

Australian Standard™

AS 3572.9

Plastics—Glass filament reinforced plastics (GRP)—Methods of test

Method 9: Determination of pressure regression characteristics as a function of time for glass filament reinforced plastics pipes

1 SCOPE

This Standard establishes the procedure for determining linear regression coefficients of the pressure/time relationship of GRP pipes, and regression ratios based on lower confidence limits used for the determination of quality control test pressures.

2 PRINCIPLE

Test specimens are subjected to internal hydraulic pressures selected so that failure will occur within prescribed ranges of time.

3 REFERENCED DOCUMENTS

The documents below are referred to in this Standard.

AS

1349	Bourdon tube pressure and vacuum gauges
3572	Plastics—Glass filament reinforced plastics (GRP)—Methods of test
3572.1	Method 1: Preparation of glass filament reinforced plastics test specimens
3572.3	Method 3: Determination of loss on ignition of glass filament reinforced plastics
3572.4	Method 4: Determination of dimensions of glass filament reinforced plastics pipes
3572.12	Method 12: Determination of initial failure pressure and initial hoop strength of glass filament reinforced plastics pipes
3572.14	Method 14: Determination of long-term ring deflection of glass filament reinforced plastics pipe subject to constant load and environmental exposure
3572.15	Method 15: Determination of resistance to long-term strain corrosion of glass filament reinforced plastics pipes

4 APPARATUS

The following is required:

- (a) *Pressurizing system* A hydraulic system capable of producing the appropriate pressure without shock or pulsations, and capable of maintaining an accuracy of $\pm 1\%$ of the set value. A hydraulic accumulator or a pump may be used for this purpose.



Provision may be made for the connection of one or more test specimens to the hydraulic system at the one time. Where more than one connection is provided, the equipment shall ensure that, if a test specimen bursts, any change in pressure on the other specimens under test will not exceed the $\pm 1\%$ tolerance allowable. Provision shall also be made to isolate each connection.

Provision may be made for an automatic accumulator to recharge during a test provided the test time automatically pauses for the full recharge period. During recharge, the pressure on the test specimen may be permitted to vary outside the specified tolerance.

- (b) *End connections* Fittings that will make a watertight connection to the test specimen and to the pressurizing system. Three types of fittings are permitted, as follows:
 - (i) Caps, provided with ring joints sealing onto the external surface of the test specimen and connected to one another by a metal rod allowing some longitudinal movement at the ends of the test specimen. Pressure is applied through one cap end, or through the connecting rod (see Figure 1(a)).
 - (ii) Metal plugs provided with ring joints sealing onto the internal surface of the test specimen and connected to one another by a metal rod with a central bore, allowing some longitudinal movement at the ends of the test specimen (see Figure 1(b)).
 - (iii) End caps, or end plugs, incorporating standard joint couplings (see Figure 1(c)).
- (c) *Timing devices* A timing or recording device on each test station to register the duration of the test on each test specimen until the moment of failure. The timing device shall stop when the test pressure falls below 98% of the set value or when the test temperature is outside the specified range. The timing device shall have an accuracy of $\pm 2\%$, or 40 h, whichever is the smaller.
 NOTE: An electric contact pressure gauge is considered a satisfactory apparatus for switching the timing device, when set in conjunction with a test gauge.
- (d) *Pressure gauge* An industrial pressure gauge in accordance with AS 1349 with an accuracy of $\pm 1\%$.
 NOTE: Digital or analogue pressure gauges which can be shown to provide capabilities and characteristics of the same or a higher degree, may be used.
- (e) *Testing environment* A water bath capable of being maintained at a temperature of $23 \pm 2^\circ\text{C}$. Alternatively, if specimens are tested in air, suitable guards shall be provided and the air shall be maintained at $23 \pm 2^\circ\text{C}$.

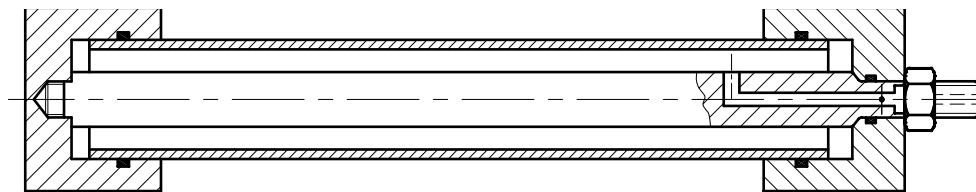
5 PREPARATION OF TEST SPECIMENS

Test specimens shall be taken from normal production pipes. The minimum length (L) of the test specimen between end connections shall be as specified in Table 1.

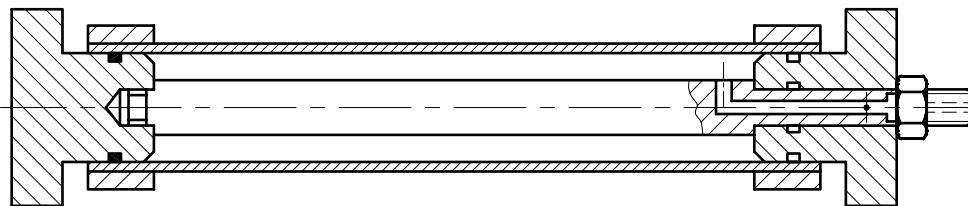
Before testing, each test specimen shall have its ends squared and cleaned. It shall have no burrs, notches or other markings which may cause premature failure.

TABLE 1
MINIMUM LENGTH OF TEST SPECIMENS

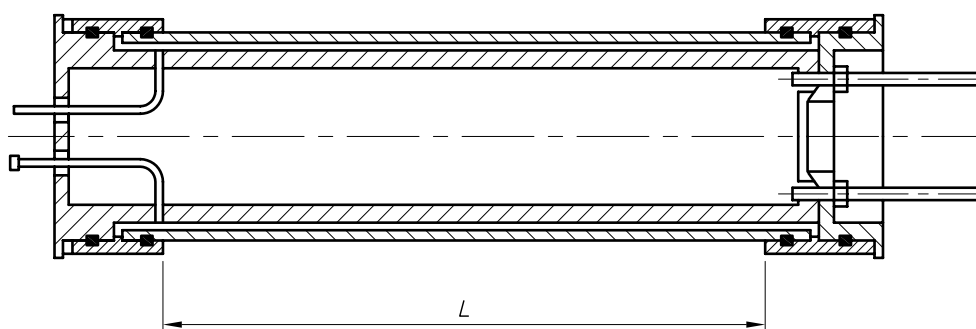
millimetres	
Nominal size (DN)	Length min. (<i>L</i>)
≤250	3DN + 250
>250	DN + 1 000



(a)



(b)



(c)

FIGURE 1 TYPICAL END CONNECTIONS FOR PRESSURE TESTS

6 NUMBER OF TEST SPECIMENS

A minimum of 18 test specimens shall be tested.

7 CONDITIONING

Test specimens shall be conditioned in accordance with AS 3572.1. Except for referee tests, conditioning shall be at ambient conditions.

8 MEASUREMENTS OF WALL THICKNESS, LENGTH AND OUTSIDE DIAMETER

The wall thickness, length, and outside diameter of each test specimen shall be measured in accordance with the relevant sections of AS 3572.4.

9 DETERMINATION OF 0.1-HOUR FAILURE PRESSURE DATA

A minimum of four 0.1-hour failure pressure results shall be obtained in accordance with AS 3572.12 for the calculation of the 0.1-hour regression ratio factor, if required.

10 DETERMINATION OF TEST PRESSURES

Test pressures shall be selected to obtain a minimum of 18 failure points, distributed as given in Table 2.

TABLE 2
FAILURE POINT REQUIREMENTS

Time h	Minimum number of failure points
$\geq 10 \leq 1\ 000$	4
$> 1\ 000 \leq 6\ 000$	3
$> 6\ 000 \leq 10\ 000$	4
$> 10\ 000$	1

11 PROCEDURE

The procedure shall be as follows:

- At the completion of the conditioning period, connect the test specimen to the apparatus provided. Ensure that all air is excluded from the system.
- Apply the test pressure to the test specimen to reach a stable condition within 5 min of first admitting pressure.
NOTE: It is essential that the pressure gauge be located in an appropriate position to avoid parallax error when taking readings.
- When the system has stabilized at the required test temperature of $23 \pm 2^\circ\text{C}$ and within the tolerance of $\pm 1\%$ of the set pressure value, commence timing.
- Continuously maintain the test pressure to an accuracy of $\pm 1\%$ of the set value, and the temperature of the test environment in contact with the test specimen at $23 \pm 2^\circ\text{C}$, throughout the test. In the event of a change in test pressure or temperature, which results in the specified tolerances being exceeded, timing (which has automatically stopped) shall only be recommenced when the test conditions have been reset within the required limits.

- (e) Record the time-to-failure of each test specimen.

The test specimen shall be considered to have failed when it develops a leak, weeps or ruptures. In the event of a failure of an end connection, or if failure occurs within $1.3\sqrt{(D_o T)}$ from the end sealing device (where D_o is the outside diameter, in millimetres and T is the wall thickness, in millimetres), a further test specimen shall be selected and the test repeated.

- (f) Results for unfailed specimens may be included.

12 NOTATION

The following notation is used in this document.

a, b	=	regression equation coefficients
C_a	=	correction factor for the 0.1-hour quality control test pressure
P	=	general symbol for pressure, in megapascals
$P_{M0.1}$	=	extrapolated 0.1-hour failure pressure, in megapascals
$P_{LC0.1}$	=	0.1-hour lower 97.5% confidence pressure obtained from type test, in megapascals
$P_{AV0.1}$	=	mean value of 0.1-hour failure pressures obtained from short term tests, in megapascals
$R_{0.1}$	=	0.1-hour regression ratio factor
P_{LC24}	=	24-hour lower 97.5% confidence pressure calculated from type test, in megapascals
R_{24}	=	24-hour regression ratio
P_{LC50}	=	50-year lower 97.5% confidence pressure calculated from type test, in megapascals
t	=	general symbol for time, in hours

13 ANALYSIS OF RESULTS

NOTE: A sample analysis is given in Appendix B.

13.1 Calculation of 24-hour regression ratio

Calculate the 24-hour regression ratio from the test results, excluding the data obtained from AS 3572.12 and referred to in Clause 9.

13.1.1 Calculation of the regression coefficients

The calculation procedure shall be as follows:

- (a) Plot the data as logarithms with time on the abscissa and pressure on the ordinate.

NOTE: The use of log-log graph paper will enable test data to be plotted directly without determining individual logarithms.

- (b) Calculate the linear regression coefficients a and b using the method of least squares (see Appendix A), for the following equation:

$$\log_{10} t = a + b \log_{10} P \quad \dots 1$$

The dependent variable is the logarithm of time (i.e., $y = \log_{10} t$)

The independent variable is the logarithm of pressure (i.e., $x = \log_{10} P$)

NOTE: Equation 1 recognizes the fact that time is the dependent variable in this test. Standard statistical calculations for the line of best fit and lower confidence limit are based on the dependent variable being the ordinate. However, convention dictates that the plot be drawn with time as the abscissa.

- (c) Calculate the 97.5% lower confidence limit of pressure at a time of 100 000 h in accordance with Paragraph A2.2 of Appendix A.
- (d) Confirm that the test data are suitable for analysis and satisfy the conditions of Paragraph A3 of Appendix A.
- (e) Calculate the estimated pressure at 100 000 hours using Equation 1.

13.1.2 Lower 97.5% confidence levels

Calculate the lower 97.5% confidence values for pressure at 24 h and 50 years, using data from type tests, as described in Paragraph A2.2 of Appendix A,

where

$$y = \log_{10} t$$

$$x = \log_{10} P$$

These values are respectively designated P_{LC24} and P_{LC50} .

13.1.3 24-hour regression ratio

Determine the 24-hour regression ratio (R_{24}) as follows:

$$R_{24} = \frac{P_{LC24}}{P_{LC50}} \quad \dots 2$$

13.2 Calculation of 0.1-hour regression ratio factor

The calculation involves the extrapolation of type test data to 0.1 h and a correlation between two different test methods, AS 3572.9 and AS 3572.12. Extrapolation beyond 1.6 decades is considered invalid, therefore a failure time of less than 4 h is required from AS 3572.9 for extrapolation to 0.1 h. The factor C_a attempts to relate the extrapolated 0.1 h AS 3572.9 result to the 0.1 h AS 3572.12 result. More than four AS 3572.12 data points may be required to ensure that C_a is statistically meaningful.

13.2.1 Mean 0.1-hour failure pressure ($P_{AV0.1}$)

Calculate $P_{AV0.1}$ by taking the arithmetic mean of the 0.1-hour failure pressure test results obtained from AS 3572.12.

13.2.2 Extrapolated 0.1-hour failure pressure ($PM0.1$)

Calculate the extrapolated 0.1-hour failure pressure using Equation 1 and type test data obtained from AS 3572.9.

13.2.3 Correction factor (C_a)

Calculate the correction factor for the 0.1-hour quality control test pressure as follows:

$$C_a = \frac{P_{AV0.1}}{P_{M0.1}} \quad \dots 3$$

13.2.4 Lower 97.5% confidence level

Calculate the lower 97.5% confidence value for pressure at 0.1 h, using data from the type test, as described in Paragraph A2.2 of Appendix A. The value is designated $P_{LC0.1}$,

where

$$y = \log_{10} t$$

$$x = \log_{10} P$$

13.2.5 0.1-hour regression ratio factor

Determine 0.1-hour regression ratio factor as follows:

$$R_{0.1} = C_a \frac{P_{LC0.1}}{P_{LC50}} \quad \dots 4$$

14 REPORT

14.1 Test report

The following shall be reported:

- (a) Full identification of the pipe tested including—
 - (i) nominal stiffness and pressure class;
 - (ii) date of manufacture;
 - (iii) identification number; and
 - (iv) any non-standard coatings or procedures.
- (b) Date of testing including the start and finish of each specimen, and the dates and nature of excursions outside the tolerances given in Clause 4(a).
- (c) Dimensions of the test specimen.
- (d) Age of the test specimen at the start of the test and conditions of storage (temperature and relative humidity).
- (e) Temperature during testing.
- (f) Raw experimental test results.
- (g) Graph of test results.
- (h) Calculated linear regression coefficients (a , b) and identification of any data points excluded from the analysis and the reasons for their exclusion.
- (i) The 97.5% lower confidence limit of pressure at 100 000 h.
- (j) The estimated pressure at 100 000 h.
- (k) The percentage difference between the 97.5% lower confidence limit and the estimated pressure at 100 000 h.
- (l) The calculated lower confidence values $P_{LC0.1}$, P_{LC24} , and P_{LC50} .
- (m) The 24-hour regression ratio factor and the 0.1-hour regression ratio factor, if applicable.
- (n) The correction factor C_a .
- (o) Mean 0.1-hour failure pressure ($P_{AV0.1}$).
- (p) Extrapolated 0.1-hour failure pressure ($P_{M0.1}$).
- (q) The number of this Australian Standard, AS 3572.9.