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.

Ring crush of paperboard (rigid support method)
(Five-year review of Official Method T 822 om-16)
(Changes from Draft 2 incorporated)

1. Scope

1.1 The ring crush test correlates with edgewise compression strength of paperboard (1,2).

1.2 This method was originally developed for paperboard between 0.28 mm (0.011 in.) and 0.61 mm (0.024 in.) thick. It may be used with higher variability for paperboard as thin as 0.18 mm (0.007 in.) and as thick as 0.76 mm (0.030 in.). A significant fraction of the paper in use in the industry now falls below the 0.28 mm (0.011 in.) value.

NOTE 1: Caution should be used when testing linerboard less or greater than the specified thickness as the results may be less reliable. Note in particular the increase in the R&R values in 10.3 as basis weight of the paper decreases. For papers thinner than 0.28 mm (0.011 in.), test values result from a combination of both buckling failure and pure compression. For papers thicker than specified, strain within the sample arising from bending the specimens into a cylinder may impact test results (3, 4, 5).
2. Significance

The edgewise compression strength of corrugated board is the principal element in determining the dynamic compression strength of the container made from that board. Fiberboard shipping containers are frequently subjected to loads which are resisted by compression strength, making this property an important measure of the performance characteristics of corrugated board, and useful in controlling the manufacturing process and in measuring the quality of the finished product. Since edgewise compression strength can be estimated by a summation of the ring crush strengths of the liners and medium, this method is useful for the corrugated boxmaker.

3. Summary

A compression force is exerted on a specimen held in ring form in a special sample holder and placed between two platens of a compression machine, by causing the driven platen to approach the rigid platen at a uniform speed until the specimen collapses.

4. Apparatus

4.1 Compression testing machine\(^1\) meeting the following requirements:

4.1.1 Rigid Support Compression Tester. Two platens, one rigidly supported and the other driven. Each platen shall have a working area of approximately 100 cm\(^2\) (16 in.\(^2\)). The platens are to have not more than 0.050 mm (0.002 in.) lateral relative movement, and the rigidly supported platen not more than 0.150 mm (0.006 in.) movement, perpendicular to the surface, within a load range of 0 to 2225 N (0-500 lbf). Within the specimen contact area, each platen shall be flat within 0.0025 mm (0.0001 in.) of the mean platen surface, and the platens shall remain parallel to each other within 1 part in 2000 throughout the test.

4.1.2 A means for moving the driven platen to achieve an initial platen separation of at least 60 mm (2.36 in.). Within a range of platen separation of 0 to 60 mm (0 to 2.36 in.) and within a load range of 0 to 2225 N (0 to 500 lbf), the nominal speed of the driven platen shall be controllable at 12.5 mm ± 0.2 mm (0.50 in. ± 0.008 in.) per minute.

**NOTE 2:** For convenience, the test machine should be capable of rapid return and automatic, settable positioning.

4.1.3 A capacity of at least 2225 N (500 lbf).

4.1.4 A means of measuring and indicating the maximum load sustained by the test specimen within 2.2 N (0.50 lbf) or 1% error, which ever is greater.

4.1.5 An indicating mechanism that can be checked accurately with dead-weight load, load cell, or proving ring. The accuracy required is 0.5% or 2.2 N (0.5 lbf), whichever is greater.

\(^{1}\)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.
4.2 Specimen holder, having the following characteristics:

4.2.1 The specimen holder will be composed of a circular block having an annular square cut groove, 6.4 ± 0.25 mm (0.25 ± 0.01 in.) deep and 49.3 ± 0.035 mm (1.940 ± 0.001 in.) outside diameter. The bottom of the annular groove is required to be parallel with the base of the block within 0.01 mm (0.0004 in.) from the nominal depth of the groove, with the sides of the groove at right angles with the base of the block. A branch groove tangent to the annular groove, of the same depth and extending to the edge of the block, is provided to insert the specimen and is not wider than 1.27 mm (0.050 in.) at its entrance to the annular groove.

4.2.2 The center “island” created by the annular groove is removable and replaceable with disks of different diameters so that the width of the groove may be adjusted to be at least 150% but not more than 175% of the nominal caliper of the specimen being tested. Each disk has a central hole to fit a receiving pin central to the annular groove and is free to turn as the specimen is inserted through the branch groove.

4.2.3 Scribe or otherwise mark one point on the perimeter of the annular groove at some distance, at least 12.5 mm (0.5 in.) away from the branch groove. This point will serve as the mark for the ends of the test specimen.

4.3 Precision die cutter, capable of accurately cutting the test specimens with clean parallel edges.

5. Sampling

Samples should be selected and gathered in accordance with TAPPI T 400 “Sampling and Accepting a Single Lot of Paper, Paperboard, Containerboard, or Related Products.”

6. Safety precautions

Care should be taken to keep fingers away from the cutting areas of cutting devices such as “Four Square” and punch cutters used to prepare samples and out of the specimen holder during the actual compressing testing.

7. Conditioning

Due to possible dimensional changes and the impact of moisture on strength properties, precondition and condition samples prior to cutting test specimens in an atmosphere in accordance with TAPPI T 402 “Standard Conditioning and Testing Atmospheres for Paper, Board, Pulp, Handsheets, and Related Products.”

NOTE 3: The ring crush test is extremely sensitive to the moisture content of the paperboard under test and failure to properly condition the sample material will impact test results. If it is not possible to condition samples as outlined in T 402, collect the test specimens immediately after testing and determine their moisture content as a composite reading according to TAPPI T 412 “Moisture in Paper. Since paperboard does not always condition to identical moisture contents, knowledge of the latter will sometimes explain differences in between-laboratory results.

8. Preparation of test specimens
8.1 Carefully die-cut test specimens with the felt side (top side) toward the male portion of the die 12.700 + 0.000 - 0.025 mm (0.500 + 0.000 - 0.001 in.) wide, 152.4 + 0.000 - 0.200 mm (6.00 + 0.000 – 0.008 in.) long. Cut specimens from areas away from creases, imperfections, or visible damage. Cut so that the long dimension is parallel with the machine direction of the board for CD specimens and the long dimension is perpendicular to the machine direction of the board for the MD specimens (if MD tests are performed). Accurate determination of the machine and cross directions is critical. In cutting the specimens take care to ensure that the long edges are parallel, such that the widths at opposite ends are within 0.015 mm (0.0006 in.) of each other.

NOTE 4: Die cutting of individual sheets is the proper way to cut the test specimens, meet the requirements of this section, and give test results within the precision stated.

8.2 Test at least 10 specimens per sample in each direction of interest.

8.3 Periodically inspect a cut specimen under an appropriate magnification to check for proper dimensions (7.1) and to ensure that cuts are clean and sharp. Any damage to the edges may indicate the die-cutter should be checked for sharpness, nicks, or burrs.

9. Procedure

9.1 It is strongly recommended to wear rubber, plastic, or disposable lint-free cotton gloves throughout the entire test procedure.

NOTE 5: Contaminants on hands, especially moisture, may have an adverse effect on test results.

9.2 Determine the average thickness (caliper) of the sample to be tested in order to select the proper disk insert (4.2.2).

9.3 Carefully insert the test specimen into the specimen holder. Locate the ends so that they are at the scribed mark (4.2.3) as not to coincide with the branch groove. Place the specimens in the holder so that half are tested with the felt side (top side for twin wire formed sheets) facing inward and half with the felt side facing outward.

NOTE 6: If the specimen buckles on insertion or the disk rises allowing the specimen to get beneath the disk during the compression test, the test results may be low. Discard these test results and test additional samples.

9.4 Place the holder with the test specimen on the center of the lower platen of the compression machine. It is desirable to fix stop blocks on the lower platen to ensure proper placing of the holder, but the holder can always be centered if the platen is marked or scribed. Position the holder so that the meeting specimen ends are always in the same position, i.e., directly in front of the operator.
NOTE 7: If the load cell supports the lower platen, the sample holder must be centered on the lower platen when checking and/or setting the zero load level.

9.5. Apply a load to the specimen by activating the driven platen at a speed of 12.5 mm/min (0.50 in/min) until a maximum force is sustained. Immediately after reaching the maximum, the specimen will fail in the area projecting above the holder. This may not be visually observed when using equipment that returns rapidly after reaching a peak load. Record this maximum load value.

9.6. For 152.4 mm (6.0 in.) test specimens, to convert test values to kilonewtons per meter, multiply the readings in pounds force (lbf) by 0.0292. Similarly, multiply readings in kilograms force (kgf) by 0.0644, and multiply readings in newtons by 0.00656.

10. Report

10.1 Report the averages of the CD and MD (if performed) test results separately. Report the force per unit specimen length required to crush the specimens and the standard deviation, in kilonewtons per meter (or in pounds force for 6 in. specimens) to three significant figures.

10.2 Include the total number of specimens tested (if different than 10).

10.3 Report the moisture content of the specimens tested if the samples have not been conditioned to TAPPI standard conditions following TAPPI T 402 “Standard conditioning and testing atmospheres for paper, board, pulp handsheets, and related products.”

11. Precision

11.1. Repeatability = 4%

11.2. Reproducibility = 17%

Repeatability and reproducibility are estimates of the maximum difference (at 95% confidence) that should be expected when comparing test results for materials similar to those described in the chart under similar test conditions to those described below. These estimates may not be valid for different materials and testing conditions.

11.3. As the estimates of repeatability and reproducibility are not proportional (the ratio of variation to average test result is not consistent between different grades), likely because the variation has both a fixed component and a basis weight-dependent component (2); users are encouraged to use the chart below to identify precision estimates for each grade.
11.4 The estimates of repeatability and reproducibility listed in the table above are based on data from the Collaborative Testing Services Inc. (CTS) Containerboard Interlaboratory Program using testing conducted in 2006. The data included either 12 weekly rounds of testing, for 36lb linerboard and 69lb linerboard, or 24 weekly rounds of testing, 26lb medium and 42lb linerboard. The precision estimates are based on 10 determinations per test result and 1 test result per lab for each round of testing. For each weekly round, between 57 and 68 (approximately 60) laboratories are included in the calculation of the precision estimates for linerboard and between 20 and 25 (approximately 20) laboratories are included in the calculation of precision estimates for corrugating medium. Only laboratories that reported using rigid-platen type instruments and TAPPI standard conditioning atmospheres are included in the calculations.

11.5 Additional Information. The precision statement above (10.1 through 10.4) replaced information derived from an interlaboratory study conducted in 1999. The current repeatability estimates are approximately 50% lower than those derived from the 1999 trial. The 1999 trial used the average of 3 results to calculate repeatability, whereas this trial uses single results from a large number of laboratories and multiple rounds of testing. The estimates for reproducibility are not significantly different. Additionally the 1999 trial used an alternate specimen cutting procedure to investigate possible differences when cutting with bottom (felt) side down v. bottom side up. The results showed no difference for most samples, however ring crush results were higher for heavy weight linerboard using the alternate specimen cutting method. The trial showed a 3.5-lbf/6-in. difference for 69-lb linerboard and a 14.5-lbf/6-in. difference for 90-lb linerboard.

12. Keywords

Paperboard, Corrugated boards, Fiberboards, Ring crush tests, Compression tests, Edge crush resistance

13. Additional Information

13.1 Effective date of issue: To be assigned.

13.2 Related method: TAPPI T 818 “Ring Crush of Paperboard” uses a deflecting beam tester operating under a loading rate of 111 N/S (25 lbf/s) but in other respects is similar. Test results from T 818 may be different from the test results obtained with method T 822.
13.3 Related method: TAPPI T 826 “Short Span Compression Strength of Paperboard.” Test results from T 826 will be different from the test results obtained with method T 822 and are not expected to be proportional (2).


13.5 The 2021 revision fixed a typo in Section 1.2 and clarified dimensional language in 4.2.1 and Note 4 (formerly Note 3). A “Safety precaution” was added as Section 6 and all subsequent Sections and sub-sections were re-numbered. Also, former Section 8.7 and its Note 7 were deleted and Note 7 and parts of former Section 8.7 were incorporated into a new Note 3 that is now a part of Section 7 “Conditioning”. Subsequent Notes were re-numbered. Section 13.5 was rewritten.

13.6 The Precision statement is now 16 years old and will be 21 years old at the next review of T 822 in 2027. It is recommended that the Precision statement be updated at the time of the next review. As with the 2006 Precision statement update current data should be available from the Collaborative Testing Services, Inc (CTS).

14. Literature cited


15. References

Allan, R., “To Ring Crush or Not To Ring Crush”, Appita Journal, 56 (2):88, March 2003
Your comments and suggestions on this procedure are earnestly requested and should be sent to the TAPPI Standards Department.