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Roughness of paper and paperboard (Sheffield method)

1. Scope

This method is a measurement of the air flow between the specimen (backed by flat glass on the bottom side) and two pressurized, concentric annular lands that are impressed into the sample from the top side. The rate of air flow is related to the surface roughness of paper or paperboard.

2. Summary

The measuring head, which has concentric annular lands, is dead-weight loaded against the specimen, which is supported by a flat glass surface. Air pressure is supplied to the zone between the annular rings that form the lands, and the flow rate of air that leaks between the surface of the paper and the metal lands in contact with the specimen is measured. The purpose of this test is to measure the extent to which the surface of a specimen deviates from a plane, as affected by the depth, width and number of departures from that plane. The measured flow rate of the leakage of air is an indirect measurement of surface roughness. This method does not read absolute roughness, but indicates the degree of roughness for comparison. The effective measuring range of this method is from 0 to approximately 445 Sheffield units.

3. Significance

3.1 Surface roughness has an important influence on the printing quality, as uniform ink coverage of the paper can be achieved only when the deepest depressions of the paper surface under impression are separated from the printing plate by not more than ink film thickness on the plate. Roughness also affects properties such as the coefficient of friction, gloss, and coating absorption.

3.2 This method describes a procedure for obtaining surface roughness data quickly, using a measuring head with air passages that can easily be inspected for blockage, and easily cleaned.

3.3 In addition to the air that leaks between the lands and the surface of the specimen, there is some leakage through the specimen due to its porosity and also to the roughness of the underside of the sheet. The degree to which the test results are affected is related to the air permeance and compressibility properties of the specimen.

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3.4 The air pressure that is supplied to the zone between the annular rings does not remain constant for the wide range of air flows that are within the capability of this test. Table 1 shows the relationship between pressure and flow.

3.5 The force with which the annular rings (lands) are loaded against the sample increases as the air pressure decreases. This is due to the force component (pressure times effective pressure area) that acts in an upward direction, opposite to the direction of the force of the dead weight.

3.6 If significant thickness variations are present in a specimen that is otherwise relatively smooth, the measured air flow will be higher than that which is measured on a similar surface that has uniform thickness.

4. Apparatus¹

The apparatus consists of an air supply, a pressure controller, a pressure measuring device, an air flow measuring device, and a test head assembly which houses a flat plate, the measuring head, and a mechanical device that lowers the test head onto the specimen that is inserted between the measuring head and the flat plate.

4.1 An *air supply*; free of oil, water, and other contaminants, capable of supplying the necessary flow and pressure to the system, as recommended by the instrument manufacturer.

Table 1. Air pressure between the annular test lands when the test head is loaded onto the specimen

Flow (mL/min) ⁽¹⁾	Pressure (kPa)	Flow (mL/min)	Pressure (kPa)
0	9.85	1700	7.20
100	9.80	1800	6.95
200	9.70	1900	6.70
300	9.60	2000	6.45
400	9.50	2100	6.20
500	9.35	2200	5.90
600	9.20	2300	5.60
700	9.05	2400	5.30
800	8.90	2500	5.00
900	8.70	2600	4.65
1000	8.55	2700	4.30
1100	8.40	2800	3.95
1200	8.20	2900	3.60
1300	8.00	3000	3.20
1400	7.80	3100	2.75
1500	7.60	3200	2.30
1600	7.40	3300	1.90

Notes:

- (1) Flow is measured in milliliters per minute (mL/min), referenced to 21°C and 760 mm Hg.
- (2) Pressure shown is ~~gage~~ gauge pressure.

4.2 A *measuring head*, on the under surface of which are concentric annular lands of a total area of $97 \pm 3 \text{ mm}^2$ ($0.15 \pm 0.005 \text{ in.}^2$) and each land being $0.380 \pm 0.010 \text{ mm}$ ($0.015 \pm 0.0004 \text{ in.}$) wide. The outer diameters of the outer and inner lands shall be $47.7 \pm 0.03 \text{ mm}$ ($1.853 \pm 0.001 \text{ in.}$) and $34.37 \pm 0.03 \text{ mm}$ ($1.353 \pm 0.001 \text{ in.}$), respectively. The lands shall be made of, or finished with a corrosion resistant material (i.e., stainless steel or chromium plating), and the finished surface shall be optically flat. The total mass of the measuring head shall be $1.640 \pm 0.005 \text{ kg}$.

4.3 A *glass surface plate*, sufficiently flat so that no greater than 10 mL/min (approximately one Sheffield unit) of air flow variation shall be detected as the measuring head is moved over the working area. The maximum leakage between the measuring head lands and the glass plate shall not exceed 15 mL/min (approximately two Sheffield units) when the gravity loading on the lands and test air pressure conform to test conditions. There is a mutually-dependent relationship between the surface finish of the glass and the measuring lands that must limit the leakage to 15 mL/min.

4.4 An *air flowmeter*, having the capability to measure the range of flow required for the samples to be tested. A range of 0 to 3400 mL/min (0-400 SU) is recommended.

¹ Names of suppliers of testing equipment and materials for this method may be found on the Test Equipment Suppliers list in the set of TAPPI Test Methods, or may be available from the TAPPI Quality and Standards Department.