Designation: F1571 – 95 (Reapproved 2008)

Standard Test Method for Determination of Abrasion and Smudge Resistance of Images Produced from Business Copy Products (Sutherland Method)[1]

This standard is issued under the fixed designation F1571; 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 test method covers a procedure for determining the amount of image transferred from one site and redeposited at another site (smudge) on a document. The Sutherland Ink Rub Tester[2] with 4-lb (1.82-kg) test block is the test instrument for producing the transfer and either a reflectometer or densitometer is employed for measuring the change in images. Alternatively, a visual rating order can be employed to establish a ranking order. The degree to which the original image is unaltered upon rubbing is considered to be the abrasion resistance.

1.2 This test method can be employed to evaluate the smudge resistance of business imaging products produced by typewriters, and impact printers.

1.3 This test method can also be employed to measure performance characteristics for a product. The user should select test equipment that is appropriate for measuring the degree of abrasion to the samples. Samples are tested before and after rubbing and comparisons of results made. In this test method product performance evaluations are optional.

1.4 Other test methods employing the Crockmeter, Taber Abrader, and Gavarti GA-C.A.T. can be employed to evaluate the smudge and abrasion characteristics. Results by these units are not necessarily equivalent to those obtained with the Sutherland.

1.5 The values stated in inch-pound units are to be regarded as the standard. The SI units given in parentheses are for information only.

1.6 *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:*[3]

D5264 Practice for Abrasion Resistance of Printed Materials by the Sutherland Rub Tester

F149 Terminology Relating to Optical Character Recognition

F221 Terminology Relating to Carbon Paper and Inked Ribbon Products and Images Made Therefrom

F497 Practice for Use of the Electric and Electronic Typewriter as a Test Instrument

F909 Terminology Relating to Printers

F1125 Terminology of Image Quality in Impact Printing Systems

F1174 Practice for Using a Personal Computer Printer as a Test Instrument

F1175 Practice for Using the Computer Impact Print-Out Unit as a Test Instrument for Manifold Comparison

F1319 Test Method for Determination of Abrasion and Smudge Resistance of Images Produced from Business Copy Products (Crockmeter Method)

F1443 Practice for Using 0.008-in. (0.203-mm) Aperture Reflectometers as Test Instruments for Measuring Visual Image Quality of Business Copy Images

2.2 *ANSI Standard:*

CGATS.4 Graphic Technology —Graphic Arts Reflection Densitometry Measurements—Terminology, Equations, Image Elements and Procedures[4]

[1] This test method is under the jurisdiction of ASTM Committee F05 on Business Imaging Products and is the direct responsibility of Subcommittee F05.02 on Inked Transfer Imaging Products.

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[2] The sole source of supply of the apparatus known to the committee at this time is James River Corp., Mechanical Services Dept., 243 E. Paterson Street, Kalamazoo, MI 49007. 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.

[3] 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.

[4] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

3. Terminology

3.1 *Definitions:*

3.1.1 *abrasion resistance*—the ability of an image to withstand the frictional force attempting to remove the surface material.

3.1.2 *smudge*—the tendency of an image to smear or streak onto an adjacent area when rubbed. Smudge involves the redeposition of abraded material.

3.1.3 *smudge resistance*—the ability of an image to withstand smudging.

3.1.4 General definitions relating to terms employed in this test method can be found in Terminology F149 (optical character recognition), Terminology F221 (carbon paper and inked ribbon products and images), Terminology F909 (printers), Terminology F1125 (impact printer image quality) and ANSI/CGATS.4 (reflection densitometry).

4. Summary of Test Method

4.1 This test method is intended to present a procedure for measuring the abrasion resistance and smudge tendency of typewritten and impact printed images.

4.2 The Sutherland Ink Rub Tester[2] and 4-lb (1.82-kg) test block covered with Buehler Ltd. microcloth is used to perform the abrasion and smudge test on images generated on a typewriter or printer. The recommended test pattern uses a series of six lines with thirty capital "I" 's per row. Spacing between characters should be sufficient to allow the positioning of the aperture of the reflectometer (or densitometer) without touching the characters.

4.3 Once the smudge has been produced by the rub tester, measure the optical density of the paper in the area adjacent to the images using a reflectometer (or densitometer). These results are compared to the reflectance (or density) values obtained on the same area prior to imaging. If a densitometer is used, the readings must be converted to percent reflectance prior to making any calculations. This procedure recommends adjusting the reflectance meter to 1.00 or densitometer to 0.00 before measuring the smudge level. In this case the smudge value will be equal to the reflectance or density of the smudged area.

4.4 For the evaluation of abrasion, reflection density readings of individual characters are measured before and after application of the rub tester.

4.5 Alternative methods for evaluation of the results include establishing a rank order of the samples or evaluation of performance characteristics of the images.

5. Significance and Use

5.1 This test method is designed to simulate the type of damage resulting from paper rubbing against a printed image. The primary method of evaluation is either reflectance or optical density readings. Depending upon the objective of the test, comparison of either the image or the area adjacent to the image is evaluated before and after rubbing.

5.2 This test method can be used for control of product quality as well as a research and development tool.

5.3 As written this test method is intended for use only with impact printed images involving ribbons. However, it can be modified to evaluate other types of business images such as those produced by non-impact printers and copiers, ink jet printers, and thermal transfer printers.

5.4 The degree of image transferred by rubbing from a printed image can be affected by various factors including the type of printer, the condition of the unit, supplies employed, time since imaging, and environmental conditions. As many as possible of these variables should be controlled during the test. A control sample with known characteristics, if available, should be run along with the test samples.

6. Interferences

6.1 Equipment cleanliness is important for accurate readings. Residual oil, dirt, or other contaminants may be transferred to the test samples and result in erroneous measurements. Care must be taken to avoid skin contact with either of the two surfaces involved in the rubbing action.

6.2 Variations in paper surfaces may affect ribbon smudge level. If sheeted paper is used, the user should be aware that sheet to sheet smoothness and brightness variations within a ream may have a significant effect on reflectance readings. Most papers contain a felt and a wire side that have different surface smoothness levels and this in turn can also affect test results. Special precautions should be taken when using preprinted or colored papers because they may affect both the reflectometer (or densitometer) calibration and measurements.

6.3 Running the test under conditions outside those found in the normal office environment may affect the degree of smudge and abrasion.

6.4 Image smudging may be affected by printer or typewriter parameters such as hammer energy level, hammer dwell time, hammer flight time, platen hardness, and print character to platen angle.

6.5 The time from print sample generation to running of the smudge test has a direct impact on the final results. If prints are to be compared the elapsed time from printing to smudge testing should be stated.

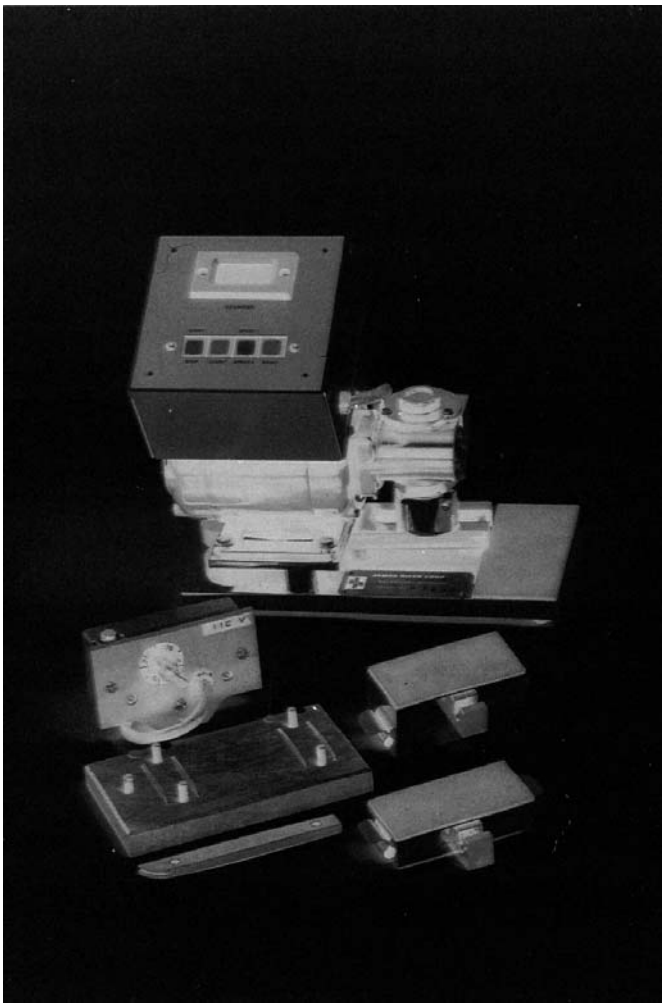
7. Apparatus and Materials

7.1 *Sutherland Ink Rub Tester* [2] with 4-lb (1.82-kg) test block, or its equivalent. See Fig. 1 for a picture of the apparatus.

7.2 *Standard Typewriter,* (electric or electronic) or printer.

7.3 *Microcloth,* Buehler Ltd. #4C—7228 with adhesive backing or equivalent.

7.4 *Reflectometer,* or densitometer with an aperture smaller than the space between characters. The primary method of evaluation is reflectance or optical density. The choice of which unit to employ depends on the density of the area to be measured. Reflectometers perform best when the image density is light, whereas densitometers give the best results where the image density is dark. If readings are desired on individual printed characters, equipment and methods referenced in Practice F1443 can be employed.



NOTE 1—The Sutherland Rub Tester shows two-pound and four-pound weights to which test specimens are attached and the scoring device.

NOTE 2—The upper receptacle of the timer is for remote timer control. The lower receptacle is the same voltage as the instrument. 115 V single phase is standard, 220 V optional. Sutherland Ink Rub Tester and Attachments

FIG. 1 Sutherland Ink Rub Tester and Attachments

7.5 *Optional*—Other test equipment which measures specific performance characteristics such as OCR readers and bar code verifiers.

8. Conditioning

8.1 For best results the paper must be conditioned at 73°F (23°C) and 50 % relative humidity and all testing conducted under these same conditions. If controlled conditions are not available, samples to be compared must be run under the same environmental conditions, on the same type of paper and at the same elapsed time between printing and smudge testing.

9. Procedure

9.1 The test specimen is an imaged area 3.5 to 4 in. (8.0 to 10.2 cm) produced on a typewriter or printer under ambient environmental conditions. Refer to Practices F497, F1174, or F1175 for directions on how to prepare the sample employing impact printing devices. If reflectance density readings will be required on individual characters, a type font should be selected so the 0.008-in. (0.203-mm) aperture area will fit within the printed character boundaries (refer to Practice F1443). Although the actual test pattern may vary, the recommended pattern that uses six rows of capital "I" 's is presented in Fig. 2.

9.2 When ribbon samples are compared, the same type of paper and side (wire or felt) must be used for all tests.

9.3 Cut the printed sample to 2½ by 5½ in. (6.4 by 14.0 cm).

9.4 Refer to the *Sutherland Operating Manual*[5] for proper set-up procedures and instructions regarding the operation of the unit.

9.5 Mount a sample strip with the image facing up onto the base of the Sutherland Ink Rub Tester.[2] Tape the sample so that the lead edge of the pattern is ½ in. (13 mm) from the right edge of the base plate. Overlap of tape on paper should not exceed ⅛ in. (3 mm).

9.6 Adhere two 1 by 2 in. (25 by 51 mm) pieces of #4C-7228 Buehler microcloth or equivalent to the bottom of the 4-lb (1.82-kg) weight of the Rub Tester.[2]

9.7 Check the two surfaces for loose material and remove with a camel's hair brush if necessary.

9.8 Carefully place the weight on top of the printed sample with the microcloth resting on the images.

9.9 Lock the weight into the radius arm.

9.10 Set and run the tester ten cycles.

9.11 Remove the weight.

9.12 Calibrate the reflectance meter or densitometer in accordance with the manufacturer's recommended procedure before each test to verify the zero or infinity setting.

NOTE 1—Since most papers that are used in this procedure are usually translucent and not opaque, if a white backing is used, some of the light transmitted through the paper will reflect back to the measuring instrument. The method recommended by ANSI/CGATS.4 that minimizes back-reflected light is to use a black backing material. This backing material should be non-selective, diffuse-reflecting, and have an ISO density greater than 1.50. Samples are often either viewed or measured with a backing of several layers of similar stock. Although this procedure is acceptable, black backing is required when communicating data.

9.13 Place the reflectance meter or densitometer on a non-image area of the sample. Set the calibration to 1.00 readout for a reflectance meter or 0.00 for a densitometer. Making several readings and calibrating the meter on the nominal value is the preferred practice. If the paper is so dark that the unit cannot be adjusted to 1.00 (or 0.00) on the background, calibrate the unit against an absolute standard. After both background and smudge data has been gathered, the smudge value of interest must be calculated using the formula in accordance with 10.2.2.

[5] *Sutherland Ink Rub Tester Operator's Instruction Manual*, available from James River Corp.[2] Also see the operator's manual for selected reflectometer or densitometer.

LOT # ________________ # TESTER ________________ DATE ____________

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FIG. 2 Sample Test Pattern

9.14 Measure the reflectance (or optical density) of the space midway between the first and second character on each of the second and third rows from the top left-hand and top right-hand corners.

9.15 Report the average of twenty measurements, five in each area.

9.16 Repeat the procedure in 9.1 – 9.15 for each additional sample. Values for smudge may be dependent on how long after the rubbing measurements are taken. To minimize this variable, make all measurements of each sample an equal time after rubbing.

9.17 For the evaluation of abrasion, measure the optical density of images before and after rubbing in accordance with 11.1.2 of Practice F1443.

9.18 *Optional*—Other test equipment, operated in accordance with the manufacturer's directions, can be employed to evaluate the functional performance of the printed sample. For example, a bar code verifier can be used to evaluate a bar code. Or an OCR reader can be used to examine the scannability of OCR images.

10. Calculation and Interpretation of Results

10.1 *Visual Means:*

10.1.1 Visually compare the rubbed images to the original for the following properties (5 or 10× magnification may aid in the evaluation):

10.1.1.1 Intensity of the smudged area,

10.1.1.2 Loss in visual density of the images, and

10.1.1.3 Loss of sharpness of characters after rubbing.

10.1.2 Establish a relative ranking order, best to worst, for the characteristics evaluated.

10.2 *Reflection or Density Measurements:*

10.2.1 If the instrument expresses results as optical density, convert the values to percent reflectance:

$$R, \% = 10^{-D} \times 100 \quad (1)$$

where:

R = reflectance, and
D = optical density.

10.2.2 If the reflectance measurement was set at 1.00 (or reflectance calculated from the formula in accordance with 10.2.1), then calculate smudge by the following formula:

$$smudge = 1.00 - R_f \quad (2)$$

The lower the value of smudge, the less is the amount of material transferred from the image to non-image area and the greater is the smudge resistance.

10.2.3 If the measuring unit was not set to 1.00 (or 0.00) then calculate smudge by the following formula:

$$smudge = (R_p - R_s)/R_p \quad (3)$$

where:

R_p = reflectance of the paper, and
R_s = reflectance of the sample.

10.2.4 Calculate the abrasion by the following formula:

$$abrasion = (D_o - D_s)/D_o \quad (4)$$

where:

D_o = optical density of the original sample, and
D_s = optical density of the sample after rubbing.

11. Report

11.1 Report the following information:

11.1.1 Ribbon identification and all pertinent data on physical properties,

11.1.2 Paper type, lot number and which side was printed (wire or felt), and all pertinent data; basis weight, surface smoothness, etc.,

11.1.3 Date and time of testing,

11.1.4 Operator identification,

11.1.5 Equipment description including serial number,

11.1.6 Temperature and relative humidity,

11.1.7 The average reflectance readings and calculated smudge values. Include the time delay between the rubbing and the measurements, and

11.1.8 The relative ranking order of the samples evaluated.

11.1.9 *Optional*—Report the average density readings and calculated abrasion values.

11.1.10 *Optional*—Report the average values of the measurements obtained in 9.18.

12. Precision and Bias

12.1 *Precision*—The precision of the procedure in this test method for measuring abrasion and smudge resistance of images produced on office products is being determined.

12.2 *Bias*—The procedure in this test method for measuring abrasion and smudge has no bias because the value of abrasion and smudge is defined only in terms of this test method.

13. Keywords

13.1 abrasion; abrasion resistance; densitometer; image permanence; impact printer; printed matter; reflectometer; smudge; Sutherland; typewriter ribbon