
**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**

*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 5: Aptitude à l'emploi du système



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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 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).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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 second edition cancels and replaces the first edition (ISO 16486-5:2012), which has been technically revised.

The main changes compared to the previous edition are as follows:

- for transition fittings, reference is made to ISO 17885;
- new [Clause 5](#), Design Coefficient, has been added;
- [Annex A](#) refers to ISO 11414 for test piece assemblies by butt fusion and has been brought in line with ISO 12176-1 for butt fusion equipment.
- [Annex A](#) has been brought in line with ISO 21307, with a definition of PA fusion parameters for the single low-pressure and the single high-pressure butt fusion jointing procedures (the dual low-pressure procedure is not investigated for PA-U so far);
- in [Table A.2](#) for the single low-pressure butt fusion procedure, the pressure, p_1 , has been changed from $(0,3 \pm 0,1)$ MPa to $(0,3 \pm 0,05)$ MPa to raise the minimum pressure from 0,2 MPa to 0,25 MPa;
- [Annex B](#) refers to ISO 11413 for test piece assemblies by electro fusion and to ISO 12176-2 for electro fusion equipment;
- Annex C of ISO 16486-5:2012, Assessment of fitness for purpose of transition fittings, has been deleted;
- new [Annex C](#), Derating coefficients for operating temperatures, has been transferred from ISO 16486-6;

- new [Annex D](#), Rapid crack propagation (RCP) resistance of pipe at temperature less than 0 °C, has been added.

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.

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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.

Requirements and test methods for material and components of the piping system are specified in ISO 16486-1, ISO 16486-2, ISO 16486-3, and ISO 16486-4.

This document covers the characteristics for fitness for purpose of the system.

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

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

Assessment of conformity of the system is to form the subject the future ISO/TS 16486-7¹⁾.

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1) Under preparation. Stage at the time of publication: ISO/AWI TS 16486-7:2021.

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

1 Scope

This document specifies the requirements of fitness for purpose of unplasticized polyamide (PA-U) piping system, intended to be buried and used for the supply of gaseous fuels. It also specifies the definitions of electrofusion and butt fusion joints.

This document 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 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 conjunction with the other parts of ISO 16486, it is applicable to PA-U fittings, their joints and to joints with components of PA-U.

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 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 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 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 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 16486-3, *Plastics piping systems for the supply of gaseous fuels — Unplasticized polyamide (PA-U) piping systems with fusion jointing and mechanical jointing — Part 3: Fittings*

ISO 16486-6, *Plastics piping systems for the supply of gaseous fuels — Unplasticized polyamide (PA-U) piping systems with fusion jointing and mechanical jointing — Part 6: Code of practice for design, handling and installation*

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

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 terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

3.1 electrofusion joint

joint between a PA-U electrofusion socket or saddle fitting and a pipe or a spigot end fitting

Note 1 to entry: The electrofusion fittings are heated 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.

3.2 butt fusion joint

joint made by heating the planed ends of matching surfaces by holding them against a flat heating plate until the PA-U material reaches fusion temperature, quickly removing the heating plate and pushing the two softened ends against one another

Note 1 to entry: This definition refers to a butt fusion joint using a heating tool.

3.3 fusion compatibility

ability of two unplasticized polyamide materials of the same type to be fused together to form a joint which conforms to the performance requirements of this part of ISO 16486

3.4 transition fitting

factory-made fitting that makes a *transition joint* (3.5) between a unplasticized polyamide (PA-U) piping and a metallic pipe as described in ISO 16486-3

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 may also act as a grip ring.

3.5 transition joint

joint at which two different piping materials (the PA-U and metal piping) are connected

4 Symbols

A_d	brittle decohesion area in percentage as calculated in ISO 13956
B	bead width
e_n	nominal pipe wall thickness
e_s	scraping depth
C	design coefficient
D_F	derating coefficient
D_n	nominal external diameter of the pipe
p	pressure applied to the butt-fusion joint interface
t	duration of each phase in the fusion cycle
T_{nor}	normal permissible ambient temperature
T_{max}	maximum permissible ambient temperature
T_{min}	minimum permissible ambient temperature
T_a	ambient temperature at which the joint is made

NOTE 1 The ambient temperature is permitted to vary from the minimum temperature, T_{min} , to the maximum temperature, T_{max} , as defined by agreement between the manufacturer and the purchaser.

L_d	brittle decohesion length in percentage as calculated in ISO 13956
L_2	heated length within socket (see ISO 16486-3)

NOTE 2 As declared by the manufacturer to be the nominal length of the fusion zone, see ISO 16486-3.

5 Fitness for purpose

5.1 Method of preparation of assemblies for testing

5.1.1 General

The joints shall be made by using pipes conforming to ISO 16486-2 and/or fittings conforming to ISO 16486-3.

Test pieces for pressure test 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.

5.1.2 Butt fusion joints

PA-U pipes and spigot end fittings intended to be used for jointing by butt fusion shall be prepared and assembled in accordance with [Annex A](#).

5.1.3 Electrofusion jointing

PA-U pipes and fittings intended to be used for jointing by electrofusion shall be prepared and assembled in accordance with [Annex B](#).

For joints with electrofusion socket fittings and joints with electrofusion saddle fittings, test joints shall be prepared to check the fitness for purpose of the fittings under extreme jointing 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.

These joints with electrofusion saddle fitting should be prepared taking national safety regulations into consideration. For straight equal electrofusion socket fittings with the same size (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 $1,5^\circ$.

5.1.4 Transition fittings

For transition fittings, the assembly of PA pipe and fitting shall be prepared in accordance with ISO 17885, as applicable.

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.

5.2 Requirements for fitness for purpose

5.2.1 Fitness for purpose for butt fusion joints

5.2.1.1 Under normal conditions — ambient temperature 23 °C

For the assessment of fitness for purpose under normal conditions, butt fusion joints shall have the characteristic of tensile strength conforming to the requirements given in [Table 5](#), using the parameters as specified in [Table A.2](#) and [Table A.3](#), at an ambient temperature of $(23 \pm 2)^\circ\text{C}$, and the scheme listed in [Table 1](#).

Table 1 — Scheme for butt fusion joints

Pipe/spigot end fitting	Pipe			
	PA-U 11 160	PA-U 11 180	PA-U 12 160	PA-U 12 180
PA-U 11 160	X	X ^a	Jointing not allowed	Jointing not allowed
PA-U 11 180	X ^a	X	Jointing not allowed	Jointing not allowed
PA-U 12 160	Jointing not allowed	Jointing not allowed	X	X ^a
PA-U 12 180	Jointing not allowed	Jointing not allowed	X ^a	X

NOTE Interpret the table as follows: as an example, for a pipe or a spigot end fitting made from a PA-U 11 160 compound, test a joint with a pipe made from PA-U 11 160 compound. When requested by the purchaser or end-user, for mixed compound joints, use test pieces incorporating PA-U 11 160 and PA-U 11 180 compounds.

^a Only when requested by the purchaser or end-user.

The pipe manufacturer shall declare, according to [5.2.1.1](#), which pipes from their own product range conforming to ISO 16486-2 are compatible to each other for butt fusion (see [3.3](#), fusion compatibility).

The fitting manufacturer shall declare, according to [5.2.1.1](#), the SDR range and MRS values of pipes conforming to ISO 16486-2 to which their fittings conforming to ISO 16486-3 can be fused by using the same procedures (e.g. times, temperatures, fusion pressures), to conform to this part of ISO 16486. If there is a need for deviation in fusion procedures, the fitting manufacturer shall state this clearly.

5.2.1.2 Under extreme conditions

For butt fusion joints, the characteristics to be examined for fitness for purpose under extreme conditions shall conform to [Table 2](#).

Table 2 — Relation between the joints and fitness for purpose 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)
Both components of the joint: same MRS and same SDR ^a Joint: minimum and maximum condition ^a	Tensile strength for butt fusion joint

^a In accordance with ISO 11414:2009, Clause 7, item a), concerning misalignment and the limit values of fusion parameters according to [Table A.3](#) for single low-pressure process and to [Table A.4](#) for single high-pressure process.

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

The fitting manufacturer shall declare, according to [Table 2](#) as applicable, the fitness for purpose under extreme conditions of their fittings.

The pipe manufacturer shall declare, according to [Table 2](#), the fitness for purpose under extreme conditions of their pipes.

5.2.2 Fitness for purpose for electrofusion joints

5.2.2.1 Under normal conditions — Ambient temperature 23 °C

For the assessment of fitness for purpose under normal conditions, electrofusion joints shall have the characteristic of decohesive resistance or cohesive strength, as applicable, conforming to the requirements given in [Table 5](#), using the assembly condition 1 as specified in [Table A.3](#), at an ambient temperature of (23 ± 2) °C, and the scheme listed in [Table 3](#).

Table 3 — Scheme for electrofusion joints

Electrofusion fitting with electrofusion socket	Pipe			
	PA-U 11 160 SDR maximum	PA-U 11 180 SDR minimum	PA-U 12 160 SDR maximum	PA-U 12 180 SDR minimum
PA-U 11 160	X	X ^a	Jointing not allowed	Jointing not allowed
PA-U 11 180	X ^a	X	Jointing not allowed	Jointing not allowed
PA-U 12 160	Jointing not allowed	Jointing not allowed	X	X ^a
PA-U 12 180	Jointing not allowed	Jointing not allowed	X ^a	X

NOTE Interpret the table as follows: as an example, for an electrofusion fitting made from a PA-U 11 160 compound, test a joint with a pipe made from PA-U 11 160 compound and a SDR maximum and test another joint with a pipe made from PA-U 11 180 compound and a SDR minimum.

^a Only when requested by the purchaser or end-user.

The fitting manufacturer shall declare, according to [5.2.2.1](#), the SDR range and MRS values of pipes conforming to ISO 16486-2 to which their fittings conforming to ISO 16486-3 can be fused by using the same procedures (e.g. times, temperatures, fusion pressures) to conform to this part of ISO 16486. If there is a need for deviation in fusion procedures the fitting manufacturer shall state this clearly.

5.2.2.2 Under extreme conditions

For electrofusion joints the characteristics to be examined for fitness for purpose 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 — Relation between the joints and fitness for purpose characteristics

Electrofusion joint with socket fitting ^a	Electrofusion joint with saddle fitting ^a	Associated characteristic
Pipe: MRS maximum ^b SDR minimum ^b Joint: conditions 2.2 and 3.2 of Table B.3 ^c		Decohesive resistance
	Pipe: MRS maximum ^b SDR minimum ^b Joint: conditions 2.2 and 3.2, of Table B.3 ^c	Cohesive strength

^a If accepted by the purchaser, the minimum and maximum energy conditions 2.2 and 3.2 may be replaced by a nominal energy at a given ambient temperature, T_a , defined by the fitting manufacturer (same conditions as presented in ISO 11413:2019, 4.3 for PE).

^b As declared by the fitting manufacturer according to [5.2.2.1](#).

^c Conditions 2.2 and 3.2 as specified in ISO 11413:2019, Table C.1, with T_{min} and T_{max} as stated in the fitting manufacturer's technical specification.

The fitting manufacturer shall declare the fitness for purpose under extreme conditions of their fittings according to [Table 4](#).

Table 5 — Characteristics for fitness for purpose of the system

Characteristic	Requirements	Test parameters	Value	Test method
Hydrostatic strength (80 °C, 165 h)	No failure during the test period of any test piece	End caps	Type A	ISO 1167-1
		Orientation	Free	ISO 1167-4
		Conditioning time	16 hrs	
		Type of test	Water-in-water	
		Circumferential (hoop) stress:		
		PA-U 11 160 and PA-U 12 160	10,0 MPa	
		PA-U 11 180 and PA-U 12 180	11,5 MPa	
		Test period	165 h	
		Test temperature	80 °C	
Cohesive resistance for electrofusion socket fittings	Length of initiation rupture $\leq L_2/3$ in brittle failure	Test temperature	23 °C	ISO 13954 or ISO 13955
Evaluation of ductility of fusion joint interface for electrofusion saddle fittings	Surface of rupture $L_d \leq 50\%$ $A_d \leq 25\%$, brittle failure	Test temperature	23 °C	ISO 13956

Table 5 (continued)

Characteristic	Requirements	Test parameters	Value	Test method
Tensile strength for: — butt fusion fittings — spigot end fittings	Test to failure: — ductile: pass — brittle: fail	Test temperature	23 °C	ISO 13953

5.2.3 Fitness for purpose for transition fittings

The following tests shall be carried out in accordance with ISO 17885:

- leaktightness test, leaktightness with temperature cycling test,
- leaktightness after tensile pull test, and
- leaktightness after constant tensile load (CTL) joint test.

6 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 shall be applied, taking into account different aspects if applicable, such as:

- a) operating temperature range;
- b) specific material aspects, for instance Rapid Crack Propagation (RCP). RCP resistance at temperatures less than 0 °C is given in [Annex D](#);
- c) storage and laying conditions.

NOTE 1 For information about derating coefficients for other operating temperatures, see [Annex C](#).

NOTE 2 The equation for the determination of the maximum operation pressure (MOP) based on the critical pressure from Rapid Crack Propagation (RCP) testing as included ISO 16486-1 does not include a design coefficient.

Annex A (normative)

Preparation of test assemblies by butt fusion

A.1 General

This annex is in line with ISO 11414 for PE and specifies a method for preparing butt fusion jointed test piece assemblies between PA-U pipes and between PA-U pipes and spigot-ended fittings.

A.2 Pipes used for test assemblies

The pipes used for test assemblies shall be taken from straight lengths.

A.3 Conditioning

Pipes and fittings of PA-U parts to be assembled shall be conditioned under the ambient temperatures of [Tables A.3](#) and [A.4](#) for periods following ISO 11414 for PE prior to assembly.

A.4 Apparatus

Conventional butt fusion equipment as defined for welding of Polyethylene (PE) pipes by ISO 12176-1 can be used for welding of PA-U pipes. In case of single high-pressure fusion process according to [A.6.2](#), the suitability for the high-pressure level shall be validated.

NOTE With rising pipe interfacial pressure, the demand on the mechanical strength of the equipment design increases. Corresponding heavy welding equipment is known for general use in North America for BF of PE.

The butt fusion machine used shall be fitted with an automatic fusion-pressure controller enabling the pressure to be kept constant during the whole of Phases 1, 2 and 5 of the fusion cycle, as described in [Table A.1](#) and ISO 11414:2009, Figure A.1.

A.5 Jointing procedure

ISO 21307 specifies three butt fusion jointing procedures for PE pipes and fittings, which differ in equipment, cycle and parameters.

These are:

- a) single low-pressure fusion jointing procedure (most common outside the USA and UK);
- b) dual low-pressure fusion jointing procedure (with focus on the UK; not developed for PA);
- c) single high-pressure fusion jointing procedure (used in the USA and common for related regions).

The single low- and high-pressure fusion jointing procedures can be applied for fusion jointing PA-U in line with ISO 21307. The fusion jointing parameters for PA-U for the single low- and high-pressure fusion jointing procedures are given in [A.6.1](#) and [A.6.2](#). For PA-U, there is so far no experience with dual low-pressure fusion jointing, and therefore there are no fusion parameters available in this document.

A.6 Butt fusion equipment, cycle and parameters

A.6.1 Single low-pressure butt fusion jointing procedure

The reference values for the fusion jointing parameters in each phase applicable to fusion jointing of PA-U are given in [Tables A.1](#) and [A.2](#).

Table A.1 — Single low-pressure butt fusion cycle and parameters

Parameters		Values	Units
Heater-plate temperature, T		245 ± 20	°C
Phase 1	Pressure, p_1^a	$0,3 \pm 0,05$	MPa
	Time, t_1	Measured as the time until B_1 is reached	s
	Bead width, B_1	See Table A.2	mm
Phase 2	Pressure, p_2^a	$0,03 \pm 0,02$	MPa
	Time, t_2	See Table A.2	s
Phase 3	Time, t_3	See Table A.2	s
Phase 4	Time, t_4	See Table A.2	s
Phase 5	Pressure, p_5^a	$0,3 \pm 0,1$	MPa
	Time, t_5	See Table A.2	min
Phase 6	Time, t_6	Minimum value: $1,5 e_n$	min
		Maximum value: 20	min

^a This pressure is the interface pressure and is related to $d_n e_n$ and the butt fusion equipment used.

Table A.2 — Wall thickness dependant butt fusion parameters^a

Wall thickness e_n mm	B_1 mm	t_2 s	t_3 s	t_4 s	t_5 min
$\leq 4,5$	0,5	45	5	5	6
$4,5 < e_n \leq 7$	1,0	45 to 70	5 to 6	5 to 6	6 to 10
$7 < e_n \leq 12$	1,5	70 to 120	6 to 8	6 to 8	10 to 16
$12 < e_n \leq 19$	2,0	120 to 190	8 to 10	8 to 11	16 to 24
$19 < e_n \leq 26$	2,5	190 to 260	10 to 12	11 to 14	24 to 32
$26 < e_n \leq 37$	3,0	260 to 370	12 to 16	14 to 19	32 to 45

^a If other parameters are considered, they shall be agreed between the pipe/fitting manufacturer and the end-user.

[Table A.2](#) gives the limits placed on the values of the parameters used in evaluating the jointing procedure.

Table A.3 — Limits on values of single-low-pressure butt fusion parameters for extreme conditions^a

Set of conditions	Conditions	Ambient temperature ^b		Heater plate temperature, T °C	Butt fusion pressure, p N/mm ²
		Symbol	Value, °C		
1	Normal	T_{nor}	23 ± 2	245 ± 5	$0,30 \pm 0,02$
2	Minimum	T_{min}	-5 ± 2	230 ± 5	$0,26 \pm 0,02$
3	Maximum	T_{max}	40 ± 2	260 ± 5	$0,34 \pm 0,02$

^a If other parameters are considered, they shall be agreed between the pipe/fitting manufacturer and the end-user.
^b Other values may be used if specified in the appropriate system standard.

A.6.2 Single-high pressure fusion jointing procedure

ISO 21307 defines the butt fusion parameters for PA-U 11 and PA-U 12 as used in [Table A.4](#). Parameters for PA-U 11 are in line with ASTM F 2945^[5] referencing to PPI TR-45^[6]. Parameters for PA-U 12 are in line with ASTM F 2785^[7], ASTM F 3372^[8] and PPI TR-50^[9].

Table A.4 — Limits on values of single high-pressure butt fusion parameters^a

Set of conditions	Conditions	Ambient temperature ^b		Heater plate temperature, T °C	Butt fusion pressure, p N/mm ²
		Symbol	Value, °C		
1	Normal	T_{nor}	23 ± 2	245 ± 5	$0,50 \pm 0,02$
2	Minimum	T_{min}	-5 ± 2	230 ± 5	$0,45 \pm 0,02$
3	Maximum	T_{max}	40 ± 2	260 ± 5	$0,55 \pm 0,02$

^a If other parameters are considered, they shall be agreed between the pipe/fitting manufacturer and the end-user.

^b Other values may be used if specified in the appropriate system standard.

Annex B (normative)

Preparation of test assemblies by electrofusion

B.1 General

This annex is in line with ISO 11413 for PE and specifies a method for the preparation of test pieces assembled from PA-U pipes or spigot-ended fittings and electrofusion fittings.

For PA-U deviations from or clarifications related to ISO 11413 as well as energy, voltage and current tolerances for electrofusion process are shown in this annex.

B.2 Symbols and clearances

For PA-U general symbols as well as such for clearances (socket fittings and saddles) and ambient temperature, refer to ISO 11413.

B.3 Joint assembly

B.3.1 General

The joints shall be made using pipes and/or spigot-ended fittings conforming to ISO 16486-2 and ISO 16486-3, as applicable, and electrofusion fittings for which the dimensions conform to ISO 16486-3. The preparation of the assembly for testing shall be carried out in accordance with the electrofusion fitting manufacturer's written procedures.

Unless a greater scraping depth is recommended by the manufacturer, the scraping depth, e_s , should be $0,1 \text{ mm} \pm 0,05 \text{ mm}$. For cleaning purposes, a minimum scraping depth of $0,1 \text{ mm}$ shall be guaranteed.

B.3.2 Procedure

For PA-U, the procedure as described by ISO 11413 for PE applies.

Proceed to the tests as given in this document.

B.3.3 Conditions for the preparation of pipes and fittings

For PA-U, the conditions as described by ISO 11413:2019, Annex C for PE apply.

B.3.4 Representation of variation in fusion energy with ambient temperature

For PA-U, the variation in fusion energy as described by ISO 11413:2019, Annex B for PE applies.