



Designation: **D 4475 – 9602**

Standard Test Method for Apparent Horizontal Shear Strength of Pultruded Reinforced Plastic Rods By the Short-Beam Method¹

This standard is issued under the fixed designation D 4475; 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.

1. Scope*

1.1 This test method covers the determination of the apparent horizontal shear strength of fiber reinforced plastic rods. The specimen is a short beam in the form of lengths of pultruded rods. This test method is applicable to all types of parallel-fiber-reinforced plastic rod samples.

1.2 This test method is primarily used for quality control and specification purposes (see 4.1).

1.3 The values stated in SI units are to be regarded as the standard.

1.4 *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 and health practices and determine the applicability of regulatory limitations prior to use.*

NOTE 1—There is no similar or equivalent ISO standard.

2. Referenced Documents

2.1 *ASTM Standards:*

D 618 Practice for Conditioning Plastics for Testing²

¹ This test method is under the jurisdiction of ASTM Committee D-20 on Plastics and is the direct responsibility of Subcommittee D20.18 on Reinforced Thermosetting Plastics.

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

E 4 Practices for Force Verification of Testing Machines³

E 691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method⁴

3. Summary of Test Method

3.1 The horizontal-shear test specimen is center-loaded as shown in Fig. 1. The ends of the specimens rest on two supports that allow the specimen to bend, the load being applied by means of a loading nose at midpoint along the support span, as shown in Fig. 2.

3.2 The specimen is deflected until a shear failure occurs at the midplane of the horizontally supported rod.

4. Significance and Use

4.1 Apparent shear strength determined by this test method is useful for quality control and specification purposes. It is also applicable to research and development programs concerned with interlaminar-shear strength. The apparent shear strength obtained by this test method cannot be used for design purposes, but can be utilized for comparative testing of composite materials, if all failures are in horizontal shear.

4.2 It is recommended that control samples be fabricated with each research test series and that care be used to compare each set of controls with corresponding test series run at different times.

5. Apparatus

5.1 *Testing Machine*—A properly calibrated testing machine that can be operated at a constant rate of crosshead motion, and in which the error in the load measuring system shall not exceed $\pm 1\%$ of the maximum load expected to be measured. The load-indicating mechanism shall be essentially free of inertia lag at the crosshead rate used. The accuracy of the testing machine shall be verified in accordance with Practices E 4.

5.2 *Loading Nose and Supports*—Shown in Fig. 2 and Fig. 3. The loading nose shall be a suitable steel rod with a groove in the diameter of the pultruded rod machined in its lower end. The groove diameter shall always have a plus tolerance and zero negative tolerance. The bottom support shall be adjustable to allow for testing at various span/diameter ratios. The surface of the groove shall be free of indentation and burrs, with all sharp edges relieved.

5.3 *Micrometers*—Suitable micrometers for measuring the diameter of the test specimen to an incremental discrimination of at least 0.025 mm (0.001 in.) shall be used.

6. Test Specimen

6.1 The specimen shall be cut from the pultruded rod to a length of one diameter greater than the test span and to a tolerance of plus or minus 0.1 times the diameter.

² Annual Book of ASTM Standards, Vol 08.01.

³ Annual Book of ASTM Standards, Vol 03.01.

⁴ Annual Book of ASTM Standards, Vol 14.02.

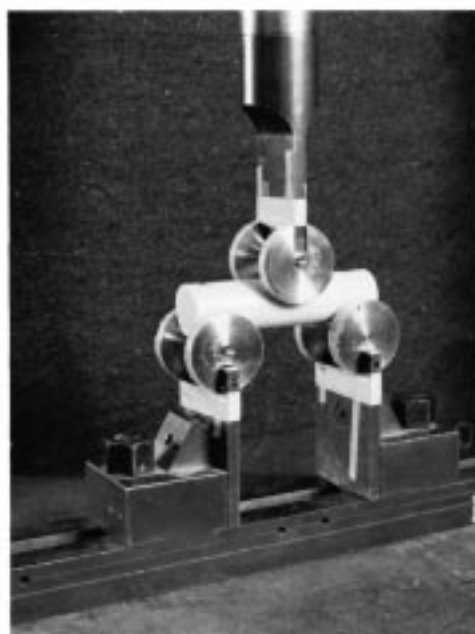


FIG. 1 Test Assembly

9.2 Place the rod test specimen in the test fixture, as shown in Fig. 1. Align the specimen so that its midpoint is centered and its long axis is perpendicular to the loading nose. Adjust the side supports to the span previously determined. Suggested span-to-diameter ratios are from 3 to 1 up to 6 to 1. The obtainment of shear fractures during the test is a major consideration in determining span length.

NOTE 3—Experimental data indicates that shear strength is a function of support span-to-specimen diameter ratio in most materials. When writing specifications, both the specimen diameter and the span-to-diameter ratio should be specified.

9.3 Apply the load to the specimen at the specified crosshead rate. Record the load to break for each specimen (maximum load on load-indicating mechanism). At times, when testing pultruded rods in various environments, specimens do not consistently fail in shear, especially when the incorrect span-to-depth ratio is chosen. It is, therefore, very important to record the type of break (shear or tensile) that occurs. For research purposes, it is also useful to record the position of the shear plane relative to the specimen center line.

10. Retest

10.1 Values for properties at break shall not be calculated for any specimen that breaks at some obvious, fortuitous flaw, unless such flaws constitute a variable being studied. Retests shall be made for any specimen on which values are not calculated. Should a specimen fail in a manner other than horizontal shear, the value shall be discarded and a retest shall be made. However, some of the specimens may not show a distinct failure mode, particularly after preconditioning. It is suggested that some form of chart movement, such as chart speed or a deflectometer, be used to help determine the fracture point. This is normally the first major load reduction or sudden change in slope of the load-deflection curve.

TABLE 1 Precision Statement

Shear Strength, 10 ³ psi						
Room Temperature						
Values in the units of psi						
Material	Rod Diameter	Mean	S _r	S _R	t _r	t _R
Material	Rod Diameter	Mean	S _r ^A	S _R ^B	t _r ^C	t _R ^D
Vinyl ester	0.85 in.	10.2	0.236	0.519	0.665	1.47
Vinyl ester	1.00 in.	9.14	0.161	0.374	0.456	1.06
Polyester	1.20 in.	8.23	0.182	0.854	0.515	2.42
150°F						
Vinyl ester	0.85 in.	7.70	0.245	0.548	0.693	1.55
Vinyl ester	1.00 in.	7.14	0.165	0.415	0.467	1.17
Polyester	1.20 in.	6.83	0.111	0.412	0.314	1.17

^A S_r = within laboratory standard deviation for the indicated material. It is obtained by pooling the within-laboratory standard deviations of the test results for all of the participating laboratories:

$$S_r = \left[\frac{(S_1)^2 + (S_2)^2 + \dots + (S_n)^2}{n} \right]^{1/2}$$

^B S_R = between-laboratories reproducibility, expressed as standard deviation:

$$S_R = \left[S_r^2 + S_r^2 \right]^{1/2}$$

where S_r = standard deviation of laboratory means.

^C t_r = within-laboratory critical interval between two test results = 2.8 × S_r.

^D t_R = between-laboratories critical interval between two test results = 2.8 × S_R.

11. Calculations

11.1 Calculate the apparent shear strength as follows:

$$S = 0.849 P/d^2 \quad (1)$$

where:

S = apparent shear strength, N/m², (or psi),

P = breaking load, N, (or lbf), and

d = diameter of specimen, m, (or in.).

11.2 *Arithmetic Mean for Each Series of Tests*—Calculate the arithmetic mean of all values obtained to three significant figures and report as the “average value”.

11.3 *Standard Deviation*—Calculate the standard deviation (estimated) as follows and report to two significant figures:

$$s = \sqrt{(\sum X^2 - n \bar{X}^2)/(n - 1)} \quad (2)$$

where:

s = estimated standard deviation,

X = value of a single observation,
 n = number of observations, and
 \bar{X} = arithmetic mean of the set of observations.

12. Report

- 12.1 The report shall include the following:
- 12.1.1 Complete identification of the material tested, including type, source, form, principle dimensions, and previous history,
 - 12.1.2 Fabrication procedure,
 - 12.1.3 Diameter of specimen,
 - 12.1.4 Conditioning procedure used,
 - 12.1.5 Atmospheric conditions in the test room,
 - 12.1.6 Number of specimens tested,
 - 12.1.7 Rate of crosshead motion,
 - 12.1.8 Span length,
 - 12.1.9 Length of specimens,
 - 12.1.10 Type of failure,
 - 12.1.11 Apparent horizontal shear strength of each specimen, average value, and standard deviation,
 - 12.1.12 Location of failure, or method of determining failure from curve,
 - 12.1.13 Average fiber content, percent by weight, and
 - 12.1.14 Date of test.

13. Precision and Bias ⁵

13.1 Table 1 is based on a round robin conducted in 1984 in accordance with Practice E 691, involving three materials tested by eleven laboratories. For each material, all the samples were prepared at one source, but the individual specimens were prepared at the laboratories which tested them. Each test result was based on the average of five individual determinations. Each laboratory obtained two test results for each material. Tests were conducted at room temperature and 150°F.

~~13.2 In~~

NOTE 4—Caution: The explanation of "r" and "R" in 13.2.1 and 13.2.2 are only intended to present a meaningful way of considering the approximate precision of this test method. The data in Table 1, for 1 should not be applied to acceptance or rejection of materials, as these data apply only to the materials indicated, tested in the round robin and are unlikely to be rigorously representative of other lots, formulations, conditions, materials, or laboratories. Users of this test method should apply the principles outlined in Practice E 691 to generate data specific to their materials and laboratory (or between specific laboratories). The principles of 13.2-13.2.2 would then be valid for such data.

13.2 Concept of "r" and "R" in Table 1—If S_r and S_R have been calculated from a large enough body of data, and for test results that are derived were averages from testing five specimens: two specimens for each test result, then:

13.2.1 S_r is the pooled within-laboratories standard deviation of the mean and $I_r = 2.83 S_r$ (see 13.2.3 for application of I_r).

13.2.2 S_R is the total between-laboratories standard deviation of the mean and $I_R = 2.83 S_R$ (see 13.2.4 for application of I_R).

13.2.3 Repeatability—In comparing:

Two results obtained within one laboratory shall be judged not equivalent if they differ by more than the "r" value for that material. "r" is the interval representing the critical difference between two mean values test results for the same material, obtained by the same operator; using the same equipment on different days; the mean should be judged not equivalent if they differ by more than same day in the I_r value for that material and condition:

13.2.4 same laboratory.

13.2.2 Reproducibility—In comparing two mean values for the same material:

Two test results obtained by different operators, using different equipment on different days, the mean should laboratories shall be judged not equivalent if they differ by more than the I_R value "R" value for that material and condition. (This applies material. "R" is the interval representing the critical difference between two test results for the same material, obtained by different laboratories or between operators using different equipment within the same laboratory.)

13.2.5 The judgments in different laboratories.

13.3 Any judgement in accordance with 13.2.3 and 13.2.4 will be correct in approximately 95% 13.2.1 or 13.2.2 would have an approximate 95% (0.95) probability of such comparisons:

13.2.6 Other materials may give somewhat different results.

13.3 For further information on the methodology used in this section, see Practice E 691—being correct.

13.4 There are no recognized standards on by which to base an estimate of bias for of this method.

⁵ Supporting data are available at ASTM Headquarters. Request RR: D20-1118.

SUMMARY OF CHANGES

This section identifies the location of selected changes to this test method. For the convenience of the user, Committee D20 has highlighted those changes that may impact the use of this test method. This section may also include descriptions of the changes or reasons for the changes, or both.

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(I) The precision and bias statement was revised in format in 2001.

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