Designation: D4317 – 16

Standard Specification for Polyvinyl Acetate-Based Emulsion Adhesives[1]

This standard is issued under the fixed designation D4317; 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.

INTRODUCTION

This specification is a replacement for Federal Specification MMM-A-180C, Class B, August 6, 1979, Adhesive, Vinyl Acetate Resin Emulsion, which superseded MMM-A-193C, October 26, 1967. It has been expanded to include the more water-resistant polyvinyl acetate-based adhesives now on the market, in addition to the less water-resistant ones formerly covered by the Federal Specification.

1. Scope*

1.1 This specification covers polyvinyl acetate or polyvinyl acetate copolymer resin emulsion adhesives suitable for use on wood, wood-based substrates, or plastic laminates. It does not cover the group of polyvinyl-based adhesives which are suitable for bonding flexible films.

1.2 The adhesives are classified at three performance levels in accordance with water-resistance as shown in Table 1 and Table 2. See Section 5 for a description of the expected exposure conditions for each class of adhesive. See Table X1.1 for a classification of typical end products that are manufactured using adhesives at the three performance levels covered by this specification.

1.3 The following index is provided as a guide to the test methods portion of this specification:

	Section
Tests for Physical Properties	9
Viscosity	9.1.1
Density	9.1.2
Nonvolatiles	9.1.3
pH	9.1.4
Tests for Adhesive Bond	10
Block Shear Strength, Compression	10.2
Plywood Shear Tests	10.3

1.4 The values stated in SI units are to be regarded as the standard. The values given in parenthesis are for information purposes only.

1.5 The following safety hazards caveat pertains only to the test method portion, Sections 9 and 10, of this specification: *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.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D905 Test Method for Strength Properties of Adhesive Bonds in Shear by Compression Loading

D906 Test Method for Strength Properties of Adhesives in Plywood Type Construction in Shear by Tension Loading

D907 Terminology of Adhesives

D1084 Test Methods for Viscosity of Adhesives

D1490 Test Method for Nonvolatile Content of Urea-Formaldehyde Resin Solutions

D1875 Test Method for Density of Adhesives in Fluid Form

D2556 Test Method for Apparent Viscosity of Adhesives Having Shear-Rate-Dependent Flow Properties Using Rotational Viscometry

E4 Practices for Force Verification of Testing Machines

E70 Test Method for pH of Aqueous Solutions With the Glass Electrode

E1953 Practice for Description of Thermal Analysis and Rheology Apparatus

[1] This specification is under the jurisdiction of ASTM Committee D14 on Adhesives and is the direct responsibility of Subcommittee D14.30 on Wood Adhesives.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@.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**

TABLE 1 Test Requirements

Test	Section Number	Test Requirement, min, psi (kPa)	Required Tests		
			Type 1	Type 2	Type 3
Block shear (compression) dry at 75°F (24°C)	10.2	2800 (19 306)	X	X	X
Plywood (tension):					
dry at 75°F (24°C)	10.3.3.1	400 (2758)	X	X	X
dry at 160°F (71.1°C)	10.3.3.2 or 10.3.3.3	250[A] (1724)	X	X	X
Two-cycle boil	10.3.3.4	see Table 2	X		
48-h soak	10.3.3.5	250 (1724)	X	X	
Humidity exposure	10.3.3.6	250[A] (1724)			X
Freeze-thaw stability	10.3.3.7	[B]	optional[B]	optional[B]	optional[B]
Storage life	10.3.3.8	[C]	X[C]	X[C]	X[C]

[A] Or 40 % of dry value at 75°F (24°C), whichever is larger.
[B] Testing and certification for freeze-thaw stability is optional. To classify a test adhesive as freeze-thaw stable, test an initial lot of the adhesive brand in accordance with 6.2 and 10.3.3.7.
[C] Testing of an initial lot of the adhesive brand in accordance with 6.3 and 10.3.3.8 is required.

TABLE 2 Test Requirements (*Continued*)

Average Failing Load, psi (kPa)[A]	Type I Test Requirement Two-Cycle Boil (10.3.3.4) (Minimum Wood Failure, %)	
	Average of All Specimens	Individual Specimen
Under 250 (1724)	50	25
250 to 350 (1724 to 2413)	30	10
Above 350 (2143)	15	10

[A] See Table 9 in Interim Voluntary Product Standard for Hardwood and Decorative Plywood, HP-1, 1993.

2.2 *Federal Standards:*
Fed. Std. No. 123 Marking for Shipment (Civil Agencies)[3]
PPP-C-96 Cans, Metal, 28-Gauge and Lighter[3]
PPP-D-723 Drums, Fiber[3]
PPP-D-729 Drums, Shipping and Storage, Steel, 55 gal (208 L)[3]

2.3 *Military Standard:*
MIL-STD-129 Marking for Shipment and Storage[3]

3. Terminology

3.1 *Definitions:*

3.1.1 Many terms in this specification are defined in Terminology D907.

3.1.2 *emulsion, n*—a two-phase liquid system in which small droplets of one liquid (the internal phase) are immiscible in, and are dispersed uniformly throughout, a second continuous liquid phase (the external phase).

3.1.2.1 *Discussion*—The *internal phase* is sometimes described as the *disperse phase*.

3.1.3 *latex, n*—a stable dispersion of polymeric substance in an essentially aqueous medium.

3.1.4 *polyvinyl acetate emulsion adhesive, n*—a latex adhesive in which the polymeric portion comprises polyvinyl acetate, copolymers based mainly on polyvinyl acetate, or a mixture of these, and which may contain modifiers and secondary binders to provide specific properties.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *adhesive designation, n*—an adhesive that is manufactured by a unique combination of raw materials and process, that conforms to a given set of physical and performance properties, and is identified by a specific name, number, or alphanumeric designation.

3.2.2 *lot, n*—adhesive manufactured at one place from the same batch or blend of raw materials subjected to the same operation and conditions.

3.2.3 *assembly, n*—See *adhesive assembly* in Terminology D907.

NOTE 1—In this specification, the maple block lamination in Test Method D905 and the birch plywood construction in Test Method D906 are described as assemblies.

4. Significance and Use

4.1 This specification addresses the need for a set of testing procedures that demonstrates the difference in physical properties and in adhesive bonding properties among the many available polyvinyl acetate-based adhesives. Because of the diverse nature of the end products bonded with these adhesives, testing in compliance with this specification can only evaluate the adhesive tested under a given set of conditions. The physical properties of the adhesive are tested and included in the report in order to give information on certain handling and working properties. The adhesive bonding properties are measured by tests performed on maple block specimens and birch plywood specimens, prepared and tested in accordance with Test Methods D905 and D906, respectively. The test requirements are based on knowledge within the industry of values which may be expected. Test Methods D905 and D906 have a long history of use as a basis for many specifications.

4.2 This specification does not describe the end-use products for which each class of adhesive is acceptable, but it does describe the general exposure conditions for which each class will perform in a satisfactory manner. See Appendix X1.

5. Classification of Adhesive Performance

5.1 For purposes of this specification, adhesives are classified on the basis of water resistance at three performance levels, wet-use, intermediate use, and dry-use:

5.1.1 *Type 1, Wet Use*—An adhesive passing Type 1 test requirements as given in Table 1 and Table 2, and having

[3] Available from DLA Document Services, Building 4/D, 700 Robbins Ave., Philadelphia, PA 19111-5094, http://quicksearch.dla.mil.

high-water resistance, capable of producing sufficient adhesive-joint strength and durability to make the bonded product serviceable under conditions in which the equilibrium moisture content (EMC) of the wood may be 16 % to a maximum of 21 % for short periods of time, and where the temperature may reach levels as high as 71°C (160°F) (at times) during service. This adhesive will withstand most outdoor conditions, such as repeated soakings. It is not, however, suitable for marine conditions where immersion would be continual. As tested in this specification, a Type 1 adhesive is water-resistant, but not necessarily waterproof.

5.1.2 *Type 2, Intermediate Use*—An adhesive passing Type 2 test requirements as given in Table 1, and having good water-resistance, capable of producing sufficient adhesive-joint strength and durability to make the bonded products serviceable under interior or protected conditions in which there will be occasional intermittent exposure to wet conditions or high humidity and where the temperature may reach levels as high as 71°C (160°F) (at times) during service.

5.1.3 *Type 3, Dry Use*—An adhesive passing Type 3 test requirements as given in Table 1, and capable of producing sufficient adhesive-joint strength and durability to make the bonded lumber product serviceable under normal interior service conditions where the relative humidity is not high and does not fluctuate between wide limits, and where the temperature may reach levels as high as 71.1°C (160°F).

6. Test Requirements

6.1 To meet the requirements of this specification, subject the test adhesive to the tests in Section 9, and make the results of these tests a part of the report. In addition, the adhesive is to meet the requirements of the tests described in Section 10 and listed in Table 1 and Table 2, for the adhesive classification for which it is to be certified.

6.2 Testing for freeze-thaw stability is optional. In order to certify that an adhesive brand meets the requirements for freeze-thaw stability, test an initial lot in accordance with 10.3.3.7. All test requirements shall be passed for the applicable adhesive classification. Following this initial test, certification for this requirement may be based on submission of the manufacturer's certification.

6.3 To meet the storage life requirements, test an initial lot of the adhesive brand in accordance with 10.3.3.8. All test requirements shall be passed for the applicable adhesive classification. Following this initial test, certification for this requirement may be based on submission of the manufacturer's certification.

7. Retest and Rejection

7.1 When a specimen fails at a load less than that specified, the failure taking place 50 % or more in the wood, disregard that specimen in computing the average. If more than one third of the test specimens for any one test condition are discarded for this reason, repeat the test.

7.2 If the results of any initial test do not conform to the requirements prescribed in this specification, repeat that test on an additional set of specimens made from the same lot of adhesive, each of which conforms to the requirements specified. If this set of specimens fails to meet the requirements, reject the lot.

8. Sampling

8.1 Take a 2-L (2-qt) sample of adhesive that is representative of the lot to be tested. Place 1 L qt of the adhesive in a wide-mouth, glass, 1-L (1-qt) container and seal tightly. Use for all tests with the exception of freeze-thaw stability (10.3.3.7), and storage life (10.3.3.8). For the initial test only, to provide samples for testing these two properties, divide the second quart 1-L (1-qt) equally and use half for freeze-thaw stability and half for storage life. See 10.3.3.7 and 10.3.3.8 for instructions.

9. Tests for Physical Properties

9.1 Test the properties of the adhesives by the following methods and report the values.

9.1.1 *Viscosity:*

9.1.1.1 Bring the adhesive sample to 25 ± 0.5°C (77 ± 1°F) and hold at this temperature during the viscosity reading. Test in accordance with Test Methods D1084, Method B, except for (*1*) temperature requirement, and (*2*) addition of concentric cylinder rotational viscometers (see section 5.6 of Practice E1953) with torque constants of 60 to 80 µN-m, 8 rotational speeds between 0.5 and 60 r/min stable to within 1 %, and a right circular cylinder spindle to the list of acceptable viscometers in 6.1 of Test Methods D1084.

9.1.1.2 For adhesives requiring the addition of a catalyst, take two viscosity measurements of the test adhesive (*1*) *before* the addition of the catalyst, and (*2*) *after* the addition of the catalyst. Test in accordance with 9.1.1.1.

NOTE 2—Other temperatures may be used upon agreement between the contracting parties, but the ±0.5°C (±1°F) tolerance must be observed.

NOTE 3—Upon agreement between the contracting parties viscosity may be tested and reported in accordance with Test Method D2556, using the concentric cylinder rotational viscometer specified in Test Methods D1084, Method B.

9.1.2 *Density*—Measure the density of the adhesive in accordance with Test Method D1875 and report as weight per gallon in pounds.

9.1.3 *Nonvolatiles*—Determine the nonvolatile content of the adhesive in accordance with Test Method D1490.

9.1.3.1 For adhesives requiring the addition of a catalyst, measure the nonvolatiles of the adhesive without catalyst.

NOTE 4—Test Method D1490 covers the determination of the nonvolatile content of urea-formaldehyde resin; however, the procedure given is applicable to polyvinyl acetate adhesives.

9.1.4 *pH*—Bring the adhesive to 25 ± 0.5°C (77 ± 1°F) and determine the pH in accordance with Test Method E70.

10. Tests for Adhesive Bond

10.1 For all tests, select equipment that complies with Practices E4.

10.2 *Block Shear Strength (Compression):*

10.2.1 Prepare the test specimens in accordance with Test Method D905, using the adhesive manufacturer's instructions for conditions and procedures for preparing the adhesive,

applying it to the stock, and for assembling, pressing, and curing the joint. Use a two-week curing period unless otherwise instructed by the adhesive manufacturer.

10.2.2 *Number of Test Specimens*—Test 20 test specimens representing at least four joints.

10.2.3 *Cured (Dry) Test*—Following the prescribed conditioning period for the assembly being tested, bring one test group of 20 test specimens to 8 ± 1 % moisture content (MC) and test in accordance with Test Method D905. Apply the load through a self-aligning seat to ensure uniform lateral distribution of the load, except apply the load with a continuous motion of the movable loading head at a rate of 12.7 mm (0.5 in.)/min (±10 %).

10.2.4 *Calculation*—Calculate the shear stress at failure in kilopascals (kPa) or pounds per square inch (psi), based on the test specimen's breaking load and tested bond-line area, measured to the nearest 6.5 mm^2 (0.01 $in.^2$).

10.3 *Plywood Shear Tests:*

10.3.1 Prepare the test specimens in accordance with Test Method D906, using the adhesive manufacturer's instructions for conditions and procedures for preparing the adhesive, applying it to the stock, and for assembling, pressing, and conditioning the panel. Use a two-week conditioning period unless otherwise instructed by the adhesive manufacturer.

10.3.2 *Number of Test Specimens*—See Table 3.

10.3.3 *Exposure Conditions and Treatments:*

10.3.3.1 *Dry Shear at 24°C (75°F)*—Following the prescribed curing period and cutting the test specimens, bring one test group (16 specimens for Type 1 and 15 specimens for Type 2 or Type 3), described in part in 10.3.2, to 8 ± 1 % MC and 24 ± 1°C (75 ± 2°F) and test in accordance with Test Method D906.

10.3.3.2 *Dry Shear at 71°C (160°F) Method 1*—Following the prescribed curing period and cutting the test specimens, place one test group (16 specimens for Type 1 and 15 specimens for Type 2 or 3), described in part in 10.3.2, in an oven at 71 ± 3°C (160 ± 5°F) and hold for 6 h. Remove specimens and immediately wrap individually in two layers of PVDC wrap (see Note 5) or its equivalent. Place wrapped test specimens in a single layer in an oven at 77 ± 1°C (170 ± 1.8°F) and hold for 12 to 20 min. Remove from the oven, one specimen at a time, and test within 30 s without removing the PVDC wrap, in a room with an ambient temperature of 24 ± 1°C (75 ± 2°F).

NOTE 5—PVDC (polyvinylidene chloride) wrap is the generic designation for the tightly adhering flexible films commonly used for covering food containers in the home.

NOTE 6—The exposure of the specimens for 6 h at 71 ± 30°C, unwrapped, is to dry the specimens. The use of PVDC wrap is to slow the cooling rate while testing. The temperature of the specimen 30 s after removal from the oven will be approximately 71°C.

TABLE 3 Plywood Shear Tests—Number of Test Specimens

	Type 1	Type 2	Type 3
Number of panels	8	6	6
Number of specimens/panel	10	10	10
Total number of specimens	80	60	60
Number of specimens/group[A]	16	15	15
Group/performance level[A]	5	4	4

[A] This provides for a reserve group of specimens in the event that a test must be repeated.

10.3.3.3 *Dry Shear at 71°C (160°F), Method 2*—Following the prescribed curing period and cutting the test specimens, place one test group as described in 10.3.3.2 in an oven at 71 ± 3°C (160 ± 5°F) and hold for 6 h. Then remove them one at a time and test immediately in a temperature-controlled chamber at 160°F.

10.3.3.4 *Two-Cycle Boil*—Following the prescribed curing period and cutting the test specimens, take one test group of 16 specimens, described in part in 10.3.3.2. Immerse in boiling water for 4 h. Then dry for 20 h at 62.8 ± 2.8°C (145± 5°F) with sufficient air circulation to lower the moisture content to within the range from 8 to 10 %. Immerse the specimens again in boiling water for 4 h, then remove and cool in running water at 18.3 to 26.7°C (65 to 80°F) for 1 h. Remove test specimens from the vessel and place in a plastic bag to keep them wet. Test within 1 h. In the event that 1 h is not sufficient time for testing 16 specimens, divide the specimens into smaller groups scheduling the time the exposure cycle is completed. Report individual and average test values. Dry the broken specimens to less than 8 % moisture content and note the percentage of wood failure.

10.3.3.5 *48-Hour Soak*—Following the prescribed curing period and cutting the test specimens, take one test group (16 specimens for Type 1 and 15 specimens for Type 2), described in part in 10.3.2. Immerse in water at 24 ± 1°C (75± 2°F) and soak for 48 h ± 15 min. Remove from water and test immediately in accordance with Test Method D906, conducting the test in the wet state. Report individual and average test values. Dry the broken specimens to less than 8 % MC and note the percentage of wood failure.

10.3.3.6 *Humidity Exposure*—Following the prescribed curing period and cutting the test specimens, place one test group of 15 specimens (described in part in 10.3.2.3) in a chamber maintained at 24 ± 1°C (75 ± 2°F) and 90 ± 2 % relative humidity. Place the test specimens in a single layer on a rack, not touching each other. Following an exposure period of 1 week, remove the specimens individually and test immediately at 24 ± 1°C (75 ± 2°F) in accordance with Test Method D906, taking precautions to avoid any appreciable change in moisture content during the test. Report individual and average test values along with the percentage of wood failure.

10.3.3.7 *Freeze-Thaw Stability*—Fill a 1-pt jar to a level approximately 90 % of capacity, with the test adhesive described in Section 6 and seal tightly. Store this sample at a temperature of −18 ± 2°C (0 ± 3.6°F), for 18 h. Remove from freezer and restore the sample to a temperature of 24 ± 1°C (75 ± 2°F), without stirring. This constitutes one freeze-thaw cycle. Then subject the sample to two additional cycles. Following these freeze-thaw cycles, test the thawed sample for the requirements of the applicable adhesive type, as listed in Table 1 and Table 2. Report the number of cycles run.

NOTE 7—Upon agreement between contracting parties, additional cycles may be run before the adhesive is tested.

10.3.3.8 *Storage Life*—Fill a 0.5-L jar with the test adhesive described in Section 8 and seal tightly. Store this sample at 24 ± 1°C (75 ± 2°F). Following the period of time given by the

manufacturer as the storage life of the test adhesive, test the storage sample for the requirements as listed in Table 1 and Table 2 for the applicable adhesive type. Specify in the report the length of the storage period.

11. Reporting

11.1 Report the values obtained for the tests for physical properties (Section 9).

11.2 For the adhesive bond tests (Section 10) report the individual and average test values and the estimated percentages of wood failure for the specimens for all tests.

11.3 As a part of the report, include:

11.3.1 Number of freeze-thaw cycles passed,

11.3.2 Manufacturer's recommended allowable storage period, and

11.3.3 Mix-ratio used, if the adhesive is a two-or-more component system.

12. Supplemental Government Requirements

12.1 *Packaging and Packing:*

12.1.1 *Preparation for Delivery*—Packaging and packing shall be Level A, B, or commercial as specified.

12.1.2 Unless otherwise specified, when Level A or B is specified, packaging and packing shall be in accordance with the following criteria:

12.1.2.1 Metal containers conforming to PPP-C-96, Type V, Class 2 for quantities of 22.7 kg (50 lb) max,

12.1.2.2 Fiber drums conforming to PPP-D-723, Type II, Grade A or Type III, Grade A for Level A or fiber drums conforming to PPP-D-723, Type I, Grade A for Level B for quantities of 90.9 kg (200 lb) max, and

12.1.2.3 Metal drums conforming to PPP-D-729, Type II or Type IV for quantities of 181.8 kg (400 lb) max.

12.2 *Containers:*

12.2.1 Containers shall be uniform in shape and size, with the necessary protection required. Containers shall contain quantities in accordance with the applicable container specification. All fiber drums shall be furnished with a 0.1-mm (0.004-in.) thick polyethylene liner, properly heat sealed.

12.2.2 Drums, as specified in PPP-D-723 or PPP-D-729 will require no overpacking.

12.3 *Shipment and Delivery*—Unless otherwise specified, when Level C is specified, the adhesive, 113 gm to 136 kg (4 oz to 300 lb), shall be packaged in containers to offer adequate protection against corrosion, deterioration, and damage during shipment, handling, and storage and shall be packed to ensure safe delivery to its destination when properly transported by any common carrier in conformance to requirements by Uniform Freight Classification or National Motor Freight Classification.

12.4 *Marking:*

12.4.1 Marking shall be as specified in the contract or purchase order. Interior packages and shipping containers shall be marked in accordance with Fed Std. No. 123 for civil agencies or in accordance with MIL-STD-129 for military agencies.

12.4.2 Special markings when specified, in contracts, purchase orders, or by the contracting officer shall include the following:

12.4.2.1 Manufacturer's name, product code designation and batch or lot number, and the national stock number,

12.4.2.2 Date of manufacture of product and expiration date,

12.4.2.3 Special handling instructions during product transfer, and

12.4.2.4 Special precautions related to toxicity, flammability, or to any information pertinent to the proper handling and storage of the product, for example, manufacturer's storage temperature range.

NOTE 8—The supplemental government requirements in Section 12 were supplied to Committee D14 by the government as part of the original specification approved in 1988. The initial wording has not been edited.

13. Packing and Marking Requirements for Nongovernmental Users

13.1 The following sections shall apply to nongovernmental users of this specification, subject to the given exceptions: 12.4.1 (except for reference to Level C), 12.4.2 (whether or not specified), 12.4.2.1 (except for the national stock number), 12.4.2.2, 12.4.2.3, and 12.4.2.4.

14. Precision and Bias

14.1 A precision and bias statement does not exist for this test method because resources necessary for round-robin testing have not been forthcoming.

15. Keywords

15.1 emulsion; polyvinyl acetate

APPENDIX

(Nonmandatory Information)

X1. TYPICAL APPLICATIONS AND END PRODUCTS

X1.1 Table X1.1 provides information on typical applications and end products for three performance levels of polyvinyl acetate adhesives covered in this specification.

TABLE X1.1 Typical Applications and End Products of PVA Adhesives[A]

Typical Applications	Type 1	Type 2	Type 3
Dowelling	arch doors exterior furniture	bathroom and kitchen applications	chairs
Edge gluing	exterior signs	butcher blocks	furniture parts
Finger joints	window and door frames molding stud grade lumber	protected molding furniture frames for bathroom and kitchen	interior molding stiles and rails interior furniture
High-pressure laminate	counter tops boat cabins sauna doors	doors and counter tops for bathroom and kitchen	table tops
Laminates	exterior furniture butcher blocks sport equipment	bowls butcher blocks	interior furniture
Panel-to-frame	garage doors exterior doors architectural doors	interior doors for bathroom and kitchen	furniture wall panelling
Plywood veneering	exterior signs exterior furniture	furniture for protected use	wall partitions

[A] Bye, Carolyn, ASTM D-14 Adhesives Report, *"Polyvinyl Acetate Adhesive Specification Revised," Adhesives Age*, August 1984. Communications Channels, Inc., Robin Sherman, ed.

SUMMARY OF CHANGES

Committee D14 has identified the location of selected changes to this standard since the last issue (D4317–98(2011)) that may impact the use of this standard. (Approved May 1, 2016.)

(1) Section 9.1.1 — addition of a technically equivalent apparatus described.