



Designation: **F904 – 98 (Reapproved 2008) F904 – 16**

Standard Test Method for Comparison of Bond Strength or Ply Adhesion of Similar Laminates Made from Flexible Materials¹

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INTRODUCTION

It has been widely discussed in the literature that bond strength of flexible multi-ply materials is impossible to measure with current technology. The above is recognized and accepted, since all known methods of measurement include the force required to bend the separated layers, in addition to that required to separate them. However, useful information can be obtained when one realizes that the bending force is included and that direct comparisons between different materials, or even between the same materials of different thicknesses, cannot be made. Also, conditioning that affects the softness or moduli of the plies will be reflected in the bond strength measurement.

1. Scope

1.1 This test method covers a procedure for comparing the bond strength or ply adhesion of similar laminates made from flexible materials such as cellulose, paper, plastic film, and foil. This includes laminates made by various processes: adhesive laminates, extrusion coatings, extrusion laminates, and coextrusion.

1.2 Because of the impact of the bending force, direct comparisons between different materials or even between the same materials of different thickness cannot be made.

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

1.4 *This standard does not purport to address all of the safety problems, 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.* Specific precautionary statements are given in 7.1.1.

2. Referenced Documents

2.1 *ASTM Standards:*²

D882 Test Method for Tensile Properties of Thin Plastic Sheeting

D1898 Practice for Sampling of Plastics (Withdrawn 1998)³

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

3. Terminology

3.1 *Definitions:*

3.1.1 *adhesive failure*—failure at the interface of two adjacent layers.

3.1.2 *cohesive failure*—failure within one of the two adjacent layers comprising the bonded area under test.

3.1.3 *bond strength*—amount of force or energy required to separate plies of material or materials plus the force to bend the plies.

¹ This test method is under the jurisdiction of ASTM Committee F02 on Flexible Barrier Packaging and is the direct responsibility of Subcommittee F02.20 on Physical Properties.

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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.

³ The last approved version of this historical standard is referenced on www.astm.org.

3.1.4 *necking*—localized reduction in cross section which may occur in a material under tensile stress.

3.1.5 *web*—refers to roll stock after it has been unwound from the roll.

4. Summary of Test Method

4.1 Ply separation is initially started mechanically by the application of heat or by using a solvent. The separated plies of the test specimen are placed into the grips of a tensile testing machine. The grips are then separated and the force required to further separate the plies is defined as bond strength. Alternatively, the energy may be used.

NOTE 1—The force to bend the separated plies is included.

5. Significance and Use

5.1 Laminates are made by bonding together two or more layers of material or materials. Their performance is often dependent on the ability of the laminate to function as a single unit. If the plies have not been properly bonded together, the performance may be adversely affected. Laminates may maintain adequate bond strength under standard test conditions, but under conditions of use may exhibit an increase or decrease in bond strength. Applying heat, such as in boilable pouch applications, may adversely affect bond strength, as may cold temperatures, such as those encountered in freezer storage of foods. Fats and oils may also influence bond strength as well as the softness or moduli of the plies. This test method can be used to compare bond strength of similar materials and to study changes under these and other conditions of end use, providing caution is used with respect to the effects of the included force to bend the separated plies.

6. Apparatus

6.1 *Grips*—A gripping system that minimizes both slippage and uneven stress distribution is required. Grips lined with thin rubber, crocus cloth or pressure sensitive tape, as well as file-faced or serrated grips have been successfully used for many materials. Air-actuated grips have been found advantageous, particularly in the case of materials that tend to “neck” in the grips, since pressure is maintained at all times.

6.2 *Testing Machine*—A tensile testing machine conforming to the requirements for Method A of Test Method D882.

6.3 *Specimen Cutter*—In accordance with Test Method D882.

7. Reagents and Materials

7.1 *Solvents*—Toluene, ethyl acetate, MEK (2-Butanone) THF (tetrahydrofuran) or other suitable solvent to weaken the bond between layers sufficiently so that delamination may be started.

7.1.1 **Warning**—Use of these solvents requires that appropriate safeguards be used to avoid hazards of skin contact, inhalation, and flammability.

8. Sampling, Test Specimens, and Test Units

8.1 Sampling must be performed in a manner that will provide the desired information. No single procedure can be given for all situations. Therefore, Practice D1898 should be used as a guide in planning sampling procedures.

8.2 *Test Specimens*—Cut strips exactly 25.4 mm (1.0 in.) wide and about 250 mm (10 in.) 1.0 in. (25 mm.) wide \pm 5% and about 10 in. (250 mm) long. It is important that the test specimens are cut with clean, uniform edges so as not to affect the test results.

8.3 *Test Unit*—Test five specimens in the longitudinal (machine) direction. It may be desirable to test specimens in the transverse (cross-machine) direction for special purposes.

9. Preparation of Apparatus and Calibration

9.1 Equip the tensile testing machine according to manufacturer’s instructions for tensile testing thin films.

9.2 Set full-scale load so that most test specimen scans fall in the center two thirds of the chart, and draw speed at 28.0 cm/min \pm 10% (10 or 12 in./min are included). A few trial runs may be required. Other draw speeds may be used if it can be shown that they yield the same results as those specified.

10. Conditioning

10.1 *Specimen Conditioning:*

10.1.1 Store specimens at $23 \pm 2^\circ\text{C}$ ($73.4 \pm 3.6^\circ\text{F}$) and $50 \pm 5\%$ relative humidity for not less than 40 h.

10.2 *End-Use Specimen Conditioning :*

10.2.1 Store specimens at the specific end-use temperature and humidity for not less than 40 h.

10.2.2 Accelerated testing conditions for “wet” materials packaging may be accomplished by placing the test specimens between paper towels saturated with distilled water, sealing in a moisture proof pouch and storing at $23 \pm 2^\circ\text{C}$ ($73.4 \pm 3.6^\circ\text{F}$) for 40 h.