



Standard Test Methods for Zero-Span Tensile Strength (“Dry Zero-Span Tensile”)¹

This standard is issued under the fixed designation D 5804; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test 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 Test Method D 5803.

1.2 In this test method, the fibers are tested as a handsheet produced using a standardized procedure such as TAPPI T 205.

1.3 While testing is possible on finished paper materials, information on fiber quality from intermediate steps in the pulping or paper making 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 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 Test Method D 828, 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 shall 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 Test Method D 828 and the tensile strength determined using this test method when all testing is

done on handsheets having random fiber orientation **(1)**.²

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

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

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 is the use of a special instrument incorporating both “zero-span” jaws and measurement and readout devices in a single instrument.³

1.7.3 When properly adjusted and calibrated, either of the instrumental approaches may be used to perform this test method.

1.8 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:

D 586 Test Method for Ash in Paper⁴

D 685 Practice for Conditioning Paper and Paper Products for Testing⁴

D 828 Test Method for Tensile Breaking Strength of Paper and Paperboard⁴

D 1193 Specification for Reagent Water⁵

D 1968 Terminology Relating to Paper and Paper Products⁴

D 5803 Test Method for Wet Tensile Strength at Zero-Span (“Wet Zero-Span Tensile”)⁴

2.2 TAPPI Test Methods:

T 205 Forming handsheets for physical tests of pulp⁶

T 220 Physical testing of pulp handsheets⁶

² The boldface numbers in parentheses refer to the list of references at the end of this test method.

³ One self-contained instrument suitable for making the measurements described in this test method is available from Pulmac Instruments International, Box 50, HCR 34, Montpelier, VT 05602. There may be other sources.

⁴ *Annual Book of ASTM Standards*, Vol 15.09.

⁵ *Annual Book of ASTM Standards*, Vol 11.01.

⁶ Available from the Technical Association of the Pulp and Paper Industry (TAPPI), Technology Park/Atlanta, P.O. Box 105113, Atlanta, GA 30348.

¹ This test method is under the jurisdiction of ASTM Committee D-6 on Paper and Paper Products and is the direct responsibility of Subcommittee D06.92 on Test Methods.

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3. Terminology

3.1 Definitions shall be in accordance with Terminology D 1968 and the *Dictionary of Paper*.⁶

4. Significance and Use

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

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

4.3 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.

4.4 Zero-span tensile strength, in conjunction with tensile strength as measured by Test Method D 828 and other physical properties tests, is useful in optimizing new fiber processing techniques and maximizing utilization of new fiber sources such as recycled fibers for the highest possible quality of the end-use paper or paperboard.

5. Apparatus

5.1 *Zero-Span Jaws*, 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 a test specimen. The essential elements that must be incorporated into any zero-span tester are shown in Fig. 1.

5.1.1 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 shall 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.

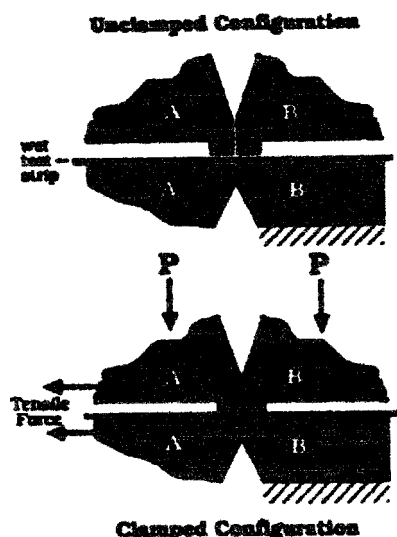


FIG. 1 Essential Elements for Any Wet Zero-Span Tester

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

5.3 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.

5.4 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 0.060 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 the ± 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 shall have widths identical to the specified tolerance; ± 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 in a wet environment (stainless steel or other rust-resistant alloy).

5.5 The spatial alignment of the two jaws is illustrated in Fig. 3. The top and bottom clamping surfaces of both sets of jaws shall come together in the clamped arrangement so as to create the two precision planes illustrated. When clamped, the horizontal surfaces of both jaws shall conform to Plane A to a tolerance of 0.005 mm or less. When clamped, the vertical surfaces which are in contact at zero-span shall conform to Plane B with a tolerance such that a light beam is completely interrupted when the jaws are in clamped zero-span contact.

5.6 The apparatus shall provide the capability to cause both clamping jaws to come together so as to induce an adjustable range of measurable clamping pressures sufficient to demonstrate optimum clamping of the fiber test strip.

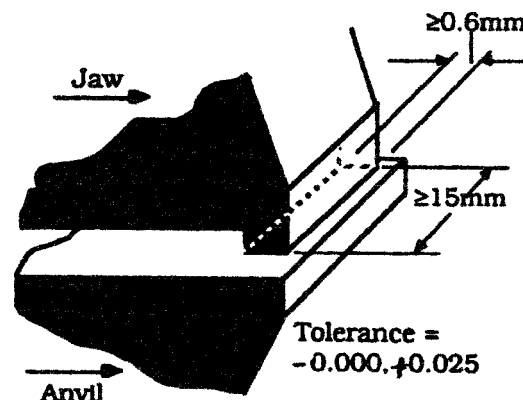


FIG. 2 Suitable Clamping Arrangement for Either of the Two Clamping Jaws

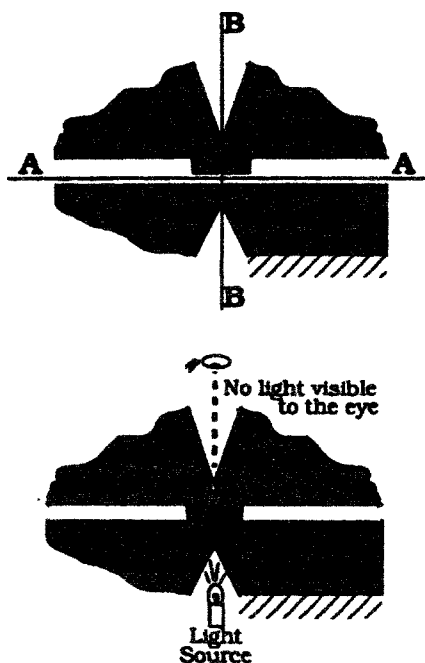


FIG. 3 Spatial Alignment of the Two Jaws

5.7 Increasing the jaw clamping pressure from a low value improves clamping efficiency, resulting in an increase in the observed zero-span tensile failure load of the fiber aggregate. Such increases will continue until the clamping pressure reaches a level which causes fiber damage, after which the zero-span tensile failure load of the fiber test strip will be observed to decline. The clamping pressure which maximizes the zero-span tensile failure load of the fiber test strip is the optimum clamping pressure.

5.8 There are at least three zero-span jaw systems complying with the requirements in Section 5. These are the specially designed zero-span jaws of Clark (4), and those of Wink and Van Eperen (5), either of which can be used with a conventional tensile testing instrument such as is described in Test Method D 828, and a self-contained unit comprised of a tensile measuring system and zero-span jaws.³ No further description of the jaws incorporated in the self-contained unit is required beyond that in 5.1 through 5.7. The description of the separate jaws which may be attached to a conventional tensile testing machine (5.2.2) is as follows:

5.9 Zero-Span Jaw Attachment (Fig. 4 and Fig. 5)³:

5.9.1 The generally available zero-span attachment jaws for use with conventional tensile testers (5.2) are pairs of jaws with flat tips made from hardened steel and of one of the two shapes shown schematically in Fig. 3. Provided that the attachment jaws are very carefully made so that the fit and alignment of the tips of the jaws is as described in 5.5, the general designs of the attachment appear to have no appreciable effect on the test results.

5.9.2 One of the attachment jaws is fixed to a plate having a tang to fit into a universal coupling or grip of the tensile tester. The other of the jaws forms a sliding member with the tensile tester. The sliding member is constrained to move parallel to and against the plate and is arranged to be clamped to the plate by means of a knurled screw. When the screw is

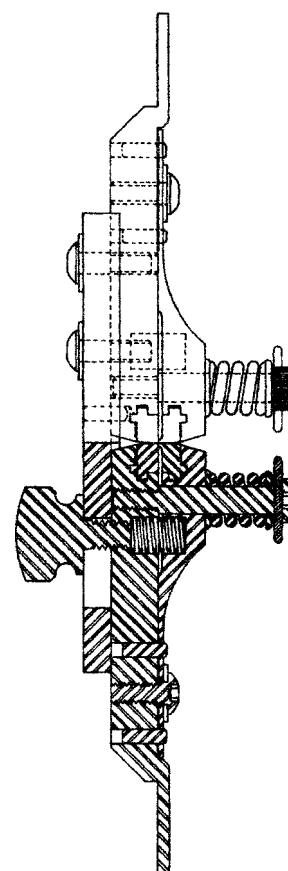
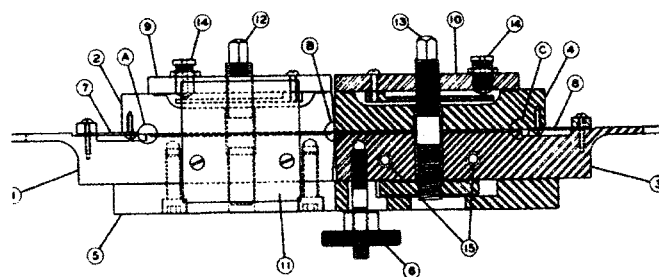


FIG. 4 Clark Attachment



- Legend: A, B, C = clamping surfaces
 1, 2 = jaw members,
 3, 4 = movable jaws,
 5 = base plate,
 6 = knurled locknut,
 7, 8 = flat spring stock,
 9, 10 = loading beams,
 11 = guide plate
 12, 13 = differential screw,
 14 = electrical contactor
 15 = knurled nuts.

FIG. 5 IPC Attachment

loosened, this member is enabled to slide without restraint along guides attached to the plate, thus moving its jaws away from the jaws fixed to the plate, and so to rupture the specimen.

5.9.3 The outer jaw of each pair is movable outward and is arranged to be clamped against its mating jaw by means of a screw. The applied closing pressure is controlled either by