

Australian/New Zealand Standard®

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

Method 18: Method for determining the ultimate tensile strength and unit modulus of flat laminates

1 SCOPE This Standard describes the test procedure to determine the ultimate tensile unit strength and unit modulus of flat laminates.

2 REFERENCE DOCUMENTS The following document is referred to in this Standard:

AS

3572 Plastics—Glass filament reinforced plastics (GRP)—Methods of test

3572.1 Method 1: Preparation of glass filament reinforced plastics test specimens

3 PRINCIPLES The following principles apply to this method:

- (a) *Ultimate tensile unit strength* A minimum of five dumbbell-shaped test pieces are machined to shape by means of a profiling system. Measurements are made to determine the mean cross-sectional area of each specimen. Each specimen is mounted in a tensile testing machine and a strain applied at the rate of 2 mm/minute. The force at yield is noted for each specimen. The mean ultimate tensile unit strength is then calculated.
- (b) *Unit modulus* Test pieces as described in Item (a) are measured and mounted in a tensile testing machine. An extensometer is set along the gauge length of each test piece before the strain is applied. A strain of 0.2% is applied and the force noted. The unit modulus of the laminate is then calculated.

4 APPARATUS The following apparatus is required:

- (a) *Tensile testing machine* Capable of indicating the force applied to the test piece with an accuracy of $\pm 1\%$ of the indicated value.
- (b) *Micrometer* For measuring the thickness and width of rigid materials; a screw micrometer reading to 0.01 mm or less shall be used.

For measuring the thickness of flexible materials, a dial gauge micrometer (or comparator) reading to 0.01 mm or less and provided with a flat circular foot that will apply a pressure of 20 ± 3 kPa shall be used.

- (c) *Extensometer* Permitting the determination, at any time during the test, of the distance between two fixed points (or reference marks) located within the central parallel portion of the test specimen.

Other techniques are not allowed; in particular, the measurement of strain by the displacement of the grips.

The extensometer used should allow a force-extension curve to be drawn.

NOTES:

- 1 Some optical devices can be used, which make it possible to follow the separation of the two reference marks.
Other extensometers (mechanical or volumetric) may be used provided that they can measure strain with an accuracy of 1% or better.
- 2 The extensometer should not damage the test specimens by causing breaks at the points of attachment.

5 PREPARATION OF TEST PIECES The dumbbell piece shown in Figure 1 shall be machined to shape by means of a profiling system (i.e. machined from a rectangular blank, which is clamped firmly between plates and traversed by a high speed router-cutter guided by a shaped template).

The machining conditions used shall not overheat the test piece. If a coolant is used, it shall not have a deleterious effect on the material being machined. All surfaces of a test piece shall be free from visible flaws, scratches or imperfections.

Marks left by machining operations or, in the case of coarse laminates, loose fibre ends may be smoothed with fine abrasants used in place of the cutting tool on the profiling machine. In all machining operations, precautions shall be taken against inhalation of dust and the occurrence of skin irritation.

A minimum of five test pieces shall be tested in each of the required directions of testing. Test pieces that do not break within the central parallel portion shall be discarded and further test pieces shall be tested.

Test pieces shall be prepared and conditioned in accordance with AS 3572.1.

6 SPEED OF TESTING The speed of grip separation on the tensile testing machine for the test shall be 2 mm/min $\pm 20\%$.

7 PROCEDURE

7.1 General The procedure for determining ultimate tensile unit strength shall be in accordance with Clause 7.2 and unit modulus shall be in accordance with Clause 7.3.

7.2 Ultimate tensile unit strength

7.2.1 Procedure The procedure shall be as follows:

- (a) Measure the width and thickness of the central parallel portion of the dumbbell-shaped test pieces as shown in Figure 1 to the nearest 0.01 mm at several points and determine the mean cross-sectional area.
- (b) Mount the test pieces in the testing machine in axial alignment with the direction of pull.
- (c) Apply stress to the test piece until failure occurs and note the force at yield.

7.2.2 Individual laminate layers If comparison with minimum nominated values is required, then each type of reinforcement shall be tested individually and the resulting loads per unit width divided by the number of kg/m² of glass in the specimen.

The ultimate tensile unit strength (u) is determined by the following equation:

$$u = \frac{F}{bm}$$

where

u = the ultimate tensile unit strength, in N/mm per kg/m² of glass

F = the maximum tensile force, in newtons

b = the mean initial width of test specimen gauge length, in millimetres

m = the mass of the single type of reinforcement of glass in the specimen

7.2.3 Combined laminates Where only combined laminates are available (e.g. when testing cut-outs from a vessel) the specimen may not achieve full tensile unit strength.

The minimum properties of the laminate can then be assessed by determination of the minimum tensile load that the test specimen shall carry without failure.

NOTE: The different strain capabilities of each type of layer will cause failure in one type before full load is achieved in other types of reinforcement. The resulting load transfer will cause premature failure of the specimen.

For each type of layer, the strain (ϵ_z) of a layer of type z at minimum ultimate unit strength shall be determined from the following equation:

$$\epsilon_z = \frac{u}{X_z}$$

where

X_z = the unit modulus of layer of type z , in N/mm per kg/m² glass

The lowest strain, ϵ_{min} , shall be used to determine the tensile unit strengths of other types of reinforcement at that strain from the following equation:

$$\text{Tensile unit strength} = X_z \epsilon_{min}$$

The resulting tensile unit strength of each layer shall then be multiplied by the total mass of each type of reinforcement and the width of the specimen to obtain the minimum required load.

7.3 Unit modulus The test procedure shall be as follows:

- Measure the width and thickness of the central parallel portion of the dumbbell-shaped test pieces shown in Figure 1 to the nearest 0.01 mm at several points and determine the mean cross-sectional area.
- Mount the test pieces in the testing machine in axial alignment with the direction of pull. Set and adjust an extensometer (if one is to be used), after appropriate calibration, along the gauge length of the test piece, before the application of stress.
- Apply a small initial tensioning force (not exceeding 10% of the expected force at 0.2% strain) to straighten the test specimen and, at this force, set the indicating device to zero.
- Increase the force steadily until an extension (Z_x) of 0.1 mm is reached on the specimen gauge length of 50 mm (0.2% strain) and note the value of the force (F_x) at this point.

Where it is expected that 0.2% strain may give rise to danger of fracture of the test piece, it is permissible to carry out the test at 0.1% strain (corresponding to an apparent extension of 0.05 mm over the 50 mm gauge length). Reduce the initial force to straighten the specimen correspondingly.

- The unit modulus of the laminate X_{LAM} (in N/mm), shall be determined from the following equation:

$$X_{LAM} = \frac{(F_2 - F_1)}{(Z_2 - Z_1)} \times \frac{L}{b}$$

where

$(Z_2 - Z_1)$ = the change in apparent extension (in mm) corresponding to a change in applied force $(F_2 - F_1)$, (in N) (see Figure 2)