

Australian/New Zealand Standard™

Methods of test for plastics pipes and fittings

Method 19: C-ring test for fracture toughness of PVC pipes

PREFACE

This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee PL-045, Plastics Pipe Systems Test and Calculation, to replace the interim edition AS/NZS 1462.19(Int):2003 without technical changes but incorporating a number of editorial amendments, corrections and clarifications.

This Standard is based on ISO 11673:2005, *Unplasticized poly(vinyl chloride) (PVC-U) pressure pipes—Determination of the fracture toughness properties*.

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

METHOD

1 SCOPE AND GENERAL

1.1 Scope

This Standard specifies a method for establishing the minimum fracture toughness of unplasticized poly(vinyl chloride) (PVC-U) pressure pipes after a specified loading time. Provision is also made for measuring alternative levels of fracture toughness.

1.2 General

This concept of this Method is based on the assumption that the constant logarithmic reductive slope holds over a considerably long time up to 100 years survival. Measurement of the fracture toughness values at longer times than 15 min can provide a reductive slope and, as a result, can give a regression equation, which allows a more reliable toughness value to be quoted for PVC-U pressure pipes.

2 PRINCIPLE

On the basis of the prior response of a test piece to immersion in dichloromethane, a C-ring section from a pipe is notched on its internal face at the region of maximum attack by dichloromethane. The notched sample is then subjected to a sustained flexural stress for the specified test period.

3 REFERENCES AND RELATED DOCUMENTS

3.1 Referenced documents

The following documents are referenced in this Standard:

ISO

- | | |
|--------|--|
| 6259 | Thermoplastics pipes—Determination of tensile properties |
| 6259-1 | Part 1: General test method |
| 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) |
| 9852 | Unplasticized poly(vinyl chloride) (PVC-U) pipes—Dichloromethane resistance at specified temperature (DCMT)—Test method |

3.2 Related document

A. Whittle, R.P. Burford and M. Hoffman, *Plastics, Rubber and Composites*, Vol 129, No. 8, p417, 2000, *Improvements to C-ring fracture toughness test for poly (vinyl chloride) pipes*

4 DEFINITIONS

For the purpose of this Standard, the definitions below apply.

4.1 C-ring

A ring cut from the test specimen in such a manner that the cut surfaces are perpendicular to the longitudinal axis of the pipe and prepared as a test specimen.

4.2 Critical stress intensity factor (K_C)

The value of the stress intensity factor at the critical condition of crack propagation where $K = K_C$.

4.3 Pipe wall thickness (e)

The measured wall thickness at any point around the circumference of the pipe, rounded up to the nearest 0.1, expressed in millimetres.

4.4 Pipe wall thickness at the reference point (e_{ref})

The measured wall thickness at the reference point on the pipe circumference where the notch is cut.

4.5 Plane strain fracture toughness (K_{IC})

The value of the stress intensity factor when the crack under load actually starts to enlarge under a plane strain loading condition around the crack tip.

NOTE: If the specimen dimensions satisfy the validity criteria for plane strain fracture toughness, then $K_C = K_{IC}$. K_{IC} is a material property.

4.6 Reference line

The line drawn along the axis of the pipe sample to mark the point at which the notch is to be cut.

NOTE: This will be either the point of greatest attack following the dichloromethane test or, if attack is even all the way around, or there is no attack, a point chosen at random.

4.7 Stress intensity factor (K)

The product of the yield stress (σ), perpendicular to the crack (y), a geometrical correction factor and the square root of a , the notch depth.

NOTES:

- 1 For a detailed explanation, see Appendix A.
- 2 The term 'factor' is used because of its common usage even though the value has dimensions.

4.8 Yield stress (σ)

Tensile stress at yield, expressed in megapascals.

5 NOTATION

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

- a = crack length (notch depth), in millimetres
- d_m = moment arm
- e = pipe wall thickness, in millimetres
- e_{ref} = the measured wall thickness, in millimetres, at the reference point on the pipe circumference where the notch is cut
- F_e = wall thickness factor
- F_r = ring geometric factor
- m = test mass
- m_c = C-ring mass
- m_L = support clamp mass
- y = geometry correction factor
- σ_c = fracture stress
- σ_{pc} = plastic collapse stress under plane stress conditions
- σ_y = uniaxial yield stress

6 PRELIMINARY TEST FOR THE RESPONSE TO IMMERSION IN DICHLOROMETHANE

6.1 Reagent—Dichloromethane, analytical, technical or industrial grade

WARNING: The boiling temperature of dichloromethane is low (40°C) and consequently has a high vapour pressure at ambient temperature. Further, it can be toxic to skin and eyes. It is, therefore, necessary to take precautions when handling dichloromethane or test pieces that have been immersed in it. The vapours are also toxic; the threshold limit value (TLV) comparable to the maximum admissible concentration (MAC) being 100 mL/m³ (ppm). Ventilation of the room, or the area in which the container is placed, and where the test pieces are dried must be given special consideration.

The consistency of colour and purity of the dichloromethane should be checked regularly, for example, by measuring the refractive index. Whenever the refractive index differs by ± 0.002 from the original value, the dichloromethane should be changed. Any alternative checking procedure that gives the same result is acceptable.

NOTE: Dichloromethane, technical grade, contains small quantities (1% maximum each) of chloromethane (CH_3Cl), of trichloromethane (CHCl_3) and tetrachloromethane (CCl_4). It has been noted that even if the level of these impurities were to attain 5% in total, the results would not be significantly different.

6.2 Apparatus

The following is required:

- (a) *Cutting equipment*—capable of cutting an external chamfer on the test piece such that the chamfer penetrates at least 90% of the wall thickness of the test piece with a minimum length of 10 mm when it is cut at an angle inclined to the longitudinal pipe axis.
- (b) *Covered tank*—resistant to dichloromethane, e.g., glass, stainless steel.
- (c) *Thermostatic control equipment*—capable of maintaining the temperature of the dichloromethane at $20 \pm 2^\circ\text{C}$.

6.3 Test specimen

The following applies to the test specimen:

- (a) The test specimen for both the dichloromethane test and fracture toughness test shall be a pipe of length not less than 200 mm.
- (b) A reference line shall be drawn along the complete length of the test specimen, and marked with arrowheads to indicate the sample orientation in such a way that the pipe is not scored. An arrowhead in the same direction shall be marked on the C-ring test piece (see 6.3(c) and (d)).
- (c) A ring of width 30 ± 3 mm shall be cut from the test specimen in such a manner that the cut surfaces are perpendicular to the longitudinal axis of the pipe. This C-ring is retained for the fracture toughness test in accordance with Clause 7.
- (d) A chamfer shall be cut on the remainder of the test specimen, which is the test piece for testing for the effect of dichloromethane in Clause 6.4, using the apparatus described in Clause 6.2(a).

NOTE: Where the tank is not big enough to take a large diameter pipe, the test piece may be cut longitudinally into sections, provided that the resultant sections can be related to the reference line.

6.4 Procedure

The procedure shall be as follows:

- (a) Place the chamfered end(s) of the test piece in dichloromethane such that the chamfer is completely submerged at $20 \pm 2^\circ\text{C}$ for a period of 15 ± 1 min.
- (b) Remove the test piece to a well-ventilated area, e.g., a fume cupboard, until the dichloromethane has evaporated from its surface.

6.5 Assessment of results

For the purpose of the dichloromethane test, the attack is classified by the extent of the lightening of the chamfered surfaces. There are three types of attack classified as follows:

- (a) Type 1—no apparent lightening of the surface under consideration.
- (b) Type 2—overall uniform lightening of the surface under consideration.
- (c) Type 3—non-uniform lightening of the surface under consideration. The area where the attack is greatest or the lightening is most dense shall be identified.

NOTE: Lightening of the chamfer surfaces may be difficult to discern in pale coloured or white pipe specimens. In such cases, the observation of surface roughening can serve to indicate the extent of attack by dichloromethane.

The chamfer surface shall be inspected and the type of attack recorded, in relation to the reference line, after carrying out an assessment as described in 6.5. In case of Type 3 attack, mark the position of the greatest attack or lightening on the C-ring test piece.

7 DETERMINATION OF FRACTURE TOUGHNESS

7.1 Apparatus

The following is required:

- (a) *Broach or other cutting equipment*—capable of cutting a notch of uniform depth, of included angle $45 \pm 2^\circ$, such that the variation in wall thickness as measured from the outside surface to the notch tip does not exceed 0.1 mm. The tip of the notch shall have a radius not exceeding 0.025 mm.

NOTE: For further information on the notch, see Appendix B.

- (b) *Loading device*—capable of applying the required force to the test piece such that the maximum initial change in the moment arm (d_m) is not greater than $d_m \pm 2\%$ (see Figure 1).

- (c) *Timing device*—accurate to ± 5 s over a period of 15 min.

- (d) *Rigid support clamps* (see Figure 2)—with an inside radius equal to the outside radius of the pipe, and sufficiently rigid to maintain this radius under the load imposed by the test mass (m).

NOTE: The clamps maintain the geometry of the C-ring, which ensures that a controlled bending moment is transmitted to the notched section. This has been accounted for in the method of calculation.

- (e) *Mounting device*—capable of mounting the assembly, such that, under load, the rotation of the specimen is prevented.

NOTE: Rotation of the specimen would shorten the moment arm d_m (see Figure 2). A counter balance is one method of restricting the rotation.

- (f) *Balance*—capable of weighing to an accuracy of ± 5 g.

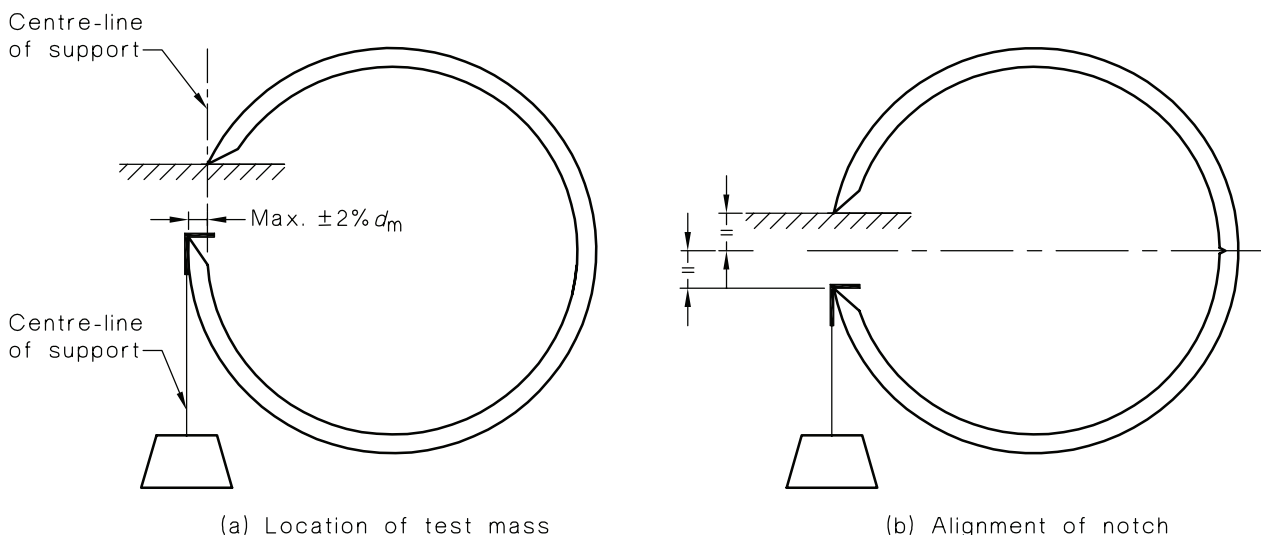


FIGURE 1 TOLERANCE ON LOCATION OF TEST MASS AND NOTCH AFTER TEST MASS IS APPLIED

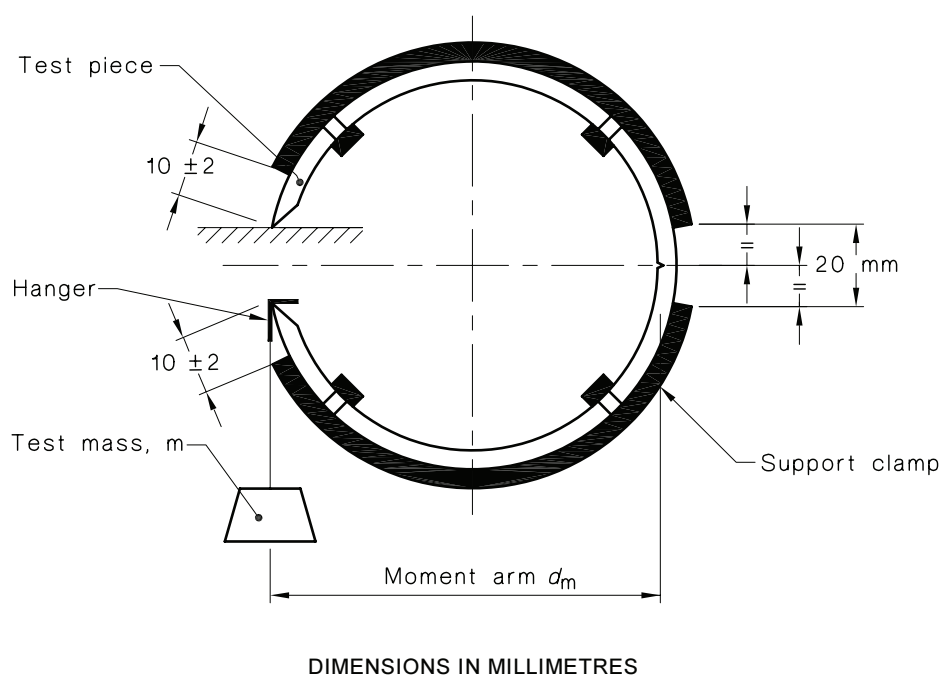


FIGURE 2 TYPICAL ARRANGEMENT OF TEST SPECIMEN AND EQUIPMENT

7.2 Preparation of the test specimen

The test specimen shall be the 30 mm pipe ring cut from the pipe specified in Clause 6.3(c). The C-ring shall be prepared as follows:

- (a) Establish the test position—
 - (i) at the reference line for Type 1 or Type 2 attack; or
 - (ii) at the marked line for Type 3 attack (see Clause 6.5).
- (b) Measure the wall thickness, at the test position, to the nearest 0.05 mm at three points across the width and use the average (e) in calculations.
- (c) Measure the outside diameter (OD) of the test specimen at the test position to the nearest 0.1 mm.
- (d) Measure the width (W) of the test specimen, at the test position, to the nearest 0.1 mm.
- (e) Cut a notch in the inside wall of the test specimen, at the test position, so that the notch extends across the complete width of the test piece (see Figure 3). The notch tip shall be parallel (within 0.1 mm) to the outside wall of the pipe and shall have a radius not exceeding 0.025 mm. The remaining wall thickness shall be between 70% and 75% of the average wall thickness.
- (f) Measure the remaining wall thickness at both ends of the test specimen. Calculate the notch depth (a) and pipe wall thickness (e_{ref}) as the average of measurements taken at each end of the notch.
- (g) Cut out a 20 ± 2 mm section from the ring diametrically opposite the notch as shown in Figure 3. The shape of the cut-out section shall be such that the C-ring is aligned and rests on the supporting surface during the test as shown in Figures 1 and 2.
- (h) Fix the support clamps to the specimen. Ensure that they are fixed symmetrically within 10 ± 2 mm of the notch tip and the cut ends of the ring.