

*An Introduction to the*  
**Critical Attributes of Folding Cartons**

iPacSolutions, LLC  
November 16, 2006

Once beyond the approval and compliance with specifications for a folding cartons size and style; what are the critical attributes that allow it to be processed on automated equipment with a high level of reliability?

While the answer to that question in a broad sense can be addressed in three specific areas: 1) **score bending efficiency**, 2) **opening force** & 3) **co-efficient of friction**; there are a multitude of contributing factors which influence all three of these attributes.

These contributing factors can best be addressed by breaking them down into an additional four areas of focus: 1) **paperboard specifications**, 2) **conversion process**, 3) **materials handling** & 4) **climatic changes**.

### **Paperboard Specifications**

Often times a paperboard is specified by requesting a certain grade such as 24 point CNB. The thickness of paperboard while referred to as "point" is actually measured in thousands of inches. Therefore, 24 point stock is in fact .024 inches thick. CNB in this case is an abbreviation for a C1S (coated one side) Clay News Back (100%) recycled fiber.

However, there are so many critical attributes that influence the performance of your folding carton that are attributable to the paperboard that it warrants understanding just what it is that makes up the material used to produce your package. While there are dozens; the most common grades of paperboard are; **CNB** (clay news back –C1S recycled), **CKB** (clay kraft back –C1S recycled), **BC** (bending chip –Uncoated recycled) **SBS** (solid bleached sulfate –C1S virgin fiber) & **SUS** (solid unbleached sulfate –C1S virgin fiber). The differences between these grades are created by both the **furnish** (mixture of fiber and other materials blended in stock suspension from which paperboard is manufactured) and the **profile** (performance attributes influenced by both the furnish and the type of machine utilized to produce the sheet).

There are no less than a dozen specifications related to paperboard; each of these specifications has a target, a minimum and a maximum which effectively establish what we will refer to as tolerances. Since we began with .024 CNB (twenty-four point clay news back coated one side recycled stock) let us examine what paperboard specifications influence the sheets performance:

- 1) **Grade** - the description of the type of material (in this case CNB –clay news back)
- 2) **Caliper** –the thickness of a sheet measured under specific conditions and expressed in thousands of an inch while referred to as "point"
- 3) **Basis Weight** –the weight in pounds per thousand square feet reflecting the density of the furnish utilized to produce the sheet

- 4) **Moisture Content** Refers to the amount of moisture found in a sheet of paper. While varying by grade and adjusted during the course of the year (lower in the Winter & higher in the Summer) an average amount ranges between 4-7%. This figure varies from sheet to sheet since paper is hydroscopic and will emit or absorb moisture according to the condition of the surrounding atmosphere. It is affected by both the drying conditions when made and the relative humidity environment in which it is stored and used. The amount of water in a sheet of paperboard affects weight, printability, physical strength and machine-ability. Moisture loss is realized in the form of shrinkage and begins at the edges of paperboard and moves across the grain causing the sheet or carton to tighten, wrinkle, curl or warp.
- 5) **Stiffness** –the ability of paperboard to resist an applied bending force (MD – machine direction vs. CD –cross direction) usually measured by a 15 degree deflection on a Taber machine. Stiffness is a highly critical property for paperboard and greatly influences a cartons performance on automated packaging equipment. Grade, caliper, basis weight & moisture content all have direct relationships to a sheets ultimate stiffness.
- 6) **Brightness** light reflecting property of paperboard in comparison with a reference standard. Standards vary, normal range 78 to 81; however, it should be noted that furnish and coating ingredients utilized at different mills result in a range of cream white to blue white hues.
- 7) **Plybond** –measure of cohesiveness of fibers and layers within paperboard in comparison with a reference standard. Paperboard demonstrating strong plybond will resist de-lamination during the conversion and end use processes.
- 8) **Water Resistance** the measure of water drop penetration to evaluate porosity and standardized within the stipulations of a widely accepted Cobb Test.
- 9) **Score Bend** a measure of paperboards ability to facilitate bending by mechanical means in comparison with reference to industry standards.
- 10) **Ink Absorption** evaluation of a paperboards surface in relation to the penetration of ink substrates in comparison with a reference standard.
- 11) **Wax Pick** –a test to determine the strength of a paperboards printed surface to resist tacky inks from picking fibers or particles during the conversion process.
- 12) **Density** –the density of paperboard is its specific gravity or weight per unit of volume. Directly related to absorbency, stiffness, opacity, and resiliency; while not routinely reported, it is calculated from basis weight and caliper.
- 13) **Tear Strength** –while predominately monitored on virgin grades of paperboard; this test measures the amount of energy required to tear a sheet. Tear is a most important attribute in evaluating the performance of carrier grades such as SUS which is utilized in the manufacture of six and twelve pack beverage cartons.

The measure and reporting of these critical attributes are most often compiled within the framework of ISO/TAPPI (International Organization for Standardization / Technical Association for the Pulp & Paper Industry) and lab testing conditions of 72 degrees at 50 percent relative humidity.

While all of the aforementioned critical attributes of paperboard are interrelated and affect not only the performance but the aesthetics of your package; once a specific grade

is approved, the most important factor may well be consistency. So influential is the consistency of the profile of the paperboard sheet utilized in the conversion of an automated folding carton that it is not unusual for more sophisticated companies, once qualifying a source, to specify particular grades run at specific mills.

At first glance, this policy might seem unnecessary or restrictive; however, this example of two recycled board mills, owned by two highly regarded companies located in the northeast, both manufacturing .024 CNB, points out how profiles can vary. (*It should be noted that, since it was obtained, upgrades may have been made or changes implemented affecting this data*) While both mills have a published basis weight of 96#/MSF, the profile furnish combination at one mill results in an MD/CD stiffness of 464/204 and the other mill produces an MD/CD stiffness of 510/175. The corresponding MD:CD stiffness ratios are 2.27:1 vs. 2.91:1. The industry would consider the lower ratio of 2.27:1 to be a more square sheet and in most cases better suited for the production of high speed automated cartoning processes. Because the advertised caliper and basis weights are identical, it is more likely that the difference in stiffness ratios are contributed to by the fiber orientation within the sheet resulting in the influence of the paper machines profile. If the fibers align themselves in the machine direction the result is a sheet that is very stiff in MD and much less stiff in CD. This allows MD carton scores to break cleanly and consistently while the flaps folding across the CD to be less predictable.

Further evidence of the wide variation in stiffness and resulting MD:CD stiffness ratios are confirmed by introducing the statistics of a high performance grade of .024 CKB produced at a Midwestern facility owned by the same company as one of the aforementioned facilities. This kraftback sheet in a .024 caliper yields a published basis weight of 94#/MSF and a 470 MD to a 230 CD or 2.04:1; much closer to the stiffness characteristics 2.27:1 CNB sheet. All three are good quality sheets which may meet many end use applications, but reflect different profiles due to variation in either furnish or the type of paper machine they were produced upon.

The conclusion of this data is only that there can be significant variation between the critical attributes of the same grade of materials produced at different mills. All of which is a moot point if any given material runs well on your converting equipment. More important is that once approved; the paperboard and the folding carton produced from the material are consistent.

Once approved; a paperboards one critical attribute that may have the most significant impact on a cartons performance could arguably be stiffness. And assuming the caliper runs consistent on any given production run and modifications have not been made to the furnish, then any variation in moisture content would have the most notable impact on the stiffness. Moisture control is so important that recycled mills run to different specifications during the period from April 1 September 30 and October 1 March 31. An example would be a winter: Target 6.0% Minimum 5.5% Maximum 7.0% and summer: Target 6.5% Minimum 6.0% Maximum 7.5%. Paperboard being hydroscopic, attempts to assume the relative humidity of its environment.

An increase in moisture content will almost assuredly result in a reduction of stiffness. Today's mills employ the use of very sophisticated monitoring & measuring systems installed on paperboard manufacturing equipment. The mill is generally well aware of any variation encountered during a production run. One important factor is whether or not the carton converter routinely receives this information and further more if it is reported in averages. As you can imagine; if 95% of a paperboard production run is produced at a target of 6.5% moisture and 5% of the run at an unacceptable level of 12% moisture the resulting average of 6.775% moisture looks to be excellent, but the random collation of the raw material throughout a folding carton run could contaminate the entire order. Ensuring that the mill does not ship the carton plant the aforementioned bad 5% is imperative. Receiving data from each and every run produced by a mill is not necessarily routine, however, establishing parameters for the production of a particular grade for a specific high volume customer and having the mill produce to those standards would not be considered unusual.

### **Conversion Process**

The three most basic folding carton converting processes are printing, die cutting and gluing. Being a highly diversified and segmented industry; many types and vintages of equipment are utilized in the marketplace. Paperboard is manufactured in a continuous stream of material and can either be automatically sheeted into specifically ordered sizes at the end of many presses or slit and wound into different width rolls. This leads to two basic conversion methods; **roll fed** and **sheet fed**.

As implied; **roll fed** equipment utilizes rolls of paperboard often purchased in specific widths for high volume folding carton production. While roll diameters are limited by numerous factors, some roll fed equipment is outfitted with automatic splicing systems that allow for one roll to transition to the next without missing a beat. While eliminating the sheeting operation, roll fed systems most often necessitate the utilization of **rotary die cutting**, which will be addressed below. Most roll fed printing and die cutting equipment is designed for very high production quantities.

**Sheet fed** equipment requires the aforementioned rolls of material to be cut into individual sheets either at the mill as the paper comes off the paper machine or at the converter. While this requires an additional step, it allows for significant flexibility in run quantities and manufacturing processes.

### **Printing**

There are at least five methods of printing folding cartons commonly in use today; 1) **Digital**, 2) **Gravure**, 3) **Flexography**, 4) **Letter Press** & 5) **Offset Lithography** and while to a great extent print quality is subjective, there are discernable differences between these commonly employed methods. Beyond coefficient of friction, it is unlikely that the type of printing utilized to manufacture a folding carton will influence its mechanical performance, however the impact on customer perception of brand image and product quality can be overwhelming.

The industry standard for quality printing of folding cartons is most often considered to be offset lithography. Offset printing while most often performed sheet fed in the highly segmented folding carton industry is also available in roll format. Flexographic and gravure printing are systems commonly used in printing roll stock. The quality of the printing can be acceptable for most applications, but the implications of rotary die cutting must be considered and will be addressed below.

- 1) **Digital** offset systems can provide the high quality of offset printing with the automation and efficiencies of digital printing. Such printing systems offer high resolution and superior registration for proofing and very low volume production runs.
- 2) **Gravure** printing utilizes engraved cylinders consisting of tiny cells varying in size to hold the ink. As the press runs, doctor blades scrape excess ink, leaving only ink in the cells to create the desired image. The paperboard substrate contacts the plate in order to transfer the graphics. Gravure is a roll fed process utilized in extremely long runs. The high tooling costs associated with the engraved cylinders dictate that they be amortized over very large volume commitments.
- 3) **Flexography** utilizes a relief type plate similar to letter press yielding plates with raised images which come in direct contact with paperboard substrate during the printing of folding cartons. These plates are made of flexible material such as rubber, plastic or UV sensitive polymers so that the plate may be attached to the cylinder for ink application. A metering cylinder, known as an anilox roll applies the ink to the plate and a doctor blade regulates ink distribution. Flexographic inks are similar to gravure inks having low viscosity and are formulated to solidify when solvents are removed with heat, unless UV curable inks are utilized.
- 4) **Letter Press** being a much older technology provides limited use in the production of branded packaging. A raised print surface indents printed copy onto the paperboard surface. This antiquated technology is not suitable for half tones or process printing.
- 5) **Offset Lithography** utilizes aluminum alloy plates that have been exposed to an image activating an ink receptive coating. The plate is first dampened with water by water rollers, then by ink rollers with the ink adhering to the image area and water to the non-image area. As the press cylinders rotate, the image is transferred to a blanket and as the paperboard passes between the blanket cylinder the image is transferred to the paperboard substrate. The object paperboard never contacting the printing plate; thus the reference to offset printing. State-of-the-art offset printing presses provide the ability to print extraordinarily high resolution in both conventional and stochastic screens. The addition of CTP (computer to plate) imaging results consistent high quality detailed reproduction of half tones and process images.

## **Die Cutting**

The two methods of die cutting utilized in the manufacture of the majority of folding cartons are: **1) Reciprocating Flat Bed**, & **2) Rotary**.

- 1) Reciprocating Flat Bed** die cutting uses steel rules in bedded in laser cut laminated hardwood composite boards to cut and crease the folding cartons. Sheets are fed to a cutting and creasing station where the die forces the areas designated for folding scores into laser cut polymer counters while simultaneously cutting out the image of the carton. Small nicks hold the sheet together while it is transferred to a stripping station where sophisticated blanking presses strip away all of the trim and deliver the cartons neatly in stacks at the delivery end of the press. State-of-the-art flat bed blanking presses are considered by many to be the most accurate form of die cutting.
- 2) Rotary Die Cutting** systems convert roll stock utilizing steel rule dies mounted on cylinders that crease and cut the paperboard substrate as it passes between the cutting die and scoring counters. The most advanced systems employ closed loop vision systems to minimize process variation. The rotary die cutting process is a cost effective manner of conversion and because of technological improvements can provide folding cartons for most applications.

The final application and use of a particular folding carton can be greatly affected by the quality of its die cutting. A) Score bending efficiency, the ability of paperboard to fold accurately and with the least resistance and B) Registration, the fit of print copy to the packages scores and cut outs can be greatly influenced by the equipment from which the carton is produced.

## **Gluing**

While the most cost effective solution of addressing high volume folding carton requirements is the utilization of an unglued machine formed blank; the diversified needs of customers warrant the manufacture of numerous pre-glued styles of folding cartons. Addressing these many folding carton styles and the application of their form and function is not necessary to understand gluing technology and the implications certain aspects of the gluing process have on the finished carton.

Most pre-glued machine formed and filled folding cartons have what are referred to as working scores. Seal end cartons as well as reverse tuck end cartons make up the largest sectors of these packages. While these style cartons need only be folded 180 degrees on two scores to glue the carton; automated cartoning processes obtain greater efficiencies when both the glue lap score and the score opposite the glue lap are pre-broken (folded over approximately 120 degrees and then flattened back out). This pre-break significantly reduces opening force. In order to ensure the predictable opening and lowest opening force, these pre-broken cartons are then packed in corrugated cases allowing for a certain amount of room so as to not apply too much pressure and crush the cartons flat. For optimal use and efficiency, folding cartons should be converted within 90 days or less. Further details addressing materials handling and the environmental influences and their effects on the critical attributes of folding cartons will be addressed below.

After a carton is pre-broken, but before it is folded together either cold or hot glue is applied. Most hot glue, often referred to as hot melt applications are used in instances where the complexity of the style of the folding carton necessitates the immediate adherence of glued panels. While cold glue is more widely utilized it requires more time to tack panels together and has to be held under compression rollers and belts until that bond is initiated.

Two methods of applying glue to folding cartons are commonly employed; the use of a glue wheel or a timed spray application. Both systems provide excellent results when coordinated with the appropriate style folding carton. In some instances; glue verification systems are utilized to insure that glue has been applied to the folding carton. Verification systems use two basic ways to accomplish this; 1) either the reflectivity of the wetted surface read by light sensors or 2) the addition of UV compound read by UV detection sensors. More advanced systems will eject cartons that do not have glue applied. In any event; it must be realized that the detection of glue does not provide any guarantee that the carton necessarily is glued correctly, only that glue was applied.

Once folding cartons are pre-broken, they travel through a compression section of the gluer allowing them to properly adhere before being packaged in cases. Case packing can be accomplished through the manual removal from the gluer by hand or auto case packing. Auto case packing systems place cartons into cases without human intervention and with greater efficiency but can only be utilized with certain style folding cartons.

### **Material Handling**

The style of a folding carton and the eventual process used to form and fill the package plays a significant roll in how the carton can be packaged and transferred from the folding carton manufacturer to you, the customer. Unglued machine formed blanks can often times be bulk shipped on custom pallets or in bulk corrugated gaylords. Even if flat-unglued machine formed blanks are packed in individual cases for ease of handling, pallets can most often be double stacked without concern of damage to the folding cartons.

However, pre-glued machine formed and filled folding cartons must be treated with greater care. The correct sizing and case count of the corrugated case, the cases strength, pallet pattern in which the cases are stacked, number of tiers stacked upon one another and any consideration of double stacking pallets all influence the performance of the folding carton. Any excessive pressure placed on a case of folding cartons destined to be machine formed and filled will, over time, distort, warp or otherwise increase opening force and significantly reduce reliability.

## **Climatic Changes**

While economical order quantity often influences our buying decisions, it is important to convert automated packaging in ninety (90) days or less. The aforementioned pre-break performed during folding and gluing cartons loses a significant portion of its benefit within that period of time. Furthermore, paperboard is hydroscopic and assumes the relative humidity of its environment. Cartons produced during the drier months of the winter when stored into summer months pick up moisture; tend to warp and lose score bending efficiency. While the opposite is true of cartons produced in the summer and stored into the winter, the outcome is the same. This often leads to greater opening force and unpredictable performance on automated equipment. Vendor managed inventories of machine formed and filled paperboard packaging materials should be closely monitored. Overall, less cartons produced more often yields better productivity.

We hope this information regarding the Introduction to the Critical Attributes of Folding Cartons assists you in making informed decisions about high quality paperboard packaging components. Should you have questions or desire further information, please contact us at:

**iPacSolutions, LLC**

[www.ipacsolutions.com](http://www.ipacsolutions.com)

packagingsolutions@frontiernet.net