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Third edition
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Plastics piping systems for the supply of gaseous fuels — Unplasticized polyamide (PA-U) piping systems with fusion jointing and mechanical jointing —

Part 3: Fittings

Systèmes de canalisations en matières plastiques pour la distribution de combustibles gazeux — Systèmes de canalisations en polyamide non plastifié (PA-U) avec assemblages par soudage et assemblages mécaniques —

Partie 3: Raccords

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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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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,* in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 155, *Plastics piping systems and ducting systems,* in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This third edition cancels and replaces the second edition (ISO 16486-3:2020), which has been technically revised.

The main changes are as follows:

— the references in the Introduction have been updated;

— a Note has been added in the Introduction for information related to the suitability of PA-U pipe systems for 100 % hydrogen and its admixtures with natural gas;

— ISO 3183 has been added to the normative references;

— in Table 3, row “315”, cut back length, the value “758” has been corrected to “75”;

— a Note has been added in 7.4 for the testing of leaktightness under pressure with air/nitrogen, appropriate for all gaseous fuels (e.g. methane and hydrogen);

— the Note in 11.3 concerning coding of traceability data has been changed and in 11.4, reference to ISO 12176-5 has been made;

— in Figure A.1, the illustration is replaced by a sketch that shows the value h_2 (= height of the active part).

A list of all parts in the ISO 16486 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

This document specifies the requirements for a piping system and its components made from unplasticized polyamide (PA-U), which is intended to be used for the supply of gaseous fuels.

NOTE 1 Additional information about the suitability of PA-U pipe systems for hydrogen and its admixtures is given in ISO 16486-1:2023, Annex D.

Requirements and test methods for material and components of the piping system, are specified in ISO 16486-1, ISO 16486-2 and ISO 16486-4.

Characteristics for fitness for purpose of the system and generic fusion parameters are covered in ISO 16486-5.

Recommended practice for installation is given in ISO 16486-6, which will not be implemented as a European Standard under the Vienna Agreement.

NOTE 2 Recommended practice for installation is also given in CEN/TS 12007-6,[3] which has been prepared by Technical Committee CEN/TC 234, *Gas infrastructure*.

Assessment of conformity of the system is covered in ISO/TS 16486-7 .

ISO 16486-1, ISO 16486-2, ISO 16486-3, ISO 16486-5, ISO 16486-6, ISO/TS 16486-7 and ISO/TS 16486-8 have been prepared by ISO/TC 138/SC 4. ISO 16486-4 has been prepared by ISO/TC 138/SC 7.

Plastics piping systems for the supply of gaseous fuels — Unplasticized polyamide (PA-U) piping systems with fusion jointing and mechanical jointing —

Part 3: Fittings

1 Scope

This document specifies the physical and mechanical properties of fittings made from unplasticized polyamide (PA-U) in accordance with ISO 16486-1, intended to be buried and used for the supply of gaseous fuels.

It also specifies the test parameters for the test methods to which it refers.

The ISO 16486 series is applicable to PA-U piping systems, the components of which are connected by fusion jointing and/or mechanical jointing.

In particular, this document lays down dimensional characteristics and requirements for the marking of fittings.

In conjunction with the other parts of the ISO 16486 series, this document is applicable to PA-U fittings, their joints, joints with components of PA-U and joints with mechanical fittings of other materials, and to the following fitting types:

— fusion fittings (electrofusion fittings and butt fusion fittings), and

— transition fittings.

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 291, *Plastics — Standard atmospheres for conditioning and testing*

ISO 307, *Plastics — Polyamides — Determination of viscosity number*

ISO 1133-2, *Plastics — Determination of the melt mass-flow rate (MFR) and melt volume-flow rate (MVR) of thermoplastics — Part 2: Method for materials sensitive to time-temperature history and/or moisture*

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

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

ISO 3183, *Petroleum and natural gas industries — Steel pipe for pipeline transportation systems*

ISO 4433-1, *Thermoplastics pipes — Resistance to liquid chemicals — Classification — Part 1: Immersion test method*

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

ISO 13950, *Plastics pipes and fittings — Automatic recognition systems for electrofusion joints*

ISO 13951, *Plastics piping systems — Test method for the resistance of plastic pipe/pipe or pipe/fitting assemblies to tensile loading*

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 13957, *Plastics pipes and fittings — Polyethylene (PE) tapping tees — Test method for impact resistance*

ISO 16486-1, *Plastics piping systems for the supply of gaseous fuels — Unplasticized polyamide (PA-U) piping systems with fusion jointing and mechanical jointing — Part 1: General*

ISO 16486-2, *Plastics piping systems for the supply of gaseous fuels — Unplasticized polyamide (PA-U) piping systems with fusion jointing and mechanical jointing — Part 2: Pipes*

ISO 16486-5, *Plastics piping systems for the supply of gaseous fuels — Unplasticized polyamide (PA-U) piping systems with fusion jointing and mechanical jointing — Part 5: Fitness for purpose of the system*

ISO 17778, *Plastics piping systems — Fittings, valves and ancillaries — Determination of gaseous flow rate/pressure drop relationships*

ISO 17885, *Plastics piping systems — Mechanical fittings for pressure piping systems — Specifications*

EN 682, *Elastomeric seals - Materials requirements for seals used in pipes and fittings carrying gas and hydrocarbon fluids*

IEC 60529, *Degrees of protection provided by enclosures (IP Code)*

API 5L, *Specification for Line Pipe*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 16486-1 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
electrofusion socket fitting
polyamide (PA-U) fitting which contains one or more integral heating elements that are capable of transforming electrical energy into heat to realize a fusion joint with a spigot end and/or a pipe

3.2
electrofusion saddle fitting
unplasticized polyamide (PA-U) fitting which contains one or more integral heating elements that are capable of transforming electrical energy into heat to realize fusion onto a pipe

3.3
tapping tee
electrofusion saddle fitting (3.2) (top loading or wraparound) which contains an integral cutter, used to cut through the wall of the main pipe, and which holds the coupon inside the cutter

Note 1 to entry: The cutter remains in the body of the saddle after installation.

3.4
spigot end fitting
unplasticized polyamide (PA-U) fitting where the outside diameter of the spigot length is equal to the nominal outside diameter, d_n, of the corresponding pipe

3.5
transition fitting
factory made fitting that makes a transition joint between an unplasticized polyamide (PA-U) piping and a metallic pipe

Note 1 to entry: The metallic parts of the fitting may be assembled to metallic pipes by screw threads, compression joints, welded or flanged connections. The fitting can allow for either a dismountable or permanently assembled joint. In some cases, the supporting ring can also act as a grip ring.

4 Material

4.1 PA-U compound

The fittings shall be made from virgin material.

The compound from which the fittings are made shall be in accordance with ISO 16486-1.

4.2 Material for non-unplasticized polyamide parts

4.2.1 General

The materials and constituent elements used in making the fitting shall be resistant to the external and internal environments in which they are intended to be used:

1) during storage;

2) under the effect of the gaseous fuels being conveyed; and

3) taking account of the service environment and operating conditions.

Fittings materials, including elastomers, greases and lubricants in contact with the PA-U pipe, shall not adversely affect pipe performance or initiate stress cracking.

In all cases, fitness for purpose of the system of the components shall be demonstrated.

4.2.2 Metal parts

All parts susceptible to corrosion shall be adequately protected.

When dissimilar metallic materials are used which can be in contact with moisture, steps shall be taken to avoid galvanic corrosion.

Metals and materials produced by corrosion shall not affect the long-term performance of the pipe/fitting.

4.2.3 Elastomers

Elastomeric materials used for the manufacture of seals shall be in accordance with EN 682.

4.2.4 Other materials

Greases or lubricants shall not exude on to the fusion areas, and shall not affect the long-term performance of the pipe/fitting.

5 General characteristics

5.1 Appearance

When viewed without magnification, the internal and external surfaces of the fitting shall be smooth, clean and free from scoring, cavities and other surface defects such as would prevent conformity of the fitting to this document.

No component of the fitting shall show any signs of damage, scratches, pitting, bubbles, blisters, inclusions or cracks to an extent that would prevent conformity of the fittings to the requirements of this document.

5.2 Design

The design of the fitting shall be such that, when assembling the fitting onto the pipe, spigot ends or other components, the electrical coils and/or seals and other functional parts (e.g. grippers) are not displaced.

5.3 Colour

The colour of fittings shall be yellow or black.

5.4 Electrical characteristics for electrofusion fittings

The electrical protection to be provided by the system depends on the voltage and the current used and on the characteristics of the electric power.

For voltages greater than 25 V, direct human contact with the energized parts shall not be possible when the fitting is in the fusion cycle during assembly in accordance with the instructions of the manufacturer of the fittings and the assembly equipment, as applicable.

This type of fitting is part of an electrical system as specified by IEC 60335-1,[4] IEC 60364-1[5] and IEC 60449.[6] Protection against direct contact with active parts (live conductors) shall be required in accordance with IEC 60529. This protection is a function of the work site conditions.

NOTE See Annex A for examples of typical electrofusion terminal connectors.

The surface finish of the terminal pins shall allow a minimum contact resistance in order to satisfy the resistance tolerance requirements (nominal value ±10 %).

5.5 Appearance of factory-made fusion joints

The following requirements apply only to joints and fittings made or assembled in the factory.

The internal and external surfaces of the pipe and fitting after fusion jointing, examined visually without magnification, shall be free from melt exudation outside the confines of the fitting apart from that which may be declared acceptable by the fitting manufacturer or used as a fusion marker.

Any melt exudation shall not cause wire movement in electrofusion fittings leading to short-circuiting when jointed in accordance with the manufacturer's instructions. There shall be no excessive creasing of the internal surfaces of the adjoining pipes.

The interface of the butt fusion joints shall be perpendicular to the pipe and/or spigot end axis.

5.6 Fusion compatibility

Components made from PA-U 11 shall be heat fusion jointed only to components made from PA-U 11.

Components made from PA-U 12 shall be heat fusion jointed only to components made from PA-U 12.

Components made from PA-U are not fusion compatible with components made from other polymers.

5.7 Appearance of transition fittings

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

No component of the fitting shall show any signs of damage, scratches, pitting, bubbles, blisters, inclusions or cracks to an extent that would prevent conformity of the fittings to the requirements of this document.

The jointing area of the PA spigot end or EF socket shall conform to the requirements as given in this document. It shall be free from melt exudation outside the confines of the fitting apart from that which may be declared acceptable by the fitting manufacturer or used as a fusion marker. When a pipe is used it shall conform to the requirements of ISO 16486-2.

The steel pipe including the welding zone shall conform to ISO 3183 or API 5L or the relevant national standard as agreed between customer and manufacturer.

The use of flange adaptors should be avoided unless there is no other solution. The suitability should be proven taking specific plastics characteristics into consideration as agreed between the involved parties and taking into consideration the regional requirements.

6 Geometrical characteristics

6.1 Measurement of dimensions

The dimensions of the fittings shall be measured in accordance with ISO 3126. In case of dispute, the measurement of dimensions shall be made not less than 24 h after manufacture and after conditioning for at least 4 h at (23 ± 2) °C.

6.2 Dimensions of electrofusion sockets

6.2.1 Diameters and lengths of electrofusion sockets

When measured in accordance with 6.1, the diameters and lengths of electrofusion sockets (see Figure 1) shall be in accordance with Table 1.

The mean inside diameter of the fitting in the middle of the fusion zone, D_1, shown in Figure 1, shall not be less than d_n. The manufacturer shall declare the actual maximum and minimum values of D_1 and L_1 for determining suitability for clamping and joint assembly.

In the case of a fitting having sockets of differing sizes, each socket shall conform to the requirements for the corresponding nominal diameter.

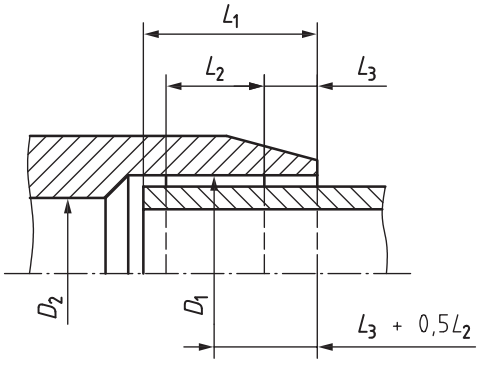
6.2.2 Wall thickness

In order to prevent stress concentrations, any changes in wall thickness of the fitting body shall be gradual.

a) The wall thickness of the body of the fitting at any point, E, shall be greater than or equal to e_{min} for the corresponding pipe at any part of the fitting located at a distance beyond a maximum of 2/3 L_1 from all entrance faces if the fitting and the corresponding pipe are made from an unplasticized polyamide having the same minimum required strength (MRS).

b) If the fitting is produced from an unplasticized polyamide having an MRS that is different from that of the corresponding pipe, the relationship between the wall thickness of the fitting, E, and the pipe, e_{min}, shall be in accordance with Table 2.

c) In the case of a wall thickness design different from that according to a), fittings and associated fusion joints shall additionally meet the performance requirements given in Table 5.



Key

D_1 mean inside diameter in fusion zone[a]

D_2 bore comprising minimum diameter of flow channel through body of fitting[b]

L_1 depth of penetration of pipe or male end of spigot fitting[c]

L_2 heated length within socket[d]

L_3 distance between mouth of fitting and start of fusion zone[e]

a D_1 is measured in a plane parallel to the plane of the mouth at a distance of $L_3 + 0{,}5L_2$.

b $D_2 \geq (d_n - 2e_{min})$.

c In the case of a coupling without a stop, it is not greater than half the total length of the fitting.

d As declared by the manufacturer to be the nominal length of the fusion zone.

e As declared by the manufacturer to be the nominal unheated entrance length of the fitting, L_3 shall be ≥5 mm.

Figure 1 — Dimensions of electrofusion sockets

Table 1 — Electrofusion socket dimensions

Dimensions in millimetres

Nominal diameter d_n	Depth of penetration		Fusion zone $L_{2,min}$
	$L_{1,min}$	$L_{1,max}$	
20	25	41	10
25	25	41	10
32	25	44	10
40	25	49	12
50	28	55	14
63	31	63	16
75	35	70	18
90	40	79	20
110	53	82	23
125	58	87	24
140	62	92	27
160	68	98	30
180	74	105	32

Table 1 *(continued)*

Nominal diameter d_n	Depth of penetration		Fusion zone $L_{2,min}$
	$L_{1,min}$	$L_{1,max}$	
200	80	112	35
225	88	120	39
250	95	129	50
280	104	139	53
315	115	150	59
335	127	164	63
400	140	179	71
450	155	195	77
500	170	212	84
560	188	235	92
630	209	255	101

Table 2 — Relationship between pipe and fitting wall thickness

Material[a]		Relationship between fitting wall thickness, E, and minimum pipe wall thickness, e_{min}
Pipe	Fitting	
PA-U 180	PA-U 160	$E \geq 1{,}12e_{min}$
PA-U 160	PA-U 180	$E \geq 0{,}9e_{min}$
[a] For material classification and designation, see ISO 16486-1:2023, 5.4.		

6.3 Dimensions of spigot end fittings

When measured in accordance with 6.1, the spigot end dimensions shall conform to the requirements given in Table 3 (see Figure 2).

The wall thickness of the fusion end, E_1, shall be at least equal to the minimum wall thickness of the pipe, except between the plane of the entrance face and a plane parallel to it, located at a distance not greater than ($0{,}01d_e$ + 1 mm), where a thickness reduction, for example, a chamfered edge, is permissible.

Table 3 — Spigot end dimensions

Dimensions in millimetres

Nominal outside diameter of spigot	Mean outside diameter of fusion end[a]		Electrofusion socket fittings			
		Grade B	Out-of-roundness	Min. bore	Cut-back length	Tubular length[b]
d_n	$D_{3,min}$	$D_{3,max}$	max.	D_2	$L_{4,min}$	$L_{5,min}$
20	20,0	20,3	0,3	13	25	41
25	25,0	25,3	0,4	18	25	41
32	32,0	32,3	0,5	25	25	44
40	40,0	40,3	0,6	31	25	49
50	50,0	50,3	0,8	39	25	55
63	63,0	63,4	0,9	49	25	63

[a] Tolerance grade B shall be in accordance with ISO 11922-1.

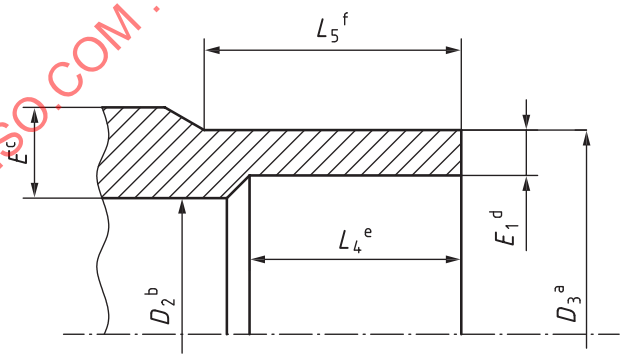
[b] For electrofusion socket fittings, the values of L_5 are as given for $L_{1,max}$ in Table 1.

Table 3 *(continued)*

Nominal outside diameter of spigot	Mean outside diameter of fusion end[a]		Electrofusion socket fittings			
		Grade B	Out-of-roundness	Min. bore	Cut-back length	Tubular length[b]
d_n	$D_{3,min}$	$D_{3,max}$	max.	D_2	$L_{4,min}$	$L_{5,min}$
75	75,0	75,5	1,2	59	25	70
90	90,0	90,6	1,4	71	28	79
110	110,0	110,6	1,7	87	32	82
125	125,0	125,8	1,9	99	35	87
140	140,0	140,9	2,1	111	38	92
160	160,0	161,0	2,4	127	42	98
180	180,0	181,1	2,7	143	46	105
200	200,0	201,2	3,0	159	50	112
225	225,0	226,4	3,4	179	55	120
250	250,0	251,5	3,8	199	60	129
280	280,0	281,7	4,2	223	75	139
315	315,0	316,9	4,8	251	75	150
355	355,0	357,2	5,4	283	75	164
400	400,0	402,4	6,0	319	75	179
450	450,0	452,7	6,8	359	100	195
500	500,0	503,0	7,5	399	100	212
560	560,0	563,4	8,4	447	100	235
630	630,0	633,8	9,5	503	100	255

[a] Tolerance grade B shall be in accordance with ISO 11922-1.

[b] For electrofusion socket fittings, the values of L_5 are as given for $L_{1,max}$ in Table 1.



Key

D_2 bore comprising minimum diameter of flow channel through body of fitting[a]

D_3 mean outside diameter of fusion end piece[b]

E body wall thickness of fitting[c]

E_1 fusion face wall thickness[d]

L_4 cut-back length of fusion end piece[e]

L_5 tubular length of fusion end piece[f]

[b] The measurement of this diameter does not include the fusion bead (if present).

[a] D_3 is measured in any plane parallel to the plane of the entrance face at a distance $L_5/2$.

[c] It comprises the thickness measured at any point of the wall of the fitting.

[d] It is measured at any point at a maximum distance of L_4 (cut-back length) from the entrance face and shall be equal to the pipe wall thickness and tolerance to which it is intended to be butt fused.

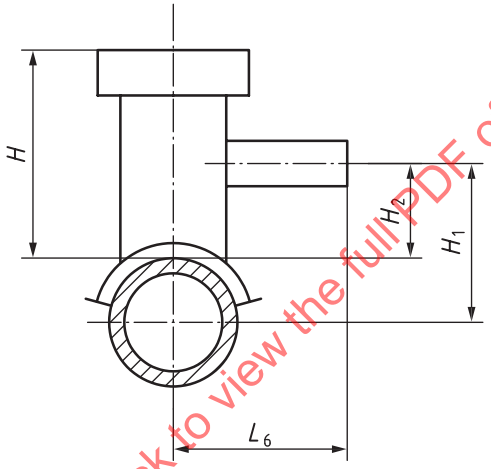
[e] It comprises the initial depth of the spigot end necessary for butt fusion or reweld and may be obtained by joining a length of pipe to the spigot end of the fitting provided the wall thickness of the pipe is equal to E_1 for its entire length.

[f] It comprises the initial length of the fusion end piece and shall allow the following (in any combination): the use of clamps required in the case of butt fusion; assembly with an electrofusion fitting.

Figure 2 — Dimensions of spigot end fittings

6.4 Dimensions of tapping tees

Outlets from tapping tees shall have spigots conforming to 6.3 or an electrofusion socket conforming to 6.2. The manufacturer shall declare the overall characteristic dimension of the fitting in the technical file. These dimensions shall include the maximum height of the saddle and the height of the service pipe measured from the top of the main, as shown in Figure 3.



Key

H height of the saddle, which comprises the distance from the top of the main pipe to the top of the tapping tee or saddle

H_1 height of service pipe, which comprises the distance from the axis of the main pipe to the axis of the service pipe

H_2 height of service pipe, which comprises the distance from the top of the main pipe to the axis of the service pipe

L_6 width of the tapping tee, which comprises the distance between the axis of the pipe and the plane of the mouth of the service tee

Figure 3 — Dimensions of tapping tees

6.5 Dimensions of transition fittings to other materials

Transition fittings shall conform to ISO 17885. Transition fittings manufactured substantially from PA-U and intended for part fusion to PA-U pipe and part mechanical jointing to other pipe components (e.g. adapters) shall in at least one joint conform to the geometrical characteristics of the PA-U jointing system to be used.

7 Mechanical characteristics

7.1 General

The fitting shall be tested as assembled with pipe or as a part of an assembly of one or more fitting(s) jointed to pipe conforming to ISO 16486-2.

Each assembly shall be prepared from components (pipes and fittings) the wall thicknesses of which shall be in accordance with 6.2.2.

7.2 Conditioning

Unless otherwise specified in the applicable test method, the test pieces shall be conditioned for at least 16 h at 23 °C and 50 % relative humidity in accordance with ISO 291 before testing in accordance with Table 4.

The test pieces shall not be tested within the period of 48 h after their manufacture.

7.3 Mechanical requirements

The test assemblies shall be tested in accordance with Table 4. When tested using the test method and parameters specified therein, the fitting/pipe assemblies shall have mechanical characteristics conforming to the requirements of Table 4.

Table 4 — Mechanical characteristics

Characteristic	Requirement	Test parameters		Test method
		Parameter	Value	
Hydrostatic strength at 20 °C for 1 000 h	No failure of any test piece during test period	End caps	Type A	ISO 1167-1 ISO 1167-4
		Orientation	Free	
		Conditioning period	16 h	
		Number of test pieces[a]	3	
		Type of test	Water-in-water	
		Test temperature	20 °C	
		Test period	1 000 h	
		Circumferential (hoop) stress[b] for:		
		PA-U 11 160 and PA-U 12 160[c]	19,0 MPa	
		PA-U 11 180 and PA-U 12 180[c]	20,0 MPa	
Hydrostatic strength at 80 °C for 165 h	No brittle failure of any test piece during test period[d]	End caps	Type A	ISO 1167-1 ISO 1167-4
		Orientation	Free	
		Conditioning period	16 h	
		Number of test pieces[a]	3	
		Type of test	Water-in-water	
		Test temperature	80 °C	
		Test period	165 h	
		Circumferential (hoop) stress[b] for:		
		PA-U 11 160 and PA-U 12 160[c]	10,0 MPa	
		PA-U 11 180 and PA-U 12 180[c]	11,5 MPa	

NOTE Components (pipes and fittings) of assemblies are of the same pressure class.

[a] The numbers of test pieces given indicate the numbers required to establish a value for the characteristic described in the table. The numbers of test pieces required for factory production control and process control should be listed in the manufacturer's quality plan.

[b] The test pressure calculation is based on the SDR of the fitting.

[c] For material classification and designation, see ISO 16486-1.

[d] If a ductile failure occurs before 165 h, the test may be repeated according to Table 5.

[e] Longest length of brittle failure in any of the test samples.

[f] 1 bar = 0,1 MPa = 10^5 Pa; 1 MPa = 1 N/mm^2

Table 4 *(continued)*

Characteristic	Requirement	Test parameters		Test method
		Parameter	Value	
Cohesive resistance for electrofusion socket fittings	Length of initiation rupture ≤ $L_2/3$ in brittle failure[e]	Test temperature Number of test pieces[a]	23 °C Shall conform to ISO 13954 and ISO 13955	ISO 13954 or ISO 13955
Evaluation of ductility of fusion joint interface for electrofusion saddle fittings	Surface of rupture L_d ≤ 50 % ≤ 25 %, brittle failure	Test temperature Number of test pieces[a]	23 °C Shall conform to ISO 13956	ISO 13956
Tensile strength for — butt fusion fittings — spigot end fittings	Test to failure: Ductile — Pass Brittle — Fail	Test temperature Number of test pieces[a]	23 °C Shall conform to ISO 13953	ISO 13953
Impact resistance of tapping tees	No failure, no leaks	Test temperature	(0 ± 2) °C	ISO 13957
		Mass of striker	(2 500 ± 20) g	
		Height	(2 000 ± 10) mm	
		Number of test pieces[a]	1	
		Conditioning period: in air in liquid	 4 h 2 h	
Pressure drop (for electrofusion saddle fittings)	Air flow rate (value indicated by the manufacturer)	Test medium Test pressure Pressure drop: for d_n ≤ 63 mm for d_n > 63 mm	Air source 25 mbar[f] 0,5 mbar[f] 0,1 mbar[f]	ISO 17778
		Number of test pieces[a]	1	

NOTE Components (pipes and fittings) of assemblies are of the same pressure class.

[a] The numbers of test pieces given indicate the numbers required to establish a value for the characteristic described in the table. The numbers of test pieces required for factory production control and process control should be listed in the manufacturer's quality plan.

[b] The test pressure calculation is based on the SDR of the fitting.

[c] For material classification and designation, see ISO 16486-1.

[d] If a ductile failure occurs before 165 h, the test may be repeated according to Table 5.

[e] Longest length of brittle failure in any of the test samples.

[f] 1 bar = 0,1 MPa = 10^5 Pa; 1 MPa = 1 N/mm^2

In case the requirements in Table 2 are not met, the fittings shall additionally conform to the requirements in Table 5.

Table 5 — Performance requirements

Characteristic	Requirement	Test parameters		Test method
		Parameter	Value	
Short-term internal pressure resistance	Failure pressure shall be greater than pressure equivalent of 2,00 × MRS calculated for thickest-walled pipe for which the fitting has been designed.	End caps	Type A	Annex B
		Orientation	Free	
		Conditioning period	16 h	
		Type of test	Water-in-water	
		Test temperature	20 °C	
		Pressure increase rate	5 bar/min	
		Minimum pressure:		
		PA-U 11 160 and PA-U 12 160[a]	64 bar[b]	
		PA-U 11 180 and PA-U 12 180[a]	72 bar[b]	
Resistance to tensile load	Fitting shall not yield before pipe or until 25 % elongation is reached.	Test temperature	23 °C	Annex C

[a] For material classification and designation, see ISO 16486-1.

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

7.4 Additional requirements for transition fittings

The additional mechanical characteristics of transition fittings shall conform to ISO 17885.

NOTE For the purpose of this document, and with reference to ISO 17885, testing of leaktightness under pressure with air/nitrogen is appropriate for all gaseous fuels (e.g. methane and hydrogen)[8].

WARNING — In general for maximum operating pressure (MOP) >4 bar, testing with water should be considered. The test conditions shall be agreed between the manufacturer and end user.

8 Physical characteristics

8.1 Conditioning

Unless otherwise specified in the applicable test method, the test pieces shall be conditioned for at least 16 h at 23 °C and 50 % relative humidity in accordance with ISO 291 before testing in accordance with Table 6.

The test pieces shall not be tested within the period of 48 h after their manufacture.

8.2 Requirements

The test pieces shall be tested in accordance with Table 6. When tested using the test method and parameters specified therein, the fittings shall have physical characteristics conforming to the requirements of Table 6.

Table 6 — Physical characteristics

Characteristic	Requirement	Test parameters		Test method(s)
		Parameter	Value	
Viscosity number	≥180 ml/g	Solvent	*m*-Cresol	ISO 307
Melt volume-flow rate (MVR)[a,b]	As recommended by the material supplier	Temperature	235 °C	ISO 1133-2
		Load	10 kg	

[a] The water content of the sample shall be <0,1 %. This is because PA-U resin is sensitive to hydrolysis. Therefore, the test sample shall be dried prior to testing at 80 °C in a dry air or vacuum dryer for 3 h, or as recommended by the PA-U resin producer. The melt volume-flow rate (MVR) report shall include the water content of the sample prior to testing with the used methodology for its determination.

[b] The MVR can be measured by the fitting manufacturer for internal quality control, as an alternative for the viscosity number, e.g. to test deviations prior to and after working with the material. In practice, the MVR is extremely sensitive to any influence of water content, even if the water content is extremely low (see ISO 1133-2:2012, Table B.1, example for PA 6). It is recommended for PA-U to compare only MVR results from one test device.

9 Chemical resistance of fittings in contact with chemicals

If, for a particular installation, it is necessary to evaluate the chemical resistance of fittings, then the method of classification specified in ISO 4433-1 shall be used.

NOTE ISO 4433-5:—[1)] is intended to cover unplasticized polyamide.

10 Performance requirements

When fittings conforming to this document are assembled to each other or to components conforming to other parts of the ISO 16486 series, the joints shall conform to the requirements given in ISO 16486-5.

11 Marking

11.1 General

All fittings shall be permanently and legibly marked in such a way that the marking does not initiate cracks or other types of failure.

Permanent markings of the fittings can be made by means of embossed stamps, laser marking or printing.

If printing is used, the colour of the printed information shall differ from the basic colour of the product. The marking shall be such that it is legible without magnification.

NOTE 1 The manufacturer is not responsible for marking that is illegible owing to actions caused during installation and use, e.g. painting, scratching, covering of components or using detergents, on the components unless agreed to or specified by the manufacturer.

There shall be no marking over the minimum spigot length of the fitting.

NOTE 2 Marking requirements on the packaging can be found in ISO 16486-6 (or CEN/TS 12007-6 for CEN member countries).

11.2 Minimum required marking of fittings

The minimum required marking shall be marked permanently and shall consist of the requirements in accordance with Table 7.

1) Under development. Stage at the time of publication: ISO/PWI 4433-5:2025.

Table 7 — Minimum required marking on fitting

Aspect	Marking
Manufacturer's identification	Name or code
Manufacturer's information	[a]
Nominal diameter/SDR	e.g. 110/SDR 11
Material and designation	e.g. PA-U 11 160[b]

[a] In clear figures or in code providing traceability to the production period within a year and month and, if the manufacturer is producing at different sites, the production site.

[b] For material classification and designation, see ISO 16486-1.

11.3 Additional information required on fitting or label

The additional information as specified in Table 8 shall be either marked on the fitting or printed on a label attached to the fitting or to its individual bag. The label shall be of sufficient quality to be intact and legible at the time of installation.

Table 8 — Additional information required on the fitting or label

Aspect	Marking
Reference to ISO 16486 series	ISO 16486
SDR fusion range	e.g. SDR 11–SDR 17
Internal fluid	Gas

NOTE Traceability data can be coded and found in line with ISO 12176-4 and ISO 12176-5.

11.4 Fusion system recognition

Fusion fittings shall have a system, either numerical, electromechanical or self-regulatory, as described in ISO 13950, for recognizing the fusion parameters to facilitate the fusion process.

When automatic recognitions systems for electrofusion fittings are used, they shall be in accordance with ISO 13950.

NOTE 1 ISO 12176-5 specifies a two-dimensional QR code which will also enable the recognition of the fusion parameters.

NOTE 2 Traceability data can be coded and found in line with ISO 12176-4 and ISO 12176-5.

12 Delivery conditions

The fittings shall be packaged in bulk or individually protected where necessary in order to prevent deterioration. Whenever possible, they shall be placed in individual bags, in cardboard boxes or cartons.

Constituents of fitting packaging shall not create contamination which can prevent normal jointing.

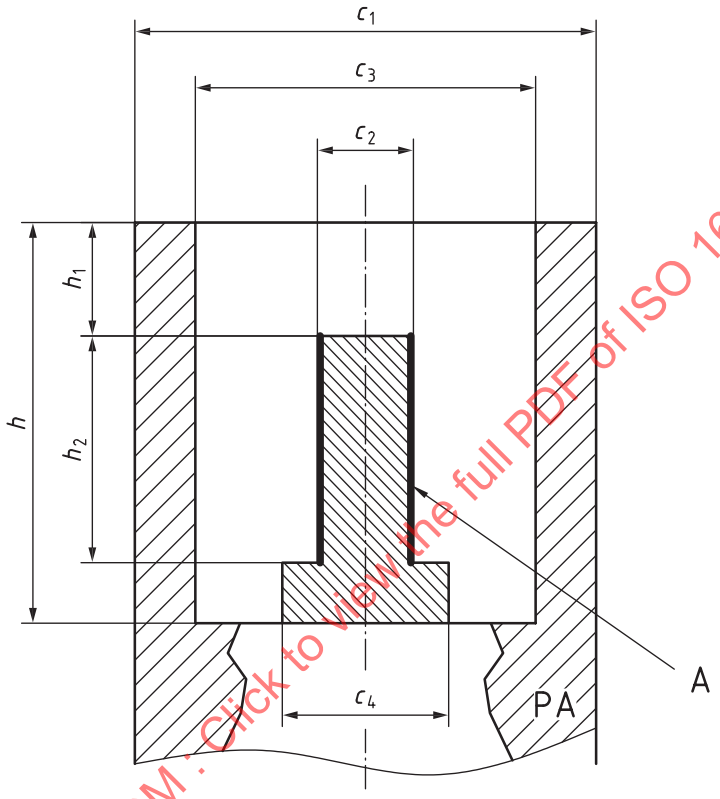
The cartons and/or individual bags shall bear at least one label with the manufacturer's name, type and dimensions of the part, number of units in the box, and any special storage conditions and any storage time limits.

Fittings should be stored in their original packing, until ready for installation.

Annex A
(informative)

Examples of typical terminal connections for electrofusion

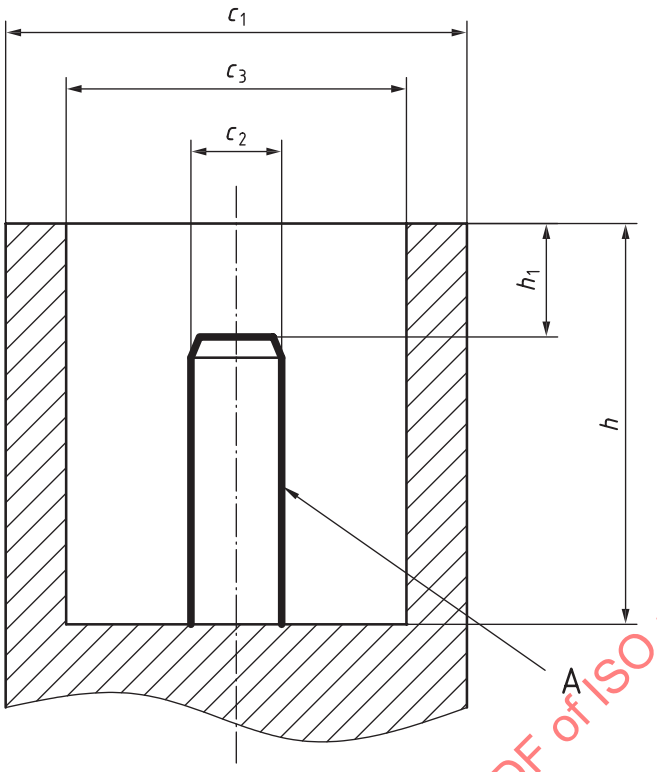
Figures A.1 and A.2 illustrate examples of terminal connections suitable for use with voltages less than or equal to 48 V (types A and B).



Key

A	active zone	
c_1	outside diameter of the terminal shroud	c_1 = ≥ 11,8 mm
c_2	diameter of active part of the terminal	c_2 = 4,00 mm ± 0,1 mm
c_3	internal diameter of the terminal shroud	c_3 = 9,5 ± 1,0 mm
c_4	maximum overall diameter of the base of the active part	c_4 = ≤ 6,0 mm
h	internal depth of the terminal shroud	h ≥ 12,0 mm
h_1	distance between the upper part of the terminal shroud and the active part	h_1 = (3,2 mm ± 0,5) mm
h_2	height of the active part	$h_2 \leq h - h_1$

Figure A.1 — Typical type A connection



Key

A	active zone	
c_1	outside diameter of the terminal shroud	c_1 = 13,00 ± 0,5 mm
c_2	diameter of the active part of the terminal	c_2 = 4,70 ± 0,1 mm
c_3	internal diameter of the terminal shroud	c_3 = 10,0 − 0,1/+0,5 mm
h	internal depth of the terminal shroud	$h \geq$ 15,5 mm
h_1	distance between the upper part of the terminal shroud and the active part	h_1 = 4,5 ± 0,5 mm

Figure A.2 — Typical type B connection