

# Plastics piping systems for the supply of gaseous fuels for maximum operating pressures up to and including 2 MPa (20 bar) — Polyamide (PA)

## Part 6: Code of practice for design, handling and installation

ICS 75.200; 83.140.30

## National foreword

This British Standard is the UK implementation of ISO 22621-6:2010.

The UK participation in its preparation was entrusted to Technical Committee PRI/88/2, Plastics piping for pressure applications.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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## **Plastics piping systems for the supply of gaseous fuels for maximum operating pressures up to and including 2 MPa (20 bar) — Polyamide (PA) —**

### **Part 6: Code of practice for design, handling and installation**

*Systèmes de canalisations en matières plastiques pour la distribution  
de combustibles gazeux pour des pressions maximales de service  
inférieures ou égales à 2 MPa (20 bar) — Polyamide (PA) —*

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



Reference number  
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## Foreword

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

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

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

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 22621-6 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*.

ISO 22621 consists of the following parts, under the general title *Plastics piping systems for the supply of gaseous fuels for maximum operating pressures up to and including 2 MPa (20 bar) — Polyamide (PA)*:

- *Part 1: General*
- *Part 2: Pipes*
- *Part 3: Fittings*
- *Part 5: Fitness for purpose of the system*
- *Part 6: Code of practice for design, handling and installation*

## **Introduction**

This part of ISO 22621 addresses the common basic principles for gas supply systems. More detailed national standards or codes of practice might exist in the ISO member countries. This part of ISO 22621 is intended to be applied in association with those national standards or codes of practice related to the above-mentioned basic principles.





# Plastics piping systems for the supply of gaseous fuels for maximum operating pressures up to and including 2 MPa (20 bar) — Polyamide (PA) —

## Part 6: Code of practice for design, handling and installation

### 1 Scope

This part of ISO 22621 specifies a code of practice dealing with polyamide (PA) piping systems, intended to be buried outside buildings and used for the supply of gaseous fuels.

It is applicable to mains and service lines, the components of which are prepared for jointing by scraping and/or machining, and gives instructions for the design, storage, handling, transportation, laying conditions and fusion quality control of PA pipes and fittings up to and including 250 mm outside diameter, as well as subsequent joint testing, backfilling, pipe system testing, commissioning and decommissioning.

The jointing methods covered by this part of ISO 22621 are butt fusion jointing and electrofusion jointing.

No special precautions are necessary for areas exposed to the influence of mining and earthquakes other than those precautions mentioned in this part of ISO 22621.

It is the responsibility of users of this part of ISO 22621 to take existing and new national regulations into account.

### 2 Normative references

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

ISO 12162, *Thermoplastics materials for pipes and fittings for pressure applications — Classification, designation and design coefficient*

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*

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

ISO 22621-1, *Plastics piping systems for the supply of gaseous fuels for maximum operating pressures up to and including 2 MPa (20 bar) — Polyamide (PA) — Part 1: General*

ISO 22621-2, *Plastics piping systems for the supply of gaseous fuels for maximum operating pressures up to and including 2 MPa (20 bar) — Polyamide (PA) — Part 2: Pipes*

ISO 22621-3, *Plastics piping systems for the supply of gaseous fuels for maximum operating pressures up to and including 2 MPa (20 bar) — Polyamide (PA) — Part 3: Fittings*

ISO 22621-5, *Plastics piping systems for the supply of gaseous fuels for maximum operating pressures up to and including 2 MPa (20 bar) — Polyamide (PA) — Part 5: Fitness for purpose of the system*

### **3 Terms and definitions**

For the purposes of this document, the terms, definitions, symbols and abbreviated terms given in ISO 22621-1 and ISO 22621-5 and the following apply.

**3.1 butt fusion machine pressure**  
pressure indicated on the manometer or on a pressure display on a butt fusion machine, giving an indication of the interface force applied to the pipe or fitting ends

**3.2 clearance**  
shortest distance between the outer limits of two objects

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

**3.4 electrofusion control box**  
unit 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

**3.5 frictional losses in the butt fusion machine**  
force necessary to overcome friction in the whole mechanism of a butt fusion machine

**3.6 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

**3.7 operator**  
person authorized to build PA systems from pipes or fittings, based on a written procedure agreed on by the pipeline operator

**3.8 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

### 3.9

#### **pipeline operator**

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

### 3.10

#### **soil cover**

vertical distance between the top of a buried pipe and the normal surface after finishing work

## 4 Symbols and abbreviated terms

$d_e$  outside diameter of pipe at any point

MOP maximum operating pressure

MRS minimum required strength

RCP rapid crack propagation

SDR standard dimension ratio

## 5 Design

### 5.1 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, 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, 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 17 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 shall be in accordance with the requirements of the jointing procedures.

General guidelines for supervision and quality control are given in Clause 8.

### 5.2 Materials, components and jointing equipment

The PA materials and components used shall conform to ISO 22621-1, ISO 22621-2 and ISO 22621-3, as relevant.

Other components not covered by the above-mentioned parts of ISO 22621 shall conform to the relevant national standards.

If pipes and fittings are to be stored outside, requirements on maximum storage time shall be given in the laying procedure. PA materials shall be stabilized to give protection against a UV radiation level of 3,5 GJ/m<sup>2</sup>. It is desirable that national bodies give recommendations for allowed storage times in their countries.

The fusion equipment used for the construction of the pipeline shall comply with 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.

### 5.3 Maximum operating pressure

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 system depends on the type of resin used (the MRS), the pipe SDR series and the service conditions, and is limited by the overall service (design) coefficient,  $C$ , and the RCP criteria.

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 greater than or equal to 2 for PA pipeline systems for natural gas.

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

NOTE The derating factor,  $D_F$ , is a coefficient used in the calculation of the MOP which takes into account the influence of the operating temperature. Derating factors for various operating temperatures are given in Annex A.

The ratio of the critical RCP pressure to the MOP shall be  $\geq 1,5$  at the minimum operating temperature. The critical RCP pressure is dependent on temperature, pipe size and type of PA material used. It is defined in this subclause in accordance with ISO 22621-1, based on the full-scale test method in accordance with ISO 22621-1:2007, Annex C, which specifies a test temperature of 0 °C.

Where the pipe temperature decreases below 0 °C, the  $p_c$ /MOP ratio shall be recalculated using a  $p_c$  (critical pressure) value determined from the minimum expected operating temperature of the pipe. If necessary, the value of the MOP shall be reduced so as to maintain the  $p_c$ /MOP ratio at a value  $\geq 1,5$ .

### 5.4 Assembly techniques

Joining procedures may vary depending on the pipe size used.

Fusion is the preferred joining method. Preference shall be given to butt fusion and electrofusion.

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

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

Components made from polyamide 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 operator, and the quality control methods to be used.

### 5.5 Squeeze-off properties

When squeeze-off techniques are considered, the suitability of the pipe for squeeze-off shall be established in accordance with the manufacturer's recommendations.

## 6 Installation

### 6.1 Joining procedure

The joining operation shall be performed in accordance with the pipeline operator's written procedure and shall take into account the procedures outlined in ISO 22621-5:2010, Annex A, for butt fusion jointing and ISO 22621-5:2010, Annex B, for electrofusion jointing.

Polyamide pipes, fittings and accessories may be jointed by heated-tool fusion jointing or electrofusion 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 and take into account the requirements of ISO 22621-5.

## 6.2 Training

The operator shall be competent in the appropriate laying and jointing methods. He or she shall possess the necessary skill and knowledge to produce joints of consistently high quality.

Operators shall receive formal training under the supervision of a qualified instructor. The gas company may require a certificate indicating that the operator has reached an adequate standard in accordance with national or local regulations.

## 6.3 Heated-tool fusion jointing

### 6.3.1 General

Heated-tool fusion joints shall be made under defined conditions of pressure, time and temperature, using a written procedure (see 6.1). Mating surfaces should be heated to their fusion temperature and then brought into contact with one another.

### 6.3.2 Fusion temperature

The production of a strong fusion bond depends, among other things, on the fusion temperature of the polyamide material: overheating can degrade the material, and insufficient heating does not soften it adequately.

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

Cold weather and wind can adversely affect the fusion temperature. Under these circumstances, special precautions, such as shielding, end caps and longer heating times shall be considered.

### 6.3.3 Fusion equipment

The butt fusion equipment used shall conform to ISO 12176-1.

As high-quality fusion joints cannot be made with fusion equipment in poor condition, maintenance 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 when used are of paramount importance.

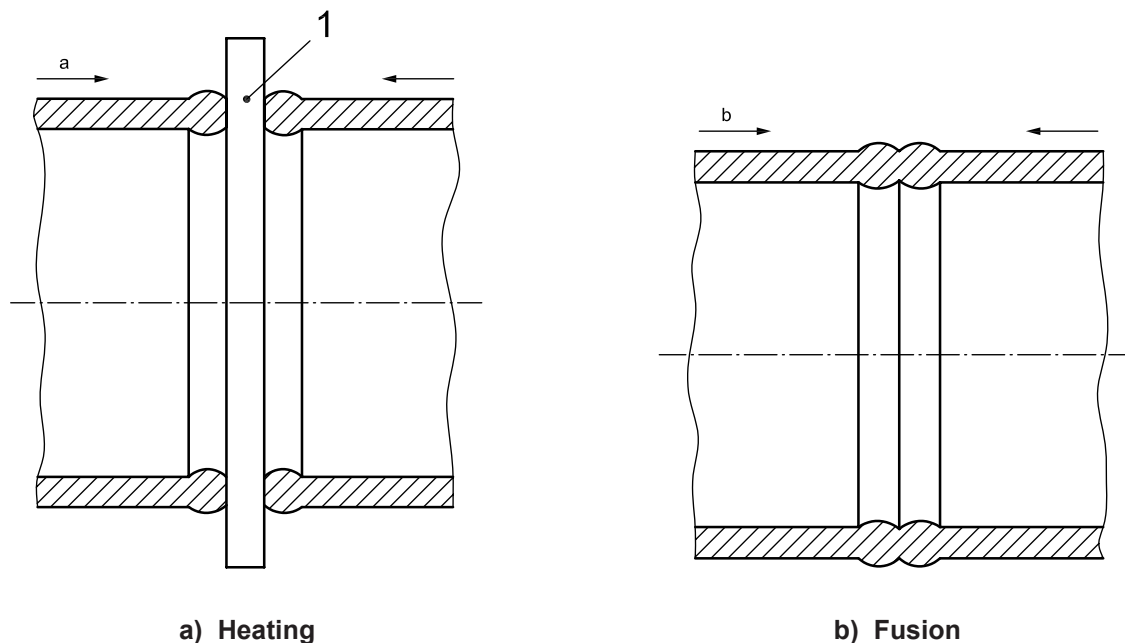
The heating tools are designed to maintain uniform temperatures within the fusion temperature range of the particular polyamide material and shall have calibrated means of measuring and indicating the temperature. A precise temperature measurement device, such as a pyrometer or a digital thermometer 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.

### 6.3.4 Butt fusion

#### 6.3.4.1 Principle

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



#### Key

- 1 heating plate
- a Pressure during heating.
- b Pressure during fusion.

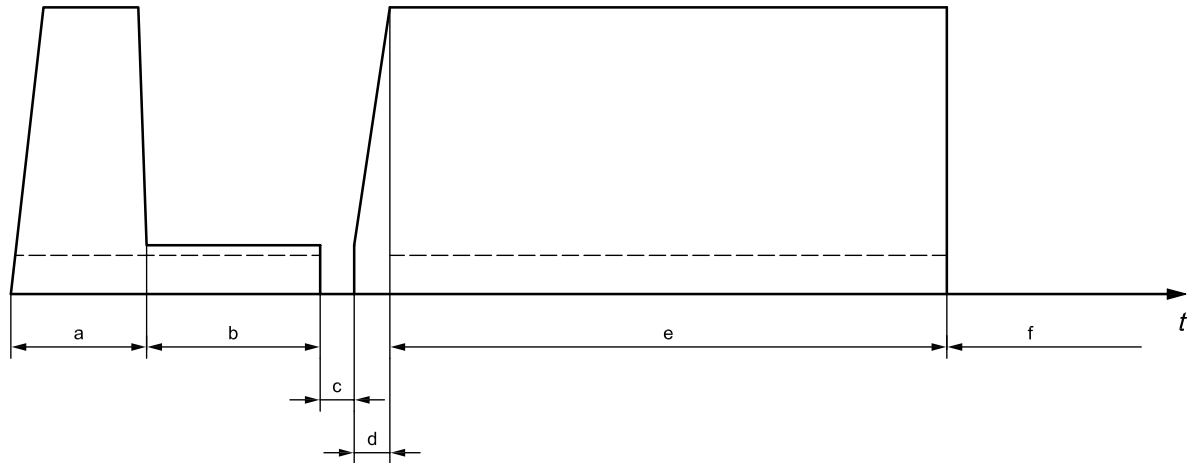
Figure 1 — Butt fusion

Pipes or fittings with fusion ends of different SDR values shall not be jointed by butt fusion.

#### 6.3.4.2 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 pipe diameter and the working conditions. The butt fusion cycle used shall be specified in the written procedure.

Figure 2 is an example of a butt fusion diagram.



**Key**

- $t$  time
- a Phase 1.
- b Phase 2.
- c Phase 3.
- d Phase 4.
- e Phase 5.
- f Phase 6.

**Figure 2 — Butt fusion cycle**

**Table 1 — Butt fusion cycle and parameters**

Parameter		Value	Unit
Heater-plate temperature, $T$		$240 \pm 20$	$^{\circ}\text{C}$
Phase 1	Pressure, $p_1^a$	$0,3 \pm 0,1$	$\text{MPa}^b$
	Time, $t_1$	Measured as the time until $B_1$ is reached	s
	Bead width, $B_1$	$d_n \leq 110$ : $0,5 < B_1 \leq 1,5$ $110 < d_n \leq 180$ : $2 < B_1 \leq 4$	mm mm
Phase 2	Pressure, $p_2^a$	$0,03 \pm 0,02$	$\text{MPa}$
	Time, $t_2$	$(30 + 0,5d_n) \pm 20$	s
Phase 3	Time, $t_3$	Maximum value: 3	s
Phase 4	Time, $t_4$	Maximum value: 3	s
Phase 5	Pressure, $p_5^a$	$0,3 \pm 0,1$	$\text{MPa}$
	Time, $t_5$	$12 \pm 3$	min
Phase 6	Time, $t_6$	Minimum value: $1,5e_n$	min
		Maximum value: 20	min
<sup>a</sup> This pressure is the interface pressure and is related to $d_n$ , $e_n$ and the butt fusion equipment used. <sup>b</sup> $1 \text{ MPa} = 1 \text{ N/mm}^2$ .			

The pressures shall be chosen such 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 hydraulic power rams, the force is normally indicated in terms of the applied cylinder pressure. For such machines, a specific calibration table is provided which gives the relationship between the real interface pressure and the pressure indicated by the manometer (pressure gauge).

#### 6.3.4.3 Butt fusion temperature

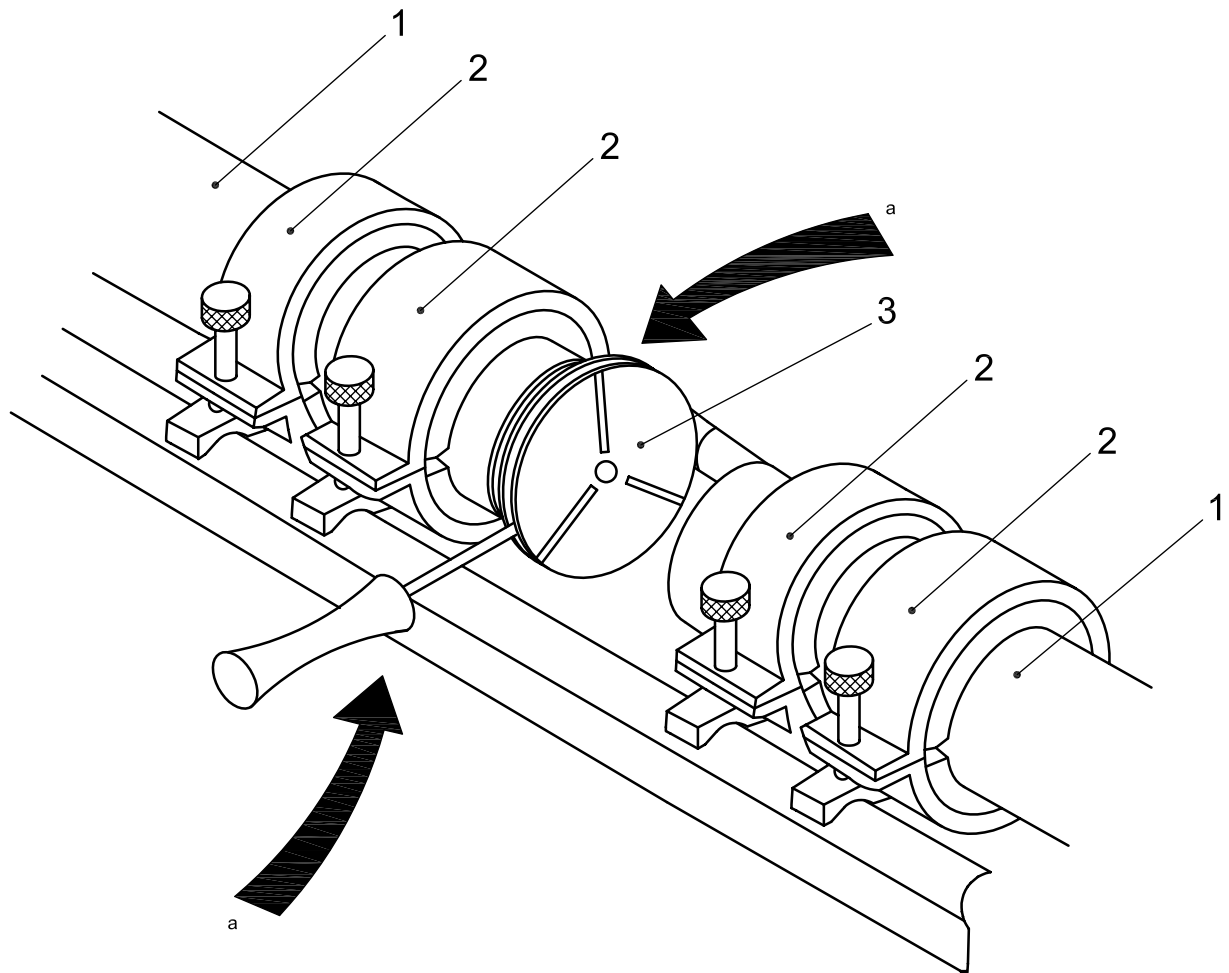
The butt fusion temperature is normally situated between 220 °C and 260 °C and is given in the jointing procedure.

#### 6.3.4.4 Butt fusion jointing

This subclause gives an overview of the minimum operations necessary to produce a butt fusion joint with a specified butt fusion cycle and temperature.

- a) Reduce the drag resistance as much as possible, for example by using pipe rollers.
- b) Clamp the spigot ends of the pipe(s) or fitting(s) in the butt fusion machine.
- c) Clean the spigot ends.
- d) Check that the butt fusion machine is compatible with the pipe diameter and the prescribed butt fusion cycle.
- e) Plane the pipes parallel by moving the movable clamp against the planing tool (see Figure 3). The closing pressure shall be sufficient to produce a steady flow of PA slivers on both sides of the planing tool. Planing is complete when the pipe face(s) or fitting face(s) are plane and parallel to each other.





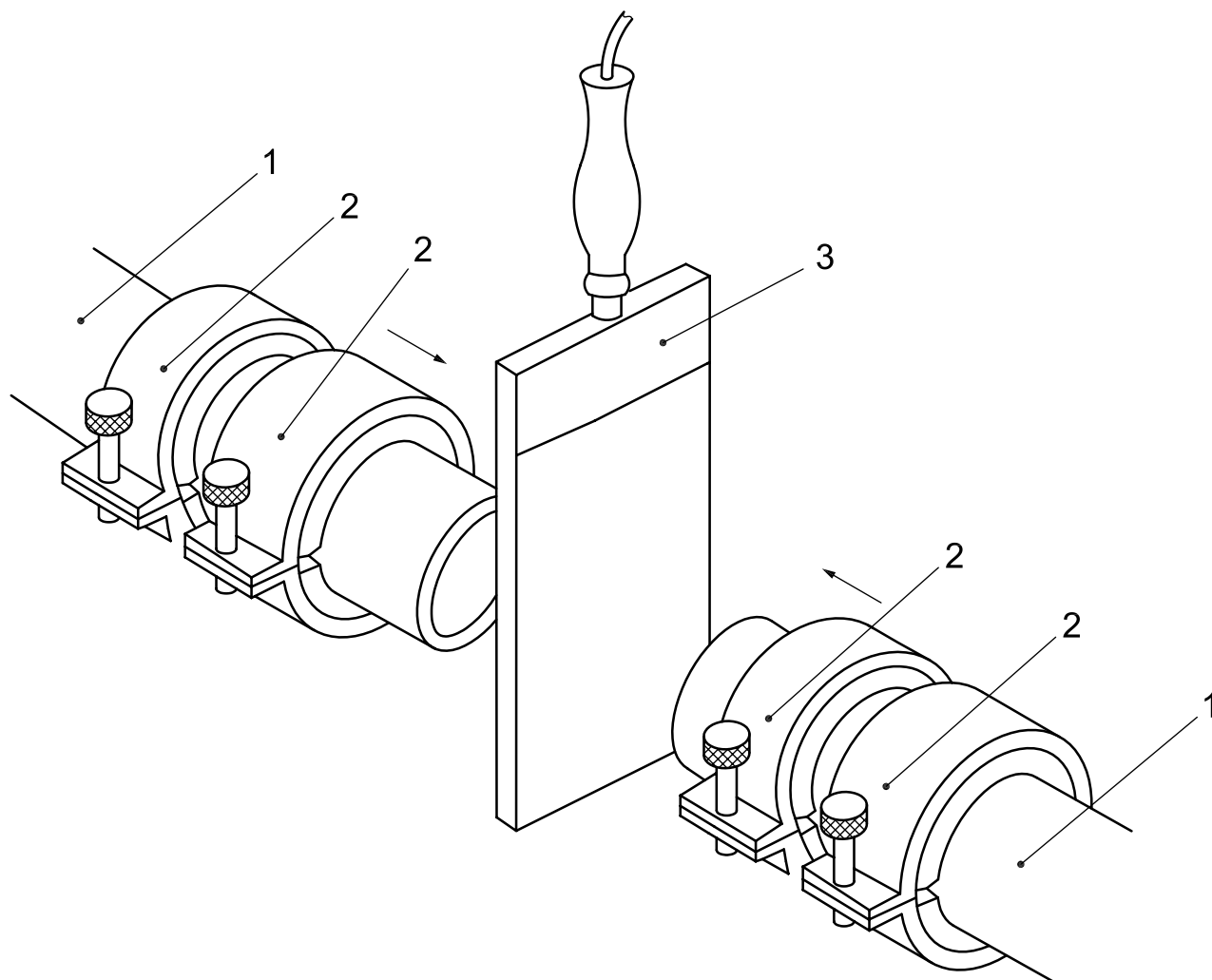
**Key**

- 1 pipe
- 2 clamp
- 3 planing tool
- a Direction of planing.

**Figure 3 — Planing the spigot ends of pipes**

- f) Lower the pressure, keeping the planing tool rotating in order to avoid a burr on the pipe or fitting faces. Move the movable clamp backwards and remove the planing tool.
- g) Close the butt fusion machine and check that the pipes are aligned. The spigot ends of pipe(s) or fitting(s) shall be aligned as much as possible and not exceed the maximum misalignment given in the jointing procedure.
- h) The gap between the pipe or fitting faces after planing shall be as small as possible and shall not exceed the maximum gap given in the jointing procedure.
- i) Measure the additional pressure caused by the frictional losses in the butt fusion machine and the drag resistance by moving the movable clamp forwards. Add this pressure to the required butt fusion pressure.
- j) If necessary, clean the fusion surfaces and the heating plate.

- k) Check that the surface coating of the heating plate is intact and without scratches.
- l) Check that the heating plate is at the correct fusion temperature.
- m) Place the heating plate between the pipe faces. Close the butt fusion machine against the heating plate to apply the fusion pressure, including the measured additional pressure, until the specified bead width has been reached (see Figure 4).



**Key**

- 1 pipe
- 2 clamp
- 3 heating plate

**Figure 4 — Heating the spigot ends of pipes**

- n) Reduce the pressure to a level at which contact is just maintained between the pipe ends and the heating plate.
- o) When the heat soak time has elapsed, open the butt fusion machine and remove the heating plate. Check the heated pipe ends quickly for possible damage to the melted ends caused by the removal of the heating 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.

- p) Store the heating plate in a protective enclosure when not in use.
- q) The butt fusion machine shall remain closed and under pressure during the whole butt fusion time and subsequent cooling period. It is important that the cooling period be respected.
- r) When the butt fusion and cooling times have elapsed, release the pressure in the butt fusion machine.
- s) When removed, the pipe shall be handled with care.

## 6.4 Electrofusion jointing

### 6.4.1 General

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.

### 6.4.2 Temperature

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.

### 6.4.3 Electrofusion equipment

The electrofusion equipment shall conform to ISO 12176-2.

As high-quality fusion joints cannot be made with fusion equipment in poor condition, maintenance of the fusion equipment is very important and shall be carried out on a regular basis.

As some types of fusion equipment are only suitable for use with fittings of a particular make and other types for use with electrofusion fittings of other makes, the jointing procedure shall specify the type of fusion equipment used.

The electrofusion control box is designed to provide, using an electrical power source (generator or domestic supply), the correct fusion parameters for the fitting, taking into account, if required, the ambient temperature. The fusion parameters are the applied voltage or current and the fusion time.

If a generator is used as the electrical power source, it shall be able to deliver the power required by the fitting, taking into account the electrical characteristics of the control box and the generator. Generators shall have suitable protection and security devices in accordance with relevant standards.

In some cases, the control box and generator may be available as a combined unit.

### 6.4.4 Electrofusion

#### 6.4.4.1 Preparation

The following procedure gives an overview of the minimum operations necessary to prepare for electrofusion jointing.

##### a) General

Electrofusion fittings shall be kept in their protective wrapping until they are ready to be joined to a pipe or spigot fitting. The surfaces fused shall be dry 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 rerounding and alignment 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 to remove oxidized material. Perform this operation with a suitable tool, such as a manual or mechanical scraper. The use of a mechanical scraper is recommended. Scraping shall be performed round the entire circumference of the pipe or spigot fitting end. The scraping depth shall be specified in the jointing procedure.

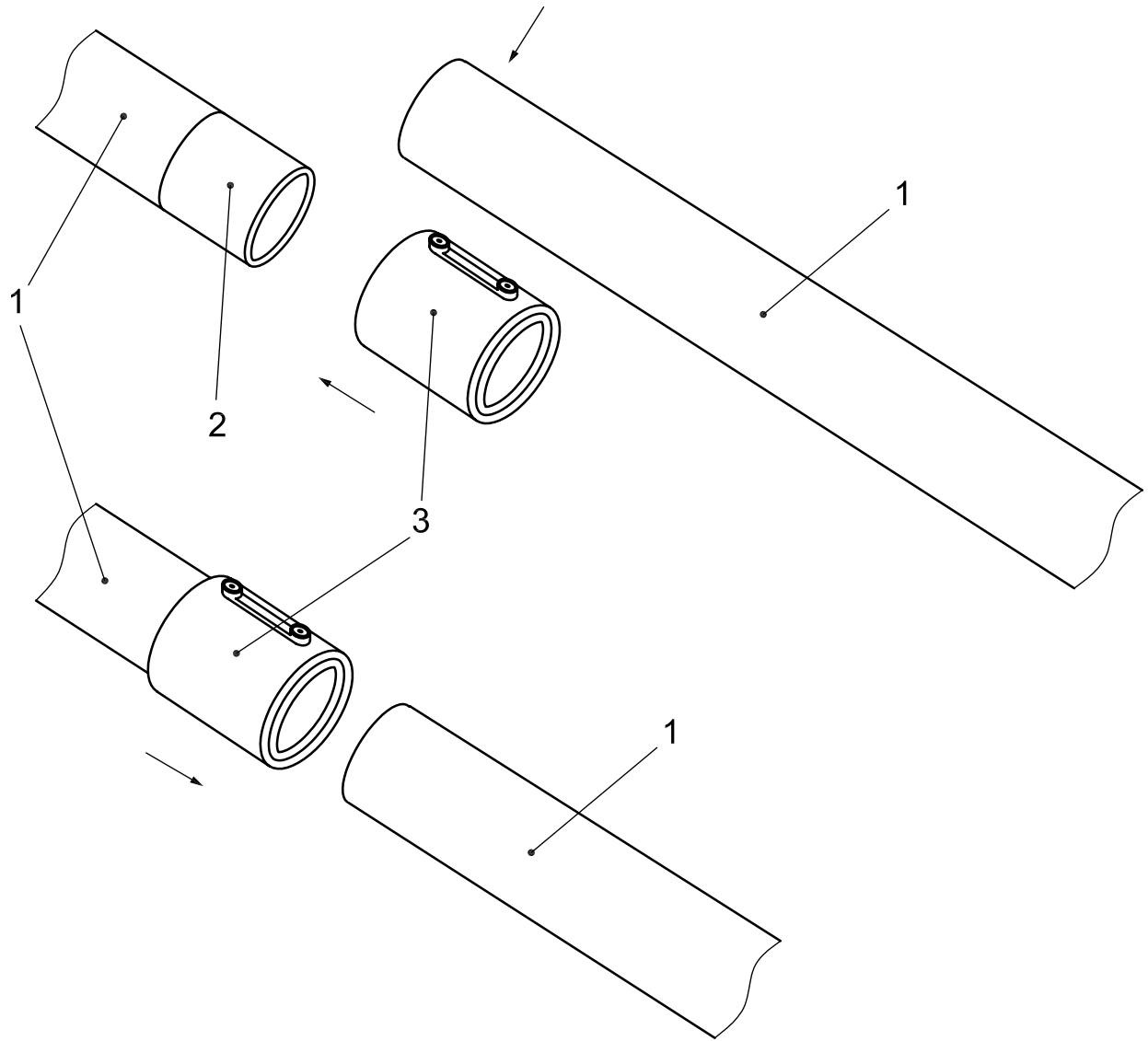
#### **b) Electrofusion fittings with socket ends**

Cut the pipe square to the pipe axis using either a plastic-pipe cutter or a fine-toothed saw with a cutting guide. Deburr the inside edges with a knife.

Scrape the fusion area of the pipe or spigot ends. If required or necessary, clean the fusion area.

Make sure that the penetration can be checked (e.g. by marking the penetration depth). Slide the socket fitting onto the spigot ends and locate it correctly.

If tie-ins are used (see Figure 5), push the full length of the electrofusion socket onto one of the pipe ends and, after clamping both pipe ends, push it back such that both pipe ends are covered. Check the depth of penetration of both pipe ends.



**Key**

- 1 pipe
- 2 pipe end
- 3 tie-in

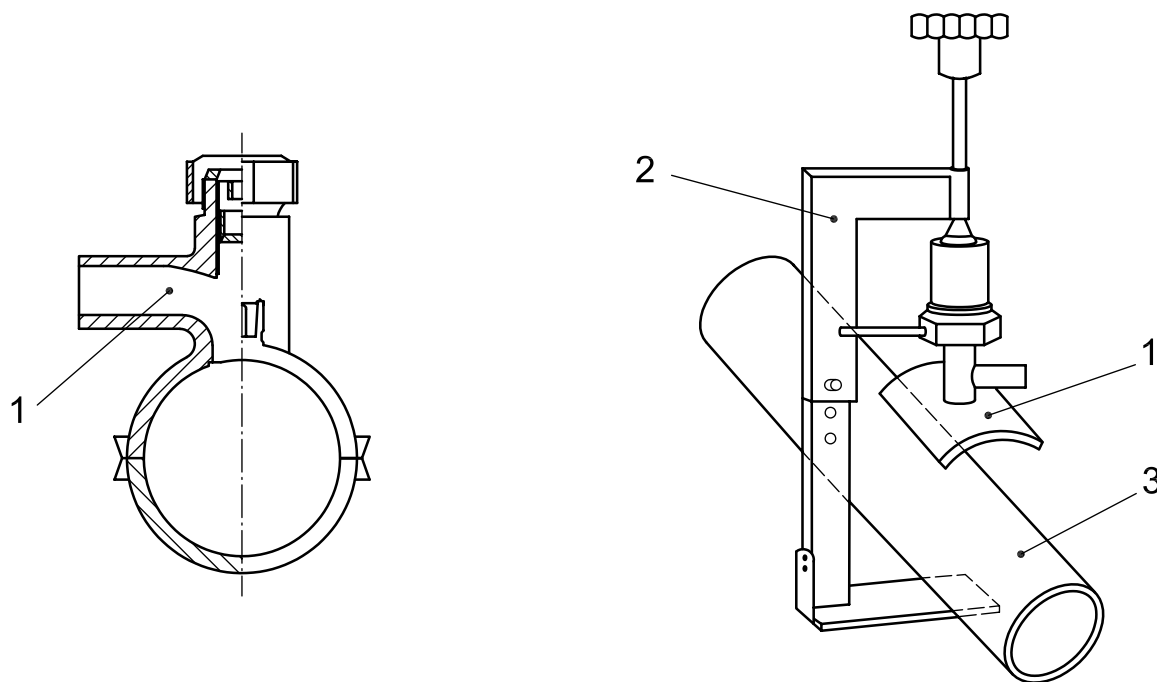
**Figure 5 — Use of tie-ins**

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

**c) Electrofusion saddle fittings**

Scrape the fusion area of the pipe. If required or necessary, clean the fusion area.

Place the saddle on the pipe in accordance with the installation instructions. If required, put an assembly tool on the pipe or saddle in accordance with the fitting manufacturer's installation instructions (see Figure 6).



**Key**

- 1 saddle
- 2 assembly tool
- 3 pipe

**Figure 6 — Example of installation of a saddle**

**6.4.4.2 Electrofusion operation**

Set the control box to give the correct fusion parameters (e.g. voltage or current, times).

In the case of an automatic process, use the procedure suitable for the fitting and the control box concerned.

Check that the fusion cycle has been correctly completed.

**6.4.4.3 Cooling**

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

When the clamps are removed, the pipe shall be handled with care.

**6.5 Laying**

**6.5.1 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.

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

The normal minimum clearance shall be  $\geq 200$  mm. 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 a hot water or steam pipeline, a petrol-carrying pipe, a petrol station or a high-voltage cable.

The position of the pipeline shall be recorded before backfilling.

To minimize the possibility of damage to the pipeline by external influences, one of the following measures can be taken:

- a) place a warning device, for example a hazard tape, along the top of the pipe;
- b) place a tracer wire at the same depth as the pipe 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.

### 6.5.2 Trench

Excavating and backfilling of the trench shall be in accordance with the written procedure.

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.

In uniform, relatively soft and 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, it may be permissible to lay pipes of all nominal sizes without the need for special preparation of the trench bottom.

### 6.5.3 Drag forces

Pipes shall not be overstressed by tensile forces during laying. If the pipe is laid by drag, care shall be taken so that the drag force is not greater than the values given by Equation (2):

$$F = \frac{14\pi d_e^2}{3 \times \text{SDR}} \quad (2)$$

where

$F$  is the maximum drag force, in newtons;

SDR is the standard dimension ratio;

$d_e$  is the external diameter of the pipe, in millimetres;

Stresses caused by differences in temperature between laying and operation shall also be taken into consideration.

### 6.5.4 Metal-body valves

Valves are available with a metal body. With metal body valves, precautions shall be taken against corrosion.

Metal-body valves shall be installed, such that they do not expose the PA pipe to unnecessary stress during opening or closing.

### 6.5.5 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.

### 6.5.6 Backfilling

Unless otherwise specified, buried pipelines and casings shall have a minimum soil cover of 0,6 m. 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 they are free of stones and sharp objects likely to damage the pipe. If not, imported backfill may be used.

NOTE Attention is drawn to the need to take any applicable national or local regulations concerning backfill materials and minimum soil cover into account.

The pipe shall be uniformly supported; material around the pipe shall be compacted according to installation practice, so as to avoid excessive pipe ovality.

### 6.5.7 Pressure testing and commissioning

Pressure testing and commissioning shall be in accordance with EN 12327.

The test pressure selected for a pipeline shall be appropriate to its MOP.

NOTE Attention is drawn to the possible need to take national regulations concerning pipeline pressures into account.

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 shall be taken into account in the pipeline preparation and test procedure adopted.

Pressurized PA pipelines at ambient temperature are subject to expansion by creep, which 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.

## 7 Storage, handling and transport

### 7.1 General

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

Mishandling of the pipes and fittings shall be avoided. Poor handling techniques can result in gouges, scratches, cuts or holes (see 8.3.1).

### 7.2 Storage

Straight pipes shall be stacked on a reasonably flat surface, free of stones, 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, piercing or extended exposure to direct sunlight.

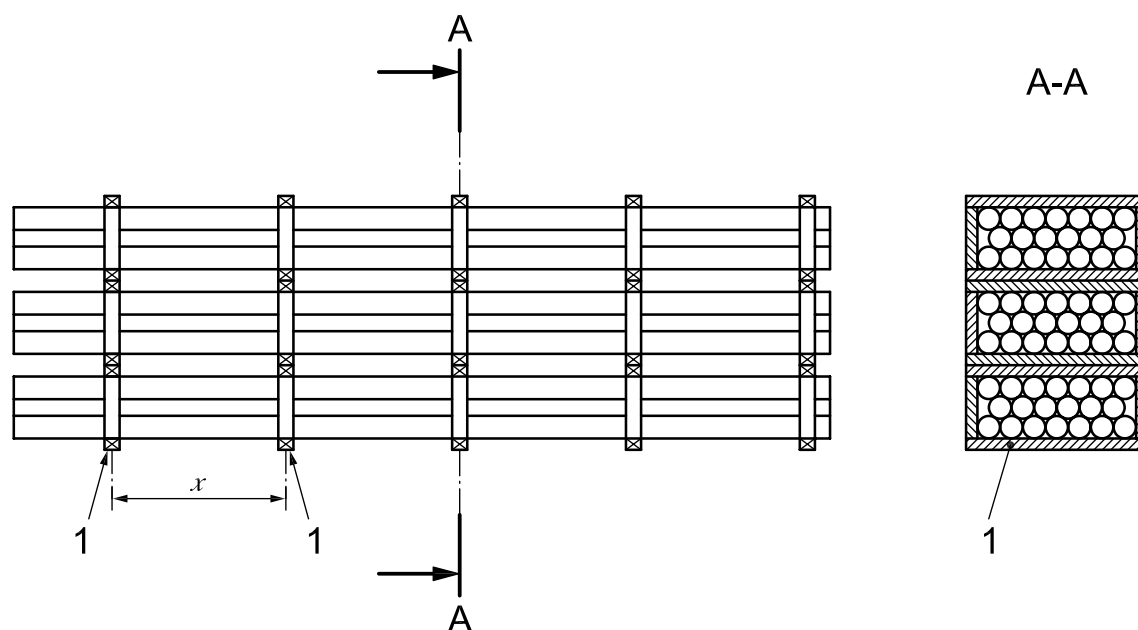


Pipes may be stored outside in direct daylight, provided the storage time is monitored and minimized to avoid exposure to excessive levels of UV radiation likely to impair the properties of the product relative to its “as purchased” condition. Maximum permissible storage times vary depending on geographical location, for example in Northern Europe a two-year outside-storage time would be considered acceptable, whilst storage at sites exposed to strong UV light could require exposure limits as low as three months. Guidance from the product manufacturer should be sought to establish local requirements.

The distances,  $x$ , between support frames holding packs of pipes together shall be equal in order to allow the frames to be stacked (see Figure 7).

Straight pipes shall rest evenly over their whole length.

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



**Key**

- 1 support frame
- $x$  distance between support frames

**Figure 7 — 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. At no time shall stacking cause the pipe cross-section to be distorted. The manufacturer's stacking recommendations shall be followed.

Fittings shall be stored in their original packaging until ready for use.

Contact with aggressive reagents or solvents shall be avoided.

In general, most manufacturers store polyamide pipes outside prior to shipment. The exposure time can be minimized by shipping from the store on a “first in, first out” basis with the extrusion date used as the control. The pipes with the earliest extrusion date shall be shipped first for installation. Pipes which have been stored outside for longer than the period recommended shall only be used if tested prior to installation for conformity with ISO 22621-2.

It is recommended that the same “first in, first out” principle be used with fittings.

### 7.3 Handling

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 or fittings.

The flexibility of polyamide pipes is reduced in cold weather, and more care needs to be taken when handling them in winter. If the temperature falls below  $-15\text{ }^{\circ}\text{C}$  for straight pipes and for fittings, or below  $0\text{ }^{\circ}\text{C}$  for coiled pipes, special handling instructions shall be followed.

Initial handling and storage of straight pipes shall be made with the pipes 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 packs.

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 offloading with a crane. Personnel shall not be required to climb on to a lorry or trailer during slinging operations.

In view of their mass, coils shall be handled with the assistance of mechanical equipment. Care shall be taken during this operation since the mass of a coil can be from about 1 000 kg to about 2 000 kg.

Before laying a pipe, ensure that the coil is positioned correctly and that its axle remains stable during the uncoiling operation.

While uncoiling, check the speed of rotation and ensure that the pipe is not damaged.

If the pipe has already been uncoiled, be careful when cutting off the required length at the bent section near the drum, especially at low temperatures.

### 7.4 Transport

When transporting straight pipes, flatbed vehicles with a partition shall be used. The bed shall be free of nails and other protuberances. The pipes shall rest uniformly on the vehicle over their whole length. The vehicle shall have side posts, which are flat with no sharp edges. During transport, the pipes shall be securely held in such a way that movement between the pipes and the posts is minimized.

Coiled pipes shall be transported on a pallet or as individual coils, depending on the diameter. The coils shall be firmly secured to the vehicle.

## 8 Quality control

### 8.1 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.

### 8.2 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 and tolerance class as given by the pipe and fitting marking information.

Pipes and fittings showing obvious defects or excessive scoring shall be discarded, clearly identified as unsuitable and, where appropriate, returned to the source of supply.

Limitations on outside storage of pipes or fittings shall not have been exceeded.

The equipment used shall be in accordance with the relevant standards. A written jointing procedure shall be available.

### **8.3 Inspection during laying**

#### **8.3.1 Laying**

Soil and trench conditions shall conform to the written procedure.

If surface defects with a depth of more than 10 % of the nominal 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 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.

#### **8.3.2 Joint integrity**

##### **8.3.2.1 General**

The quality of the joint depends on strict adherence to the written jointing procedure, the use of well-maintained 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.

##### **8.3.2.2 Visual inspection criteria**

###### **8.3.2.2.1 Butt fusion joints**

###### **8.3.2.2.1.1 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.

###### **8.3.2.2.1.2 Alignment**

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

The misalignment,  $V$ , shall not exceed  $0,1e_n$  ( $e_n$  is the nominal wall thickness). Where this leads to values of less than 1 mm, testing of joints shall be undertaken to identify the maximum allowable misalignment.

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

#### 8.3.2.2.1.3 Bead width

The bead width,  $B$ , is influenced by the production process (extrusion or injection moulding), the type of heating 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,  $B$ , not exceed  $\pm 20\%$  of  $B_m$ .

The use of GO/NO-GO gauges, manufactured to these recommended limits, could facilitate checking.

#### 8.3.2.2.2 Electrofusion socket joints

##### 8.3.2.2.2.1 Pipe alignment

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

Guidance on permissible misalignment is given in ISO 22621-5:2010, Annex B.

##### 8.3.2.2.2.2 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.

There shall be clear evidence of scraping on either side of the socket. Particular attention shall be given to inspecting the underneath of the pipe.

##### 8.3.2.2.2.3 Penetration

Penetration markings shall be checked to confirm that complete penetration of the pipe or spigot ends has been achieved.

##### 8.3.2.2.2.4 Molten material

A check shall be made that molten material from the fusion process or fusion wires has not exuded from inside the fitting.

##### 8.3.2.2.2.5 Heating indicators

If the fitting is designed with heating indicators, they shall be in positions complying with the manufacturer's instructions after jointing has been completed.

##### 8.3.2.2.2.6 Cooling time

The clamps shall not be removed before the cooling time has elapsed.

##### 8.3.2.2.2.7 Position of electric wiring

Following fusion jointing, the electric coils shall not show any abnormal displacement.

## Annex A (informative)

### Derating coefficients for operating temperatures

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

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

**Table A.1 — Temperature derating coefficients**

Temperature °C	Derating coefficient DF
20	1,0
30	1,1
40	1,25

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

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

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

in which the value of the overall service coefficient, *C*, should be not less than 2.



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