
**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**

*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 6: Code de pratique pour la conception, la manutention et
l'installation*



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Foreword

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

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

ISO draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). ISO takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, ISO had not received notice of (a) patent(s) which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at www.iso.org/patents. ISO shall not be held responsible for identifying any or all such patent rights.

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 138, *Plastics pipes, fittings and valves for the transport of fluids*, Subcommittee SC 4, *Plastics pipes and fittings for the supply of gaseous fuels*.

This second edition cancels and replaces the first edition (ISO 16486-6:2012), which has been technically revised.

The main changes are as follows:

- the structure of the document has been modified in order to generally align with the structure of ISO/TS 10839:2022;
- the normative references have been updated;
- a new [subclause 4.1.2](#) has been added, concerning regional requirements and with reference to a new [Annex F](#), also about regional requirements for CEN member countries;
- [subclause 4.3](#) has been subdivided into three further subclauses: general, MOP(LTHS) and MOP(p_c);
- a more detailed definition of MOP(p_c) has been included in [subclause 4.3.3](#) for temperatures below zero;
- a reference to [Annex G](#) has been added to [subclause 4.5](#);
- information from [subclause 5.3](#) for jointing procedures has been moved to the new [Annexes B, C and D](#);
- in [subclause 5.4.1](#), the former drag force formula for PE with fixed limiting stress ($F = 14 \text{ N}$) has been opened for PA-U;
- a new [subclause 5.4.7](#) for non-conventional installation has been added;

- for visual inspection of butt fusion joints, [subclause 6.3.2.2.1](#) shows figures with the typical single bead shape, which replaces the previous double bead;
- a new informative [Annex G](#) has been added concerning the fitness of PA-U piping systems for non-conventional installation techniques;
- the Bibliography has been updated.

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), and 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.

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 this document, which will not be implemented as a European Standard under the Vienna Agreement.

Assessment of conformity of the system is to form the subject of ISO/TS 16486-7.

Training and assessment of fusion operators is covered by ISO/TS 16486-8.

NOTE 1 For CEN member countries, the recommended practice for installation is given in CEN/TS 12007-6^[3] and the qualification of welders is given by EN 13067^[4].

NOTE 2 A list of imperial ASTM or PPI standards related to polyamide pipes and fittings for the supply of gas is given in References ^[5], ^[6], ^[7], ^[8], ^[9], ^[10] and ^[11].

NOTE 3 ISO 16486-1, ISO 16486-2, ISO 16486-3, ISO 16486-5 and ISO 16486-6 (this document) as well as 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.

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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 6: Code of practice for design, handling and installation

1 Scope

This document specifies a code of practice dealing with unplasticized polyamide (PA-U) pipes and fittings for buried pipeline systems outside buildings and designed to transport gaseous fuels (as defined in ISO 16486-1, e.g. methane, LPG, manufactured gas and hydrogen) within the temperature range $-20\text{ }^{\circ}\text{C}$ to $+40\text{ }^{\circ}\text{C}$. This document also gives appropriate temperature-related requirements.

The code of practice covers mains and service lines whose components are prepared for fusion or mechanical jointing and gives instructions for the design, storage, handling, transportation, laying conditions and fusion quality control of PA-U pipes and fittings as well as subsequent joint testing, backfilling, pipe system testing and commissioning.

NOTE Principal information for rehabilitation can be found in ISO 11295 for classification, ISO 11299-1 and ISO 11299-2 for renovation, and ISO 21225-1 and ISO 21225-2 for trenchless replacement.

More detailed national standards or codes of practice can exist. This document is intended to be applied in association with such national standards or codes of practice related to the above-mentioned basic principles.

The jointing methods covered by this document are:

- butt fusion jointing (see [Annex A](#));
- electrofusion jointing (see [Annex B](#)) and
- mechanical jointing (see [Annex C](#)).

In the case of ground movement or shaking (e.g. earthquakes, etc.) precautions mentioned in this document can need to be implemented following guidelines provided by authorities (e.g. EN 1998-4^[17], EN 12007-1:2012, Annex A^[18] etc.).

Workers' health and safety issues are outside the scope of this document

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 12176-1, *Plastics pipes and fittings — Equipment for fusion jointing polyethylene systems — Part 1: Butt fusion*

ISO 12176-2, *Plastics pipes and fittings — Equipment for fusion jointing polyethylene systems — Part 2: Electrofusion*

ISO 12176-3, *Plastics pipes and fittings — Equipment for fusion jointing polyethylene systems — Part 3: Operator's badge*

ISO 12176-4, *Plastics pipes and fittings — Equipment for fusion jointing polyethylene systems — Part 4: Traceability coding*

ISO 12176-5, *Plastics pipes and fittings — Equipment for fusion jointing polyethylene systems — Part 5: Two-dimensional data coding of components and data exchange format for PE piping systems*

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

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 16486-2:2020, *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 16486-4, *Plastics piping systems for the supply of gaseous fuels — Unplasticized polyamide (PA-U) piping systems with fusion jointing and mechanical jointing — Part 4: Valves*

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 17885:2021, *Plastics piping systems — Mechanical fittings for pressure piping systems — Specifications*

EN 12327, *Gas supply systems — Pressure testing, commissioning and decommissioning procedures — Functional requirements*

3 Terms, definitions and abbreviated terms

For the purposes of this document, the terms and definitions given in ISO 16486-1, ISO 16486-5 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

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

3.1 Terms and definitions

3.1.1

butt fusion machine pressure

pressure indicated on the gauge or on a pressure display on a butt fusion machine, giving an indication of the interface force applied to the pipe and/or fitting ends

3.1.2

clearance

shortest distance between the outer limits of two objects

3.1.3

drag resistance

frictional resistance due to the weight of the length of pipe fixed in the moveable clamp at the point at which movement of the moveable clamp is initiated (peak drag), or the friction occurring during movement (dynamic drag)

3.1.4**electrofusion control unit**

equipment implementing the output fusion parameters of voltage or current and time or energy to execute the fusion cycle as specified by the electrofusion fitting manufacturer

3.1.5**frictional losses in the butt fusion machine**

force necessary to overcome friction in the whole mechanism of a butt fusion machine

3.1.6**fusion operator**

person trained to carry out fusion jointing between unplasticized polyamide (PA-U) pipes and/or fittings

Note 1 to entry: Fusion jointing is based on a written procedure agreed by the pipeline operator.

Note 2 to entry: The fusion operator is trained for one or more fusion-jointing procedures.

3.1.7**interface force**

force between the fusion surfaces of the pipe(s) and/or fitting(s) during the fusion cycle, as specified in the fusion diagram

3.1.8**operator**

person authorized to build PA-U systems from pipes and/or fittings, based on a written procedure agreed by the pipeline operator

3.1.9**overall service (design) coefficient**

C

overall coefficient, with a value greater than 1, which takes into consideration service conditions as well as properties of the components of a piping system

3.1.10**pipeline operator**

private or public organization authorized to design, construct or operate and maintain a gas supply system

3.1.11**soil cover**

vertical distance between the top of a buried pipe and the normal surface after finishing work (e.g. including pavement)

3.2 Symbols and abbreviated terms

B	bead width
B_m	mean bead width
B_{max}	maximum bead width
B_{min}	minimum bead width
C	overall service (design) coefficient
d_e	external diameter of pipe or spigot fitting at any point
D_F	temperature derating coefficient

e_n	nominal wall thickness of pipe or fitting
F	maximum drag force, in newtons
f_s	is the safety factor
MOP	maximum operating pressure
MRS	minimum required strength
p_C	full-scale critical pressure determined in accordance with ISO 13478 at zero degrees Celsius
$p_{C,S4}$	small scale critical pressure determined in accordance with ISO 13477 at zero degrees Celsius
$p_{C,S4,REF}$	reference value of $p_{C,S4}$ to be referred to in the requirement of the S4 test specified in ISO 16486-2:2020, Table 4, footnote c.
RCP	rapid crack propagation
SDR	standard dimension ratio
T_{bz}	temperature below zero degrees Celsius
V	misalignment
σ	maximum tensile stress in MPa
σ_y	tensile stress at yield in MPa

4 Design

4.1 General and regional requirements

4.1.1 General

A written laying procedure, authorized by the pipeline operator, shall be made available prior to the construction of a pipeline. The laying procedure shall include specification of the jointing procedure (butt or electrofusion or mechanical), the pipe and fitting materials to be used, the trenching and backfilling requirements, the pressure testing and commissioning requirements, and the data to be collected for the traceability system.

The selection of materials, standard dimension ratio (SDR) series, dimensions and assembling techniques shall be the responsibility of the pipeline operator.

There are two SDR series in common use for gas supply systems: SDR 13.6 and SDR 11. Other SDR series can also be used, such as SDR 26 for renovation.

The training and the level of skill of the operator(s) shall be in accordance with the requirements of the jointing procedures.

General guidelines for supervision and quality control are given in [Clause 6](#).

4.1.2 Regional requirements

For CEN member countries, this document is substituted by CEN/TS 12007-6^[3], where the MOP is limited to up and to including 16 bar¹⁾ for the whole piping system with all components. CEN/TS 12007-6^[3] references several functional standards prepared by CEN/TC 234. More detailed information about regional requirements for CEN member countries is given in [Annex F](#).

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

In addition to CEN member countries, there are also other regions for which this document is not suitable. These other regions follow individual solutions.

EXAMPLE India, Egypt, Indonesia and some other countries besides the US and Canada follow North American ASME B 31.8^[19] while using the ISO 16486 series as the product standard.

4.2 Materials, components and jointing equipment

The PA-U materials and components used shall conform to the relevant ISO International Standards: the ISO 16486 series and ISO 17885. Other components not covered by the ISO 16486 series or ISO 17885 shall conform to relevant standards or in the absence of such documents, the components shall meet the performance requirements of the system as demonstrated by the manufacturer.

As specified by ISO 16486-5, the fusion equipment used for the construction of the pipeline shall conform to the requirements of ISO 12176-1 or ISO 12176-2. If the operation of the fusion equipment requires an operator's badge, the badge shall conform to ISO 12176-3. Traceability of PA-U materials should refer to ISO 12176-4 and/or ISO 12176-5.

4.3 Maximum operating pressure

4.3.1 General

The maximum operating pressure (MOP) of the system shall be selected by the pipeline operator on the basis of the gas supply system operating requirements and the materials used. The MOP of a PA-U system depends upon the type of resin used (the MRS), the pipe SDR series and the service conditions. It is limited by the overall service (design) coefficient, C , and the rapid crack propagation (RCP) criteria.

The MOP is the lower value when calculated using [Formula \(1\)](#) and [Formula \(2\)](#) with the critical pressure calculated from [Formula \(4\)](#).

4.3.2 Maximum operation pressure based on long-term hydrostatic strength

The overall service (design) coefficient C for thermoplastics materials is specified in ISO 12162. This coefficient is used to calculate the MOP of the pipeline. C shall be ≥ 2 for PA-U pipeline systems for natural gas. For other gases, a higher overall service (design) coefficient C according to ISO 16486-5:2021, Clause 6, can be defined.

The MOP shall be calculated using [Formula \(1\)](#):

$$MOP = \frac{20 * MRS}{C * (SDR - 1) * D_F} \quad (1)$$

where D_F is the temperature derating coefficient.

The temperature derating coefficient D_F for various operating temperatures shall be in accordance with [Annex E](#).

4.3.3 Maximum operation pressure based on rapid crack propagation

The critical RCP pressure, p_c , is dependent upon the temperature, pipe diameter, SDR and type of PA-U material used.

For design temperatures ≥ 0 °C, the rules for the MOP pressure are given by ISO 16486-1 and ISO 16486-2.

In case of design temperatures $< 0\text{ }^{\circ}\text{C}$, the MOP pressure shall be determined by following equivalent [Formula \(2\)](#):

$$MOP = \frac{p_{c,T(bz)}}{1,5} \quad (2)$$

The full-scale critical pressure for temperatures $< 0\text{ }^{\circ}\text{C}$, $p_{c,T(bz)}$ shall be determined in accordance with ISO 16486-1 and ISO 16486-2. The lab-scale critical pressure for temperatures shall be defined by RCP-S4 testing according to ISO 13477 at the $< 0\text{ }^{\circ}\text{C}$ design temperature.

Where $p_{c,S4,T(bz)} \geq 0,9 * p_{c,S4,REF}$, the critical reference pressure from full-scale testing, p_c , shall be used as the critical full-scale pressure for $< 0\text{ }^{\circ}\text{C}$ as shown by [Formula \(3\)](#):

$$p_{c,T(bz)} = p_c \quad (3)$$

where $p_{c,S4,T(bz)} < 0,9 * p_{c,S4,REF}$.

The MOP shall be determined by [Formula \(4\)](#):

$$\frac{p_c + 1}{p_{c,S4,REF} + 1} = const = \frac{p_{c,T(bz)} + 1}{p_{c,S4,T(bz)} + 1} \quad (4)$$

This RCP [Formula \(4\)](#) converts to [Formula \(5\)](#), where the result shall be used for calculating [Formula \(2\)](#).

$$p_{c,T(bz)} = \frac{p_{c,REF} + 1}{p_{c,S4,REF} + 1} * (p_{c,S4,T(bz)} + 1) - 1 \quad (5)$$

4.4 Assembly techniques

Joining procedures may vary depending upon the pipe size used. Butt fusion and electrofusion are the preferred joining methods. Butt fusion joining shall be in accordance with [Annex A](#) and electrofusion in accordance with [Annex B](#).

For electro-fusion processing, including the operation of fusion control units, reference is made to the manufacturers.

For fusion joints, evidence of the fusion compatibility between the joining materials should be given.

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

Components made from PA-U 12 shall be 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.

A written joining procedure, authorized by the pipeline operator, shall be available prior to the construction of a pipeline. The joining procedure shall include specification of the joining method, the fusion parameters, the fusion equipment, the joining conditions, the level of skill of the fusion operator, and the quality control methods to be used.

4.5 Squeeze-off properties

When squeeze-off techniques are considered, the suitability of the pipe for squeeze-off shall be confirmed in accordance with ISO 16486-2:2020, Annex A.

Further information can be taken from [Annex D](#).

5 Construction

5.1 Competence

Operators shall be competent in the field of the assigned job. Operators shall possess the necessary skill and required knowledge and the ability to operate with awareness.

NOTE 1 Specific courses provide competency training that can be certified by a third party organization operating, for example, in accordance with ISO/IEC 17020.

NOTE 2 Examples of specific training courses for fusion operators can be found in ISO/TS 16486-8.

NOTE 3 Operators and supervisors can receive formal training under the supervision of a qualified instructor. The gas company can require a certificate indicating that the operator has reached an adequate standard in accordance with national regulations.

5.2 Storage, handling and transport

5.2.1 General

Polyamide pipes are available in coils, drums or straight lengths. Fittings are normally individually packed.

Mishandling of the pipes and fittings shall be avoided to protect them against gouges, scratches, cuts or holes, kinks or flattening.

5.2.2 Storage

PA-U pipes can be stored outside and under UV radiation provided that requirements for the resin stated in ISO 16486-1 are met. Coloured pipes (e.g. yellow) can be subject to degradation if solar UV radiation exceeds the values given in ISO 16486-1. The user of this document should consider the information provided by the pipe manufacturer regarding the allowable UV radiation dose with determined regional UV radiation level during storage.

NOTE 1 Information on regional levels of UV radiation can be found on webpages of national authorities, e.g. meteorological institutes.

NOTE 2 According to ISO 16486-1, resistance to weathering is based on a cumulative exposure of 7,0 GJ/m² UV radiation level.

Non-black pipes which have been stored outdoor for longer than the period recommended by the manufacturers shall only be used if tested prior to installation for conformity with the relevant part of the ISO 16486 series. The minimum tests that shall be performed are listed in [Table 1](#).

Table 1 — Minimum tests to evaluate coloured pipes when over-exposed to the UV radiation

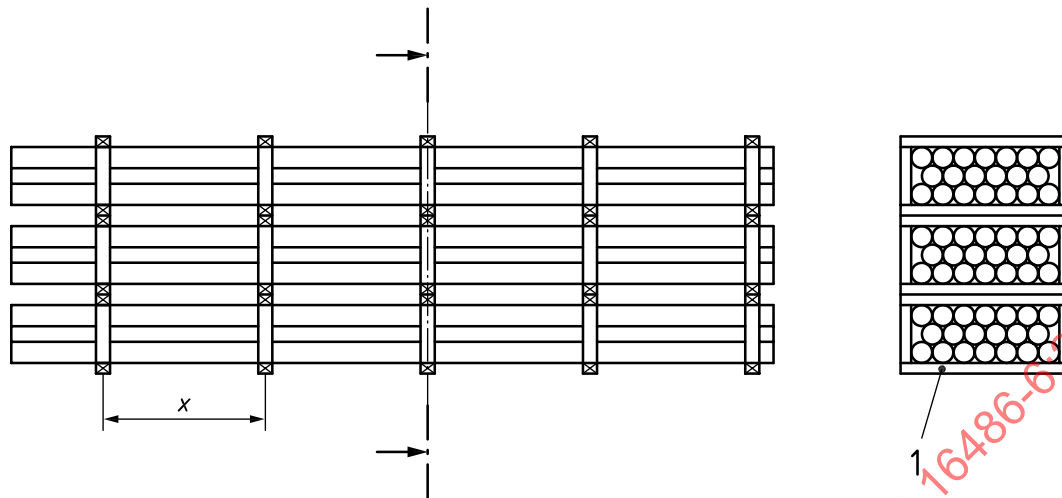
Test	Source and method
Elongation at break (all wall thicknesses)	ISO 16486-2:2020, Table 4
Hydrostatic strength (80 °C, 1 000 h)	ISO 16486-2:2020, Table 4
Cohesive resistance	ISO 16486-5:2020, Table 5

PA-U fittings and valves should be stored following the manufacturer's recommendation.

Straight pipes should be stacked on a suitable surface, preferably flat and free from stones or other projections or sharp objects likely to deform or damage the pipes. Pipes and fittings shall be stored in such a way as to minimize the possibility of the material being damaged by crushing or piercing.

The distances, "x" (see [Figure 1](#)), between support frames holding packs of pipes together should be equal in order to allow the frames to be stacked.

The support frame should not be nailed together and should be constructed in such a way that the load is directly supported by the frame and not by the pipes.



Key

- x distance between supports
- 1 support frame

Figure 1 — Support frame

The exact height to which straight pipes can be stacked depends on many factors, such as material, size, wall thickness and ambient temperature. During storage stacking shall avoid the distortion of pipes in storage over the limits as given by the manufacturer. The manufacturer's stacking recommendations shall be followed.

Polyamide pipes may be coiled or wound on drums. Coils of large-diameter pipes with $d_e \geq 110$ mm shall be stored vertically in purpose-built racks or cradles. Where loose straight pipes are stacked in pyramidal fashion, it shall not exceed a height of 1 m. Fittings shall be stored in their original packaging until being prepared-for use. Contact with aggressive reagents or solvents shall be avoided.

The pipes with the earliest extrusion date should be used first for installation. It is recommended that fittings with the earliest manufacturing date should be used first for installation. Guidance from the product manufacturer should be considered.

Fittings and valves shall be packed and transported in cartons and/or on pallets.

5.2.3 Handling

Initial handling of straight pipes shall be made with the pipes as delivered by the manufacturer (e.g. in their own packaging) in packaged form, thus minimizing damage during this phase. When loading, unloading or handling, it is preferable to use mechanical equipment to move or stack the packages. The pipes shall not be dragged or thrown along the ground. If handling equipment is not used, choose techniques which are not likely to damage the pipes and/or fittings.

Coils of pipe stacked on pallets are easily handled using a forklift truck. Individual coils shall not be rolled off the edge of a vehicle load platform. Coils shall be slung individually when off-loading with a crane. Before laying a pipe, ensure that the drum is positioned correctly and that its axle will remain stable during the unrolling operation. While unrolling, ensure that the pipe is not damaged.

Fittings and valves shall be handled in accordance with manufacturer instructions and left in original packaging until use.

5.2.4 Transport

When transporting straight pipes, flatbed vehicles shall be used. The bed shall be free from nails and other protuberances. The pipes shall rest uniformly on the vehicle over their whole length and shall be securely held in place during transport.

Coiled pipes shall be transported stacked on a pallet or as individual coils and be firmly secured to the vehicle. For safety reasons, the height of the top of a drum when loaded on a vehicle shall not be larger than the maximum height and any limitations expected on the route. Drums shall be firmly secured to the vehicle.

Fittings and valves shall be transported in accordance with manufacturer instructions.

5.3 Jointing

The jointing operation, either mechanical or fusion, shall be performed in accordance with the pipeline operator's written procedure. The fusion procedure specification shall take into account the relevant fusion standards, if existing, and any recommendation from the pipe, fitting and accessory manufacturers. The relevant standard for the butt-fusion jointing procedure is ISO 16486-5.

NOTE 1 In some countries "fusion procedure specification" is also defined as "welding procedure specification (WPS)".

Polyamide pipes, fittings and accessories may be jointed either by heated-tool fusion jointing, electrofusion jointing or mechanical jointing. The jointing and quality control methods used for the construction of the gas supply system shall be appropriate to the design of the network.

Fusion operators shall possess the necessary skill and knowledge and ability to produce joints of consistently high quality. Therefore, they shall receive formal training under the supervision of a qualified instructor.

The jointing methods covered by this document are:

- butt fusion jointing (which shall conform to [Annex A](#));
- electrofusion jointing (which shall conform to [Annex B](#)); and
- mechanical jointing (which shall conform to [Annex C](#)).

The gas company can require evidence of training or qualification for fusion. Examples of training and assessment can be found in ISO/TS 16486-8.

NOTE 2 For qualification purposes, ISO/TS 16486-8 is replaced by EN 13067^[4] for example.

The same level of skill, knowledge and ability is required for mechanical jointing. The gas company may require evidence of training or qualification. When tightening or untightening a mechanical joint, it is essential that torsional stress is not transmitted to the pipe.

5.4 Laying

5.4.1 General

Care shall be taken to prevent damage to the pipes and fittings during the whole of the laying process.

Changes in direction of a polyamide pipeline when laying can be made using pre-formed bends or elbow fittings or by making use, within limits, of the natural flexibility of the pipe. Natural flexibility may be used for bend radii $\geq 25 \times d_e$, and also for smaller radii for certain SDR values and materials provided this is consistent with operational experience and good engineering practice.

NOTE 1 In general, the flexibility is a factor of SDR, environmental temperature and material. Consult the pipe manufacturer for additional guidance or instructions.

NOTE 2 Information on the bend radii for mechanical joints are given in [Annex C](#).

The flexibility of polyamide pipes is reduced in cold weather. If the temperature falls below 0 °C, special handling instructions, issued by the manufacturers, shall be followed for straight or coiled pipes and for fittings.

Machine-bending of pipes or bending after the application of heat in the field shall not be used.

Where PA-U pipes, fittings and valves are allowed to be installed above ground they shall be protected against mechanical damage and, in case of non-black pipes, UV degradation.

If the gas pipeline is not protected by the surrounding soil, special consideration should be taken to reduce any kind of risk, e.g. ignition sources, high temperatures, etc.

The minimum clearance between the pipe and obstacles (e.g. utilities, structures or immovable rocks) shall be 200 mm from the pipe surface. If this minimum clearance cannot be observed, a protection barrier shall be installed. Special precautions shall be taken if the gas pipeline crosses or is laid alongside other buried services, e.g. a hot water or steam pipeline, a petrol-carrying pipe, a petrol station or a high-voltage cable, etc.

Stresses caused by differences in temperature between laying and operation shall be taken into consideration. The position of the pipeline shall be recorded before backfilling.

To minimize the possibility of damage to the pipeline by external influences, at least one of the following measures shall be considered:

- a) place a warning device, for example a protection tile, hazard tape, etc. along the top of the pipe;
- b) place a tracer wire to enable the pipe to be located again in future;
- c) install permanently visible above-ground markings, especially at road, railway and water crossings, at blow-off devices, on private land, at boundaries between plots of land, and at points where the pipeline changes direction.

5.4.2 Trench

Excavating and backfilling of the trench shall be in accordance with the written procedure authorized by the pipeline operator. The width of the trench bottom shall be large enough to allow correct installation and backfilling.

If it should be necessary to perform any fusion jointing in the trench, the width of the trench may need to be larger, depending on the type of fusion jointing and the type of equipment used.

Pipes may be laid in the trench without preparation of the bottom if it consists of uniform, relatively soft, fine-grained soils free of large flints, stones and other hard objects, and where the bottom of the trench can readily be brought to an even finish providing uniform support for the pipes over their whole length.

5.4.3 Drag forces

Pipes shall not be overstressed by tensile forces during laying. If the pipe is laid by drag, care shall be taken to ensure that the drag force is not greater than the values given by [Formulae \(6\)](#) and [\(7\)](#):

$$F = \frac{\sigma * \pi * d_e^2}{f_s * SDR} \quad (6)$$

$$\sigma = \frac{\sigma_y}{1,25} \quad (7)$$

where

- F is the maximum drag force, in Newtons;
- σ is the maximum tensile stress in MPa;
- σ_y is the tensile stress at yield in MPa;
- f_s is the safety factor
- SDR is the standard dimension ratio;
- d_e is the external diameter of the pipe, in millimetres;

NOTE 1 As the safety factor, f_s , a value of 2,0 is normally used.

NOTE 2 The tensile stress at yield, σ_y , as provided by the pipe manufacturer.

The drag force, F , obtained by [Formula \(1\)](#) relates to an environmental temperature of 20 °C and it can be applied to the pipe for during the drag. For higher temperatures, derating factors from [Table E.1](#) should be applied in the denominator of [Formula \(6\)](#).

5.4.4 Valves

Valves shall be installed so that they do not expose the PA-U pipe to unnecessary stress during opening or closing. PA-U valves shall conform to ISO 16486-4.

Valves are available with either a steel/iron or a plastics body. With steel/iron-body valves, special precautions shall be taken against corrosion and to avoid stresses to the PA-U pipe induced by their weight.

5.4.5 Connection to existing systems

Where there can be a release of gas in the working area, static-charge accumulation shall be avoided.

In order to avoid static charges, the pipeline system shall be connected to earth during manipulations, for example by draping water-soaked cloths, made of natural fibre, over all pipes and fittings likely to be handled so that the cloths touch both the pipe and the ground.

5.4.6 Backfilling

Unless otherwise specified, buried pipelines and casings shall have a minimum soil cover of 0,6 m (0,6 m cover can be unnecessary for small diameter PA-U service pipes). Exceptions may be made for pipes entering metering or regulating boxes, but such pipes shall be protected against external interference. Greater soil cover shall be provided in areas of deep ploughing, drainage, roads with heavy traffic, and railway or waterway crossings.

Excavated materials may be used as backfill provided that they are free from stones and sharp objects likely to damage the pipe and also free of wooden materials. If not, qualified backfill material shall be used. Any applicable national or local regulations concerning backfill materials shall be taken into account.

NOTE Excavated materials containing stones and/or sharp objects can be used as backfill. This can be agreed between the parties based on the fitness of the appropriate PA-U grade for non-conventional installation techniques (see [5.4.7](#) with [Annex G](#)).

The pipe shall be uniformly supported. Material around the pipe shall be compacted so, as to avoid excessive pipe ovality. This shall be done layer by layer.

5.4.7 Non-conventional installation

For PA-U non-conventional laying shall be agreed between the parties.

NOTE 1 [Annex G](#) provides additional information for demonstrating the fitness of PA-U piping systems for non-conventional installation techniques.

NOTE 2 PA-U samples are considered in an interlaboratory test for a revision of ISO 18489 with the target of considering several additional thermoplastic resins. Regarding PA-U, a future edition of ISO 18489 would provide a reference for defining a test procedure for PA-U compounds including a maximum failure cycle number as threshold for slow crack growth in a future revision of ISO 16486-1.

5.5 Pressure testing and commissioning

Pressure testing and commissioning shall be in accordance with EN 12327 (it can be necessary to take into account national regulations concerning pipeline pressures).

NOTE An example for a regional implementation of the functional standard EN 12327 is given by the relevant paragraph of DVGW G 472^[22] with reference to DVGW G 469^[23].

Consideration shall be given to the need for any special precautions to be taken to protect persons and property if air or inert gas is used as the test medium.

For test temperatures below 0 °C, the possibility of a reduction in critical RCP pressure, p_c , shall be taken into account in the pipeline preparation and test procedure adopted.

Pressurized PA-U pipelines at ambient temperature are subject to expansion by creep that could affect the results of pressure testing. At higher test pressures, this effect can be significant. Appropriate allowance shall be made for pressure losses due to creep when interpreting pressure test results.

If air is used, oil from the compressor shall be prevented from entering the pipeline and the air temperature shall not exceed 40 °C, to prevent damage to the pipes and/or fittings.

After the finalization of the piping installation, including the positive result of pressure testing, the piping system is prepared for commissioning.

6 Quality control

6.1 General

The pipes, fittings and associated equipment shall be inspected to confirm the conformity with the laying procedure. The inspection may be carried out by the personnel engaged in jointing. Additional inspections shall be carried out by a competent person at a frequency depending on the conditions of use. The results of each inspection shall be recorded.

Destructive testing on joints made in the field may also be carried out to ensure that the quality conforms to the jointing procedure.

NOTE In addition, non-destructive testing^{[24],[25]} of welded joints can be carried out to ensure that the quality conforms to the jointing procedure. Established techniques can be applicable after calibration for PA-U.

6.2 Inspection prior to laying

Pipes, fittings and associated equipment shall be inspected prior to laying to confirm conformity with the required International Standard, pipe and fitting diameters, SDR and MRS as given by the pipe and fitting marking information.

Pipes and fittings showing obvious defects such as excessive scoring shall be discarded and clearly identified as unsuitable. Limitations on outside storage of pipes or fittings shall not have been exceeded.

The jointing equipment shall be in accordance with the relevant International Standards (e.g. in case of equipment for fusion jointing, ISO 12176-1 and ISO 12176-2) and their use shall be in accordance with the manufacturers' instruction of use and maintenance. A written jointing procedure shall be available.

6.3 Inspection during laying

6.3.1 Laying

Soil and trench conditions shall conform to the written installation procedure authorized by the pipeline operator.

If surface defects with a depth of more than 10 % of the nominal pipe wall thickness are found, the section concerned shall be cut out or repaired in accordance with the relevant procedure.

Inspection during the laying of pipelines and the construction of associated installations shall include the following:

- a) inspection of the pipes for serious surface defects, deformation or pipe end toe-in immediately prior to and during laying;
- b) inspection of the trench to ensure that it is the correct depth and width and that it provides the minimum clearance with respect to other buried structures;
- c) inspection of the bottom of the trench immediately prior to lowering the pipeline into place and during backfilling of the trench to ensure that the pipeline is not damaged by sharp objects, such as stones or pieces of metal;
- d) inspection during the lowering of the pipeline into the trench to ensure that this takes place correctly, that no damage occurs and that the pipeline is placed in the correct position.

NOTE This inspection programme can be modified for trenchless installation if a specific PA-U compound is used, where comprehensive test reports underline the suitability for alternative installation methods including a verification of a superior slow crack growth (SCG) resistance by brittle failure mode. References [26], [27], [28] and [29] provide guidance for such test reports.

6.3.2 Joint integrity

6.3.2.1 General

The quality of the joint depends on strict adherence to the written jointing procedure, the use of well-maintained/calibrated equipment conforming to the relevant standard, and the competence of the operators.

Quality control shall be performed on site by the persons involved in the work concerned. Further, supervision and inspection may be carried out by a supervisor who shall guarantee the quality of the work performed and in addition provide a quality control report.

6.3.2.2 Visual inspection criteria

6.3.2.2.1 Butt fusion joints

In case of PA-U, the bead shall not be removed.

a) Bead symmetry

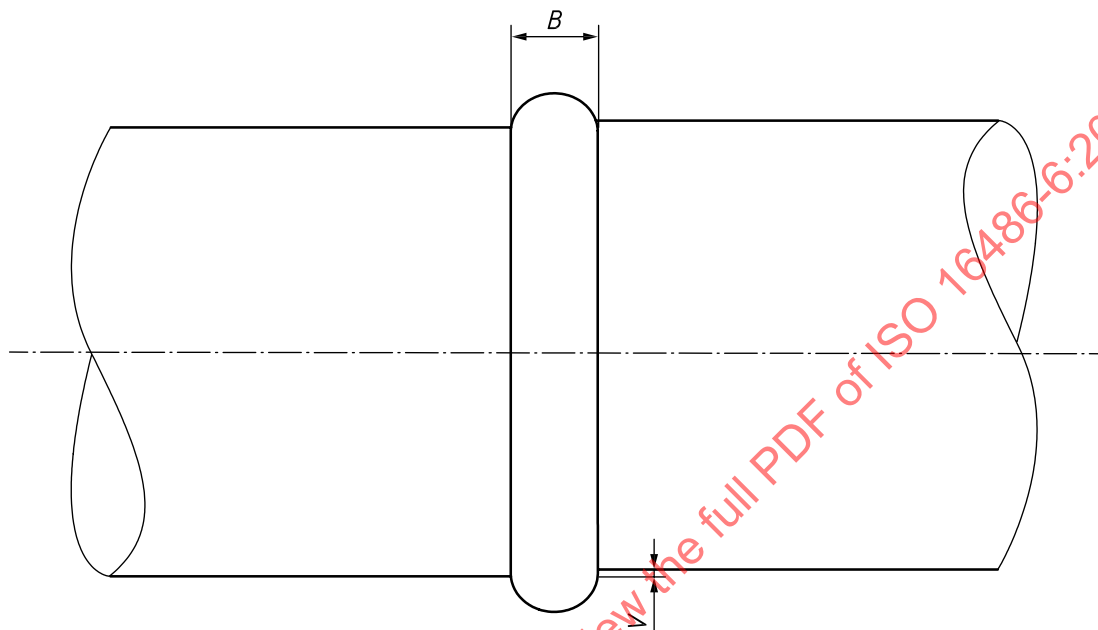
An asymmetrical bead profile between the same components shall initially be considered as indicative of poor joint quality subject to a confirmation assessment by an authorized person. In assessing the results of the joint tests under standard conditions, acceptable levels of asymmetry shall be determined.

b) **Bead alignment**

Pipes, fittings and valves shall be as closely aligned as possible.

The misalignment, V , shall not exceed $0,1e_n$. Where this leads to values of less than 1 mm, testing of joints shall be undertaken to identify the maximum allowable misalignment (see [Figure 2](#)).

This value shall not be exceeded anywhere around the circumference of the two parts adjacent to the fusion bead.



Key

- V misalignment
- B bead width

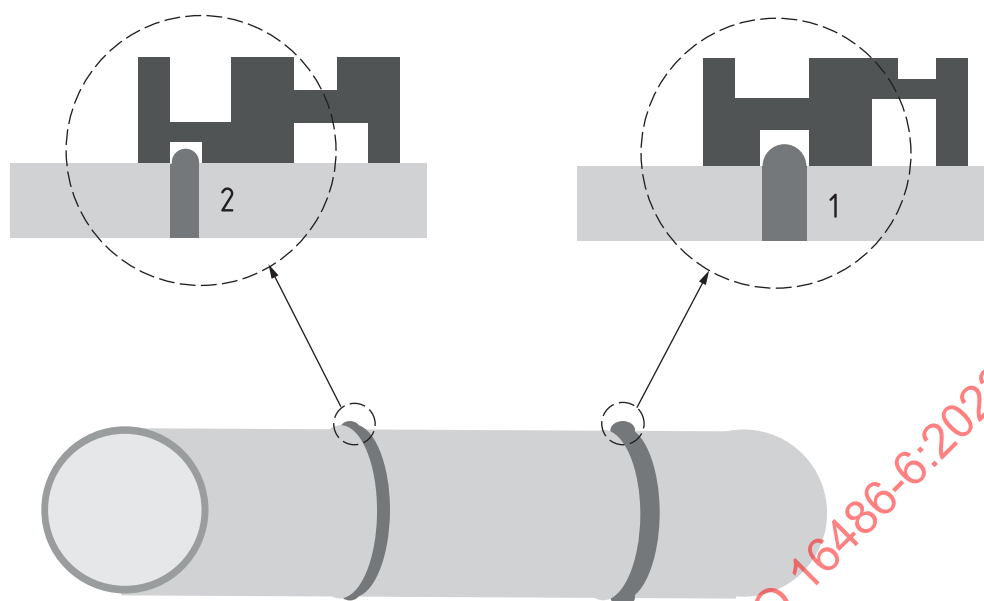
Figure 2 — Alignment

c) **Bead width**

The bead width, B , (see [Figure 2](#)) is influenced by the type of heater plate used, its temperature and the fusion cycle used. Consequently, it is difficult to specify a single set of bead width values. It is however a good indicator that the specified jointing procedure has been followed.

One method of determining an acceptable bead width value B is experimentally, using pipes and a butt fusion machine operating at the specified conditions. The mean value, B_m , is determined from several joints made under the conditions defined in the jointing procedure. It is recommended, for quality control purposes on site, that the measured bead width, B , does not exceed $\pm 20\%$ of B_m .

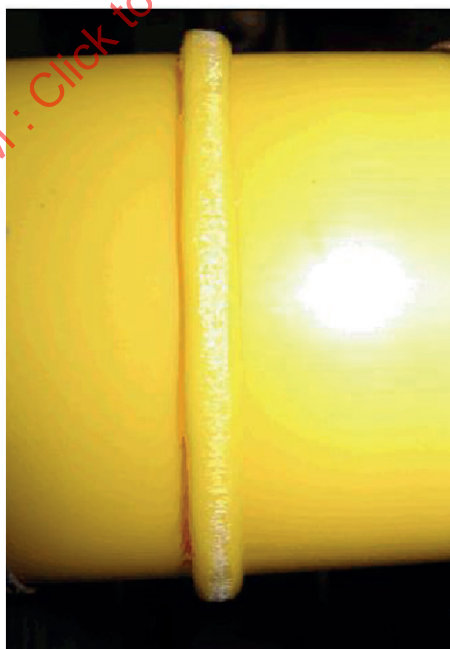
The use of GO/NO-GO gauges, manufactured to these recommended limits, can potentially facilitate checking (see [Figure 3](#)).

**Key**

- 1 $B_{\max}$
 2 $B_{\min}$

Figure 3 — Bead gauges**d) Bead appearance**

For butt fusion joints of PA-U, typical bead appearance is shown in [Figures 4](#) and [5](#).

**Figure 4 — Typical single bead shape around the entire pipe circumference**

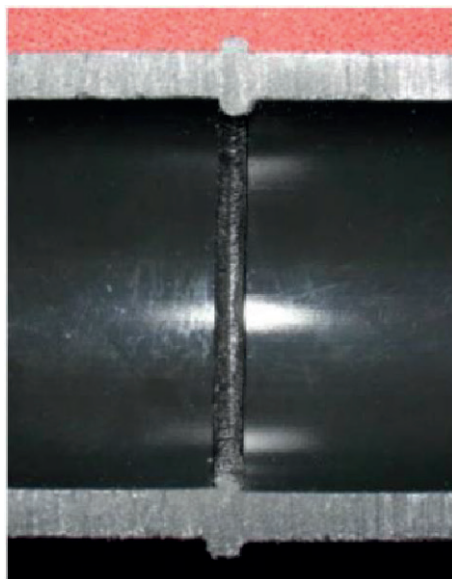


Figure 5 — Typical single bead shape in a sectioned joint

6.3.2.2.2 Electrofusion socket joints

The jointing process shall be carried out in the following steps.

a) Pipe alignment

A check shall be made that the pipes and fittings have been properly aligned in conformity with the written jointing procedure.

b) Scraping

A check shall be made that scraping in accordance with the written jointing procedure has been carried out over the entire circumference of the pipe (see [Figure 6](#)). There shall be clear evidence of scraping on either side of the socket.

In consideration of the tolerances of pipes and fittings and of their capacity to be assembled, the fit between pipe end and socket should be tight or close.

Particular attention shall be given to inspecting the underside of the pipe.

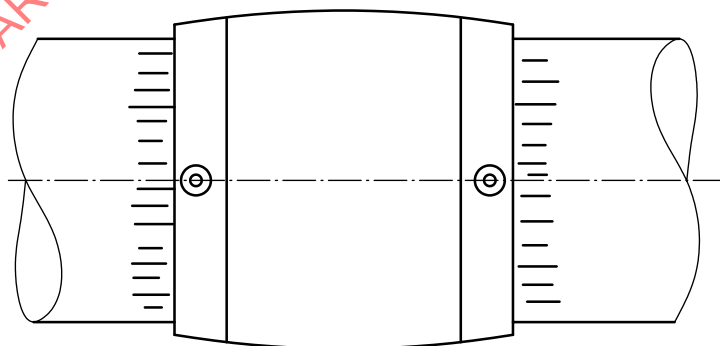
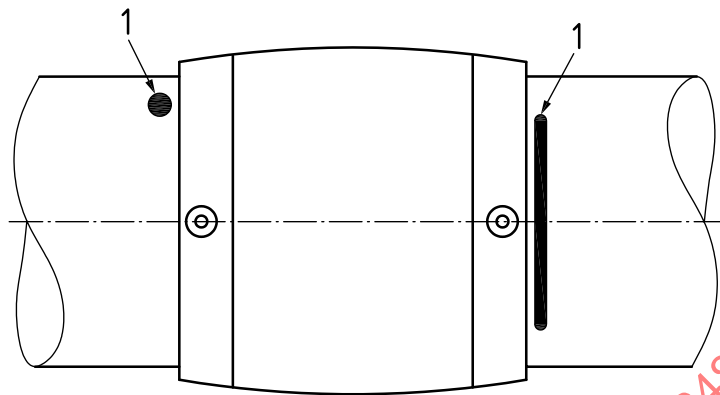


Figure 6 — Scraped area of pipe ends larger than the insertion depth (criss-cross lines)

c) **Pipe insertion**

Insertion markings on pipe or spigot end shall be checked to confirm that correct insertion depth has been achieved and maintained during the fusion process (see [Figure 7](#)).



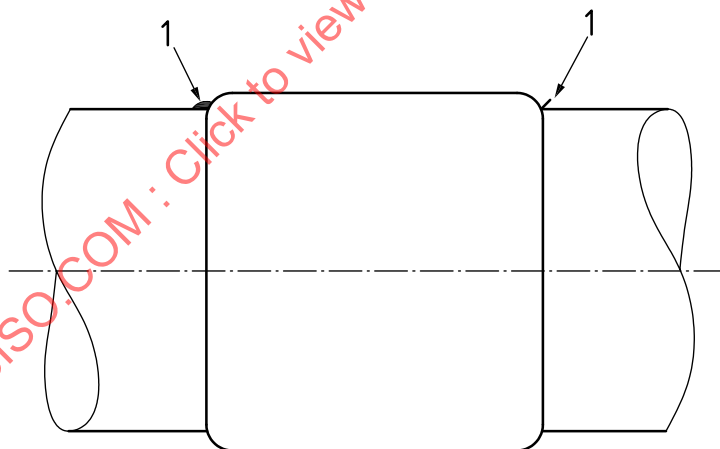
Key

1 insertion markings

Figure 7 — Insertion markings

d) **Molten material**

A check shall be made that molten material from the fusion process or heating wires has not exuded out from inside the fitting (see [Figure 8](#)).



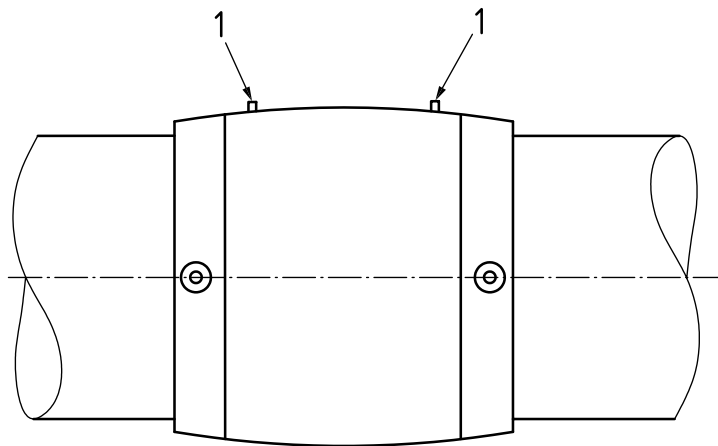
Key

1 exuded molten material or heating wires

Figure 8 — Molten material

e) **Heating indicators**

If the fitting is designed with heating indicators, they should be in positions conforming to the manufacturer's instructions after jointing has been completed (see [Figure 9](#)).



Key

- 1 activated heating indicators

Figure 9 — Heating indicators

f) Cooling time

When special clamps are required, the clamps shall be removed only once the cooling time (as indicated on the fittings, e.g. "C.T.") has elapsed.

g) Position of heating wires

Following fusion jointing, the electric coils heating wires shall not show any abnormal displacement outside the fitting body influencing the fusion quality.

For larger EF couplers, e.g. diameter ≥ 315 mm, the first winding can become visible after the electrofusion. This has no negative effect on the fusion quality.

NOTE The first winding of the heating coil is not part of the fusion zone.

h) Jointing energy

The completed electrofusion joint fusion energy should be checked to be within acceptable limits.

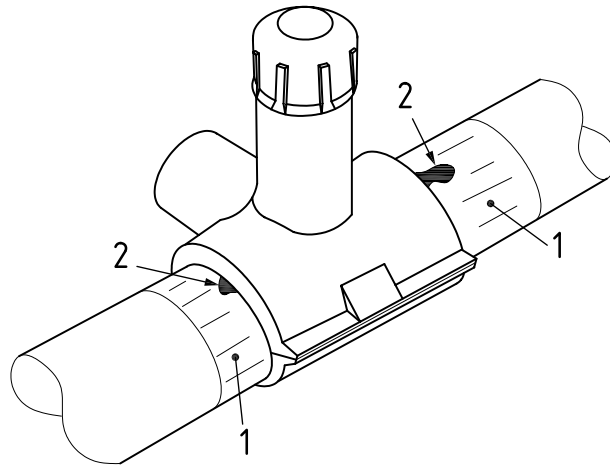
NOTE Automatic fusion control units conforming to ISO 12176-2 record electrical output parameters, the duration of the fusion process and the environment temperature. These data are used for the purpose of this subclause.

6.3.2.2.3 Saddles and tapping tee

The jointing process shall be carried out in the following steps:

a) Scraping

A check shall be made that scraping has been carried out in accordance with the written jointing procedure over the entire fusion area (see [Figure 10](#)).

**Key**

- 1 scraping
- 2 exuded molten material

Figure 10 — Checking saddles and tapping tees**b) Further visual checks**

The pipe wall shall show no signs of collapse.

A check shall be made that molten material from the fusion process or heating wires have not exuded out from inside the fitting (see [Figure 10](#)).

c) Heating indicators

If the saddle or tapping tee is designed with heating indicators, they shall be in positions conforming to the manufacturer's instructions after jointing has been completed.

d) Cooling time

When a special clamp is required for saddles or tapping tees, it shall not be removed nor the joint disturbed before the specified cooling time has elapsed. Before the tapping of the pipe, further cooling time may be required as specified by the fitting manufacturer.

e) Ancillary tooling

The use of ancillary tooling, such as pipe clamps, shall not result in significant damage to pipe surfaces adjacent to the joint.

f) Jointing energy

The completed electrofusion joint fusion energy should be checked to be within acceptable limits.

NOTE Automatic fusion control units conforming to ISO 12176-2 record electrical output parameters, the duration of the fusion process and the environment temperature. These data are used for the purpose of this subclause.

Annex A **(normative)**

Butt fusion jointing procedure

A.1 General

Butt fusion joints shall be made using defined parameters of pressure, time and temperature, using a written procedure (see 6.3.2.1). The procedure shall consider the fusion environment and shall provide guidance, e.g. for wind and temperatures. Mating surfaces are heated to their fusion temperature and then brought into contact with one another. In the following clauses of this annex, the reader can find some basic information relating to a general butt fusion procedure in line with ISO 21307.

NOTE The pipe manufacturer can be contacted in advance for confirmation of the chosen butt fusion procedure as described in ISO 21307.

ISO 16486-5 provides specifications for jointing PA-U. Other industrial butt fusion jointing procedures may be used, provided that they are suitable for the PA-U piping system.

A.2 Climate conditions

The fusion operation may be carried out in different ambient temperatures, provided these variations are within the limits specified in the jointing procedure.

Extreme ambient temperatures, rain and wind can adversely affect the fusion process. For cold weather and wind, special precautions such as shielding, end caps and longer heating times shall be taken. For high ambient temperatures and situations with significant solar heating of the pipe surface, special precautions such as shielding and extended cooling time shall be taken.

A.3 Fusion temperature

The production of a strong fusion joint depends, among other things, upon the fusion temperature of the polyamide material: overheating may degrade the material, and insufficient heating will not soften it adequately.

The fusion temperature range over which any particular PA-U material may be satisfactorily jointed shall be considered. The jointing procedure shall specify the heating cycle and the temperature levels for the polyamide material chosen.

A.4 Fusion equipment

The butt fusion equipment for PA-U used shall conform to ISO 12176-1. As high-quality fusion joints cannot be made with fusion equipment in poor condition, maintenance and calibration of the fusion equipment is very important and shall be carried out on a regular basis. The cleanliness and integrity of the heating surfaces, the ability of the heating tools to produce the correct temperature, and the correct alignment and operation of the equipment are of paramount importance.

The heater plates are designed to maintain uniform temperatures within the fusion temperature range and shall have a means of measuring and indicating the temperature. A precise temperature measurement device such as a pyrometer or a digital thermometer with a surface temperature sensor may be used to check the surface temperature of the heating tools, although additional care is necessary to avoid inconsistency of readings when such a device is used.

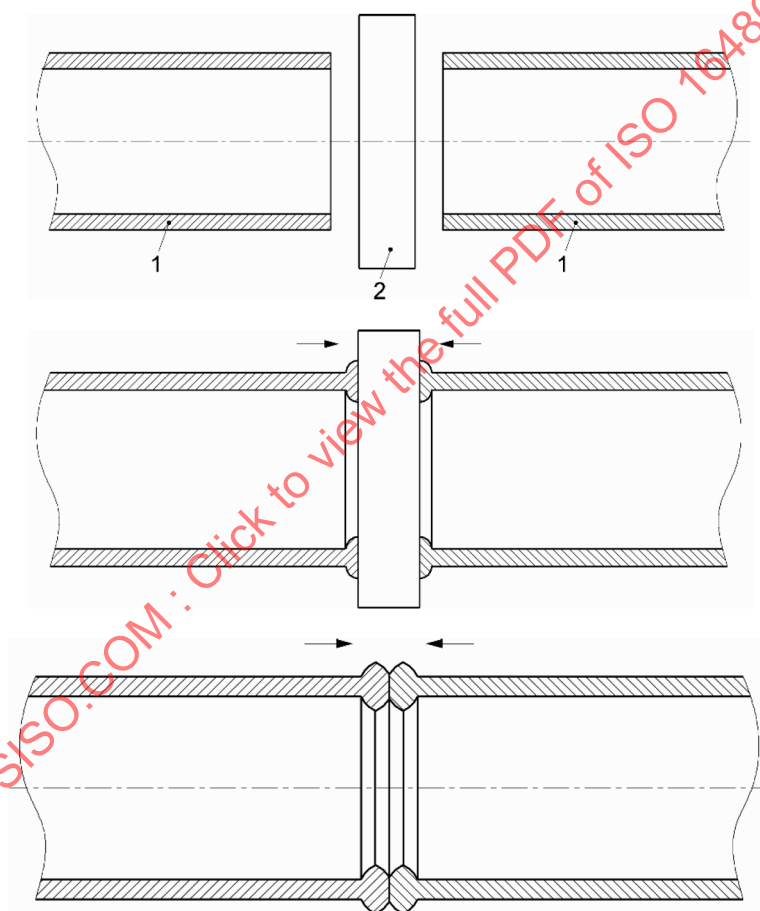
All heating tools used shall be electrically heated. It is preferable to use fully automated butt fusion equipment with retrievable jointing records.

Power generators and butt fusion machines shall be designed taking into consideration the generally accepted safety requirements and national safety regulations.

A.5 Butt fusion

A.5.1 Principle

The butt fusion technique consists of heating the planed ends of the mating surfaces by holding them against a flat heater plate until molten, removing the heater plate, pushing the two softened ends against one another, holding under pressure for a prescribed time and allowing the joint to cool (see [Figure A.1](#)).



Key

- 1 pipe/fitting ends
- 2 heater plate

Figure A.1 — Butt fusion

Butt fusion is not recommended for pipes ≤ 63 mm in diameter. Pipes and/or fittings with fusion ends of different SDR values or PA-U class shall not be joined by butt fusion.

A.5.2 Butt fusion cycle

The butt fusion cycle can be represented by a pressure/time diagram for a defined fusion temperature. Different butt fusion cycles are available, depending on the PA-U material used, the pipe diameter, wall thickness and the working conditions.

The butt fusion cycle to be used shall be specified in the written procedure.

An example of a butt fusion diagram is given in [Figure A.2](#).

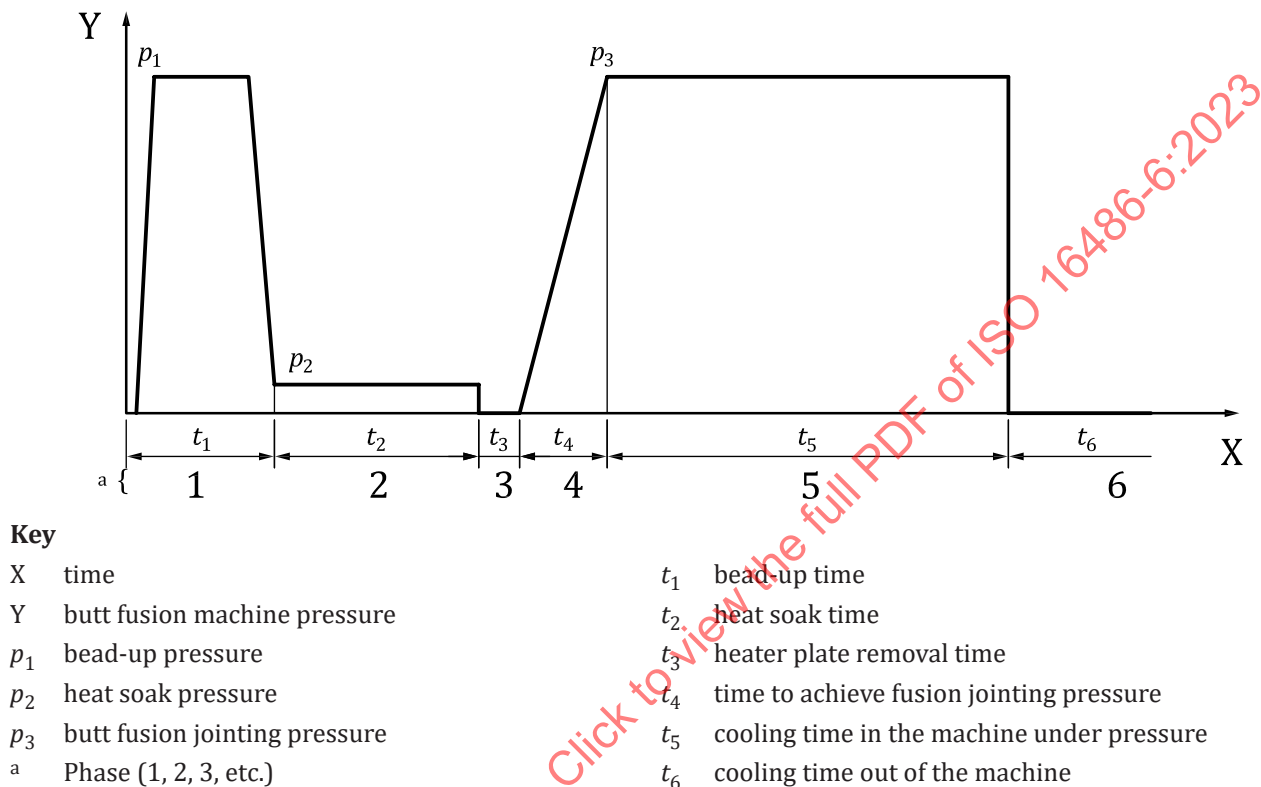


Figure A.2 — single low-pressure fusion jointing cycle

The pressures shall be chosen so that the required force is produced at the interface, irrespective of frictional and pressure losses in the butt fusion machine and drag resistance from the pipe system.

In the case of machines with fluid power rams, the force may be indicated in terms of the applied cylinder pressure. For such machines, a specific calibration table shall be provided that gives the relationship between the real interface force and the pressure indicated by the pressure gauge.

A.5.3 Butt fusion temperature

The butt fusion temperature is normally situated between 225 °C and 265 °C and is given in the jointing procedure, e.g. ISO 16486-5.

A.5.4 Butt fusion jointing

The following list gives an overview of the minimum operations necessary to produce a butt fusion joint with a specified butt fusion cycle and temperature and a powered ram butt fusion machine:

- Check that the butt fusion machine is compatible with the pipe diameter and wall thickness and the prescribed butt fusion cycle.
- Reduce the drag resistance as much as possible, for example by using pipe rollers.

- Firmly clamp the ends of the pipe(s) and/or the spigot ends of the fitting(s) in the butt fusion machine.
- Clean the spigot ends.
- Plane the spigot ends parallel by moving the movable clamp against the planing tool (see [Figure A.3](#)). The closing pressure shall be sufficient to produce a steady flow of PA-U shavings on both sides of the planing tool. Planing is complete when the spigot ends are planed and parallel to each other over the entire spigot circumferences.

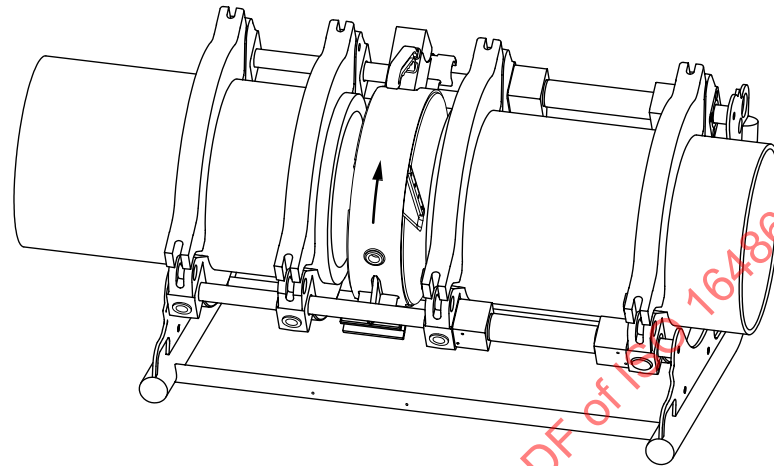


Figure A.3 — Planing the pipe or spigot ends by the planing tool between the ends

- Lower the pressure, keeping the planing tool rotating in order to avoid a burr on the pipe and/or fitting faces. Move the movable clamp backwards and remove the planing tool.
- Inspect the pipe or fitting ends for incomplete planing, voids or other imperfections, and then bring them together to check for proper alignment and gap. The spigot ends shall be diametrically rounded and aligned to ensure conformance with this document. Other relevant codes of practices, national regulations or industry guidelines may be used as an alternative.
- Gauge the pressure caused both by the frictional losses in the butt fusion machine and the drag resistance, by moving the clamp forwards, and add this pressure to the required jointing fusion pressure (see [Figure A.2, p₃](#)).
- Ensure that the fusion surfaces are not contaminated before starting with the bead-up process.
- The heater plate shall be clean. Polyamide residues shall only be removed from the heater plate with a wooden spatula.
- Check that the surface coating of the heater plate is intact and without scratches.
- Check that the heater plate is at the correct fusion temperature.
- Install the heater plate in the butt fusion machine and bring both pipe or fitting ends simultaneously into full contact with the heater plate to produce molten surfaces for fusion jointing (see [Figure A.4](#)). Apply the fusion pressure, including the measured additional pressure, until the minimum specified bead-up width has been reached.

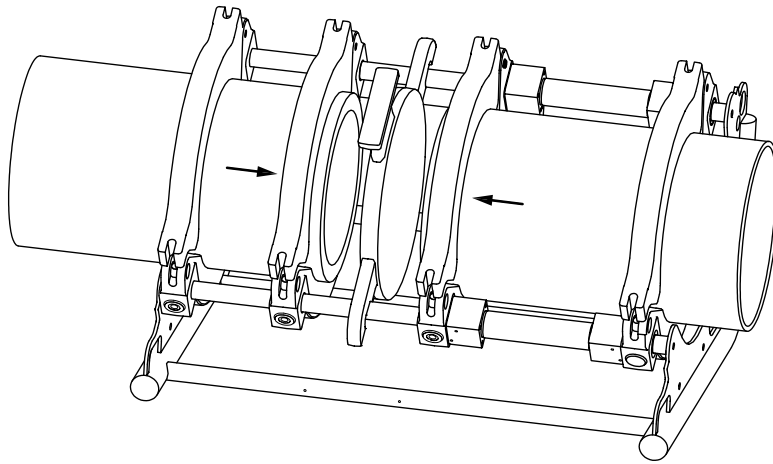


Figure A.4 — Heating the spigot ends

- Reduce the pressure to a level at which contact is just maintained between the spigot ends and the heater plate.
- When the heat soak time has elapsed, open the butt fusion machine and remove the heater plate. Check the heated spigot ends quickly for possible damage to the melted ends caused by the removal of the heater plate and close the butt fusion machine again. The period between opening and closing shall be within the maximum time given in the jointing procedure.
- Store the heater plate in a protective enclosure when not in use.
- The butt fusion machine shall remain closed and the joint under pressure during the cooling time in the machine under pressure (see [Figure A.2](#), t_5). It is important that the cooling period is respected.
- When the required cooling time in the machine under pressure has elapsed, release the pressure in the butt fusion machine.
- When removed, the assembly shall be handled with care.

Annex B (normative)

Electrofusion jointing

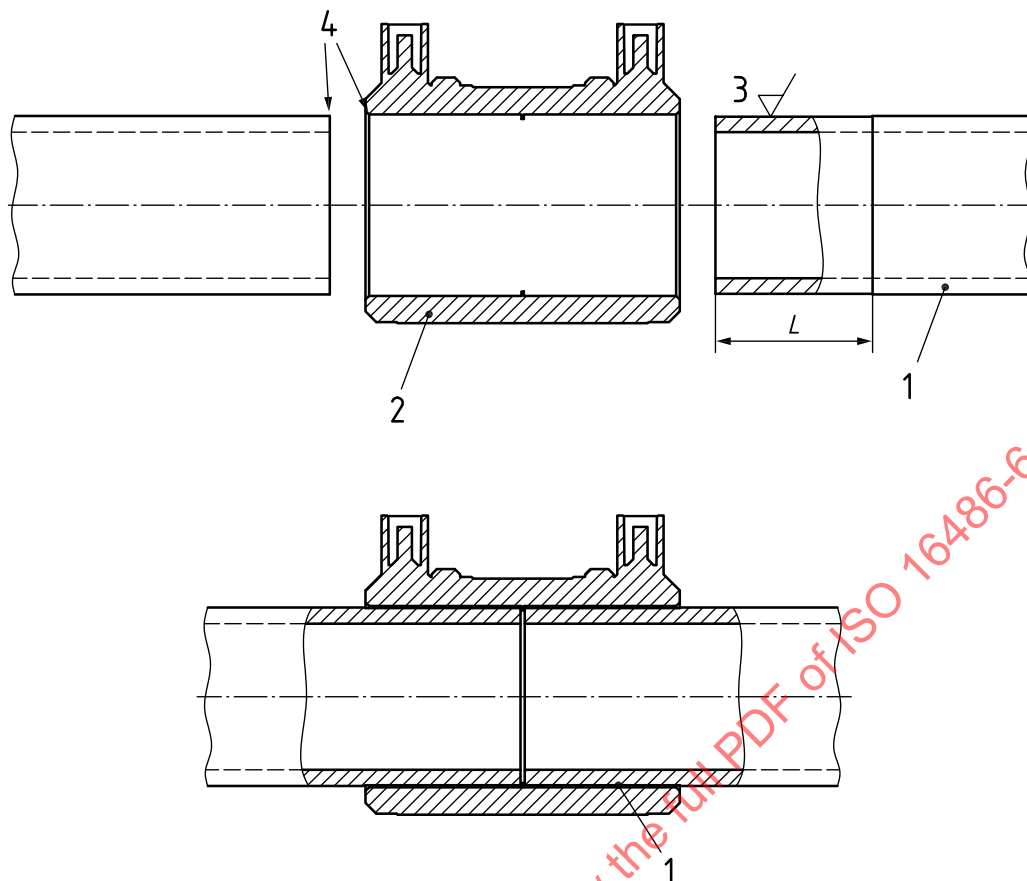
B.1 General

Electrofusion fittings may include sockets, e.g. couplers, reducers, tees, end caps, elbows and saddles, e.g. tapping tees and branches. The basic principle of joining such fittings by electrofusion consists of heating, using the Joule effect, an electrical coil incorporated in the internal surfaces (fusion surfaces) of the fitting, causing the material adjacent to the coil to melt and making the pipe and fitting surfaces fuse; see [Figure B1](#).

Electrofusion fittings can be used to join piping components e.g. pipes, branches or spigot fittings.

Electrofusion fittings and piping components shall be made from PA-U designated according to ISO 16486-1 and different SDR ranges according to ISO 16486-3.

Care shall be taken to use only electrofusion fittings with a design MOP and SDR range compatible with the PA-U pipes and spigot fittings to be joined.



Key

- 1 pipe with surface area for jointing
- 3 fitting's body
- 3 pipe/fitting scraped surface
- 4 diameters
- L prepared length (greater than insertion depth of the fitting)

Figure B.1 — Basic principle of electrofusion jointing process

B.2 Climate conditions

The fusion operation may be carried out without any special precautions for variations in ambient temperature, provided these variations are within the limits specified in the jointing procedure. If some adjustment in the electrical power supplied to the fitting is necessary to cater for extreme ambient temperatures, the jointing procedure shall specify suitable electrofusion equipment. Cold weather, rainfall and wind can adversely affect the fusion process. Under these circumstances, special precautions based on the electrofusion fittings manufacturers' instructions shall be considered.

B.3 Electrofusion equipment

B.3.1 General

Maintenance and calibration of the control units and generator is very important and shall be carried out on a regular basis to achieve high-quality fusion joints. Other equipment (e.g. scraper tools, power cables) also require a check of correct function and maintenance.

Power generators and control units shall be designed taking into consideration generally accepted safety requirements and safety regulations.

B.3.2 Control unit

The control unit shall conform to ISO 12176-2. Preferable automated electrofusion equipment with retrievable jointing records should be used, which is able to decode data from ISO 12176-3, ISO 12176-4 and ISO 12176-5.

The jointing procedure shall specify the type of fusion equipment to be used. The electrofusion control unit is designed to provide the correct fusion energy to electrofusion fittings. This energy input is based on the parameters set by the fitting manufacturers (e.g. voltage, fusion time, temperature). Parameters can be given in different ways, e.g. barcode or two-dimensional coding.

The electrical supply to the control unit can be either supplied by mains or power generators or others.

The electrofusion control unit output cable connectors shall be compatible with the fitting electrical terminals. Use appropriate terminal adaptors if necessary.

B.3.3 Power generator

If a power generator is used it shall be able to deliver the power required by the fitting. Information on the required power can be found in technical documentation released either by fitting or control unit manufacturers.

B.4 Electrofusion

B.4.1 Preparation

The following general procedure gives an overview of the minimum operations necessary to prepare for electrofusion jointing. More specific instruction, if any, can be given by the electrofusion fitting manufacturer.

B.4.2 General

Electrofusion fittings shall be kept in their protective packaging until they are ready to be joined to a pipe or spigot fitting. The surfaces to be fused shall be dry and clean before beginning the jointing procedure.

Ensure that the electrofusion fitting is suitable for use within the ambient temperature range and for the pipe or spigot fitting series or SDR value concerned.

Use alignment clamps and, if required, re-rounding clamps. for all types of electrofusion fitting to minimize pipe ovality, misalignment and movement during the jointing and cooling phases.

Scrape the outer fusion surface of the pipe or spigot fitting for a length that is greater than the length of the fusion depth or the contact area of saddles, to remove oxidized material.

Perform this operation with a suitable tool such as mechanical scraper or a manual one. The use of a mechanical scraper is recommended. Either type of scraper should be maintained regularly, e.g. sharpness of the blade. Scraping shall be performed around the entire circumference of the pipe or spigot fitting end. For a visible check of scraping after the fitting is installed, allow at least +5 mm to the area covered by the fitting. The scraping depth shall be specified in the jointing procedure and shall not be less than 0,15 mm.

Inadequate scraping of pipes and spigot fittings will lead to failure of the joint.

B.4.3 Electrofusion socket fittings

Where the pipe end is not perpendicular to the axis or there is significant toe-in, cut the pipe square to the pipe axis using, for example a plastic-pipe cutter or a fine-toothed saw with a cutting guide. Cutting the pipe ends square is of paramount importance.

The following conditions shall be avoided:

- incompletely covered fusion zones by the inserted pipe, e.g. due to uneven pipe end(s) or incomplete pipe insertion depth;
- presence of chips and saw dust;
- strong draught in the pipe (e.g. pipe placed in vertical position).

NOTE In extreme cases, a combination of the above points can potentially lead to serious failures including the burning of the electrofusion fittings.

Deburr the edges with a scraper or deburring tool. Re-round the pipe ends if necessary.

Scrape the fusion area of the pipe or spigot ends. If required and/or necessary, clean the scraped areas and the fitting's fusion surface using only suitable cleaning materials. Allow cleaning solvent to evaporate completely. Make sure that the pipe depth penetration into the socket can be checked (for example by marking the penetration depth). Slide the socket fitting on to the spigot ends to the correct depth.

If tie-ins are used (see [Figure B.2](#)), scrape and clean the pipe over the complete length of the fitting (i.e. double insertion depth), mark insertion depth on both pipe ends, remove from the coupler the centre stop(s) if present, push the full length of the electrofusion socket on to one of the pipe ends and, after clamping both pipe ends, push it back so that both pipe ends are covered. Check the depth of penetration of both pipe ends.

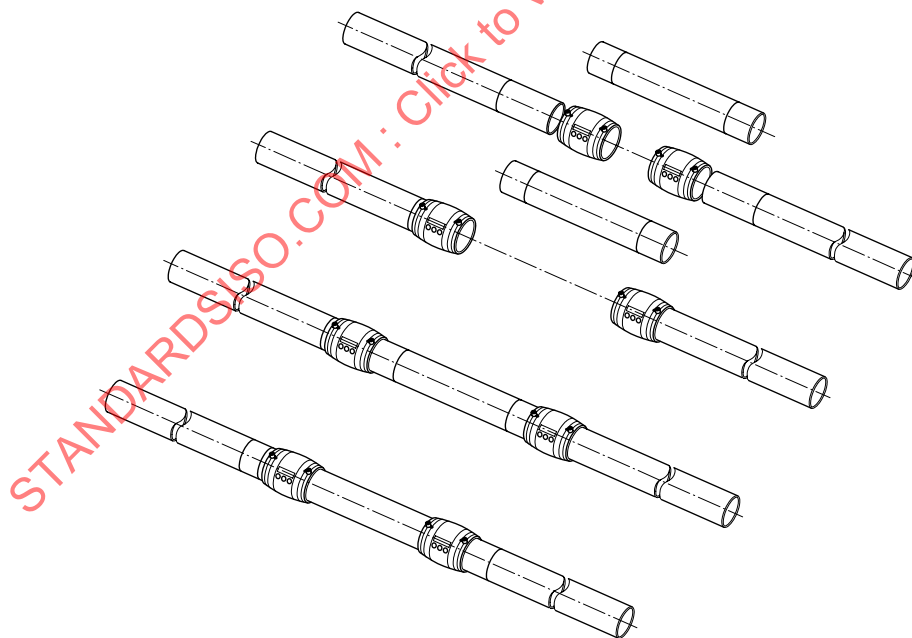


Figure B.2 — Use of tie-ins

Fit an alignment clamp and/or positioning clamp and check the alignment of the pipe ends.

B.4.4 Electrofusion saddle fittings

Re-round the PA-U pipe when necessary. Scrape the fusion area of the pipe. If required and/or necessary, clean the scraped areas only using suitable cleaning materials. Allow cleaning solvent to evaporate completely.

Place the saddle on the pipe in accordance with the installation instructions. If required, put an assembly tool on the pipe and/or saddle in accordance with the fitting manufacturer's installation instructions (see [Figure B.3](#)). After assembly, check that there is no gap between the saddle fitting and the pipe.

For the purpose of connecting to different main diameters, some saddle designs allow a close fit adaption of the saddle onto the pipe using appropriate clamping tools, according to the manufacturer's instructions.

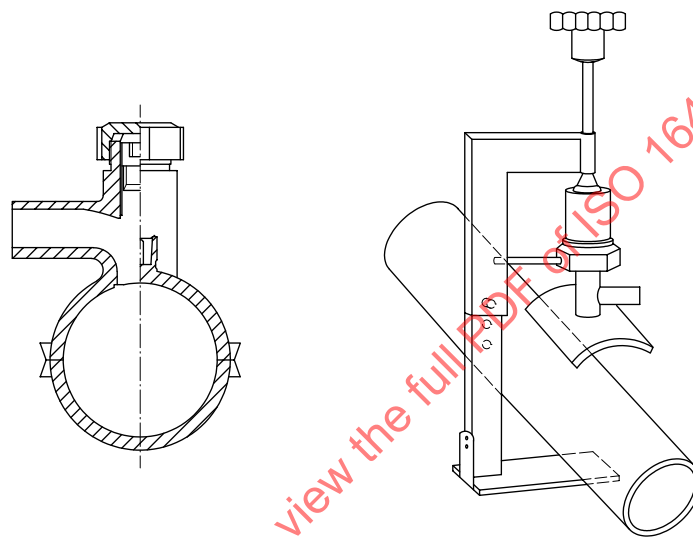


Figure B.3 — Example of installation of a saddle fitting

B.4.5 Electrofusion operations

Check that all joints are installed free of tension and insertion depths are respected correctly.

Set the control unit to give the correct fusion parameters.

Connect electrofusion control unit cable leads to electrofusion fitting terminals.

In the case of an automatic process, use the procedure suitable for the fitting and the control unit concerned. Automatic recognition systems for electrofusion fittings shall meet with ISO 13950 and/or ISO 12176-5. The operator badge shall meet with ISO 12176-3. Traceability coding shall meet with ISO 12176-4 and/or ISO 12176-5. Two-dimensional data coding of components and data exchange format for PA-U piping systems shall meet with ISO 12176-5. For non-automatic control units, follow the manufacturer's instructions.

Before the start of the fusion cycle, check that all joints are installed free of angular deflection and insertion depths are respected correctly.

Stand clear (e.g. > 1 m) of the fitting and do not disturb pipe or fitting while fusion is in progress.

Check that the fusion cycle has been completed correctly without any error message from the electrofusion control unit, and any heating indicators have operated properly.

For non-automatic electrofusion control units check the jointing record(s) to ensure that the fusion parameters like fusion energies, resistances, voltages, fusion cycle times, temperatures, etc. are in order.

B.4.6 Cooling

Leave the joint clamped for the time required for it to cool. Cooling times are normally prescribed by the fitting manufacturer and are given in the jointing procedure.

When the clamps are removed, the pipe shall be handled with care until the cooling time for rough handling has been completed.

For saddle fittings, follow the manufacturer's recommended cooling time before tapping the pipe.

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Annex C **(normative)**

Mechanical jointing

C.1 General

All mechanical joints shall be resistant to end load as specified in ISO 17885, as applicable.

The metal parts of fittings shall be corrosion-resistant or protected against corrosion.

All mechanical joints shall be assembled as specified in the jointing procedure and in accordance with the manufacturer's instructions, the design pressure of the network and the materials used. The joint shall be assembled free of stress.

Mechanical jointing systems include:

- a) steel stub flanges, pre-mounted to a polyamide pipe, and with a loose backing flange;
- b) pre-mounted or over-molded steel-to-polyamide transition fittings;
- c) compression-type couplings and fittings.

The polyamide pipe shall not be weakened in the coupling and any lubricant used shall not be detrimental to the polyamide pipe.

PA-U pipes shall not be threaded.

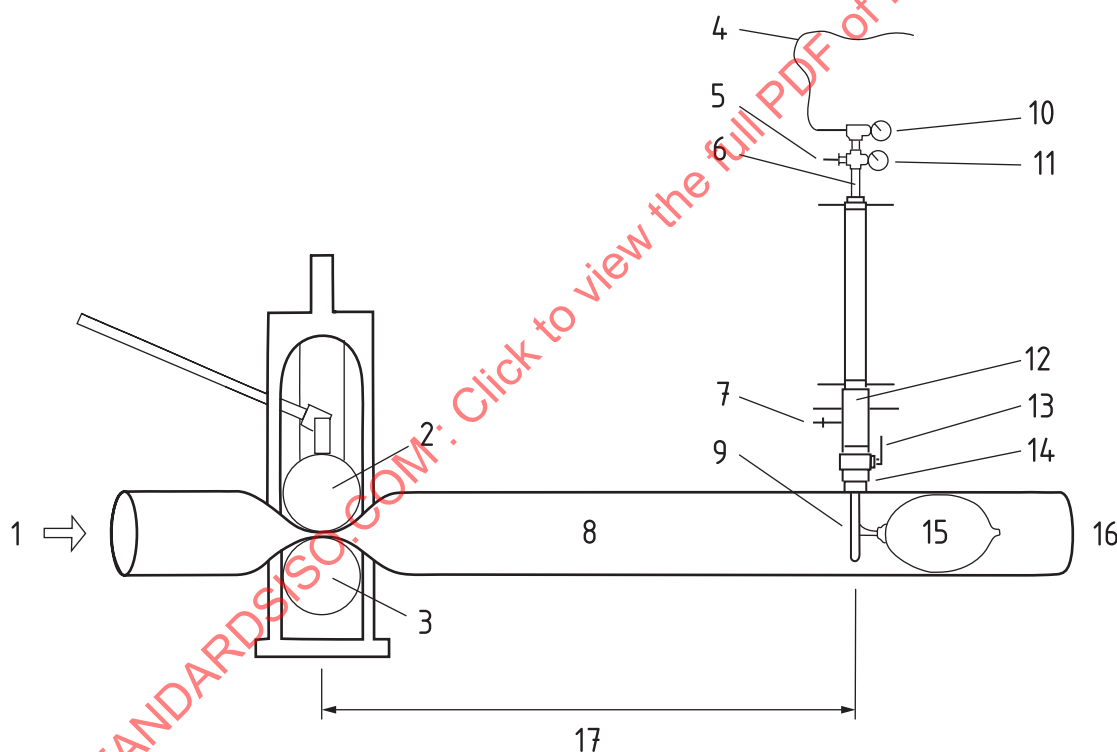
Design and installation factors may affect the minimum allowed bending radii of piping connected by mechanical joint, e.g. SDR(s). Information on the minimum allowed bending radii and/or on the use of stiffeners should be provided by the mechanical fitting manufacturer. If stiffeners are used, they shall conform to ISO 17885:2021, Annex B.

Annex D (informative)

Squeeze-off and re-rounding

D.1 General

For pipes at operating pressures higher than 1 bar,²⁾ squeeze-off is used for a temporary shut of the gas flow, which makes it possible to work downstream from the squeezed zone, while the pipe upstream remains pressurized. In case of lower pressures, a single squeeze-off device can potentially be suitable to shut the pipe. For higher pressures, a single squeeze-off cannot guarantee the prevention of creeping gas, so the double shut and degas method is recommended. [Figure D.1](#) shows the squeeze-off device with a moving bar (key element 2) and a fixed bar (key element 3) and as second shut-off a balloon setting and degassing device, which enables potentially creeping gas (key element 8) to bleed out through a bypass (key element 4).



Key

- 1 operating pressure
- 2 moving bar
- 3 fixed bar
- 4 bypass for decompression of interspace
- 5 connection to fill the bag
- 6 bag setting rod
- 7 decompression port
- 8 potentially leaking gas (interspace pressure)
- 9 balloon setting tube

2) 1 bar = 0,1 MPa = 10^5 Pa; 1 MPa = 1 N/mm².