

An Annotated Bibliography of ECT

Prepared by

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Sources:

- 1) Elsevier Engineering Information, PaperChem database
- 2) "Corrugated Crossroads" John Koning
- 3) Maltenfort, G.G. "Corrugated Shipping Containers: an Engineering Approach" Jelmar Publishing, Plainview , NY. 1988.
- 4) Word of mouth, private communications
- 5) IPST Continuing Education courses: 1986-1988

Disclaimer:

References reviewed in this bibliography were subjectively selected as being significant and relevant towards understanding the nature of the edge compression phenomenon of corrugated board. Citations are restricted to those in common languages and publicly available in the common published literature. The order of the references in the list below is arbitrary.

Catalogue by subject:

Span length, loading rate: Bormett 21, Stockmann 41, Theilert 24

Manufacturing effects of ECT: Singh 8, Kutt 43, Hoke 27, Schaepe 42, Koning 48, Sprague 35

Crushing effects : Nordmann 50, Crisp 45, Kroeschell 4, Batelka 1

Details of the clamp method: Schrampf 10, 15 Eriksson 40, Frank 38, Kroeschell 30

Neckdown method: Koning 23, 14 Frank 38, Eriksson 40

FEFCO method: Stott 20, Ernst 6, Du Plooy 19

Rule 41 implications: Troll 7, Young 3

Component effects on ECT: Byrd 11, Whitsitt 13, Nordmann 44, Hoke 31, Seth 28, El-Hosseiny 22

Unique lab studies: Bormett 21, Urbanik 9, Wasteland 51, Hahn 5, Urbanik 2

Ring crush and ECT: Seth 17,29, Dahl 25, Frank 33, Tenzer 37

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	Title	Authors	Source	Synopsis
1	Effect of Box-Plant Operation on Corrugated-Board Edge Crush Test	Batelka , J.,	Tappi Journal v 77 n 4 193- 198 April 1994	Effects of crushing on ECT are characterized. Caliper recovery after crushing occurs within 1 minute of crushing
2	Edgewise Crush Test Streamlined by Shorter Time After Waxing	Urbanik, T.J., Catlin, A.H., Friedman, D.R., Lund, R.C.,	Tappi Journal v 77, n 1, 83-86, Jan 1994	In T 811 method it is shown that it reconditioning for 2 hours is sufficient after waxing the edges
3	ECT Has Edge over Mullen	Young, R.,	Paperboard Packaging, v 83, n 3, 48-50, March 1998	ECT is shown to have an advantage over Mullen towards cost effectiveness, engineering of corrugated structures and is influenced by corrugator variation, flutings detail, etc.
4	Edge Crush Test	Kroeschell, W.O.	Tappi Journal v 75, n 1, 79-82, Jan 1992	Procedure, advantages and limitations of ECT are examined, ECT is insensitive to variables in the corrugating and box making process, effects of crushing on ECT are shown
5	Edge-Compressive Fixture for Buckling Studies of Corrugated Board Panels	Hahn, E.K., Carlsson, L.A., Westerlind, B.S.,	Exp. Mech., v32 n 3, 252 – 258, Sept 1982	The compressive response of ECT loaded specimens is examined using shadow-Moire method showing out-of-plane displacement panel buckling, analyses suggest results approximate simply supported conditions
6	Influence of Sample Preparation on the Edge Crush Strength of Corrugated Board	Ernst, U., Graf, E.,	Papier, v 45, n 9 549 – 559 Sept 1991	Effects of sample preparation were studied to propose a modification of the FEFCO n 8 method
7	Better Understanding Rule 41 and Item 22	Troll, D	Boxboard Containers International, v 98, n 10 34-36, May 1991	The use of ECT over Mullen allows for flexibility in liner medium combinations in complying with shipping regulations towards using lightweight materials, meeting ECT requirements rather than Mullen allows wider use of recycled fiber
8	Effect of Handling on the Compression Strength of Corrugated Fiberboard Containers	Singh, Sp., Crofts, B., Burgess, G.,	J. Test Eval., v 19, n 5, 374 – 378	Package weight and drop height were varied, bursting strength and basis weight are suggested to be replaced by mean edge crush, flat crush as performance criteria
9	Correcting for Instrumentation with Corrugated Fiberboard Edgewise Crush-Test Theory	Urbanik, T.J.	Tappi Journal, v73, n 10 , 263 – 268, Oct 1990	A theory is developed that is consistent with local buckling and accounts for the interrelationship of paper strength and stiffness to correct for differences in techniques and instrumentation
10	Faster Alternative ECT Test Procedure	Schramper, K.E., Whitsitt, W.J.,	Tappi Corrugated Containers Conference, Oct 1988	Development and verification of the T 839 clamp method is described, 2 x 2 inch specimens are suitable for all grades of corrugated boards, results with a loaded clamp are shown to be comparable to T 811 but with lower variability
11	Compressive Properties are Important to Container Design	Byrd. V.L.,	American Papermaker v 51, n 4, 57- 58 April 1988	Studies are reviewed that determined the dependence of compression resistance on other paperboard characteristics, machine direction, drying conditions, furnish composition and the papermaking process
12	Measuring Corrugated Box Performance	Leake, C. H.	Tappi Journal, v 71, n 10 Oct 1988	Differences in box performance are attributed to fluting basis weight, combining adhesive and environmental changes

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13	Papermaking factors Affecting Box Properties	Whitsitt, W.J.,	Tappi Corrugated Containers Conference Orlando, 1988	Effects of wet pressing, reduced directionality, strength additives on ECT and flexural stiffness , increases in liner strength from wet pressing are shown to be more important than reductions in thickness accompanying wet pressing
14	Toward and International Standard for the Edgewise-Compression Test of Corrugated Board – Second Opinion	Koning, J.W.,	Appita Journal, v 41, n 5 , 396 – 397, Sept 1988, Tappi Journal, v 71 n 10, 62 -64, Oct 1988	An ECT test should be sensitive to material of structural defects, be consistent with theory, be applicable to all grades of corrugated fiberboard, neck-down specimen shape and T 823 procedure meet the criteria best
15	Clamped Specimen Testing: Faster Edgewise Crush Procedure	Schramper, K.E., Whitsitt, W.J.,	Tappi Journal v71, n 10, 65 -69, Oct 1988	Several types of cutters were evaluated, clamped method compared to waxed method, a 2 x 2” specimen was found to be suitable for all grades of corrugated board, results were similar to T 811 results but with lower variability
16	Optimizing Fluting and Liner Properties	Nordkvist, B.	Paperboard Packaging v 73, n 10 91 -92 Oct 1988	Increasing the basis weight of the semi-chemical pulp fluting resulted in higher ECT and BCT
17	Effect of Papermaking Variables on Linerboard Strength	Seth, R.S.	CPA Ann. Mtg. Montreal, Jan 28 – 29, 1988	Ring crush does not measure the true potential of the sheet under compression, factors that control the intrinsic CT of paperboard are considered.
18	Relevance of Flat Crush and Edgewise Compression Strengths to Corrugated Box Compression Strength	Du Plooy, A.B.J.	Paper Southern Africa, v 8 n 5, 56 – 60 Sept/Oct 1988	ECT is shown to be the primary criterion for measurement of the protective capacity of containers although South Africa specifies flat crush strength for its classification for board. A strong correlation was shown between the ECT of board and the ECT if its components
19	Edgewise Compression Strength of Corrugated Board	Du Plooy, A.B.J.	CSIR Spec. Rep. No 462, Feb 1987	The most accurate ECT values were obtained by using accurately cut sample measuring 100 x 25 mm whose loading edges were impregnated with wax
20	Toward and International Standard Method for the Edgewise Compression Test of Corrugated Board	Stott, R.A.	Appita Journal, v 40n 6, 436- 438 , Nov 1987	The FEFCO method is recommended with the use of a Billerud-type cutter as an international standard for ECT
21	Predicting Edgewise Compressive Strength	Bornett, D.W.	Boxboard Containers International v 94, n 4, 30 -34, Nov 1986	A system for predicting ECT of single wall board from the components strengths is presented linking FPL vacuum restraint compression apparatus, ECT neck-down and the predictive model of Johnson-Urbanik
22	New Specifications for Corrugated Boxes Can Affect Board Making	El-Hosseiny, F.	Pulp and Paper, v 60, n 13, 56-67 Dec 1986	Effects of furnish and papermaking variables on compressive strength are reviewed
23	New Rapid Method for Determining Edgewise Compressive Strength of Corrugated Fiberboard	Koning, J.W.	Tappi Journal, v 69, n 1, Jan 1986.	A comparison was made between T 811 and the neckdown method

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24	Edgewise Compression Resistance and Static Load-Lifetime Relationships of Corrugated Board Samples	Theilert, R.	Tappi Journal v 69, n 1, 77 -81, Jan 1986	This was an attempt to link the edgewise compression resistance dependence on loading speed of corrugated samples and the constant load-lifetime relationship of small corrugated board samples
25	Limited Range of the Ring Crush Test	Dahl, C.B.	Tappi Journal, v 68, n 10, 10- 109, Oct 1985	A graphical method was used to show that below a liner caliper of 305 microns the ring crush test becomes progressively less accurate
26	Corrugated Board Boxes: Actual Performances	Pommier, J.C., Poustis, J.	ATIP, v 40, n 7, 358, 397 – 400 1986	Flexural rigidity appears to be representative of the final behavior of a package, edge crush does not reflect the loss of a container's characteristics during its life cycle.
27	Compressive Strength of Paper, Corrugated Board and Boxes	Hoke, U., Gottsching, L.	Papier, v 39, n 10 A V 65- 73, Oct 1985	Boundary conditions of the vertical edges (crease along the flaps) have a significant effect on the compressive failure load of the box. Stiffness of the edges can raise the failure load considerably
28	Relationships Between Edgewise Compressive Strength of Corrugated Board and its Components	Seth, R.S.	Tappi Journal v 568, n 3, 98 -101 Mach 1985	A relationship was found between the ECT of the combined board and the intrinsic compressive strengths of the corresponding component paperboards
29	Edgewise Compressive Strength of Paperboard and the Ring Crush Test	Seth, R.S.	Tappi Journal, v 67, n 2, 114-115, Feb. 1984	Ring crush does not measure the true intrinsic compressive edgewise strength because of the presence of bending or buckling deformation in the test specimen, ring crush strength is only 30 to 60% of the STFI and varies with sheet weight , for sheets below 200 gsm, the ring crush strength drops with increased sheet density for constant sheet weight
30	Edge Crush Test of Corrugated Board: Development of Tappi Test Methods T 811 and T 823	Kroeschell, W.O.	Tappi Journal, v 67, n 10, Oct 1984	Critical variables of the test are the method of cutting and edge reinforcement, specimen heights were determined by IPC to minimize bending and edge effects
31	Crush Tests of Corrugating Medium and Liner and their Relation to Properties of Corrugated Board and Boxes	Hoke, U., Gottsching, L.	Papier, v 37, n 10A, V67-76, Nov. 1983.	Compression tests for paper and board are correlated with each other and with the properties of paper and board. Correlations are discussed, hardness and flat crush are mentioned.
32	Effect of Cutting System in the Preparation of Corrugated Board Samples for ECT	Auria, A.D., Marchese, P.	Cartotec. Imballagio, v 2 n6, 15 -21, Sept 1982	The effects of eight different cutting systems on ECT were studied: knife thickness, shape, stiffness and the effect of the operator in manual systems. Specimens should be cut by automatic systems both sides simultaneously, knives ground on one side should be 0.2mm+ , thinner blades should be double ground

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33	Ring crush and short span compressive strength for predicting edgewise compressive strength	Frank, B.	Tappi Journal, v2 n 11, November 2003 13 - 16	Ring Crush appears to be a better predictor of ECT using the production plant data set g
34	Cutting and Laboratory Effects on the ECT for Corrugated Board	Eriksson, L.E.	Cartotec Imballagio V 2 n7, 31, 33-36 Dec 1982	Causes for ECT result deviations intralaboratory, results show that cutting of the test pieces is the most sensitive part of the ECT procedure leading to decrease in strength by 14%, Variation sin conditioning atmosphere during testing lead to +/- 5% changes
35	Medium Fracture and Strength Losses in Fluting	Sprague, C.H., Whitsitt, W.J.	Tappi Journal, v 65, n 10 133- 134, Oct 1982	The CD compressive strength of medium can decrease by 20% through the fluting process, compensation can be made through allowing shear deformation and stretch in the tip region of the flutes
36	Crush Tests Rely on Parallel-to-flute Loading	McLain, T.E., Boitnott, R.L.	Tappi Journal, v 65, n 3 148, March 1982	Samples were made with fluting direction at various angles with the specimen vertical edge, maximum load decreased with increasing flute orientation angle described by a linear equation. Failure mode observed was crushing of the linerboards and not buckling between the flute tips
37	Measuring and Calculating the Edge Crush Resistance of Solid and Corrugated Board	Tenzer, H.J., Grossmann, V., Koschnicke, H.	Papier und Druck, v 30, n 3 44-47, March 1981	Experiments have been run on corrugated and solid fiber board to compare various methods of running the edge crush test and determining relationships between the edge crush test and the ring crush tests.
38	Which ECT ?	Frank, B.	Corrugated International, August 2003.	The clamp method is shown through data to produce higher results than neckdown or waxed edge methods
39	Maximizing Top-to-Bottom Compression Strength	Johnson, M.W. Urbanik, T.J., Denniston, W.E.	Paperboard Packaging, v 65 n4, 98, 100, 102-104 , 106, 108 April 1980	A theory of thin plates in large deformations is used to analyze the strength of a single wall fibreboard element modeled as a composite structure, either an elastic instability or compressive failure is allowed, the results are used to explain how to adjust facing and corrugating medium thicknesses to maximize the edgewise compression strength per board weight
40	Review of the Edge Crush Test of Corrugated Board	Eriksson, L.E.	Boxboard Containers International, v 86, n 8 34 – 36, no. 9 64 – 67 March/April 1979	Coefficient of variation of ECT varies from 1 to 11%, cutting of test pieces was determined to be critical, factors that increase ECT are neckdown, waxing, reinforcement of facings, clamping of the test piece. Factors decreasing ECT are excess height of sample, dimensional errors, angle errors, fuzzy edges, high moisture, complete flat crushing. Irrelevant factors are sample length and width, warp, asymmetry of liner, and moderate flat crushing, intralaboratory c.v. is 5% or less.

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41	Edgewise Compressive Strength of Paper: A Physical or Structural Property	Stockmann, V.E.	Tappi Annual Meeting, 257-264, March 15-17, 1976.	Shown is that the specimen slenderness ratio must be from 10 to 30 (corresponding to a spacing/thickness ratio of 3 to 9) to prevent buckling/bending and the compressive strength remains constant and the failure mode is in shear.
42	The influence of pin adhesion strength on edge crush and box compression strength	Schaepe, M.,	Corrugating International, v 2 n2 April 2000	Lowering pin adhesion through increasing corrugator speed showed a minimal effect of the ECT
43	Structural and Strength Characteristics of Containers	Kutt, H., Mithel, B.	Tappi Journal, v 52, n 9, 1683 -5 , Sept 1969	Experiments with rectangular corrugated tubes, vertical edge effects were studied in isolated form, a predictive model for a corrugated container was developed based on the performance of a vertical edge, conversion accounts for about 40% loss in compression strength.
44	Influence of the Components of Corrugated Board on the Stiffness and Strength Properties	Nordman, L., Toroi, M.	International Paperboard Industry, v 11 n9, 16 -22, Sept 1968	Mathematical expressions are given relating the strength properties of board to those of the board components, the compression strength of boxes is related to the constructional features and the properties of corrugated board.
45	Resistance of corrugated board to flat crushing loads	Crisp, C.J., Stott, R.A. Tomlinson, J.C.	Tappi Journal v 51 n5, 80A-83A	The effect of flat crushing on combined board on ECT and other properties were made.
46	Influence of the combining adhesive on box performance	Leake, C.H., Wojcik, R.	Tappi Journal, August 1989, 61-65	ECT creep of board samples was observed to correlate with box creep indicating a longer lifetime occurs when a high amylase starch is used as the adhesive
47	Some Aspects of the Compressive Strength of Cartons	Grangard,H. Kubat J.	Svensk Papperstidning , August 1969, 466-473	The mechanics of buckling of cartonboard is discussed and the application of the block and corner compression tests are evaluated to produce a McKee like model for cartonboard
48	Effect of Glue Skips on Compressive Strength of Corrugated Fiberboard Containers	Koning, J.W., Moody, R.C.	Tappi Journal, vol 52, n 10, October 1969, 1910 – 1915.	Width of fingerline glue skips on ECT was examined experimentally using A flute, is the glue skip width is less than 0.42, the effect on BCT is less than 10%
49	Compressive strength relationships and evaluation	Sprague, C.H., Whitsitt, W.J.,	Tappi Journal, December 1982, 104 - 105	An overview of the role of ECT on box performance, the ECT is related to the component properties of board
50	Investigation of the Compression of Corrugated Board	Nordman, L., Kolhonen, E., Toroi, M.,	Paperboard Packaging, October 1978, 48 - 62	The effects of varying degrees of crushing on ECT, Caliper, Flexural stiffness, were studied,
51	Compressive response of corrugated board	Westerlind, B.S., Carlsson, L.A.	Tappi Journal, July 1992, 145 - 154	The predictive model for ECT using the summation of compression strengths of the components is critically examined using specialized compression rig, local buckling is shown to extend deformation and slightly reduces the compression strength.