Bursting strength of corrugated board
(Five-year review of Official Method T 810 om-17)
(Changes from Draft 1 incorporated)

1. Scope

1.1 This method describes a procedure for measuring the bursting strength of single wall and double wall corrugated board within the range of 690 kPa (100 psi) to 4825 kPa (700 psi) employing an instrument which uses a disk shaped, molded diaphragm.

NOTE 1: Single wall corrugated board is comprised of two facings with one fluted medium in between; double wall corrugated board is comprised of three facings which alternate in the construction with two fluted mediums.

1.1.1 A specimen of board is clamped between two platens with circular opening in their centers. The lower platen is fixed; the upper platen has an adjustable depth but remains stationary for the duration of the test. An expansible diaphragm is distended through the lower platen by means of hydraulic pressure until the specimen bursts. The maximum hydraulic pressure when the specimen ruptures, is recorded.

Approved by the Standard Specific Interest Group for this Test Method
TAPPI
1.2 For the bursting strength of paper, see TAPPI T 403 “Bursting Strength of Paper,” and for-linerboard see TAPPI T 807 “Bursting Strength of Linerboard.” This method is not applicable for triple wall corrugated board.

2. Significance

2.1 The minimum bursting strength of corrugated board is a requirement of various carrier and governmental specified regulations for shipping containers. While bursting strength is an empirical property, this test, in combination with grammage (basis weight), serves to define some of the “standard grades” in commerce. The bursting strength test of corrugated board is a composite measure of certain properties of the board structure, principally tensile and elongation of the linerboard (facings and any non-corrugated interior papers) comprising the combined board. In general, bursting strength is dependent on preparation and amount of fibers present in the sheet and on their formation, internal bond and, to some degree, the surface treatment and combining operation.

2.1.1 Bursting strength is the measure of the force required to puncture through (rupture) the corrugated board. It is often compared to edge crush strength (ECT: T 811, T 839), which is a measure of the compressive force a sample of the board can sustain in its vertical or loading direction before collapsing. While both are material properties of the corrugated board, depending on the papers used and how they are combined together, they measure different things. They are not exclusive or contradictory properties, nor can they be directly related one to the other. While they both can be used to describe corrugated board, the different measurements emphasize the importance of different board properties that may be relevant to the transport environment.

2.2 Testing of double-wall board is of questionable accuracy since it is rarely possible to get sufficiently simultaneous bursts of the multiple facings. Some advocate crushing double-wall board before testing to reduce or eliminate the multiple “pops” of the structure. This will typically result in higher values than on uncrushed board.

2.2.1 Do not test triple-wall corrugated board with this method, or board constructions with even more than four layers of liner, as test values generated will be unreliable due to the inability to achieve simultaneous bursts of the various facings.

2.3 The test is simple and rapid to execute, but it must be recognized that it is subject to serious errors if instrument, diaphragm, and gages are not properly maintained or if improper procedures are used (1, 2, 3).

3. Apparatus

3.1 Bursting tester¹, consisting of the following:

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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, available as part of the CD or printed set of Standards, or on the TAPPI website general Standards page.
3.1.1 Means for clamping the test specimen between two annular, plane surfaces having fine concentric or spiral tool marks to minimize slippage. The upper clamping platen (clamping ring) has a minimum diameter of 95.3 mm (3.75 in.), and a circular opening of 31.50 ± 0.03 mm (1.240 ± 0.001 in.) diameter. The lower edge of the opening (side in contact with the board) has a 0.64 mm (0.025 in.) radius. Platen thickness dimensions are not critical but shall be sturdy enough to ensure that the platens do not distort during use. A minimum thickness of 9.5 mm (0.374 in.) has been found satisfactory in use. The lower clamping surface (diaphragm plate) has an opening 31.50 ± 0.03 mm (1.240 ± 0.001 in.) in diameter and an overall diameter at least as large as the upper clamping plate. The upper edge of the opening (in contact with the board) has a 0.41 mm ± 0.1 mm (0.016 ± 0.004 in.) radius and the lower edge of the opening (in contact with the rubber diaphragm) has a radius of 3.1 ± 0.1 mm (0.122 ± 0.004 in.) to prevent cutting the rubber when pressure is applied.

3.1.2 The upper clamping ring is connected to the clamping mechanism through a swivel joint to facilitate even clamping pressure. The openings in the two clamping plates are required to be concentric to within 0.13 mm (0.0051 in.) and their clamping faces flat and parallel (see T 807 Appendix A.1.1).

3.1.3 A molded (disk-shaped) diaphragm requiring a pressure of not less than 160 kPa (23.2 psi) nor more than 210 kPa (30.5 psi) to distend it to a height of 9.53 mm (0.375 in.) above the diaphragm plate (see T 807, Appendix A.1.2)

3.1.4 Hydraulic system, to apply an increasing pressure to the inner surface of the diaphragm until the specimen test piece ruptures through the surface not in contact with the diaphragm. The pressure shall be generated by a driven piston forcing a suitable liquid (glycerin, ethylene glycol containing corrosion inhibitor or low viscosity silicone oil which is compatible with the diaphragm material) against the diaphragm. The hydraulic system and the fluid used shall be free from air bubbles. The pumping rate shall be 170 mL/min ± 15 mL/min (0.045 gal/min ± 0.004 gal/min).

3.1.5 Pressure measuring system to measure bursting strength. It may employ any principal which produces a measurement and display accuracy equal to ± 10 kPa (± 1.45 psi) or ± 3% of the measurement, whichever is greater. The rate of response to the rising hydraulic pressure shall be such that the indicated maximum pressure is within ± 3% of the true peak pressure as determined by a calibration system. When more than one gage is mounted on a single apparatus, only the gage on which the measurement is being made should be open to the hydraulic system so as to not reduce the rate of distention of the sample. If a lazy-hand type gauge is used, it should be mounted at an angle between horizontal and 30° from the horizontal.

**NOTE 2:** Care should be taken when comparing results between bourdon tube and electronic measuring systems. Differences in test results can arise due to differences in system expansibility and speed of data acquisition.

4. **Calibration**

4.1 The apparatus should be fitted, or able to be fitted, with suitable test points to facilitate checking of the fluid pumping rate, calibration of the maximum pressure measurement and display system and calibration of a clamping depth measurement device.
4.2 Calibration shall be performed before initial use and at sufficiently frequent intervals to maintain the specified accuracy. Calibration of the pressure-sensing device should be performed with it mounted in the same position it occupies on the apparatus and preferably on the apparatus itself. If the pressure sensor unit is accidentally subjected to pressure beyond its rated capacity, it shall be recalibrated before further use. Refer to manufacturer recommendations to maintain calibration.

4.2.1 Calibration of the instrument can be checked using certified foils produced for this purpose. Aluminum foils of various thickness are available from various suppliers for use as test pieces of known burst value. These check foils come from controlled batches of material with specified thicknesses that have been tested on certified machines. They are typically packaged in groups of 10 with the certified reference value printed on the package or with accompanying certificates of analysis. Burst values should fall within the tolerance of these foils in various ranges. Such devices are a useful means of checking the overall function of an instrument, but since the behavior of foil under stress is different from paper, they should not be used as calibration standards. It is important to note that commercial/consumer aluminum foil, plastic films, and other similar materials are typically not produced in such a way as to produce consistent or reliable results batch-to-batch, are not certified to a reference machine, and should not be used for this purpose.

5. Sampling and test specimens

From each test unit obtained in accordance with T 400, prepare five specimens at least 305 × 305 mm (12 × 12 in.). If size does not permit this, cut specimens no less than 152 mm (6 in.) wide and of sufficient length or number to permit a total of 20 bursts.

6. Conditioning

Precondition and condition all specimens prior to testing and conduct tests in an atmosphere in accordance with TAPPI T 402 “Standard Conditioning and Testing Atmospheres for Paper, Board, Pulp Handsheets, and Related Products.”

7. Procedure

7.1 Insert the specimen between the clamping ring and the diaphragm plate. Clamp the specimen uniformly so that no slippage is visible during or after the test. Recommended minimum clamping pressures appear in Table 1 below, though clamping pressure should be adjusted to assure that the no-slip condition is met. Note that clamping pressure = gauge pressure x (area of piston/area of clamp).
Table 1. Recommended minimum clamping pressures

<table>
<thead>
<tr>
<th>Sample bursting strength</th>
<th>Minimum recommended clamping pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>kPa</td>
</tr>
<tr>
<td>Up to 2000</td>
<td>600</td>
</tr>
<tr>
<td>2000-2500</td>
<td>800</td>
</tr>
<tr>
<td>Over 2500</td>
<td>1000</td>
</tr>
</tbody>
</table>

NOTE 3: The specimen must not slip during the test and clamping pressures can be increased to assure this no-slip condition is met. However, excessive clamping pressure can damage the board surface, leading to lower readings. Sample slippage, either from insufficient clamping pressure or from clamping plates that are not parallel, will lead to erroneously higher readings.

7.2 Apply the bursting pressure by forcing the piston forward until the diaphragm ruptures the specimen. Record the maximum pressure registered. A minimum area of 152 x 152 mm (6 x 6 in.) is required for each burst. Make a maximum of four bursts, two from each side on each 930 cm² (1 ft²) specimen. Leave a margin of at least 25 mm (1 in.) between the periphery of the clamping ring and the edge of the specimen. Locate the bursts so that not more than one burst from each side is made in line with the same corrugation. Make a minimum of 20 bursts.

NOTE 4: Occasionally a “double pop” may occur on some corrugated materials. Include these results in the report labeled as double pops. This is particularly common on doublewall board, possibly leading to erroneously low test results. If there is upward movement in the upper platen (slippage), the test is invalid.

8. Report

8.1 For each test unit report:

8.1.1 The average of the test determinations in kilopascals (or in lb/in.² equivalent to kPa/6.89) to three significant figures.

NOTE 5: In some countries, other classical unit systems are in use (Kg/cm², bar, etc.). One may report values in these other systems in addition to the forms above if it would be particularly useful to the report recipient.

8.1.2 The number of test determinations made
8.1.3 The maximum and minimum values and/or,
8.1.4 The standard deviation about the average
NOTE 6: For purposes of determining compliance with the optional carrier classification requirements, Uniform Freight Classification Rule 41 and National Motor Freight Classification Item 222 specify a minimum bursting test rather than an average of the test determinations. These rules state, in effect, that only one burst (out of the six prescribed) is permitted to fall below the minimum test required. Board failing to pass the foregoing will be accepted if, in a retest consisting of 24 bursts, not over 4 bursts fall below the minimum test required.

9. Safety precautions

9.1 Safety issues which involve this test method include the use of box cutters and paper cutters used to prepare samples. It is recommended that cut proof gloves be used any time that a box cutter is being manipulated.

9.2 The burst tester upper platen comes down to secure the specimen creating a potential nip (pinch) point. Care should be taken on unguarded older units. Care should also be taken to ensure that newer units have properly functioning guards.

9.3 The internal pressurizing fluid can be released with significant force if a diaphragm or rupture disc fails. Goggles are recommended when using an unshielded machine to protect the eyes from such discharges.

10. Precision

10.1 The following estimates of repeatability and reproducibility are based on data from an interlaboratory trial involving 6 laboratories and five different types of materials. The trial was conducted in 2004 using T 810. Testing is based on five determinations per test result and one result per lab, per material.

NOTE 7: Results given here are psi, not kPa.

Average repeatability: \[ r = 12.93 \]
\[ \%r = 5.98\% \]

Average reproducibility: \[ R = 30.69 \]
\[ \%R = 13.4\% \]

See Table below from individual \( r \) and \( R \) for sample types.
Precision data

<table>
<thead>
<tr>
<th>Material</th>
<th>Grand mean</th>
<th>Standard deviation between labs</th>
<th>Repeatability r and %r</th>
<th>Reproducibility R and %R</th>
<th>Instruments included</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;E&quot; Flute</td>
<td>195.41</td>
<td>10.77</td>
<td>8.90 4.6%</td>
<td>30.70 15.7%</td>
<td>6</td>
</tr>
<tr>
<td>&quot;C&quot; Flute</td>
<td>351.76</td>
<td>17.19</td>
<td>16.10 4.6%</td>
<td>48.06 13.7%</td>
<td>6</td>
</tr>
<tr>
<td>&quot;BC&quot; Flute</td>
<td>256.25</td>
<td>10.03</td>
<td>11.72 4.6%</td>
<td>29.38 11.5%</td>
<td>6</td>
</tr>
<tr>
<td>Corrugated Box</td>
<td>165.66</td>
<td>7.22</td>
<td>13.54 8.2%</td>
<td>22.85 13.8%</td>
<td>6</td>
</tr>
</tbody>
</table>

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.

10.2 The above are in accordance with the definitions of these terms in TAPPI T 1200 “Interlaboratory Evaluation of Test Methods to Determine TAPPI Repeatability and Reproducibility.”

10.3 The above values were obtained using test results, each an average of 20 determinations among 6 laboratories on four different corrugated combinations and one solid fiberboard specimen. The interlaboratory study was conducted in accordance with TAPPI T 1200.

11. Keywords

Corrugated boards, Boxes, Burst strength

12. Additional information

12.1 Effective date of issue: To be assigned.

12.2 Revisions:

12.2.1 This method was revised in 2005, and a new precision statement was added.

12.2.2 In the 2011 revision, solid fiberboard was removed, safety precautions were added, and concerns about applying this method to double-wall and triple-wall board were clarified. As well, the specification for clamping pressure was added and the specification for clamping depth was removed to better match current practice (and equipment capability) across the industry. The 2017 revision made no changes. In 2022 only minor editorial changes were required.

12.3 Related methods: ASTM D 2738; APPITA P 438; ISO 2759.
Literature cited


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