

Australian/New Zealand Standard™

**Oriented PVC (PVC-O) pipes for
pressure applications
(ISO 16422:2014, MOD)**



AS/NZS 4441:2017

This Joint Australian/New Zealand Standard was prepared by Joint Technical Committee PL-021, PVC, ABS and Polyamide Pipe Systems. It was approved on behalf of the Council of Standards Australia on 20 March 2017 and by the New Zealand Standards Approval Board on 5 April 2017.
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Australian/New Zealand Standard™

Oriented PVC (PVC-O) pipes for pressure applications (ISO 16422:2014, MOD)

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PREFACE

This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee PL-021, PVC, ABS and Polyamide Pipe Systems, to supersede AS/NZS 4441:2008.

The objective of this Standard is to specify the general aspects of pipes and joints made of oriented unplasticized poly(vinyl chloride) (PVC-O) for piping systems intended to be used underground or above-ground where not exposed to direct sunlight, for water mains and for services, for pressurized sewer systems and for irrigation systems.

This Standard is an adoption with national modifications and has been reproduced from ISO 16422:2014, *Pipes and joints made of oriented unplasticized poly(vinyl chloride) (PVC-O) for the conveyance of water under pressure—Specifications*. The modifications are additional requirements and are set out in Appendices ZZ and ZA. This revision contains the following key changes:

- (a) Table 4—Physical characteristics—Resistance to dichloromethane and alternative tests.
- (b) Annex A—Determination of pipe material classification—Procedures for classified and non-classified feedstock material.
- (c) Annex F—Determination of axial and tangential orientation factor.

Appendix ZA sets out means by which compliance with this Standard has to be demonstrated by a manufacturer.

Appendix ZB sets out the provisions for best environmental practice PVC for PVC-O pressure pipe. These provisions are in accordance with the credit criteria established by the Green Building Council of Australia in their Green Star rating program.

For best environmental practice PVC satisfying the provisions of Appendix ZB, an attestation of compliance for upstream materials such as chlorine and vinyl chloride, is necessary. Such attestations can take the form of a declaration of conformity prepared and maintained in accordance with ISO/IEC 17050, *Conformity assessment—Supplier's declaration of conformity*, Part 1: *General requirements*, and Part 2: *Supporting documentation*. Part 1 addresses the contents of the declaration of conformity and the procedures necessary to ensure ongoing compliance. Part 2 addresses the documentation required to support a declaration of conformity including the contents, traceability, availability and retention period.

Statements expressed in normative terms in notes to tables are deemed to be requirements of this Standard.

As this Standard is reproduced from an International Standard, the following applies:

- (i) In the source text 'this International Standard' should read 'this Australian/New Zealand Standard'.
- (ii) A full point substitutes for a comma when referring to a decimal marker.

References to International Standards should be replaced by references to Australian or Australian/New Zealand Standards, as follows:

<i>Reference to International Standard</i>		<i>Australian/New Zealand Standard</i>	
ISO		AS/NZS	
2507	Thermoplastics pipes and fittings— Vicat softening temperature	1462	Methods of testing plastic pipes and fittings
2507-1	Part 1: General test method	1462.5	Method 5: Vicat softening temperature

The terms 'normative' and 'informative' have been used in this Standard to define the application of the annex or appendix to which they apply. A 'normative' annex or appendix is an integral part of a Standard, whereas an 'informative' annex or appendix is only for information and guidance.

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INTRODUCTION

Molecular orientation of thermoplastics results in 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 in circumferential and axial directions under controlled conditions.

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. PVC-O can therefore be considered as highly resistant to notches and no testing is needed. Because of the morphology of oriented PVC-U pipe-material, there is no risk of long-line rapid crack propagation.

Improved hoop strength, allows reduced wall thickness with material and energy savings. Improved resistance to impact and fatigue also result.

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

Variations in stretch ratios should be within 10 % of the value determined on the pipes used for classification. The determination of the stretch ratios may be carried out as shown in [Annex F](#).

AUSTRALIAN/NEW ZEALAND STANDARD

**Oriented PVC (PVC-O) pipes for pressure applications
(ISO 16422:2014, MOD)****1 Scope**

This International Standard specifies the requirements of pipes and joints made of oriented unplasticized poly(vinyl chloride) (PVC-O), for piping systems intended to be used underground or above-ground where not exposed to direct sunlight, for water mains and services, pressurized sewer systems and irrigation systems.

The piping system according to this International Standard is intended for the conveyance of cold water under pressure, for drinking water and for general purposes up to and including 45 °C, and especially in those applications where special performance requirements are needed, such as impact loads and pressure fluctuations, up to pressure of 25 bars¹⁾.

Joints constructed of other materials should meet their own relevant standards in addition to the fitness-for-purpose requirements of this International Standard.

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 3:1973, *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 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 1167-4, *Thermoplastics pipes, fittings and assemblies for the conveyance of fluids — Determination of the resistance to internal pressure — Part 4: Preparation of assemblies*

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 1452-5:2009, *Plastics piping systems for water supply and for buried and above-ground drainage and sewerage under pressure — Unplasticized poly(vinyl chloride) (PVC-U) — Part 5: Fitness for purpose of the system*

ISO 1628-2, *Plastics — Determination of the viscosity of polymers in dilute solution using capillary viscometers — Part 2: Poly(vinyl chloride) resins*

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*

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

ISO 2507-2, *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*

ISO 2531, *Ductile iron pipes, fittings, accessories and their joints for water applications*

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), 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 13783, *Plastics piping systems — Unplasticized poly(vinyl chloride) (PVC-U) end-load-bearing double-socket joints — Test method for leaktightness and strength while subjected to bending and internal pressure*

ISO 13844, *Plastics piping systems — Elastomeric-sealing-ring-type socket joints for use with plastic pipes — Test method for leaktightness under negative pressure, angular deflection and deformation*

ISO 13845, *Plastics piping systems — Elastomeric-sealing-ring-type socket joints for use with thermoplastic pipes — Test method for leaktightness under internal pressure and with angular deflection*

ISO 13846, *Plastics piping systems — End-load-bearing and non-end-load-bearing assemblies and joints for thermoplastics pressure piping — Test method for long-term leaktightness under internal water pressure*

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 following terms and definitions apply.

3.1 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 $d_{em, min}$.

3.2

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 $e_{y, min}$.

3.3

nominal pressure

PN

alphanumeric designation related to the mechanical characteristics of the components of a piping system and used for reference purposes

3.4

hydrostatic pressure

p

internal pressure applied to a piping system

3.5

working pressure

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 bar.

3.6

hydrostatic stress

σ

stress, expressed in megapascals, induced in the wall of a pipe when it is subjected to internal water pressure

Note 1 to entry: It is calculated using the following approximate equation:

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

where

p is the applied internal pressure, in bar;

d_n is the nominal outside diameter of the pipe, in millimetres;

e_n is the nominal wall thickness, in millimetres.

Note 2 to entry: If σ and p are given in the same units, the denominator becomes $2e_n$

3.7

long-term hydrostatic strength for 50 years at 20 °C

σ_{LTHS}

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: It 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.

3.8

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.

3.9

minimum required strength

MRS

required value of σ_{LPL} for a temperature T of 20 °C and a time t of 50 years

Note 1 to entry: For a particular material, its MRS is established from the value of σ_{LPL} rounded to the next lower value of the R 10 series from ISO 3:1973, when σ_{LPL} is less than 10 MPa, or to the next lower value of the R 20 series when σ_{LPL} is greater than 10 MPa.

Note 2 to entry: See also ISO 1452-2:2009, Clause 7.

3.10

design coefficient

C

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} .

3.11

pipe series

S

dimensionless number for pipe designation

Note 1 to entry: See ISO 4065

3.12

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 expressed in the following equation:

$$SDR = 2S + 1$$

3.13

orientation factor

factor related to the stretch ratio used in orientation processing

4 Symbols and abbreviated terms

4.1 Symbols

C	overall service (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
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
K	K -value
p	internal hydrostatic pressure
p_T	test pressure
PN	nominal pressure
δ	material density
σ	hydrostatic stress
σ_s	design stress
λ_a	axial orientation factor
λ_c	circumferential orientation factor
σ_{LPL}	Lower predicted confidence limit

4.2 Abbreviations

DN	nominal size
MRS	minimum required strength
PFA	allowable operating pressure
PVC-O	oriented unplasticized poly(vinyl chloride)
PVC-U	unplasticized poly(vinyl chloride)
S	pipe series
S _{calc}	calculated value of the pipe series
SDR	standard dimension ratio

5 Material

5.1 General

The material from which the pipes are made shall be PVC-U compound/formulation. This compound/formulation shall consist substantially of PVC-U resin/powder to which shall be added only those additives necessary to facilitate the production of pipes and fittings in accordance with this International Standard. All additives shall be uniformly dispersed.

5.2 Rework material

The use of the manufacturer's own reprocessed material, produced during the manufacture and works testing of products and conforming to the material requirements of this International Standard, is permitted. Reprocessed or recycled material obtained from external sources shall not be used.

6 Effect of materials on water quality

All plastics and non-plastic materials for components of the PVC piping system, e.g. pipes, fittings, valves, elastomeric sealing rings, solvent cement, and lubricants, when in permanent or in temporary contact with water which is intended for human consumption, shall not adversely affect the quality of the drinking water. Where applicable, all materials for components shall conform to the current national regulations concerning materials in contact with drinking water.

7 Material classification

7.1 MRS value

Oriented pipes made from a defined PVC-U compound and with a well-defined orientation level in circumferential and axial direction, shall be evaluated according to the procedures of [Annex A](#). The minimum required strength (MRS) values shall be classified in accordance with [7.3](#) and [Table 1](#).

7.2 Design coefficient

The design coefficient of oriented PVC-U pipes shall be a minimum of 1,6. Alternatively, 1,4 is permitted for MRS 450 and MRS 500, provided that axial contraction of the pipe (due to higher design stress) does not result in pull-out of the joints. In this case, evidence shall be given according to [Annex B](#).

7.3 Design stress

The design stress shall be based on the value of the lower confidence limit σ_{LPL} of the long term hydrostatic strength for the resistance to internal pressure as determined in accordance with ISO 9080. This σ_{LPL} value shall be converted into a minimum required strength (MRS) in accordance with ISO 12162. The MRS shall be divided by an overall service (design) coefficient C to give the design stress σ_s , which is expressed by the following equation:

$$\sigma_s = \frac{\text{MRS}}{C} \quad (1)$$

Table 1 — Material classification

Pipe material classification number	315		355		400		450			500		
MRS MPa ^a	31,5		35,5		40		45			50		
C	1,6	2	1,6	2	1,6	2	1,4	1,6	2	1,4	1,6	2
σ_s MPa	20	16	22	18	25	20	32	28	23	36	32	25
^a Higher MRS classes can be chosen, provided they fall in the R20 range of ISO 3:1973.												

8 Classification and selection of pipes

8.1 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 following relationship.

$$PN \cong \frac{10\sigma_s}{S} \quad (2)$$

$$S = \frac{SDR - 1}{2} \quad (3)$$

$$SDR = \frac{d_n}{e_n} \quad (4)$$

$$\sigma_s = \frac{\text{MRS}}{C} \quad (5)$$

where

- e_n is expressed in millimetres (mm);
- PN is expressed in megapascals (MPa);
- MRS is expressed in megapascals (MPa);
- C is nondimensional.

8.2 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 MRS, C, and d_n in the formula

$$e_n = \frac{d_n}{2S_o + 1} \quad (6)$$

where

S_o is the calculated preferred value of the nominal S series number of the pipe from [8.1](#).

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

NOTE 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 International Standard, 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](#).

8.3 Determination of the allowable operating pressure, PFA, for temperatures up to 45 °C

The allowable operating pressure, PFA, for temperatures up to 25 °C is 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 , shall be applied to the nominal pressure, PN, as follows:

$$[PFA] = f_T \times [PN] \quad (7)$$

This factor is given in [Figure C.1](#).

8.4 Derating factor related to application of the system

For applications which need additional derating factors, e.g. more safety than included in the overall service (design) coefficient, an additional factor f_A shall be chosen at the design stage.

The allowable operating pressure in continuous use shall be then calculated by

$$[PFA] = f_T \times f_A \times PN \quad (8)$$

NOTE [PFA] and [PN] are expressed in the same unit of pressure, preferably in bar.

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

Material 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					
	Pressure class PN for design coefficient $C = 2,0$												
315	5		6,3		8		10		12,5		16		20
355		6,3		8		10		12,5		16		20	
400	6,3		8		10		12,5		16		20		25
450		8		10		12,5		16		20		25	
500	8		10		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	8,9125	7,9433
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