1. **Scope**

This method is used to measure the bending resistance of corrugated fiberboard in the machine or cross machine direction with a bench-type instrument.

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**CAUTION:**

This Test Method may include safety precautions which are believed to be appropriate at the time of publication of the method. The intent of these is to alert the user of the method to safety issues related to such use. The user is responsible for determining that the safety precautions are complete and are appropriate to their use of the method, and for ensuring that suitable safety practices have not changed since publication of the method. This method may require the use, disposal, or both, of chemicals which may present serious health hazards to humans. Procedures for the handling of such substances are set forth on Safety Data Sheets which must be developed by all manufacturers and importers of potentially hazardous chemicals and maintained by all distributors of potentially hazardous chemicals. Prior to the use of this method, the user must determine whether any of the chemicals to be used or disposed of are potentially hazardous and, if so, must follow strictly the procedures specified by both the manufacturer, as well as local, state, and federal authorities for safe use and disposal of these chemicals.

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**Flexural stiffness of corrugated board**

(Proposed WITHDRAWAL of Classical Method T 820 cm-09 in favor of a future transformation to a Useful Method)

(See justification in Section 13.4)

(Re-balloted due to insufficient SSIG members)
2. Summary

2.1 This method measures the flexural stiffness of corrugated board using a four-point beam test (Fig. 1). A specimen cut either in the machine or cross direction is placed on two supporting anvils. Two loading anvils are placed on top of the specimen. The top anvils are then successively loaded with weights of equal increments. The deflection caused by each weight is measured with a micrometer.

![Four point beam](image)

Fig. 1. Four point beam.

2.2 This method is intended to be used as a bench test. Mechanical instrumentation can be used for loading and measuring deflection.

3. Significance

3.1 Work performed by the Institute of Paper Chemistry shows that the top-to-bottom compression strength of corrugated boxes is partly dependent on the load-carrying ability of the central panel areas. The ability of these central areas to resist bending under load will increase the stacking strength of the box. The difference in box compression strengths between boxes of identical size made from the same components but of different flute sizes (if the load is applied parallel to the flutes) is primarily due to differences in the flexural stiffness of the box panels. Flexural stiffness measurements of the combined board when used with the edge crush test can accurately predict the top-to-bottom compression strength of a box.

3.2 Flexural stiffness measurements may be of value in determining the board requirements for such uses as construction materials where rigidity is desired.
4. **Apparatus**

4.1 The four-point beam test can be run either manually or on automatic testing equipment. This procedure describes the apparatus for the manual test only.

4.2 The lower support assembly consists of two vertical support anvils having a 0.318-cm (1/8-in.) radius on the loading edge. The anvils should be 5.08 to 7.62 cm (2 to 3 in.) high, 5.08 cm (2 in.) wide and movable on the support base. The span should be adjustable from 5.08 to 30.48 cm (2 to 12 in.). A micrometer caliper hooked to a battery and a light is used to measure the amount of deflection of the beam under load. This micrometer caliper should be attached to the support base but made movable for centering within the span.

4.3 The upper loading assembly is constructed of lightweight metal such as magnesium. It consists of two vertical loading anvils attached perpendicular to the length of the support beam. The radius of the loading anvils is 0.318 cm (1/8 in.). The anvils should be 5.08 cm (2 in.) wide and adjustable to provide a span of 10.16 to 45.72 cm (4 to 18 in.). In the center of the support beam is mounted a platform to carry weights. It is essential that the upper loading assembly be made as light as possible without sacrificing rigidity.

5. **Sampling**

5.1 Select specimens of corrugated board for testing from undamaged areas. Avoid scores or other crushed areas which may affect the test results.

5.2 Cut 10 specimens 2.54 to 5.08 cm (1 to 2 in.) wide in each of the two principal directions (MD, CD). The specimen should be 5.08 cm (2 in.) longer than the length of the span on the upper assembly, so that a minimum of 2.54 cm (1 in.) will overhang the edges of the top anvils. Make all cuts accurately within ± 0.025 cm (± 0.010 in.) with a sharp knife or saw using a template or proper guide. All cuts must be parallel or perpendicular to the corrugation.

6. **Conditioning**

Precondition and condition the specimens in accordance with TAPPI T 402 "Standard Conditioning and Testing Atmospheres for Paper, Board, Pulp Handsheets, and Related Products" prior to testing.

7. **Procedure**

7.1 Adjust the bottom anvils on the bottom support frame to a minimum span of 10.16 cm (4 in.). Center the micrometer within the span. Adjust the loading anvils on the top assembly so that the span between the upper
loading anvils is at least two times greater than the span on the lower support anvils. Center the weight platform on the upper assembly within the span.

7.2 On the underside of the test specimen (the side facing the bottom support anvils), adhere a thin strip of conducting metal (using a thin piece of pressure sensitive tape) so that it will be centered on the specimen. Next attach a wire to this metal strip and connect it to the outside terminal of a small light bulb. Connect another wire from the micrometer to the negative terminal of a flashlight battery. Complete the circuit by contacting the tip of the light bulb to the positive side of the battery.

7.3 Place the test specimen on the bottom anvils. For a machine direction test, make sure that the tips of the flutes rest on the tips of the anvils. If this is not possible, use a small spreader bar consisting of a thin strip of metal which is slightly wider than the width of the flutes. Place the spreader bar so that it will cover two flute tips and will rest on the tip of the anvil.

7.4 Place the upper loading assembly on the specimen making sure that the loading anvils are properly centered so that the overhang on either end is equal. If the tip of the anvil does not come to rest on the tip of the flute, add a spreader bar as described in 7.3. Adjust the micrometer until contact is made with the metal strip as noted when the light goes on. Record this micrometer reading. Place a weight on the platform of the loading anvils. Again adjust the micrometer until contact is made and record this reading. Place a second and equal weight on the platform and again measure the amount of deflection with the micrometer. Measurements and weight additions should be made as rapidly as possible to reduce the amount of creep.

7.5 Plot the weight versus the deflection for the three readings obtained. A straight line should result between the initial reading and the addition of the second weight. If not, repeat the test using smaller weights.

7.6 Test ten specimens in each direction. Of the ten, test five with the single face side up and five with the double face side up.

8. Safety Statement

See the Caution statement for a quick view of how this standard deals with safety and chemical issues. Issues specific to this standard follow:

8.1 Read and follow all safety precautions suggested by the equipment manufacturer(s).

8.2 Use appropriate personal safety equipment which may include safety glasses, goggles, gloves, and steel toe shoes.

8.3 Avoid shock hazards by making certain that the wiring (condition and grounding) and circuit breakers are suitable for the test device.

8.4 Appropriate care should be taken when dealing with the sharp blades in cutting tools and/or machines used in the preparation of test samples

8.5 Avoid pinch points when handling or operating the test device or fixture to avoid injury.

8.6 Use automatic test shut off limit switch or stop blocks where appropriate to avoid damaging the device/fixture and to prevent dangerous movement of parts.

8.7 Use care in handling weights if using the totally manual method, see Section 7.4. Safety actions
include care in handling of weights, fencing/blocking off the test area to contain falling weights, and use of steel toe shoes.

9. Calculations

Calculate the flexural stiffness as follows:

$$D = \frac{1}{16} \left( \frac{P}{Y} \right) \left( \frac{L^3}{w} \right) \left( \frac{a}{L} \right)$$

where

- $D$ = flexural stiffness
- $P$ = sum of the two weights
- $Y$ = deflection of the center span, $L$, caused by the two weights, $P$
- $L$ = distance between the bottom support anvils, cm (in.)
- $a$ = distance between the bottom support anvil and upper loading anvil
- $w$ = width of the specimen, cm (in.).

10. Precision

The following estimates of repeatability are based on data from an intra-laboratory trial conducted in 2020 using the “cm-09” revision of the test method. Data is from one laboratory. The laboratory tested conditioned specimens of three representative grades of combined board in both the CD and MD orientations. Ten observations were made per each of the six sets by each of three operators. Each of the operators used new specimens cut from the same lot of combined board per grade. The reported repeatability represents the combination of the variability of the test process, the materials, and the operators.

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<tr>
<th>Property Measurement Results</th>
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<td>Material Type</td>
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The repeatability values reported in this section are estimates of the maximum difference which should be expected in 19 of 20 instances, when comparing two test results for materials similar to those described under similar test conditions. These estimates may not be valid for different material or testing conditions.
11. Report

11.1 For each test report
11.1.1 Date and time of test
11.1.2 Sample ID
11.1.3 Mean bending stiffness, N·m (lb·in), from D in Section 8
11.1.4 Number of replicate tests
11.1.5 Stand Deviation of result
11.1.6 Include the statement that the test was conducted in compliance with this method and a description of any deviations.

12. Keywords

Corrugated boards, Fiberboards, Bend strength, Stiffness, Bending

13. Additional information

13.1 Effective date of issue: To be assigned.
13.2 TAPPI T 836 “Bending Stiffness, Four Point Method” is a test method to measure this property using an automated testing instrument.
13.3 WG Members – participants included Dave Carlson, Ben Frank, Ed Hughes, and Dick Lund
13.4 This method was reclassified in 1985 as a Classical Method and was reaffirmed in 2000. Such procedures are no longer in common use or have been superseded by advanced technology; they are technically sound, have a history of use, and contain a body of literature references that make their preservation valuable. This 2021 version is upgraded from the 2009 version with the additions of Precision and Safety Statements. The beliefs of several members of the T 820 SSIG is that preservation of the body of knowledge in T 820 is best preserved by the creation of a TAPPI Useful Method (UM). TAPPI rules on their Standards require that before a UM can be created that is substantially identical to an existing Official or Classical Method, the existing Standard must be Withdrawn. A tentative Working Group has already been established and will begin work on a Flexural Stiffness UM as soon as T 820 is officially Withdrawn. The proposed UM is intended to be identical to the language in Draft 4 of T 820.

References


Your comments and suggestions on this procedure are earnestly requested and should be sent to the TAPPI Standards Department.