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Buried polyethylene (PE) pipes for the supply of gaseous fuels — Metric series — Specifications

Canalisations enterrées en polyéthylène (PE) pour réseaux de distribution de combustibles gazeux — Série métrique — Spécifications

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Foreword

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

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

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

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.

ISO 4437 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 third edition cancels and replaces the second edition (ISO 4437:1997), which has been technically revised as follows. A clear distinction has been made between requirements on compounds and requirements on pipes. Substantial changes have been made in introducing specifications for pipes, including additional layers, and in amending the relationship of the S4 critical pressure to the maximum operating pressure and FS critical pressure. An informative annex (Annex B) has been added, giving an alternative design approach using a pre-set, overall service (design) coefficient. Normative references have been updated and changed as appropriate. It also incorporates the Technical Corrigendum ISO 4437:1997/Cor.1:1999.

Buried polyethylene (PE) pipes for the supply of gaseous fuels — Metric series — Specifications

1 Scope

This International Standard specifies the general properties of the polyethylene (PE) compounds for the manufacture of pipes, the physical and mechanical properties of the pipes made from these compounds, and the requirements for the marking of such pipes, intended to be used for the supply of gaseous fuels.

It deals with three types of pipe:

— 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 C, where all layers have the same MRS rating;

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

This International Standard also gives guidance on a calculation and design scheme on which the maximum operating pressure (MOP) of the pipes is based. The pipes are intended to be buried.

NOTE For above-ground application of pipes conforming to this International Standard, the pipes need always to be protected by a casing pipe.

2 Normative references

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

ISO 3, *Preferred numbers — Series of preferred numbers*

ISO 161-1, *Thermoplastics pipes for the conveyance of fluids — Nominal outside diameters and nominal pressures — Part 1: Metric series*

ISO 497, *Guide to the choice of series of preferred numbers and of series containing more rounded values of preferred numbers*

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

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 (all parts), *Plastics — Methods for determining the density of non-cellular plastics*

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

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

ISO 4065, *Thermoplastics pipes — Universal wall thickness table*

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 and basic specification*

ISO 8085-3, *Polyethylene fittings for use with polyethylene pipes for the supply of gaseous fuels — Metric series — Specifications — Part 3: Electrofusion fittings*

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)* [1)]

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

ISO 11414:1996, *Plastics pipes and fittings — Preparation of polyethylene (PE) pipe/pipe or pipe/fitting test piece assemblies by butt fusion*

ISO 11922-1:1997, *Thermoplastics pipes for the conveyance of fluids — Dimensions and tolerances — Part 1: Metric series*

ISO 12162:1995, *Thermoplastics materials for pipes and fittings for pressure applications — Classification and designation — Overall service (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 (notch test)*

ISO 13480, *Polyethylene pipes — Resistance to slow crack growth — Cone test method*

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*

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1) To be published. (Revision of ISO 11357-6:2002)

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

ISO 18553, *Method for the assessment of the degree of pigment or carbon black dispersion in polyolefin pipes, fittings and compounds*

ASTM D3849, *Standard test method for carbon black — Morphological characterization of carbon black using electron microscopy*

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

3 Terms and definitions

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

3.1
nominal outside diameter
d_n
numerical designation of size which is common to all components in a thermoplastics piping system other than flanges and components designated by thread size

NOTE 1 It is a convenient round number for reference purposes.

NOTE 2 For metric pipes conforming to ISO 161-1, the nominal outside diameter, expressed in millimetres, is the minimum mean outside diameter, $d_{em,min}$.

3.2
mean outside diameter
d_{em}
measured length of the outer circumference of the pipe divided by π, rounded up to the nearest 0,1 mm

NOTE The value for π is taken to be 3,142.

3.3
minimum mean outside diameter
$d_{em,min}$
minimum mean outside diameter of the pipe

3.4
maximum mean outside diameter
$d_{em,max}$
maximum mean outside diameter of the pipe

3.5
out-of-roundness
ovality
difference between the measured maximum outside diameter and the measured minimum outside diameter in the same cross-sectional plane of the pipe

3.6
nominal wall thickness
e_n
wall thickness, in millimetres, tabulated in ISO 4065, corresponding to the minimum wall thickness $e_{y,min}$ at any point e_y

3.7
wall thickness at any point
e_y
measured wall thickness at any point around the circumference of the pipe, rounded up to the nearest 0,1 mm

3.8
minimum wall thickness
$e_{y,min}$
minimum wall thickness of the pipe

3.9
standard dimension ratio
SDR
ratio of the nominal outside diameter of the pipe to its nominal wall thickness

$$\mathrm{SDR} = \frac{d_n}{e_n}$$

3.10
lower confidence limit of predicted hydrostatic strength
σ_{LPL}
quantity with the dimension of stress, which represents the 97,5 % lower confidence limit of the predicted hydrostatic strength for a single value at a temperature T and a time t

NOTE It is denoted as $\sigma_{LPL} = \sigma_{(T,t,0,975)}$.

3.11
minimum required strength
MRS
value of σ_{LPL} at a temperature of 20 °C and a time of 50 years ($\sigma_{(20,50years,0,975)}$), rounded down to the next smaller value of the R10 series or of the R20 series conforming to ISO 3, ISO 497 and ISO 12162, depending on the value of σ_{LPL}

3.12
gaseous fuel
any fuel which is in the gaseous state at a temperature of 15 °C and a pressure of 1 bar

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

3.13
maximum operating pressure
MOP
maximum effective pressure of the gas in a piping system, expressed in bar, which is allowed for continuous use

NOTE 1 It takes into account the physical and the mechanical characteristics of the components of the piping system and the influence of the gas on these characteristics.

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

3.14
compound
homogeneous extruded mixture of base polymer (PE) and additives, i.e. antioxidants, pigments, UV-stabilizers and others, at a dosage level necessary for the processing and use of components conforming to the requirements of this International Standard

3.15
rework material
unused material from a manufacturer's retained production that has been reground, granulated or pelletized for reuse by that same manufacturer

4 PE compound

4.1 Technical data

The technical data concerning the materials used, relevant to the performance of the pipe, shall be made available to the purchaser of the compound by the compound manufacturer.

4.2 Change in compound quality

Any change in dosage levels or processing of the compound affecting the performance of the pipe may require a new qualification of the compound.

NOTE Guidelines can be found in Bibliographic references [4] and [6].

4.3 Identification compound

Where applicable, the compound used for identification stripes shall be made from the same base resin as one of the pipe compounds for which fusion compatibility of pipes is proven by the pipe manufacturer.

4.4 Rework material

Clean rework material may be used, provided that it is derived from the same pipe and/or fitting compound as used for the relevant production.

4.5 Characteristics of PE compound

The PE compound shall be in accordance with Tables 1 and 2.

4.6 Fusion compatibility of PE compound

The compound manufacturer shall demonstrate fusion compatibility for the compounds of his own product range by checking that the requirement for tensile strength given in Table 3 is fulfilled for butt-fusion joints prepared using the parameters specified in ISO 11414:1996, Annex A, at an ambient temperature of (23 ± 2) °C.

4.7 Classification

PE compounds shall be classified by MRS in accordance with Table 4.

The classification in accordance with ISO 12162 shall be given and demonstrated by the compound producer.

The long-term hydrostatic strength of the compound shall be evaluated in accordance with ISO 9080, with pressure tests performed at least three temperatures, where two of the temperatures are fixed to 20 °C and 80 °C, and the third temperature free between 30 °C and 70 °C. At 80 °C, there shall be no knee detected in the regression curve at $t < 5\,000$ h.

Table 1 — Characteristics of PE compound

Characteristic	Unit	Requirement	Test parameter	Test method
Density [a]	kg/m^3	⩾ 930	23 °C	ISO 1183
Melt flow rate	g/10 min	± 20 % of the nominated value or ± 0,1 g/10 min, whichever is the greatest	condition T [b]	ISO 1133
Thermal stability	min	> 20	200 °C [c]	ISO 11357-6
Volatile content [d]	mg/kg	⩽ 350		EN 12099
Water content [d, e]	mg/kg	⩽ 300		ISO 15512
Carbon black content [f]	% (mass fraction)	2,0 % to 2,5 %		ISO 6964
Carbon black or pigment dispersion	Grade	⩽ 3		ISO 18553
	Rating of appearance	A1,A2,A3 or B		
Carbon black particle size [f]	nm	10 to 25		ASTM D3849

[a] For the base polymer only.

[b] The condition used for determining the MFR shall be related to the conditions used by the manufacturer.

[c] Testing may be carried out at 210 °C provided there is clear correlation with the results at 200 °C. In case of dispute, the reference temperature shall be 200 °C.

[d] This test method may be used for quality control purposes.

[e] Only applicable if the compound does not conform to the requirement for volatile content. In case of dispute, the requirement for water content shall be decisive. 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).

[f] Only applicable for black compounds.

Table 2 — Characteristics of PE compound — Tested in pipe form

Characteristic	Unit	Requirement	Test parameter	Test method
Resistance to gas constituents	h	$\geqslant$ 20	80 °C 2 MPa	Annex A
Resistance to rapid crack propagation (RCP): S4 test ($e \geqslant 15$ mm)	bar	$p_c \geqslant 1{,}5 \times$ MOP with $p_c = 3{,}6 \times p_{cS4} + 2{,}6$ (in bar) [a]	0 °C	ISO 13477
Resistance to slow crack growth	h	$\geqslant$ 500	80 °C; 8,0 bar [b] 80 °C; 9,2 bar [c]	ISO 13479
Resistance to weathering (for non-black compounds only)	—	After weathering	$E \geqslant 3{,}5$ GJ/m^2 [e]	ISO 16871
		Hydrostatic strength of pipe [d]	80 °C; $\geqslant$1 000 h	ISO 1167-1 ISO 1167-2
		Elongation at break of pipe	$\geqslant$ 350 %	ISO 6259-1 ISO 6259-3
		De-cohesion of an electrofusion joint — percentage brittle failure	23 °C; $\leqslant$ 33,3 %	ISO 13954 ISO 11413 [f] Jointing condition 1 ISO 8085-3

[a] The full-scale/S4 correlation factor is equal to 3,6 and is defined by the formula:

$$p_{cFS} + p_{atm} = 3{,}6\ (p_{cS4} + p_{atm})$$

where p_{cFS} is the full-scale test critical pressure, p_{atm} is the atmospheric pressure, and p_{cS4} is the small-scale, steady-state (S4) test critical pressure.

NOTE Attention is drawn to the fact that the correlation factor could be modified.

If the requirement is not met, then retest using the full-scale test ISO 13478. In this case, critical pressure $p_c = p_{c,FS}$.

[b] Test parameter for PE 80, d_n 110 mm or 125 mm, SDR 11.

[c] Test parameter for PE 100, d_n 110 mm or 125 mm, SDR 11.

[d] Test parameter for PE 80: 4,0 MPa. Test parameter for PE 100: 5,0 MPa.

[e] The value of 3,5 GJ/m^2 represents the yearly exposure to sunlight near the 50th degree of latitude. This value might not be appropriate for other global locations, in which case, national standards and regulations will apply.

[f] ISO 11413:1996 does not take into account peelable pipe. It is intended that its next revision will cover this aspect.

Table 3 — Characteristic of PE compound — Tested in butt-fusion joint form

Characteristic	Unit	Requirement	Test parameter	Test method
Tensile strength for butt fusion (d_n: 110 mm or 125 mm — SDR 11)	—	Test to failure: Ductile — Pass Brittle — Fail	23 °C	ISO 13953