Flat crush test of corrugated board (rigid support method)

1. **Scope**

The flat crush test is a measure of the resistance of the flutes in corrugated board to a crushing force applied perpendicular to the surface of the board under prescribed conditions. The test is satisfactory for single-faced or single wall (double-faced) corrugated board, but not for double-wall or triple-wall corrugated board, because of lateral motion of the central facing or facings. In this method the specimen rests on an essentially rigid support and is tested at a constant strain rate. TAPPI T 808 “Flat Crush Test of Corrugated Board” describes a procedure in which the specimen rests on a flexing support and is tested at a constant rate of loading. For corrugated board with rolled or leaning flutes see TAPPI Useful Method 810 “Leaning Flute Free (LFF) Flat Crush of Corrugated Board.”

2. **Significance**

2.1 Flat crush is a measure of the flute rigidity of corrugated board. A high flat crush value indicates a combination of good flute formation and adequate strength medium. Low flat crush can indicate a number of conditions. Among these are low strength medium, leaning flutes, and/or crushed flutes.

2.2 Boxes made from crushed corrugated board may have low flat crush and may not perform well. Board with leaning flutes may have low flat crush, but this may not affect box performance. For leaning flutes to cause low flat crush, there must be lateral movement between the two liners during the tests. After the board is formed into a box, lateral movement between the two liners is restricted by the geometry of the box, and the low flat crush may not become operative. Also, this test method does not take into account the effect of linerboard stiffness in resisting crushing forces.

3. **Apparatus**

3.1 **Compression tester** having the following:

3.1.1 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.) movement, perpendicular to the surface, within a load range of 0 to 4500 N (0 to 1000 lbf). Within a 100 cm² (15.5 in²) working area each platen shall be flat within 0.0125 mm (0.0005 in.) T.I.R. (Total Indicated Readout) and the platens shall remain parallel with each other within 1 part in 2000, or 50 μm/100 mm (0.0005 in./in.) throughout the test. To prevent slippage of the specimens the platens may be faced with crocus or emery cloth, free of ridges, by means of double sided tape. These facings shall be changed after every 2000 tests.

3.1.2 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 (2.36 in.) and within a load range of 0 to 4500 N (0 to 1000 lbf), the
speed of the driven platen shall be controllable at 12.5 ± 0.25 mm (0.50 in.) per minutes. For convenience, the test machine should be capable of rapid return and automatic, settable positioning.

3.1.3 A capacity of at least 4500 N (1000 lbf).
3.1.4 A means for measuring and indicating the maximum load sustained by the test specimen within 2.2 N (0.5 lbf).
3.1.5 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.

3.2 Specimen cutter, consisting of a device capable of cutting through the corrugated combined board structure without crushing areas at the cut edges. This may be circular, square, or rectangular.

4. Sampling and test specimens

4.1 From each test unit of a sample obtained in accordance with TAPPI T 400 “Sampling and Accepting a Single Lot of Paper, Paperboard, Containerboard, or Related Product,” select a minimum of 10 specimens free of abnormalities not representative of the combined board. Each specimen should be cut, preferably in circular form, so that each is either 32.3 cm² (5.00 in.²) or 64.5 cm² (10.00 in.²) in area. All specimens should be cut at least 38 mm (1.5 in.) away from printed matter, scores, and diecuts.

4.1.1 If the specimens are not circular, exercise special care to maintain the desired area accurately.
4.2 Avoid crushing areas at the cut edges, and, where possible, avoid fractional flute counts.

5. Procedure

5.1 Precondition, condition and test the board in an atmosphere in accordance with TAPPI T 402 “Standard Conditioning and Testing Atmospheres for Paper, Board, Pulp Handsheets, and Related Products.”

5.1.1 Position each specimen centrally on the lower platen. Apply the crushing load to the specimen until the side walls of the corrugations collapse completely. Failure is defined as the maximum load sustained before complete collapse.

NOTE 1: Normally, a preliminary end point occurs when the tips of the corrugation flatten on one or both sides of the specimen. This should not be confused with the final end point when the corrugations collapse completely. If the collapse of the corrugations is so gradual that no such peak load is distinctly registered, note this fact. Maximum crush load is often near total collapse of the flutes. A strip chart recorder connected to the load cell output will aid in the determination of the correct endpoint of the test.

6. Report

6.1 Report the flat crush test results, in kilopascals (kPa) or pounds force per square in., (psi) as the average of ten determinations, to three significant figures (1 psi = 6.895 kPa).
6.2 Include for a complete report:
6.2.1 The standard deviation.
6.2.2 The total number of specimens tested.
6.2.3 The number of specimens exhibiting rolling failure (see Note 2).
6.2.4 The testing machines used, specify type and model.
6.2.5 Indicate the flute size and type. Flute counts can vary significantly for a given contour.

NOTE 2: Rolling failure is defined as an irregular skewed pattern or leaning type of collapse of the flutes.

7. Precision

7.1 The following estimates of precision are based on an interlaboratory study with three grades of combined board that had flat crush strengths ranging between 30 psi and 40 psi, which were tested using replicates in 7 different laboratories.

Repeatability (within a laboratory) = 5.5 psi.
Reproducibility (between laboratories) = 9.5 psi.

7.2 Repeatability and reproducibility are estimates of the maximum difference, which should be expected when comparing replicate measurements for materials similar to those used in the round robin of testing.

7.3 The round robin of testing was performed on three samples of C-fluted board with the following liner and medium combinations:
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A. 52-26-52
B. 42-33-42
C. 42-26-33

The summary of the data collected and analyzed by Collaborative Testing Services has been placed on file at TAPPI.

8. Keywords

Flat crush tests, corrugated board, compression tests.

9. Additional information

9.1 Effective date of issue: March 1, 1996.
9.2 TAPPI T 808 “Flat Crush of Corrugated Board” uses a deflecting beam tester and may produce significantly different flat crush values than those obtained with TAPPI T 825 (Rigid Support Method).

Reference


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