a pipe

3.5.6

spigot end fitting

polyethylene (PE) fitting where the outside diameter of the spigot end is equal to the *nominal outside diameter* (3.1.2) of the corresponding pipe

4 Symbols and abbreviated terms

4.1 Symbols

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

C	design coefficient
d_n	nominal outside diameter
E	wall thickness (at any point) of a fitting and valve body
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
$\langle G_p \rangle$	strain hardening modulus
p_c	critical pressure
$p_{c,\text{full-scale}}$	critical pressure obtained in full-scale test
$p_{c,S4}$	critical pressure obtained in S4-test
S	pipe series
t	time
θ	temperature
$\Delta\sigma_0$	stress range
σ_s	design stress
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.

AFNCT	accelerated full notch creep test
ANPT	accelerated notched pipe test
CRB	cracked round bar (test)
DN/OD	nominal size
FNCT	full notch creep test
LPL	lower predicted limit
LPG	liquefied petroleum gas
MFR	melt mass-flow rate
MOP	maximum operating pressure
MRS	minimum required strength
NPT	notched pipe test
OIT	oxidation induction time
PE	polyethylene
PLT	point load test
RC	raised crack resistance
RCP	rapid crack propagation
SCG	slow crack growth
SDR	standard dimension ratio

SHT strain hardening test

5 Material

5.1 Material of the components

The pipes, fittings and valves shall be made of a PE compound conforming to this document.

This document includes materials classified PE 80 and PE 100.

Another type of PE 100, designated PE 100-RC with enhanced resistance to SCG, is also included in this document; see [Annex A](#) for additional information.

The material described in this document is a compound, which shall be supplied in the form of granules, suitable for the production of pipes conforming to ISO 4437-2, fittings conforming to ISO 4437-3 or valves conforming to ISO 4437-4.

5.2 Compound

5.2.1 Additives and pigments

The compound shall be made by adding to the PE base polymer only those additives and pigments (e.g. carbon black) necessary for the manufacture of pipes, fittings and valves conforming to ISO 4437-2, ISO 4437-3 and ISO 4437-4, as applicable, and for their fusibility, storage and use.

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

All additives and pigments shall be uniformly dispersed.

5.2.2 Colour

The colour of the compound shall be yellow (PE 80), orange (PE 100 and PE 100-RC) or black (PE 80, PE 100 and PE 100-RC).

5.2.3 Characteristics

5.2.3.1 Characteristics of the compound in the form of granules

The compound in the form of granules used for the manufacture of pipes, fittings and valves shall have characteristics conforming to the requirements given in [Table 1](#).

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

Characteristic	Requirement ^a	Test parameters		Test method
		Parameter	Value	
Compound density	$\geq 930 \text{ kg/m}^3$	Test temperature	23 °C	ISO 1183-1 or ISO 1183-2 ^c
		Number of test pieces ^b	Shall conform to ISO 1183-1 or ISO 1183-2 ^c	
Oxidation induction time (OIT) (thermal stability)	$\geq 20 \text{ min}$	Test temperature	210 °C ^d	ISO 11357-6
		Test atmosphere	Oxygen	
		Sample mass	(15 ± 2) mg	
		Number of test pieces ^b	3	
Melt mass-flow rate (MFR)	(0,20 ≤ MFR ≤ 1,40) g/10 min Maximum deviation of ±20 % of the nominated value ^{e, f}	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	
Volatile content	≤ 350 mg/kg	Number of test pieces ^b	1	EN 12099
Water content ^g	≤ 300 mg/kg (Equivalent to < 0,03 % by mass)	Number of test pieces ^b	1	ISO 15512
Carbon black content ^h	(2,0 to 2,5) % (mass fraction)	Number of test pieces ^b	Shall conform to ISO 6964 ⁱ	ISO 6964
Carbon black dispersion ^h	Grade ≤ 3 Rating of appearance A1, A2, A3 or B	Preparation of test pieces	Free ^j	ISO 18553
		Number of test pieces ^b	Shall conform to ISO 18553	
Pigment dispersion ^k	Grade ≤ 3 Rating of appearance A1, A2, A3 or B	Preparation of test pieces	Free ^j	ISO 18553
		Number of test pieces ^b	Shall conform to ISO 18553	
Resistance to SCG for PE 100-RC Strain hardening test (SHT) ^l	$\langle G_p \rangle \geq 53,0 \text{ MPa}$	Test temperature	80 °C	ISO 18488
		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 ^l	$\geq 1,5 \times 10^6$ cycles at an interpolated stress range ($\Delta\sigma_0$) of 12,5 MPa	Test temperature	23 °C	ISO 18489
		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 ^b	Shall conform to ISO 18489	

Table 1 (continued)

Characteristic	Requirement ^a	Test parameters		Test method
		Parameter	Value	
Resistance to SCG for PE 100-RC Accelerated FNCT (AFNCT) ^l	≥ 550 h at an interpolated reference tensile stress of 4 MPa ^m or ≥ 300 h at an interpolated reference tensile stress of 5 MPa ^m	Test temperature	90 °C	ISO 16770
		Environment	Lauramine oxide ⁿ	
		Concentration	2 % (mass fraction)	
		Test piece dimension	10 mm square	
		Failure mode ^o	Brittle	
		Number of test pieces ^b	Shall conform to ISO 16770	

^a Conformity to these requirements shall be proven by the compound producer.

^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.^[9]

^c ISO 1183-3 may be used as alternative. In case of dispute, ISO 1183-1 or ISO 1183-2 shall apply.

^d 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. The test may be carried out on melt flow extrudate or pellet. In case of dispute, the test shall be carried out on pellet. The sample thickness is free and not in accordance with ISO 11357-6.

^e Nominated value given by the compound manufacturer.

^f Materials (0,15 ≤ MFR < 0,20) g/10 min may be introduced. In such cases, attention is drawn to the fusion compatibility (see 5.3). The lowest MFR value resulting from the maximum lower deviation of the nominated value is to be not less than 0,15 g/10 min.

^g Volatile or water content shall be measured. In case of dispute, the requirement for water content shall be used. As an alternative method, ISO 760 may be used. The requirement applies to the compound producer at the stage of manufacturing and to the compound user at the stage of processing (if the water content exceeds the limit, drying is required prior to use).

^h Only for black compounds.

ⁱ In case of dispute, Method A "Electric Tube Furnace" shall be used.

^j In case of dispute, the test pieces shall be prepared by the microtome method.

^k Only for non-black compounds.

^l These tests are only performed on PE 100-RC material.

^m This requirement correlates to a test in accordance with ISO 16770, with a stress of 4 MPa at 80 °C in nonylphenol ethoxylate with no failure for a period of 8 760 h.^[17] and can be used as an alternative. 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 of 2 % (mass fraction). In case of dispute, the AFNCT applies.

ⁿ Lauramine oxide (CAS Registry Number® 85408-49-7) is commercially available as Dehyton® PL. The dilution of the lauramine oxide in the product shall be taken into account when calculating the concentration of 2 % (mass fraction). For example, when Dehyton® PL is used, it is already diluted to 30 % (mass fraction). Therefore, 6,67 % (mass fraction) of Dehyton® PL is needed to obtain 2 % (mass fraction) lauramine oxide.

^o Test specimens tested at a reference tensile stress of ≥ 4 MPa (or ≥ 5 MPa) may be terminated once the minimum failure time of 550 h (or 300 h) has been achieved, in which case there is no failure mode. Test specimens tested at a reference tensile stress of < 4 MPa (or < 5 MPa) may be terminated once the interpolated failure time of 550 h (or 300 h) is achieved, taking possible scatter in the actual tensile stress into account.

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.

5.2.3.2 Characteristics of the compound in the form of pipe

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.

Table 2 — Characteristics of compound in the form of pipe

Characteristic	Requirement ^a	Test parameters		Test method
		Parameter	Value	
Resistance to gas condensate	No failure during the test period of all test pieces	End caps	Type A	ISO 1167-1 and ISO 1167-2
		Test temperature	80 °C	
		Orientation	Free	
		Number of test pieces ^b	3	
		Circumferential (hoop) stress	2,0 MPa	
		Pipe dimensions:		
		d_n	32 mm	
		e_n	3 mm	
		Type of test	Synthetic condensate ^c internal and water external to the test piece ("liquid-in-water")	
	Test period	≥ 20 h		
	Conditioning period (pipe filled with condensate)	1 500 h in air at 23 °C		
Resistance to weathering ^{d,e}	The weathered test pieces shall fulfil the requirements of the following characteristics, a), b) and c) below:	Preconditioning (weathering): cumulative radiant exposure	≥ 3,5 GJ/m ²	ISO 16871
		Number of test pieces ^b	See below	
		Pipe dimensions	d_n : 110 mm SDR 11	
a) Decohesion of an electrofusion joint	a) Sample prepared in accordance with ISO 11413:2019, Jointing condition 1: 23 °C; ≤ 33 % brittle failure			a) ISO 13954
b) Hydrostatic strength (1 000 h at 80 °C)	b) Shall conform to ISO 4437-2:2024, Table 4			b) ISO 1167-1 and ISO 1167-2
c) Elongation at break	c) Shall conform to ISO 4437-2:2024, Table 4			c) ISO 6259-1 and ISO 6259-3
Resistance to rapid crack propagation (RCP) (Critical pressure, p_c)	$p_c \geq 1,5$ MOP with $p_c = 3,6 p_{c,s4} + 2,6$ f.g	Pipe dimension	d_n : 250 mm SDR 11	ISO 13477
		Test temperature	0 °C	
		Pressurizing fluid	air	
		Number of test pieces ^b	Shall conform to ISO 13477	
Resistance to SCG for PE 80 and PE 100 Notched pipe test (NPT) ^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 80, SDR 11	8,0 bar	
		PE 100, SDR 11	9,2 bar	
		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		

Table 2 (continued)

Characteristic	Requirement ^a	Test parameters		Test method
		Parameter	Value	
Resistance to SCG for PE 100-RC Accelerated notched pipe test (ANPT) ⁱ	No failure during the test period	Pipe dimension	d_n : 110 mm SDR 11	ISO 13479:2022 Annex D
		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	
Determination of the failure mode in a tensile test on a butt-fusion weld	Test to failure: Ductile – pass Brittle – fail	Pipe dimension	d_n : 110 mm SDR 11	ISO 13953
		Test temperature	23 °C	
		Number of test pieces ^b	Shall conform to ISO 13953	

^a Conformity to these requirements shall be proven by the compound producer.

^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.^[9]

^c 50 % *n*-decane and 50 % (mass fraction) 1-3-5 trimethylbenzene.

^d Only for non-black compounds.

^e For outdoor storage for one year to be applicable in some parts of the world, a cumulative radiant exposure of up to 7 GJ/m² is valid based on current measurements.

^f If the requirement is not met or S4 test equipment is not available, then (re)testing by using the full-scale test shall be performed in accordance with ISO 13478. In this case: $p_c = p_{c,full-scale}$. Further information is given in Annex C.

^g For PE 80 materials, smaller pipe diameters may be used for the RCP test. RCP performance is dependent on wall thickness. Pipe of thickness ≥ 15 mm shall be tested for RCP performance.

^h This test is not performed on PE 100-RC materials.

ⁱ The ANPT is specifically for testing PE 100-RC materials.

^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, and can be used as an alternative^{[19][20][21]}. In case of dispute, the ANPT applies, see ISO 13479:2022, Annex D.

^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 a 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.

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 may 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.

5.3 Fusion compatibility

5.3.1 The compounds conforming to Table 1 shall be fusible. The compound manufacturer shall check that the requirement for the failure mode in a tensile test given in Table 2 is fulfilled for a butt fusion joint. The test sample shall be 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.

Fusion compatibility shall be demonstrated by the compound manufacturer for each compound of their own product range.

For $(0,15 \leq MFR < 0,20)$ compounds, butt 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.

5.3.2 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 their own range covered by this request.

5.4 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

Classification by MRS MPa	Designation
8	PE 80
10	PE 100
	PE 100-RC

The compound shall be evaluated in accordance with ISO 9080 on pipes at least at three temperatures, where the first temperature is either 20 °C or 23 °C, the second temperature is 80 °C, and the third temperature is free 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 a time $t < 5\,000$ h.

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 shall be the same as for pipes.

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.

5.5 Design coefficient and design stress

The design coefficient, C , for pipes, fittings and valves for the supply of gaseous fuels shall be greater than or equal to 2. The maximum value for the design stress, σ_s , shall be 4,0 MPa for PE 80 and 5,0 MPa for PE 100 and PE 100-RC materials.

A higher design coefficient, C , should be considered for the use of liquefied petroleum gas (LPG) or manufactured gas (see [Annex B](#)).

5.6 Change of compound formulation

Any change in the dosage levels or manufacturing process of the compound affecting its performance can require a new qualification of the compound.

NOTE Guidance can be found in CEN/TS 1555-7^[9] and PPI TR-3.^[12]

Annex A
(informative)

Additional information related to the installation of PE 100-RC systems

A.1 Pipe material

Polyethylene materials have been used for the manufacture of piping systems for gas supply since the 1960s, offering a corrosion resistant system. Since this time, the materials used for these systems have been developed and improved in terms of performance, potential pressure rating, and above all, durability and resistance to RCP.

While initial improvements increased the material's pressure resistance (PE 63, PE 80 and PE 100), considerable progress has been made in recent years in increasing the resistance to SCG.^[18]

The main technical advantage of PE 100-RC is that it is even more resistant to SCG. PE 100-RC materials for piping systems require a separate number of tests to assess SCG performance. Piping systems made of such a material can be used for alternative trenchless installation methods when more surface damage can be encountered or for installations where excavated soil is used as the embedding material, respecting local regulations. As a result, the durability of the system is potentially increased by using these materials.

The material and product requirements of PE 100-RC compared to the well-known and established PE 100 are identical in each part of the ISO 4437 series, with the exception of requirements defining the resistance to SCG behaviour for the material and the pipe, fitting and valve components, as appropriate. [Table A.1](#) gives a comparison between the performance of PE 100 and PE 100-RC materials related to resistance to slow crack test methods.

Table A.1 — Resistance to SCG for PE 100 and PE 100-RC

PE 100 typical performance	PE 100-RC expected performance	Accelerated test method for PE 100-RC to reduce test time
NPT ≥ 500 h	NPT ≥ 8 760 h	ANPT 80 °C, ≥ 300 h 2 % (mass fraction) solution Arkopal® N100
FNCT ≥ 300 h at 4 MPa stress, 80 °C, 2 % (mass fraction) solution Arkopal® N100	FNCT ≥ 8 760 h at 4 MPa stress, 80 °C, 2 % (mass fraction) solution Arkopal® N100	AFNCT ≥ 550 h at 4 MPa stress ^a ≥ 300 h at 5 MPa stress ^a (Brittle fracture surface required) 90 °C, 2 % (mass fraction) solution Lauramine oxide
SHT $\langle G_p \rangle \geq 40 \text{ MPa}^a$	SHT $\langle G_p \rangle \geq 53 \text{ MPa}^a$	Not applicable
CRB ≥ 0,9 × 10 ⁶ cycles ^a	CRB ≥ 1,5 × 10 ⁶ cycles ^a	Not applicable
^a Derived from DVGW study, see Reference [17] .		
NOTE 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.		

The NPT in accordance with ISO 13479 simulates scratches on the outside of the pipe, which under pressure and stress would slowly drive the crack through the pipe wall. In this test, the PE 100-RC offers a significantly higher resistance to slow crack propagation resistance so that failure time of > 500 h for PE 100 increases to > 8 760 h for PE 100-RC. Such a long test time is not practical. A correlated accelerated method, the accelerated notch pipe test (ANPT) has been developed with the stress cracking media on the outside of the pipe reducing failure time to > 300 h (see ISO 13479:2022, Annex D). This has been proven in broader technical studies and is referred to in References [\[19\]](#), [\[20\]](#) and [\[21\]](#).

In the past, a point load test (PLT) to simulate the effect of stone indentation as included in DIN PAS 1075^{[10]2)} has been performed on 110 mm SDR 11 PE 100-RC materials in Europe. A correlation between the PLT and FNCT has been demonstrated.^[18] Instead of the PLT, the combination of the SHT, CRB, ANPT and AFNCT methods for PE 100-RC compounds is referenced in this document.

A.2 Installation conditions

Using PE 100-RC material with low notch sensitivity and reduced rates of SCG potentially increases the safety, reliability and lifetime of the pipe system. It is therefore used especially for:

- installation without sand embedding and re-use of the excavated soil in open trenches;
- installation using trenchless installation techniques – replacement of pipeline systems, replacement of the line:
 - horizontal directional drilling (HDD),
 - impact moling,
 - pipe jacking:
 - auger boring,
 - microtunneling;
- installation using trenchless installation techniques – rehabilitation of pipeline systems, replacement on the line:
 - pipe bursting,
 - pipe removal:
 - pipe eating,
 - pipe extraction;
- rehabilitation of pipeline systems using renovation methods:
 - lining with continuous pipe;
 - lining with close-fit pipes,
 - lining with inserted hoses.

NOTE Terminology from ISO 11295.

A selection between PE 100 or PE 100-RC for the pipe system material according to the installation method, soil condition, backfill characteristics, degree of compaction and design coefficients should be determined by agreement with the network owner, the installation company and the producer.

2) Withdrawn.

Annex B
(informative)

LPG and manufactured gas

Internal fluids such as gases and condensates when absorbed can have the effect of reducing the material strength upon which the design stress is based, the influence of gas being much less severe than condensate. For LPG gas, the design coefficient, C , should be 10 % greater than that of natural gases, i.e. a minimum of 2,2. This difference is in line with the values already in use by the gas industry in the ISO code of practice, ISO/TS 10839. The design coefficient, C , for manufactured gas should take into consideration the analysis of the gas with special reference to liquid hydrocarbons and should be at least 2,4. However, this component needs to be the subject of further discussion. See PPI MS-2^[11] and PPI TR-22/2013.^[13]

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