

Interim Australian Standard™

**Oriented PVC (PVC-O) pipes for
pressure applications**



This Interim Australian Standard was prepared by Committee PL-021, PVC, ABS and Polyamide Pipe Systems. It was approved on behalf of the Council of Standards Australia on 28 March 2003 and published on 23 May 2003.

The following are represented on Committee PL-021:

- Australian Gas Association
- Australian Nuclear Science and Technology Organisation
- Certification Bodies (Australia)
- CSIRO Manufacturing and Infrastructure Technology
- Institution of Engineers Australia
- Local Government New Zealand
- Master Plumbers, Gasfitters and Drainlayers New Zealand
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Oriented PVC (PVC-O) pipes for pressure applications

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PREFACE

This Interim Australian Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee PL-021, PVC, ABS and Polyamide Pipe Systems to supersede AS 4441(Int)—1996. After consultation with stakeholders in both countries, Standard Australia and Standards New Zealand decided to develop this Standard as an Australian Standard rather than an Australian/New Zealand Standard.

This Standard incorporates Amendment No. 1 (May 2004). The changes required by the Amendment are indicated in the text by a marginal bar and amendment number against the clause, note, table, figure or part thereof affected.

This Interim Standard is based on and reproduced from ISO/WD 16422.4 Pipes and joints made of oriented unplasticized poly(vinyl chloride) (PVC-O) for water transport—Specifications.

Statements expressed in mandatory terms in notes to tables and figures are deemed to be requirements of this Standard. Other notes are for information and guidance only.

The term ‘normative’ has been used in this Standard to define the application of the appendix to which it applies. A ‘normative’ appendix is an integral part of a Standard.

Standards Australia and Standards New Zealand invite comment on this Interim Standard from persons and organizations concerned with the subject. The Joint Committee will monitor all comment as it is received. The date of expiry for comment is nominally 2 years after publication, but the status of the Interim Standard will be reviewed upon publication by ISO of the next edition of ISO 16422. At that time the Interim Standard will be confirmed, withdrawn or revised in the light of public comment received.

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FOREWORD

Molecular orientation of plastics enhances the yield strength of the material, enabling higher operating stresses to be utilized. Orientation also improves the performance of plastics materials in other respects, for example, imparting enhanced resistance to crack propagation across the planes of orientation. In the case of oriented PVC pipes, this amounts to an increased resistance to radial crack propagation through the pipe wall

The level of strength enhancement achievable is limited by practical process factors and the limits of the intended application. Some processes have a capability for a higher draw ratio for higher orientation than others. Requirements for lateral stiffness may dominate design in certain cases, and may limit the reduction of wall thickness achievable. Hence this standard incorporates five levels of orientation, or material classifications, suitable for a wide range of processes and applications. These material classes have a range of design stresses up to 32 MPa, compared with 23.6 MPa for the previous edition of this Standard, and 12.3 MPa for standard PVC-U pipes.

The design basis used is the standard one used for plastics pipes, namely the Barlow formula relating dimensions to stress, pressure.

$$\frac{d_n}{e_n} = 2 \times \frac{\sigma_s}{p_n} + 1$$

where

$$\left. \begin{array}{ll} e_n & = \text{nominal wall thickness} \\ d_n & = \text{nominal outside diameter} \end{array} \right\} \text{with consistent units}$$

$$\left. \begin{array}{ll} p_n & = \text{nominal working pressure at } 20^\circ\text{C} \\ \sigma_s & = \text{hydrostatic design stress at } 20^\circ\text{C} \end{array} \right\} \text{with consistent units}$$

Terminology in this Standard follows International Standards practice where nominal dimensions are equal to the minima.

In computation of wall thicknesses from the above equation, ISO modern practice is also adopted, where the stress/pressure ratio σ_s/p_n is substituted by S the pipe series number, using calculated preferred values taken from ISO 3, giving the universal wall thickness specifications found in ISO 4065.

Pipe specification has not been limited by consideration of lateral stiffness, which is considered primarily a matter for application design. Lower limits on wall thickness have been adopted from consideration only of mechanical damage. In order to take full advantage of the economics and performance of PVC-O pipes, it is essential that application designers are cognizant of the limitations of thin walled pipes and information is presented in this Standard on lateral stiffness, negative pressure resistance and aspects of joint performance. Users should refer to AS/NZS 2566 for further advice.

Pipe diameters and pressure classes follow ISO Standards. ISO external diameters are the same as those of Series 1 for diameters 160 and larger, called up in previous editions of this Standard. Series 1 pipes were designated by nominal diameters which were different from actual. The equivalence of diameter terminology is given in Table 10.1 of this Standard. Series 2 (ductile iron equivalent) diameters are also permitted, where it is necessary to adapt to existing systems.

It is the intention that pipes complying with this Standard will comply directly with the future ISO 16422 (at committee draft stage at the preparation of this Standard), without further evaluation. This document, therefore, follows closely the ISO draft, and calls up

ISO test protocols, even where Australian test methods may exist. It includes some requirements such as opacity, which are considered redundant for Australian PVC pipe standards and omits some that might normally be expected.

STANDARDS AUSTRALIA

Australian Standard

Oriented PVC (PVC-O) pipes for pressure applications

1 SCOPE AND GENERAL

1.1 Scope

This Interim Australian Standard specifies the general aspects of pipes and joints made of oriented unplasticized poly (vinyl chloride) (PVC-O), for piping systems intended to be used underground and 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 Standard is intended for the conveyance of cold water under pressure up to 40°C 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 ratings of 25 bar.

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

NOTE: Means for demonstrating compliance with this Standard are given in Appendix A. Pipes intended for drinking water are required to conform to the cold water requirements of AS/NZS 4020. The validity of compliance is limited to 40°C, and it is a recommendation of the Water Services Association of Australia that temperatures of water supply systems be limited to this value.

1.2 Referenced Documents

The following documents are referred to in this Standard:

AS

- 1145 Determination of tensile properties of plastics materials
- 1145.2 Part 2: Test conditions for moulding and extrusion plastics
- 1199 Sampling procedures and tables for inspection by attributes

AS/NZS

- 1462 Methods of test for plastics pipes and fittings
 - 1462.1 Method 1: Methods for determining the dimensions of pipes and fittings
 - 1462.3 Method 3: Method for determining the impact characteristics of pipes
 - 1462.5 Method 5: Vicat softening temperature
 - 1462.6 Method 6: Method for hydrostatic pressure testing of pipes
 - 1462.14 Method 14: Method for determination of the light transmission of pipe
 - 1462.15 Method 15: Method for determination of vinyl chloride monomer content
 - 1462.22 Method 22: Method for the determination of pipe stiffness
 - 1646 Elastomeric seals for water works purposes
 - 1646.3 Part 3: Material requirements used for pipe joint seals used in water and wastewater applications with the exception of natural rubber and polyisoprene compounds
 - 4020 Testing for products in contact with drinking water
- SAI/SNZ
- HB18 Guidelines for third-party certification and accreditation

HB18.28 (ISO/IEC guide 28)	Guide 28: General rules for a model third-party certification scheme for products
ISO	
3	Preferred numbers—Series of preferred numbers
161	Thermoplastics pipes for the conveyance of fluids — Nominal outside diameters and nominal pressures
161-1	Part 1: Metric series
1167	Thermoplastics pipes for the conveyance of fluids—Resistance to internal pressure—Test method
1628	Determination of the polymers in dilute solution using capillary viscometers
1628-2	Part 2: Poly(vinyl chloride) resins
2045	Single sockets for unplasticized poly(vinyl chloride) (PVC-U) and chlorinated poly(vinyl chloride) (PVC-C) pressure pipes with elastic sealing ring type joints; minimum depths of engagement
2507	Thermoplastics pipes and fittings—Vicat softening temperature
2507-1	Part 1: General test method
2859	Sampling procedures for inspection by attributes
2859-1	Part 1: Sampling schemes indexed by acceptance quality limit (AQL) for lot-by-lot inspection
3126	Plastics pipes—Measurement of dimensions
3127	Thermoplastics pipes—Determination of resistance to external blows—Round-the-clock method
3951	Sampling procedures and charts for inspection by variables for percent non-conforming
4065	Thermoplastics pipes—Universal wall thickness table
4422	Pipes and fittings made of unplasticized poly(vinyl chloride) (PVC-U) for water supply—Specifications
4422-2	Part 2: Pipes (with or without integral sockets)
6259	Thermoplastic pipes—Determination of tensile properties
6259-2	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)
6401	Plastics; Homopolymer and copolymer resins of vinyl chloride; Determination of residual vinyl chloride monomer; Gas chromatographic method
DIS 7686	Plastics pipes and fittings—Determination of opacity
9080	Plastics piping and ducting systems—Determination of long-term hydrostatic strength of thermoplastic materials in pipe form by extrapolation
9969	Thermoplastic pipes—Determination of ring stiffness
11922	Thermoplastics pipes for the transport of fluids—Dimensions and tolerances
11922-1	Part 1: Metric series
12162	Thermoplastics materials for pipes and fittings for pressure applications—Classification and designation — Overall service (design) coefficient

- 13844 Plastics piping systems—Elastomeric-sealing-ring-type socket joints of unplasticized poly(vinyl chloride) (PVC-U) for use with PVC-U pipes—Test method for leaktightness under negative pressure
- 13845 Plastics piping systems—elastomeric-sealing-ring-type socket joints for use with unplasticized poly(vinyl chloride) (PVC-U) pipes—Test method for leaktightness under internal pressure and with angular deflection
- 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 water pressure
- 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

1.3 Definitions

For the purposes of this Interim Australian Standard, the definitions below apply.

1.3.1 Nominal diameter

The specified pipe diameter, in millimetres equal to the minimum mean outside diameter ($d_{\text{em min}}$). (d_n)

1.3.2 Nominal size

A numerical designation of size which is common to all components in a thermoplastics piping system other than flanges and components designated by thread size. It is a convenient round number for reference purposes. (DN)

1.3.3 Nominal wall thickness

The specified wall thickness, in millimetres. It is identical to the specified minimum wall thickness at any point ($e_{\text{min y}}$). (e_n)

1.3.4 Nominal pressure class

An alphanumeric designation specifying the nominal operating pressure in bar at 20°C which is related to the mechanical characteristics of the components of a piping system and used for reference purposes. (PN)

1.3.5 Hydrostatic pressure

The internal pressure applied to a piping system. (p)

1.3.6 Nominal working pressure

The maximum continuous hydrostatic pressure which a piping system can sustain for the whole life under given service conditions whilst maintaining a margin against rupture equal to the recommended design coefficient. (p_n)

1.3.7 Hydrostatic stress

The stress induced in the wall of a pipe when it is subjected to internal pressure (σ). 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 equation:

$$\sigma = \frac{p \times (d_n - e_n)}{2e_n}$$

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

1.3.8 Lower confidence limit of the predicted hydrostatic strength

a 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), (σ_{LPL}). It is denoted as

$$\sigma_{\text{LPL}} = \sigma_{(T,t,0,975)}$$

NOTE: The value of this quantity is determined by the method given in ISO 9080.

1.3.9 Minimum required strength (MRS)

The required value of σ_{LPL} for a temperature (T) of 20°C and a time (t) of 50 years. For a particular material the MRS is established from the value of $\sigma_{(20,50,0,975)}$ 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.

NOTE: See also ISO 4422-2.

1.3.10 Material class

A number identifying the material strength in accordance with ISO 12162. The material class (or classification number) is 10 times the MRS expressed in megapascals.

1.3.11 Overall service (design) coefficient

An 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} . (C)

1.3.12 Pipe series

A dimensionless number for pipe designation (see ISO 4065). (S)

1.3.13 Standard dimension ratio (SDR)

A 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 . (SDB)

1.3.14 K-value

A number related to the molecular weight of the polymer.

1.4 Symbols

For the purpose of this Standard, the following symbols apply:

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_n	= nominal outside diameter
DN	= nominal size
e_y	= wall thickness (at any point)
e_m	= mean wall thickness
e_n	= nominal wall thickness
f_T	= rating factor for water temperatures
PN	= nominal pressure class
P	= internal pressure

P_{cr}	= unsupported critical buckling pressure
p_n	= nominal working pressure
p_T	= test pressure
S	= pipe series
T	= temperature
t	= time
σ	= hydrostatic stress
σ_s	= design stress
ν	= Poisson's ratio

1.5 Abbreviations

The following abbreviations are used in this Standard:

LPL	= lower predicted limit
MRS	= minimum required strength
OOR	= out of roundness
PFA	= allowable operating pressure
PVC	= poly(vinyl chloride)
PVC-U	= unplasticized poly(vinyl chloride)
PVC-O	= oriented poly(vinyl chloride)
SDR	= standard dimension ratio

2 MATERIAL

2.1 General

Pipe materials shall be PVC-U compound. This compound shall consist substantially of PVC resin, to which shall be added only those additives necessary to facilitate the production of pipes and joints conforming to this Standard. All additives shall be uniformly dispersed.

When determined in accordance with ISO 1628-2, the K -value of the PVC-U resin that is used shall be at least 64.

When determined in accordance with ISO 2507-1 or AS/NZS 1462.5 (see Note), the Vicat softening temperature of the compound shall be not less than 80°C. In case of a dispute, ISO 2507-1 shall be the reference document.

NOTE: The method in AS/NZS 1462.5 may be considered to produce an equivalent result to the method in ISO 2507-1; however, they are not identical.

The compound shall contain a minimum of 1.5 parts of rutile titanium dioxide per 100 parts of PVC by mass. The PVC content of the compound shall be not less than 83%. Manufacturers shall ensure that the above compositional requirements may be verified through process control records.

2.2 Rework material

The use of the manufacturer's own reprocessible material produced during the manufacture and works testing of products conforming to the material requirements of this Standard is permitted. No reprocessible or recyclable material obtained from external sources shall be used.

2.3 Effect of materials on water quality

When used under the conditions for which they are designed, materials in contact with, or likely to come into contact with, drinking water shall not constitute a toxic hazard, shall not support microbial growth and shall not give rise to any unpleasant taste or odour, cloudiness or discoloration of the water.

Pipes, joints and sealing rings intended for use with potable water shall conform to the requirements of AS/NZS 4020. A scaling factor of 1 shall be applied to pipes. A scaling factor of 0.01 shall be applied to joints and sealing rings.

When determined in accordance with ISO 6401 or AS/NZS 1462.15 (see Note), the vinyl chloride monomer level shall not exceed 1 mg/kg. In case of dispute, ISO 6401 shall be the reference document. Where the pipe is manufactured from resin with a residual vinyl chloride monomer content of less than 1 mg/kg, this requirement shall be considered to have been met.

NOTE: The method in AS/NZS 1462.15 may be considered to produce an equivalent result to the method in ISO 6401; however, they are not identical.

2.4 Material classification

2.4.1 MRS value

Oriented pipes made from a defined PVC-U compound in tangential and axial direction shall be evaluated in accordance with Appendix B. The minimum required strength (MRS) values shall be classified in accordance with Clause 2.4.3 and Table 1.

2.4.2 Overall service (design) coefficient

The overall service (design) coefficient of oriented PVC-O pipes shall be a minimum of 1.6.

2.4.3 Design stress (σ_s)

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 value σ_{LPL} 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.

$$\sigma_s = \frac{MRS}{C} \quad \dots 1$$

TABLE 1
MATERIAL CLASSIFICATION

Pipe material classification number	315	355	400	450	500
MRS in MPa*	31.5	35.5	40	45	50
C	1.6	1.6	1.6	1.6	1.6
σ_s	20	22	25	28	32

* Higher MRS classes may be chosen, provided they fall in the R 20 range of ISO 3.

3 CLASSIFICATION AND SELECTION OF PIPES

3.1 Classification

Pipes shall be classified by their nominal pressure class (PN), equal to the nominal working pressure (p_n) expressed in bar.

The nominal pressure class (p_n), the pipe series (S) and the design stress (σ_s), are connected by the following relationship:

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

where

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

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

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

TABLE 2
S SERIES NUMBERS AND PRESSURE CLASSES OF PVC-O PIPES FOR MRS CLASSES

Pipe series S numbers	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
Calculated values S_0 (ISO 3)	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
Standard dimension ratios (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
Material class	Design stress σ_s MPa	Nominal pressure class (PN)											
315	20	6.3		8		10		12.5		16		20	25
355	22		8		10		12.5		16		20		25
400	25	8		10		12.5		16		20		25	
450	28		10		12.5		16		20		25		
500	32	10		12.5		16		20		25			

3.2 Calculation of the minimum wall thickness

Values of the minimum wall thickness shall be in accordance with ISO 4065, as appropriate to the nominal diameter and S series number for the pipe, from Table 2 for the relevant nominal pressure class, and material class. These values, and values not included in ISO 4065, may be calculated from the following equation;

$$e_n = \frac{d_n}{2S_0 + 1} \quad \dots 6$$

where S_0 is the exact calculated value of the S series number for the pipe, from Table 2.

Values shall be rounded to one decimal place, in accordance with to ISO 4065.

The minimum wall thickness shall be 1.5 mm.