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Air resistance of paper (Gurley method)

1. Scope

1.1 This method is used to measure the air resistance of approximately 6.45 sq. cm. (1 sq. in.) circular area of paper using a pressure differential of 1.22 kPa. The recommended range of the liquid column instrument is from 5 to 1800 seconds per 100 mL cylinder displacement. For more impermeable papers the time requirements become so excessive that other techniques are preferable.

1.2 This method measures the volume of air that passes through the test specimen, along with any possible leakage of air across the surface; therefore it is unsuitable for paper or paperboards which cannot be securely clamped so as to avoid significant surface and/or edge leakage.

1.3 For a similar method of measuring air resistance that tests paper at a higher pressure (approx. 3 kPa), and has higher resolution in measuring smaller air volumes, refer to TAPPI T 536. For a method of measuring air permeance at pressures up to 9.85 kPa, using both smaller and larger test areas, refer to TAPPI T 547.

2. Summary

This method measures the amount of time required for a certain volume of air to pass through a test specimen. The air pressure is generated by a gravity-loaded cylinder that captures an air volume within a chamber using a liquid seal. This pressurized volume of air is directed to the clamping gasket ring, which holds the test specimen. Air that passes through the paper specimen escapes to atmosphere through holes in the downstream clamping plate.

3. Significance

The air resistance of paper may be used as an indirect indicator of Z-directional fluid permeance, as well as other variables such as: degree of refining, absorbency (penetration of oil, water, etc.), apparent specific gravity, and filtering efficiency for liquids or gases. Air resistance is influenced by the internal structure and also the surface finish of the

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paper. Internal structure is controlled largely by the type and length of fibers, degree of hydration, orientation, and compaction of the fibers; as well as the type and amount of fillers and sizing. The measurement of air resistance is a useful control test for machine production; but due to the number and complexity of factors outlined above; careful judgment should be used in the specification limits for air resistance.

4. Definition

Air resistance is the resistance to the passage of air, offered by the paper structure, when a pressure difference exists across the boundaries of the specimen. It is quantified by obtaining the time for a given volume of air to flow through a specimen of given dimensions under a specified pressure, pressure difference, temperature, and relative humidity.

5. Apparatus¹

5.1 Oil sealed instruments

5.1.1 Air resistance apparatus, consisting of a vertically positioned outer cylinder which is partly filled with a sealing fluid, and an inner cylinder that can slide freely in the outer cylinder. Air pressure, generated by the weight of the inner cylinder, is applied to the specimen which is held between clamping plates. The outer cylinder should be filled with a sealing fluid to a depth of about 125 mm, as indicated by a ring on the inside surface of the cylinder or to a depth specified by the manufacturer

5.1.2 The clamping plates are located at the bottom of the apparatus, and a center feed tube directs the pressurized air to the clamping plates. The top of the floating inner cylinder is closed.

NOTE 1: On some earlier instruments, the clamping plates are mounted on top of the floating inner cylinder. Refer to Appendix A.1 for additional details.

Some versions of this apparatus utilize a hand-tightened capstan (jackscrew) arrangement to tighten the clamping plates together, while other versions are equipped with a dead weight (typically 0.907 kg) loading a lever arm. The recommended clamping force is 180 ± 30 newtons. This mechanism provides a technique to give uniform loading, and thus minimize the operator influence on the test. Controlled clamping force is the preferred method of clamping the specimen.

5.1.3 An elastomeric gasket is attached to the clamping plate on the side exposed to air pressure to minimize the leakage of air between the surface of the paper specimen and the clamping plate. The gasket is 28.58 ± 0.13 mm inside diameter and 34.93 ± 0.13 mm outside diameter. A satisfactory material is Thiokol, grade ST, polished plate molded, 0.8 ± 0.1 mm thick, 50-60 IRHD (International Rubber Hardness Degrees – ISO 48). Other materials may be recommended by the instrument manufacturer. Since the hardness of the elastomer will change with age, this gasket must be replaced on a periodic basis to ensure optimum sealing characteristics. For alignment and protection, the gasket is cemented in a groove machined in the clamping plate. The groove is concentric with the aperture in the opposing plate. The groove is $28.45 +0.000/-0.08$ mm inside diameter and about 35 mm outside diameter to fit the outside diameter of the basket, at a depth of 0.50 ± 0.03 mm.

5.1.4 The outer cylinder is 254 mm high with an internal diameter of 82.6 mm. It has four vertical bars, each 245.5 mm long, 2.4 mm wide and 2.4 mm thick, mounted equidistantly on the inner surface of the outer cylinder to serve as guides for the inner cylinder. It has a fluid level indicator to assist in adding the proper amount of sealing fluid.

5.1.5 The inner cylinder is 254 mm high with an outside diameter of 76.2 mm, an inside diameter of 74.1 mm, and has a total mass of 567 ± 0.5 g, so as to produce a nominal pressure of 1.22 kPa. It is made of an aluminum alloy and has graduation marks on the outside diameter which represent the volume circumscribed within the cylinder. These marks are used to indicate a certain volume of air that passes through the clamping area that holds the paper specimen. The cylinder is graduated in units of 50 mL with a total range of 350 mL.

NOTE 2: Some inner cylinders are also graduated in units of 25 mL for the first 100 mL, and have a graduation at the 400 mL interval.

¹ Names of suppliers of testing equipment and materials for this method may be found on the Test Equipment Suppliers list, available as part of the CD or printed set of Standards, or on the TAPPI website general Standards page..

5.1.6 A stopwatch or electric timer, capable of recording time to the nearest 0.1 second, is required. Some instruments are available with automatic timing devices.

5.2 *Electronic instruments*

5.2.1 There is another technique in use (1) that utilizes an electronic mass airflow meter to measure the outflow of air from a paper specimen that is subjected to a pressure differential of 1.22 kPa. By measuring the outflow (discharge of air) from the specimen, surface leakage does not bias the measurement. The test results are virtually identical to those obtained from the liquid column instrument when there is no surface leakage at the clamping rings of the liquid column instrument.

6. Materials

Sealing fluid: The outer cylinder is filled to the liquid level indicating mark with a lubricating oil having a kinematic viscosity of 10 to 13 mm²/s (60-70 s Saybolt Universal) at 38°C and a flash point of at least 135°C. The specific gravity at 23°C must be between 0.86 and 0.89.

NOTE 3: A light spindle oil is suitable for this purpose. Oil must be used instead of water because it does not affect the moisture content of the specimen. Also, the higher specific gravity of water will affect the volume of air that passes through the specimen, as there is a “manometer effect” that causes a different amount of air to pass through the specimen than indicated by the graduations on the inner cylinder.

7. Calibration

7.1 The instrument can be tested for air leakage by clamping a thin piece of smooth impervious metal foil or cellophane between the clamping plates. A maximum leakage of 50 mL in 5 h is allowable. This test does not ensure a similar low surface leakage for a paper specimen under test.

7.2 Electronic timing devices should be checked in accordance with the manufacturer's instructions. Calibration flow restrictor plates will facilitate this test. Perform the calibration checks in accordance with the manufacturer's instructions.

8. Sampling

Obtain a sample of the paper in accordance with TAPPI T 400 “Sampling and Accepting a Single Lot of Paper, Paperboard, Containerboard, or Related Product.”

9. Test specimens

Prepare 10 test specimens of sufficient size from each test unit of the sample. A 50 mm square, or larger size, is generally adequate.

NOTE 4: The test results for some grades of paperboard may be affected by specimen cut size when there is inadequate stick-out from the clamping rings. This is due to transverse flow through the edge of the specimen, rather than all of the air flowing through the sheet in the Z direction.

10. Conditioning

Condition and test the specimens in an atmosphere in accordance with TAPPI T 402 “Standard Conditioning and Testing Atmospheres for Paper, Board, Pulp Handsheets, and Related Products.”

11. Procedure

11.1 *Oil sealed instrument*

11.1.1 Place the instrument on a level surface, free of vibrations, so that the outer cylinder is vertical.