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Zero-span breaking strength of pulp (dry zero-span tensile)

1. Scope

1.1 This method provides a quick, reliable means to measure the zero-span tensile strength of a randomly oriented specimen of fibers when dry.

1.1.1 Similar procedures for determining the zero-span tensile strength of a randomly oriented specimen of fibers when wet are found in TAPPI T 273 “Wet Zero-Span Tensile Strength of Pulp” (currently withdrawn).

1.2 In this test method, the fibers are tested as a handsheet produced using a standardized procedure such as TAPPI T 205 “Forming Handsheets for Physical Tests of Pulp.”

1.3 While testing is possible on finished paper materials, information on fiber quality from intermediate steps in the pulping or papermaking process, or both, is frequently more useful for improving finished paper quality or improving fiber utilization of, for example, recycled fibers, or fibers subjected to new pulping, bleaching, or finishing processes.

1.4 The modifications of the standard procedure described in this test method required for testing finished paper is straightforward, however testing must be done in the two principle directions of the sheet, as required in TAPPI T 494 “Tensile Breaking Properties of Paper and Paperboard (using Constant Rate of Elongation Apparatus),” since the finished paper or paperboard will generally have non-random fiber orientation, resulting in different strength properties in the two principle directions of the finished sheet. Testing of sheets having a grammage greater than 100 g/m², which includes some paper materials described as paper and many paperboards, is difficult because of problems associated with clamping of individual fibers as the number of fibers per unit area increases.

1.5 Such modifications are not described in this test method, and if they are made, they must be acknowledged and clearly described in the Report as deviations from the standard procedure.

1.6 In addition to a measure of the dry zero-span tensile strength of the specimen of fibers, an index of the cohesiveness of fibers in the sheet is also provided by the ratio of the tensile strength determined using TAPPI T 494 and the tensile strength determined using this test method when all testing is done on handsheets having random fiber orientation (1).

1.7 Two instrumental approaches for accomplishing the measurement of dry tensile strength at zero-span are described.

1.7.1 One approach is use a specially constructed pair of “zero-span” jaws which are used in conjunction with a conventional tensile testing machine¹.

1.7.1.1 One such design for “zero-span” jaws was proposed by Clark (1). A second design was proposed by Wink and Van Eperen (2).

1.7.2 A second approach incorporates both “zero-span” jaws and measurement and readout devices in a single instrument¹.

1.7.3 When properly adjusted and calibrated, either approach may be used to perform this test.

2. Significance

2.1 The zero-span tensile test measures the tensile strength at the moment of tensile failure of fibers randomly oriented in a sheet.

2.2 One important use of zero-span tensile data is to determine the maximum strength of pulp fibers when beaten under idealized laboratory conditions.

2.3 Zero-span tensile strength is an excellent measure of the “maximum strength” of a pulp, and is almost completely independent of the laboratory beating procedure used.

2.4 Zero-span tensile strength, in conjunction with tensile strength as measured by TAPPI T 494 and other physical properties tests, is useful in optimizing fiber processing techniques and maximizing utilization of fiber sources such as recycled fibers for the highest possible quality of the end-use paper or paperboard.

3. Applicable documents

3.1 TAPPI documents: TAPPI T 211 “Ash in Wood, Pulp, Paper and Paperboard, Combustion at 525°C,” or TAPPI T 413 “Ash in Wood, Pulp Paper and Paperboard, Combustion at 900°C,” TAPPI T 205 “Forming Handsheets for Physical Tests of Pulp,” TAPPI T 220 “Physical Testing of Pulp Handsheets,” TAPPI T 402 “Standard Conditioning and Testing Atmospheres for Paper, Board, Pulp Handsheets, and Related Products,” TAPPI T 494 “Tensile Breaking Properties of Paper and Paperboard (Using Constant Rate of Elongation Apparatus),” TAPPI T 273 “Wet Zero-Span Tensile Strength of Pulp” (currently withdrawn).

3.2 ASTM documents: D 1193 “Specification for Reagent Water.”

4. Definitions

4.1 Zero-span, *in tensile testing*, having a grip separation of 0.00 mm (0.000 in.).

5. Apparatus

5.1 Zero-span jaws.

5.1.1 Apparatus comprised of two adjacent, spatially aligned clamping jaws in initial intimate contact (“zero-span”), which reliably and reproducibly exert a very high, optimum and uniform clamping pressure on fibers in test specimen reagent water using a designed procedure. The essential elements that must be incorporated into any zero-span tester are shown in Fig. 1.

5.1.1.1 The clamping pressure required ensures a maximum clamping effect but cannot totally prevent the microslippage whereby the tensile load transmitted in the clamped fibers is dissipated by frictional shear into the clamping jaws. This microslippage means that the ends of some fibers will slip out from beneath a clamping jaw thereby diminishing the number of fibers carrying the load at tensile failure. For this reason, careful interpretation of zero-span tensile strength values must be exercised in order to separate effects due to the relative number of fibers which are carrying the load at failure and the effects due to the average tensile strength of the individual fibers present in the aggregate.

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

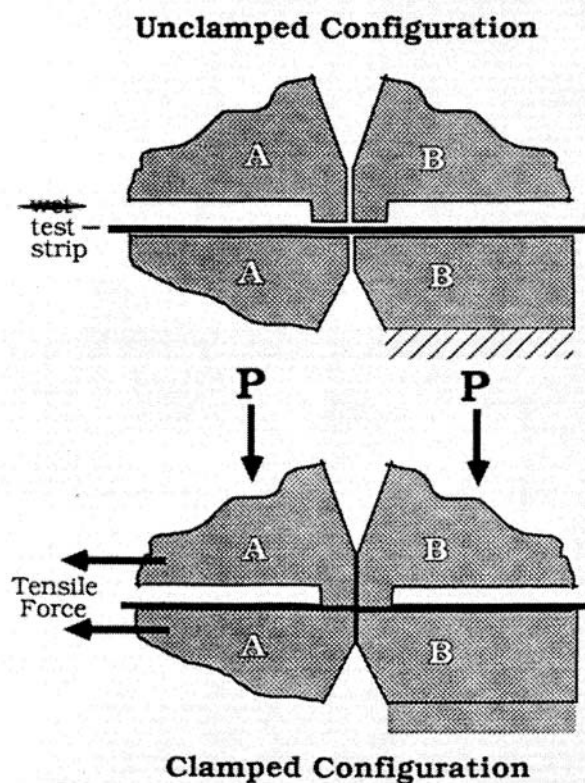


Fig. 1. Essential elements for any zero-span tester.

5.1.2 While firmly clamping the specimen, the clamps must be able to separate at a defined uniform rate of loading until the sample fails.

5.1.3 There are two adjacent clamping jaws which, in an unpressurized configuration, allow a test strip to be inserted between them. In the pressurized configuration both jaws come together to apply a very high and uniform clamping pressure to the test strip. This securely clamps the fibers in the specimen that cross the clamping line defined by the intimate and very accurate spatial alignment of the two jaws at zero-span.

5.1.4 A suitable clamping arrangement for either of the two clamping jaws is illustrated in Fig. 2. The required clamping dimensions include a clamping width of not less than 15.0 mm and a clamping length of not less than 0.60 mm. Clamping widths as great as 22.0 mm and clamping lengths of 0.80 mm have been found satisfactory. It is extremely important that the clamping width be accurately determined to ± 0.01 mm using a digital caliper or similar device with calibration accuracy traceable to NIST or equivalent national standardizing body, and that the two clamps making up a pair have identical clamping widths to the same tolerance. The exact length of the clamp is not so critical, but pairs of clamps must have widths identical to the tolerance specified above; ± 0.01 mm. The clamping jaws should come together to provide a clamping pressure which is uniform across the clamping width to better than 1 part in 1000. The clamping jaws should be manufactured to ensure the maintenance of such precision over an extended period of repetitive high pressure clamping (stainless steel or other rust resistant alloy).

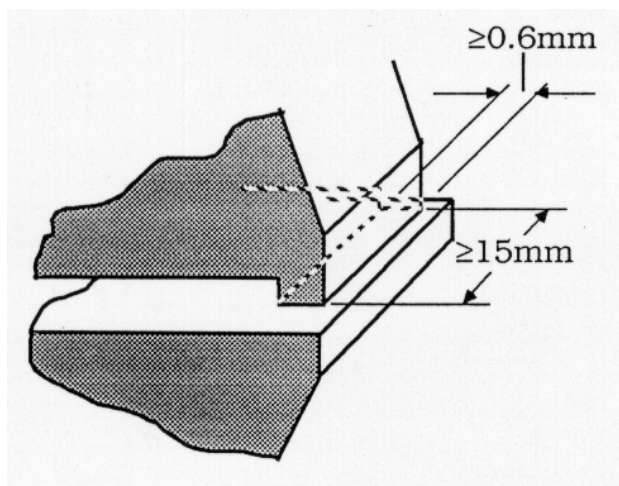


Fig. 2. Suitable clamping arrangement for either of the two clamping jaws.

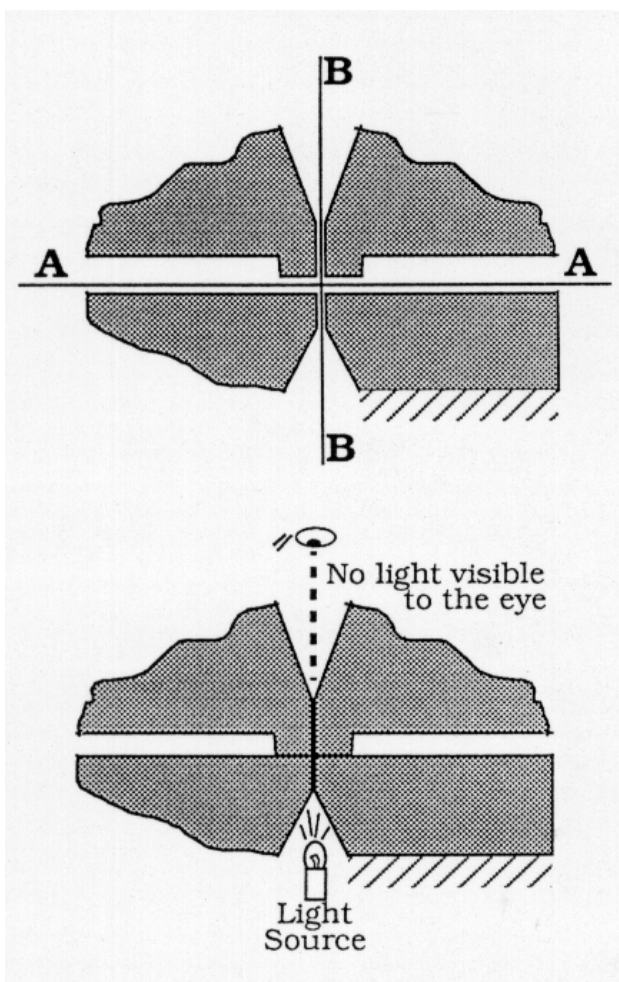


Fig. 3. Spatial alignment of the two jaws.

5.1.5 The spatial alignment of the two jaws is illustrated in Fig. 3. The top and bottom clamping surfaces of both sets of jaws must come together in the clamped arrangement so as to create the two precision planes illustrated. The horizontal surfaces of both jaws must, when clamped, conform to Plane A to a precision of better than 0.005 mm. The