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Standard Practice for Determining the Adhesion of Print Media Utilizing Mechanical Stress: Two Different Test Methods—Score/Tape and Cross Hatch[1]

This standard is issued under the fixed designation F2452; 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 practice describes procedures to obtain subjective, but comparative data for adhesion of print media used in printers, copies and other reprographic devices.

1.2 This method is applicable to constructions where the print media is subject to failure under mechanical stress from mostly peel conditions (that is, paper, film, cloth, and so forth).

1.3 *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]

F2226 Practice for Determining the Adhesion of Prints and Laminating Films

3. Terminology

3.1 *Definitions:*

3.1.1 *film and high sized paper substrate*—recording element having low water permeability. An internal or surface sizing of a porous paper substrate minimizes water absorption and improves internal bonds. In the adhesion test fibers do not tear off a paper substrate.

3.1.2 *porous paper substrate*—recording element having limited internal or surface sizing. This type of papers has weak internal bonds. It is common in the adhesion test that fibers tear off a porous substrate.

3.1.3 *print media*—recording elements used by printers to receive inks or toners. The substrate may be paper, plastic, canvas, fabric, or other ink-receptive material. The substrate may, or not, be coated with an ink receptive layer(s).

4. Significance and Use

4.1 Good adhesion is a prime consideration for print media. For coated papers failure can occur between the coating and the substrate or between coated layers, while for uncoated papers failure can occur between the imaged area and the substrate. This practice utilizing mechanical stress allows comparative studies of print media by examining adhesion in both printed and unprinted areas.

4.2 Factors in the office and outdoor environments, such as heat, cold, thermal shock, ultraviolet/visible radiation and water vapor can have a similar effect on adhesion as mechanical stress.

4.3 This practice is used to obtain comparative data of adhesion strength of print media.

5. Interferences

5.1 Since adhesion is dependent on temperature and humidity, it is important that the effects of mechanical stress be assessed under the conditions appropriate to the end use applications. While print media may be handled and displayed under a variety of conditions, this test practice is intended to measure adhesion in typical indoor environments.

5.2 Adhesion is dependent on temperature and should be tested at the manufacturers' recommended temperature for the best performance.

5.3 The adhesion of printed images is dependent on the printing mode, the type of color and the amount of applied ink.

5.4 The practice is intended to measure adhesion of print media without specifying above-mentioned parameters.

6. Materials

6.1 *Razor blade,* single edge or cutting board, pressure-sensitive tape (25 mm (1 in.) wide).

6.1.1 The adhesion strength of pressure-sensitive tape is dependent on lot number due to batch production process and storage time. The same manufacturing tape with identical lot

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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.

number should be used for testing conducted in different laboratories. The pressure-sensitive tape's adhesion varies depending on the coating and substrate. The adhesion strength of the tape should be agreed upon between the manufacturer of the tested coating and the end user.

6.2 *Test specimens,* at least three. They have to be printed with a test image if prints adhesion is evaluated.

7. Test Specimens

7.1 The print media method of printing, ink or toner lay down, and handling of printed specimens shall be consistent with their anticipated end use.

7.2 The test image can be any picture printed using print files containing the appropriate printer setup specific for each application.

7.3 The same test image and printer set up should be used for comparison purposes.

7.4 The recommended test image should consist of a standardized arrangement of color patches printed using print files containing the appropriate printer setup specific for each application. This test image should contain color patches at maximum print density of 100 % for each of the primary colors of cyan, magenta, yellow, and black, 200 % for the secondary colors of red, green, and blue, and 300 % for composite black.

7.5 The recommended color patches should be circular with minimum diameter of 125 mm (5 in.).

7.6 It is recommended that the samples be conditioned 24 h after printing. The actual testing time after printing should be presented in the report.

8. Conditioning

8.1 It is recommended that samples be conditioned at 23°C and 50 % RH for at least 24 h after coating or printing. Specimens should be visually inspected for surface irregularities that could adversely affect adhesion.

8.2 The above conditioning step is pertinent only where media evaluation or comparison is needed. Obviously, as a production tool, the conditioning period is not practical. Therefore, when media are coated 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 operators use caution in selecting and preparing specimens to maintain good uniformity.

9. Adhesion Tests

9.1 Tests should be carried out under temperature and humidity conditions similar to those of end-use applications.

9.2 *Score/Tape Procedure:*

9.2.1 Place the print media on a flat surface, printed side up.

9.2.2 Take a 75 by 25 mm (3 by 1 in.) piece of pressure-sensitive tape and firmly adhere 50 mm (2 in.) of it to the surface of each of the colored patches and a non-printed area so that the long dimension of the tape is parallel to the CD (cross direction) of the sample. The tape is pressed down with the flat of a finger.

9.2.3 While holding the specimen against a flat, horizontal surface, grasp the loose end of the tape and pull the tape away sharply from the sample at a 90° angle from the sample (altering the 90° angle may cause the results to be invalid).

9.2.4 Examine the coating surface and the tape for removal of coating or ink. Rate adhesion according to the scale 1–5, where "poor" is the lowest rating and "excellent" is the highest rating.

Adhesion Characteristic	Percent Area Removed	Rate
The coating is completely smooth. No coating transfer to the tape.	0	5
Small flakes of the coating or prints are detached to the tape.	10	4
Medium flakes of the coating or prints are detached to the tape.	10–35	3
Large flakes of the coating are detached to the tape.	35–65	2
Flaking and detachment worse than Rate 2.	>65	1

9.3 *Cross Hatch Procedure—Film and High Sized Paper Substrate:*

9.3.1 Place a sample of the print media to be tested on a flat surface, printed side up.

9.3.2 Using a sharp razor blade, cut cross hatch lines 3 mm (0.125 in.) apart through the coating for each of the colored patches and a non-printed area, being careful not to cut through the base material.

9.3.3 Take a 75 by 25 mm (3 by 1 in.) piece of pressure-sensitive tape and firmly adhere 50 mm (2 in.) of it to the cross hatched surface to be tested so that the long dimension of the tape is parallel to the CD (cross direction) of the sample. The tape is pressed down with the flat of a finger.

9.3.4 While holding the specimen against a flat, horizontal surface, grasp the loose end of the tape and pull the tape away sharply from the sample at a 90° angle (altering the 90° angle may cause the results to be invalid).

9.3.5 Examine the coating surface and the tape for removal of coating or ink. Rate adhesion according to the scale 1–5, where "poor" is the lowest rating and "excellent" is the highest rating.

Adhesion Characteristic	Percent Area Removed	Rate
The edges of the cuts are completely smooth. None of the square of the lattice is detached.	0	5
Small flakes of the coating or prints are detached at intersection.	10	4
Small flakes of the coating are detached along edges and at intersections of cuts.	10–35	3
Large flakes of the coating are detached.	35–65	2
Flaking and detachment worse than Rate 2.	>65	1

9.4 *Cross Hatch Procedure—Porous Paper Substrate:*

9.4.1 Place a sample of the print media to be tested on a flat surface, printed side up.

9.4.2 Using a sharp razor blade, cut cross hatch lines 3 mm (0.125 in.) apart through each of the colored patches and a non-printed area, being careful not to cut through the base material.

9.4.3 Take a 75 by 25 mm (3 by 1 in.) piece of pressure-sensitive tape and firmly adhere 50 mm (2 in.) of it to the cross hatched surface to be tested so that the long dimension of the tape is parallel to the CD (cross direction) of the sample. The tape is pressed down with the flat of a finger.

9.4.4 While holding the specimen against a flat, horizontal surface, grasp the loose end of the tape and pull the tape away sharply from the sample at a 90° angle (altering the 90° angle may cause the results to be invalid).

9.4.5 Under some conditions, a quick stripping of the tape may not cause separation or may otherwise yield misleading results. A slow strip, at a rate of about 50-mm (2-in.) in 3 s may start separation.

9.4.6 Examine the coated surface and the tape for removal of coating or ink.

9.4.7 Rate the adhesion according to the descriptions shown in Table 1, where 5 is excellent and 1 is poor.

9.4.8 *Calculation*—Adhesion ratings are defined as "poor" for the lowest rating and "excellent" as the highest rating. The average rating from five test specimens determines the final rating applied to the coating structure being tested. Each rating is assigned points as noted in Table 1 for adhesion and the points are averaged.

9.4.8.1 *Example*—Five specimens were tested from a sample and three were rated as excellent and two good. Since each excellent rating is worth 5 points, then 3 × 5 = 15 points; each good rating is worth 3 points, so 2 × 3 = 6 points; for a total of 21 points. Average rating = (Total points/Number of specimens) = (21/5) = 4.1. The average test result would thus be reported as "good (4.1)."

TABLE 1 Adhesion Ratings

Assigned Value	Adhesion Characteristic	Rating
Coating cannot be separated by tape.	Excellent	5
Coating separates with 100 % fiber tear of a porous substrate (paper, cloth, and so forth).	Very good	4
Coating has considerable adhesion.	Good	3
Coating separates with more than 50 % fiber tear of a porous substrate.		
Coating has slight adhesion.	Fair	2
Coating separates with less than 50 % fiber tear of a porous substrate.		
Coating has no adhesion.	Poor	1
Coating separates with no evidence of fiber tear of a porous substrate.		

10. Report

10.1 Report the following information:

10.1.1 Specimen identification, including the printer, method of printing, and the media type,

10.1.2 Relative humidity and temperature in the room where printing is carried out, and time after printing,

10.1.3 Each specimen rating,

10.1.4 Average test result, and

10.1.5 Any unusual characteristics, that is, extremes or irregularities noted in test results. Include backing if required and the conditioning cycle if other than standard.

11. Precision and Bias

11.1 A statement of bias is not applicable in view of the unavailability of a standard reference for these properties.

12. Keywords

12.1 accelerate aging; adhesion; bond strength; coating; debonding; ink jet; media; printing; thickness

APPENDIX

X1. COMMENTARY

X1.1 The Tape Selection

X1.1.1 Major limitations of the tape test are its low sensitivity and applicability to coatings of relatively low bond strength. The test is determined as pass for the most outside layer through failure. Adhesion can still occur on the interface between two other layers in multi coating or between the first coating and substrate.

X1.1.2 The adhesion strength of pressure-sensitive tapes is dependent on lot number due to batch production process and aging during storage because bond strength of the tape may change over time.

X1.1.3 Small changes in back stiffness and adhesive rheology of the tape can cause significant changes in the tension area. Some commercial tapes are manufactured to meet minimum standards. However, adhesion strength of most commercially available tapes can vary up to 50 % from the value claimed by the manufacturer.

X1.1.4 Different tapes can lead to different results. The pressure-sensitive tape's adhesion varies depending on the coating and the substrate. The data in Table X1.1 show peel strength of four tapes: 3M 899, 3M 600, 3M 610, and Permacel 99. Depending on paper substrate or coating layer, adhesion to all tapes could be nearly the same or vary significantly. It is recommended to use 2 to 3 tapes for comprehensive evaluation.

X1.2 Reproducibility

X1.2.1 The precision and reproducibility depend largely upon the skill of the operator. The angle and rate of tape removal and the visual assessment of the tested sample are dependent on the operator's skills. It is important to perform the test in a consistent manner. It is very common that different operators might obtain different results.

TABLE X1.1 Peel Strength Comparison[A]

Tested Material	Tape	Static Peak	Kinetic Peak	Valley	Average	RPS	Test Average
Paper I	3M 898, 0.71 in.	322.9	439.8	175.5	292.2	41.4	372
Coating A	3M 610, 1 in.	202.9	232.1	124.8	194.4	16.7	
	3M 600, 1 in.	568	702.5	457.8	635.5	47.4	
	Permacel 99, 1 in.	397.7	723	191	367.4	82.4	
Paper II	3M 898, 0.71 in.	926.4	1206.7	143.6	760.2	208.2	748
Coating B	3M 610, 1 in.	631.5	641.2	549.8	603.2	16.2	
	3M 600, 1 in.	718.7	816.1	655.5	730.8	29.6	
	Permacel 99, 1 in.	1371	1359	472.6	899.7	160.5	
Paper III	3M 898, 0.71 in.	734.5	946.6	478.9	705.1	81.4	707
Coating B	3M 610, 1 in.	563.2	618.2	506.7	582.8	25.4	
	3M 600, 1 in.	771.3	736.3	611.4	678.5	20.9	
	Permacel 99, 1 in.	1477	1312	380.5	861.3	148.2	
Paper IV	3M 898, 0.71 in.	867.1	1108	743.1	875.7	55.9	973
Coating C	3M 610, 1 in.	767.9	785	543	616.2	66	
	3M 600, 1 in.	1111	1518	1009	1292	128	
	Permacel 99, 1 in.	1536	1651	499.4	1108	198.6	
Paper IV	3M 898, 0.71 in.	803.8	957.7	477.2	685.2	74.5	872
Coating D	3M 610, 1 in.	540.8	663.4	511.8	582.8	37.4	
	3M 600, 1 in.	1269.8	1354.5	1029	1197	69.1	
	Permacel 99, 1 in.	1251	1324	646.5	1021	126.8	

[A]The comparison of peel strength of four tapes applied to four coatings on four different papers. The peel strength was measured according to Practice F2226.