Short span compressive strength of containerboard

1. Scope

1.1 This method describes a procedure for determining the compressive resistance of containerboard.
1.2 This method is intended for containerboard having a span-to-thickness ratio of 5 or less. This is often equivalent to a grammage of at least 100 g/m² (20.5 lb/1000 ft²) \(^1\) and not much over 439 g/m² (90 lb/msf) \(^2\).2

2. Significance

The edgewise compressive strength of corrugated board is the most important property governing the compressive strength of corrugated containers. Research has shown that the short span compressive strengths of linerboard and medium can be used to predict the compressive strength of corrugated board and, hence, to box compressive strength \(^2, 3\). For example, summations of the compressive strengths of the components correlate very well with the combined board edgewise compressive strength.

3. Summary

A test specimen, 15 mm wide (0.59 in.), is clamped in two clamps, 0.7 mm (0.0276 in.) apart. The clamps are forced towards each other until a compressive failure occurs. The maximum force causing failure is measured.

4. Apparatus

4.1 Compression tester, having the following:
4.1.1 Two clamps for holding a test specimen 15 mm (0.59 in.) wide (Fig. 1). Each clamp has a stationary and a movable jaw. The clamps shall be 30 mm (1.18 in.) deep and have a surface of high friction, for example, a sand-blasted surface. The clamps shall grip the test specimen firmly over its full width. The stationary jaws shall be on the same side of the test specimen. The clamping surfaces of the movable jaws shall be in the same plane and parallel to those of the stationary jaws (see Appendix A).
4.1.2 The clamps shall be able to grip the test specimen with a constant clamping force of 2300 ± 500 N (517 ± 112 lb).
4.1.3 A means for indicating the clamping pressure exerted by the clamps.
4.1.4 At the start of the test the free span between the clamps shall be 0.70 ± 0.05 mm (0.0276 ± 0.002 in.).
After the test is started, the clamps shall move toward each other at a speed of 3 ± 1 mm/min (0.12 ± 0.04 in./min), the deformation of the load cell being considered.
4.1.5 A means for measuring and indicating the maximum load sustained by the specimen which can accurately be checked with dead weight loads or equivalent means. The accuracy required is ± 1% of the test reading when this is within 10–100% of the full scale range.
4.2 Cutting device, capable of accurately cutting the specimen to a width of 15 mm (0.59 in.) and a convenient length, usually about 150 mm (6 in.). A precision die-type cutter is preferred.
4.3 Some machines may be equipped with means for measuring the moisture content of the specimen being tested. Refer to Appendix B and the manufacturer's instructions for use of this feature.

5. Sampling and test specimens

5.1 From each test unit obtained in accordance with TAPPI T 400 “Sampling and Accepting a Single Lot of Paper, Paperboard, Containerboard, or Related Product.” Precondition and condition in an atmosphere according to TAPPI T 402 “Standard Conditioning and Testing Atmospheres for Paper, Board, Pulp Handsheets and Related Products” and carefully cut specimens in the form of strips at least 70 mm (2.8 in.) in length and with a width of 15 ± 0.1 mm (0.59 ± 0.004 in.). For MD tests, cut the specimen so that the long direction is parallel to the machine direction; cut CD specimens so the long direction is perpendicular to the machine direction. In cutting the specimens take care to insure that:
5.1.1 The area to be tested is not touched because this test is very moisture sensitive.
5.1.2 The long edges are parallel to each other, such that the widths at opposite ends are within 0.1 mm (0.004 in.) of each other.
5.1.3 The long edges are parallel to the machine direction or cross direction, whichever direction is being tested and do not deviate more than 1.6 mm (0.063 in.) from the true machine direction or cross direction.
5.1.4 The edges are cleanly cut, without tears or frays.

NOTE 1: If multiple tests are performed on one specimen, the test areas shall be spaced apart by at least 12.7 mm (0.5 in.) when any moisture measuring device incorporated with the machine is not being used. If a moisture measuring device is being used, see Appendix B.

6. Procedure

6.1 Test the specimens in an atmosphere in accordance with TAPPI T 402 “Standard Conditioning and Testing Atmospheres for Paper, Board, Pulp Handsheets, and Related Products.”
6.2 Select the program for the grade to be tested if this feature is available and follow the prompts.
6.3 Insert the test specimen in the machine and actuate the clamps so that the prescribed pressure is applied and there is no slippage. Avoid handling the specimen in the test area with bare fingers because compressive strength tests are sensitive to the moisture content of the containerboard under test.
6.4 Operate the machine to apply a compressive load to the specimen and record the maximum compressive load.
6.5 Multiple tests can be run on each strip but do not test any area of the strip that has been compressed by the clamping jaws.
6.6 A minimum of 10 tests should be run in each direction.
6.7 Determine the moisture content of the sample tested.

7. Report

7.1 Report separately the MD and CD test results (each an average of 10 determinations of maximum compressive force per unit area width) in kilonewtons per meter (or in pounds force per inch) to three significant figures.

NOTE 2: Results in kilonewtons per meter may be converted to pounds force per inch by dividing by 0.17513.

7.2 Report the standard deviations of the MD and CD compressive loads separately.
7.3 Include, for a complete report, the number of determinations in each direction.
7.4 Report the moisture content.

8. Precision

8.1 The values of repeatability and reproducibility provided below have been calculated for test results, each of which is the average of ten replicate determinations. The values are based on data contained in Report 196, January 1986, of the Collaborative Reference Program for Container Board.
8.2 Repeatability (within a laboratory) = 6.5%.
8.3 Reproducibility = 19.7%.
8.4 Refer to TAPPI T 1206 “Precision Statement for Test Methods” for complete definitions of these terms.

9. Additional information

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Appendix A. Specifications for the clamps (4,5)

A.1 The four jaw edges in contact with the test specimens in the 0.7-mm (0.0276 in.) span shall not be blunted. The difference in the free span at the top and bottom of the jaws shall be less than 0.03 mm (0.001 in.).
A.2 Those parts of the two surfaces of the stationary jaws that grip the test piece close to the free span shall lie between two parallel planes, 0.01 mm (0.0004 in.) apart. All points of the two surfaces, 30 mm (1.18 in.) in each direction from the free span, shall lie between two parallel planes, 0.2 mm (0.008 in.) apart (Fig. 2).

Fig. 2 Specifications for the maximum permissible departure from parallelism of the clamping surfaces (4).

A.3 All points of the bottom surfaces of the jaws shall lie between two parallel planes 0.1 mm (0.004 in.) apart (Fig. 3).
A.4 If jaw alignment is other than specified, between tester correlation will be poor (5).

Appendix B. Moisture determination and load correction

B.1 Test machines complying generally with the requirements in Section 4 are available which also incorporate means for measuring the moisture content of the specimen under test and, in one instance, correcting the load readings at a given moisture content to the load which would be obtained at a specified moisture content, usually 7.5%.

B.2 The moisture measurement system shall have the following:

B.2.1 Moisture measurement sensors which firmly contact the specimen under test.

B.2.2 Means for indicating the moisture content of the specimen under test within ±0.25%.

B.3 Calibrate the moisture indicating system for the sample lot being tested following the manufacturer's directions.

NOTE 3: Experience indicates that the moisture systems employed are sensitive to many factors such as furnish, basis weight, calendering, and impurities in the test material. For this reason it is necessary to calibrate the sensor systems on the material being tested to obtain accurate results.

B.4 Load correction. Some machines have a microprocessor system for estimating the failure load at a specified moisture content, usually 7.5%, from the load and moisture content at the time of test. In this case, it is necessary to determine the relationship between the failure load and moisture content for the material being tested.

B.5 When employing the moisture correction system, carry out the tests following the procedures in Section 5. If replicate tests are made on one specimen, avoid having the moisture sensors contact any previously tested area. Report the following:

B.5.1 The maximum compressive force per unit width and standard deviation at the test moisture content and at the specified moisture content in kilonewtons per meter (or in pounds per force per inch) to three significant figures.

B.5.2 The moisture content at time of test and the specified moisture content.

B.5.3 The moisture and load correction factors used.

B.5.4 The number of test determinations in each direction.

Literature cited

2. Whitsitt, W. J., Compression Symposium, Forest Products Laboratory, Madison, WI, October 1–3, 1985.

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