Determination of thermoplastic coating adhesion to non-porous substrates

1. Scope

This method provides a procedure for determining the comparative peeling or stripping characteristics of thermoplastic coatings extruded to low-stiffness non-porous substrates. The test procedure specifies size of specimens and defines conditions of pretreatment for measurement of resistance to 90° angle “T” peel at a separation speed of 254 mm (10 in.) per minute.

2. Significance

2.1 Good adhesion is a prime consideration in extrusion coating. A coating which does not adhere to a substrate generally has no commercial value. This method is used to obtain comparative data of stripping strengths of extruded thermoplastic coatings from non-porous substrates such as cellophane, aluminum foil, etc.

2.2 Stripping strength can be measured up to a point where the stripping strength is equal to the tensile strength of the coating or substrate. In some instances, the yield point for the coating or substrate will be lower than the yield point of the adhesion between the coating and substrate.

3. Definitions

3.1 **Peel or stripping strength:** The average load per unit width of bond required to separate one member from the other at the adhered interface at a separation angle of approximately 90° and at a separation rate of 254 mm (10 in.) per minute. It is expressed in newtons per 25.4 mm width, ounces per inch width, or grams per inch width.

3.2 **Flexible:** The property of the material which indicates a material of proper flexural strength and thickness to allow turnback at an approximate 90° angle in the expected loading range of the test without failure. In order to fulfill all terms of the definition, at least one of the adhered materials must be flexible.

4. Apparatus

4.1 **Constant-rate-of-elongation** tensile tester with adequate load range to handle all materials of this type, appropriate grips, and 254 mm (10 in.) per minute test speed.

4.1.1 If the tensile tester has a variable speed electronic drive, the speed shall be set properly using a ruler and stopwatch.

4.2 Precision 25.4 mm (1 in.) width razor blade cutter, die cutter, or equivalent to prepare 254 mm × 25.4 mm (10 in. × 1 in.) specimens.
5. Calibration

5.1 Ensure that the tensile tester is level.
5.2 Follow the manufacturer's instructions for zeroing and calibrating the tensile tester and setting it to the proper speed and load range to properly measure the anticipated load.

6. Sampling and specimen preparation

6.1 Obtain a sample in accordance with T 400 “Sampling and Accepting a Single Lot of Paper, Paperboard, Containerboard or Related Product.”
6.1.1 A sample is defined as being no less than machine width × 91-122 cm (3-4 ft) in the machine direction. Specimens are obtained by random marking and removal of areas such that ten areas of approximately 305 mm × 51 mm (12 in. × 2 in.), cut the long way in the machine direction, are obtained from five areas across the web and five areas along the web.
6.2 Using the specimen cutter, cut a 254 mm × 25.4 mm (10 in. × 1 in.) specimen from each test unit.

7. Conditioning

7.1 Normally, condition all adhesive containing specimens 40 hours by exposure to a relative humidity of 50% ± 5% at 23°C ± 2°C (73.4°F ± 3.6°F) to provide additional time for equilibration of adhesive containing interfaces. If no adhesive is used, condition specimens for 24 hours at 23°C, 50% RH.
7.2 The above conditioning step is pertinent only where adhesion from a primer evaluation or comparison of various adhesion promotion methods is needed. Obviously, as a production tool, the conditioning period is not practical. Therefore, where adhesion is measured in production, the specimens should be obtained from each roll and checked as soon as possible in a repeatable procedure appropriate to the operation. It is imperative that the operators use caution in selecting and preparing specimens as uniformly as possible.

8. Procedure

8.1 Initiate delamination by pulling the coating from the substrate or separating the plies of the lamination.
8.1.1 Sealing the two coated surfaces together at one end of a specimen and pulling the seal apart often produces a separation at the desired interface.
8.1.2 Immersion of one end of a specimen in dilute ammonia, dilute acetic acid, water, or other suitable solvent for about 2 minutes will often aid in initiating delamination. Immise only enough of the specimen to initiate a separation and avoid wicking into the area to be tested. Rinse the site with water to remove any of these agents, and dry. Allow the specimens to recondition per 7.1 prior to testing.
8.1.2.1 If any of the above solutions or solvents are used, use them in a well ventilated area of a fume hood. Ingestion of these materials by any means, olefactory or otherwise, must be avoided.
8.2 Conduct testing as soon as possible after removal of the test specimens from the conditioning atmosphere and preferably under the same environmental conditions.
8.3 To maintain a separation rate of 254 mm (10 in.) per minute, specimens must be relatively non-extensible in the expected loading range. Where a material is sufficiently extensible (i.e., stretch is greater than about 15%) to radically lessen the stripping rate, reinforce the extensible member with 25.4 mm (1 in.) width non-extensible tape. In reporting such a test, the backing material and method must be completely identified.
8.4 Cohesive or adhesive failure may be determined by observation. A cohesive failure is one which has occurred in the adhesive or specimen material itself. Adhesive failure refers to the lack of adherence between materials.
8.5 Separate the free ends of the test specimen (by hand) for a distance of approximately 51 mm (2 in.).
8.6 Place the specimen in the tester by clamping the free end of the substrate or non-extensible member, when appropriate, in the upper grip. Turn back the free end of the coating or extensible member and clamp it in the lower grip.
8.6.1 Align the free ends of the specimen symmetrically in the grips so the tension is distributed uniformly.
8.7 Start the tester and when the specimen is under tension, support the tail so there is a 90° angle between the tail and the direction of pull.
8.8 Adjust the load range as required so the readings are between 30% and 90% of the full load range.
8.9 Observe the stripping force over a separation distance of at least 100 mm (4 in.), then stop the tester and return the movable grip to its starting position. Remove the tested specimen.
8.10 Repeat steps 8.1 through 8.9 with remaining specimens.
8.11 Alternative: Instead of attaching the specimen as described in paragraph 8.6 and supporting it as in paragraph 8.7, replace the lower grip with a freely rotating wheel of at least 100 mm (4 in.) in diameter and at least 50 mm (2 in.) width. Attach the test specimen (substrate side down) to the wheel using two side pressure sensitive tape. Turn back the free end of the coating and clamp it in the upper grip so that the tension is distributed uniformly. Start the test and continue as in paragraph 8.8. This alternative should not be used on samples for which the coating adhesion strength is greater than the strength of adhesion between the substrate and the two side pressure sensitive tape.

8.11.1 This alternative procedure should not be interchanged indiscriminately and should be noted when used.

9. Calculations

9.1 Determine the peel or stripping strength for each specimen in newtons per 25.4 mm (or grams or oz. per 1 in.) width. For standard 25.4 mm (1 in.) width specimens, the strength value is equal to the recorded load. The average strength over the entire separation distance is the generally preferred value.

9.2 For each series of specimens, calculate the arithmetic average of all of the values obtained as the average for the sample.

10. Report

10.1 Report the following information:
10.1.1 Complete sample identification and date.
10.1.2 Individual test loads.
10.1.3 Average peel or stripping strength in newtons per 25.4 mm (or grams or oz. per 1 in.) width (Newtons/25.4 mm = 0.2780 × oz./in.).
10.1.4 Type of failure, whether adhesion, cohesion in the adhesive or in the material being bonded (substrate failure).
10.1.5 Any unusual characteristics. Include backing if required and conditioning cycle if other than standard.

11. Precision

11.1 Repeatability = 30% of mean for the measurement of 0.13 mm (0.005 in.) thick polyethylene laminated to 0.18 mm (0.007 in.) foil. The precision may vary dependent on the thickness of the flexible member. Repeatability has not been determined for other substrate combinations.
11.2 Reproducibility = not known.
11.3 Comparability = not known in accordance with the definitions set forth in T 1206 “Precision Statement for Test Methods.”

12. Additional information

12.1 Effective date of issue: May 13, 1993.
12.2 This method was formerly UM 541 “Adhesion to Non-Porous Flexible Substrates.”

References


Your comments and suggestions on this procedure are earnestly requested and should be sent to the TAPPI Technical Divisions Administrator.