

NOTICE: This document is a TAPPI Standard in ballot. Although available for public viewing, it is still under TAPPI's copyright and may not be reproduced or distributed without permission of TAPPI. This document is current under review to be maintained as a TAPPI Standard.

WI _____ 250808.04 _____

T _____ 437 _____

BALLOT NO. _____ 02-SARG _____

DRAFT NO. _____ 01 _____

DATE _____ October 16, 2025 _____

WORKING GROUP
CHAIR _____ N/A _____

SUBJECT
CATEGORY _____ Physical Properties _____

RELATED
METHODS _____ See "Additional Information" _____

CAUTION:

This Test Method may include safety precautions which are believed to be appropriate at the time of publication of the method. The intent of these is to alert the user of the method to safety issues related to such use. The user is responsible for determining that the safety precautions are complete and are appropriate to their use of the method, and for ensuring that suitable safety practices have not changed since publication of the method. This method may require the use, disposal, or both, of chemicals which may present serious health hazards to humans. Procedures for the handling of such substances are set forth on Safety Data Sheets which must be developed by all manufacturers and importers of potentially hazardous chemicals and maintained by all distributors of potentially hazardous chemicals. Prior to the use of this method, the user must determine whether any of the chemicals to be used or disposed of are potentially hazardous and, if so, must follow strictly the procedures specified by both the manufacturer, as well as local, state, and federal authorities for safe use and disposal of these chemicals.

Dirt In Paper and Paperboard

(Five-year review of Official Method T 437 om-21)

1. Scope

1.1 This method (I-3) is suited for the visual estimation of dirt in paper or paperboard in terms of equivalent black area. For dirt in pulp, see TAPPI T 213 "Dirt in Pulp."

1.2 This method is a visual inspection method for the evaluation of the Equivalent Black Area (EBA) measurement of dirt in paper and paperboard. An equivalent instrumental method using image analysis for the measurement of dirt in pulp, paper, and paperboard in units of parts per million is given in TAPPI T 563 "Equivalent Black Area (EBA) and count of visible dirt in paper and paperboard by image analysis." T 537 "Dirt count in paper and paperboard (optical character recognition - OCR)" reports the number of specks of 0.02 mm² or larger per square meter.

2. Definitions

2.1 Dirt in paper or paperboard is defined as any foreign matter embedded in the sheet, which, when examined by reflected, not transmitted, light has a contrasting color to the rest of the surface and has an equivalent black area of 0.04 mm² or over.

2.2 The equivalent black area of a dirt speck is defined as the area of a round black spot on the white background of the TAPPI Dirt Estimation Chart that makes the same visual impression on its background as does the dirt speck on the particular background in which it is embedded.

3. Significance

3.1 The method provides a measure of the apparent dirt area of a white or a colored sheet, affecting its aesthetic appearance using reflected light. A transparent dirt estimation chart **must not** be used.

3.2 The estimated equivalent black area of a gray or colored speck is smaller than its actual area, in inverse proportion to the intensity of its color contrast with its background. Thus the equivalent black area of a black spot in a brown paper would be considerably smaller than its actual area because its appearance would not be as pronounced as it would be if it were embedded in a white sheet.

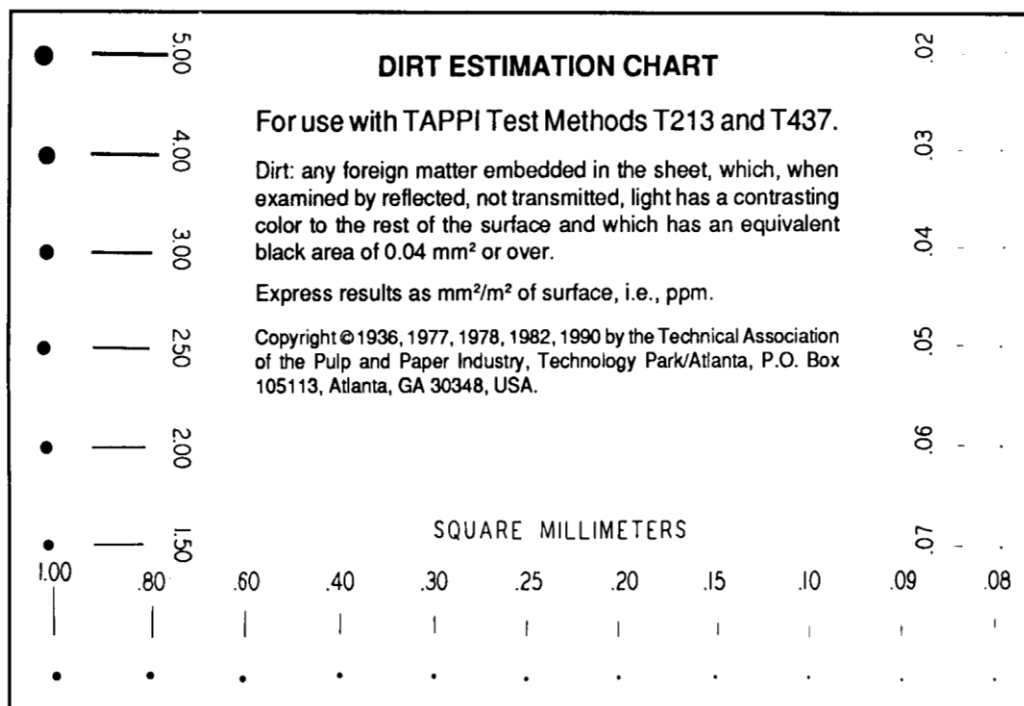
3.3 This method differs from T 537 "Dirt Count in Paper and Paperboard (OCR)," where each dirt speck is counted, regardless of size, shape or color.

4. Apparatus

4.1 *Dirt estimation chart*¹ (see Fig. 1). The actual chart is a photograph approximately 3 1/2 in. x 5 in. (89 mm x 127 mm) of a series of round black spots of various areas on a white background such that using an instrument and method in accordance with TAPPI T 452 "Brightness of Pulp, Paper, and Paperboard (Directional Reflectance at 457 nm)" the reflectance of the white background is $81.5 \pm 1.0\%$ and that of the black dots is $2.4 \pm 0.4\%$. In accordance with Graff's findings (4) all the round spots on the present chart are correct to within an average 10% or 0.005 mm^2 , whichever is the larger. The dirt estimation chart is intended for use on this method only. The chart is sufficiently precise within the limits of human visual acuity. It is not intended for use as a calibration standard on high resolution image analyzers.

4.1.1 Plastic-covered cards, photocopies, or printed charts other than the TAPPI Dirt Estimation Chart print, do not give equivalent results (5). Transparent dirt estimation charts must not be used.

4.1.2 Only the round spots are used for analysis (see 11.5).



¹ Available for purchase from TAPPI.

4.1.3 For highly precise work, the spot sizes can be measured microscopically, and correction factors can be developed and used as indicated by Graff (4).

4.2 *Illuminant*, lighting arrangements to give about 540 lm/m² (50 fc) of white light or daylight on the specimens. Because the light affects equally the appearance of both the dirt specks and the comparison spots on the charts, the intensity of illumination is not critical.

4.3 *Common reading glass* (optional).

5. Test specimens

5.1 Sample the paper in accordance with TAPPI T 400 "Sampling and Accepting a Single Lot of Paper, Paperboard, Containerboard, or Related Product."

5.2 From each test unit, select ten or more sheets having a total exposed area (both sides) of at least 10 m². Keep the specimen sheets clean between two outer extra sheets.

NOTE 1: There may be instances where less than 10 m² is examined. This may be acceptable when the quantity of dirt in the paper or paperboard exceeds the minimum required to reach a chosen level of counting precision and the sample is representative of the manufacturing process. Choose a consistent target of counting precision (see Section 9.5) and measure enough paper surface to reach that precision. Because the equivalent black area is disproportionately influenced by larger specks, one should count at least twice as many specks as the minimum dictated by the counting precision to achieve comparable precision in ppm.

6. Procedure

6.1 Make sure that hands are clean before examining the paper. Examine both sides of the specimens in a dust-free place, preferably on a bench top covered with a large sheet of clean white paper.

6.2 If the paper is fairly clean, as is usually the case, all dirt spots with an equivalent black area of 0.04 mm² or more should be counted. If the paper is not clean, the specks may be numerous enough to make the examination of the required area of the sample tedious. In this case, select a particular reference spot on the dirt chart which has an estimated black area such that at least one such size speck or larger will be found on each 500 cm² of the exposed surface of the specimens. (The size of the reference spots elected might vary from 0.08 mm² for a clean paper to 0.25 mm² or more for a dirty paper.) Dirt of this size and larger will be counted on the entire sheet. Dirt smaller than this will be counted on a smaller area as described in 6.4.

6.3 With one hand hold the specimen and place an edge of one of the sides of the dirt chart against it with the other. Examine the dirt specks on that side. Ignore the specks which are smaller than the reference spot selected in 6.2, or if no reference spot was selected, ignore specks smaller than 0.04 mm². Scratch each speck with a microscope pick in order to be sure that it is embedded dirt. Then estimate and record its equivalent black area.

NOTE 2: When estimating the equivalent black area of a colored speck or an irregularly shaped black spot on a white or colored sheet, proceed to select from the dirt chart with its white background an appropriate black spot that is equally noticeable. If the paper spot and selected chart spot have equivalent black area, both will become indistinguishable at the same distance when moved away from the eyes. They will also disappear together when observed through a film that scatters light slightly. Operators can easily train themselves to estimate the equivalent black area of specks more quickly and accurately than they can their actual area, especially if the specks have a shape different from those on the comparison chart. With the dirt chart in one hand and a specimen sheet in the other, they should be able to accurately gauge the equivalent black area of each speck on the specimen about as rapidly as they can mentally sum their areas. This is conveniently done by adding the equivalent black areas of the spots in units of hundredths of square millimeters.

6.4 Shives or specks which appear dark only at some particular angle of observation are not counted as dirt. However, if their number is noticeable, they should be recorded separately in the report, giving approximately their average actual area, their color or appearance, and the average number per square meter, for each side of the specimen.

6.5 If there are an unusual number of specks present in the sheet less than 0.04 mm² but over 0.02 mm², which normally are too small to be regarded as "dirt", their total equivalent black area may be estimated by scanning the area of each of the specimens with a one-twentieth open mask and reporting the equivalent black area separately.

6.6 If a reference spot larger than 0.04 mm² was used as the lower limit for the count in 6.3, prepare a mask having an opening equal to one-fifth of the area of the sheet. Place the mask on the same side of the specimen

sheet and examine the exposed one-fifth area for the specks smaller than the reference spot (but not less than 0.04 mm²) and sum up or record these.

6.7 Turn the specimen sheet over. Examine and record the equivalent black area of the specks on the other surface in the same way.

7. Calculation

Measure the area to be examined on both sides of the specimen sheets and record as square meters. Total the equivalent black area of the dirt specks on each side and record in square millimeters. Calculate the total square millimeters of dirt per square meter of surface examined for wire and felt sides. If the mask is used, total the equivalent black area of the larger specks on the entire area and add five times the equivalent black area of the smaller specks observed. Calculate the total square millimeters of dirt per square meter of surface examined.

8. Report

8.1 For each test unit, report the average dirt in terms of square millimeters of equivalent black area of dirt per square meter of surface examined (parts per million) for each side, as may be required, to two significant figures.

8.2 State the area and the number of specimen sheets examined.

8.3 Note the presence of any unusual number of shives or tiny specks as described above.

9. Precision

9.1 The following estimates of precision are based on limited experience with 3 lots of paper that had dirt levels ranging between 0.24 and 569 ppm. These lots were tested in 6 different laboratories.

9.2 Repeatability (within a laboratory) = 65%.

9.3 Reproducibility (between laboratories) = 158%.

9.4 The precision is poor because of differences in operator judgement. The technique is useful in spite of the poor precision because it is the best available method and because of the importance of the measurement. Individuals should determine if these repeatabilities and reproducibilities are satisfactory for their specific purposes.

9.5 The size distribution of naturally occurring dirt particles is log-normal and is approximated by a Poisson like distribution where the counting precision P (see Appendix of Ref. 7) is given by:

$$P = 100\% / N^{1/2}$$

where N is the total accumulated speck count. This implies that the precision of the count is dependent on the number of specks counted. For example: If a judge examined two samples, of equal area, where Sample A has a total speck count of 100 ($P = \pm 10.0$) and Sample B has a total speck count of 107 ($P = \pm 9.7$), then the counts are different by less than one standard deviation (i.e. 1 sigma) and would not be considered significantly different at 66%, or higher, confidence.

10. Keywords

Dirt, Dirt count, Paper, Paperboard, Contraries, Surfaces, Reflectance, Light

11. Additional information

11.1 Effective date of issue: To Be Assigned

11.2 This method was revised in 1939, 1943, 1955, 1963, 1978, 1985, 1996₂ and 2003. Revisions in this 2008 edition include a reference to the instrument image analysis methods in the scope.

11.3 With progress of bleaching and stock cleaning, commercial papers often contain less than 1 ppm of dirt.

11.4 By the procedure described in this method, the equivalent black area of any size, color, or shape on any surface can be estimated quickly, accurately, and more objectively, for example, by using a reading glass held slightly out of focus and comparing the speck with the series of round spots on the standard black and white chart. It should be appreciated that one cannot accurately measure the actual area of a dirt speck by visual comparison without using a comparison chart which not only has the same size, but also has approximately the same shape as the speck. Even then, if other than black, care is needed (especially in the case of a speck having a low contrast with its background) not to underestimate its true area. The use of a transparent chart for measuring the actual area of a speck is no more helpful; it merely accentuates the difficulty of estimating the areas of those specks having little contrast with their background. By definition, it is not possible to use a transparent dirt chart or transmitted light to measure the equivalent black area of specks of various sizes, shapes, and colors, since not only these factors but also the contrast between the speck and its own background and the reference spot and its standard white background (the TAPPI chart) are equally important.

11.5 In examining the dirt chart, it will be noticed that none of the rectangles stand out as well as the round dots having the same area. If examined with a reading glass held out of focus, with the particular shape of the rectangles used in the chart, it will be seen that their equivalent black area is only about two-thirds that of the round dots of the same actual area. Furthermore, in the actual photographic chart, the rectangles adjacent to the 0.02- and 0.03-mm² dots are invisible because of their thinness in relation to the resolving power of the photographic emulsions used. If all the rectangles shown were made still more slender, e.g., like long, thin black fibers, and their actual areas were correctly depicted, the discrepancy between their equivalent black areas and their actual areas would be still greater. Thus, as a measure of “dirt” - apart from the influence of color and background - the true criterion is not the actual area of the dirt speck but its equivalent black area.

11.6 Related methods: ASTM P2019 “Standard Test Method for Dirt in Paper and Paperboard,” AS/NZS 1301.204 rp 1993 “Estimation of dirt and shives in paper,” TAPPI T 213 “Dirt in Pulp,” PAPTAC D36.P “Dirt in Paper.”

11.7 The precision statement of this method is relatively poor and relates to the imprecision associated with the visual size estimation of small dirt specks. Instrumental methods, such as TAPPI T 563 “Equivalent Black Area (EBA) and Count of Visible Dirt in Pulp, Paper and Paperboard by Image Analysis,” have better precision.

References

1. Clark, J. d'A., von Hazmburg, R. S., and Knoll, R. J., “The Estimation of Dirt and Shives in Pulp and Paper,” *Paper Trade J.* **96** (5): 40 (1933).
2. Clark, J. d'A., “Method of Estimating the Dirt in Pulp and Paper,” *Tech Assoc. Papers* **16** (1): 347 (1933); *Paper Trade J.* (June 29, 1933); *Paper Maker* **86** (4): TS 188 (1933).
3. Clark, J. d'A., “An Improved Measure of Dirt in Pulp and Paper,” *Tappi* **42** (7): 173A (1959).
4. Graff, J. H., and Nihlen, E. K., “A Chart for the Estimation of Dirt in Pulp and Paper,” *Tech. Assoc. Papers* **25**: 331 (1942); *Paper Trade J.* **114** (21): 61 (1942).
5. “Dirt in Paper,” proposed revision of TAPPI Tentative Standard T 437, *Tappi* **46** (3): 131A (1963).
6. Clark, J. d'A., “Pulp Technology and Treatment for Paper”, Second Edition, Miller Freeman Publications, San Francisco, CA, 1985.
7. Trepanier, R. J., “User-Friendly System Analyzes Paper Formation, Dirt Speck Content, and Solid-Print Nonuniformity,” *Tappi* **72** (12): 153 (1989) (Appendix).

Your comments and suggestions on this procedure are earnestly requested and should be sent to the TAPPI Standards Department. ■