Corrugated board glue bond wet shear test

1. Scope

1.1 This method is used to measure the force required to separate the facing components from the flute medium of corrugated board when employing a shearing force in the cross machine direction.

2. Significance

2.1 Adequate adhesion between facings and fluted medium provide the foundation for the usefulness of corrugated board. Never is the usefulness as challenged as when the board is exposed to high levels of humidity and/or direct moisture. When the starch based glue forming the bond between facings and fluted medium is softened or resolubilized by excess moisture, the geometry of the fluted construction will begin to change, leading to the ultimate failure of the box to support or protect its contents. When the geometry of the bonded area changes, the stacking properties are reduced, and the usefulness of the container is lost.

2.2 The test described in this method will measure the force required to shear the facings from the fluted medium of corrugated board after it has been exposed to warm water. The warm water exposure is limited but produces an environment which is very hostile to bond integrity.

2.3 By testing the glue bond in the cross machine direction, or stacking direction, we gain greater insight into the possibility of changing board geometry, and decreasing stacking strength in highly humid or wet conditions.

3. Apparatus

3.1 Tensile testing machine, which applies a progressively increasing tensile load at a rate of 10.0 ± 0.5 N/Min (2.2 ± 0.11 lbf/sec). This tensile tester is to be calibrated against weights or a standard force gauge to ensure that it indicates the maximum load failure to within 0.01 N (0.002 lbf). The machine is set up with a special fixture that allows test specimens to be fitted into a comb assembly appropriate for the flute size, and once fitted, clamped into place. (See Figure 1.)

3.2 Tensile testing jigs, which are manufactured to fit the specifications of each individual flute size. Each jig mounts on the tensile testing machine to allow the testing of test specimens of a particular flute size.

3.3 Plastic strips, which will serve as test specimen holders. Each plastic strip will measure 100 mm × 45 mm × 1.2 - 1.5 mm thick (3.94 in × 1.77 in × 0.047 - 0.059 in). The strips will have a hole located on one end to allow attaching the strip to the draw bar of the tensile testing machine. The hole will be oblong and measure 9 mm × 16 mm (0.35 in × 0.63 in). At the opposite end of the plastic strip, the thickness will be reduced in thickness by 0.25 mm (0.0098 in) for the last 25 mm (0.98 in). This facilitates the mounting of the test specimen in a specific location on the plastic strip. (See Figure 2.)

3.4 Water bath, which will be thermostatically controlled to maintain a water temperature of 40 ± 1ºC (104 ± 2.6ºF). It shall be fitted with racks on which the test specimen holders can be hung to ensure that the test specimens are submerged to a depth of 25 - 30 mm (0.98 in - 1.18 in).

3.5 Test specimen cutter, which could be a template and sharp hand-held razor knife, or any one of a number
of cutting devices, capable of producing 25 mm (0.98 in) wide specimens with clean unfrayed edges. Knives used should have blades 0.3 - 0.6 (0.011 - 0.022 in) mm thick.

3.6 Stop watch or timing device, which is capable of measuring to 1.0 ± 0.5 seconds.

3.7 Adhesive tape, which is double sided and waterproof.

4. Sampling

4.1 Samples shall be obtained in accordance with TAPPI T 400 “Sampling and Accepting a Single Lot of Paper, Paperboard, Containerboard, or Related Product.”

5. Conditioning

5.1 Since the specimens to be tested will ultimately be immersed in 40°C ± 1°C (104 ± 2.6°F) water for 15 minutes prior to testing, there is no need to precondition or condition the specimens prior to testing.

6. Test specimens

6.1 From each lot of corrugated board to be tested, cut strips approximately 200 mm (7.87 in) in the MD and 25 ± 0.2 mm (0.98 ± 0.008 in) in the CD using any one of the numerous types of cutting devices available, ranging from the Billerud type to the hand-held razor.

6.2 Once the strips are cut and marked, a thin blade razor knife is then used to prepare test specimens. A test specimen is cut from the previously prepared strips in a particular manner shown in Figure 3. Cut the test specimen in such a way that the side of the board to be tested has four intact gluelines while the opposite side has five intact gluelines. Both liners and the medium must be cut through in a direction parallel to the flutes and about midway between the gluelines. Cut four test pieces for each side of the board to be tested.

6.3 Apply double sided tape to the test sides of the specimens and press firmly to ensure an adequate tape bond. Avoid crushing the board during this step. (The test side of the specimen is that side with four intact flutes or gluelines.)

6.4 Remove the backing from the double sided tape and apply the test specimens to the test specimen holder. Be certain that the flutes of the test specimen are parallel to the longer sides of the test specimen holder. When centering the leading edge of the test specimen onto the test specimen holder, be sure the test specimen is fitted snugly against the milled down edge of the test specimen holder.

7. Test procedure

7.1 Fit the first test specimen onto the rack of the warm water bath so that it extends 25 - 30 mm (0.98 in - 1.18 in) below the surface of the water. Fit additional samples onto the rack in a similar manner at timed intervals, e.g. two minute intervals. The intervals allow for continuous testing with all test specimens receiving the identical amount of exposure to the warm water.

7.2 When the first test specimen has been in the warm water bath for 15 minutes ± 10 seconds, remove it and install it in the tensile testing machine. This is done by sliding the flutes into the correct tensile testing jig. Once inserted, the test specimen is clamped down while the opposite end of the test specimen holder is fitted to the drawing device by use of the drawing bar hook and the hole in the test specimen holder.

7.3 Actuate the draw bar within 15 seconds of the test specimen removal from water. Observe the tensile force exerted upon the sample and note the force in newtons at test specimen failure. As the test specimen is removed from the tensile testing machine, also note whether medium failure or fiber tear occurred, and in the case of fiber tear, whether it was from the medium or the liner.

7.4 As the time interval for each of the remaining test specimens in the warm water bath reaches 15 minutes ± 10 seconds, remove these test specimens and test as describe above. Typically, test specimens are removed from the warm water bath in the same order in which they were put into the warm water bath.

7.5 Calculate the mean and the standard deviation of the results for each side of the board tested. Since we are testing 100 mm (3.94 in) of glueline (25 mm (0.98 in) × 4 gluelines), multiply the results by a factor of ten to report in Newtons/meter.
8. **Report**

8.1 For each lot of board tested reported the following:
8.1.1 Complete identification of test specimens.
8.1.2 Date and place of testing.
8.1.3 The mean of the test results for each side tested expressed in N/m (lbf/ft) to the nearest N/m (lbf/ft).
8.1.4 The standard deviations of the test data and the number of tests done to determine each test result.
8.1.5 Whether or not medium failure or fiber tear occurred and, in the case of fiber tear, whether it is from the medium or the liner.

9. **Precision**

9.1 The following estimate of repeatability is based on data from one mill using eight sets of replicate measures on various corrugated board samples in the range of 50 to 150 glue bond strength (GBS) units. This estimate of repeatability is based on ten determinations per sample.

Repeatability (within a laboratory) = 20%

10. **Keywords**

Corrugated boards, Shear tests, Shear strength, Glue failure, Adhesion, Wet strength

11. **Additional information**

11.1 Effective dated of issue: April 1, 1999.

12. **Literature cited**

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