Designation: D2343 – 17 (Reapproved 2023)

Standard Test Method for Tensile Properties of Glass Fiber Strands, Yarns, and Rovings Used in Reinforced Plastics[1]

This standard is issued under the fixed designation D2343; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope

1.1 This test method covers the determination of the comparative tensile properties of glass fiber strands, yarns, and rovings in the form of impregnated rod test specimens when tested under defined conditions of pretreatment, temperature, humidity, and tension testing machine speed. This test method is applicable to continuous filament, glass fiber materials that have been coated with a resin compatible sizing. This method is intended for use in quality control and R & D, and is not intended to be used to develop composites design data.

NOTE 1—This method is technically equivalent to the short method described in ISO 9163.

NOTE 2—Prime consideration should be given to the use of a polymeric binder that produces specimens that yield the highest consistent values for the glass fiber material under test. Tensile properties vary with specimen preparation, resin impregnation system, and speed and environment of testing. Consider these factors where precise comparative results are desired.

1.2 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D618 Practice for Conditioning Plastics for Testing

D883 Terminology Relating to Plastics

E4 Practices for Force Calibration and Verification of Testing Machines

E6 Terminology Relating to Methods of Mechanical Testing

2.2 *ISO Standard:*

ISO 9163 Textile Glass—Rovings—Manufacture of Test Specimens and Determination of Tensile Strength of Impregnated Rovings

3. Terminology

3.1 *Definitions:*

3.1.1 Definitions of terms and symbols relating to this test method appear in Terminologies E6 and D883.

4. Summary of Test Method

4.1 This test method consists of impregnating glass fiber strands, yarns, or rovings with a suitable polymeric binder material and loading the resulting test specimens to failure in a tension testing machine having a constant-rate-of crosshead movement. The cross sectional area is determined from skeins of glass fiber taken before and after each set of test specimens. After impregnation and curing, the specimens shall either be tabbed using glass fiber mat or cardboard and tested with standard grips; or the ends shall be sanded with 240 grit sandpaper or fine emery cloth and tested using rubber faced grips.

5. Significance and Use

5.1 Tensile properties determined by this test method are of value for identifying and characterizing materials for control and specification purposes as well as for providing data for research and development studies.

[1] This test method is under the jurisdiction of ASTM Committee D20 on Plastics and is the direct responsibility of Subcommittee D20.18 on Reinforced Thermosetting Plastics.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For Annual Book of ASTM Standards volume information, refer to the standard's Document Summary page on the ASTM website.

*A Summary of Changes section appears at the end of this standard

5.2 This test method is intended for use in testing resin-compatible sized glass fiber materials that have been designed specifically for use with certain generic types of plastics. The use of a resin system that is compatible with the reinforcement material under test produces results that are most representative of the actual strength that is available in the material when used as intended in an end item. Premature reinforcement failures occur if the elongation of the resin system is less than that of the reinforcement being tested. It is critical to select a resin system that does not lead to premature reinforcement failure. Use of compatible resin system and complete resin impregnation is recommended to avoid invalid failures and misleading results.

5.3 This test method is useful for testing pretreated specimens for which comparative results are desired. Gage length, gripping system, testing speed, and the resin impregnation ratio of the specimen affects the values obtained by this test method.

6. Apparatus

6.1 *Impregnation Apparatus*—An example of an acceptable impregnation apparatus for strands is shown in Fig. 1. Minor modifications to the apparatus are acceptable providing consistent samples are produced. The apparatus shall consist essentially of the following:

6.1.1 *Free Wheeling Spindle (Optional)*—A freely turning spindle with a horizontal axis for holding the yarn spool or roving ball. A spindle allows fiber to be pulled from a yarn bobbin or the outside of a roving package. Alternately, inside payout or drawing of the fiber from the interior of a roving package or forming cake without the use of spindle is possible.

6.1.2 *Tension Regulating System* capable of maintaining the roving or yarn under tension between 0.2 newton and 20 newton.

6.1.3 *Impregnation Tank,* as illustrated in Fig. 2, consisting of a container and a static spreader bar assembly. The tank must have the capability of maintaining the required resin temperature within ±5°C.

NOTE 3—Heating and temperature maintenance may be accomplished by use of a double walled vat, with heating fluid circulating between the walls, or by use of an external heating plate.

6.1.4 *Die,* as illustrated in Fig. 3, made of stainless steel, which gives a defined circular cross-section to the impregnated roving.

6.1.5 *Winding Device and Frame,* for collecting the impregnated roving, which ensures that the fibers are kept under constant tension and places the strands onto the fixture in a manner, which allows separate specimens to be fabricated.

6.2 *Template for Tabbing (Optional)*—A template, as shown in Fig. 4, shall be used to provide proper positioning of end tabs.

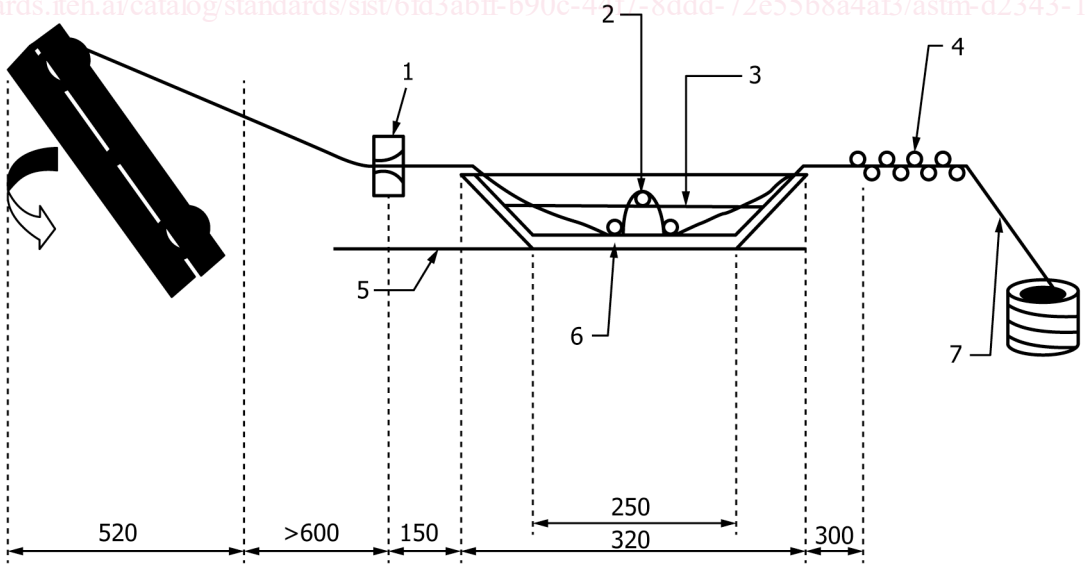
6.3 *Tension Testing Machine*—A testing machine having a constant-rate-of-crosshead movement and comprising essentially the following shall be available:

6.3.1 *Stationary Member,* with one grip.

6.3.2 *Movable Member,* with a second grip.

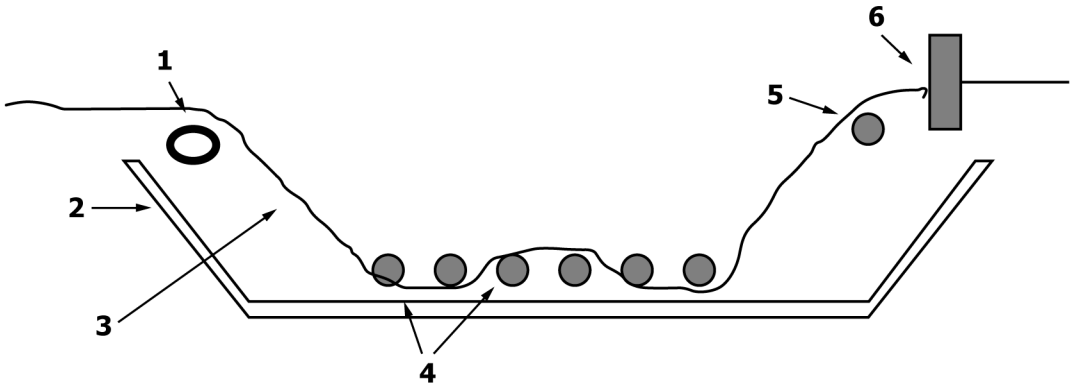
6.3.3 *Grips*—Grips for holding the test specimen between the fixed and the movable member shall be of the self-aligning type (that is, they shall be attached to the fixed and movable members in such a manner that they will move freely into alignment as soon as any load is applied). The long axis of the test specimens will then coincide with the direction of the applied pull through the center line of the grip assembly.

NOTE 4—Air-actuated grips have been found advantageous and are recommended for use in this test method.



1 Die
2 Tensioning Bars
3 Resin Level
4 Tensioning Device
5 Moving Support
6 Impregnation Vat (temperature regulated)
7 Glass Input

FIG. 1 Typical Impregnation Equipment Configuration



1 Entrance Guide Eye
2 Impregnating Vat
3 Glass Roving or Yarn
4 Breaker Bars
5 Exit Tensioning Bar
6 Die

FIG. 2 Impregnation Tank

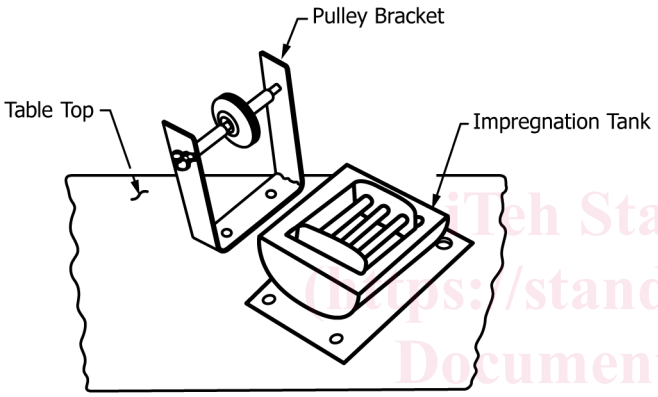


FIG. 3 Guide Pulley and Impregnation Tank

NOTE 5—Rubber with a Shore A hardness of 91 has been found to work well as a grip surface.

NOTE 6—Recommended starting gripping pressures are 80 bars for specimens with no tabs, 60 bars for specimens with cardboard tabs, and 40 bars for composite tabs. Adjust these as necessary to prevent slippage provided damage to the specimen due to crushing is prevented.

6.3.4 *Jaws*—A set of removable jaws to match the required grips shall be used for clamping the test specimens. One of the faces of the jaws shall be adjustable to compensate for thickness of the specimen ends, so that the tension force is aligned with the center of the jaw. Rubber-faced jaws, with a gripping length of at least 50 mm, shall be used for gripping specimens unless tabs are used. The jaws shall be wider than the test specimen and shall have a gripping length of at least 50 mm. Their faces shall be plane and parallel and shall ensure uniform pressure over the whole width of the test specimen to ensure the specimen is held without slippage. If slippage of the test specimens is observed, 240 grit sandpaper strips shall be used to improve gripping. Replace sandpaper when it has lost its grittiness, or after every 30 to 50 breaks. Alternatively, tabbing shall be used.

6.3.5 *Drive Mechanism*—A drive mechanism capable of imparting a uniform controllable speed to the movable member of the apparatus.

6.3.6 *Load Indicator*—A suitable load-indicating mechanism capable of showing the total tensile load carried by the test specimen when held by the grips shall be used. This mechanism shall be essentially free of inertial lag at the specified rate of testing and shall indicate the load with an accuracy of at least ±1 % of the indicated load value. The accuracy of the testing machine shall be verifiable in accordance with Practices E4.

6.3.7 *Deflection-Measuring Device and Recorder*—A suitable instrument for measuring deflection (extensometer) and a suitable mechanism for recording this deflection shall be provided. It is desirable that this instrument and recorder automatically record this deflection as a function of the load on the test specimen. An extensometer gauge length of 50 mm is recommended.

6.4 *Balance, Analytical.*

7. Test Specimens

7.1 Test specimens shall consist of straight lengths of impregnated glass fiber strands, yarns, or roving. The lengths shall be at least 250 mm.

7.2 *Effective Gage Length*—The distance between the tabs or the distance between the rubber faced jaws shall be 150 mm.

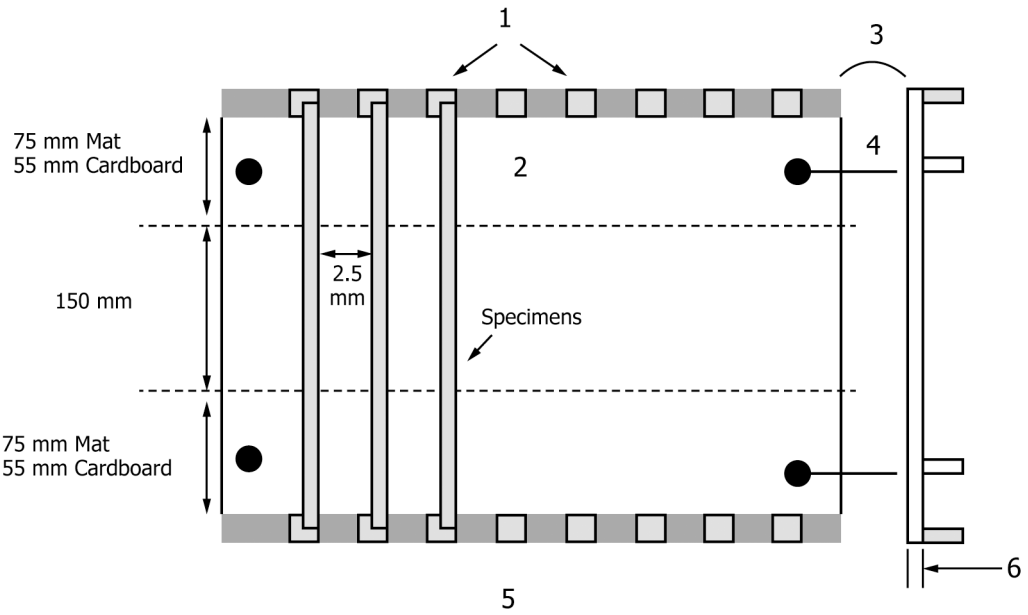
7.3 *Number of Specimens*—At least five tension test specimens shall be tested for each ball or spool of glass fiber material for each property tested.

7.4 *Glass Content*—The glass content of the impregnated glass samples shall be 70 ± 5 % unless otherwise specified.

8. Conditioning

8.1 *Strands, Yarns, and Rovings Conditioning*—The glass fiber from which test specimens are to be prepared shall be kept in a room or enclosed space maintained at 23 ± 2°C (73.4 ± 3.6°F) and 50 ± 10 % relative humidity in accordance with Procedure A of Practice D618, except that 12 h shall be the minimum conditioning time.

8.2 *Test Specimen Conditioning*—The specimens shall be conditioned and tested in a room or enclosed space maintained



1 Notches for locations for impregnated rods
2 Position for strip of cardboard or mat
3 Border
4 Dimension depending on number of specimens
5 Thickness of cardboard or mat
6 Stops

FIG. 4 Tabbing Template

at atmospheric conditions of 23 ± 2°C (73.4 ± 3.6°F) and 50 ± 10 % relative humidity in accordance with Procedure A of Practice D618, except that 16 h shall be the minimum conditioning time.

9. Speed of Testing

9.1 Speed of testing shall be the relative rate of motion of the grips or test fixtures during test.

9.2 The standard speed of testing is 10 mm/min for tensile strength and 5 mm/min for apparent modulus of elasticity unless otherwise specified.

10. Impregnation Procedure

10.1 Set up the impregnating apparatus in accordance with Fig. 1.

10.2 Cover the ends of the winding fixture using 0.025 mm (0.001 in.) nominal thickness, heat-resistant plastic film, aluminum foil, or equivalent parting film.

10.3 Prepare a sufficient quantity of resin system suitable for impregnating the material under test. Pour the impregnating mixture into the tank so that the level is about 10 mm (0.39 in.) above the static breaker bars (see Fig. 2).

10.4 Immediately prior to threading the material through the impregnation apparatus, cut a 1000 ± 1-mm (40 ± 0.04-in.) skein of the material under test. Repeat the procedure immediately after winding one set of specimens. Place the two skeins in a muffle furnace maintained at a temperature that will give complete burn-off (usually 450°C for 2 h). Remove the two skeins from the furnace and place in a desiccator for a minimum of 15 min. Weigh the two skeins to the nearest 0.001 g and record as Weight *X*.

10.5 Select a stripper die of the proper diameter by using the chart or calculations in 12.3.

10.6 Thread the glass fiber material through the impregnating apparatus in an "under, over, under" path through the static spreader bars. Firmly attach the end of the glass fiber to the winding fixture with heat-resistant masking tape. Drape the material on the winding fixture. Rotate the fixture either manually or at a motorized rate not exceeding 8 m/min (26 ft/min).

10.6.1 Maintain a resin-to-glass weight ratio of 70 % for the preparation of the test specimens (see Note 7).

NOTE 7—The choice of die and the tex of the fiber will determine the glass content and is also influenced by viscosity of the resin used. Use the calculations in 12.2 to determine the die size to be used. If the calculated die size does not yield the needed glass-weight ratio, then adjustment of the die diameter will be needed.

10.6.2 After the required number of specimens are wound, hold the winding tension on the material and use heat-resistant masking tape to attach the material to the winding fixture. Cut the material after attachment has been made.

NOTE 8—Optionally, a flat tongue depressor or metal spatula may be used to flatten the end 100 mm (3.9 in.) of the glass strands. This flattening of the gripped portion of the strands allows better clamping of the specimens while minimizing crushing in the grip jaws.

10.6.3 Place the loaded winding fixture in a horizontal position in an air-circulating oven at a temperature and for a length of time necessary to cure the resin per manufacturer's instructions. After curing, cool to room temperature and remove the specimens from the winding fixture.

10.7 Cut the specimens to the required length. Exercise care to prevent damage to the specimens during handling.