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Standard Practice for Determining the Scratch Hardness and Scrape Adhesion of Prints and Coatings[1]

This standard is issued under the fixed designation F2496; 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.

ε[1] NOTE—Revised the units presentation and added a units statement editorially in October 2011.

1. Scope

1.1 This practice describes procedures to obtain subjective, but comparative data for scratch hardness and scrape adhesion of coatings and color images produced by printers, copies and other reprographic devices.

1.2 This method simulates conditions where the surface of various substrates such as paper, film, cloth, and so forth may be subject to failure under mechanical force.

1.3 This test method covers the determination of the scratch hardness and scrape adhesion of coatings. Results are expressed in terms of force-to scratch coatings on substrates used in printing.

1.4 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.5 *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. Terminology

2.1 *Definitions:*

2.1.1 *scratch hardness*—the force necessary to cut through the coating to the substrate.

2.1.2 *scrape adhesion–scratch resistance*—the force required to scrape a path through the coating or print, when the stylus begins its motion. By moving a free edge of the test coating against a round stylus or loop under a variable load expressed in grams, scrape resistance is determined as the minimum load in grams required to cut through the film to the substrate.

3. Summary of Practice

3.1 The scratch hardness and scrape adhesion is determined by pushing the substrate with coating beneath a rounded stylus or loop that is loaded in increasing amounts (weights) until the coating is scratched.

4. Significance and Use

4.1 The image life of printed media displayed in both typical office and outdoor environments is dependent on coating scratch resistance. While natural aging is the most reliable method of assessing coating scratch resistance, the length of the time required makes this method impractical for most materials.

4.2 Factors in the office and outdoor environments, such as heat, cold, thermal shock, ultraviolet/visible radiation and water vapor can have similar effect on the scratch resistance of coatings and prints as mechanical force.

4.3 Good scratch resistance is a prime consideration for coated media and prints. Highly absorptive coatings in digital printing have a tendency to dusting, flaking and cracking when folded.

4.4 This practice utilizing mechanical force allows comparative studies of coated and printed media. It is most useful in providing relative ratings for media which exhibit significant differences in performance.

5. Interferences

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

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

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

[1] This practice is under the jurisdiction of ASTM Committee F05 on Business Imaging Products and is the direct responsibility of Subcommittee F05.07 on Ink Jet Imaging Products.

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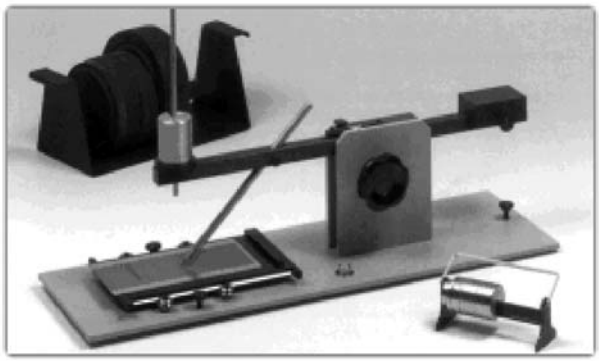

FIG. 1 Balanced Beam Scrape Adhesion Tester

5.4 The practice is intended to measure scratch resistance of printed media without specifying above-mentioned parameters.

6. Apparatus

6.1 *Balanced Beam Scrape Adhesion and Mar Tester (Catalog Number SG-8101)*—for example available from BykGardner[2] (Fig. 1) consisting of a balanced beam to which is secured a platform for supporting weights, and a rod at an angle of 45° that holds the scraping loop or the stylus. The rod shall be set so that the scraping loop or the rounded stylus contacts test surfaces directly below the weights. On the other end of the beam is a counter-weight. A cam is rotated to lower and raise the stylus and a sample bed mounted on ball bearings is used to move the test sample against the stationary stylus.

6.2 The loop shall be 0.0825 in. (1.6 mm) diameter rod, bent into a "U" shape with an outside radius of 0.128 ± 0.002 in. (3.25 ± 0.05 mm) and hardened to Rockwell HRC 56 to 58, and shall be a smooth finish.

6.3 The round stylus shall be a smooth cylinder 0.284 in. (7.21 mm) OD and 0.138 in. (3.50 mm) high with attaching rod 0.380 in. (9.67 mm) long for assembling and hardened to Rockwell HRC 56 to 58.

6.4 The loop and the stylus can be either chromium plated, nickel plated, or heat-treated polished steel.

6.5 The testers are adjustable to accommodate flat specimen to 0.5 in. (12 mm) thick and 4 to 16 in. (100 to 400 mm) wide and long; the specimens should be at least 1 in. (25 mm) wide.

6.6 Supplied with the Tester is a set of twelve slotted brass weights with storage track. In the adhesion test, weights are applied in 100 g increments to a maximum of 2 kg. It is maximum recommended weight for paper substrate without its damage. Higher weights can be used for film and plastic substrates.

7. Test Specimens

7.1 The substrate, 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 specimens should be completely flat because paper curls can significantly alternate the scratch resistance.

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

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

7.5 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.

7.6 The recommended color patches should be rectangular with minimum diameter of 1 by 8 in. (25.4 by 203 mm).

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

7.8 At least three test specimens have to be printed with a test image if prints scratch resistance is evaluated.

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, which 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. Procedures

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

9.2 Test procedure can be carried using the rounded stylus or the loop. For paper substrates the round stylus is recommended if resistance to flaking, cracking is evaluated.

9.3 Ensure that the apparatus is level.

9.4 Place the apparatus so that the weight holder is toward the operator. This places the beam release on the operator's right and allows freedom to move the test specimen manually under the weighted scraping element. Insert the sharp circular rim into the holder as far as it will go and tighten the clamping screw.

9.5 Adjust the main bearing support so that the beam is balanced in the horizontal plane when the loop is just touching the specimen surface. The alignment of the beam should be such that the end of the loop is over the midline of the movable table.

[2] The sole source of supply of the apparatus known to the committee at this time is Byk-Gardner, Rivers Park II, 9104 Guilford Road, Columbia, MD 21046. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.

9.6 Examine the round stylus or the loop. Ensure that the original smooth surface of the loop is intact. If the contacting surface is worn, reverse the loop. When both sides are worn, replace with a new loop.

9.7 Raise the beam and lock it in the raised position. Wipe the round stylus with a clean cloth or chamois. Locate the specimen on the siding platform against the stop so that the specimen can be moved in the direction of the operator and there is an area at least 5 in. (100 mm) long by 0.5 in. (12 mm) wide on the sample parallel to the horizontal plane through the beam.

9.8 The stylus is moved in the direction of the operator and the stylus is sliding on the surface of the tested materials. Moving the stylus in the opposite direction could crease soft materials such as paper and thin film and can limit the reproducibility of the practice.

9.9 Place weights on the weight support using an initial amount that is estimated to be appropriate for the particular coating. Release the beam and carefully lower it until the loop rests on the coated test specimen and the full load is applied. Then slowly push the sliding platform in the direction of the operator at approximate rate of 0.125 in./s (6 mm/s) for a distance of at least 5 in. (100 mm).

9.10 *Maximum Load Procedure:*

9.10.1 If the coating is scratched, continue the testing using successfully smaller loads (100 g increments) until the coating is not scratched. If the coating is not scratched by the initial scrape, continue the test using successive larger load (100 g increments) until the coating is scratched or until the maximum load of 2 kg has been applied. Use a new area of the test surface each time a scrape is made.

9.10.2 When the critical load has been approximately located, repeat the test at least three times at each of three loadings: above, below and at the load determined, in the first trial. Apply different loads in random fashion so that all scrapes at one load are not made in succession.

9.10.3 For each applied load, tabulate the number of times the coating was scratched.

9.11 *Three Loads Procedure:*

9.11.1 Place 100-g load on the weight support. Release the beam and carefully lower it until the round stylus (smooth cylinder is recommended) rests on the coated test specimen and the full load is applied. Then slowly push the sliding platform into the direction of the operator at a approximate rate of 0.125 in./s (6 mm/s) for a distance of at least 5 in. (100 mm). Repeat the procedure five times. The stylus has to follow the same path.

9.11.2 Place 200-g load on the weight support. Release the beam and carefully lower it until the round stylus rests on the coated test specimen and the full load is applied. Then slowly push the sliding platform into the direction of the operator at a approximate rate of 0.125 in./s (6 mm/s) for a distance of at least 5 in. (100-mm). Repeat the procedure three times. The stylus has to follow the same path.

9.11.3 Place 500-g load on the weight support. Release the beam and carefully lower it until the round stylus rests on the coated test specimen and the full load is applied. Then slowly push the sliding platform into the direction of the operator at a approximate rate of 0.125 in./s (6 mm/s) for a distance of at least 5 in. (100-mm). It is single path procedure.

9.11.4 Repeat the test three times at each of three loading. Apply different loads in random fashion so that all scrapes at one load are not made in succession.

9.11.5 Examine the coating surface. Rate adhesion according to the scale 1–5, where 1–"poor" for the lowest rating and 5–"Excellent" as the highest rating. The average of three loads is calculated.

9.11.6 For each applied load, tabulate the rating and average for all three loads.

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 Load in grams at the scratch failure point,

10.1.4 Each specimen rating,

10.1.5 Average test result,

10.1.6 The round stylus and the "U" shape loop surface finish, and

10.1.7 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; balanced beam scrape adhesion; balanced beam tester; bond strength; coatings; debonding; ink jet; media; printing; scrape adhesion; scratch hardness; scratch resistance; thickness