



Designation: D4317 – 16 (Reapproved 2023)

Standard Specification for Polyvinyl Acetate-Based Emulsion Adhesives¹

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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for Federal Specification MMM-A-180C, Class B, August 6, 1979, Adhesive, Vinyl Acetate Resin Emulsion, which superseded MMM-A-193C, October 26, 1967.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
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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*

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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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.

1.6 *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

- 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 Calibration and 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

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.

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 (2413)	15	10

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

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:

2.2 Federal Standards:

Fed. Std. No. 123 Marking for Shipment (Civil Agencies)³

PPP-C-96 Cans, Metal, 28-Gauge and Lighter³

PPP-D-723 Drums, Fiber³

PPP-D-729 Drums, Shipping and Storage, Steel, 55 gal (208 L)³

2.3 Military Standard:

MIL-STD-129 Marking for Shipment and Storage³

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

5.1.1 *Type 1, Wet Use*—An adhesive passing Type 1 test requirements as given in [Table 1](#) and [Table 2](#), and having 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 (1 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 °C ± 0.5 °C (77 °F ± 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 5.6 of Practice [E1953](#)) with torque constants of 60 μN·m to 80 μN·m, 8 rotational speeds between 0.5 r/min 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 °C ± 0.5 °C (77 °F ± 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 mm² (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 °C ± 1 °C (75 °F ± 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 °C ± 3 °C (160 °F ± 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 °C ± 1 °C (170 °F ± 1.8 °F) and hold for 12 min 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 °C ± 1 °C (75 °F ± 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 °C ± 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.

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 °C ± 3 °C (160 °F ± 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 °C ± 2.8 °C (145 °F ± 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 °C to 26.7 °C (65 °F 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 °C ± 1 °C (75 °F ± 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 °C ± 1 °C (75 °F ± 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 °C ± 1 °C (75 °F ± 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 °C ± 2 °C (0 °F ± 3.6 °F), for 18 h. Remove from freezer and restore the sample to a temperature of 24 °C ± 1 °C (75 °F ± 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.

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.