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Plastics piping systems for industrial applications — Poly(vinylidene fluoride) (PVDF) — Specifications for components and the system

Systèmes de canalisations en matières plastiques pour les applications industrielles — Poly(fluorure de vinylidène) (PVDF) — Spécifications pour les composants et le système

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Foreword

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

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 10931 was prepared by Technical Committee ISO/TC 138, *Plastics pipes, fittings and valves for the transport of fluids*, Subcommittee SC 3, *Plastics pipes and fittings for industrial applications*.

This first edition of ISO 10931 cancels and replaces ISO 10931-1:1997, ISO 10931-2:1997, ISO 10931-3:1996, ISO 10931-4:1997 and ISO 10931-5:1998, of which it constitutes a technical revision.

Introduction

This International Standard specifies the characteristics and requirements for a piping system and its components made from poly(vinylidene fluoride) (PVDF) intended to be used for industrial applications, above-ground, by authorities, design engineers, certification bodies, inspection bodies, testing laboratories, manufacturers and users.

At the date of publication of this International Standard, International Standards for piping systems of other plastics used for industrial applications were ISO 15493, for acrylonitrile-butadiene-styrene (ABS), unplasticized poly(vinyl chloride) (PVC-U), chlorinated poly(vinyl chloride) (PVC-C) and ISO 15494, for polybutene (PB), polyethylene (PE), polypropylene (PP).

Plastics piping systems for industrial applications — Poly(vinylidene fluoride) (PVDF) — Specifications for components and the system

IMPORTANT — Requirements for industrial valves are given in this International Standard and/or in other International Standards. Valves may be used with components conforming to this International Standard provided they conform additionally to its relevant requirements. Where existent, national regulations for specific applications (e.g. water treatment) apply. Other application areas are permitted if the requirements of this International Standard and/or applicable national requirements are fulfilled. Relevant regulations in respect of fire behaviour and explosion risk are applicable if applications are envisaged for inflammable media. Components conforming to any of the product standards listed in the Bibliography or to national standards, as applicable, may be used with components conforming to this International Standard, provided they conform to the requirements for joint dimensions and the relevant requirements of this International Standard.

1 Scope

This International Standard specifies the characteristics and requirements for components such as pipes, fittings and valves made from poly (vinylidene fluoride) (PVDF), intended to be used for thermoplastics piping systems in the field of industrial applications above-ground.

It is applicable to PVDF pipes, fittings, valves and ancillary equipment, their joints and to joints with components of other plastics and non-plastics materials, depending on their suitability, intended to be used for the conveyance of liquid and gaseous fluids as well as of solid matters in fluids for industrial applications including

— chemical plants,

— industrial sewerage engineering,

— power engineering (cooling and general purpose water),

— electroplating and pickling plants,

— semiconductor industry,

— agricultural production plants, and

— water treatment.

This International Standard is applicable to PVDF piping systems for use at temperatures up to 150 °C. However, for applications above 120 °C, which depend upon the crystalline melting point of the PVDF material, it is advisable to seek the advice of the manufacturer of the component (the components have to withstand the mechanical, thermal and chemical demands to be expected and to be resistant to the fluids to be conveyed).

Characteristics and requirements which are applicable for PVDF in general are covered by the relevant clauses of this International Standard. Those characteristics and requirements which depend on the material used are given in Annex A.

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 7-1, *Pipe threads where pressure-tight joints are made on the threads — Part 1: Dimensions, tolerances and designation*

ISO 228-1, *Pipe threads where pressure-tight joints are not made on the threads — Part 1: Dimensions, tolerances and designation*

ISO 265-1, *Pipes and fittings of plastics materials — Fittings for domestic and industrial waste pipes — Basic dimensions: Metric series — Part 1: Unplasticized poly(vinyl chloride) (PVC-U)*

ISO 472, *Plastics — Vocabulary*

ISO 1043-1, *Plastics — Symbols and abbreviated terms — Part 1: Basic polymers and their special characteristics*

ISO 1167:1996, *Thermoplastics pipes for the conveyance of fluids — Resistance to internal pressure — Test method.* Incorporating ISO 1167:1996/Cor 1:1997

ISO 1183-2, *Plastics — Methods for determining the density of non-cellular plastics — Part 2: Density gradient column method*

ISO 2505-1:1994, *Thermoplastics pipes — Longitudinal reversion — Part 1: Determination methods*

ISO 2505-2:1994, *Thermoplastics pipes — Longitudinal reversion — Part 2: Determination parameters*

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

ISO 4065, *Thermoplastics pipes — Universal wall thickness table*

ISO 9080:2003, *Plastics piping and ducting systems — Determination of the long-term hydrostatic strength of thermoplastics materials in pipe form by extrapolation*

ISO/TR 10358, *Plastics pipes and fittings — Combined chemical-resistance classification table*

ISO 11357-3, *Plastics — Differential scanning calorimetry (DSC) — Part 3: Determination of temperature and enthalpy of melting and crystallization*

ISO 11922-1:1997, *Thermoplastics pipes for the conveyance of fluids — Dimensions and tolerances — Part 1: Metric series*

ISO 12092:2000, *Fittings, valves and other piping system components made of unplasticized poly(vinyl chloride) (PVC-U), chlorinated poly(vinyl chloride) (PVC-C), acrylonitrile-butadiene-styrene (ABS) and acrylonitrile-styrene-acrylester (ASA) for pipes under pressure — Resistance to internal pressure — Test method*

ISO 15853:1999, *Thermoplastic materials — Preparation of tubular test pieces for the determination of the hydrostatic strength of materials used for injection moulding*

ISO 12162:1995, *Thermoplastics materials for pipes and fittings for pressure applications — Classification and designation — Overall service (design) coefficient*

ISO 16135, *Industrial valves — Ball valves of thermoplastics materials* [1)]

ISO 16136, *Industrial valves — Butterfly valves of thermoplastics materials* [1)]

ISO 16137, *Industrial valves — Check valves of thermoplastics materials* [1)]

ISO 16138, *Industrial valves — Diaphragm valves of thermoplastics materials* [1)]

ISO 16139, *Industrial valves — Gate valves of thermoplastics materials* [1)]

ISO 21787, *Industrial valves — Globe valves of thermoplastics materials*

IEC 60364-1, *Electrical installations of buildings — Part 1: Scope, object and fundamental principles*

IEC 60449, *Voltage bands for electrical installations of buildings*

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 472 and ISO 1043-1, and the following apply.

3.1 Geometrical definitions

NOTE The symbols d_e and e correspond to d_{ey} and e_y given in other International Standards such as ISO 11922-1.

3.1.1
nominal outside diameter
d_n
specified outside diameter of a component which is identical to the minimum mean outside diameter, $d_{em,min}$, in millimetres

NOTE The nominal inside diameter of a socket is equal to the nominal outside diameter of the corresponding pipe.

3.1.2
outside diameter at any point
d_e
measured outside diameter through the cross-section at any point of a pipe or the spigot end of a fitting, rounded up to the next 0,1 mm

3.1.3
mean outside diameter
d_{em}
measured length of the outer circumference of a pipe or the spigot end of a fitting divided by π ($\approx$ 3,142), rounded up to the next 0,1 mm

3.1.4
mean inside diameter of a socket
arithmetical mean of two measured inside diameters perpendicular to each other

1) To be published.

3.1.5
nominal size of flange
DN
numerical designation of the size of a flange, used for reference purposes and related to the manufacturing dimension in millimetres

3.1.6
out-of-roundness
⟨pipe/spigot end of fitting⟩ difference between the measured maximum outside diameter and the measured minimum outside diameter in the same cross section of a pipe or the spigot end of a fitting

3.1.7
out-of-roundness
⟨socket⟩ difference between the measured maximum inside diameter and the measured minimum inside diameter in the same cross section of a socket

3.1.8
nominal wall thickness
e_n
wall thickness, in millimetres, corresponding to the minimum wall thickness, e_{min}

3.1.9
wall thickness at any point
e
measured wall thickness at any point around the circumference of a component, rounded up to the next 0,1 mm

3.1.10
pipe series S
S
dimensionless number related to the nominal outside diameter, d_n, and the nominal wall thickness, e_n

NOTE 1 The pipe series S is related to a given pipe geometry as shown in Equation (1):

$$S = \frac{d_n - e_n}{2e_n} \tag{1}$$

NOTE 2 Flanges are designated on the basis of PN.

3.1.11
standard dimension ratio
SDR
ratio of the nominal outside diameter, d_n, of a pipe to its nominal wall thickness, e_n

NOTE According to ISO 4065, the standard dimension ratio, SDR, and the pipe series S are related as shown in Equation (2):

$$\text{SDR} = 2\text{S} + 1 \tag{2}$$

3.2 Material definitions

3.2.1
virgin material
material in a form such as granules or powder that has not been subjected to use or processing other than that required for its manufacture and to which no reprocessable or recyclable materials have been added

3.2.2
own reprocessable material
material prepared from rejected unused pipes, fittings and valves, including trimmings from the production of pipes, fittings and valves, that will be reprocessed in a manufacturer's plant after having been previously processed by the same manufacturer by a process such as moulding or extrusion and for which the complete formulation or material specification is known

NOTE Only those thermoplastics parts of valves made from material conforming to this International Standard are used.

3.3 Definitions related to material characteristics

3.3.1
lower confidence limit
σ_{LCL}
quantity, expressed in megapascals, which can be considered as a material property, representing the 97,5 % lower confidence limit of the predicted long-term hydrostatic strength for water at a given temperature, T, and time, t

3.3.2
minimum required strength
MRS
value of σ_{LCL} for water at 20 °C for 50 years, rounded to the next lower value of the R10 series when σ_{LCL} is less than 10 MPa, or to the next lower value of the R20 series when σ_{LCL} is $\geqslant$ 10 MPa

NOTE The R10 and R20 series are given in ISO 3 and ISO 497.

3.3.3
design stress
σ_s
allowable stress, in megapascals, for a given application or service condition

NOTE It is derived by dividing the MRS by the coefficient C, as given in Equation (3), then rounding to the next lower value of the R10 series or R 20 series, as applicable:

$$\sigma_s = \frac{\text{MRS}}{C} \tag{3}$$

3.3.4
overall service coefficient
design coefficient
C
overall coefficient with a value greater than one which takes into consideration service conditions as well as the properties of the components of a piping system other than those represented in the lower confidence limit, σ_{LCL}

3.4 Definitions related to service conditions

3.4.1
nominal pressure
PN
numerical designation used for reference purposes related to the mechanical characteristics of the components of a piping system

NOTE 1 A pressure, in bar, with the numerical value of PN is identical to the pressure, p_s, as defined by EU Directive 97/23/ECC (PED), if both pressures are taken at 20 °C.

NOTE 2 For plastics piping systems conveying water, it corresponds to the maximum continuous operating pressure, in bar, which can be sustained for water at 20 °C for 50 years, based on the minimum overall service/design coefficient and calculated using Equation (4):

$$PN = \frac{10\sigma_s}{S} = \frac{20\sigma_s}{SDR - 1} \quad (4)$$

where

σ_s is the design stress, expressed in newtons per square millimetre;

PN is expressed in bar [2].

3.4.2
hydrostatic stress
σ
stress induced in the wall of a pipe when an internal hydrostatic pressure is applied

NOTE The hydrostatic stress, in megapascals, is related to the applied internal hydrostatic pressure, p, the wall thickness, e, at any point and the mean outside diameter, d_{em}, of a pipe and calculated using Equation (5):

$$\sigma = p\frac{d_{em} - e}{2e} \quad (5)$$

NOTE Equation (5) is applicable for pipes only.

3.4.3
long-term hydrostatic stress
constant hydrostatic stress that is maintained in a component during a sustained period of time

4 Symbols and abbreviated terms

4.1 Symbols

C overall service (design) coefficient (design factor)

d nominal outside diameter of the test piece

d_e outside diameter (at any point)

d_{em} mean outside diameter

d_n nominal outside diameter

DN nominal size of flange

e wall thickness (at any point)

e_n nominal wall thickness

l_0 free length

p internal hydrostatic pressure

p_s maximum allowable pressure

2) 1 bar = 0,1 MPa = 0,1 N/mm^2 = 10^5 N/m^2.

T temperature

t time

ρ material density

σ hydrostatic stress

σ_{LCL} lower confidence limit

σ_s design stress

4.2 Abbreviations

MOP maximum operating pressure

MRS minimum required strength

PN nominal pressure

PS maximum allowable pressure

PT test pressure

PVDF poly(vinylidene fluoride)

S pipe series S

SDR standard dimension ratio

5 Material

5.1 General

The PVDF material from which the components are made shall be homopolymer resin.

NOTE Only homopolymers are covered by this edition of ISO 10931. It is intended that copolymer materials also be covered at a later date.

5.2 Hydrostatic strength properties

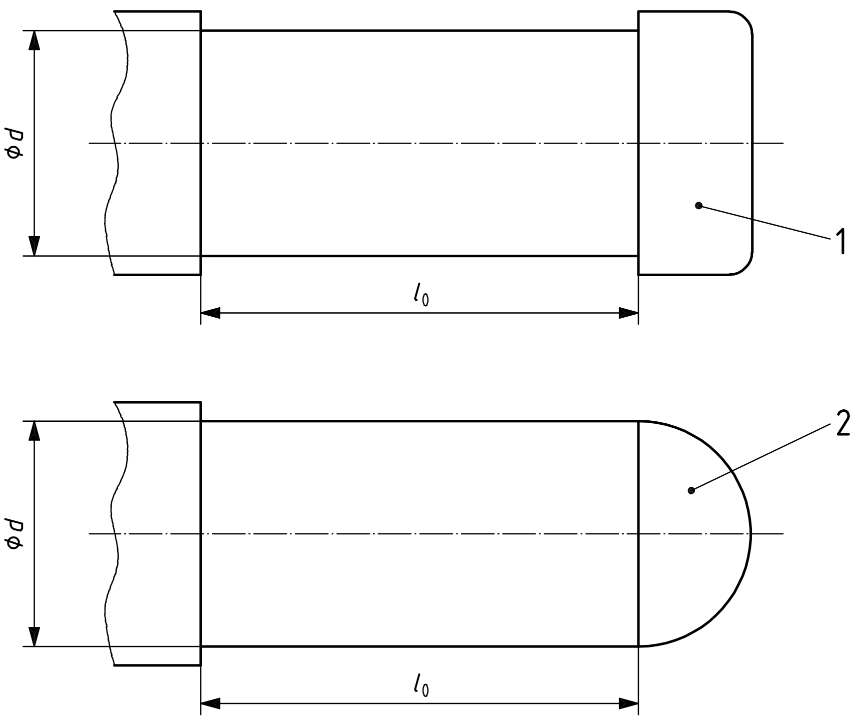
The material shall be evaluated according to ISO 9080 where a pressure test is carried out according to ISO 1167 to find the MRS value in accordance with ISO 12162. The test shall be carried out using test pieces of pipe series S $\leqslant$ 10.

Conformity of PVDF to the reference curves given in Annex A shall be proved according to that annex. At least 97,5 % of the data points shall be on or above the reference curves.

The material shall be classified by the raw material producer.

Where fittings and valves are manufactured from the same material as pipes, the material classification shall be the same as for pipes.

For the classification of a material intended only for the manufacture of fittings and valves, the test piece shall be an injection-moulded or extruded test piece in the form of a pipe (see Figure 1) where a test pressure is applied according to ISO 1167. The free length l_0 shall be $3d_n$, as defined in ISO 15853.



Key

1 end cap

2 injection-moulded end

Figure 1 — Free length l_0 of test pieces

5.3 Material characteristics

The details of the material characteristics of PVDF are given in Annex A.

5.4 Reprocessable and recyclable material

The use of own reprocessable material obtained during the production and testing of components according to this International Standard is permitted in addition to virgin material, provided that the requirements of this International Standard are fulfilled.

Reprocessable material obtained from external sources and recyclable material shall not be used.

5.5 Materials for parts not made from PVDF

5.5.1 General

All components shall conform to the relevant International Standard(s). Alternative standards may be applied in cases where a suitable International Standard does not exist. In all cases, fitness for purpose of the components shall be demonstrated.

Materials and constituent elements used in making the relevant component (including rubber, greases and any metal parts as may be used) shall have resistance to the external and internal environments comparable to that of all other elements of the piping system according to this International Standard.

Materials other than PVDF in contact with components conforming to this International Standard shall not adversely effect the performance of the components or initiate stress cracking.

5.5.2 Metallic materials

All metal parts susceptible to corrosion shall be adequately protected.

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

5.5.3 Sealing materials

Sealing materials shall have no detrimental effects on the properties of the components, joints and assemblies.

5.5.4 Other materials

Greases or lubricants shall not exude onto fusion areas and shall not affect the long-term performance of materials conforming to this International Standard.

6 General characteristics — Appearance

When viewed without magnification, the internal and external surfaces of the components shall be smooth, clean and free from scoring, cavities and other surface defects that would prevent conformity to this International Standard.

Each end of a component shall be square to its axis and shall be deburred.

7 Geometrical characteristics

7.1 General

Dimensions shall be measured in accordance with ISO 3126 at (23 ± 2) °C after being conditioned for at least 4 h. The measurement shall not be made less than 24 h after manufacture.

The given figures are schematic sketches only, indicating the relevant dimensions. They do not necessarily represent the manufactured component(s). The given dimensions shall be followed.

Dimensions not given shall be specified by the manufacturer.

7.2 Diameters and related tolerances

For components made from PVDF, the diameters and related tolerances shall conform to Annex A.

The out-of-roundness shall be measured at the point of manufacture.

7.3 Wall thicknesses and related tolerances

For components made from PVDF, the wall thicknesses and related tolerances shall conform to Annex A.

7.4 Angles

The permitted deviations from the nominal or declared angle for a non-linear fitting shall be ± 2°, where the angle comprises the relevant change of axis of the flow through the fitting.

NOTE The preferred nominal angles for a non-linear fitting are 45° or 90°.

7.5 Laying lengths

The laying lengths for fittings and valves shall be declared by the manufacturer.

NOTE The laying lengths are intended to assist in the design of moulds and are not intended to be used for quality control purposes. ISO 265-1 can be used as a guideline.

7.6 Threads

Threads used for jointing shall conform to ISO 7-1. Where a thread is used as a fastening thread for jointing an assembly (e.g. union nuts), a thread conforming to ISO 228-1 is preferred.

7.7 Mechanical fittings

Mechanical fittings such as adaptors, unions and reducing bushes may be used, provided that their joint dimensions are in accordance with the applicable dimensions of components conforming to this International Standard.

7.8 Joint dimensions of valves

The joint dimensions of valves shall conform to the relevant dimensions of pipes and fittings conforming to this International Standard.

8 Mechanical characteristics

8.1 Resistance to internal pressure of components

Components shall withstand the hydrostatic stress induced by internal hydrostatic pressure without bursting or leakage when tested in accordance with ISO 1167 (for fittings together with ISO 12092) and the test conditions specified for PVDF in Annex A.

8.2 Calculation of the test pressure for components

8.2.1 Pipes

The hydrostatic test pressure, PT, in bar, shall be determined for pipes using Equation (6):

$$\sigma = \mathrm{PT}\,\frac{d_{\mathrm{em}} - e_{\mathrm{min}}}{2e_{\mathrm{min}}} \tag{6}$$

where σ is the hydrostatic stress for PVDF in conformance with Annex A.

8.2.2 Fittings

The hydrostatic test pressure, PT, in bar, shall be determined for fittings using Equation (7). For S and SDR respectively, the value of the corresponding pipe shall be taken:

$$\mathrm{PT} = \frac{10\sigma}{\mathrm{S}} = \frac{20\sigma}{\mathrm{SDR\text{-}1}} \tag{7}$$

8.2.3 Valves

The hydrostatic test pressure, PT, in bar, is defined for valves in ISO 16135, ISO 16136, ISO 16137, ISO 16138, ISO 16139 or ISO 21787, as applicable, depending on the valve type.

9 Physical characteristics

The physical characteristics of components made from PVDF shall conform to Annex A.

10 Chemical characteristics

10.1 Effect on component material(s)

Where fluids other than water are to be conveyed, the effect of the fluid on the component material(s) may be established by reference to the component manufacturer or to ISO/TR 10358.

10.2 Effect on fluids

Where fluids other than water are to be conveyed, the effect on the fluids may be established by reference to the component manufacturer.

11 Electrical characteristics

The electrical protection that shall be provided by the fusion process depends on the characteristics of the electricity power source.

NOTE The relevant component during the fusion process is part of an electrical system as defined in IEC 60364-1 or IEC 60449.

Protection against direct contacts with active parts (live conductors) is required in accordance with IEC 60529. This protection is a function of the work site conditions.

The surface finish of the terminal pins shall allow a minimum contact resistance.

12 Performance requirements

12.1 General

When components made from the same material conforming to this International Standard are jointed to each other, the pipes, fittings, valves and the joints shall conform to the requirements of Annex A.

NOTE If test pressures defined for pipes are used for assemblies made from PVDF components (e.g. screwed joints, flanged joints), the resulting strain exceeds the strain occurring under service conditions. These strains unavoidably cause leakage. Therefore, in this International Standard, the time-related strain behaviour of the assemblies is taken into account and the test pressures derived from the isochronous stress-strain-diagram are used.

12.2 Preparation of test assemblies

12.2.1 General

The joints shall be tested using pipes and fittings conforming to this International Standard.

The preparation of test assemblies shall take into account the tolerances of component manufacturing, field assembly, equipment tolerances, ambient temperature variations during installation and, where appropriate, sealing material and related tolerances.

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

12.2.2 Heated tool jointing

12.2.2.1 Butt fusion and infrared fusion jointing

Pipes and spigot ended fittings for jointing by butt fusion and infrared fusion shall be prepared and assembled in accordance with the instructions of the manufacturer.

12.2.2.2 Socket fusion jointing

Pipes and fittings for jointing by socket fusion shall be prepared and assembled in accordance with the instructions of the manufacturer.

12.2.3 Electrofusion jointing

Pipes and fittings such as couplers for jointing by electrofusion shall be prepared and assembled in accordance with the instructions of the manufacturer.

12.2.4 Mechanical jointing

Pipes and fittings for mechanical jointing shall be prepared and assembled in accordance with the instructions of the manufacturer.

12.3 Fusion compatibility

The manufacturer of components shall declare which components and materials conforming to this International Standard may be fused by using the same procedures (e.g. times, temperatures, fusion pressures) so as to conform to the requirements to this International Standard. If there is a need for deviation in fusion procedures, the manufacturer shall state this.

12.4 Permanent jointing

If permanent jointing is used to manufacture parts of the components, the welding or cementing by solvent process shall be carried out by instructed and supervised personnel in accordance with written instructions.

13 Classification of components

The classification of pipes shall be based on the pipe series S or the standard dimension ratio, SDR, or the nominal pressure, PN, as applicable.

The classification of fittings shall be based on the corresponding pipe together with the pipe series S or the standard dimension ratio, SDR, or the nominal pressure, PN, as applicable.

Valves shall be classified in accordance with the requirements of ISO 16135, ISO 16136, ISO 16137, ISO 16138, ISO 16139 or ISO 21787, as applicable, depending on the valve type.

14 Design of a thermoplastics piping system for industrial applications

NOTE Because several calculation methods are available for the design of thermoplastics piping systems for industrial applications, only some general parameter can be given.

For the design of a piping system (e.g. determination of the maximum allowable pressure, p_S), the following parameters should be taken into account:

— temperature, T, usually constant, if changing, then Miner's Rule should be used;

— although usually constant, where the pressure, p, is changing, Miner's Rule should be used;

— lifetime, t, is usually 25 years;

— stress, σ, calculated with Equations (A.1) and (A.2);

— chemical resistance of the material against the fluid;

— required design factor, C;

— influence of wear and abrasion by solid matters in fluids;

— influence of changing of length (caused by temperature, swelling, internal pressure);

— kind of installation (fixed, floating, etc.);

— supporting distances in the installed piping system.

With these parameters, together with the minimum required hydrostatic strength curves, the design of a piping system can be carried out, taking into account the legislative requirements, where appropriate, complemented by experimental design methods.

15 Installation of piping systems

For the installation of components conforming to this International Standard, legislative requirements and relevant codes of practice apply.

In addition, the pipe manufacturer may give a recommended practice for installation which refers to transport, storage and handling of the components as well as to installation in accordance with legislative requirements.

16 Declaration of compliance with this International Standard

The manufacturer shall declare compliance with this International Standard by marking the component in accordance with Clause 17.

17 Marking

17.1 General

Marking elements shall be printed or formed directly on the component or on a label affixed to the component such that, after storage, weathering and handling and the installation, legibility is maintained.

NOTE The manufacturer is not responsible for marking of the component becoming illegible due to actions caused during installation and use such as painting, scratching, covering or by use of detergents etc. unless agreed or specified by the manufacturer.

Marking shall not initiate cracks or other types of defects which adversely influence the performance of the component.

If printing is used, the colouring of the printed information shall differ from the basic colouring of the component.

The size of the marking shall be such that the marking is legible without magnification.

17.2 Minimum required marking of pipes

The minimum required marking of pipes shall be in accordance with Table 1.

Pipes shall be marked at intervals of maximum 1 m, at least once per pipe.

Table 1 — Minimum required marking of pipes

Aspect	Marking or symbol
Number of this International Standard	ISO 10931
Manufacturer’s name and/or trademark	*Name or symbol*
Nominal outside diameter, d_n	e.g. 110
Nominal wall thickness, e_n or Pipe series S or standard dimension ratio, SDR, or Nominal pressure, PN	e.g. 3,4 e.g. S 16, SDR 33 e.g. PN 10
Material	PVDF
Manufacturer’s information	[a]

[a] To provide traceability, the following details shall be given:

— the production period, year and month, in figures or in code;

— a name or code for the production site if the manufacturer is producing at different sites.

17.3 Minimum required marking of fittings

The minimum required marking of fittings shall be in accordance with Table 2, except for fittings with $d_n \leqslant 32$ mm, for which the minimum required marking shall be directly on the fitting, as follows:

— manufacturer's name and/or trade mark;

— nominal outside diameter(s);

— material;

— nominal wall thickness, e_n, or pipe series S, or SDR, or PN, as applicable.

Table 2 — Minimum required marking of fittings

Aspect	Marking or symbol
Number of this International Standard [a]	ISO 10931
Manufacturer's name and/or trademark	*Name or symbol*
Nominal outside diameter (s), d_n	e.g. 63 – 32 - 63
Nominal wall thickness, e_n, or Pipe series S or standard dimension ratio, SDR, or Nominal pressure, PN	e.g. 2,0 e.g. S 16, SDR 33 e.g. PN 10
Nominal size, DN [b]	e.g. DN 50
Material	PVDF
Manufacturer's information	[c]

[a] This information may either be marked directly on the fitting or on a label attached to the fitting or on the packaging.

[b] Applicable to flanges only.

[c] To provide traceability, the following details shall be given:

— the production period, year and month, in figures or in code;

— a name or code for the production site if the manufacturer is producing at different sites.

17.4 Minimum required marking of valves

Valves shall be marked in accordance with the requirements of ISO 16135, ISO 16136, ISO 16137, ISO 16138, ISO 16139 or ISO 21787, as applicable, depending on the valve type.

18 Manufacture

The manufacturer shall ensure that

— the materials of the components are in accordance with Clause 5;

— the marking in respect of the material supplied is in accordance with Table 1 or Table 2, as appropriate.

— the component is marked with the manufacturer's name or trademark and with a code for the year of production.

Annex A
(informative)

Specific characteristics and requirements for industrial piping systems made from poly(vinylidene fluoride) (PVDF)

A.1 Material

A.1.1 General

The material from which the components are made shall be a PVDF homopolymer (see 5.1).

A.1.2 Material for components

The material shall be tested in accordance with 5.2 at 20 °C, 95 °C and 120 °C as well as at various hydrostatic (hoop) stresses such that at each temperature at least three failure times fall in each of the following time intervals:

— 10 h to 100 h;

— 100 h to 1 000 h;

— 1 000 h to 8 760 h;

— $>$ 8 760 h.

In tests lasting more than 8 760 h, any time which is reached at a certain stress and time at least on or above the relevant reference curve may be considered as failure time.

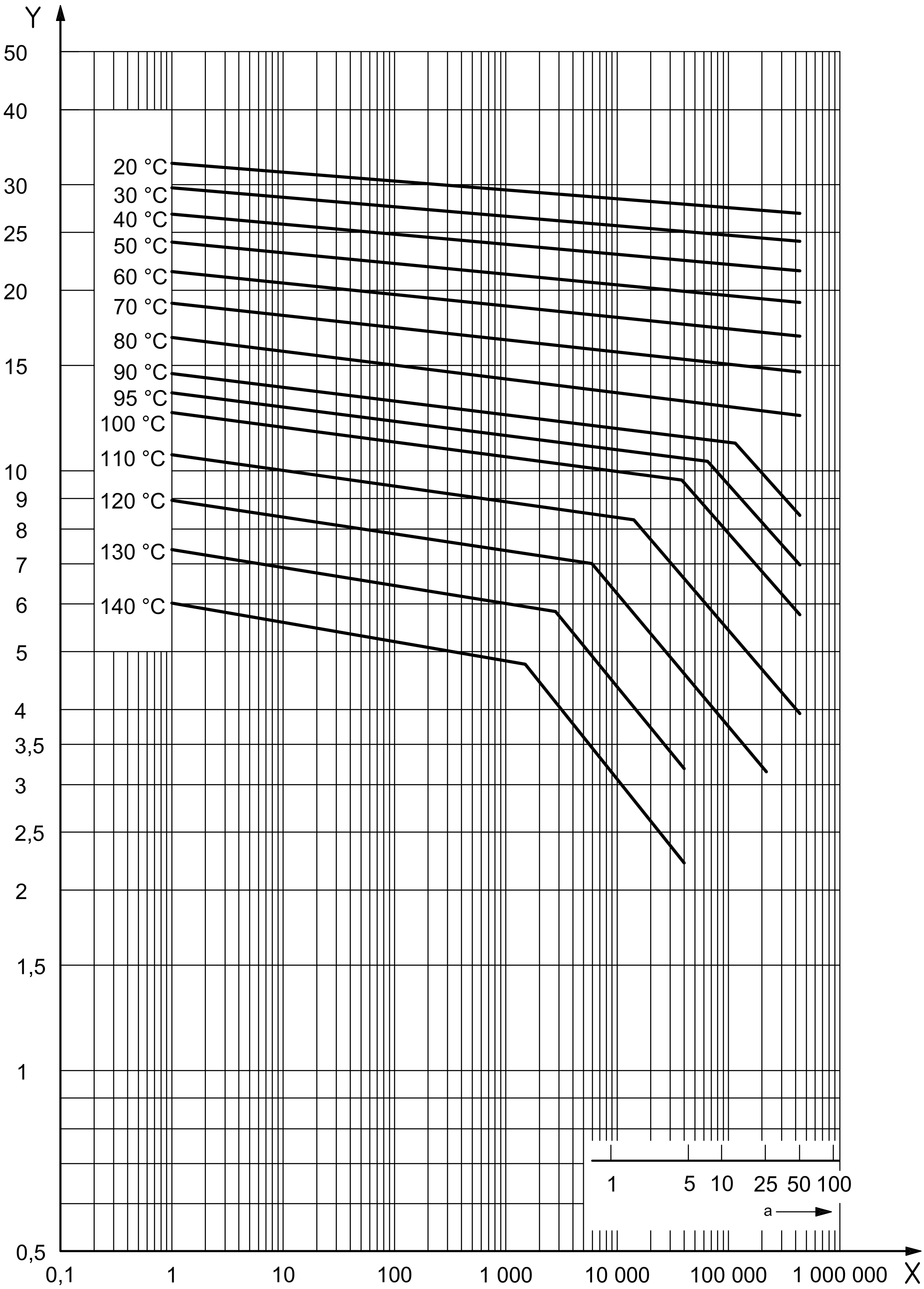
The values of the minimum required hydrostatic strength (see reference curves given in Figure A.1) in the temperature range of 10 °C to 140 °C are calculated using Equations (A.1) to (A.2).

First branch (i.e. the left hand portion of the curves shown in Figure A.1):

$$\lg t = -165{,}495\,8 - 36\,518{,}7 \cdot \frac{\lg \sigma}{T} + 78\,465{,}65 \cdot \frac{1}{T} + 57{,}046\,7 \cdot \lg \sigma \qquad \text{(A.1)}$$

Second branch (i.e. the right hand portion of the curves shown in Figure A.1).

$$\lg t = -23{,}194\,26 - 1\,611{,}69 \cdot \frac{\lg \sigma}{T} + 12\,100 \cdot \frac{1}{T} - 0{,}404\,73 \cdot \lg \sigma \qquad \text{(A.2)}$$



Key

X time to failure, h

Y hoop stress, MPa

a Years.

Figure A.1 — Minimum required hydrostatic strength curves for PVDF

A.1.3 MRS value

When evaluated in accordance with 5.2, PVDF shall have a minimum required strength, MRS, at least equal to 25,0 MPa.

A.1.4 Material characteristics

The material from which the components are manufactured shall be accordance with Table A.1.

Table A.1 — Material characteristics of PVDF

Characteristic	Requirement [a]	Test parameter	Test method
Density	$\geqslant$ 1,76 g/cm^3	ISO 1183-2	ISO 1183-2
Crystalline melting point	$\geqslant$ 168 °C	ISO 11357-3	ISO 11357-3, DSC

[a] Conformance with these requirements shall be declared by the raw material producer.

A.2 Geometrical characteristics

A.2.1 Dimensions of pipes

A.2.1.1 Diameters and related tolerances

The mean outside diameter, d_{em}, and the related tolerances shall conform to Table A.2, appropriate to the tolerance grade, whereby the average value of the measurements of the outside diameter made at a distance of d_n and $0,1d_n$ as well as from the end of the test pieces shall be within the tolerance range for d_{em} specified in Table A.2.

A.2.1.2 Out-of-roundness

The out-of-roundness for straight lengths shall be in accordance with Table A.2 when measured at the point of manufacture. If values for the out-of-roundness other than those given in Table A.2 are necessary, they shall be agreed between manufacturer and purchaser.

Table A.2 — Mean outside diameters, related tolerances and out-of-roundness of pipes

Dimensions in millimetres

Nominal outside diameter d_n	Mean outside diameter d_{em} min.	Tolerance of outside diameter	Out-of-roundness max.
8	8,0	+ 0,3	0,1
10	10,0	+ 0,3	0,2
12	12,0	+ 0,3	0,2
16	16,0	+ 0,3	0,3
20	20,0	+ 0,3	0,3
25	25,0	+ 0,3	0,4
32	32,0	+ 0,3	0,5
40	40,0	+ 0,4 [a]	0,5
50	50,0	+ 0,4 [a]	0,6
63	63,0	+ 0,4	0,8
75	75,0	+ 0,4	0,9
90	90,0	+ 0,4	1,1
110	110,0	+ 0,5	1,3
125	125,0	+ 0,6	1,5
140	140,0	+ 0,8	1,7
160	160,0	+ 1,0	2,0
180	180,0	+ 1,1	2,2
200	200,0	+ 1,2	2,4
225	225,0	+ 1,4	2,7
250	250,0	+ 1,6	3,0
280	280,0	+ 1,8	3,4
315	315,0	+ 2,0	3,8
355	355,0	+ 2,2	4,1
400	400,0	+ 2,4	4,5

[a] Not in accordance with ISO 11922-1:1997.

A.2.1.3 Wall thicknesses and related tolerances

The wall thickness, e, and the related tolerances shall be in accordance with Table A.3.

Table A.3 — Wall thicknesses and related tolerances

Dimensions in millimetres

Nominal outside diameter	Wall thickness, *e*, and related tolerances [b]							
	Pipe series S and standard dimension ratio SDR							
	S 16 SDR 33		S 10 SDR 21		S 8 SDR 17		S 6,3 SDR 13,6	
d_n	*e* min.	[a]	*e* min.	[a]	*e* min.	[a]	*e* min.	[a]
8	—	—	—	—	—	—	1,9	+ 0,4
10	—	—	—	—	—	—	1,9	+ 0,4
12	—	—	—	—	—	—	1,9	+ 0,4
16	—	—	—	—	—	—	1,9	+ 0,4
20	—	—	—	—	—	—	1,9	+ 0,4
25	—	—	—	—	—	—	1,9	+ 0,4
32	—	—	—	—	—	—	2,4	+ 0,5
40	—	—	—	—	2,4	+ 0,5	—	—
50	—	—	—	—	3,0	+ 0,6	—	—
63	2,0	+ 0,5	3,0	+ 1,5	3,8	+ 0,6	—	—
75	2,3	+ 0,5	3,6	+ 1,5	4,5	+ 0,7	—	—
90	2,8	+ 0,5	4,3	+ 1,5	5,4	+ 0,8	—	—
110	3,4	+ 0,6	5,3	+ 1,5	6,6	+ 0,9	—	—
125	3,9	+ 0,6	6,0	+ 1,5	—	—	—	—
140	4,3	+ 0,7	6,7	+ 1,5	—	—	—	—
160	4,9	+ 0,7	7,7	+ 1,5	—	—	—	—
180	5,5	+ 0,8	8,6	+ 1,5	—	—	—	—
200	6,2	+ 0,9	9,6	+ 1,5	—	—	—	—
225	6,9	+ 0,9	10,8	+ 1,5	—	—	—	—
250	7,7	+ 1,0	11,9	+ 1,5	—	—	—	—
280	8,6	+ 1,1	13,4	+ 1,5	—	—	—	—
315	9,7	+ 1,2	—	—	—	—	—	—
355	10,9	+ 1,3						
400	12,3	+ 1,5						
For safety reasons, the minimum wall thickness should be not less than 1,9 mm.								

[a] Tolerances of the wall thickness: (0,1 *e* + 0,2) mm, rounded up to the nearest 0,1 mm.

[b] All dimensions correspond to those of ISO 4065.

A.2.2 Dimensions of fittings

A.2.2.1 General

This annex is applicable to the following types of fittings:

— butt fusion fittings;

— socket fusion fittings;

— electrofusion fittings;

— flange adaptors and loose backing flanges;

— mechanical fittings.

A.2.2.2 Butt fusion fittings

A.2.2.2.1 Outside diameters

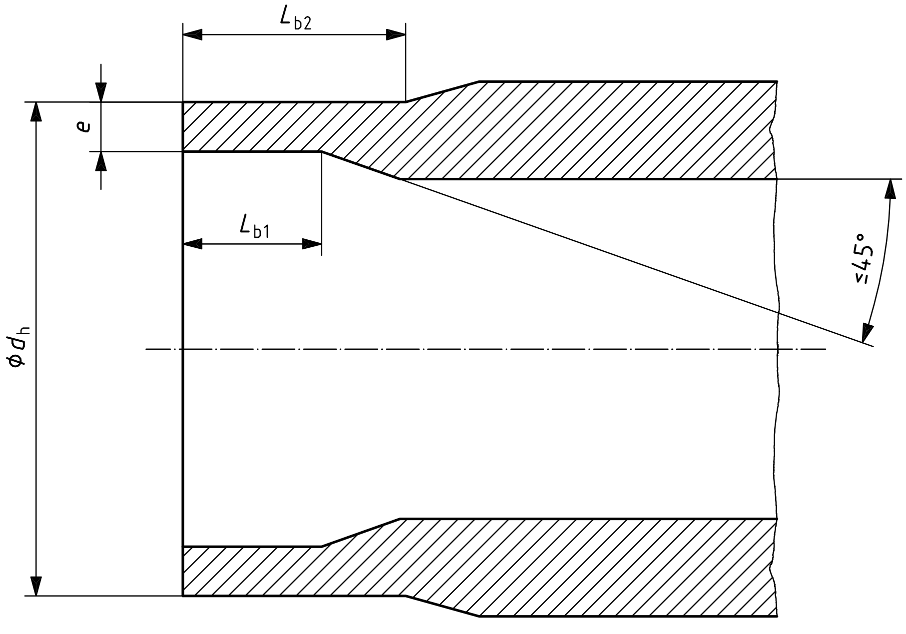
The mean outside diameter, d_{em}, of the spigot end (see Figure A.2) over the length, L_{b2} (see Table A.4) shall conform to A.2.1.1, except for between the plane of the entrance face and the plane parallel to it, located at a distance not greater than $0{,}01d_n + 1$ mm, where a reduction of the outside diameter is permissible, e.g. for circumferential reversion.

A.2.2.2.2 Out-of-roundness

The out-of-roundness of the spigot end (see Figure A.2) over the length, L_{b2} (see Table A.4), shall conform to A.2.1.2.

A.2.2.2.3 Wall thickness of the spigot end

The wall thickness, e, of the spigot end (see Figure A.2) over the length, L_{b1} (see Table A.4), shall conform to A.2.1.3, except for between the plane of the entrance face and the plane parallel to it, located at a distance not greater than $0{,}01d_n + 1$ mm, where a thickness reduction is permissible, e.g. for chamfered edge.



Key

L_{b1} min. inside tubular length of fusion end, comprising initial depth of spigot end necessary for butt fusion

L_{b2} min. outside tubular length of fusion end, comprising initial length of fusion end

Figure A.2 — Dimensions of spigot end for butt fusion fittings

Table A.4 — Dimensions of spigot ends for butt fusion fittings

Dimensions in millimetres

Nominal outside diameter d_n	Inside tubular length [a] L_{b1} min.	Outside tubular length [a] L_{b2} min.
8	4	10
10	4	10
12	4	10
16	4	10
20	4	10
25	4	10
32	5	10
40	5	10
50	5	12
63	6	12
75	6	12
90	7	12
110	8	12
125	8	15
140	9	15
160	9	20
180	10	20
200	11	20
225	12	25
250	13	25
280	14	30
315	15	30

NOTE The minimum tubular lengths given in this table are too short for electrofusion joints. For this jointing method a tubular length conforming to the depth of penetration according to Table A.5 is necessary.

[a] For bends, a reduction of the tubular length(s) is permissible.

A.2.2.2.4 Wall thickness of fitting body

The wall thickness, e, of the fitting body shall be at least equal to the minimum wall thickness of the corresponding pipe (see A.2.1.3).

A.2.2.2.5 Other dimensions

Other dimensions of butt fusion fittings shall be as specified by the manufacturer.

A.2.2.3 Socket fusion fittings

A.2.2.3.1 Types of socket fusion fittings

Socket fusion fittings (see Figure A.3) shall be classified in two types as follows:

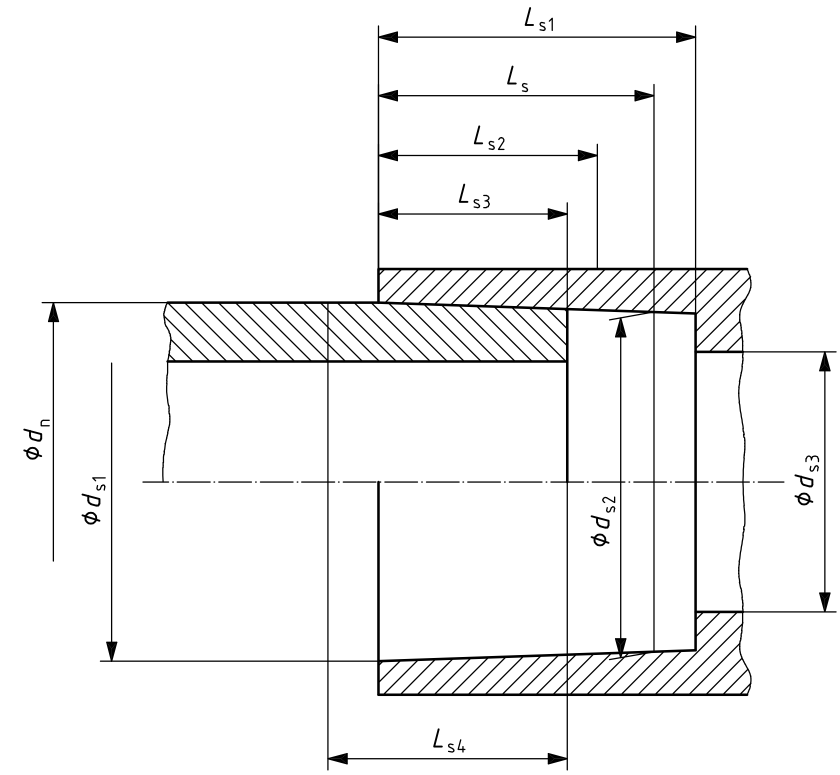
— **Type A**

Fittings intended to be used with pipes where no external machining of the pipe is required.

NOTE Type A is not applicable for pipes made from PVDF. However, for pipes from other materials, this type is used (e.g. ISO 15494). For the purposes of this International Standard, description of type A is given for information only.

— **Type B**

Fittings intended to be used with pipes having dimensions as given in A.2 where machining of the outside surface of the pipe shall be in accordance with the instructions of the manufacturer.



Key

d_n nominal diameter

d_{s1} inside diameter of socket mouth, comprising mean diameter of circle at inner section of extension of socket with plane of socket mouth

d_{s2} mean inside diameter of socket root, comprising mean diameter of circle in plane parallel to plane of socket mouth, separated from it by a distance of L_s, the reference socket length

d_{s3} min. diameter of flow channel (bore) through body of fitting

L_s reference socket length, comprising theoretical min. socket length used for calculation

L_{s1} actual length of socket, comprising distance from socket mouth to shoulder, if any

L_{s2} heated length of fitting, comprising length of penetration of heated tool into socket

L_{s3} insertion length, comprising depth of penetration of heated pipe end into socket

L_{s4} heated length of pipe, comprising depth of penetration of pipe into heated tool

Figure A.3 — Diameters and lengths of socket fusion fittings

A.2.2.3.2 Diameters and lengths of sockets

The nominal diameter(s), d_n, of a socket fusion fitting shall correspond to, and be designated by, the nominal outside diameter(s) of the pipe(s) for which it is designed.

The diameters and lengths of sockets for socket fusion fittings of type B shall be in accordance with Table A.5.

Table A.5 — Diameters and lengths of sockets for socket fusion fittings of type B

Dimensions in millimetres

Nominal outside diameter of pipe	Mean outside diameter of pipe		Mean inside diameter				Out-of-roundness	Bore [a]	Reference socket length [b]	Heated socket length [c]		Penetration of pipe into socket [d, e]	
			Socket mouth		Socket root								
d_n	d_{em}		d_{s1}		d_{s2}			d_{s3}	L_s	L_{s2}		L_{s3}	
	min.	max.	min.	f	min.	f	maximum	min.	min.	min.	max.	min.	max.
16	15,8	16,0	15,2	+ 0,3	15,1	+ 0,3	0,4	11,0	13,0	10,5	13,0	9,5	12,0
20	19,8	20,2	19,2	+ 0,3	19,0	+ 0,3	0,4	13,0	14,5	12,0	14,5	11,0	13,5
25	24,8	25,0	24,2	+ 0,3	23,9	+ 0,4	0,4	18,0	16,0	13,5	16,0	12,5	15,0
32	31,8	32,0	31,1	+ 0,4	30,9	+ 0,4	0,5	25,0	18,0	15,5	18,0	14,5	17,0
40	39,8	40,0	39,0	+ 0,4	38,8	+ 0,4	0,5	31,0	20,5	18,0	20,5	17,0	19,5
50	49,8	50,0	48,9	+ 0,5	48,7	+ 0,5	0,6	39,0	23,5	21,0	23,5	20,0	22,5
63	62,7	63,0	61,9	+ 0,6	61,6	+ 0,5	0,6	49,0	27,5	25,0	27,5	24,0	26,5
75	74,7	75,0	73,7	+ 0,5	73,4	+ 0,5	1,0	59,0	31,0	28,5	31,0	27,5	30,0
90	89,7	90,0	88,6	+ 0,6	88,2	+ 0,6	1,0	71,0	35,5	33,0	35,5	32,0	34,5
110	109,6	110,0	108,4	+ 0,6	108,0	+ 0,6	1,0	87,0	41,5	39,0	41,5	38,0	40,5

[a] Only applicable if a shoulder exists.

[b] Actual length of the socket: $L_{s1} \geqslant L_s$.

[c] Heated socket length: $L_{s2} \geqslant L_{s3}$ 1,0 mm.

Minimum heated socket length: $L_{s2,min} = L_s - 2{,}5$ mm.

Maximum heated socket length: $L_{s2,max} = L_s$.

[d] Minimum penetration of pipe into socket: $L_{s3,min} = L_s - 3{,}5$ mm.

Maximum penetration of pipe into socket: $L_{s3,max} = L_s - 1{,}0$ mm.

$L_{s3,max}$ may be equal to L_s if the construction of the fitting ensures that, at the socket root, there is sufficient space for the inside weld bead.

[e] Heated length of pipe: $L_{s4} \geqslant L_{s3}$.

[f] The tolerances of the inside diameter of socket are rounded up to the next 0,1 mm.

A.2.2.3.3 Other dimensions

Other dimensions of socket fusion fittings shall be as specified by the manufacturer.

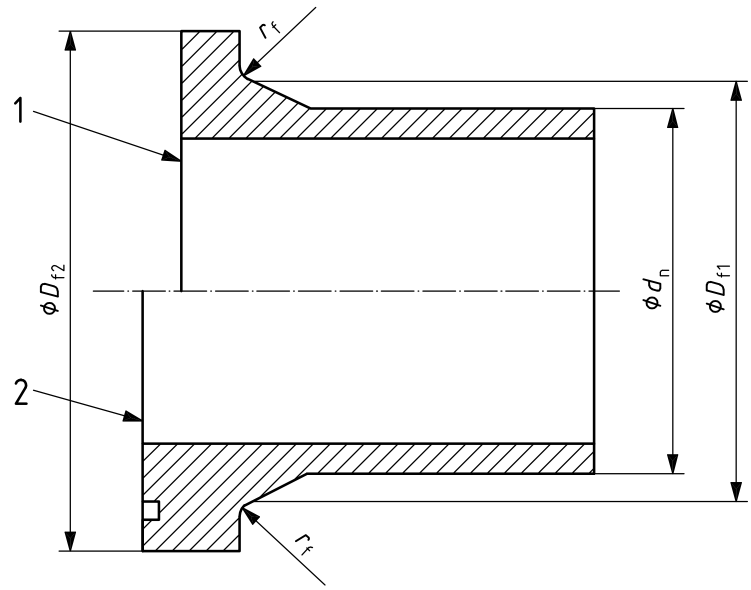
A.2.2.3.4 Other dimensions

Other dimensions of electrofusion fittings shall be as specified by the manufacturer.

A.2.2.4 Flange adaptors and loose backing flanges

A.2.2.4.1 Dimensions of flange adaptors for butt fusion

The dimensions of flange adaptors for butt fusion (see Figure A.4) shall be in accordance with Table A.6.



Key

1 jointing face for flat seal

2 jointing face with O-ring groove

Figure A.4 — Dimensions of flange adaptors for butt fusion

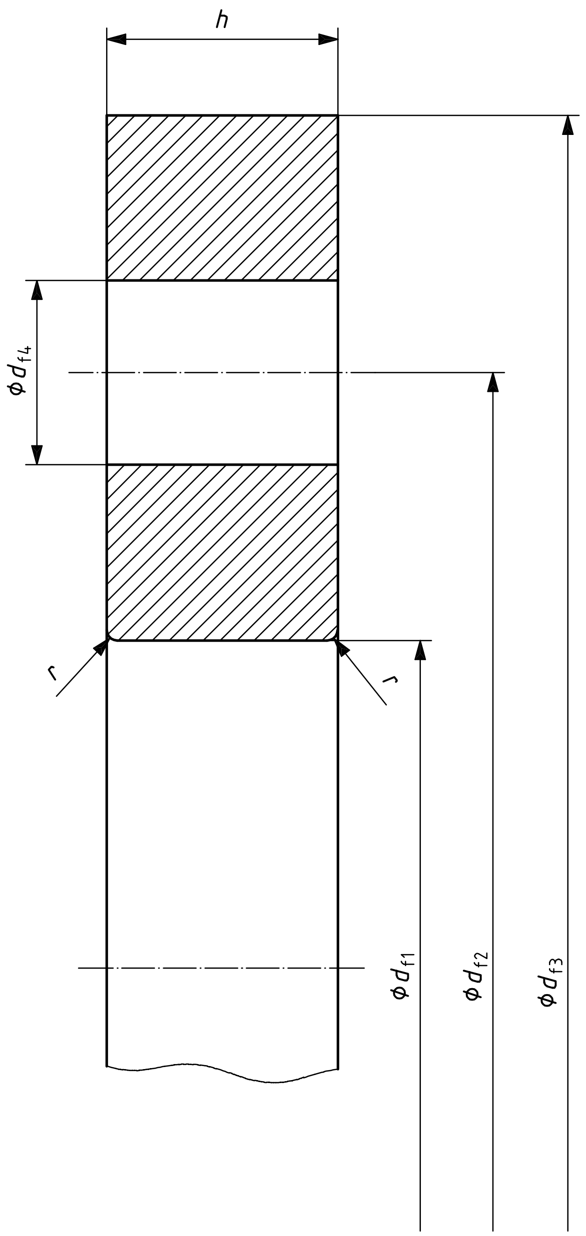
Table A.6 — Dimensions of flange adaptors for butt fusion

Dimensions in millimetres

Nominal outside diameter of corresponding pipe d_n	Outside diameter of chamfer on shoulder D_{f1}	Outside diameter of flange adaptor D_{f2}	Radius of chamfer on shoulder r_f
16	22	40	3
20	27	45	3
25	33	58	3
32	40	68	3
40	50	78	3
50	61	88	3
63	75	102	4
75	89	122	4
90	105	138	4
110	125	158	4
125	132	158	4
140	155	188	4
160	175	212	4
180	183	212	4
200	232	268	4
225	235	268	4
250	285	320	4
280	291	320	4
315	335	370	4

A.2.2.4.2 Dimensions of loose backing flanges for use with flange adaptors for butt fusion

The dimensions of loose backing flanges for use with flange adaptors for butt fusion (see Figure A.5) shall be in accordance with Table A.7.



NOTE The thickness, h, of the loose backing flange is dependent on the material used.

Figure A.5 — Dimensions of loose backing flanges for use with flange adaptors for butt fusion

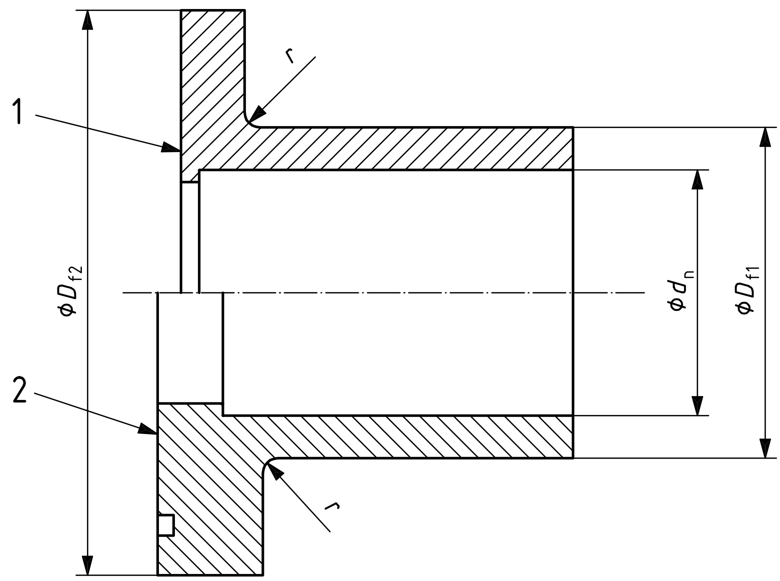
Table A.7 — Dimensions of loose backing flanges for use with flange adaptors for butt fusion

Dimensions in millimetres

Nominal outside diameter of corresponding pipe d_n	Nominal size of flange DN	Inside diameter of flange d_{f1}	Pitch circle diameter of bolt holes d_{f2}	Outside diameter of flange d_{f3} min.	Diameter of bolt holes d_{f4}	Radius of flange r	Number of bolt holes n	Metric thread of bolt
16	10	23	60	90	14	3	4	M12
20	15	28	65	95	14	3	4	M12
25	20	34	75	105	14	3	4	M12
32	25	42	85	115	14	3	4	M12
40	32	51	100	140	18	3	4	M16
50	40	62	110	150	18	3	4	M16
63	50	78	125	165	18	3	4	M16
75	65	92	145	185	18	3	4	M16
90	80	108	160	200	18	3	8	M16
110	100	128	180	220	18	3	8	M16
125	100	135	180	220	18	3	8	M16
140	125	158	210	250	18	3	8	M16
160	150	178	240	285	22	3	8	M20
180	150	188	240	285	22	3	8	M20
200	200	235	295	340	22	3	8	M20
225	200	238	295	340	22	3	8	M20
250	250	288	350	395	22	3	12	M20
280	250	294	350	395	22	3	12	M20
315	300	338	400	445	22	3	12	M20

A.2.2.4.3 Dimensions of flange adaptors for socket fusion

The dimensions of flange adaptors for socket fusion (see Figure A.6) shall be in accordance with Table A.8.



Key

1 jointing face for flat seal

2 jointing face with O-ring groove

Figure A.6 — Dimensions of flange adaptors for socket fusion

Table A.8 — Dimensions of flange adaptors for socket fusion

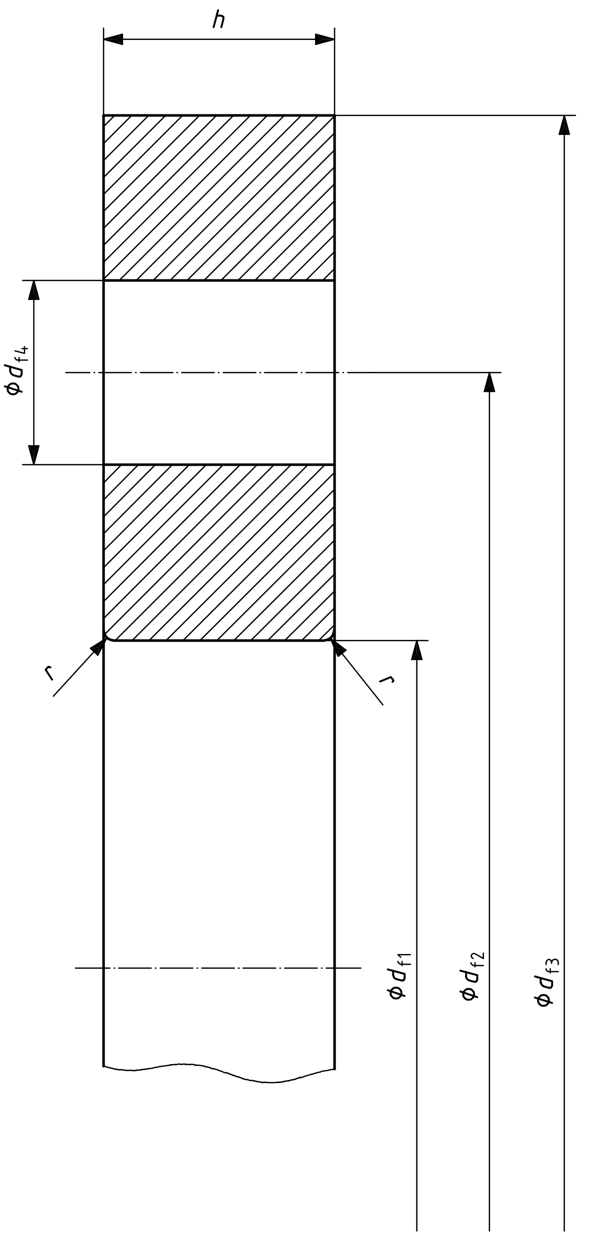
Dimensions in millimetres

Nominal outside diameter of corresponding pipe d_n	Outside diameter of chamfer on shoulder [a] D_{f1}	Outside diameter of flange adaptor [a] D_{f2}	Radius of chamfer on shoulder r_f
16	22	40	3
20	27	45	3
25	33	58	3
32	41	68	3
40	50	78	3
50	61	88	3
63	76	102	4
75	90	122	4
90	108	138	4
110	131	158	4

[a] At the time of publication of this International Standard, smaller diameters were present in the market. It can be assumed that in the course of time these diameters will be replaced by those according to this International Standard.

A.2.2.4.4 Dimensions of loose backing flanges for use with flange adaptors for socket fusion

The dimensions of loose backing flanges for use with flange adaptors for socket fusion (see Figure A.7) shall be in accordance with Table A.9.



NOTE The thickness, h, of the loose backing flange is dependent on the material used.

Figure A.7 — Dimensions of loose backing flanges for use with flange adaptors for socket fusion

Table A.9 — Dimensions of loose backing flanges for use with flange adaptors for socket fusion

Dimensions in millimetres

Nominal outside diameter of the corresponding pipe d_n	Nominal size of flange DN	Inside diameter of flange d_{f1}	Pitch circle diameter of bolt holes d_{f2}	Outside diameter of flange d_{f3} min.	Diameter of bolt holes d_{f4}	Radius of flange r	Number of bolt holes n	Metric thread of bolt
16	10	23	60	90	14	3	4	M12
20	15	28	65	95	14	3	4	M12
25	20	34	75	105	14	3	4	M12
32	25	42	85	115	14	3	4	M12
40	32	51	100	140	18	3	4	M16
50	40	62	110	150	18	3	4	M16
63	50	78	125	165	18	3	4	M16
75	65	92	145	185	18	3	4	M16
90	80	110	160	200	18	3	4	M16
110	100	133	180	220	18	3	4	M16

A.3 Mechanical characteristics

A.3.1 Mechanical characteristics of pipes and fittings

When tested in accordance with Table A.10, under the conditions given in Table A.11, the components shall withstand the required hydrostatic stress without bursting or leakage according to the parameters given in both tables.

Table A.10 — Requirements for internal pressure testing

Characteristic	Requirement	Test parameter		Test method [a]
		Hydrostatic (hoop) stress MPa	Time h	
Resistance to internal pressure at 95 °C	No failure during test period	11,5	⩾ 200	ISO 1167 ISO 12092

[a] Fittings shall be prepared in accordance with ISO 12092 and tested in accordance with ISO 1167.

Table A.11 — Test conditions for internal pressure testing

Test parameters	
End caps	Type A according to ISO 1167:1996
Orientation	At discretion of tester
Conditioning period	⩾ 1 h
Type of test	Water-in-water or water-in-air [a]
[a] In case of dispute, water-in-water shall be used.	

A.3.2 Mechanical characteristics of valves

Valves shall be in accordance with ISO 16135, ISO 16136, ISO 16137, ISO 16138, ISO 16139 or ISO 21787, as applicable, depending on the valve type.

A.4 Physical characteristics of pipes

When tested in accordance with Table A.12, pipes shall possess the physical characteristic and meet the requirements as specified in that table.

Table A.12 — Physical characteristics of pipes

Characteristic	Requirement	Test parameter		Test method [a]
Longitudinal reversion	⩽ 2 % The pipe shall exhibit no bubbles or cracks	Temperature Immersion time Length of test pieces	150 °C 30 min 200 mm	ISO 2505-1:1994 together with ISO 2505-2:1994 Method A: Liquid bath
			or	
		Temperature Immersion time Length of test pieces	150 °C 60 min 200 mm	ISO 2505-1:1994 together with ISO 2505-2:1994 Method B: Air
[a] The choice of method is at the discretion of the tester. In case of dispute, method B shall be used.				

A.5 Fitness for purpose of system

Fitness for purpose of the system shall be deemed to have been achieved when test pieces assembled in accordance with 12.2, and tested according to Table A.13, conform to the requirements given in that table.

Table A.13 — General requirements for fitness for purpose of the system

Characteristic	Requirement	Test parameter		Test method [b]
Hydrostatic strength at 95 °C For fusion joints	No failure during test period	End caps	Type A according to ISO 1167:1996	ISO 1167 ISO 12092
		Orientation	At discretion of tester	
		Test temperature	95 °C	
		Type of test	Water-in-water or water-in-air [a]	
		Hydrostatic (hoop) stress	11,5 MPa	
		Conditioning period	⩾ 1 h	
		Test period	⩾ 200 h	
Hydrostatic strength at 20 °C For mechanical joints	No failure during test period	End caps	Type A according to ISO 1167:1996	ISO 1167 ISO 12092
		Orientation	At discretion of tester	
		Test temperature	20 °C	
		Type of test	Water-in-water or water-in-air [a]	
		Hydrostatic (hoop) stress	23,2 MPa	
		Conditioning period	⩾ 1 h	
		Test period	⩾ 1 000 h	

[a] In case of dispute, water-in-water shall be used.

[b] Assemblies of pipes and fittings shall be prepared in accordance with ISO 12092 and tested in accordance with ISO 1167.

Bibliography

[1] ISO 3, *Preferred numbers — Series of preferred numbers*

[2] ISO 497, *Guide to the choice of series of preferred numbers and of series containing more rounded values of preferred numbers*

[3] ISO 2507-1:1995, *Thermoplastics pipes and fittings — Vicat softening temperature — Part 1: General test method*

[4] ISO 2507-2:1995, *Thermoplastics pipes and fittings — Vicat softening temperature — Part 2: Test conditions for unplasticized poly(vinyl chloride) (PVC-U) or chlorinated poly(vinyl chloride) (PVC-C) pipes and fittings and for high impact resistance poly (vinyl chloride) (PVC-HI) pipes*

[5] ISO 4433 (all parts), *Thermoplastics pipes — Resistance to liquid chemicals — Classification*

[6] ISO 9001:2000, *Quality management systems — Requirements*

[7] ISO 9393 (all parts), *Thermoplastics valves — Pressure test methods and requirements*

[8] ISO 9631:2003, *Rubber seals — Joint rings for pipelines for hot-water supply up to 110 °C — Specification for the material*

[9] ISO 10241, *International terminology standards — Preparation and layout*

[10] ISO 15493:2003, *Plastics piping systems for industrial applications — Acrylonitrile-butadiene-styrene (ABS), unplasticized poly(vinyl chloride) (PVC-U) and chlorinated poly(vinyl chloride) (PVC-C) — Specifications for components and the system — Metric series*

[11] ISO 15494:2003, *Plastics piping systems for industrial applications — Polybutene (PB), polyethylene (PE) and polypropylene (PP) — Specifications for components and the system — Metric series*

[12] ISO/TR 16913, *Plastics pipes and fittings — Definitions of types of test*

[13] EN 1778, *Characteristic values for welded thermoplastic constructions — Determination of allowable stresses and moduli for design of thermoplastic equipment*

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