TECHNICAL REPORT

ISO/TR 4191

Second edition
2014-01-15

Plastics piping systems for water supply — Unplasticized poly(vinyl chloride)(PVC-U) and oriented PVC-U (PVC-O) — Guidance for installation

Systèmes de canalisations en plastique pour l'alimentation en eau — Polychlorure de vinyle non plastifié (PVC-U) et orienté PVC-U (PVC-O) — Pratique recommandée pour la pose

Reference number
ISO/TR 4191:2014(E)

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Published in Switzerland

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Foreword

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 138, *Plastics pipes, fittings and valves for the transport of fluids*, Subcommittee SC 2, *Plastics pipes and fittings for water supplies*.

This second edition cancels and replaces the first edition (ISO/TR 4191:1989), which has been technically revised.

Introduction

This Technical Report is a guidance document and gives a recommended practice for the installation of unplasticized poly(vinyl chloride) (PVC-U) and oriented unplasticized poly(vinyl chloride) (PVC-O) piping systems conveying water under pressure for buried and above-ground drainage and sewerage systems.

Molecular orientation of PVC-U results in the improvement of physical and mechanical properties.

Unless specifically mentioned, the recommendations are valid for both PVC-U and PVC-O and expressed as PVC.

Plastics piping systems for water supply — Unplasticized poly(vinyl chloride)(PVC-U) and oriented PVC-U (PVC-O) — Guidance for installation

1 Scope

This ISO Technical Report gives recommended practices for installation of unplasticized poly(vinyl chloride) (PVC-U) and oriented unplasticized poly(vinyl chloride) (PVC-O) pipes, fittings, valves, and ancillaries when used in piping systems conveying water under pressure.

The recommendations are intended to give practical guidance of design and installation of piping systems incorporating pipes, fittings, valves, and ancillary equipment made from PVC materials and used for the following purposes:

— water mains and services buried in ground;

— waste water under pressure;

— conveyance of water above ground for both outside and inside buildings,

for the supply of water under pressure at approximately 20 °C (cold water) intended for human consumption and for general purposes.

This Technical report is also applicable to components for the conveyance of water up to and including 45 °C. For temperatures between 25 °C and 45 °C, Figure 1 of ISO 1452-2:2009 applies.

In addition, recommendations are given for the connection to fittings, valves, and ancillary equipment made from materials other than PVC.

2 Normative references

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

ISO 3, *Preferred numbers — Series of preferred numbers*

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

ISO 1452-1:2009, *Plastics piping systems for water supply and for buried and above-ground drainage and sewerage under pressure — Unplasticized poly(vinyl chloride) (PVC-U) — Part 1: General*

ISO 1452-2:2009, *Plastics piping systems for water supply and for buried and above-ground drainage and sewerage under pressure — Unplasticized poly(vinyl chloride) (PVC-U) — Part 2: Pipes*

ISO 1452-3, *Plastics piping systems for water supply and for buried and above-ground drainage and sewerage under pressure — Unplasticized poly(vinyl chloride) (PVC-U) — Part 3: Fittings*

ISO 1452-4, *Plastics piping systems for water supply and for buried and above-ground drainage and sewerage under pressure — Unplasticized poly(vinyl chloride) (PVC-U) — Part 4: Valves*

ISO 1452-5, *Plastics piping systems for water supply and for buried and above-ground drainage and sewerage under pressure — Unplasticized poly(vinyl chloride) (PVC-U) — Part 5: Fitness for purpose of the system*

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 7387-1, *Adhesives with solvents for assembly of PVC-U pipe elements — Characterization — Part 1: Basic test methods*

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

ISO 9311-1, *Adhesives for thermoplastic piping systems — Part 1: Determination of film properties*

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

ISO/DIS 16422:2013, *Pipes and joints made of oriented unplasticized poly(vinyl chloride) (PVC-O) for the conveyance of water under pressure — Specifications*

3 Terms and definitions, symbols, and abbreviations

3.1 Terms and definitions

For the purposes of this document, the terms and definitions in ISO 1452-1:2009 and the following apply.

3.1.1
nominal outside diameter
d_n
numerical designation of size which is common to all components in a thermoplastics piping system other than flanges and components designated by thread size

Note 1 to entry: It is a convenient round number for reference purposes.

Note 2 to entry: For pipe conforming to ISO 161-1, the nominal outside diameter, expressed in millimetres, is the minimum mean outside diameter $d_{em, min}$.

3.1.2
nominal wall thickness
e_n
specified wall thickness, in millimetres

Note 1 to entry: It is identical to the specified minimum wall thickness at any point $e_{y,min}$.

3.1.3
nominal pressure (PN)
alphanumeric designation related to the mechanical characteristics of the components of a piping system and used for reference purposes

3.1.4
hydrostatic pressure
p
internal pressure applied to a piping system

3.1.5
working pressure (PFA)
maximum pressure which a piping system can sustain in continuous use under given service conditions without pressure surge

Note 1 to entry: For thermoplastics piping systems, the value of the nominal pressure is equal to the working pressure at a temperature of 20 °C expressed in bars.

3.1.6
hydrostatic stress
σ
stress induced in the wall of a pipe when it is subjected to internal water pressure

Note 1 to entry: The stress in megapascals is related to the internal pressure, p, in bars, the nominal wall thickness, e_n, in millimetres, and the nominal outside diameter of the pipe, d_n, in millimetres by the following formula:

$$\sigma = \frac{p \times (d_n - e_n)}{20 e_n}$$

Note 2 to entry: If σ and p are given in the same units, the denominator becomes 2*en*.

3.1.7
long-term hydrostatic strength at 20 °C
σ_{lhts}
quantity with the unit of stress, i.e. MPa, which can be considered to be a property of the material under consideration and which 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 a time of 50 years with internal water pressure

Note 1 to entry: ISO 9080 gives the possibility to extrapolate to 100 year lifetime.

3.1.8
lower confidence limit of the predicted hydrostatic strength

σ_{LPL}
quantity with the dimension of stress, which represents the 97,5 % lower confidence limit of the predicted hydrostatic strength for a single value at a temperature T and a time t

Note 1 to entry: It is denoted as $\sigma_{LPL} = \sigma_{(T,t,0,975)}$.

Note 2 to entry: The value of this quantity is determined by the method given in ISO 9080.

3.1.9
minimum required strength
MRS
value of σ_{LPL} rounded to the next lower value of the R 10 series from ISO 3 when σ_{LPL} is below 10 MPa or to the next lower value of the R 20 series when σ_{LPL} is higher than 10 MPa

3.1.10
design coefficient
C
overall coefficient with a value greater than one, which takes into consideration service conditions, as well as properties of the components of a piping system other than those represented in σ_{LPL}

3.1.11
pipe series S
dimensionless number for pipe designation (see ISO 4065)

3.1.12
standard dimension ratio
SDR
numerical designation of a pipe series which is a convenient round number approximately equal to the dimension ratio of the nominal outside diameter, d_n, and the nominal wall thickness, e_n

Note 1 to entry: According to ISO 4065, the standard dimension ratio, SDR, and the pipe series S are related as follows:

[SDR] = 2[S] +1

3.2 Symbols

C design coefficient

d_e outside diameter (at any point)

d_{em} mean outside diameter

d_i inside diameter (at any point)

d_{im} mean inside diameter of socket

d_n nominal (outside or inside) diameter

DN nominal size

E wall thickness (at any point)

e_m mean wall thickness

e_n nominal wall thickness

f_A derating ($_{or}$ uprating) factor for application

f_T derating factor for temperatures

Δ material density

Σ hydrostatic stress

P internal hydrostatic pressure

p_T test pressure

σ_S design stress

σ_{LPL} stress at lower predicted confidence limit

3.3 Abbreviations

LPL lower predicted confidence limit

MRS minimum required strength

MOP maximum operating pressure

PFA allowable operating pressure

PEA allowable site test pressure

PN nominal pressure

DN nominal diameter

PVC-U unplasticized poly(vinyl chloride)

SDR standard dimension ratio

PVC-O oriented poly(vinyl chloride)

4 Parameters influencing design

4.1 Allowable operating pressure

4.1.1 Where pipe material temperatures do not exceed 25 °C, and where no extra safety considerations are applicable, nominal pressures are given in Table A.1 of ISO 1452-2:2009 and in Table 2 of ISO/DIS 16422:2013. These nominal pressures have been calculated on the basis of well-established data, taking into account a service life of at least 50 years of continuous operation. For common water supply systems up to 25 °C, the allowable operating pressure PFA in bars (1 bar = 105 N/m2 = 0,1 MPa) is equal to the nominal pressure, PN.

4.1.2 Design coefficient, *C*, should comply with those specified in ISO 1452, for PVC-U, and ISO 16422, for PVC-O.

4.1.3 Where the water service temperature is between 25 °C and 45 °C, it is required that the maximum allowable pressure is reduced by applying a derating factor, f_T, as shown in Figure A.1 of ISO 1452-2:2009 and Annex C of ISO/DIS 16422:2013.

Figure A.1 of ISO 1452-2:2009 shows that for temperatures up to and including 25 °C, the derating factor to be applied is 1,0 and for temperatures above 25 °C, the derating factor reduces from 1,0 to 0,63 at 45 °C. The same is valid for PVC-O pipes.

Where water service temperatures are expected to exceed 45 °C, the manufacturer's advice should be obtained.

4.2 Ring stiffness of pipes

Where a calculation of the initial pipe deflection is applied, the initial ring stiffness of the pipe should be taken from Table 1.

Table 1 — Initial ring stiffness of pipes

	Pipe series							
	S 20 (SDR 41)	S 16,7 (SDR 34,4)	S 16 (SDR 33)	S 12,5 (SDR 26)	S 10 (SDR 21)	S 8 (SDR 17)	S 6,3 (SDR 13,6)	S 5 (SDR 11)
Nominal pressure for d_n ≤90	–	PN 6	PN 6	PN 8	PN 10	PN 12,5	PN 16	PN 20
Nominal pressure for d_n >90	PN 6	PN 7,5	PN 8	PN 10	PN 12,5	PN 16	PN 20	PN 25
Calculated ring stiffness in kN/m2 (S_{calc})	3,9	6,7	7,6	16	31,3	61	125	250
Nominal ring stiffness *SN*	4	8	–	16	32	–	–	–

The initial ring stiffness S_{calc} in Table 1 has been calculated using the following formula:

$$S_{calc} = \frac{E \times I}{(d_e - e_n)^3} = \frac{E}{96\,[S]^3} \qquad (1)$$

where

S_{calc} is the calculated initial ring stiffness in kilonewtons per square metre;

E is the modulus of elasticity in flexure, having the value of 3,2 × 106 kN/m2 for PVC-U and having the value of 4 × 106 kN/m2 for PVC-O;

I is the moment of inertia in cubic millimetres with $\frac{1 \times e_n^3}{12}$ for 1 m pipe length;

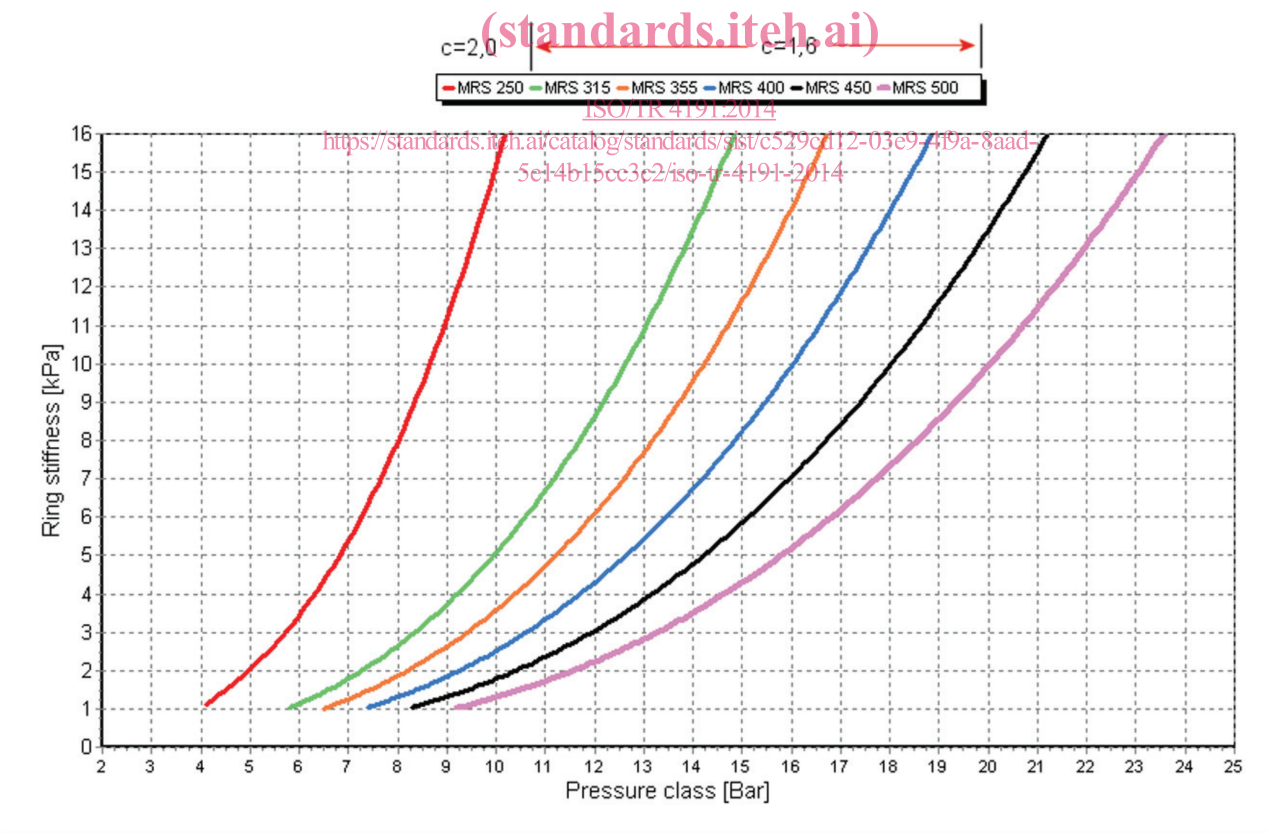
d_e is the nominal outside diameter in millimetres;

e_n is the nominal wall thickness in millimetres;

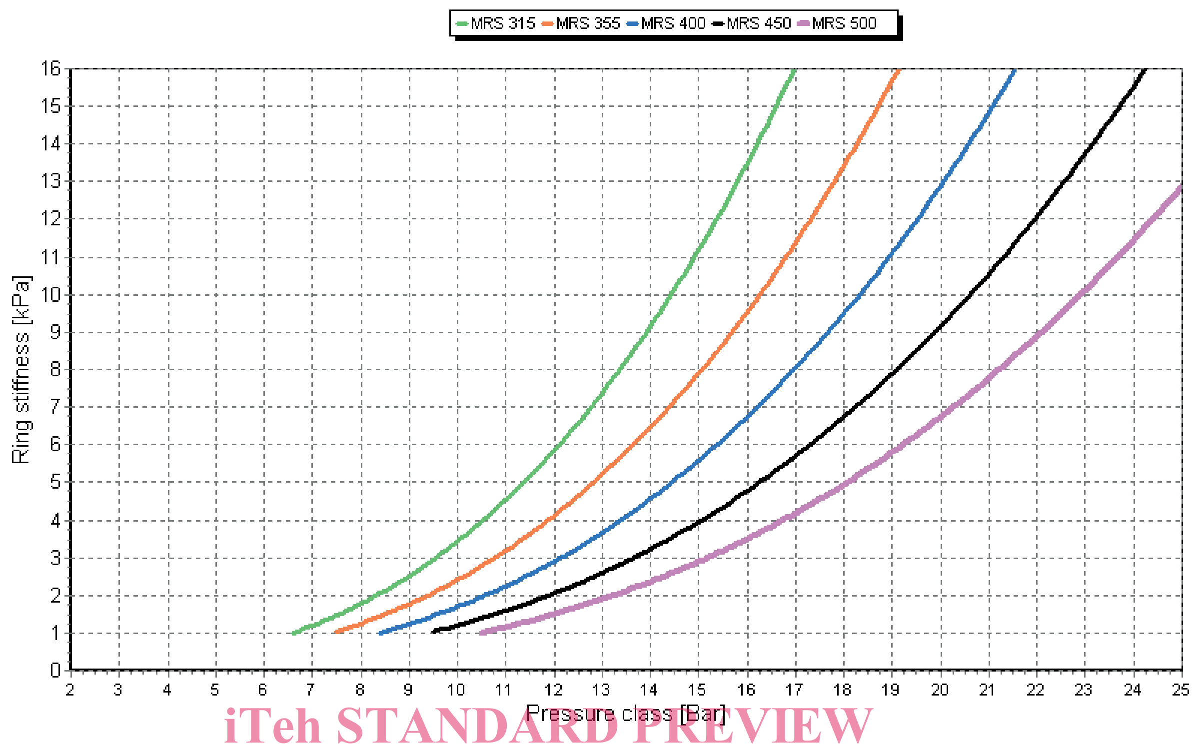
S is the pipe series.

The initial ring stiffness of PVC-O pipes with the different MRS values are given in the graphs of Figure 1.

E: PVC-O: 4 × 10^6 kN/m^2 (4 000 Mpa) E: PVC-U: 3,2 × 10^6 kN/m^2 (3 200 Mpa).



NOTE The following C factor has been used: MRS 250 (PVC-U): C = 2,0; PVC-O: C = 1,6.



NOTE The following C factor has been used: PVC-O: C = 1,4.

Figure 1 — Initial ring stiffness of pipes of PVC-O

In case the actual modulus measured or stated by the manufacturer or designer is known, then use the following correction formulae:

For PVC-U: SN = SN1 × E/3 200

For PVC-O: SN = SN1 × E/4 000

(SN1 = taken from the graph)

5 Hydraulic properties

5.1 Loss of head

For head losses through fittings, the manufacturer’s advice should be obtained.

PVC pressure pipes are specified by nominal diameters, d_n. Internal diameters vary according to pipe series (see Table 2 of ISO 1452-2:2009 and ISO/DIS 16422:2013). This shall be taken into account when calculating the flow characteristics of pipes.

The flow is characterized by the Reynolds number as follows:

$$Re = v \times \mathrm{dh}/\mu \quad (2)$$

where

Re is the Reynolds number [-];

v is the flow speed [m/s];

μ is the kinematic viscosity [m^2/s].

The friction value f is then calculated by an iterative manner using Formula (3):

$$\frac{1}{\sqrt{f}} = -2 \log_{10}\left(\frac{\varepsilon / D_h}{3{,}7} + \frac{2{,}51}{\mathrm{Re}\sqrt{f}}\right) \quad (3)$$

where

D_h is the hydraulic diameter (for a circular pipe, full flow = internal pipe diameter) [m];

Re is the Reynolds number [-];

ε is the roughness of the pipe [m].

And finally, the pressure loss is calculated by

$$\Delta p = f \times \frac{L}{D} \times \frac{\rho V^2}{2} \quad (4)$$

where

Δp is the pressure loss [m];

f friction value;

L is the length of the pipe [m];

D is the internal diameter of the pipe [m];

ρ is the density of the fluid [kg/m^3];

V is the flow speed [m/s].

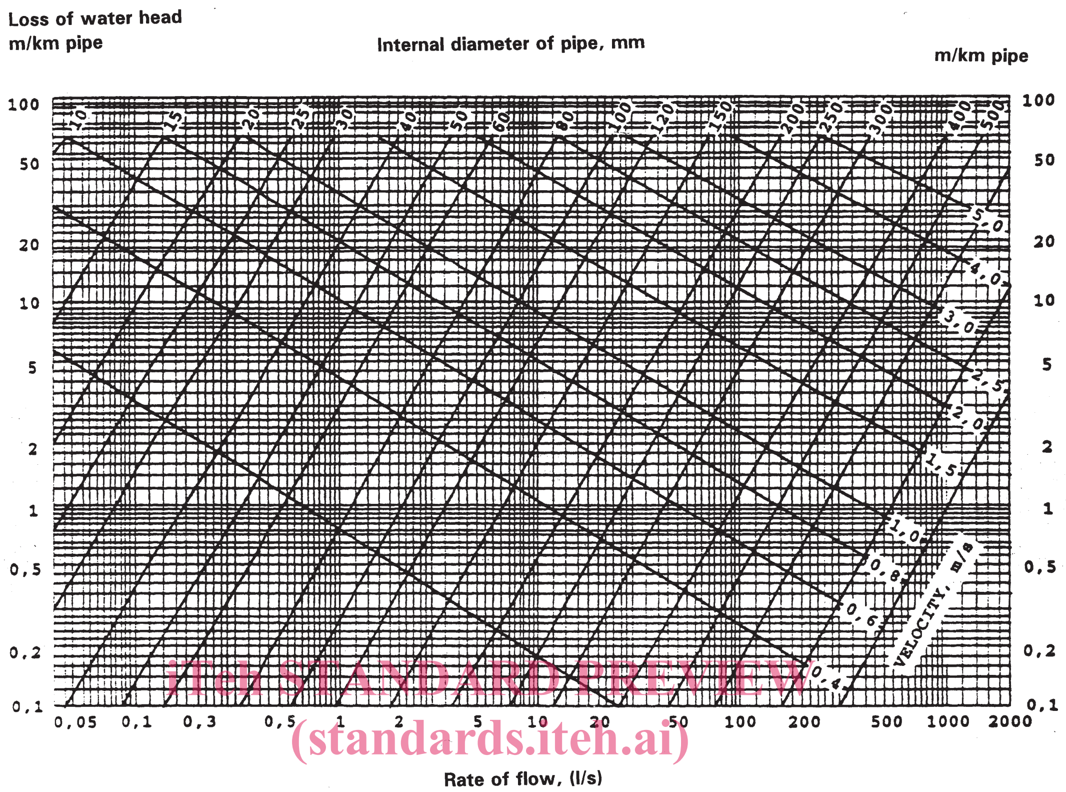


Figure 2 — Example of flow chart for head losses in pipes

Figure 2 comprises the friction loss diagram for PVC-U pipes calculated by L-E Janson in accordance with Colebrook. For internal diameters up to 200 mm, k = 0,02 mm and for larger diameters, k = 0,05 mm. The temperature of the water is ±10 °C.

6 Assembly methods

6.1 General

6.1.1 PVC pressure pipes conforming to ISO 1452-2:2009 are supplied in nominal lengths and with one of the following three end conditions:

a) plain, for jointing by means of separate couplers;

b) integral elastomeric ring socket (one end), for push-fit jointing;

c) integral socket (one end), for solvent cement jointing.

6.1.2 Fittings of PVC for use with PVC pipes are specified in ISO 1452-3 and can either have socket-type joints for solvent cementing or elastomeric ring joints for push-fit jointing. Valves and ancillaries of PVC-U are specified in ISO 1452-4.

6.1.3 The principal types of joints and their characteristics are as follows: