International Standard

ISO 16422-2

First edition
2024-02

Pipes and joints made of oriented unplasticized poly(vinyl chloride) (PVC-O) for the conveyance of water under pressure —

Part 2: Pipes

Tubes et assemblages en poly(chlorure de vinyle) non plastifié orienté (PVC-O) pour le transport de l'eau sous pression —

Partie 2: Tubes

Reference number
ISO 16422-2:2024(en)

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

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Foreword

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

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

This document was prepared by Technical Committee ISO/TC 138, *Plastics pipes, fittings and valves for the transport of fluids*, Subcommittee SC 2, *Plastics pipes and fittings for water supplies.*

This first edition of ISO 16422-2, together with ISO 16422-1 and ISO 16422-5, cancels and replaces the second edition of ISO 16422:2014, which has been technically revised.

The main changes are as follows:

— ISO 16422:2014 has been split into several parts, under the general title "*Pipes and joints made of oriented unplasticized poly(vinyl chloride) (PVC-O) for the conveyance of water under pressure*". The information previously included in ISO 16422:2014 has been divided into ISO 16422-1, ISO 16422-2 (this document) and ISO 16422-5, with the following additions to ISO 16422-2:

  — DN1200 values have been introduced;

  — the tolerances of chamfers in plain ends have been modified;

  — minimum values for orientation factors have been introduced;

  — tolerances in density have been introduced;

  — minimum length of engagement values have been introduced;

  — the long-term test at 60ºC is performed on the pipe only;

  — minimum hoop stress values for production control tests have been introduced;

  — differential scanning calorimetry (DSC) has been identified as the preferred test method for gelation in case of dispute.

A list of all parts in the ISO 16422 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Molecular orientation of thermoplastics results in the improvement of physical and mechanical properties. Orientation is carried out at temperatures well above the glass transition temperature.

Orientation of PVC-U pipe-material can be induced by different processes.

In general, the following production process is common.

— A thick-wall tube is extruded (feedstock) and conditioned at the desired temperature.

— The orientation process is activated primarily in circumferential direction under controlled conditions. Axial orientation can also be activated in the product.

— After the orientation process, the pipe is cooled down quickly to ambient temperature.

The orientation of the molecules creates a laminar structure in the material of the pipe wall. This structure gives the ability to withstand brittle failure emanating from minor flaws in the material matrix or from scratches at the surface of the pipe wall.

Improved hoop strength allows reduced wall thickness with material and energy savings. It also results in improved resistance to impact and fatigue.

The classification of the pipe depends on material compound/formulation and stretch ratios used. Therefore, with the classification, these characteristics may be specified or determined.

Regarding potential adverse effects on the quality of water intended for human consumption caused by the products covered by this document, this document provides no information as to whether or not the products can be used without restriction.

The ISO 16422 series, of which this is Part 2, specifies the requirements for a piping system made from oriented unplasticized poly(vinyl chloride) (PVC-O) and its components. The piping system is intended to be used for water supply, pressurized drainage and sewerage and irrigation systems to be used underground or above ground where protected to direct sunlight.

Requirements and test methods for PVC-O components are specified in in this document, as well as in ISO 16422-1 and ISO/TS 16422-3. For other components (not manufactured from PVC-O), reference is made to the following documents: ISO 1452-3 (PVC-U) and EN 12842 (Cast Iron). Characteristics for fitness for purpose (mainly for joints) are established in ISO 16422-5.

Pipes and joints made of oriented unplasticized poly(vinyl chloride) (PVC-O) for the conveyance of water under pressure —

Part 2:
Pipes

1 Scope

This document specifies the characteristics of solid-wall pipes made of oriented unplasticized poly(vinyl chloride) (PVC-O) for piping systems intended to be used underground or above-ground (where protected from direct sunlight), for water supply, buried drainage, sewerage, treated wastewater and irrigation under pressure. It also specifies the test parameters for the test methods referred to in this document.

In conjunction with ISO 16422-1 and ISO 16422-5, this document is applicable to oriented PVC-O pipes, with or without integral socket, intended to be used for the following:

a) water mains and services lines;

b) conveyance of water for both outside and inside buildings;

c) drainage, sewerage and treated wastewater under pressure;

d) irrigation under pressure.

This document is applicable to piping systems intended for the supply of water under pressure up to and including 25 °C (cold water), intended for human consumption and for general purposes as well as for wastewater under pressure.

This document is also applicable to components for the conveyance of water and wastewater up to and including 45 °C. For temperatures between 25 °C and 45 °C, see Figure C.1.

The piping system according to this document is intended for the conveyance of cold water up to pressures of 25 bar[1)] and especially in those applications where special performance requirements are needed, such as impact loads and pressure fluctuations, up to pressure of 25 bar.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 16422-1, *Pipes and joints made of oriented unplasticized poly(vinyl chloride) (PVC-O) — Part 1: General*

ISO 16422-5, *Pipes and joints made of oriented unplasticized poly(vinyl chloride) (PVC-O) — Part 5: Fitness for purpose of the system*

ISO 161-1, *Thermoplastics pipes for the conveyance of fluids — Nominal outside diameters and nominal pressures — Part 1: Metric series*

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

ISO 1167-1, *Thermoplastics pipes, fittings and assemblies for the conveyance of fluids — Determination of the resistance to internal pressure — Part 1: General method*

ISO 1167-2, *Thermoplastics pipes, fittings and assemblies for the conveyance of fluids — Determination of the resistance to internal pressure — Part 2: Preparation of pipe test pieces*

ISO 2505, *Thermoplastics pipes — Longitudinal reversion — Test method and parameters*

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

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

ISO 3127, *Thermoplastics pipes — Determination of resistance to external blows — Round-the-clock method*

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

ISO 4633, *Rubber seals — Joint rings for water supply, drainage and sewerage pipelines — Specification for materials*

ISO 6259-2, *Thermoplastics pipes — Determination of tensile properties — Part 2: Pipes made of unplasticized poly(vinyl chloride) (PVC-U), oriented unplasticized poly(vinyl chloride) (PVC-O), chlorinated poly(vinyl chloride) (PVC-C) and high-impact poly(vinyl chloride) (PVC-HI)*

ISO 7686, *Plastics pipes and fittings — Determination of opacity*

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

ISO 9852, *Unplasticized poly(vinyl chloride) (PVC-U) pipes — Dichloromethane resistance at specified temperature (DCMT) — Test method*

ISO 9969, *Thermoplastics pipes — Determination of ring stiffness*

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

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

ISO 18373-1, *Rigid PVC pipes — Differential scanning calorimetry (DSC) method — Part 1: Measurement of the processing temperature*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 16422-1 and the following apply.

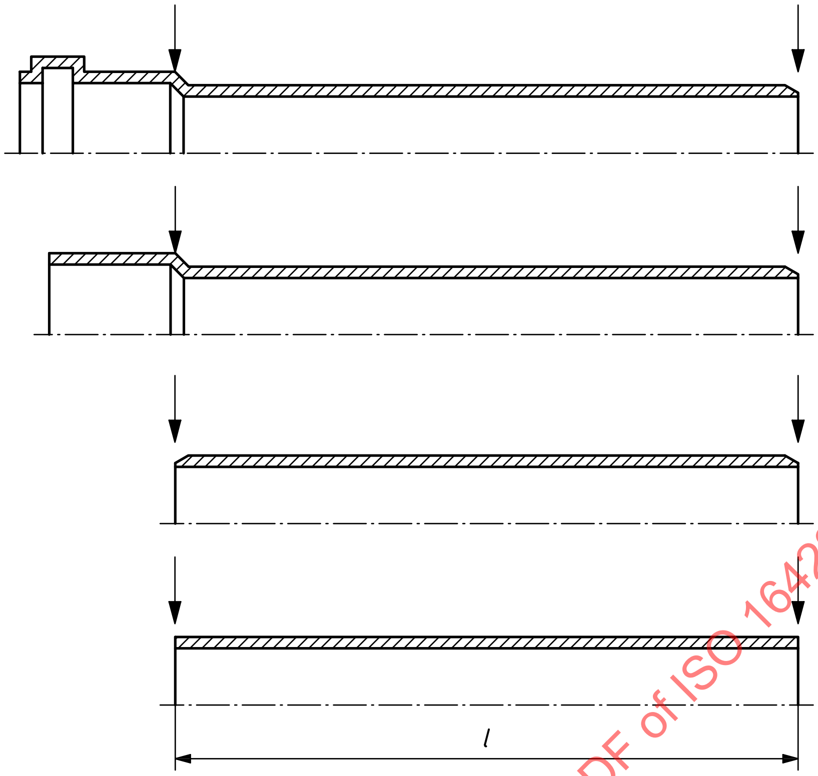
ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
nominal length
minimum length which does not include the depth of the socketed portions

Note 1 to entry: See Figure 1.



Key

l nominal length of the pipe

Figure 1 — Points of measurement for nominal lengths

3.2
nominal size DN
numerical designation of the size of a component, other than a component designated by thread size, which is a convenient round number approximately equal to the manufacturing dimension in millimetres (mm)

3.3
out-of-roundness
ovality
difference between the measured maximum and the measured minimum outside diameter in the same cross-section of a pipe or spigot, or the difference between the measured maximum and the measured minimum inside diameter in the same cross-section of a socket

3.4
Poisson contraction
shortening of the length of the pipe when pressurized

3.5
temperature contraction
shortening of the length of the pipe due to drop in temperature

3.6
angular deflection
retraction of one side of the spigot due to angular deflection of the spigot within the socket

3.7
tolerance
permitted variation of the specified value of a quantity, expressed as the difference between the permitted maximum and the permitted minimum value

3.8
long-term hydrostatic strength for 50 years at 20 °C
$\sigma_{LPL20°C,50years}$
quantity with the unit of stress, i.e. MPa, which can be considered to be a property of the material under consideration

Note 1 to entry: This represents the 97,5 % lower confidence limit for the long-term hydrostatic strength and equals the predicted average strength at a temperature of 20 °C and for a time of 50 years with internal water pressure.

3.9
working pressure
maximum pressure which a piping system can sustain in continuous use under given service conditions

4 Symbols

a	start of sealing area in the socket
b	end of cylindrical part of socket and pipe
C	overall service design coefficient
D_{em}	measured outside diameter before conditioning (orientation factor test)
D_i	measured outside diameter after conditioning (orientation factor test)
d_e	external diameter (at any point)
d_i	inside diameter of the socket
d_{im}	mean inside diameter of the socket
d_n	nominal (outside or inside) diameter
E	Young’s modulus
E_c	elastic modulus in the circumferential direction (2,0 GPa)
e	wall thickness (at any point)
e_{em}	mean wall thickness before conditioning (orientation factor test)
e_i	mean wall thickness after conditioning (orientation factor test)
e_{min}	minimum wall thickness
e_n	nominal wall thickness
I	moment of inertia of a pipe = $e_n^3/12$
L	length of pipe in metres
L_o	measured length before conditioning (orientation factor test)
L_i	measured length after conditioning (orientation factor test)
l	nominal length of the pipe
l_s	length of the socket
m	depth of engagement

m_a	minimum depth of engagement due to angular deflection of the pipe
m_{calc}	minimum depth of engagement calculated
m_{min}	lower limit of the minimum depth of engagement
m_p	minimum depth of engagement due to the Poisson contraction
m_s	minimum depth of engagement due to safety allowance
m_T	minimum depth of engagement due to temperature contraction
P_{cr}	unsupported critical buckling pressure, in kilopascals
R	radius of the striker nose
S_{calc}	calculated preferred value of the nominal S series number of the pipe according to ISO 4065:2018, Table 2
S_{Ncalc}	calculated initial ring stiffness
α	coefficient of linear expansion, (7×10^{-5}) °C^{-1}
β	angle chamfer
ΔT	temperature differential
θ	maximum angle of deflection of spigot within the socket
λ_{ai}	coefficient of axial orientation
λ_{ci}	coefficient of circumferential orientation
μ	Poisson ratio (0,40)
ρ	density
σ	hydrostatic stress in the circumferential direction
$\sigma_{LPL20°C,50years}$	long-term hydrostatic strength for 50 years at 20 °C
σ_s	design stress

5 Material

5.1 General

The material from which the pipes are made shall conform to ISO 16422-1 and to the requirements given in 5.2 and 5.4.

5.2 Density

The density, ρ, at 23 °C of the pipe, when measured in accordance with ISO 1183-1, shall be within the following limits:

$$1\,350 \text{ kg/m}^3 < \rho < 1\,460 \text{ kg/m}^3$$

5.3 MRS class

Oriented pipes made from a defined PVC compound/formulation and with a well-defined orientation level in circumferential and axial direction, shall be evaluated according to the procedures of Annex A. The MRS (minimum required strength) value shall be classified in accordance with ISO 16422-1.

The MRS class shall be declared by the manufacturer.

5.4 Orientation factor

The level of orientation is an indirect parameter for the material classification of the pipes and is dependent on the production process.

The circumferential and axial orientation factors shall be declared by the manufacturer and shall conform to the minimum values as defined in Table 1.

The orientation factors shall be measured according to Annex E and specified by the manufacturer to be within $\pm_{5}^{15}$ % deviation from the declared values.

Table 1 — Minimum declared orientation factor

Dimensions in MPa

Minimum required strength (MRS)	31,5	35,5	40,0	45,0	50,0
Axial			1,0		
Circumferential	1,5	1,6	1,7	1,8	1,9

6 General characteristics

6.1 Appearance

When viewed without magnification, the internal and external surfaces of pipes shall be smooth, clean and free from scoring, cavities and other surface defects to an extent that would prevent conformity to this document. The material shall not contain any impurities visible without magnification. The ends of the pipe shall be cut cleanly and square to the axis of the pipe.

6.2 Colour

The colour of the pipes shall be uniform throughout the wall.

The preferred colour of pipes shall be as follows:

a) for water supply cream, blue, white or white with blue stripes;

b) for irrigation under pressure blue, white or white with blue stripes;

c) for pressurized drainage and sewerage grey, brown or white with brown stripes;

d) for treated waste water, purple.

NOTE The colouring of pipes for the supply of water for human consumption can be subject to national regulations.

6.3 Opacity

If a pipe is required to be opaque for use in above-ground applications, the wall of the pipe shall transmit not more than 0,2 % of visible light falling on it when tested in accordance with ISO 7686.

6.4 Classification of pipes

6.4.1 Classification

Pipes shall be classified to their nominal pressure, *PN*.

The nominal pressure, *PN*, the pipe series, S, and the design stress, σ_s, are connected by the relationship described in Formulae (1) to (4):

$$PN \cong \frac{10\sigma_s}{S} \quad (1)$$

$$S = \frac{SDR - 1}{2} \quad (2)$$

$$SDR = \frac{d_n}{e_n} \quad (3)$$

$$\sigma_s = \frac{MRS}{C} \quad (4)$$

6.4.2 Calculation of wall thickness

The relationship between the nominal wall thickness, e_n, and the nominal outside diameter d_n is specified in ISO 4065. The values for nominal pipe wall thickness, e_n, for nominal pressure ratings, *PN*, can be calculated by substituting the values for d_n and S_{calc} as shown in Formula (5):

$$e_n = \frac{d_n}{2S_{calc} + 1} \quad (5)$$

Values shall be rounded to one decimal place according to the rules of ISO 4065.

Nominal S numbers and their calculated values are given in ISO 4065 for the R10 series of preferred numbers. For the R20 series required for this document, refer to ISO 3.

The nominal outside diameter and nominal wall thickness for the relevant nominal pressure and material classes are specified in Table 2.

7 Geometrical characteristics

7.1 Measurement of dimensions

The dimensions of pipes shall be measured in accordance with ISO 3126.

7.2 Length of pipes

It is recommended that pipes be supplied in one or more of the following lengths: 6 m, 10 m, 12 m, where these lengths do not include the depth of any (integral) socket(s). Other lengths are subject to agreement between the manufacturer and the purchaser.

The nominal length of the pipe shall not be less than that specified by the manufacturer.

7.3 Nominal outside diameters and wall thicknesses

The nominal outside diameter of pipes in accordance with ISO 161-1, and the corresponding wall thickness, shall be selected from Table 2 as appropriate for size, nominal pressure and pipe material class.

The tolerances for mean outside diameters shall be in accordance with ISO 11922-1:2018, grade C. For other outside diameters not mentioned in ISO 11922-1, the tolerance shall be calculated according to 0,003 d_n rounded to the nearest 0,1 mm with a minimum value of 0,3 mm.

The nominal wall thickness shall conform to the minimum values given in Table 2.

The mean wall thickness shall be declared by the manufacturer.

The tolerances on the mean wall thickness shall be in accordance with ISO 11922-1:2018, grade W; otherwise they shall be specified by the manufacturer. For other wall thicknesses, the tolerance can be calculated according to the formula (0,1 × e_{min} + 0,2), rounded up to the nearest 0,1 mm. Due to the additional processing step, being the orientation of the material, the tolerance for mean wall thickness of the PVC-O pipe can potentially be increased.

The tolerances on out-of-roundness shall be in accordance with ISO 11922-1:2018, grade M.

Other diameters can be used provided that the calculations of minimum thicknesses are calculated according to 6.4.2.

Table 2 — Nominal outside diameters, d_n, and nominal wall thickness, e_n

MRS class	**Pressure class PN for design coefficient C = 1,6**												
315	6,3		8		10		12,5		16		20		25
355		8		10		12,5		16		20		25	
400	8		10		12,5		16		20		25		
450		10		12,5		16		20		25			
500	10		12,5		16		20		25				
	Pressure class PN for design coefficient C = 1,4												
450	10		12,5		16		20		25				
500		12,5		16		20		25					

Pipe series S numbers preferred and computed values (ISO 3) and standard dimension ratios (SDR)													
S	32,0	28,0	25,0	22,4	20,0	18,0	16,0	14,0	12,5	11,2	10,0	9,0	8,0
S_{calc}	31,623	28,184	25,119	22,387	19,953	17,783	15,849	14,125	12,589	11,220	10,000	8,9 125	7,9 433
SDR	65,0	57,0	51,0	45,8	41,0	37,0	33,0	29,0	26,0	23,4	21,0	19,0	17,0

d_n	e_n (mm)												
63					1,6	1,8	2,0	2,2	2,5	2,7	3,0	3,4	3,8
75			1,5	1,7	1,9	2,1	2,3	2,6	2,9	3,2	3,6	4,0	4,5
90		1,6	1,8	2,0	2,2	2,5	2,8	3,1	3,5	3,9	4,3	4,8	5,4
110	1,8	2,0	2,2	2,4	2,7	3,1	3,4	3,8	4,2	4,7	5,3	5,9	6,6
125	2,0	2,2	2,5	2,8	3,1	3,5	3,9	4,3	4,8	5,4	6,0	6,7	7,4
140	2,2	2,5	2,8	3,1	3,5	3,9	4,3	4,8	5,4	6,0	6,7	7,5	8,3
160	2,5	2,8	3,2	3,5	4,0	4,4	4,9	5,5	6,2	6,9	7,7	8,5	9,5
180	2,8	3,2	3,6	4,0	4,4	5,0	5,5	6,2	6,9	7,7	8,6	9,6	10,7
200	3,2	3,5	3,9	4,4	4,9	5,5	6,2	6,9	7,7	8,6	9,6	10,7	11,9
225	3,5	4,0	4,4	5,0	5,5	6,2	6,9	7,7	8,6	9,6	10,8	12,0	13,4
250	3,9	4,4	4,9	5,5	6,2	6,9	7,7	8,6	9,6	10,7	11,9	13,3	14,8

280	4,4	4,9	5,5	6,2	6,9	7,7	8,6	9,6	10,7	12,0	13,4	14,9	16,6
315	4,9	5,5	6,2	6,9	7,7	8,7	9,7	10,8	12,1	13,5	15,0	16,8	18,7
355	5,6	6,2	7,0	7,8	8,7	9,8	10,9	12,2	13,6	15,2	16,9	18,9	21,1
400	6,3	7,0	7,9	8,8	9,8	11,0	12,3	13,7	15,3	17,1	19,1	21,3	23,7
450	7,0	7,9	8,8	9,9	11,0	12,4	13,8	15,4	17,2	19,2	21,5	23,9	26,7
500	7,8	8,8	9,8	11,0	12,3	13,7	15,3	17,1	19,1	21,4	23,9	26,6	29,7
560	8,8	9,8	11,0	12,3	13,7	15,4	17,2	19,2	21,4	23,9	26,7	29,8	33,2
630	9,9	11,0	12,3	13,8	15,4	17,3	19,3	21,6	24,1	26,9	30,0	33,5	37,4
710	11,2	12,4	14,1	15,4	17,5	19,2	21,8	24,4	27,6	30,2	34,2	37,3	42,2
800	12,6	14,0	15,9	17,4	19,8	21,6	24,5	27,4	31,1	34,0	38,5	42,0	47,6
900	14,1	15,7	17,9	19,6	22,2	24,3	27,6	30,9	35,0	38,2	43,3	47,3	53,5
1 000	15,7	17,5	19,9	21,7	24,7	27,0	30,6	34,3	38,9	42,5	48,1	52,5	59,4
1 200	18,4	21,1	23,5	26,2	29,3	32,4	36,4	41,4	46,2	51,3	57,1	63,2	70,6

NOTE With specified SDR class and applying a higher design coefficient other pressure classes can be derived.

7.4 Pipes with integral sockets with elastomeric sealing ring type

The nominal inside diameter of socket, d_n, and the minimum mean inside diameter of socket, $d_{im,min}$, with elastomeric ring seal joint type shall conform to the values given in Table 3 and Figure 2.

The minimum value for the depth of engagement, m, shall be as calculated in Annex B using the appropriate parameters for the pipe. In all cases, the minimum depth of engagement calculated, m_{calc}, shall not be less than m_{min} as given in Table 3.

Table 3 — Dimensions of sockets for elastomeric ring seal joints

Nominal inside diameter of socket d_n	Minimum mean inside diameter of socket $d_{im,min}$	Lower limit of the minimum depth of engagement m_{min}	Minimum depth of engagement according to Annex B [a] m_{calc}
63	63,4	58	80,5
75	75,4	60	80,7
90	90,4	61	81,0
110	110,5	64	81,3
125	125,5	66	81,6
140	140,6	68	81,8
160	160,6	71	82,2
180	180,7	73	82,5
200	200,7	75	82,9
225	225,8	78	83,3
250	250,9	81	83,8
280	281,0	85	84,3
315	316,1	88	84,9
355	356,2	90	85,6

[a] Values calculated with the following parameters as an example:

L = 6 m ; μ =0,40; C=1,6; σ_s = 31,25 MPa (MRS 50); E_c =2,0 GPa;

α = (7 × 10^{-5}) °C^{-1}; ΔT = 50 °C; θ = 1°;

S = 20 mm

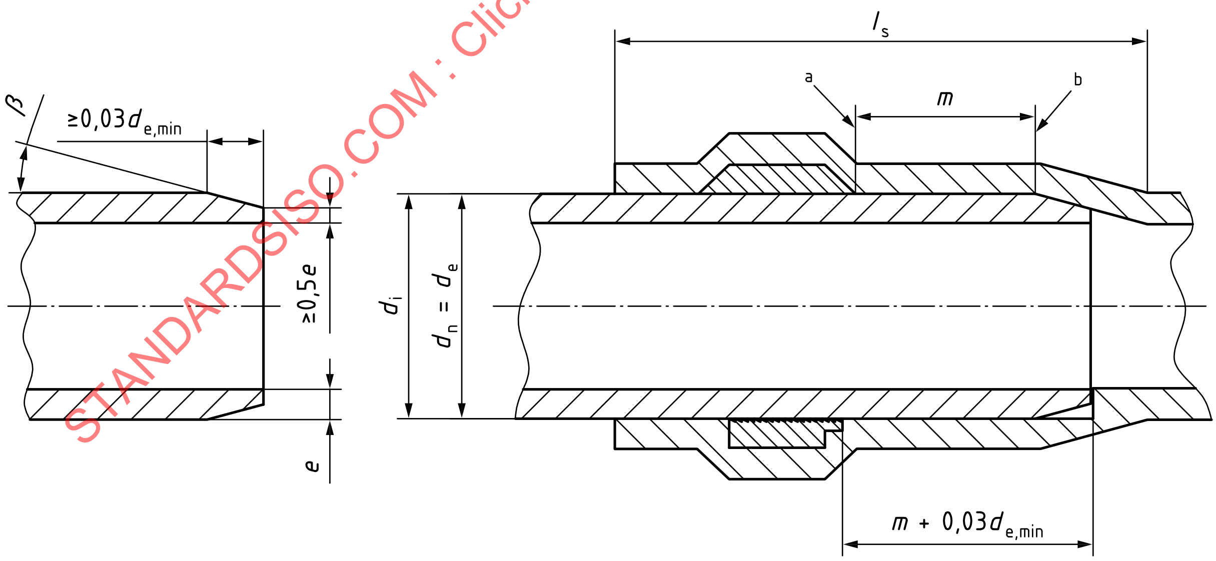
Table 3 *(continued)*

Nominal inside diameter of socket d_n	Minimum mean inside diameter of socket $d_{im,min}$	Lower limit of the minimum depth of engagement m_{min}	Minimum depth of engagement according to Annex B [a] m_{calc}
400	401,3	92	86,4
450	451,5	95	87,3
500	501,6	97	88,1
560	561,8	101	89,2
630	632,0	105	90,4
710	712,3	109	91,8
800	802,5	114	93,4
900	902,8	120	95,1
1 000	1 003,1	125	96,9
1 200	1 203,7	136	100,3

[a] Values calculated with the following parameters as an example:
L = 6 m ; μ =0,40; C=1,6; σ_s = 31,25 MPa (MRS 50); E_c =2,0 GPa;
α = (7 × 10^{-5}) °C^{-1}; ΔT = 50 °C; θ = 1°;
S = 20 mm

NOTE There is no minimum wall thickness requirement for sealing ring type sockets. It is considered as being more relevant to verify the strength of the sockets as being at least the same as the strength of the pipe in accordance with 9.1.3.

The design coefficient of oriented PVC-O pipes shall be a minimum of 1,6 providing that axial contraction of the pipe (due to higher design stress) does not result in pull-out of the joints. For pipes, a design coefficient of 1,4 is only permitted for MRS 45,0 and MRS 50,0 if proven according to ISO 16422-2:2023, Annex B that there is no risk on pull-out of the joints.



Key

a Start of sealing area.

b End of cylindrical part of socket and pipe.

β angle chamfer

m depth of engagement

d_e external diameter of pipe

d_i inside diameter of the socket
l_s length of the socket
e wall thickness

Figure 2 — Socket and spigot end for pipes with elastomeric sealing

7.5 Plain ends

Pipes with plain end(s) to be used with elastomeric sealing ring type joints shall have a chamfer conforming to Figure 2 with $12° \leq \beta \leq 15°$.

8 Selection of pipes

8.1 Selection of nominal pressure and pipe series S for water up to and including 25 °C

The nominal pressure, *PN*, shall be based on the classification in accordance with 6.4.1.

The applicable pipe series shall be taken from Table 2.

8.2 Determination of the allowable operating pressure for water up to 45 °C

The allowable operating pressure, *PFA*, for temperatures up to and including 25 °C shall be equal to the nominal pressure, *PN*.

To determine the allowable operating pressure, *PFA*, for temperatures between 25 °C and 45 °C, a supplementary derating factor, f_T, from Annex C, shall be applied to the nominal pressure, *PN*, as given in Formula (6):

$$PFA = f_T \times PN \qquad (6)$$

This factor is given in Figure C.1.

NOTE Another derating factor, f_A, can be used, taking account of the application. Normally f_A equals 1. For other values, see related installation documents, e.g. ISO/TR 4191.

9 Mechanical characteristics

9.1 Resistance to hydrostatic pressure

9.1.1 General

Resistance to hydrostatic pressure shall be verified using the test conditions established in Table 4. The induced stresses are derived from the reference curves according to A.2.1.

When tested using either end cap type A or type B in accordance with ISO 1167-1 and using the combinations of test temperatures and induced stresses so derived, the pipe shall not fail in less than the times stated in Table 4. In case of dispute, end cap type B shall be used.

Table 4 — Test conditions

<table>
<tr><th rowspan="3">Character-istic</th><th rowspan="3">Require-ment</th><th colspan="9">Test parameters</th><th rowspan="3">Test meth-od</th></tr>
<tr><th rowspan="2">Tempera-ture °C</th><th colspan="5">Hoop stress (MPa) [b]</th><th rowspan="2">Time h</th><th rowspan="2">Type of test</th><th rowspan="2">Num-ber of pieces</th></tr>
<tr><th>MRS 31,5</th><th>MRS 35,5</th><th>MRS 40,0</th><th>MRS 45,0</th><th>MRS 50,0</th></tr>
<tr><td rowspan="3">Short- and long-term strength</td><td rowspan="3">No failure during the test</td><td>20</td><td>41</td><td>46</td><td>52</td><td>60</td><td>65</td><td>10</td><td rowspan="3">Water in water</td><td rowspan="3">1 [a]</td><td rowspan="3">ISO 1167-1 and ISO 1167-2</td></tr>
<tr><td>20</td><td>36</td><td>42</td><td>46</td><td>53</td><td>58</td><td>1 000</td></tr>
<tr><td>60</td><td>20</td><td>22</td><td>25</td><td>28</td><td>31</td><td>1 000</td></tr>
</table>

[a] The number of test pieces required for factory production control and process control should be listed in the manufacturer's quality plan.

[b] For calculation of test pressure of pipes, minimum measured wall thickness shall be used. In case of integral sockets, e_n shall be used for calculation.

9.1.2 Pipes

Pipes shall withstand without bursting or leakage the hydrostatic stress induced by internal hydrostatic pressure when tested using the test conditions specified in 9.1.1.

9.1.3 Pipes with integral sockets

Integral sockets assemblies shall withstand without bursting or leakage the hydrostatic stress induced by internal hydrostatic pressure when tested using the test conditions at 20 °C specified in 9.1.1. When testing integral sockets assemblies, the pipe spigot inserted into the socket may be of a different material or higher-pressure class than the test specimen.

In case of sealing ring, it may be restrained from blow-out by adhesive or mechanical means, provided such means do not materially reduce the stress on the pressurized portion of the socket.

9.2 Impact strength

Pipes shall be tested at 0 °C in accordance with ISO 3127, and shall have a true impact rate (TIR) of not more than 10 % when using masses given in Table 5 and the drop height of 2 m. The radius of the striker nose shall be R = 12,5 mm.

Table 5 — Classified striker mass for impact test

Nominal size DN	Total mass kg
63	4
75	5
90	5
110	6,3
125	6,3
140	8
160	8
180	10
200	10
≥ 225	12,5

NOTE Impact characteristics can change over time. These values are applicable only at the time of manufacture.

9.3 Ring stiffness

If relevant, the ring stiffness of pipes conforming to this document shall be determined in accordance with ISO 9969.

NOTE 1 Pipes of stiffness less than 4 kN/m^2 can be unsuitable where there is the possibility of high vacuum or external pressure being developed. They can also require special installation techniques when installed below ground.

NOTE 2 National regulations and/or national practices on use of specific fittings can require minimum stiffness of pipes.

NOTE 3 Minimum stiffness of pipes is sometimes required for installation with certain type of fittings.

NOTE 4 Theoretical ring stiffness of pipes is given in Annex D.

10 Physical characteristics

When tested in accordance with the test methods as specified in Table 6 using the indicated parameters, the pipe shall have physical characteristics conforming to the requirements given in Table 6.

Table 6 — Physical characteristics

Characteristic	Requirements	Test parameters		Test method
Vicat softening temperature (VST) [a]	≥ 80 °C	Shall conform to ISO 2507-1		ISO 2507-1
Resistance to dichloro-methane at a specific temperature [a,b]	No attack [c]	Temperature of bath Immersion time	(15 ± 1) °C 15 min	ISO 9852
Uniaxial tensile strength [b]	≥ 48 MPa	Speed Temperature	(5 ± 1) mm/min (23 ± 2) °C	ISO 6259-1 and ISO 6259-2
DSC [b]	B-onset temperature ≥ 185 °C [d]	Shall conform to ISO 18373-1	Number of test pieces: 4	ISO 18373-1

[a] To be carried out on feedstock pipe or on reverted pipe.

[b] DSC = differential scanning calorimetry. One test method shall be chosen by the producer for factory production control, taking into consideration national regulations or internal health and safety policies. In case of dispute, the DSC method shall be used.

[c] Isolated spots less than 2 mm shall not be considered as an attack.

[d] For CaZn and organic-based stabilized formulations, the B-onset temperature shall be ≥ 180 °C.

11 Sealing rings

The material of the elastomeric sealing ring used in joint assemblies for pipes shall be chosen from ISO 4633 and shall conform to the appropriate class.

The sealing ring shall have no detrimental effect on the properties of the pipe and shall not cause the test assembly to fail the functional requirements of ISO 16422-5.

12 Marking

12.1 General

The marking elements shall be printed or formed directly on the pipe with a maximum interval of 1 m in such a way that after storage, weathering, handling and installation, legibility is maintained during the use of the products.

NOTE The manufacturer is not responsible for marking being illegible due to actions caused by installation and use such as painting, scratching, covering of the pipes or by use of detergents on the pipe.

Marking shall not initiate cracks or other types of defects which would impair conformity to the requirements of this document.

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

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

12.2 Minimum required marking

The minimum required marking on pipes shall conform to Table 7.

Table 7 — Minimum required marking on pipes

Aspects	Mark or symbol
— Number of this document	ISO 16422-2
— Manufacturer's name and/or trademark	xyz
— Material	PVC-O
— MRS class and C-factor	e.g. 45,0 C=1,6
— Nominal outside diameter d_n × nominal wall thickness e_n	e.g. 110 × 6,6
— Nominal pressure PN	e.g. PN 16
— Manufacturer's information[a]	e.g. mm yyyy
— Intended use[b]	e.g. W/P

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

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

— a name or code for the production site, if the manufacturer is producing in different sites, nationally and/or internationally.

— Identification of the extrusion line, if there is more than one.

[b] Optionally; for information on abbreviations, see CEN/TR 15438[5] and/or national rules.

12.3 Additional marking

Pipes conforming to this document and also conforming to other document(s) may be marked additionally with intended use information and the number(s) of the other document(s), together with the minimum required marking in accordance with the other document(s).

Annex A
(normative)

Establishment of the pipe material classification

A.1 General

The minimum required strength of the pipe materials for the purpose of this document shall be evaluated according to the procedures of ISO 9080.

NOTE The establishment of the PVC-O pipe material classification is limited to PVC-O pipes with the same orientation factor.

A.2 Determination of PVC-O pipe material classification

A.2.1 Procedure

Pipe material shall be designated by the material type (PVC-0) in pipe form and the level of the minimum required strength (MRS) in accordance with Table 1.

The pipe material shall have an MRS equal to the values as specified in Table 1. The MRS value for classification shall be derived from σ_{LPL} in accordance with ISO 12162. The $\sigma_{LPL 20\,°C, 50\,years}$ value is determined by analysis, in accordance with ISO 9080, of hydrostatic pressure tests carried out in accordance with ISO 1167-1 and ISO 1167-2 and using end caps type A or B, tested with water in water at the temperatures 20 °C and 60 °C

Alternatively, the conformance to the PVC-O reference lines can be demonstrated by plotting the ISO 9080 data points of 20 °C (and 60 °C) on the graph. At least 97,5 % of the data points shall lie on or above the reference lines.

The reference lines for PVC-O pipe materials are the reference curves in the temperature range of 20 °C to 60 °C for PVC-O 315, PVC-O 355, PVC-O 400, PVC-O 450 and PVC-O 500 are derived from Formulae (A.1) – (A.5):

For PVC-O 315:

$$\log t = -86{,}914 + \frac{44\,942{,}044}{T} + 9{,}173 \cdot \log \sigma - \frac{14\,575{,}356 \cdot \log \sigma}{T} \qquad (A.1)$$

For PVC-O 355:

$$\log t = -98{,}404 + \frac{49\,246{,}158}{T} + 14{,}322 \cdot \log \sigma - \frac{16\,290{,}412 \cdot \log \sigma}{T} \qquad (A.2)$$

For PVC-O 400:

$$\log t = -91{,}994 + \frac{47\,752{,}530}{T} + 10{,}513 \cdot \log \sigma - \frac{15\,023{,}175 \cdot \log \sigma}{T} \qquad (A.3)$$

For PVC-O 450:

$$\log t = -63{,}962 + \frac{38\,408{,}460}{T} - 5{,}866 \cdot \log \sigma - \frac{9\,170{,}842 \cdot \log \sigma}{T} \qquad (A.4)$$

For PVC-O 500:

$$\log t = -94{,}470 + \frac{49\,653{,}145}{T} + 10{,}789 \cdot \log \sigma - \frac{15\,114{,}450 \cdot \log \sigma}{T} \qquad (A.5)$$

A.2.2 Classified feedstock material

If the PVC(-U) feedstock material is classified as MRS 25 MPa material in accordance with ISO 9080, and the final pipe orientation factor conforms to the minimum values given in Table 1, the following procedure for classification of the PVC-O pipe material shall be followed.

The classification involves the determination of at least 15 failure points at 20 °C on PVC-O pipes. The observations shall have the following failure time distribution:

- times from 10 h up to and including 10 000 h, of which at least 3 samples shall be:
  - between 10 h and 100 h;
  - between 100 h and 1 000 h;
  - between 1 000 h and 10 000 h of which at least 3 samples above 3 000 h and at least one sample above 5 000 h.

Conformance to the applicable PVC-O reference lines can be demonstrated by plotting the data points of 20 °C on the graph. All data points shall lie on or above the reference lines.

A.2.3 Not-classified feedstock material

If the PVC(-U) feedstock material is not classified as MRS 25 MPa material, the procedure for classification of the pipe material shall be followed as described in ISO 9080. The test temperatures shall be 20 °C and 60 °C.

Alternatively, conformance to the PVC-U 250 reference lines (ISO 1452-1) can be demonstrated by plotting the ISO 9080 data points of 20 °C and 60 °C on the graph. At least 97,5 % of the data points shall lie on or above the reference lines.

If the feedstock material has an MRS of 25 MPa or above, or at least 97,5 % of data points lying on or above the reference lines as described in this subclause, the material can be designated as classified feedstock material for PVC-O pipes. In this case, the procedure in A.2.2 shall be applicable via conformance testing on the PVC-O pipes.

If 97,5 % of PVC-U data points do not lie on or above the PVC-U reference lines, or if the feedstock material has an MRS below 25 MPa, the procedure in A.2.1 shall be applicable via ISO 9080 testing on the PVC-O pipes at 20 °C and 60 °C.

Annex B
(normative)

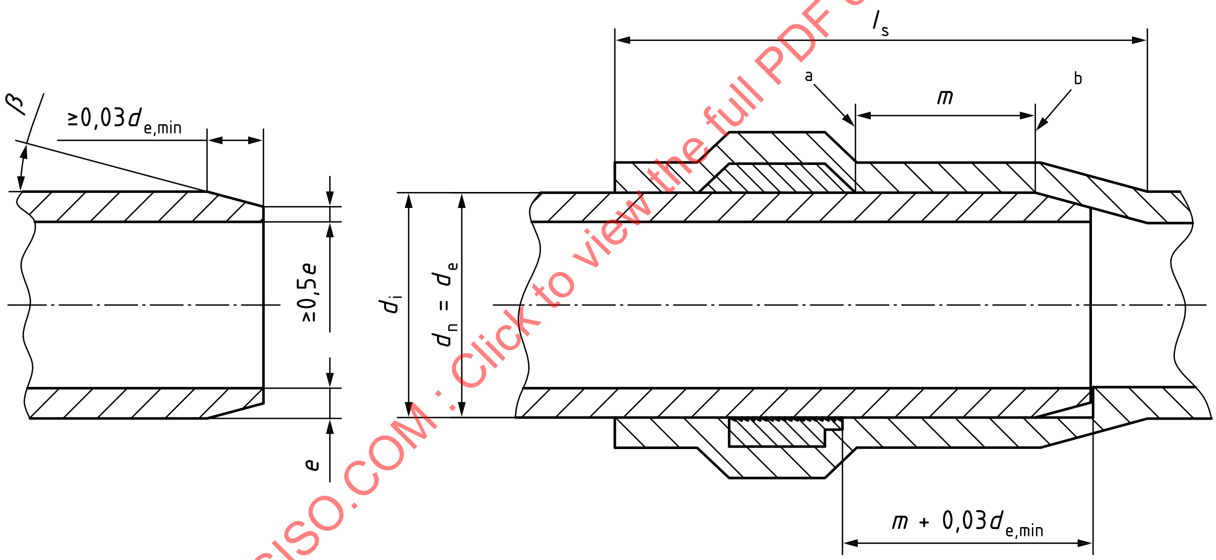
Minimum depth of engagement of sockets

B.1 General

The minimum depth of engagement of integral sockets with elastomeric sealing ring type joints is given in ISO 1452-2 and Figure B.1

Attention is drawn to the fact that the depths of engagement required by ISO 1452-2 can potentially be insufficient for PVC-O pipes conforming to this document under certain circumstances, particularly pipes of length greater than 6 m, and can potentially result in “pull-out” and leakage under adverse conditions. Primarily, this is due to the higher strain levels developed at the higher operating stresses invoked in PVC-O pipes compared with the PVC-U pipes for which ISO 1452-2 was developed.

The potential for pull-out also exists with short-socketed fittings of PVC or other materials used in conjunction with PVC-O pipes.



Key

a Start of sealing area.

b End of cylindrical part of socket and pipe.

β angle chamfer

m depth of engagement

d_e external diameter of pipe

d_i inside diameter of the socket

l_s length of the socket

e wall thickness

Figure B.1 — Depth of engagement

B.2 Calculation of depth of engagement

a) Depth of engagement, *m*, is calculated using Formula (B.1):

$$m_{cacl} = m_p + m_T + m_a + m_s \qquad (B.1)$$

where

m_{calc} is the minimum depth of engagement calculated, in mm;

m_p is the minimum depth of engagement due to the Poisson contraction, in mm;

m_T is the minimum depth of engagement due to temperature contraction, in mm;

m_a is the minimum depth of engagement due to angular deflection of the pipe, in mm;

m_s is the minimum depth of engagement due to safety allowance, in mm.

b) The minimum depth of engagement due to the Poisson contraction, m_p, (shortening of length when pressurized) is calculated using Formula (B.2):

$$m_p = \frac{L \times \mu \times \sigma}{E_c} \qquad (B.2)$$

where

L is the length of pipe, in m;

μ is the Poisson ratio (0,40);

σ is the hydrostatic stress in the circumferential direction. in MPa;

E_c is the elastic modulus in the circumferential direction (2,0 GPa).

σ is usually taken as the long-term operating stress at working pressure, or the design stress, σ_s, for the pipe material, and E_c as the long-term creep modulus.

EXAMPLE 1 For an MRS 50,0 pipe with values C = 1,6 and σ_s = 32 MPa, then m_p = 6 × 0,40 × 32/2,0 = 38,4 mm.

For buried pipelines, resistance to contraction is offered by the soil and the full Poisson contraction is unlikely to be realized. However, an unrestrained above-ground pipeline can be subject to the full contraction. A worst-case situation arises during field testing of lines not yet back-filled, where a test pressure margin of 25 % could be applied.

EXAMPLE 2 With a short-term modulus of 4,0 GPa, then m_p = 6 × 0,40 × 32 × 1,25/4,0 = 24 mm.

c) The minimum depth of engagement due to temperature contraction, m_T, (shortening due to drop in temperature) is calculated using Formula (B.3):

$$m_T = L \times \alpha \times \Delta T \times 10^3 \qquad (B.3)$$

where

L is the length of pipe, in m;

α is the coefficient of linear expansion (7 × 10^{-5}) °C^{-1};

ΔT is the temperature differential, in °C.

This can occur, for example, during construction as a result of filling the pipeline with water. Again, for buried pipelines, soil friction will reduce the range of movement, but above-ground lines could realize the