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

Part 5: Fitness for purpose of the system

Systèmes de canalisations en matières plastiques pour la d istribution de combustibles gazeux — Polyéthylène (PE) —

Partie 5: Aptitude à l'emploi du système

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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 documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is 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 first edition of ISO 4437-5 together with the first editions of ISO 4437-1, ISO 4437-2 and ISO 4437-3 cancel and replace ISO 4437:2007, ISO 8085-1:2001, ISO 8085-2:2001 and ISO 8085-3:2001, of which they constitute a technical revision.

ISO 4437 consists of the following parts, under the general title *Plastics piping systems for the supply of gaseous fuels — Polyethylene (PE)*:

— *Part 1: General*

— *Part 2: Pipes*

— *Part 3: Fittings*

— *Part 4: Valves*

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

Introduction

This part of ISO 4437 specifies the requirements of a piping system and its components made from polyethylene (PE), and which is intended to be used for the supply of gaseous fuels.

Requirements and test methods for material and components are specified in ISO 4437-1, ISO 4437-2, ISO 4437-3, and ISO 4437-4.

Recommended practice for installation is given in ISO/TS 10839.[2]

This part of ISO 4437 covers the characteristics of fitness for purpose of the system.


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

Part 5: Fitness for purpose of the system

1 Scope

This part of ISO 4437 specifies the requirements of fitness for purpose of the polyethylene (PE) piping system to be used for the supply of gaseous fuels.

It specifies the definitions of electrofusion, socket fusion, butt fusion, and mechanical joints.

It specifies the method of preparation of test piece joints and the tests to be carried out on these joints for assessing the fitness for purpose of the system under normal and extreme conditions.

It specifies the test parameters for the test methods referred to in this part of ISO 4437.

In conjunction with ISO 4437-1, ISO 4437-2, ISO 4437-3, and ISO 4437-4, it is applicable to PE pipes, fittings, valves, their joints, and joints with components of PE and other materials intended to be used under the following conditions:

a) the maximum operating pressure (MOP) is based on the design stress, determined from the compound minimum required strength (MRS) divided by the *C* factor, and taking into account rapid crack propagation (RCP) requirements;

b) a temperature of 20 °C as reference temperature for the design basis.

NOTE 1 For other operating temperatures, derating coefficients are given in Annex A.

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

2 Normative references

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

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

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

ISO 1167-4, *Thermoplastics pipes, fittings and assemblies for the conveyance of fluids — Determination of the resistance to internal pressure — Part 4: Preparation of assemblies*

ISO 4437-2, *Plastics piping systems for the supply of gaseous fuels — Polyethylene (PE) — Part 2: Pipes*

ISO 4437-3, *Plastics piping systems for the supply of gaseous fuels — Polyethylene (PE) — Part 3: Fittings*

ISO 10838-1[1)], *Mechanical fittings for polyethylene piping systems for the supply of gaseous fuels — Part 1: Metal fittings for pipes of nominal outside diameter less than or equal to 63 mm*

ISO 10838-2[1)], *Mechanical fittings for polyethylene piping systems for the supply of gaseous fuels — Part 2: Metal fittings for pipes of nominal outside diameter greater than 63 mm*

ISO 10838-3[1)], *Mechanical fittings for polyethylene piping systems for the supply of gaseous fuels — Part 3: Thermoplastics fittings for pipes of nominal outside diameter less than or equal to 63 mm*

ISO 11413:2008, *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 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 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 13955, *Plastics pipes and fittings — Crushing decohesion test for polyethylene (PE) electrofusion assemblies*

ISO 13956, *Plastics pipes and fittings — Decohesion test of polyethylene (PE) saddle fusion joints — Evaluation of ductility of fusion joint interface by tear test*

ISO 21751, *Plastics pipes and fittings — Decohesion test of electrofusion assemblies — Strip-bend test*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 4437-1 and the following apply.

3.1
mechanical joint
joint made by assembling a PE pipe with a fitting that generally includes a compression part to provide for pressure integrity, leak tightness, and resistance to end loads

4 Fitness for purpose of the system

4.1 Method of preparation of assemblies for testing

4.1.1 General

The joints shall be made by using pipes conforming to ISO 4437-2 and fittings conforming to ISO 4437-3.

Test pieces for pressure testing shall be closed with pressure-tight, end-load-bearing end caps, plugs, or flanges which shall be provided with connections for the entry of water and release of air.

The peelable layer of peelable-layer pipe shall be removed in the area of the joint prior to jointing.

Test assemblies should be prepared taking into consideration applicable national safety regulations.

1) These International Standards are under revision and will be replaced by ISO 17885.

4.1.2 Butt fusion joints

PE pipes, spigot end fittings, and valves intended to be used for jointing by butt fusion shall be prepared and assembled in accordance with ISO 11414:2009. The conditions for the preparation of the joints are given in 4.2.2.1 for the assessment of fitness for purpose of the system under normal conditions and in 4.2.2.2 for the assessment of fitness for purpose of the system under extreme conditions.

4.1.3 Electrofusion joints

PE pipes, fittings and valves intended to be used for jointing by electrofusion shall be prepared and assembled in accordance with ISO 11413:2008. The conditions for the preparation of the joints are given in 4.2.3.1 for the assessment of fitness for purpose of the system under normal conditions and in 4.2.3.2 for the assessment of fitness for purpose of the system under extreme conditions.

For joints with electrofusion saddle fittings, the electrofusion saddle fitting shall be fused to the pipe while it is pneumatically pressurized to the allowable maximum operating pressure. The pipe shall be cut immediately after the manufacturer prescribed cooling time has elapsed.

For straight equal electrofusion socket fittings (couplers), test joints on selected diameters out of the product range shall be prepared with a gap of $0{,}05 d_n$ between the pipe end and the maximum theoretical depth of penetration of the fitting, where for diameters greater than 225 mm, the adjoining pipes shall be arranged to provide the maximum angular deflection possible for the fitting, limited to 1,5°.

4.1.4 Mechanical joints

For mechanical joints, the assembly of the PE pipe and the fitting shall be prepared in accordance with ISO 10838-1, ISO 10838-2, or ISO 10838-3, as applicable.

NOTE The ISO 10838 series will be replaced by ISO 17885.

A support sleeve inserted into the pipe bore should be used to provide a permanent support for the PE pipe to prevent creep in the pipe wall under radial compressive forces. The metallic part of this fitting can be assembled to a metallic pipe by screw threads, compression joints, welded or brazed flanges, or by other means.

4.1.5 Socket fusion joints

Fitness for purpose of the system testing shall be agreed between the manufacturer and the end-user.

4.2 Requirements for fitness for purpose of the system

4.2.1 General

When tested in accordance with the test methods in Table 5 using the indicated parameters, joints prepared in accordance with 4.1 shall have mechanical characteristics conforming to the requirements given in Table 5, as applicable to the following types of joints:

— (A) electrofusion socket fittings;

— (B) electrofusion saddle fitting;

— (C) spigot end fitting, pipe.

4.2.2 Fitness for purpose of the system for butt fusion joints

4.2.2.1 Under normal conditions (ambient temperature 23 °C)

For the assessment of fitness for purpose of the system under normal conditions, butt fusion joints shall have the characteristic of tensile strength conforming to the requirement given in Table 5, using the

parameters as specified in Annex B, condition 1 of ISO 11414:2009 at an ambient temperature of 23 °C ± 2 °C and the scheme listed in Table 1.

Table 1 — Scheme for butt-fused joints

Pipe/spigot end fitting/valve with spigot ends	Pipe	
	PE 80	PE 100
PE 80	X	X[a]
PE 100	X[a]	X
[a] Only when requested by the purchaser.		

NOTE Table 1 is to be interpreted as follows: as an example, for a pipe or a spigot end fitting or a valve with spigot end made from a PE 80 compound, the joint is tested with a pipe made from PE 80 compound. When requested by the purchaser, for mixed compound joints, test pieces are used incorporating PE 80 and PE 100 compounds.

The pipe manufacturer shall declare, according to 4.2.2.1, which pipes from his own product range manufactured from different compounds conforming to ISO 4437-2 are compatible to each other for butt fusion.

The fitting or valve manufacturer shall declare, according to 4.2.2.1, the standard dimension ratio (SDR) range and MRS values of pipes conforming to ISO 4437-2 to which the manufacturer's fittings conforming to ISO 4437-3 can be fused by using the same procedures (e.g. times, temperatures, and fusion pressures) to conform to this part of ISO 4437. If there is a need for deviation in fusion procedures, the fitting or valve manufacturer shall state this clearly.

4.2.2.2 Under extreme conditions

For butt fusion joints, the characteristics to be examined for fitness for purpose of the system under extreme conditions shall conform to Table 2.

Table 2 — Relationship between joints and fitness for purpose of the system characteristics

Butt fusion joint	Associated characteristics
Both components of the joint: same MRS and same SDR Joint: minimum and maximum condition[a]	Hydrostatic strength (80 °C, 165 h)
	Tensile strength for butt fusion joint
a As specified in Clause 7, item a) of ISO 11414:2009 concerning misalignment and the limit values of fusion parameters conforming to conditions 2 and 3 in Annex B of ISO 11414:2009.	

When tested in accordance with the test methods as specified in Table 5 using the indicated parameters, the joints shall have characteristics conforming to the requirements given in Table 5.

The fitting or valve manufacturer shall declare according to Table 2, as applicable, the fitness for purpose of the system under extreme conditions of the fittings or valves.

The pipe manufacturer shall declare according to Table 2 the fitness for purpose of the system under extreme conditions of the pipes (PE pipes, PE pipes with co-extruded layers, and PE pipes with peelable layers).

4.2.3 Fitness for purpose of the system for electrofusion joints

4.2.3.1 Under normal conditions (ambient temperature 23 °C)

For the assessment of fitness for purpose of the system under normal conditions, electrofusion joints shall have the characteristic of decohesive resistance or cohesive strength, as applicable, conforming to the requirement given in Table 5, using the assembly condition 1 as specified in Annex C of ISO 11413:2008 at an ambient temperature of 23 °C ± 2 °C and the scheme listed in Table 3.

Table 3 — Scheme for electrofused joints

Electrofusion fitting/ valve with electrofusion socket	Pipe	
	PE 80 SDR maximum	PE 100 SDR minimum
PE 80	X	X
PE 100	X	X

NOTE Table 3 is to be interpreted as follows: as an example, for an electrofusion fitting or a valve with electrofusion socket made from a PE 80 compound, the joint is tested with a pipe made from PE 80 compound and the SDR maximum as declared by the manufacturer, and another joint is tested with a pipe made from PE 100 compound and the SDR minimum as declared by the manufacturer.

The fitting or valve manufacturer shall declare, according to 4.2.3.1, the SDR range and MRS values of pipes conforming to ISO 4437-2 to which the manufacturer's fittings conforming to ISO 4437-3 can be fused by using the same procedures (e.g. times, temperatures, and fusion pressures) to conform to this part of ISO 4437. If there is a need for deviation in fusion procedures, the fitting or valve manufacturer shall state this clearly.

4.2.3.2 Under extreme conditions

For electrofusion joints, the characteristics to be examined for fitness for purpose of the system under extreme conditions shall conform to Table 4.

When tested in accordance with the test methods as specified in Table 5 using the indicated parameters, the joints shall have characteristics conforming to the requirements given in Table 5.

Table 4 — Relationship between joints and fitness for purpose of the system characteristics

Electrofusion joint including socket fitting[a] (A)	Electrofusion joint including saddle fitting[a] (B)	Associated characteristics
Pipe: MRS maximum[b] SDR minimum[b] Joint: conditions 2 and 3[c]		Decohesive resistance
	Pipe: MRS maximum[b] SDR minimum[b] Joint: conditions 2.2 and 3.2[c]	Evaluation of ductility of fusion joint interface

[a] If accepted by the end-user, the minimum and maximum energy conditions 2.2 and 3.2 can be replaced by a nominal energy at a given ambient temperature T_a defined by the fitting manufacturer (see 4.3 of ISO 11413:2008).

[b] As declared by the fitting manufacturer according to 4.2.3.1.

[c] As specified in Annex C of ISO 11413:2008 with T_{min} and T_{max} as stated in the fitting manufacturer's technical specification.

The fitting or valve manufacturer shall declare according to Table 4, column(s) A or B, as applicable, the fitness for purpose of the system under extreme conditions of the fittings or valves with the type of pipe being specified.

4.2.4 Fitness for purpose of the system for mechanical joints

For fitness for purpose of the system of mechanical joints, the performance of the joints shall conform to ISO 10838-1, ISO 10838-2, or ISO 10838-3, as applicable.

NOTE The ISO 10838 series will be replaced by ISO 17885.

4.3 Conditioning

The test pieces shall be conditioned at 23 °C ± 2 °C before testing, unless otherwise specified by the applicable test method as specified in Table 5.

4.4 Requirements

The requirements for characteristics of fitness for purpose of the system are given in Table 5.

4.5 Retest in case of failure at 80 °C

A fracture in a brittle mode in less than 165 h shall constitute a failure; however, if a sample in the 165 h test fails in a ductile mode in less than 165 h, a retest shall be performed at a selected lower stress in order to achieve the minimum required time for the selected stress obtained from the line through the recommended stress/time points given in Table 6.

5 Design coefficient

The minimum value of the design coefficient, C, for pipes, fittings, and valves for the supply of gaseous fuels shall be 2, or higher values according to national legislation.

To this value, other coefficients can be applied taking into account different aspects such as:

a) operating temperature range;

b) specific material aspects, for instance, RCP;

NOTE 1 For information about RCP resistance at temperature less than 0 °C, see Annex B.

c) storage and laying conditions.

NOTE 2 For information about derating coefficients for other operating temperatures, see Annex A.

Table 5 — Characteristics for fitness for purpose of the system

Characteristic	Requirements	Test parameters			Test method
		Parameter		Value	
Hydrostatic strength (80 °C, 165 h)[d] (C)	No failure during the test period[a]	End caps		ISO 1167-1:2006, Type A	ISO 1167-1:2006 together with ISO 1167-2, or ISO 1167-4, as applicable
		Orientation		Free	
		Conditioning time		Shall conform to ISO 1167-1	
		Number of test pieces[b]		3	
		Type of test		Water-in-water	
		Circumferential (hoop) stress	PE 80	4,5 MPa	
			PE 100	5,4 MPa	
		Test period		165 h	
		Test temperature		80 °C	
Decohesive resistance[f] (A)	Length of initiation rupture ≤ $L/3$ in brittle failure[c]	Test temperature		23 °C	ISO 13954
		Number of test pieces[b]		Shall conform to ISO 13954	
		Test temperature		23 °C	ISO 13955
		Number of test pieces[b]		Shall conform to ISO 13955	
Evaluation of ductility of fusion joint interface[f g] (B)	Ld ≤ 50 % and Ad ≤ 25 %, brittle failure	Test temperature		23 °C	ISO 13956
		Number of test pieces[b]		Shall conform to ISO 13956	
Tensile strength for butt fusion[e] (C)	Test to failure: ductile: pass brittle: fail	Test temperature		23 °C	ISO 13953
		Number of test pieces[b]		Shall conform to ISO 13953	

[a] Only brittle failures shall be taken into account. If a ductile failure occurs before 165 h, the test is permitted to be repeated at a lower stress. The stress and the associated minimum test period shall be selected from Table 6 or from a line based on the stress/time points given in Table 6.

[b] The number of test pieces given indicates the number required to establish a value for the characteristic described in Table 5. 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 Reference [3].

[c] L is the nominal length of the fusion zone of the electrofusion socket fitting.

[d] Alternatively, for d_n > 450 mm, the test can also be performed in air. In case of dispute, water-in-water shall be used.

[e] Applicable to d_n 90 mm and above.

[f] Test sample can be mechanically reduced in wall thickness for testing purpose of large diameter fittings by keeping a minimum of 15 mm wall thickness of each component.

[g] Alternatively, for fittings type (B) d_n > 450 mm, this characteristic can be checked by the strip-bend test according to ISO 21751.

Table 6 — Circumferential (hoop) stress at 80 °C and associated minimum test period

PE 80		PE 100	
Stress MPa	**Minimum test time** h	**Stress** MPa	**Minimum test time** 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	—	—

Annex A
(informative)

Derating coefficients for operating temperatures

Derating factor (D_F) is a coefficient used in the calculation of the MOP, which takes into account the influence of operating temperature.

Table A.1 gives derating coefficients for various operating temperatures.

Table A.1 — Temperature derating coefficients

Temperature	Derating coefficient D_F
20 °C	1,0
30 °C	1,1
40 °C	1,3

For other temperatures between each step, linear interpolation is permitted.

The calculation of MOP for a given operating temperature is based on Formula (A.1):

$$\text{MOP} = \frac{20 \times \text{MRS}}{(\text{SDR} - 1) \times C \times D_F} \quad \text{(A.1)}$$

in which the value of the design coefficient, C, shall not be less than 2 in accordance with Clause 5.

NOTE 1 Operating temperature is defined as the average annual temperature profile of the pipe taking into account the internal and external environment.

NOTE 2 This part of ISO 4437 does not consider temperatures above 40 °C. For operation of systems at higher temperatures, see ISO 15494.[4]

Annex B
(normative)

Rapid crack propagation (RCP) resistance of pipe at temperatureless than 0 °C

Piping system intended for the distribution of gas at temperature less than 0 °C, e.g. liquid petroleum gas (LPG) systems and in use downstream of pressure reduction stations, shall be subjected to additional RCP evaluation in accordance with ISO 13477 or ISO 13478 to determine the critical pressure, p_c, at the minimum expected operating temperature (see ISO 4437[1]).

NOTE More information can be found in ISO/TS 10839.[2]

Bibliography

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

[2] ISO/TS 10839, *Polyethylene pipes and fittings for the supply of gaseous fuels — Code of practice for design, handling and installation*

[3] CEN/TS 1555-7, *Plastics piping systems for the supply of gaseous fuels — Polyethylene (PE) — Part 7: Guide for the assessment of conformity*

[4] ISO 15494, *Plastics piping systems for industrial applications — Polybutene (PB), polyethylene (PE), polyethylene of raised temperature resistance (PE-RT), crosslinked polyethylene (PE-X), polypropylene (PP) — Specifications for components and the system — Metric series*

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