

Understanding box compression strength as related to the revised Rule 41 and its alternatives

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Changes in the way box strength is measured may cause corrugated manufacturers and converters to reevaluate their production methods.

On April 1, 1992, the new Alternate Rule 41 and Item 222 gave boxmakers the opportunity to use the Edge Crush Test (ECT) as the primary measure of corrugated board strength.

The implications of that change were considered several months earlier during a workshop at the 1991 Corrugated Containers Conference. The workshop was prepared and moderated by the chairmen of the two sponsoring committees (CORBORTEC [Corrugated Board Technical Service Committee] and FISCOTEC [Fibreboard Shipping Container Testing Committee]), Barry Hoffman, quality control superintendent of Domtar Inc., and Robert H. Quick, project manager of Weyerhaeuser Paper Co. The keynote presentation was given by Ralph A. Young, manager, marketing-containerboard sales, of the Georgia-Pacific Corp.

Bursting strength has been the measure of record for more than 70 years, but at least since World War II, with the knowledge generated about corrugated container construction, it has been recognized that burst, or Mullen, is not a measure of any property significant in the container's use.

With the recognition of ECT, we can now put the Mullen test to bed. As stated by Dick Morris, the "father" of the Rule 41 revision, the important contribution of the corrugating medium to the strength of the corrugated structure is finally recognized by ECT. Corrugated board is a "sandwich" construction and just like a sandwich, the center is most important. The medium is the "meat" of the sandwich. Because it is fluted, the medium could not contribute to the bursting strength. In the most popular grade of corrugated board in use today, the medium contributes one-third of the total strength.

TAPPI's new video on "Testing the Strength Properties of Corrugated Board" tells us that individual board strength comes from the length of the individual fibers, the papermaking process, the combining process, and the strength of the adhesive bond formed on the corrugator.

A new list of words and phrases will spring up with the increased use of the Alternate Rules and ECT: bondability, cycle creep, contaminants, flexural stiffness, high intensity pressing, printability, recyclability, ring crush, STFI, solid waste, and source reduction.

No two of the more than 60 linerboard machines in the United States make their product in the same way. Fiber furnish varies from 100% virgin unbleached kraft pulp to 100% secondary fiber, with nearly every option in between represented. The pulp may be made at many levels of kappa number, illustrating varying yield. The recycled fiber portion can be old corrugated or double-lined kraft box plant waste or any combination. It should be noted that a sheet with 20% secondary fiber is still categorized as "virgin." Bonding additives may be used. The paper machine can be the standard fourdrinier with or without a secondary headbox or top-wire formers or both, or it can be one of the multiformers producing a two- or three-ply structure. The machine may have high intensity pressing or long nip pressing or both.

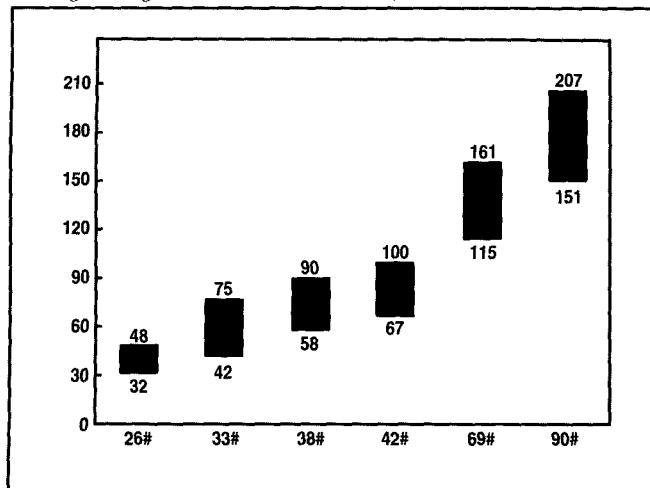
Another speaker, Roy L. Burch, manager of quality control of the St. Joe Forest Products Company, presented specific data as to the effect of the high impulse pressing of extended- and long-nip presses on linerboard compression strength. While contributing markedly to the strength/weight relationship of the board, this pressing can significantly affect its density. It also is necessary to control the squareness of the formation on the fourdrinier wire to maximize cross-machine compression strength.

With this kind of variability in manufacturing and no control over the properties related to compression strength, it is no wonder that the industry data presented by Young showed a wide range in ring crush values for the linerboard made prior to the enactment of the Rule change (Fig. 1). In turn, because of its dependence on the edge crush strength of the component materials, it is no surprise that ECT of the corrugated board produced also exhibited wide variability (Fig. 2). In the 200 psi test grade alone, which represents 50% of the industry production, we see a range from 27–46 lb/in., a 70% variation.

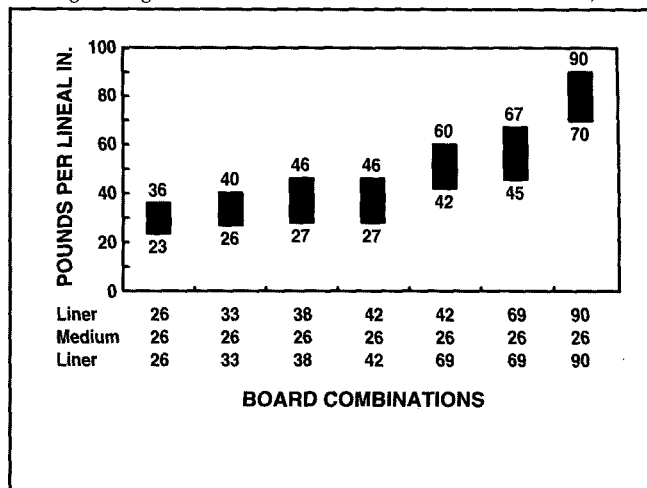
Taking this range of ECT values and applying it to the known relationship between ECT and box compression strength, Young calculated that a typical box, 16-in. x 12-in. x 10-in. in size, could vary from 620–790 lb in ultimate compression load. He speculates that this variation promotes overpackaging.

The dense structure of high-performance linerboards has posed

1. Range in ring crush values for linerboard, IPST



2. Range in edge crush values for conventional combined boards, IPST



difficulties in bonding between facing and medium. Burch stated that control of porosity of the sheet is essential to assure bondability while creating the high-performance grades. He felt that a Gurley Densometer test of <100s would assure adequate bonding.

Some manufacturers also note an apparent loss of compression strength of boxes made with these high-performance facings under conditions of high or cyclic humidities. Some have suggested that this could be due to inadequate adhesion. Improved adhesion is possible with the technology known today, starch manufacturers suggest. Use of dual viscosity formulations and application of moisture (steam) rather than preheating might also resolve the problem.

Young said that the strength of the bond between facings and medium has a direct effect on ECT and, in turn, on the compression strength of the box made from that corrugated board. "It is a very inexpensive way to add strength to a corrugated structure, but a very costly way to experience box failure," Young said.

That statement was amplified by David A. Carlson, quality assurance manager of the Stone Container Corp. Of course, the edgewise compression strength of the component facings and corrugating medium are most influential. In addition, absence of crushing, proper scoring and slotting, and box squareness are also important in maximizing box compression strength. The boxmaker should pay special attention to potential damage caused by pull and feed rolls and kicker feeders and by bundle strapping.

Another concern is the effect of recycled or secondary fiber on compression performance. Young had indicated that the recycled content in linerboard can vary from 0-100% and all the possible combinations in between. A test was made comparing boxes with equal fiber weight but one made from 100% virgin kraft facings and a semichemical medium and the other made from 100% recycled fiber facings and medium. The latter did not meet the burst requirements of the old Rule 41/Item 222. It had 20% lower bursting strength than the virgin combination. There was also a significant difference in ECT. The 100% recycled combination would not have met the requirements of the new Alternate Rule 41/Item 222. Finally, box compression strengths were compared at standard and at 85% humidity conditions. The 100% secondary

fiber construction had 11% lower strength at 50% RH and 28% lower strength under high humidity conditions.

Similar results were reported by George S. Rennie, senior technical consultant of Domtar Inc. In studies that are continuing, boxes made from recycled fiber facings did not perform as well, in most instances, as those made with 100% virgin fiber. He did state, however, that all parameters may not have been constant in these trials. Adhesion met the company's minimum standards. Rennie felt that it may be necessary to identify and perform tests that are influenced by the flexural rigidity of the combined board to properly differentiate between grades in predicting compression performance. Tensile stiffness was proposed.

Rennie's most significant finding was that calculation of the expected box compression strength from the short-span (STFI) compressive strength of the facings and medium was more accurate than calculation from the measured ECT of the combined corrugated board. This confirms similar results reported by researchers in Scandinavia.

Much is yet to be learned about compression strength despite the volumes of studies that have been conducted in the past. Rennie's findings underscore the importance of the linerboard and corrugating medium in determining ECT and box compression strength. Manufacturing the raw materials and combining them into corrugated structures to meet the new requirements of the Alternate Rule 41/Item 222 will enable the industry to focus on this one property. Variability should be narrowed. The stronger but denser high-performance grades will require closer attention to the bonding process. New adhesives may need to be developed. A caveat has been thrown up by the need to increase the use of secondary fiber. There is no question that more of this must be incorporated into containerboard in the future. We must learn how to make optimum use of this raw material without sacrificing box performance. [U]

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