Designation: D 5626 – 94 (Reapproved 2001)

An American National Standard

Standard Test Methods for U.S. Postal Service Optical Measurements for Small Areas[1]

This standard is issued under the fixed designation D 5626; 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 These test methods deal with the measurement of optical properties important to automatic equipment used by the United States Postal Service, such as optical character recognition (OCR) readers and barcode readers. These test methods can be used to examine finished mailpieces bearing address information, as well as the unconverted materials intended to be subsequently used in mailpiece construction. These test methods are limited to the use of a single instrument, the U.S. Postal Service Envelope Reflectance Meter Model 2 (ERM-2),[2] designed for use with mailpieces and materials intended for mailpiece construction such as paper and paper-like synthetics and inks.

1.2 These test methods cover examination of small areas, measuring 0.152 by 0.254 mm (0.006 by 0.010 in.). This enables measurement of the reflectance characteristics of regions as small as the inked portion of a single printed character or a single bar in a barcode pattern.

1.3 These test methods deal with the measurement of four different optical properties important to automatic mail handling, as follows:

1.3.1 *Background Reflectance* (see 11.1)—These test methods cover the determination of the relative reflectance factor of small areas of a specimen that do not contain printing or apparent show-through of printing, and so are representative of the base material.

1.3.2 *Print Reflectance Difference and Print Contrast Ratio* (see 11.2)—These test methods characterize the difference in reflectance between the envelope material and the characters printed upon the envelope with ink.

1.3.3 *Print Show Through* (see 11.3)—These test methods characterize the difference in reflectance between the envelope material backed with an unprinted insert and the envelope material examined in a region where it covers a printed character on the insert or a character printed on the back side of the envelope material itself.

1.4 *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:*

D 585 Practice for Sampling and Accepting a Single Lot of Paper, Paperboard, Fiberboard, or Related Products[3]

E 284 Terminology of Appearance[4]

E 1347 Test Method for Color and Color Difference Measurements by Tristimulus (Filter) Colorimetry[4]

3. Terminology

3.1 *Definitions:*

3.1.1 The definitions contained in Terminology E 284 are applicable to these test methods.

3.1.2 Relative reflectance factor is defined in Test Method E 1347.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *background reflectance (BR), n*—the relative directional reflectance factor, expressed as a percent, obtained from a portion of the material under any test which has not been printed on either side and does not show printing from any backing material. Also referred to as paper reflectance.

3.2.2 *bar code reader (BCR), n*—as used by the United States Postal Service (USPS) in the automatic processing of mail.

3.2.3 *bar code sorter (BCS), n*—as used by the USPS in the automatic processing of mail.

3.2.4 *directional, adj*—descriptor for the optical geometry employed in the ERM-2 for which illumination is from two sources disposed at + 50° and − 50° from the vertical, and detection is at 0° from the vertical.

3.2.5 *Envelope Reflectance Meter, Model 2 (ERM-2), n*—manufactured by Chamberlain MRC.

NOTE 1—This instrument renders ERM-1 obsolete. The ERM-1 cannot be used to implement these test methods.

[1] These test methods are under the jurisdiction of ASTM Committee D06 on Paper and Paper Products and are the direct responsibility of Subcommittee D06.92 on Test Methods.

Current edition approved Oct. 15, 1994. Published December 1994.

[2] The ERM-2 is available from Chamberlain MRC, Division of Duchossois Industries, Inc., 336 Clubhouse Road, Hunt Valley, MD 21031-1325.

[3] *Annual Book of ASTM Standards*, Vol 15.09.

[4] *Annual Book of ASTM Standards*, Vol 06.01.

3.2.6 *optical character reader (OCR), n*—as used by the USPS in the automated processing of mail.

3.2.7 *print contrast ratio (PCR), n*—the ratio between print reflectance difference and background reflectance, defined as PCR = (BR − PR)/BR = PRD/BR.

3.2.8 *print reflectance (PR), n*—the relative directional reflectance factor, expressed as a percent, obtained from a portion of the material under test which has been printed; also referred to as ink reflectance.

3.2.9 *print reflectance difference (PRD), n*—the difference between background reflectance and print reflectance, defined as PRD = BR − PR.

3.2.10 *print show-through (PS), n*—the print contrast ratio associated with printed or contrasting material on the reverse side of the material under test or on a backing that shows through the material under test, defined as PS = (BR − SR)/BR.

3.2.11 *show-through reflectance (SR), n*—the relative directional reflectance factor, expressed as a percent, obtained from a portion of the material under test which shows printing from a backing material or a pattern printed on the opposite side.

4. Summary of Test Methods

4.1 Measurements of background reflectance, show-through, print reflectance difference, and print contrast ratio are used for mailpieces or materials to be used for mailpieces that will be read on United States Postal Service OCRs and BCRs/BCSs. Test results can be compared with the requirements of the USPS as listed in the Domestic Mail Manual (DMM)[5] to let paper manufacturers, printers, envelope manufacturers, form manufacturers, ink manufacturers, mailers, etc. have a way to determine whether their materials or products, or both, will function correctly in the postal automation system.

5. Significance and Use

5.1 These test methods are to be used to determine the suitability of mailpieces for processing on automation equipment such as optical character readers and bar code readers and sorters. These test methods can be used to test finished mailpieces bearing address information or POSTNET bar codes, or both, as well as materials to be used in mailpiece construction.

5.2 The test methods to be described will measure parameters relevant to machine readability such as the reflectance of the mailpiece background and printed areas. Specifically these parameters will be measured to determine acceptability in accordance with postal requirements for mailpieces submitted for automation discounts in accordance with the Domestic Mail Manual (DMM).

6. Apparatus

6.1 The ERM-2 is a microprocessor-based instrument used to measure the reflectance of printed characters or bar codes, or both, as well as the envelope or envelope-representative surface on which they appear.

6.1.1 The ERM-2 measures a printed specimen of unknown reflectance in two different spectral bands, and in both a printed and unprinted location. It makes an indirect comparison against its attached reflectance standards, and it automatically calculates and displays the paper reflectance (BR), ink reflectance (PR), print contrast ratio (PCR), and print reflectance difference (PRD) of the printed specimen. If the specimen is unprinted, the instrument outputs can be related to paper reflectance (BR) and print show-through (PS) of the specimen.

6.2 The ERM-2 optical system is comprised of eight basic components (Fig. 1). These are, in order of light-path sequence, the illuminator, measurement window, objective lens, mirror, view plate, beam splitter, red and green filters, and photodetectors.

6.2.1 The illuminator focuses light on the specimen surface under test. The level of illumination is sufficient to project a visible image on the view plate and to activate the photovoltaic detectors behind it. It consists of two lamps focused directly beneath an objective lens. The lamps are positioned in the plane of incidence so the light is incident upon the specimen surface at 50° from the vertical. This eliminates specular reflection and leaves diffused light (0°) to be captured by the objective lens. The rated color temperature of the lamps is 2490 K.

6.2.2 The measurement window defines the focal plane of the optical system. The specimen is held flat against the measurement window by a spring-loaded base.

6.2.3 The objective lens (24.02 mm, f/1.4 variable focus) collects diffusely reflected light from the specimen surface and images it on the view plate. A magnification of 10× is achieved by placing the specimen against the measurement window when the view plate is 290 mm (11.44 in.) from the lens.

6.2.4 A planar mirror, mounted approximately 60 mm (2.4 in.) from the objective lens, reflects light from the objective lens onto the view plate.

6.2.5 The view plate is a reflective porcelain surface for viewing the magnified image of the envelope (Fig. 2). It also serves as the information display for the specimen's reflectance characteristics.

6.2.5.1 The view plate contains a rectangular reticule pattern near its center to highlight the area of the specimen surface under test. (The shape of this reticule pattern is designed to gage the dimensions of POSTNET bar codes, an application of the ERM-2 beyond the scope of these test methods.) Centered in the pattern is a 1.5 by 2.5-mm (0.06 by 0.10-in.) aperture

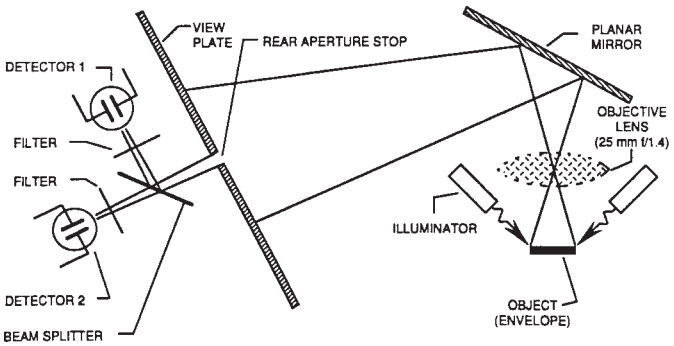

FIG. 1 Optical Schematic of the ERM-2

[5] United States Postal Service Domestic Mail Manual (DMM), available from the Government Printing Office, Washington, DC 20402.

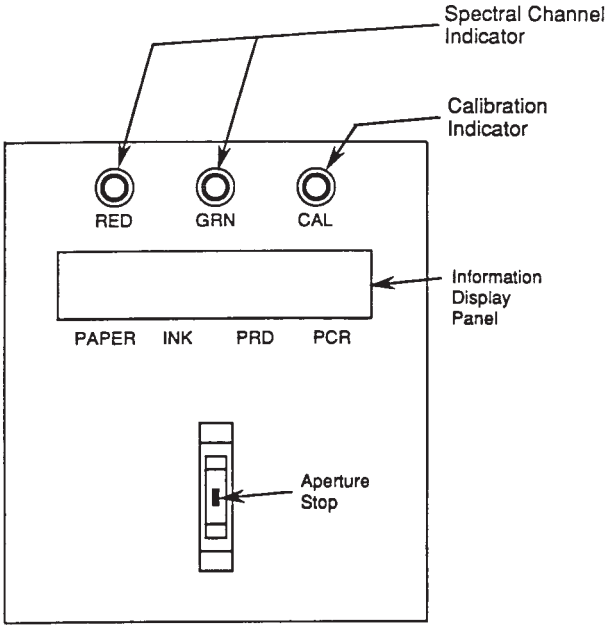

FIG. 2 View Plate

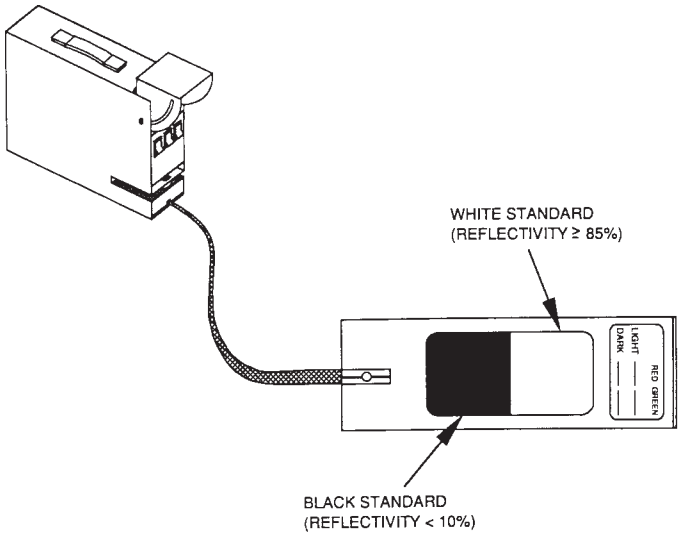

FIG. 3 Calibration Standards Plate

stop. The aperture stop is an opening in the view plate that admits light from the specimen to the photodetectors. Since this light is not available for viewing, the aperture stop appears black to an observer. The aperture stop indicates the actual 0.15 by 0.25-mm (0.006 by 0.010-in.) area of the specimen being measured.

6.2.6 A beam splitter is located immediately behind the aperture stop. It divides the light into two separate ray paths. The ray paths contain either a red filter having a fundamental wavelength of 595 nm, or a green filter with a fundamental wavelength of 530 nm. The overall system response maximizes at a wavelength of 650 nm in the red part of the spectrum, and at a wavelength of 540 nm in the green part of the spectrum.

6.2.7 A photodetector is positioned at the end of each ray path to collect the light and produce a voltage proportional to optical power.

6.2.8 A ceramic calibration standards plate is provided to calibrate the meter (Fig. 3). It consists of a white standard (reflectance of 85 % or more) and a black standard (reflectance of 10 % or less). It is labeled with the recorded calibration values for the red and green channels.

6.2.9 A set of acrylic-coated secondary standards are provided to check the calibration of the meter. The standards consist of a white, gray, and two colored chips. The reflectance values are recorded on each of the chips and are traceable back to the master ERM-2.

6.3 A microprocessor converts photodiode voltages to reflectance characteristics. These are displayed in a rectangular panel located above the reticule on the viewing screen. The same panel displays messages to the operator. Indicator lights at the top of the viewing screen indicate whether the displayed values are for the red or green channel. There is also a yellow light activated during calibration.

7. Hazards

7.1 **Warning**—Do not use the ERM in a wet or humid environment. Plug the unit directly into a properly grounded outlet. Electrical shock may result from improper use.

8. Sampling, Test Specimens, and Test Units

8.1 *Test Specimens*, consisting of single mailpieces or single sheets of paper of comparable size or larger.

8.2 *Test Unit*, consisting of one test specimen.

8.3 Follow a valid sampling plan; for example, Practice D 585.

9. Conditions of Testing

9.1 Specimens should be tested in a noncondensing atmosphere and at temperatures in the range from 10 to 30°C (50 to 86°F).

10. Calibration and Standardization

10.1 Turn the ERM-2 on and let it warm up for at least 15 min.

10.2 Using the calibration tiles attached to the meter, calibrate the ERM-2 in accordance with the instructions in the operator's manual. If the meter will not calibrate properly, or if the meter displays readings different from those written on the calibration tiles, the meter is in need of service and should be returned to the manufacturer.

10.3 With the ERM-2 in the operate mode, measure the red and green reflectances of the four secondary standards. Make sure that all measurements are taken on areas of the standards that are clean and free from scratches. To preserve the standards in their original condition, store them in a closed container, avoid touching the surfaces to be measured, and remove dust by gently wiping with a lint-free cloth. Contact the manufacturer for further information.

10.4 Compare the ERM-2 reading with the values recorded on the secondary standards. If any of the readings vary by more than 2 reflectance units, the meter is in need of service and should be returned to the manufacturer for repair and recalibration.

11. Procedures

11.1 *Measuring Background Reflectance*:

11.1.1 Select one of the test units.

11.1.2 Place the test unit in the sample slot of the ERM-2 with the surface to be measured facing up. The spring-loaded base should hold the test unit against the measurement window firmly and without wrinkles or waviness.

11.1.3 Measure and record the red and green reflectance characteristics of the test unit at five different locations. At each location, observe the image of the test unit on the viewing screen to ensure that the measurements are not being made on any extraneous material or dirt on the test unit's surface. If possible, none of the five measurement locations should be closer than one centimetre to its nearest neighbor.

11.1.4 Repeat the measurements for the other test units making up the sample.

11.2 *Measuring Print Reflectance Difference and Print Contrast Ratio:*

11.2.1 This test is relevant for mailpieces and paper sheets which have been printed.

11.2.2 Select one of the test units. The test unit may also be used for simultaneous measurement of background reflectance.

11.2.3 Locate the area of interest for the measurement. Usually this would be in the area of the address or bar code on the mailpiece.

11.2.4 Measure the background reflectance of the test unit adjacent to the contrast area of interest. Avoid areas showing ink-spatter or other colored matter extraneous to the background material. Move the test unit so that an unprinted area is completely covered by the aperture stop. Toggle the "sample" switch toward the "paper" position for approximately three seconds and then back to the "hold" position.

11.2.5 Move the test unit so that a printed area is completely covered by the aperture stop. Measure the contrast area by toggling the" sample" switch to the "ink" position for approximately 3 s and then back to the "hold" position.

11.2.6 Record the PRD and PCR values for both the red and green channels. The number associated with the "paper" value may also be recorded as the background reflectance (BR).

11.2.7 Measure and record the readings from five locations on the test unit.

11.3 *Measuring Print Show Through*:

11.3.1 Select one of the test units.

11.3.2 If the test unit is a mailpiece, identify contrast areas of interest as those where printing shows through the envelope. This may be printing from an insert or from a pattern printed on the back surface of the envelope. Perform 11.2.4 and 11.2.5. In performing 11.2.5, the contrast area showing through the envelope is positioned over the aperture stop.

11.3.3 If the test unit is a sheet of paper or empty envelope, insert a single layer of the paper into the sample slot and measure the background reflectance by toggling the "sample" switch to the" ink" setting and then back to "hold". Then place the white porcelain calibration tile attached to the instrument beneath the paper test unit without moving the test unit. Measure the reflectance of the test unit by toggling the "sample" switch to the "paper" position for 3 s and back to "hold".

11.3.4 Following completion of either 11.3.2 or 11.3.3, as appropriate, record the red and green PCR values as the print show through.

11.3.5 Measure and record the print-show-through values for five locations on the test unit, preferably no closer together than 1 cm.

NOTE 2—If the range of measured values for any property exceeds 10 % of the average value, then measure and record five additional readings for that property.

12. Calculation

12.1 For each test unit, calculate the mean value of background reflectance, print contrast ratio, print reflectance difference, and print show through, as appropriate.

13. Report

13.1 These test methods provide information describing procedures for measuring the background reflectance, print reflectance difference, print contrast ratio, and print show through of mailpieces and envelope papers. For each of these parameters, as required and as appropriate, report the following information for each test unit:

13.2 Mean for the red channel and the mean for the green channel.

13.3 Range for the red channel and the range for the green channel.

13.4 Number of readings taken.

13.5 Any deviations from these test methods which may have affected the results.

13.6 Any observations relevant to the quality of the test specimens.

13.7 In testing paper rather than mailpieces, any observations influencing the measurements, such as machine-direction orientation and side-of-sheet measured.

14. Precision and Bias

14.1 *Repeatability*—Based on a limited, preliminary interlaboratory test, the repeatability standard deviation and 95 % repeatability limits for background reflectance (see 3.2.6) are approximately 0.43 % and 1.2 % for the red channel, and 0.43 % and 1.2 % for the green channel.

14.2 *Reproducibility*—Based on a limited, preliminary interlaboratory test, the reproducibility standard deviation and 95 % reproducibility limits for background reflectance (see 3.2.6) are approximately 1.5 % and 3.7 % for the red channel, and 2.3 % and 6.4 % for the green channel.

14.3 Initial repeatability and reproducibility estimates for print reflectance (see 3.2.7) are believed to be similar to those for background reflectance, based on preliminary work. Precision estimates for print reflectance difference (see 3.2.9), print contrast ratio (see 3.2.10), and print show through (see 3.2.11) may be slightly larger than those for background reflectance, as these properties are calculated from values such as background reflectance and print reflectance in combination.

14.4 Additional interlaboratory testing is in progress or in planning, or both. Results of that work will be added as it becomes available. Use of this written procedure with preliminary precision estimates will facilitate those studies.

14.5 *Bias*—The properties in these test methods have no bias because these properties are defined only in terms of these test methods. No relationship should be inferred between the property values determined by these test methods and property values of the same name or measurement units, or both, determined by other test methods.

ANNEX

(Mandatory Information)

A1. DETAILS OF ERM-2 OPERATION FOR DETERMINATION OF PRINT CONTRAST RATIO AND PRINT REFLECTANCE DIFFERENCE BY MEASURING REFLECTANCE VALUES

A1.1 Follow procedures in Section 10 and in the operator's manual for calibrating and standardizing the ERM-2.

A1.2 With the "oper/cal mode" switch in the "oper" position, place the test unit under the aperture plate. The test unit should be held firmly against the aperture plate, without exhibiting waviness or wrinkles.

A1.3 Observe the image of the test unit on the view screen. The small black aperture stop in the middle of the larger rectangular template defines the area of the test unit that is measured (Fig. 2).

A1.4 With the test unit positioned firmly against the aperture plate, adjust its location so that the aperture stop is adjacent to the printing being tested (Fig. A1.1). Avoid areas displaying ink-splatter or other dirt associated with the printing process.

A1.5 Measure the reflectance of the test unit by moving the" paper/ink sample" switch from" hold" position to the "paper" position for approximately 3 s, then back to "hold".

A1.6 Move the test unit until the black rectangle completely covers an inked area for which PCR or PRD, or both, is to be determined (Fig. A1.2).

A1.7 Measure the reflectance of the printed area by moving the "paper/ink sample" switch to" ink" for 3 s, then back to "hold".

A1.8 Set the "red/green channel" switch to "red". The indicator light for "red" should be displayed on the view screen. Four numbers should be displayed.

A1.9 Record the red PRD and PCR values displayed.

A1.10 Move the "red/green channel" switch to "green" and record the green PRD and PCR values.

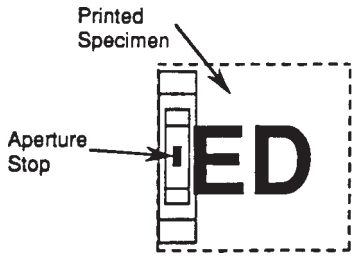

FIG. A1.1 Background Reflectance Measurement

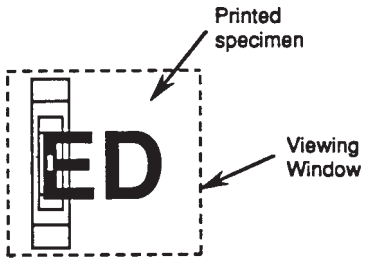

FIG. A1.2 Print Reflectance Measurement