Ring crush of paperboard (rigid support method)

1. Scope

1.1 The ring crush test correlates with edgewise compression strength of paperboard(1).
1.2 This method is intended for paperboard between 0.28 mm (0.01 in.) and 0.51 mm (0.02 in.) thick.

NOTE 1: Caution should be used when testing linerboard less or greater than the specified thickness as the results may be less reliable.

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, 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 tester having the following:

4.1.1 A rigidly supported platen and a driven platen, each having a working area of approximately 100 cm² (about 15.5 in²). The platens are required to have not more than 0.050 mm (0.002 in.) lateral movement and the rigidly supported platen not more than 0.150 mm (0.006 in.) vertical movement within a load range of 0 to 2500 N (0 to 560 lbF). Within the 100 cm² (15.5 in²) working area each platen shall be flat to within 0.0025 mm/25 mm (0.0001 in./22 in.) of the mean platen surface and the platens shall remain parallel with each other within 1 part in 2000, or 0.0005 in./in., or 50 um/100 mm 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 speed of the driven platen shall be controllable at 10± 0.2 mm (0.4 ± 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 $N$ (0.5 lbf).

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 49.2 ± 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. 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.

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, felt side down, 12.700 + 0.000 - 0.025 mm (0.500 + 0.000 - 0.001 in.) wide, 152.4 + 0.000 - 0.200 mm (6.00 + 0.00 - 0.01 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. 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.

7.1.2 The long edges are parallel, for the CD tests, (perpendicular for the MD tests) with the machine direction of the board.

7.1.3 The edges are cleanly cut without tears or frays.

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.

7.3 Periodically inspect a cut specimen under a low 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 4: Contaminants on hands, especially moisture, has 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 facing inward and half with the felt side facing outward.

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.

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.

8.4 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 insure 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.

8.5 Apply a load to the specimen by activating the driven platen at a speed of 10 mm/min (0.39 in/min) until a maximum force is sustained. Immediately after reaching the maximum, the specimen will fail in the area projecting above the holder. 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.”

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 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).

9.2 Include, the total number of specimens tested.

9.3 Report the moisture content of the specimens tested.

10. Precision

10.1 Repeatability (within a laboratory) = 4.3%

10.2 Reproducibility (between laboratories) = 6.7%

10.3 Comparability (between materials) = not known.

10.4 These data have been calculated for cross direction test results based on ten replicate determinations. The values are based on data contained in Report 260, May 1991, of the Collaborative Reference Program for Containerboard. The results from tests on 42 and 69 / MSF lb liners and 26 / MSF lb medium were averaged using data from twelve laboratories using the rigid support method.

10.5 Refer to TAPPI T 1206 “Precision Statement for Test Methods” for complete definitions of these terms.

11. Additional Information

11.1 Effective date: May 28, 1993.

11.2 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.

11.3 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.
Literature Cited


References

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.

*Your comments and suggestions on this procedure are earnestly requested and should be sent to the TAPPI Technical
Divisions Administrator.*