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The edge crush test (ECT): its relationship to box compression and its derivation from containerboard edge stiffness

Scope

The Edge Crush Test (ECT) using a short column specimen is an important test for the boxmaker. This TIP describes the relationship between containerboard edge stiffness, ECT, and box compression (BCT).

Safety precautions

While there are no safety precautions involved in performing the calculations, if one is performing any one of the ECT procedures, please keep extremities clear of saw blades, router tooling, or the knife blade(s) in air-driven or manually driven sample cutters. Use eye protection if using a circular saw. In addition, use care when using the hot wax required in the T 811 method.

Edge crush test methods

There are several methods available to measure ECT. TAPPI T 811 (the wax dip method) and TAPPI T 839 (the “holder” method) are the two methods most frequently used. A third method, TAPPI T 838 (the “neck-down” method), is less frequently used. TAPPI T 811 is the referee test method to measure ECT for compliance to the carrier regulations.

Rationale and formulas

Why should anyone want to perform this test? Well, it may be the most useful test for corrugated board.

The first reason is fairly obvious. If the corrugated box is being made to conform to Alternate Rule 41/Item 222, in which the ECT is the specification test, the boxmaker should perform the ECT to determine compliance with the regulations.

The second reason is not quite so obvious. Edge crush is the single most important property of corrugated board used to estimate box compression strength. The most widely adopted formula for predicting box compression is the McKee equation:

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$$BCT = k_1 \times P_m \times h^{0.508} \times Z^{0.492}$$

where:

BCT	=	box compression strength
k_1	=	a constant 5.874
P_m	=	edge crush
h	=	caliper of the corrugated board
Z	=	box perimeter $2(L+W)$

The above is the “modified” form of the McKee equation. This version of the McKee equation is used in commercially available computer programs used to calculate BCT. The original McKee equation involved the use of the flexural stiffness instead of caliper. Since flexural stiffness is not a frequently performed test, caliper is substituted. The substitution is only appropriate when used to analyze materials for which the caliper has not been damaged.

A “short” version of the McKee formula is:

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

The “short” version yields predicted compression values approximately 5% higher than the “modified” version.

The important points to note when estimating BCT for any box is that Z (perimeter) is already determined and the only two controllable variables are P_m (edge crush) and h (caliper). P_m is three times as important as h .

NOTE 1: When using any of the versions of the McKee predictive formulas for box compression, caution is advised. Several factors in addition to ECT can affect box compression. Moderate (up to .006 in) crushing (caliper loss) during fabrication may not affect ECT, but will affect compression. Deep slotting, finger/vacuum lines, poor corrugator or press scoring, box squareness (score line-up), box skewness (fishtailing), and bundle strap damage are additional manufacturing defects that will affect box compression.

The third reason for performing the ECT test is that it is basically a material test, as Edge Crush is a measure of the combined edge stiffness qualities of the liners and medium used. The ECT strength of corrugated board is largely dependent on attributes of the linerboard and medium components. A box manufacturer can get a good estimate of the quality of their paper supply by performing edge crush testing on a regular basis. Of course, good quality fabrication is required. Provided corrugated board is free of defects like delamination, voids in the adhesive lines, excessive caliper loss, etc., ECT can be accurately estimated using edge stiffness values of the linerboard and medium components. The relationship between containerboard edge stiffness and ECT has been well known for a long time.

Two versions each of formulas using Ring Crush and–Short Span Compression (SCT, also known as STFI) to predict ECT are shown:

1. $ECT = 1.57 \times [(RC_{L1} + RC_{L2}) + .321(RC_M \times TUF)] + 3.93$
2. $ECT = k_2 [(RC_{L1} + RC_{L2}) + (RC_M \times TUF)] + a$
3. $ECT = .786 \times [(S_{L1} + S_{L2}) + (S_M \times TUF)] - 7.21$
4. $ECT = .633(S_{L1} + S_{L2}) + 1.03(S_M) + .62$

where:

RC_{L1}	=	the ring crush of liner #1
RC_{L2}	=	the ring crush of liner #2
RC_M	=	the ring crush of the medium