NOVEMBER 2010

ADVANCED ADHESIVES REPORT

Your corrugating newsletter from Harper/Love Adhesives Corporation

ECT: Since 1991, the best predictor of stacking strength

By Bill Kahn

Corrugated boxes were first approved for rail shipment of cereal boxes in 1906. The railroads, which had vested interests in lumber, immediately began to demand a hefty penalty for shipments in corrugated rather than wood boxes. In 1914 the Pridham decision by the Interstate Commerce Commission removed the penalty and allowed corrugated to evolve from its earlier role as merely a substitute for wood, into the shipping material of choice.

Prior to 1991 the specifications for corrugated were governed by Rule 41 of the Uniform Freight Classification of the railroads and the nearly identical Item 222 of the National Motor Freight Classification. These archaic specifications detailed only the minimum basis weight of the liners, the burst test strength, the limitations on the sum of the box dimensions (L + W + D), and the maximum total weight of the contents of the box.

Burst test has limited value

The burst test may be important as a measure of containment to predict the force that occurs when a box is dropped *but offers very little value in predicting the stacking strength of the corrugated package.* The value of this test, except for limited specific purposes, is questionable.

The McKee formula

Box compression is predicted or calculated using a formula. The most widely used formula is known as the McKee Formula. It employs ECT, caliper, and box perimeter to predict box compression.

A version of the McKee formula

$$C = 5.87 \times P \times \sqrt{hZ}$$

where:

P = Edge Crush Test value

h = caliper of the corrugated board

Z = box perimeter 2(L + W)

Today: Performance Specified Packaging

Since 1991 the industry has moved more toward Performance Specified Packaging. This move was brought about with the approval for the corrugated industry-sponsored initiatives to allow for the use of the edge crush test (ECT) rather than the traditional liner basis weights and board burst strength requirements.

ECT measures the ability of a small vertically placed sample of combined board to sustain a top-to-bottom load. ECT is the single most important property in predicting box compression and the test helps to validate the quality of the raw materials.

The failure of ECT samples is often accompanied by interflute buckling (above, left). This defect is similar to the patterned buckling of the liner board facings, which occurs during the compression test.

Better adhesives, higher ECT values, stronger boxes.

With the introduction of high ring-crush liner, box manufacturers are able to reduce combined board weights while maintaining ECT and compression values. It stands to reason that innovations in starch adhesive additives could also contribute to these values. By using our well-equipped board testing facility and establishing a dedicated R&D project, Harper/Love is extremely active in developing new products that will give us a better understanding of the adhesive technology needed for improving ECT and box compression values.

Preparing ECT samples

By Rex Woodville-Price

Edge Compression Test (ECT) is a short column test of the vertical compression load that a standard sample size will bear. The results for the test are usually expressed in pounds.

There are three ways to prepare a sample (photo): waxed, necked down, and plain, in a holder. All three methods are valid and each has its advantages and disadvantages. In any case, sample size is the same (usually 2″ square).

For the test to measure accurately the strength potential of the sample, we must make sure the failure does not occur on the edge, which is generally the weakest, due to the ease with which it can deflect. We accomplish this by isolating the edges altogether. All three sample methods do that.

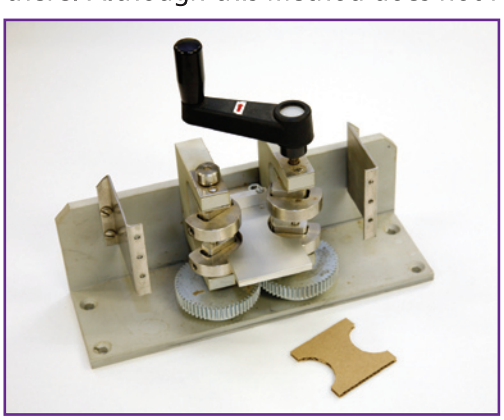
Waxed sample (TAPPI T811)

The waxed sample's edges are dipped in molten wax (photo, left). When the wax hardens, the edges become the strongest part of the sample, which precludes failure at that point. The advantage is that no holder is required; the disadvantage is that sample preparation takes additional time and effort.

Sample height for T811 must be accurately cut with a cutter that uses side bevel blades angled away from the test sample to ensure that the cut edge is perpendicular to the board surface. Just a .015″ angle on the board can lower test results over 10%. Also wax temperature and the amount of wax left on the sample can alter the test results.

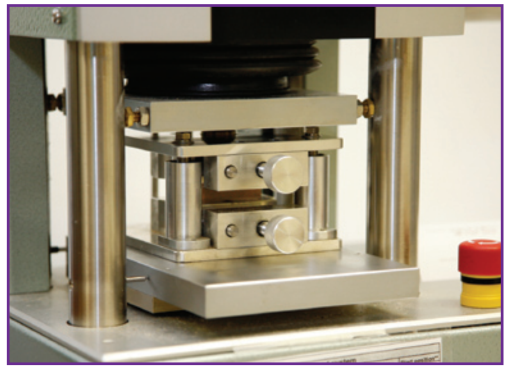
Necked down sample (TAPPI T838)

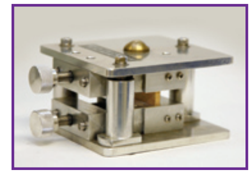
The necked-down sample has a smaller area in the middle which by design is weaker, so the failure is certain to occur there. Although this method does not require a holder, it requires an apparatus that cuts the necks accurately into the 2″ x 2″ sample. These devices must have the cutting edges kept clean and sharp or they will cause tears in the sample, which will lower test results.



Clamp method (TAPPI T839)

The newest method T839 (clamp) uses a 2″ x 2″ sample that is held tightly in a test fixture. The clamping force on the top and bottom portions of the sample hold it perpendicular to the test force so there is no chance of tipping that causes lower results and the failure will always occur in the center of the sample. This method gives the most reliable results while eliminating most of the sample preparation errors.





With any of the three methods, it is important that the load be applied in a straight line through the walls of the board. (This is true not only of the ECT sample, but also of the box itself. The load-bearing walls of the box must be straight and perpendicular to the base. Any deflection in the board will become the starting point for the failure.) On the sample, edges are cut straight and perpendicular to the sides to ensure that the load is applied through the walls.

Variables that may affect results

- The sample must be supported and held vertically in the apparatus.
- The edges of the sample must be cut square.
- The moisture content of the sample will affect its strength. Higher moisture will generally yield lower values. Samples tested right off the corrugator will have lower values since they will generally contain more moisture. When comparing values from different laboratories, it can be useful to condition all samples the same, for example so many hours at a standardized temperature and humidity.
- If the samples are crushed, whether in the manufacturing process or in the handling of the samples, they will yield lower values. Sometimes the board is crushed during the manufacturing process. Even though it springs back and does not exhibit measurable caliper loss, this mechanical damage may still affect test values. Caliper measurement is still a valuable predictor of possible ECT losses in the process.
- Samples that are poorly bonded (low pin adhesion test values) will yield lower ECT values because the liner will separate from the fluted medium and deflect. Failure begins with deflection.

ECT Testing & variability

By John Kohl

There are three different official test methods approved by TAPPI for determining ECT values that are currently being used in labs, and the results from each one is slightly different. TAPPI T811 (wax-dipped), TAPPI T838 (neck-down), and TAPPI T839 (clamp). All are based on crushing a small corrugated board sample, obtained from a box or blank, and forcing the sample to fail in compression, to simulate a finished box failure under load.

The sample preparation for each method can greatly affect the test results, so care and precision are very important. All three methods need samples cut that are exactly square (parallel and perpendicular to the flutes) to obtain credible results. (See article, *Preparing ECT samples*, at left.)

ECT is the single most important property in predicting box compression performance

Repeatability and reproducibility

There is intrinsic variability in a lab, and from lab to lab, for each method used. Each test method has a statement of repeatability within a lab and one for reproducibility between laboratories;

TAPPI T811 (wax-dipped)	***Repeatability***	***= 06%***
	Reproducibility	***= 23%***
TAPPI T838 (necked-down)	***Repeatability***	***= 06%***
	Reproducibility	***= 18%***
TAPPI T839 (clamp)	***Repeatability***	***= 3.5%***
	Reproducibility	***= 19%***

This shows that not only there is variability between each group within a lab but there is also a huge variability from lab to lab. The variability within a given lab is the lowest for T839 clamp method, indicating that you will have less error and a lower standard deviation within each test group when using this method.

Allow for results that vary from your customer's lab

One factor often overlooked is that the test reproducibility from lab to lab is large and varies from test to test. Your results will probably not match your customer's test lab and you will need to build in an additional safety factor into your boxes.

Also, the original wax-dipped method was used to develop McKee's equation. Now more labs have switched to the clamp method to reduce their variability. With the change in liner board and medium in the 40 years since the McKee formula was derived, there is a new dilemma: is the current equation accurate or does it need revising to accommodate higher ECT results for the same board samples?

Build for average, minimum average, or minimum?

Box plants also need to educate their customers on the natural variations in the liner and medium, and not assume that the average test results for box compression will always provide the level of performance required for a given box. The end user needs to understand the difference between average, minimum-average, and minimum box compression results.

McKee's original study showed a natural variation in raw materials and process that resulted in a ±17% in compression strength. If a customer requires a box with 1200# compression, some of the test samples will be as low as 996#. If the 1200# specification is the minimum requirement for the box, the liner and medium may need to be upgraded at an additional cost to meet the required minimum average. The new specification will need to be 1446# compression strength to allow for the few boxes that fall below the average but not fail while in use.

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of making
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In this issue, all about Edge Crush Testing:

- ***Predicting stacking strength***
- ***Preparing test samples***
- ***Test repeatability and reproducibility***