Pin adhesion of corrugated board by selective separation

1. Scope

This method is used to measure the force required to separate corrugated board between the flute tips of corrugated medium and its linerboard facings.

2. Significance

2.1 Good adhesion of the corrugated medium to its facings is important in obtaining high quality corrugated board and boxes. The pin adhesion test provides a means of determining the nature and strength of the bond formed during the combining operation and may be used to detect some manufacturing defects, such as poor adhesive penetration, spotty adhesion, and containerboard with a low internal bond strength.

2.2 The test described in this procedure will measure the force required to separate selectively either the inside or outside facing of corrugated board.

2.3 Unfortunately there is a defect in this test which can cause low readings, especially with lightweight liners. When a liner is very flexible, it tends to bend around the pressure pins and a shear type failure occurs rather than a straight Z direction failure which results in lower readings. According to our latest studies, based on a very limited number of samples, the loss is almost twice as severe when using the nonselective pin adhesion test method. Because of this weakness, the nonselective method will not be described or recommended in this method. For further information on this phenomena, see sections 10.5.1 through 10.5.4.

3. Apparatus

3.1 Pin adhesion attachment\(^1\), consisting of pins of the proper diameter and length. The requirement is seven support pins, 76.2 mm (3 in.) long [69.8 mm (2.75 in.) inside dimension] when resting on supports and six pressure pins 63.5 mm (2.5 in.) [57.2 mm (2.25 in.) inside dimension] when resting on supports. One end of the support and pressure pins may be attached to a separate frame which will keep the pins in each set properly spaced according to the number of flutes per unit length for the board to be tested. Means for supporting the open ends (or other end of the pins) must be provided. This other support may consist of a series of holes in a frame into which the open ends of the pins are inserted. As an alternate, notches in the end of this frame are acceptable. Base plates are required to hold the frames and pins in fixed and rigid positions. All pins, when firmly engaged in the holder, must be parallel throughout their entire length within ± 0.05 mm (± 0.002 in.) to the base plate.

\(^1\)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.

Approved by the Fiberboard Shipping Container Testing Committee of the Corrugated Containers Division TAPPI
3.1.1 An illustration of a commonly used instrument is shown in Figs. 1 and 2.

3.1.2 Because the radius of curvature is different for the various flute sizes, use the pin diameter as shown in Table 1.

3.1.3 Pins should be made from cold roll steel No. 1018 and should be checked before each test for straightness. Test instruments with crooked pins should not be used.

NOTE 1: The dimensions shown in Table 1 apply to distance between pins in a set of support or a set of pressure pins. Dimensions will vary for other flute counts per unit length.

3.2 Compression machine [see TAPPI T 808 “Flat Crush Test of Corrugated Board,” Section 3.1, or TAPPI T 825 “Flat Crush Test of Corrugated Board (Rigid Support Method),” Section 3.1].

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,” cut a minimum of ten test specimens as follows: “A” and “C” flute board 50 mm x 150 mm (2 in. x 6 in.) and “B” flute 32 mm x 100 mm (1.25 in. x 4 in.) from firm, uncrushed areas of corrugated board so that the 50-mm (2-in.) or 31.8-mm (1.25-in.) direction is in the flute direction of the corrugation. There are a few small compression machines where a 6 in. long sample creates too tight of a fit, due to their small platen size and the workable area around the platens. In cases like this a 5 in. long sample with the pins properly centered seems to work better, and causes no negative effects. This does not effect the area of glue line being tested, and therefore no change in the conversion factor is needed.

4.2 Care should be taken to ensure that all cuts are parallel or perpendicular to the corrugation.

5. Conditioning

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

5.2 For special testing, such as measuring bond strength of a water-resistant adhesive, specimens may be conditioned in a high-humidity atmosphere or immersed in water, depending on the type of test desired.

6. Procedure

6.1 With the designated facing to be separated face down, insert the pressure pins midway between the facing and fluted medium so as to contact only the facing to be separated when the specimen is under load. Next, insert the
support pins between each of the pressure pins. Finally, complete the assembly of the test instrument and center it on the platens of the compression machine, with the designated facing for separation facing down (Fig. 2).

Table 1. Pin diameters and distance between pins for various flutes*.

<table>
<thead>
<tr>
<th>Flute size</th>
<th>No. of flutes per mm (foot)</th>
<th>Pin diameter, mm (in.)</th>
<th>Distance between pins, center to center, mm (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.110 33</td>
<td>3.56 ± 0.05 (0.140 ± 0.002)</td>
<td>18.47 ± 0.05 (0.727 ± 0.002)</td>
</tr>
<tr>
<td>B</td>
<td>0.155 47</td>
<td>2.03 ± 0.05 (0.080 ± 0.002)</td>
<td>12.98 ± 0.05 (0.511 ± 0.002)</td>
</tr>
<tr>
<td>C</td>
<td>0.130 39</td>
<td>3.05 ± 0.05 (0.120 ± 0.002)</td>
<td>15.62 ± 0.05 (0.615 ± 0.002)</td>
</tr>
</tbody>
</table>

*Flutes per foot may vary with corrugator manufacturer. Thus, to make appropriate apparatus use pin diameter and tolerance for each flute size, and adjust pin spacing as required to tolerances noted.

6.2 Apply a load at a constant rate of 111± 22 N (25 ± 5 lbf) per TAPPI T 808 or 12.5 ± 2.5 mm (0.5 ± 0.1 in.) per minute per TAPPI T 825 with the compression machine until separation of the facing from the flute tips takes place. Separation of all bond lines is not necessary.

7. Report

7.1 Report the following:
7.1.1 Average force, in newtons per lineal meter (pounds per lineal foot) of glue line, to the nearest 0.2 N (nearest pound) for separation. [All normal A, C, and B-flute fixtures have seven support pins and six pressure pins. With these type fixtures, divide the A or C-flute pin results by 2 and divide the B-flute by 1.25 to obtain pounds per lineal foot of glue line. Naturally, the sample sizes recommended in section 4.1 must also be used in order for these conversion factors to be accurate].
7.1.2 The compression machine used as specified in TAPPI T 808 or TAPPI T 825.
7.1.3 The percent and nature of fiber failure.
7.1.4 The standard deviation.
7.1.5 The number of specimens tested and the side tested.
7.1.6 Any observations which may assist in interpreting the results.
7.1.7 Test conditions if other than standard.

8. Precision

8.1 Repeatability (within a laboratory) = 5.1%, 10 specimens/average.
8.2 Reproducibility (between laboratories) = 11.8%, 10 specimens/average.
8.3 Comparability (between materials) = not known.
8.4 These data were obtained in a round robin among 11 laboratories, testing the outside facing of 200-pound test C-flute board.
8.5 Variability in these statements might be found for different grades of board, between inside and outside facings and different flute sizes.

9. Keywords

Pin adhesion tests, Corrugated boards, Bonding strength.

10. Additional Information

10.1 Effective date of issue: March 1, 1996.
10.2 Low test results, when accompanied by a high percent of fiber separation, do not necessarily mean poor bond strength. This condition would reflect the inner strength of the paper fibers under test.
10.3 A good pin adhesion test can be misleading if, for example, there is uncooked starch in the glue line. Under stress and/or abuse the glue can crack and fail, thus reducing box performance.

10.4 Related methods: APPITA P 430 “Liner Adhesion of Corrugated Board (Force Applied to Both Facings to Rupture the Weaker Bond),” Technical Association of the Australian and New Zealand Pulp and Paper Industry, Parkville, Australia; FEFCO No. 11, European Federation of Corrugated Board Manufacturers.

10.5 Light weight liners.

10.5.1 Unfortunately there is a defect in the pin adhesion test which can result in lower values especially with lightweight liners. Lightweight liners are more flexible and tend to bend around the pressure pins during testing. Unfortunately, if the liner distorts too much, the adhesive bond undergoes more of a shear type separation instead of the straight Z direction pull which the test was designed to provide. When this happens, the results can be significantly lower.

10.5.2 The fact that this can lower the final pin adhesion results was proven by tests conducted by TAPPI's Corrugated Board Technical Service Committee. In these tests, half of the samples from 33-26-33 C-flute trial were reinforced on both sides with 90-lb kraft liner using double coated pressure sensitive tape and the remaining half were left untouched. The pin adhesion results showed a 29% loss in the unreinforced samples despite the fact that the liners laminated to the outside area should have had no effect on the actual bond itself.

10.5.3 These first tests were performed using the weak side pin adhesion method (the non selective method), which is more vulnerable to this shearing action since both the SF and DB liners are being misshapen at the same time. Subsequent tests using the selective side test method confirm that this method is less sensitive to shearing failure on lightweight liners as the maximum loss using this method has been found to be approximately 15%. It should be cautioned that these conclusions are based upon a very limited number of trials.

10.5.4 A number of experiments to redesign the pin adhesion holder by either squaring the pins or coming up with some easy way to clamp a thin metal plate to the selective side being tested have not proven to be workable. To date, the only solution is to reinforce lightweight samples with heavier liner using double coated adhesive tape. If the results are suspiciously low, also remember that the weak side failure (non selective) method appears to be almost twice as sensitive to this weakness than the selective side method. It was also found that by using the selective side method the majority of combined board samples having liner weights of 42 lb and higher were not susceptible to a shearing loss.

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