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T 822

DRAFT NO. 2

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TAPPI

WORKING GROUP CHAIRMAN Benjamin Frank

SUBJECT CATEGORY FISCOTEC

RELATED METHODS See "Additional Information"

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 Material 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 T 822 om-02)

(underscores and strikeouts indicate changes from Draft 1)

1. Scope

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

1.2 This method is intended for paperboard between 0.28 mm (0.011 in.) and 0.61 mm (0.024 in.) thick. It may be used with less reliability for paperboard as thin as 0.18 mm (0.007 in.) and as thick as 0.76 mm (0.030 in.).

NOTE 1: Caution should be used when testing linerboard less or greater than the specified thickness as the results may be less reliable. For papers thinner than 0.28 mm (0.011 in.), test values may 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*).

Approved by the Standard Specific Interest Group for this Test Method
TAPPI

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 test becomes a useful one 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.

~~**NOTE 3:** 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 Technical Services Department.~~

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

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

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.

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 ± 0.01 mm (0.0004 in.), 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. ~~The minimum groove width should be large enough for the test piece to be inserted without resistance and the maximum groove width should not exceed 150% of the nominal thickness of the test piece.~~ 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 to exact dimension 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. Conditioning

Due to possible dimensional changes, samples should be preconditioned and conditioned 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"

7. Preparation of test specimens

7.1 Carefully die-cut test specimens 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 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). In cutting the specimens take care to ensure that:

7.1.1 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**~~ **NOTE 3:** Die cutting of single sheets is the proper way to cut the test specimens, meet the requirements of this section, and give test results within the precision stated.

7.2 For the purposes of this method, test a minimum of 10 specimens ~~of each test unit for each direction~~ per sample in each direction of interest.

7.3 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.

8. Procedure

8.1 Rubber, plastic, or disposable lint-free cotton gloves should be worn throughout the entire test procedure.

~~**NOTE 5**~~ **NOTE 4:** Contaminants on hands, especially moisture, may have an adverse effect on test results.

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

8.3 Wearing gloves, 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**~~ **NOTE 5:** If the specimen buckles on insertion or the disk rises allowing the specimen to get beneath the disk during the compression test it should be noted in the report as these test results may tend to be low.

8.4 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~~ **NOTE 6:** 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.

8.5 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.

8.6 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.

8.7 Collect the test specimens and determine their moisture content as a composite reading according to TAPPI T 412 "Moisture in Paper," if the samples have not been conditioned to TAPPI standard conditions as outlined in T 402 "Standard Conditioning and Testing Atmospheres for Paper, Board, Pulp Handsheets, and Related Product"

~~NOTE 8~~ **NOTE 7:** The ring crush test is extremely sensitive to the moisture content of the paperboard under test. Since paperboard does not always condition to identical moisture contents, knowledge of the latter will sometimes explain differences in between-laboratory results.

9. Report

9.1 Report separately the CD and MD (if performed) test results (each an average of a minimum of ten determinations) of the force per unit specimen length required to crush the specimens in kilonewtons per meter to three significant figures (or in pounds force for 6 in. specimens ~~to the nearest pound~~). Report standard deviations to 3 significant figures.

9.2 Include, the total number of specimens tested as required.

9.3 Report the moisture content of the specimens tested if thee 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."

10. Precision

~~10.1 The following estimates of repeatability and reproducibility are based on data from interlaboratory study conducted in November 1999. The materials on which this data is based were 3 samples of corrugating medium and 5 samples of linerboard. Participants were asked to follow TAPPI Official Test Method T 822 om-93. Testing is based on 10 determinations per test result and 3 test results per lab, per material. Results for each material are shown in Table 1.~~

~~Repeatability 8.7%~~

~~Reproducibility 19.2%~~

~~**NOTE 9:** Repeatability and Reproducibility are the worst for lighter weight (thinner) materials. Refer to data table for the actual numbers for various grades of both liner and medium.~~

~~10.2 Repeatability and reproducibility are estimates of the maximum difference (at 95%) which should be expected when comparing test results for materials similar to those described above under similar test conditions. These estimates may not be valid for different materials or testing conditions.~~

~~10.3 Additionally, each material was tested using an alternate specimen cutting procedure to investigate possible differences when cutting with felt side down (contrary to the om-93 version of the method). Three test results were obtained cutting the specimens felt side down. The results do not appear to be significantly higher for most samples. However, ring crush results are higher for heavy weight linerboard using the alternate specimen cutting method. The difference between the results obtained from the two cutting methods are shown in the table below. The results from the alternate specimen cutting procedure are not included in the calculation of the precision statistics.~~

~~**Table 1. Data Table**~~

~~**Material**~~	~~**Grand Mean**~~	~~**Stnd Dev Btwn Labs**~~	~~**Repeatability r and %r**~~	~~**Reproducibility R and %R**~~	~~**Labs Included**~~	~~**Difference (alt cutting)**~~
~~26# med~~	~~37.2~~	~~2.4~~	~~2.9 7.9%~~	~~7.2 19.2%~~	~~11~~	~~-0.22~~
~~26# med~~	~~38.1~~	~~2.2~~	~~3.3 8.7%~~	~~6.7 17.5%~~	~~11~~	~~-0.29~~
~~33# med~~	~~54.4~~	~~2.6~~	~~2.3 4.2%~~	~~7.5 13.7%~~	~~11~~	~~0.71~~
~~35# liner~~	~~74.5~~	~~3.8~~	~~4.2 5.6%~~	~~11.0 14.8%~~	~~10~~	~~0.73~~
~~42# liner~~	~~88.3~~	~~4.4~~	~~5.2 5.9%~~	~~12.8 14.5%~~	~~10~~	~~1.06~~
~~42# liner~~	~~88.7~~	~~4.1~~	~~2.5 2.8%~~	~~11.6 13.1%~~	~~10~~	~~0.58~~
~~69# liner~~	~~147.6~~	~~8.2~~	~~5.6 3.8%~~	~~23.1 15.6%~~	~~10~~	~~3.46~~
~~90# liner~~	~~204.7~~	~~10.4~~	~~11.0 5.4%~~	~~30.2 14.7%~~	~~9~~	~~14.5~~

10.1 Repeatability = 4%

10.2 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.

10.3 As the estimates of repeatability and reproducibility are not proportional (the ratio of variation to average test result is not consistent between different grades), users are encouraged to use the chart below to identify precision estimates for each grade.

Table 1

Material	Average	Repeatability r and %r		Reproducibility R and %R		Labs Included
26# medium	40.4	2.14	5.2%	9.09	22.5%	~ 20
35# linerboard	75.4	3.50	4.6%	12.58	16.6%	~ 60
42# linerboard	106.9	3.41	3.2%	16.13	15.2%	~ 60
69# linerboard	161.1	4.76	3.0%	21.89	13.6%	~ 60

Data in the table above are listed in lbf for 6in specimen

10.4 The estimates of repeatability and reproducibility listed in the table above are based on data from the 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.

10.5 *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.

11. Keywords

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

12. Additional Information

12.1 Effective date: to be assigned.

12.2 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.

12.3 Related method: TAPPI T 826 "Short Span Compression Strength of Paperboard," performs a similar test. Test results from T 826 may be different from the test results obtained with method T 822.

12.4 Related method: ISO 12192 "Paper and board – Compressive strength – Ring crush method."

12.5~~4~~ In 1997, by committee action, the preparation step (7.1) was changed to cut samples felt side up (top up for twin wire formed liner) rather than felt side down (bottom down for twin wire formed liner). This was done because cutting the samples felt side up (top side up) may result in somewhat higher ring crush numbers. The above mentioned precision data were generated using this sample preparation method.

Literature Cited

1. Koning, J.W., "A short column crush test of corrugated paperboard," *Tappi* 47 (3):134 (1964).
2. Frank, B., "Ring crush and short span compression for predicting edgewise compressive strength," *Tappi Journal* **2** (11): 12 (2003)
3. "Effect of specimen dimensions on edgewise compression tests of linerboard and corrugating medium," Parts 1 and 2, Testing Compression Reports 82 and 83, Institute of Paper Chemistry, Project 1108-4, March 23, 1966.
4. Fellers, C., and Donner, B. C., "Edgewise compression strength of paper," in *Handbook of Physical Testing of Paper*, Vol. 1, Chapter 9, Marcel Dekker Inc., 2nd edition.

References

1. Smith, J.H., "A Discussion of the Ring Crush Test," *Tappi*, Vol. 42 (1959).
2. Travers, R., "Improving the Reliability of the Ring Crush Test," Appita, Nov. 1976.
3. Koning, J.W., Kuenzl, E.W., Mood, R.C., & Godshall, W.D., "Improving the Comparability of Paperboard Test Results Using Flexible and Rigid Type Testing Machines," *Tappi*, May 1972.
4. Dahl, Carl B., Jr. "Limited Range of Ring Crush Test," *Tappi Journal* 68 (10): 108-109, October 1985.

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