**Designation: D 5117 – ~~96~~03**

# Standard Test Method for Dye Penetration of Solid Fiberglass Reinforced Pultruded Stock[1]

This standard is issued under the fixed designation D 5117; 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 dye-penetrant test method covers a means of evaluating solid fiberglass reinforced pultruded ~~rock~~ rod stock for longitudinal wicking. There are generally three mechanisms that promote wicking, any or all of which may be operating at a given time.

NOTE 1—The specimen's cross-section may reflect delaminations, longitudinal continuous voids, or the presence of hollow fibers, or all three. Occasionally these flaws may be detected by this test, but other tests are usually required.

1.2 The results of a wicking test are dependent on specimen type and size, penetrant type, time of exposure in the penetrant, penetrant viscosity, etc. Any attempt to use a wicking test to establish specification criteria should be made with great care.

1.3 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in nonconformance with 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.* For specific hazard statements, see 10.3 and 10.6.

NOTE 2—There is no similar or equivalent ISO standard.

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[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.**

## 2. Referenced Documents

2.1 *ASTM Standards:* [2]

D 618 Practice for Conditioning Plastics for Testing

D 3918 Definitions of Terms Relating to Reinforced Plastic Pultruded Products

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

## 3. Terminology

3.1 *Definition of Term Specific to This Standard:*

3.1.1 *wicking*—transmission of a gas or liquid due to pressure differential or capillary action along fibers incorporated in a fiberglass reinforced pultruded product.

## 4. Summary of Test Method

4.1 Pultruded ~~rock~~ rod stock of circular cross-section is tested by placing the specimen(s) on end into the dye penetrant to a specified depth and observing the wicking action as spots, or dots, on the opposite, dry face.

4.2 The wicking action through the length of the specimen is due to the capillary action of the penetrant through the open pathways in the composite. These pathways are typically occupied by air and can be caused by continuous voids, cracks, or hollow fibers, or all three, in the reinforcement.

## 5. Significance and Use

5.1 This test method is useful for establishing the integrity of composite rod. The presence of voids, cracks, and hollow fibers are considered detrimental to the structural integrity of the composite and may cause reduced electrical resistance and increased current leakage.

5.2 A perfect composite would be flaw-free, and there would be no possibility of wicking. Composites of this type are virtually nonexistent, as there will typically be entrapped air in the resin developed during manufacture, occasional hollow fibers, and occasional cracks due to thermal stresses.

5.3 This test method is intended to provide a tool for measuring the extent of flaws in a composite over very short lengths of material. The presence of wicking over 1 in. [2.54 cm] lengths may not necessarily imply that the composite will perform unsatisfactorily for its intended end-use. Therefore, interpretation of test results should be made with care.

5.4 This test method was developed as a technique for estimating quality and consistency of pultruded rod stock, which is a composite of resin and reinforcement. The process may also affect the quality of the product. It should be useful for a manufacturer in determining whether any gross changes in quality have taken place due to process or raw material changes.

5.5 Since the results of this test are so sensitive to sample size, penetrant type, penetrant used, viscosity, duration of test, and other factors, no attempt to arrive at or recommend development of a specification for these materials has been made. It is suggested that such a specification should be negotiated between supplier and end user.

## 6. Apparatus

6.1 *Dye Penetrant*[3]

6.2 *Ultraviolet Light Source*—The penetrant used is fluorescent, and requires a black lamp light source.

6.3 *Dark Room*—An area for viewing the presence of fluorescent spots on the test specimens is required.

6.4 *Hood*—There is a need to provide adequate air ventilation for the elimination of any annoying vapors from the penetrant. These vapors are nontoxic, but could be an irritant.

6.5 *Shallow Pan*, for holding the penetrant is required. A thin, spongy material that can be placed in the pan and upon which the specimens may rest is recommended.

6.6 *Stop Watch*, or other means for timing the length of the test is required.

6.7 *Magnifying Glass*, 5×, recommended for identifying very small fluorescent specks, or dots, on the specimen's upper face. It is not regarded as essential.

## 7. Materials

7.1 This test method was developed for use on solid pultruded rod stock reinforced with fiberglass. An evaluation employed 1 in. diameter rod stock using epoxy, vinyl ester and polyester resins. It is recognized that this test method will be used with other resin system and rod-stock sizes.

7.2 Use rod-stock representative of typical production lots and select random specimens for testing.

## 8. Sampling and Test Specimens

8.1 Take at least three test specimens for each sample.

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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, ~~Vol 08.01.~~ volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Zyglo Penetrex ZL 30A dye penetrant, manufactured by Magnafl ~~B~~ex, or equivalent, is suitable for this purpose. During the initial round-robin work, three standard penetrants of ~~ASTM Standards, Vol 08.02.~~ the industry were evaluated. The above referenced penetrant provided the most discriminating, rapid, and consistent results.

8.2 Specimens shall not be taken from material that has been damaged or subjected to previous testing.

8.3 Select at least three 1-in. [2.54 cm] length specimens taken at random locations along the rod stock to be tested. These should be cut dry with a diamond-dust blade to ensure a smooth test surface.

8.4 In order to prevent the problem of wicking up the sides of some composites, paint a ring of clear nail polish or other suitable inhibitor below the top surface and around the circumference of each test specimen.

## 9. Conditioning

9.1 Condition the test specimens at 23 ± 2°C ~~(~~ [73.4 ± 3.6°F~~)~~] and 50 ± 5 % relative humidity for not less than 40 h prior to test in accordance with Procedure A of Practice D 618.

9.2 *Test Conditions*—Conduct all testing in the Standard Laboratory Atmosphere of 23 ± 2°C ~~(~~ [73.4 ± 3.6°F~~)~~] and 50 ± 5 % relative humidity, unless otherwise specified.

## 10. Procedure

10.1 Preheat the ultraviolet light source for 15 min or in accordance with the manufacturer's recommendations. Position the light to shine on the pan (penetrant) surface.

10.2 Place a thin, spongy material such as common household plastic foam sponge on the bottom of the pan to support the specimens. This material aids in properly wetting the bottom surface of the specimen and reduces possible problems associated with air entrapment.

10.3 Add sufficient dye to the pan such that the specimens will be immersed to a depth of ⅛ in. [0.32 cm] while resting on the sponge. This depth should be predetermined with an extra piece of rod stock. ~~NOTE 3—~~**~~Caution:~~**

10.4 **Warning—**Avoid hand contact with the penetrant to preclude possible contamination of the specimens during handling. Wash hands thoroughly before proceeding, should contact with the penetrant occur.

~~10.4 Place~~

Place each specimen on end in the penetrant to the depth specified in 10.3 and staggered from the rest of the group. The actual time of immersion for each shall be recorded if more than six specimens are to be tested at one time. Otherwise, all specimens shall be considered to be immersed at the same time. When more than six specimens are tested, an interval of 30 s between the respective immersions shall be observed. For example, if a group of nine specimens were to be tested, one could be added at $T = 0$, the next at $T = 30$ s, and the last at $T = 4.0$ min.

10.5 Immerse each specimen such that its lower face is inserted into the dye normal to the supporting sponge to ensure optimum coating of its surface. Press down lightly on the upper face of the specimen to effect its positive sealing.

10.6 See ~~Note 3.~~ Warning in 10.4.

10.7 Position the specimens in the penetrant in a row left to right such that the first, second, etc. can be easily identified.

10.8 Count upper face wicking dots (fluorescent specks) following 30 min of penetrant immersion. For a large group of specimens, the counting must be completed between 29 min, 45 s and 30 min, 15 s for each specimen.

10.8.1 The immersion time of 30 min for all specimens is particularly critical and must be observed within the limits specified under 10.8 if meaningful data are to be obtained. In fact, the time at which the extent of wicking is determined has been found to be the greatest single source of error in interlaboratory comparisons of wicking data.

10.9 If an error is made, or if a specimen falls into the penetrant, reject that specimen and run a retest from retained stock.

10.10 Test at least three specimens per sample.

10.11 Record the total number of wicking dots, or specks, for each specimen after 30-min immersion, discounting those that have merged as one. Should the latter condition exist, discontinue the test for that particular specimen and test another.

## 11. Report

11.1 Report the following information:

11.1.1 Complete identification of the material tested, including resin type, machine identification, dimensions, reinforcement type, manufacturer's code, etc.,

11.1.2 Conditioning procedure used, if different than stipulated,

11.1.3 Test room conditions,

11.1.4 Individual specimens tested, with individual wicking data,

11.1.5 The average of the individual wicking data for each sample,

11.1.6 Date of test, and

11.1.7 Any deviations from the test method shall be included, such as alternate penetrant source, etc.

## 12. Precision

12.1 *Repeatability*—The critical difference ~~within which two averages~~ table below was obtained on the same material by a single operator using the same ~~instrument, can be expected to lie 95 %~~ instrument. Two averages of ~~the time because of random variation~~ wicking data taken within a ~~laboratory. The following criteria were established~~ single laboratory for a 1- in. [2.54 cm] diameter fiberglass reinforced solid rod stock can be considered significantly different at 95 % confidence if the values differ by more than those listed in the ~~resins indicated:~~ following table.

**TABLE Number of Wicking Dots**

| | Polyester | Epoxy | Vinyl Ester |
|---|---|---|---|
| Repeatability | 7.85 | 4.17 | 13.5 |

~~If the results in average wicking data on a given sample tested in the same laboratory differ by more than the above indicated values, the averages can be considered significantly different.~~

12.2 *Reproducibility*— The critical difference ~~within which two averages,~~ table shown below represents data obtained by two different operators using different instruments in different ~~laboratories, can be expected to lie 95 % of the time because of random variation within and between~~ laboratories. ~~The following criteria were established~~ Two averages of wicking data taken in different laboratories for ~~one-inch~~ a 1 in. [2.54 cm] diameter fiberglass reinforced solid rod stock can be considered significantly different at 95 % confidence if the values differ by more than those listed in the ~~resin indicated:~~ following table.

**TABLE Number of Wicking Dots**

| | Polyester | Epoxy | Vinyl Ester |
|---|---|---|---|
| Reproducibility | 9.41 | 4.17 | 14.6 |

~~If the results in average wicking data on a given sample tested in different laboratories differ by more than the indicated values, the averages can be considered significantly different.~~

12.3 The above precision data were generated as the result of an industry round-robin in which seven laboratories participated, using rod stock from a single supplier's standard inventory.

## 13. Keywords

13.1 dye penetration test; pultruded rod; rod stock; wicking

## 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.

*D 5117 - 03:*
(*1*) Editorial revisions to correct typographical errors.
(*2*) Editorial revisions to comply with ASTM directives on SI unit usage.
(*3*) Editorial revisions to the wording of the Precision and Bias statement.