



Standard Test Method for Equivalent Black Area (EBA) of Dirt in Pulp, Paper and Paperboard by Image Analysis¹

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INTRODUCTION

The level of visible dirt present in pulp, paper or paperboard can impact its usefulness in a specific end use application. In such cases, the presence of visible dirt specks that are high in number, easily noticed in visual examination, or both, may detract more from the apparent usefulness of the paper material than does a lower number of specks, or specks that are less easily noticed by the eye. Both the number of dirt specks and their visual impact may be important. For someone controlling or monitoring the papermaking process, the absolute physical area of dirt, or the number of dirt specks present in an inspection area may be of greatest importance. For the end user of the paper material, the overall visual impression may be the critical parameter.

1. Scope

1.1 This test method covers the use of image analysis to determine the level of dirt in pulp, paper, and paperboard in terms of Equivalent Black Area (EBA) of dirt specks within the physical area range of 0.02 to 3.0 mm² reported in parts per million as well as the number of dirt specks per square meter of sample. Using the algorithm prescribed in this test method, the maximum dirt size is limited to 3.0 mm². Extension to other speck sizes (for example those greater than 3.0 mm² in physical area), may require changes in equipment, calculation procedures, or both, and is not covered in this test method. This test method cannot be used for physical area measurements since it does not correctly measure the dirt specks for that mode of measurement.

1.2 The specimen to be evaluated must have a brightness, as determined by Test Method D985, of 30 % or greater. It may be necessary to reform some pulp sheets into handsheets if the surface is too rough or textured.

1.3 This test method is an instrumental equivalent of Test Method D2019, TAPPI T 437, and TAPPI T 213, all three of which report the equivalent black area of dirt in parts per million, and TAPPI T 537, which reports the number of specks of 0.02 mm² or larger per square meter. This test method can be implemented using any image analysis system, provided that it meets the criteria specified herein.

2. Referenced Documents

2.1 ASTM Standards:²

D585 Practice for Sampling and Accepting a Single Lot of Paper, Paperboard, Fiberboard, and Related Product

D985 Test Method for Brightness of Pulp, Paper, and Paperboard (Directional Reflectance at 457 nm)

D2019 Test Method for Dirt in Paper and Paperboard

E122 Practice for Calculating Sample Size to Estimate, With Specified Precision, the Average for a Characteristic of a Lot or Process

2.2 TAPPI Standards:³

T 213 Dirt in Pulp

T 272 Forming handsheets for reflectance testing of pulp (sheet machine procedure)

T 437 Dirt in Paper and Paperboard

T 537 Dirt Count in Paper (Optical Character Recognition—OCR)

T 1206 Precision Statement for Test Methods

3. Terminology

3.1 Definitions of Terms Specific to This Standard:

3.1.1 *dirt, n*—any foreign matter embedded in or on the sheet, which, when examined by reflected light has a contrasting, darker color to the sheet surface and has an equivalent black area of 0.02 mm² or greater as determined by this test method.

¹ This test method is under the jurisdiction of ASTM Committee D06 on Paper and Paper Products and is the direct responsibility of Subcommittee D06.92 on Test Methods.

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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.

³ Available from TAPPI, 15 Technology Parkway South, Norcross, GA 30092.

3.1.2 *equivalent black area (EBA), n*—the area of one of the round black spots (brightness of 2.4 % measured by Test Method **D985**) on the TAPPI Dirt Estimation Chart that has the same apparent area when examined visually upon its white background (brightness of 81.5 % measured by Test Method **D985**) as does the dirt speck when examined visually upon the particular sheet in or upon which it is embedded.

3.1.2.1 *Discussion*—A larger “gray” dirt speck has the same visual impact as a smaller “black” one when viewed on the same sheet and under the same conditions. The equivalent black area (EBA) of a dirt speck determined visually is generally less than its physical area. The EBA approaches the physical area only as the speck becomes large. This definition of EBA is technically identical to that found in Test Method **D2019**, **T 213** and **T 437**, and this test method produces results that are the technical equivalent of those test methods.

4. Significance and Use

4.1 The visual impact of a dark speck on a light background varies as a function of the speck size. The calculation of this visual impact is done based on Ricco’s law in this test method, and reported in terms of equivalent black area. As the dirt speck becomes sufficiently large, the equivalent black area of a black speck (brightness of 2.4 % as measured by Test Method **D985**) on a white background (brightness of 81.5 % as measured by Test Method **D985**) will approach the speck’s physical area. The use of the equivalent black area calculation procedure in this test method is highly significant, as it provides data continuity of dirt measurement with procedures such as Test Method **D2019** and TAPPI **T 437** which have been in use for over 50 years.⁴

4.2 Dirt is usually found on the surface of the sheet, however dirt particles that are imbedded may also be discernible by the eye in papers that are transparent or translucent. The level of visible dirt present in papers used in printing, writing, and other forms of communication may be both an aesthetic and performance requirement. For example, bond and writing papers may be subjected to close visual inspection in their intended use, but may also be required to perform on scanners, bar code readers, or other automated optical recognition devices where dirt above some critical level could impact performance.

4.3 Similar considerations may be appropriate for papers used in wrapping and packaging. In addition, special considerations may be required where such materials come in contact with foodstuffs, and where visible specks may be considered unacceptable.

4.4 Dirt in the form of gritty materials embedded in the sheet is a serious defect in many printing papers used in contact printing because of the pitting and wear that they can cause in printing plates. Such dirt can also occur in paperboard such as linerboard, and when present may cause significant reduction in bursting strength. Dirt of this type is not easily detected using this procedure, because there is little color contrast between the dirt speck and the background sheet.

4.5 In addition, the repeatability precision of this test method is significantly better than that of Test Method **D2019** or TAPPI **T 437**.

5. Apparatus

5.1 Description of the Apparatus:

5.1.1 *Detector*—The detector is densitometric with at least 256 gray levels (G.L.) of sensitivity with the physical pixel resolution having an effective area of 0.02 mm² or less. Precision improves with resolution. Therefore it is advisable to have as high a pixel resolution as is practical for the smallest dirt specks. The detector must view the specimen normal to its surface. The light is un-polarized and is concentrated in the visible portion of the spectrum such that 95 % of the detected light reflected from a white surface will be between 380 nm and 740 nm. The illumination must be diffuse or axially symmetric with an incident angle of $45 \pm 5^\circ$; the uniformity of the illumination on the specimen stage before any software corrections must be within ± 4 %. The specimen stage must be shielded to prevent influence from ambient light.

5.1.2 *Analyzer*—An analyzer incorporating “Equivalent Black Area” (EBA) calculations and using a technique called the “visual impact parameter” (see **Annex A1**).⁴ This parameter permits the system to perceive dirt in the same manner as would a human judge.

5.1.3 *Calibration Plates*—Calibration plates must be matte and have at least one solid white area and a solid black area. Two other image areas containing a minimum of 16 dots each with a brightness difference to their background of 20 % and 55 %. Additionally, the calibration plates must meet the specifications in **Annex A2**. Calibration plates are available from TAPPI.

5.2 Calibration:

5.2.1 Turn on the light source. Allow the equipment to warm up and adjust the hardware settings according to the instructions or recommendations. If there is an adjustable focus on the detector, verify that the calibration plate image is sharply focused. The system will have reached a steady state condition when five consecutive GL readings are within 2 % of each other.

5.2.2 *Contrast Calibration*—Place the calibration plate with the greatest contrast flat on the stage. If a device is used to hold a sample flat on the stage, then this same device must be used to hold the calibration plate flat.

5.2.2.1 *Zero Adjust*—With the black square in the field of view, scan the black area on the plate, adjust the instrument to report a value of not less than 9 out of 255 gray levels or 3.5 % of the full gray scale. Successive scans of the black area must give results within ± 0.4 % G.L. values.

5.2.2.2 *Span Adjust*—With the white square in the field of view, scan the white area on the plate, adjust the instrument to report a value not greater than 220 out of 255 gray levels or 86.3 % of the full gray level scale. Successive scans of the white area must give results within ± 0.4 % G.L. values. A minimum of 210 G.L. resolution between the black and white squares is required. The gray level scale must be precise enough that each gray level corresponds to a step of not more than 0.5 % reflectance units.

⁴ Jordan, B. D. and Nguyen, N. G., “Emulating the TAPPI Dirt Count with a Microcomputer,” *JPPS*, 14(1), 1988, J16–19.