T 543 om-00
PROVISIONAL METHOD – 1984
OFFICIAL METHOD – 1994
REVISED – 2000

This TAPPI Test Method has been adopted and endorsed by the Tag and Label Manufacturers Institute, Inc. (TLMI).

Bending resistance of paper (Gurley-type tester)

1. Scope

1.1 This procedure determines the bending resistance of paper, paperboard, and other materials by measuring the force required to bend a specimen under controlled conditions. The instrument described allows for a wide variation in specimen length and width, and in applied force.

1.2 This procedure is not recommended for soft or limp materials such as tissue, toweling and newsprint, or for materials with a pronounced degree of curl.

2. Significance

The bending resistance of paper affects many converting operations and most end-uses. The bending resistance of paperboard is basic to most of the uses to which this material is put. It is necessary to have a convenient, reproducible test method to measure this fundamental characteristic.

3. Definitions

3.1 *Bending resistance*: The ability to resist an applied bending force.

3.2 *Machine direction bending resistance*: The bending resistance of a test specimen, clamped with the machine direction of the paper perpendicular to the specimen clamp.

3.3 *Cross direction bending resistance*: The bending resistance of a test specimen, clamped with the cross direction of the paper perpendicular to the specimen clamp.

3.4 *Gurley units, the* units assigned to represent the force required to bend the specimen as calculated by Equation 1 (see 9.1). Traditionally the results have been reported in terms of milligrams of force (mgf) which are identical to the now preferred term of Gurley units. In terms of force units (millinewtons) the following applies:

$$\text{Force, mN} = 9.807 \times 10^{-3} \text{ (Gurley units)}$$

4. Apparatus

4.1 *Bending resistance*[1]

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

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4.1.3 Weights of 5 g, 25 g, 50 g, and 200 g are provided. The tolerance on weight is ± 0.1%. They are attachable to the lower end of the pendulum at distances of 25.4 mm (1.0 in.), 50.8 mm (2.0 in.), and 101.6 mm (4.0 in.) from the pivot.

4.1.4 The instrument is mounted upon a base which is provided with a spirit level, leveling screws and a reversing switch for operating the motor.

4.1.5 The instrument provides for 150 different combinations of specimen size and loading, encompassing a stiffness range of 1.39 to 56,888 Gurley units.

4.2 *Paper cutter.* See Note 1 in 6.1 below.

5. Sampling

5.1 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. "

5.2 Select test units free from watermarks or unusual flaws or creases that might subsequently affect the test results.

5.3 Avoid unnecessary handling of the test units prior to testing.

6. Test specimens

6.1 From each test unit cut specimens 50.8 ± 0.4 mm (2 ± 1/64 in.) wide by 63.5 ± 0.4 mm (2.5 ± 1/64 in.) long. This is the nominal length of 50.8 mm (2.0 in.) plus an extra 12.7 mm (0.5 in.) to provide 6.4 mm (0.25 in.) for clamping and 6.4 mm (0.25 in.) for the vane overlap. Ten specimens should be cut five in the machine direction and five in the cross direction.

NOTE 1: The length of the strip is very critical. An error of 1% in the length of the 63.5 mm strip can cause an error of 4% in the bending resistance reading. Therefore, it is required that the strips be cut with a 63.5 mm (2.5 in.) double knife cutter such as that used for the Elmendorf tearing resistance test. The specimens should be cut one at a time to avoid the burrs produced by cutting several sheets at one time.

6.1.1 Although the length of 63.5 mm (2.5 in.) and width of 50.8 mm (2 in.) should be used wherever possible, the test specimen length and width may be varied to provide a test reading between 2 and 6 on the scale. Specimen width between 12.7 mm (0.5 in.) and 50.8 mm (2 in.) can be used. If a width other than the preferred width of 50.8 mm is used, this should be reported with results. Specimen length can be selected from the table below:

Cut length	*Test length, L_t*	*Length ratio, L_r*
25.4 mm (1.0 in.)	12.7 mm (0.5 in.)	0.167
38.1 mm (1.5 in.)	25.4 mm (1.0 in.)	0.333
63.5 mm (2.5 in.)	50.8 mm (2.0 in.)	0.667
88.9 mm (3.5 in.)	76.2 mm (3.0 in.)	1.000
114.2 mm (4.5 in.)	101.6 mm (4.0 in.)	1.333

The cut length refers to entries in the conversion factor table; the test length and length ratio are used in evaluating Equation 1.

NOTE 2: For all specimens, a suitable cutter should be used to insure accurate specimen preparation.

7. 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."