PAPER TASK FORCE

*Duke University ** Environmental Defense Fund*
*Johnson & Johnson ** McDonald's*
*The Prudential Insurance Company of America ** Time Inc.*

WHITE PAPER NO. 6B

FUNCTIONALITY ISSUES FOR FOLDING CARTONS ASSOCIATED WITH RECYCLED CONTENT, SOURCE REDUCTION AND RECYCLABILITY

December 19, 1995

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I. INTRODUCTION

This paper analyzes functional aspects of paperboard used to make folding cartons, concentrating on performance issues affected by recycled content. This paper is one element of an extensive research process in support of the task force's recommendations for purchasing "environmentally preferable paper" (paper that reduces environmental impacts and meets business needs). Copies of the Task Force's recommendations and final report will be available in mid-December.

The economics of recycling and solid waste management, which affect the supply and cost of recovered paper to manufacturers, are examined in White Paper No. 2. The economics of manufacturing paper and paperboard with recycled content are covered in White Paper No. 9. Environmental aspects of recycling and solid waste management and recycling and virgin paperboard production are reviewed in White Papers Nos. 3 and 10C. Functional issues associated with recycled content in uncoated business papers, coated publications papers and corrugated boxes are covered in White Paper Nos. 1, 6A and 8 respectively. The full list of Paper Task Force White Papers is presented in Appendix A.

This White Paper was not the subject of an expert panel discussion held by the Task Force. Comments on this paper from a number of paper suppliers were consolidated by the American Forest & Paper Association. International Paper Co. also offered its own comments on the paper. Acknowledgment of these reviewers does not imply endorsement of this paper or the Paper Task Force's findings or recommendations.

The Task Force's recommendations integrate findings on environmental, economic and functional aspects of paper use in a balanced manner that reflects the needs of paper users in the private sector. This paper does not contain purchasing recommendations.

The Paper Task Force members endorse the broad principles set forth by the Task Force's final report. The findings and research in this White Paper reflect the contributions of Paper Task Force Working Groups and changes made in response to comments received from expert reviewers through the White Paper review process. The contents of this paper do not reflect the policy of individual Task Force member organizations.

A. Scope Of The Paper

The three major grades of paperboard used to make folding cartons are solid bleached sulfate, coated unbleached kraft, and clay-coated recycled paperboard. These three types of paperboard differ in significant ways in their manufacturing process, functional properties and price.

Other White Papers written by the Paper Task Force on functionality and recycled content have focused on paper products that have been introduced on a large scale only within the last five years, such as recycled content in office reprographic papers and coated publication papers. In these White Papers, the Task Force is addressing basic questions about how these new recycled-content products work in photocopiers and on offset printing presses, for example. In contrast, in the case of folding cartons, "More than half of the products on supermarket shelves are now packaged in cartons using recycled paperboard, and growth in nonfood products has also been good."[1] In other words, the fundamental question of whether recycled paperboard can meet the basic functional requirements of many consumer product packages is not at issue.

This White Paper is intended to summarize some of the major issues in the comparative performance of different types of paperboard used in folding cartons. It also covers some recent development in manufacturing technology and recycled content. This paper does not define which is the "best" type of paperboard for a specific use. There are thousands of different types of folding cartons, and each has its own specific performance requirements that may be slightly or substantially different. At the same time, there is substantial overlap among the different grades of paperboard that can be used for many types of folding cartons.

This paper is intended to provide non-specialists with an understanding of the scope of the functional issues involved in evaluating paperboard using in folding cartons. Long-held assumptions or "rules of thumb" about using different types of paperboard for folding cartons may be true for some paperboard or carton manufacturers and outdated for others. In particular, modifications in carton design, converting, printing or filling may be able to address functional issues raised for specific types of paperboard. Professional package designers will have a more technical understanding of some of the issues covered here.

B. Definitions

The following definitions are used throughout this paper:

Basis weight - Weight, measured in pounds, of a set quantity of paper in its basic size (e.g., for reprographic paper, a ream, or 500 sheets, for paperboard, 1,000 square feet).

Coated unbleached kraft (CUK) - paperboard made from unbleached kraft fibers and coated with clay on one side. Coated unbleached kraft paperboard goes by several names. The two companies that manufacture this grade in the United States have trademarked certain abbreviations. "CNK," for coated natural kraft, is used by Mead Corp., and "SUS," for solid unbleached sulfate, is used by Riverwood International Corp. The generic term coated unbleached kraft (CUK) is used in this paper.

Density - The weight of the paper compared to its volume; the density of the paperboard sheet is measured by the basis weight divided by the point caliper.

Folding Boxboard (Carton Board) - paperboard used to make folding boxes and other packages requiring folding carton board, such as record jackets, blister packs, etc. Boxboard refers to non-shipping containers. The term "boxboard" is used in many statistical summaries to denote a specific use of paperboard. However, we primarily use the term "paperboard" to describe specific grades in this White Paper.

Folding cartons - paperboard boxes that are creased and folded to form containers that are generally shipped and stored flat and erected at the point where they are filled. Folding cartons are designed to contain and present products, and are generally small enough to hold in one hand.[2]

Foodboard - board used for folding packaging in food-contact applications having a single ply or multiply construction, usually made from 100% virgin bleached pulp. In 1994, 1.7 million tons of paperboard were produced for food service applications and milk and juice cartons.[3]

Point caliper - the thickness of a paperboard sheet in thousandths of an inch, as measured by calipers (also referred to simply as "point" or "caliper").

Setup boxes - boxes that are manufactured in the shape in which they will be used, and are not folded flat. They are most often used for small boxes containing goods such as candy, stationary, jewelry, etc., usually overwrapped with printed paper.[4] Setup boxes are not considered folding cartons. In 1994, 316,000 tons of paperboard were produced for set-up boxes and 1.7 million were produced for food service and milk and juice cartons.[5]

Recycled paperboard - 100% recycled paperboard is used in a variety of products, such as folding cartons, chipboard (a solid board made from the same type of recovered fiber throughout, used for writing tablet backs, hardcover books and internal partitions in shipping containers), core and tube stock (used for tissue roll cores, composite paperboard cans such as motor oil cans and industrial roll cores for products such as textiles, carpet and paper), and gypsum linerboard (the paperboard liner used in gypsum wallboard, i.e., "sheetrock"). The applications listed for chipboard, core and tube stock and gypsum linerboard are not considered part of the folding carton category. All of these types of paperboard are typically made on multi-ply paper machines, as described in the text. ***In this paper, we use "recycled paperboard" to refer to 100% recycled paperboard used in folding cartons.*** "Paperboard" itself is a broader category that also encompasses linerboard, corrugating medium and other grades.

Solid bleached sulfate (SBS) - paperboard made from bleached kraft fibers, typically clay-coated on one side of the sheet when used in folding cartons. Until recently this grade has been made with 100% virgin content. A relatively small quantity of SBS now contains preconsumer and/or postconsumer recycled fiber.

Because of the relatively small amount of setup boxboard produced and the dominance of virgin paperboard in the foodboard market, folding boxboard is emphasized in this paper.

II. FINDINGS

1. Solid bleached sulfate, coated unbleached kraft and recycled paperboard differ in performance characteristics and price. Each tends to be used to package a different set of goods, though there is substantial overlap and competition in some product areas.

In 1994, there were 7.0 million short tons of folding boxboard produced in the United States, with 800,000 tons exported. Of the folding boxboard produced for domestic consumption, 2.9 million tons were made from recycled paperboard, 2.0 million tons were made from SBS and 1.3 million tons were made from unbleached kraft paperboard. The domestic market share of recycled folding carton board declined from a high of 60% in 1970 to a low of 44.5% in 1988. By 1994, the market share for recycled board had risen to 46.5%. The major gain in domestic market share has been in unbleached kraft paperboard, increasing from 8% in 1970 to almost 21% in 1994.[6] Within the recycled segment, coated board has grown in use over this period, replacing uncoated recycled board that was once over-wrapped with printed paper in certain packaging applications.

SBS holds the majority of market share for fatty and aqueous food-contact packaging, perishable bakery goods, cosmetics and pharmaceutical products, sporting equipment, toys and cigarette cartons. CUK has traditionally been used primarily in beverage carton carriers, which require comparatively high wet strength, tear resistance and stiffness, and consistent performance on high-speed filling lines and under wet and humid conditions. CUK is beginning to penetrate other folding carton markets, such as frozen food products and hardware. Recycled paperboard holds the leading market share in dry food products (e.g., cereal, rice, pasta, biscuits and crackers), soaps and detergents, paper goods, office products and auto parts and hardware and miscellaneous uses.

2. Users of folding cartons are generally concerned with four criteria for the paperboard: strength (primarily defined in terms of stiffness, but also including other criteria), machinability (the ability of the carton to set up and run smoothly and quickly through packaging filling lines), appearance and printability.[7] Folding cartons must meet performance requirements through their entire use cycle, including converting and printing, filling and gluing, distribution, retail presentation and use by the final customer. Packaging buyers most often specify performance criteria for the overall package, rather than the paperboard itself.

> **a. With regard to appearance (smoothness and brightness) and printability, SBS offers better performance compared to CUK and recycled paperboard. The color of the inside of the box (white, brown or gray) appears to be diminishing as a selection factor for some packaging uses while still important for others.**
>
> **b. With regard to strength (stiffness, tear, compression strength, scoring and bending strength), at comparable caliper levels, CUK generally offers better performance levels compared to SBS with recycled paperboard ranked third.**

c. Machinability depends on the type of filling and gluing machines being used, the characteristics of the paperboard and how well the carton maker has optimized scoring and cutting to these characteristics. Machinability is most critical when there is a challenging filling environment (e.g., beverage filling lines tend to create wet and humid conditions) or when the speed of the filling line is a critical factor in determining the overall production line speed for the product. Conventional filling machines are usually fairly flexible and can be tuned to compensate for the properties of different types of board. CUK manufacturers state that CUK meets the machinability demands of the most challenging filling environments as well as providing consistency for the varied performance requirements of conventional filling lines. SBS also runs on high-speed machines, particularly in the tobacco industry.

d. Within these criteria, performance can vary depending on the mill that manufactures the paperboard.

3. Maintaining parity in stiffness when using recycled paperboard in place of SBS has traditionally required an increase in board weight equivalent to roughly two points of caliper. The thickness of the board does not necessarily change with a shift to recycled paperboard, but the density (and therefore basis weight) increases, due to the type of fiber used in recycled paperboard and its processing in order to maintain stiffness levels. CUK manufacturers state that CUK can be used at one point in caliper less than SBS in the lower caliper ranges, and as many as six points less compared to recycled board in the higher caliper ranges.

a. Advances in forming technology at recycled paperboard mills such as multi-ply fourdrinier machines, multiformers and ultraformers can reduce the range of differential in basis weight equivalents by roughly 50% for some smaller, lighter packages in which strength is not a critical factor. Lighter-weight recycled paperboard (in the 12-14 point range) is not available in the same quantities as heavier-weight recycled board.

b. Advances in coating, printing and varnish technology also have increased the availability of recycled paperboard used in high-quality graphic applications.

4. The use of recycled paperboard raises issues in the converting and printing process, but these can be resolved by process modifications and operator experience and training. Recycled paperboard can pose problems with respect to response to moisture (causing curvature of the board) and increased dusting and linting. Modernized recycled paperboard machines, which account for more than half the production of this grade, minimize paperboard curl problems. These problems can also be addressed through proper storage, inventory management and climate control at the converting plant, and by installing vacuuming and dust collection equipment.

5. SBS paperboard is available with 10-30% postconsumer recycled content in limited quantities. CUK paperboard is available with 20-25% recycled content. At these levels of

recycled content, manufacturers state that there is no loss in performance characteristics, as measured by the equivalent set of specifications used to assess performance of the same manufacturers' virgin paperboard.

6. Folding cartons are collected for recycling in a comparatively small but growing number of communities in the United States. There is little systematic data on how they are collected or the types of paper mills that use them as a raw material. In a program promoted by recycled paperboard manufacturers in Ontario, citizens can recycle folding cartons through a two-part separation of paper products, with newspapers, magazines, catalogs and phone books on one side of a partitioned bin, and corrugated boxes, mail, ledger paper and paperboard packaging on the other. U.S. paperboard producers are using new or expanded curbside collection programs to increase recovery of folding cartons. Recycled paperboard mills also use old corrugated containers, which may contain up to 20% chipboard as inner partitions. Carton converters generate preconsumer paperboard scrap, which is recycled at a high rate.[8]

a. The most likely candidates for using folding cartons as a feedstock are mills producing different grades of recycled paperboard, unbleached tissue and toweling and construction paper and board. The manufacturing processes at these mills can handle more contaminants compared to other types of paper and paperboard.

b. Mills that use folding cartons as a feedstock will face higher levels of contaminants, due to the presence of packaging components such as polyethylene coatings, metal and plastic tear strips, plastic handles, pouring spouts, etc. Some of these contaminant issues may be addressed at the mill by limiting the total percentage of incoming folding cartons and blending them with less contaminated recovered paper grades, by changes in monitoring, storage and blending of pulp in the mill's recycling process, and by installation of additional fiber cleaning and screening equipment.

c. Packaging designers may be able to reduce some of the contaminants in paperboard packaging that cause problems at recycling mills through their choice of varnishes, adhesives and packaging components. For example, aqueous coatings are considered more recyclable than UV-set coatings.

III. PAPERBOARD PRODUCTION AND USE

A. Uses for Paperboard

This paper is concerned with the use of paperboard for folding cartons, i.e., non-shipping containers used to contain and present products to the customer. The development of the folding carton made possible the shift from old-fashioned grocery store, in which clerks custom-packed bulk food items for individual customers, to the modern supermarket, which allows customers to select pre-packaged items off the shelf. The first major use of the folding carton was for the "Uneeda Biscuit" soda cracker, introduced by the National Biscuit Company (Nabisco) in 1897.[9]

There are three major grades of paperboard used in folding cartons: solid bleached sulfate (SBS), coated unbleached kraft (CUK) and recycled. Because SBS, CUK and recycled paperboard differ in performance characteristics and price, each tends to be used to package a different set of goods, though there is substantial overlap and competition outside of direct food-contact packaging. SBS is generally used for items that are perishable or for which retailers believe that a highly printable or smooth, bright white appearance inside and outside helps differentiate the product (e.g., baked goods, cigarettes, fatty and aqueous foods, medicine, cosmetics, high-priced sporting goods and toys and new product introductions such as audio, video and PC software).

Beverage carriers for beer and soda drink bottles make up about 70% of the use of CUK. CUK is also used to package frozen foods and to make large packages for detergents and other nonfood items, and as institutional packaging for wholesale distribution. CUK paperboard can be used both as a shipping container and in point-of-purchase displays. Coated unbleached kraft paperboard works well for high-quality printing and foil and film laminating. Westvaco makes a grade of unbleached paperboard that is not coated with clay, but is laminated with polyethylene in the converting process and is used in food-contact applications.

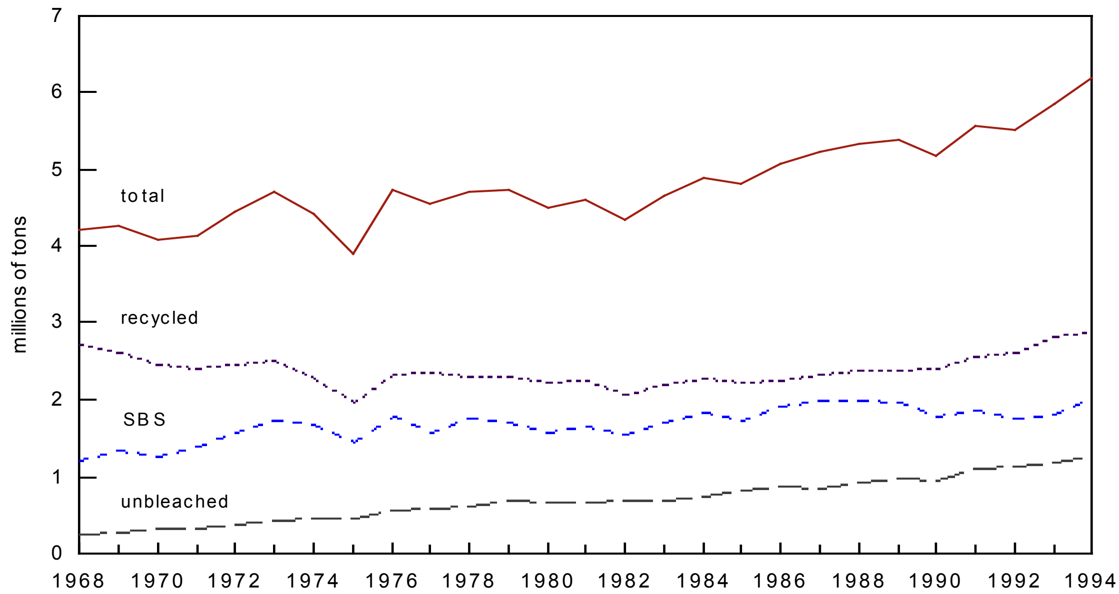
Recycled paperboard is used to package items such as dry foods, which may or may not be packaged with plastic inner liners (e.g., cereal, pasta, rice, cookies, crackers and pet food), paper goods (e.g., envelopes and stationary), hardware and powdered laundry detergents.

Paperboard for fatty and aqueous food packaging is primarily made from SBS and is used for packaging moist or oily food products. Most of this type of paperboard is coated with polyethylene to provide a moisture barrier and to maintain the integrity of the board. Fatty and aqueous food packaging applications of folding cartons include ice cream cartons and packaging used by quick service restaurants to serve sandwiches and french fries.

Of the 6.2 million tons of paperboard produced for the U.S. folding-carton market in 1994, 2.9 million tons (47%) were recycled paperboard, 2.0 million tons were SBS (32%), and 1.3 million tons were CUK (21%). Not all of the packaging made from this paperboard was strictly defined as folding cartons; packaging such as record jackets and blister packs are also included in this category. An additional 800,000 tons of paperboard for folding cartons were exported in 1994.[10]

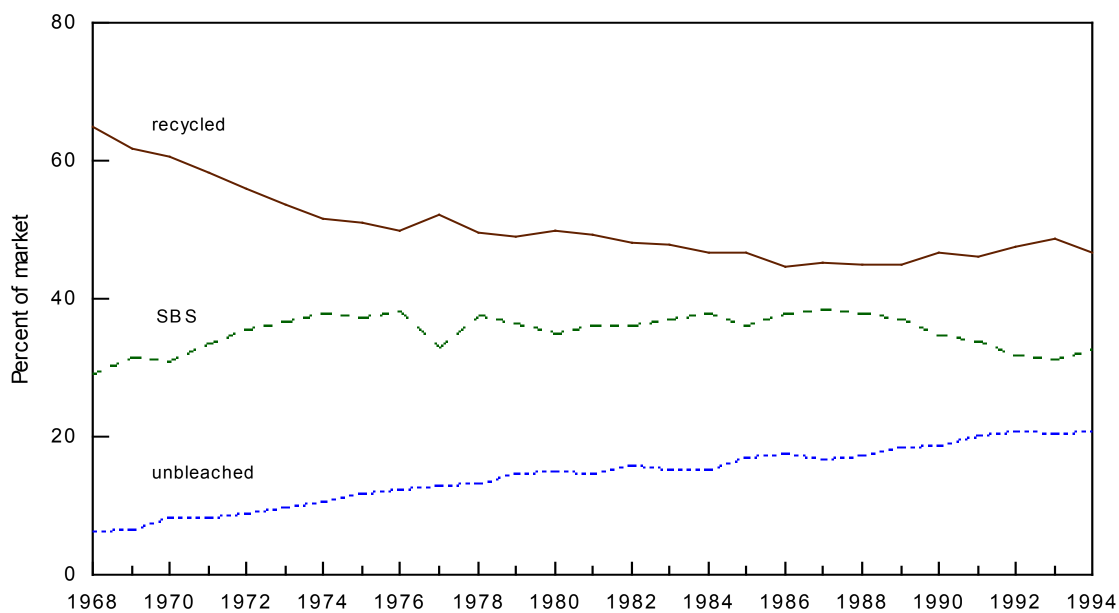
As shown in **Figure 1**, production of recycled paperboard for folding cartons fell 24% between 1968 and 1982. Recycled paperboard production began to slowly rise again in 1982, growing by 16% overall between 1982 and 1989. Between 1989 and 1993, production grew more rapidly, by a total of 18%. CUK production has been on a steady rise over the last two decades. SBS production, while tending to rise, has been more volatile on a year-to-year basis.[11]

Figure 1. U.S. Production of Boxboard for Folding Cartons for Domestic Use



Source: AF&PA, 1995 Statistics, Paper, Paperboard and Wood Pulp

Figure 2. U.S. Market Share for Boxboard Grades Used in Folding Cartons for Domestic Use



Source: AF&PA, 1995 Statistics, Paper, Paperboard and Wood Pulp

As shown in **Figure 2**, the domestic market share of recycled folding carton board declined from a high of 60% in 1970 to a low of 44.5% in 1988. By 1994, the market share for recycled board has risen to 46.5%. The major gain in domestic market share has been in unbleached kraft paperboard, increasing from 8% in 1970 to almost 21% in 1994.[12] Within the recycled segment, coated board has grown in use over this period, replacing uncoated recycled board that was once over-wrapped with printed paper in certain packaging applications.

B. Paperboard Manufacturing Processes

1. SBS and CUK manufacturing processes

As suggested by their name, solid bleached and coated unbleached kraft paperboard are made from pulp produced by the kraft process. SBS and CUK paperboard are made on fourdrinier paper machines. A fourdrinier machine consists of a moving mesh screen (the "wire") held horizontally by sets of rollers. At one of the fourdrinier section, pulp is held in the headbox, and is released in a metered stream onto the wire. Gravity and mechanical suction drain water from the pulp. As the cellulose fibers interlock and form a mat, the web (paper sheet) leaves the end of the forming section and is carried through a series of presses and dryers, which continue to remove water. Near the end of the machine, the paper is coated and wound onto a large reel.

Some machines used to make SBS and CUK use headboxes that form two or three plies, which are joined together on the machine, allowing the production of multi-ply board. One of the advantages of multi-ply board is that relatively more hardwood kraft pulp can be used on the outer liner of the board, for smoothness, while more softwood kraft can be used to provide stiffness to the inner plies.

2. Recycled paperboard characteristics

Recycled paperboard usually consists of six to nine plies. The recovered fiber composition of the board varies depending on the properties desired. In general, a board is "lined" when the inner layers are different from the outer layers (the lining). With multi-ply forming technologies, different types of pulp can be used for the inner and outer layers of the sheet.. The lining becomes part of the sheet when the fibers in the plies bond as the plies are squeezed together by the press rolls.[13] For example, filled newsboard is a combination board with both sides having vat liners made from a furnish of recycled newsprint and other clean fibers. It is stiff and has a clean surface suitable for use in high-quality boxes. In contrast, plain chipboard is made using one grade of stock throughout, and is used for writing tablet-backs, industrial shipping applications, covers for hard-cover books and laminated applications.

For 18 point clay-coated folding paperboard, the outer coating is about 5% of the weight of the sheet and is typically composed of 80% clay, 12% latex and 8% protein, although different manufacturers may have their own recipes. (The point of a specific paperboard sheet refers to its thickness in thousandths of an inch, as measured by calipers.)[14] The top liner, which is about 20% of the sheet, often includes ledger grades or unprinted or lightly printed secondary fiber, such as unprinted newsprint sections or lightly printed SBS converting scrap. The filler, or inner layers and back of the board, consist of about 50-60% of the sheet; one common formulation consists of 80% old newspapers (ONP) and 20% old corrugated containers (OCC) or double-lined kraft cuttings (DLK), the scrap from corrugated box making operations.[15] Mixed paper can also be used for the inner plies.

The back ply (inside of the box) can be made of old news, corrugated or pulp substitutes, depending on strength and appearance requirements. OCC is also used in the outer plies because the longer kraft fibers drain more readily than ONP (as the sheet is formed, water is pulled from the inside to the outside layers in the sheet). These different layers can be seen when the edge of a recycled paperboard carton is pulled apart.

More than 70% of recycled board produced for folding cartons is clay-coated on one or both sides to make it white and smooth. Waxes, polyethylene, and other coatings may be applied to give the package special properties. Clay-coated paperboard is either backed by kraft (brown) or ONP (gray) fibers. "Clay-coated news back" (CCNB) is a common coated recycled paperboard grade.

3. Recycled paperboard manufacturing processes

Recycled paperboard primarily is made on multi-ply machines. In a traditional cylinder machine, the forming cylinders are covered in wire mesh and sit in a vat filled with a recycled fiber pulp. As the cylinders turn, the fibers form a web on the surface. At the top of the cylinder, the sheet is transferred off the cylinder onto a felt, and is combined with other sheets that are pressed and dried to make a multi-ply board. Typical cylinder machines have six to nine cylinders.

A main limitation of traditional cylinder machine technology is that it is expensive and difficult to run the large drums at high speeds; 600 feet per minute is a typical limit. In comparison, running speeds on fourdrinier machines used to make SBS and CUK are in the 2,000 - 3,000 feet per minute range. Another drawback of this technology is non-uniform or washy deposits of fiber on the wire cylinder, which results in high mechanical wet pressing demands and excessive heat requirements to remove moisture in the dryer section.[16] An advantage of the multi-cylinder forming technology is that inexpensive, low-grade recovered fibers can be sandwiched into the middle of the board. It is also a very low-cost manufacturing method for grades of paperboard such as chipboard, core and tube stock and construction board.

A number of technological advances in multi-ply recycled paperboard manufacturing have made better and faster sheet formation possible. Most of these involve a different means of applying pulp to the rotating cylinders of a conventional multi-ply machine. Improvements in press section and coating technology are also common.

Multiformers, for example, use pressurized chambers mounted on the cylinder mold to disperse the pulp evenly onto the cylinder. Ultraformers, a technology developed in Japan in the 1960's, use a fourdrinier-type headbox at the top of the cylinder to apply the pulp. Some cylinder machines have also been retrofitted with short fourdrinier sections prior to one or more of the forming cylinders. These fourdrinier additions dewater the web more quickly and evenly than cylinder-based formers alone, and are sometimes used for the top liner or inner liner of the paperboard.[17]

Another major innovation is the use of multi-fourdrinier technology to manufacture recycled paperboard. These machines use two or three top-former fourdrinier sections arrayed above a longer bottom fourdrinier to produce a multi-ply sheet at relatively high speeds. There are now two multi-fourdrinier recycled paperboard machines operating in North America. Cascades, a Canadian company, produces a three-ply sheet on a multi-fourdrinier machine at its Jonquiere, Quebec mill. The mill has the capability of combining various combinations of recycled and virgin pulp in the inner and outer layers of the board.

James River Corp. produces clay-coated 100% recycled paperboard on a multi-fourdrinier machine installed as part of a renovation of what was formerly a cylinder machine at its Kalamazoo, MI, mill. At a cost of $97 million, the company doubled the machine's production capacity, to 284,000 tons per year.[18] The use of this new technology allows the board to offer greater stiffness and strength at basis weight that is closer to that of SBS.

4. Distribution of paperboard manufacturers and folding carton converters

The recycled paperboard segment of the paper industry is populated by a large number of relatively small mills. The typical output of a recycled paperboard mill in the U.S. is about 200-400 tons per day (tpd) compared with 600-800 tpd and higher for SBS and 750+ for CUK.[19] Recycled paperboard mills are located across North America, often in urban settings, with the greatest concentration in the industrial Midwest. Mills making SBS and CUK are concentrated in the South. In total, these paperboard mills supply the raw material to more than 600 carton-making plants in the United States.

The large majority of folding cartons are printed using the offset process. Rotogravure printing is used for some long printing runs, such as cigarette carton cases. Flexography is sometimes used, although this printing method is in decline.[20]

IV. FUNCTIONAL PERFORMANCE OF PAPERBOARD USED IN FOLDING CARTONS

The major functional issues for paperboard used in folding cartons relate to strength (stiffness), appearance and uniformity from package to package. Folding paperboard is die-cut in the converting process so that it can be folded into a carton. The folding cartons are produced in collapsed form and are not set up until used. Folding cartons must meet rigid folding specifications, since the performance of high-speed folding-gluing machines depends on consistent bending quality and accurate creasing and scoring of the paperboard.

To produce a score or crease in paperboard, the board is pressed between two metal surfaces, one of which has a recessed groove and the other a tongue. The score is made along the line on which the sheet is to be folded and alters the sheet structure so that it will fold readily with less tendency to crack or break. A full bending board, when properly scored, may be folded

180 degrees without showing pronounced failure of the top liner. A semibending sheet may be folded 90 degrees.[21]

A. Strength

1. Criteria for measuring strength

Measurements of the strength of a particular type of paperboard or folding carton include the following.[22]

> Stiffness is measured in terms of the amount of force required to deflect a sample to an angle of 15 degrees. Stiffness is often defined as the most important strength characteristic of paperboard.[23] Paperboard is measured in terms of its machine direction (MD) stiffness and cross-direction (CD) stiffness. Because of the tendency of the fibers to align themselves with the direction of the paper machine, MD stiffness is greater than CD stiffness. In other words, the board is stiffer if bent in the machine direction than in the cross direction. This can be an issue depending on how the package is designed; a higher MD to CD ratio can be a benefit in some folding carton applications. Recycled paperboard has a higher ratio of MD to CD stiffness than SBS and CUK. Modern recycled paperboard machines have reduced the MD-CD ratio compared to recycled paperboard produced on traditional cylinder machines.
>
> Compression strength is related to the ability of a carton to retain its shape under external loads. This is measured by a Carton Compression Tester, which applies measured top-to-bottom pressure on the carton. Block compression and box compression measure the edgewise compression force on a side panel of paperboard and on an entire box respectively.
>
> Burst strength measures the strength of the board to withstand pressure in a specific area. It is measured by the Perkins Mullen Tester, which utilizes a rubber diaphragm pressed against the board backed by a reservoir of fluid under pressure. As pressure is increased, the device measures the pressure at which the board ruptures.
>
> Tear strength is the ability of a sample of paperboard to resist tearing. It is measured by the force exerted by a pendulum required to turn a cut in the paperboard into a tear.
>
> Bulge resistance is the amount of curvature of a sample of board as a function of compression.
>
> Score bend strength is related to the ability of the sheet to remain intact (the board should not delaminate and the coating should not crack along the score). This property is measured by the PCA Score Bend Tester.
>
> Moisture resistance measures the ability of the board to maintain its strength under humid conditions. For packaging items like beverage carrier stock, sizing and wet strength agents are impregnated into the board to improve its “wet strength,” which is defined as

the ability of the board to retain 15% of its tear and burst strength when completely saturated with water. Having wet strength is not the same as being "water proof."

There are many ways to measure paperboard strength. Emphasizing the attributes of its CUK board, Mead's Coated Board Division has defined "Robustness"™ as "the cumulative sum of the characteristics of a paperboard material that provide a comprehensive, high level of physical performance for optimal carton package integrity throughout its life." This definition encompasses ten different strength measurements, including block compression, box compression, Cobb/water resistance, cyclical compression, dry tear, fold, modulus of elasticity, puncture resistance, stiffness and tensile strength.[24] These properties have been determined to be the most critical to carton performance by technical institutions (PIRA, for example), packaging schools (such as Clemson University) and packaging engineers for companies that use folding cartons.[25]

Manufacturers and converters of recycled paperboard suggest that quantitative measurements of individual strength parameters do not automatically mean that the overall package meets the functional needs of the customer. This is also a function of the design of the package. For example, it is possible to design a strong package with a board that has medium compression strength.[26]

B. Stiffness and basis weight relationship

Stiffness is probably the strength criteria that packaging buyers consider most important, with tear strength second. Across comparable basis weights, measured in terms of tear, burst, stiffness and compression strength, CUK paperboard is stronger than SBS. This allows a lower caliper CUK paperboard to be substituted for SBS, for a 3-15% material savings.[27] One manufacturer of CUK paperboard states that at the same stiffness level, the caliper of CUK board can be reduced by 2 points compared to 16-22 point SBS and by 6 points compared to 24 point and higher recycled board. According to this supplier, CUK board broke into the frozen food packaging market by dropping 1 basis point compared to 15 point SBS.[28]

At the same basis weight, SBS is stronger along these major parameters than recycled paperboard.[29] Traditionally, this has meant that heavier grades of recycled paperboard have substituted for SBS and CUK paperboard in equivalent applications in most cases. More recently, most package conversions from SBS to recycled paperboard have utilized recycled paperboard made on modern paper machines at the same caliper. The fact that the recycled board weights more at the same caliper is a function of the fiber used and how it is processed.[30]

From a packaging perspective, recycled paperboard has lower corner stacking and panel strength than SBS and CUK. As a result, it is necessary to increase the gauge of the board, for example, from 16 to 18 point. This means more material is used in the package and that it is approximately 1/9th of its original weight heavier. Even with the addition of bulkers and squeezing the board to enhance the cross-linking of fibers, it is still not possible to produce a recycled board of equal strength as a virgin board without increasing the caliper thickness. In other words, the board thickness must be increased to bring the package "back into spec."[31]

Making a package from thicker caliper board can be somewhat more challenging for a number of reasons. It can be harder to score and bend the thicker board, for example. Some experts state that this is not necessarily a difficult process, however, but requires re-ruling of scoring dies to allow for proper male penetration into the female die channel.[32] In general, clay-coated recycled paperboard cracks more easily in the direction of the grain than SBS or CUK.[33]

To put this issue in perspective, it is important to remember that the strength requirements for folding cartons are not nearly as high as for corrugated boxes used as shipping containers. The strength/basis weight tradeoff is in part an issue for small packages, such as cosmetics, film and over-the-counter pharmaceuticals. For virgin paperboard used in smaller cartons sizes, board weights in the 12-15 point range are preferred. The products are not heavy, and they are protected during shipping by corrugated boxes or stretch wrap. In order to minimize costs using a specific type of paperboard, the thinner the board the better.

Recycled paperboard produced on a traditional cylinder machine cannot currently be made in the 10-14 point range. In addition, on traditional cylinder machines there has historically been an incentive to produce heavier board for larger packages (e.g., powdered laundry detergent), for reasons of productivity. Making a lower weight board does not allow greater machine speed production volume, due to the economic limits of the cylinder technology.

Some of the challenges and solutions in using recycled paperboard for packages that have traditionally been made from SBS are best illustrated in short case examples. Many of the packaging shifts described here were initially motivated by the fact that SBS production in the U.S. reached full capacity at the end of the 1980's (97% in 1989). With SBS capacity so tight, in 1989, the price differential between SBS and recycled paperboard grew to an unprecedented $350/ton (although the actual difference is smaller if heavier recycled board is used in place of SBS). Consequently, many paperboard buyers moved orders to recycled mills. Production at the recycled mills was only 90% of capacity that year. By the end of 1990, however, most clay-coated recycled paperboard mills were running close to capacity. From 1987 to 1990, coated recycled paperboard was in tight supply itself compared to previous years, and gained market share for a variety of reasons, including price, functionality and environmental considerations.[34]

The experience of McDonald's, one of the members of the Paper Task Force, illustrates the nature of source reduction and recycled content issues that purchasers can face. Faced with higher prices for SBS shortage in 1989, McDonald's began looking for alternatives to SBS for their growing Happy Meal carton business. The SBS board McDonald's had been using was a 52 lb., 15 pt. clay-coated board, designed to meet all performance specifications outlined by McDonald's for the Happy Meal carton. The most widely available and cost-effective option was recycled paperboard. To meet all functional requirements using the recycled board, McDonald's had to increase the basis weight of the board to 67 lb., maintaining a 15 pt caliper.

Once the board market settled, McDonald's reevaluated the choice between SBS and recycled board for the Happy Meal carton business. For McDonald's needs, the recycled board performed as well as the SBS, and there was no loss in customer acceptance. In this instance, cost and availability were not issues and there was the measurable environmental benefit of achieving progress toward McDonald's goal of increasing the amount of recycled content in its packaging. McDonald's made the decision to continue using the recycled Happy Meal cartons. One issue remains with the recycled board, which is the increase in basis weight. McDonald's top environmental priority has always been source reduction, never wanting to increase the basis weight of an item to accommodate recycled content. In 1990, the supply situation dictated the choice. However, over the years, on-going evaluation of functional specifications and basis weight availability has enabled McDonald's to reduce the basis weight of the Happy Meal cartons to from 67 lb. to 61 lb., 15 pt. board.

C. Appearance and Printability

Because folding cartons are used to present products to the consumer, appearance is critical. The most important visual criteria for finished folding cartons relate to printability, and include smoothness, ink receptivity, ink holdout, rub resistance, coating strength, ink and varnish gloss and mottle resistance.[35] Brightness, cleanliness, gloss and the absence of debris or loose fiber are also important attributes. These qualities translate to the accurate reproduction of the graphic information desired by the carton user and help convey a high quality image of the product.[36] Not all criteria are important for every printing technique. The properties of the board coating are critical in meeting these criteria, and each manufacturer tends to use a different formulation.

Smoothness is measured by the Sheffield test and by the Parker test. Both tests measure the flow rate of forced air moving across the surface of the paper, but the Parker print test examines a smaller surface area and is becoming used more widely. Print mottling and ink receptivity can be assessed by smearing an excess of ink on the board, holding it for two minutes, and then wiping the ink off. This will allow a measurement of the reduction in brightness. Printers also measure ink receptivity and mottle based on standards that they establish in their own operations.[37]

SBS is generally recognized as being better in appearance and printability attributes, as demonstrated by quantitative measurements according to the criteria defined above.[38] Good printabilty, consistency in physical properties, availability in low caliper and basis weights, cleanliness, and superior fiber-to-fiber bonding are qualities that promote the use of SBS in higher value-added products, such as fatty and aqueous food, health care, pharmaceuticals, cosmetics, etc.[39]

Brightness for clay-coated SBS paperboard ranges from 80 to 86 GE brightness (based on a percentage scale in which the ability of magnesium oxide to reflect light is 100%). CUK and recycled board are somewhat less bright, in the high 70's. The inner liner of SBS is bright white (sometimes brighter than the clay-coated outer surface), the inner liner of CUK is dark brown, and the inner liner of recycled board can be gray, tan, medium brown, or off white, depending on the type of recovered fiber used. The appearance of the printed carton can be affected as much by the type of printing process and post-printing operations (e.g., varnishes) as the board itself.

Generally speaking, printability and stiffness tend to trade-off against each other. For a given type of board, stiffness is primarily a function of increasing caliper. As caliper increases, some manufacturers state that the surface of the paperboard sheet becomes rougher and therefore more difficult to coat to a high degree of uniformity. All paperboard manufacturers are working on several techniques to further reduce the density of their product while increasing smoothness and stiffness simultaneously.[40]

The majority of folding cartons are printed on offset presses. The tackiness of the ink and the contact of the press blanket with the paper sheet mean that cleanliness of the paper sheet is a key issue for this type of printing. Rotogravure printing is used for long printing runs for which the cost of preparing gravure cylinders can be recouped through the volume of the run. Flexography is growing for some applications. Flexography uses raised rubber or photopolymer plates, and has the advantage of comparatively short makeready times. The potential to use water-based inks in flexography may offer some advantages in complying with environmental regulations.[41]

D. Printing, Converting and Package Filling Line Operations

1. Printing and converting

Switching from virgin to recycled paperboard raises a number of issues for converters, who cut and print rolls of board to form folding boxes. While these technical issues all have solutions, they can lead to inertia in packaging selections made by manufacturers. A strong and enduring demand for recycled products must be demonstrated to induce converters to change.

Although a paperboard manufacturer may say that it is "no problem" to run recycled board, the converter may have trouble using it. Some converters are very particular about their raw materials. They tune their machines for a specific type of paperboard, often from a specific manufacturer. For this reason, the less predictable properties of recycled paperboard can disrupt the die-cutting, folding and gluing process. Other converters, typically those that are subsidiaries of recycled paperboard manufacturers, routinely run two or three different types of paperboard in their plants. They have learned to adapt to the different qualities of recycled board.

Moisture uptake and printability are the two properties of greatest concern to the converter. Proper conditioning of the paper is critical to the converting process to ensure that the board has flat edges and the proper moisture content. Recycled paperboard absorbs moisture more readily than SBS or CUK, and if recycled board is improperly conditioned, it may develop wavy or tight edges making it more difficult to put through the presses. Too high a moisture content also adversely affects the printability of the board. Proper climate controls and inventory management are part of the solution to this issue.[42] Converters who have not installed these systems will face economic costs in doing so.

Another factor affecting printability is dust. Recycled paperboard is more dusty than SBS or CUK, in part because the die-cutting process exposes the inner plies of the recycled board, which can dislodge small amounts of fiber. Part of the conditioning process is to remove the dust using a vacuum or a static charge system. Many converters of recycled paperboard use a piece of equipment that takes stacks of paperboard sheets and blows pressurized air along the edges (something akin to running one's thumb along the edge of a ream of photocopy paper before feeding it into the copier). The effect of this step is to make the board easier to feed through the printing process. Maintaining sharp cutting blades is another means of reducing this problem.[43]

If the converter does not have a dust removal system, the dust collects on the press blankets and causes white spots with dark centers to form during printing. The result is that the converter must take costly downtime to clean the printing press blankets. Dust and fines are incompatible with gravure printing because they fill the wells on the gravure cylinders. Experience at some gravure plants suggests that press operators prefer using recycled paperboard because of superior compressibility, which produces sharper printed images.[44]

To reduce the impact of dust and debris associated with recycled paperboard on offset printing operations, web cleaners are being explored, operating either on the sheeter or the infeed of web presses. Automatic blanket washers, plate washers and the filtration of ink and fountain solution are being incorporated into the newest offset printing presses. Some retrofits are available for existing presses.[45]

The experience of Eastman Kodak Co. illustrates some of the issues and possibilities in using recycled paperboard for folding cartons. In the late 1980's, Kodak had desired for several years to switch from virgin paperboard to recycled, but it took some time to develop a recycled board that could reproduce the company's distinctive gold and red colors. The precise hue of the gold and red, Kodak's "trade dress," is critical to its point-of-purchase sales. The company worried that if its packaging looked recycled, it would imply that its film was of poor quality. Having found a source of recycled paperboard that can hold the colors of its trade dress, Kodak is now using 100% recycled film boxes.[46]

2. Filling on packaging lines

The performance of folding cartons on packaging lines, or "machinability" depends on the type of filling and gluing machines being used as well as the paperboard and carton design. Folding cartons are shipped flat. In order to run smoothly and consistently on packaging lines, they have to erect well, accept the product without changing shape and maintain their shape when sealed, without flaps popping open. How the paperboard sheet responds to being scored is one key factor in performance on filling lines. Ideally, when a box is opened on the packaging line, it will spring back into shape without the outside surface of the scores cracking or the box deforming.

The stiffness of the paperboard is an important property affecting smooth erection of the carton blank into its tubular form before filling and efficient flap closure and sealing afterwards. Another important property is the effect on the board's resistance to folding caused in the scoring operation when the cartons are produced. The ratio of the stiffness of the board and the stiffness of the crease after it has been bent 90 degrees must lie within certain for the sealing machine to work properly.[47]

SBS manufacturers state that their product has the most consistent performance on conventional filling lines due to an intermediate level of "memory" (response to scoring and folding) in the sheet compared to recycled and CUK paperboard.[48] Other manufacturers dispute this claim, stating that memory is more a function of proper scoring techniques than the paperboard itself. With correct carton scoring, the opening force for CUK carton erection has been demonstrated to meet that of SBS.[49] The greater MD to CD stiffness ratio of recycled paperboard can be exploited to improve filling line operations in some cases.

Machinability is most critical when there is a challenging filling environment (e.g., beverage filling lines tend to create wet and humid conditions) or when the speed of the filling line is a critical factor in determining the overall production line speed for the product. CUK manufacturers state that CUK runs best through modern filling machines that run at very high speeds. However, in general, conventional filling machines are fairly flexible and can be tuned to compensate for the properties of different types of board.[50]

E. Improvements in the Performance of Recycled Paperboard

The growth of public interest in the environment has led to performance improvements in recycled paperboard. In the last five years, "... continued investments in quality and productivity improvements have allowed have raised the efficiency and competitiveness of recycled paperboard mills. At the same time, buyers of recycled paperboard products, particularly large consumer products companies, have demanded higher quality from suppliers. Consumer preference for recycled products has also played an important role in the increased use and quality improvements of recycled paperboard packaging."[51]

The performance improvements in the recycled board industry have taken several forms. As noted in section B, traditional cylinder machines have been upgraded using a range of forming and press section technologies that allow the formation of a thinner, smoother, more uniform sheet at higher rates of speed.[52] These changes in turn have improved the printability of recycled paperboard by producing a smoother surface that can be coated more easily and evenly. This makes it possible for some product manufacturers that use virgin packaging to convert to recycled paperboard and maintain a high level of quality in graphics. Examples of such packaging conversions include small cartons used to package cosmetics and consumer health care products. Since these modifications have been made on a machine-by-machine basis, variation of printabilty is still significant across the recycled paperboard industry.[53]

F. Paperboard and Folding Carton Costs

This paper is primarily about paperboard performance issues, rather than economics. The cost of using a particular type of board can be evaluated by the purchaser when selecting a specific package and supplier. One general point about the relationship between performance and cost is worth making, however. Recycled paperboard has traditionally sold at a lower price than SBS and CUK, reflecting both its lower manufacturing costs and comparatively lower strength and appearance characteristics. Between 1985 and 1995, prices for CUK ranged between 72% and 93% of prices for SBS. During the same period, prices for recycled paperboard ranged between 59% and 79% of SBS prices.[54] These data compare 20 pt. CUK and 20 pt. recycled board to 15 pt. SBS so they do not translate directly to the cost of board in the same type of package. Since the actual caliper and weight of the board may vary depending on specific carton requirements, and since paperboard is sold on an area basis (dollars per thousand square feet), these data do not translate directly to the value of the board in the same type of package. However, the Task Force does not have publicly available price data in this form.

Users of folding cartons buy packages from converters, rather than paperboard itself. The design of the carton, type of printing, basis weight of paperboard used, the value of converting scrap and other factors will influence the final cost of the package. In 1995, the cost of paperboard made up 58% of the average overall cost of printing and converting folding cartons, based on an average price for the three types of board weighted by market share.[55] From the standpoint of the company that purchases folding cartons to package its products, the price of the board and the carton is only one component of the total cost of the packaging filling, distribution and retailing system. Poor printing characteristics and inconsistent quality leading to packaging line problems associated with some older recycled-content grades had the potential to significantly raise the overall cost of the packaging system.[56] On the other hand, newer, thinner recycled paperboard products that have improved formation, printing and strength characteristics and compete directly with SBS tend to sell for higher prices on a per ton basis than the traditional clay-coated newsback of the past.

G. Introduction of Recycled Content in SBS and CUK

Manufacturers of virgin SBS and CUK are beginning to introduce recycled content into their products. Some SBS manufacturers are blending deinked market pulp with virgin fiber at the 10% recycled content level. This presents an issue in terms of the operation of the mill, however. Most virgin SBS producers make all of their product to meet food contact specifications, because they do not know what the board will be used for before they manufacture it. Introducing deinked pulp into the fiber lines for these mills causes a lag in the time it can take for the mill to switch back to a food-contact grade.[57]

It is theoretically possible to pulp and clean recovered fiber from OCC or office papers and run it through the bleach plant of a conventional (chlorine-based) virgin kraft pulp mill.[58] At its mill in Cornwall, Ontario, Domtar is constructing a recycling system to process OCC through a conventional virgin kraft pulping and bleaching line to make recycled-content uncoated freesheet. In this case, the bleaching process would remove dirt particles and destroy bacteria and potentially problematic compounds (for food-contact packaging) such as fluorescent brightening agents.

Westvaco is producing a SBS products at its Covington, VA mill with 10% to 30% postconsumer recycled content that meets FDA requirements for direct contact with aqueous food products.[59] The Westvaco process is proprietary. Westvaco states that performance specifications for its recycled-content bleached paperboard are the same as for its 100% virgin products.[60]

In the case of CUK, it is possible to add recycled content using a conventional OCC pulping and cleaning system similar to that used in many linerboard mills. Because of the coating process, CUK is more sensitive to contaminants than linerboard. However, Riverwood International is using this technology to produce CUK with up to 20% postconsumer recycled content and an additional 15% preconsumer recycled content at it West Monroe, LA mill. Mead

Corp. manufacturers beverage carrier stock with 20% postconsumer recycled content from OCC, and is studying the same approach for its folding carton board products.[61] Riverwood Intl. states that its fiber processing technology allows the recycled-content board to meet the same performance specifications as its virgin board.[62]

V. RECYCLABILITY OF FOLDING CARTONS

As the paper industry installs more and more recycling capacity, mills are seeking new sources of recovered fiber. Making up more than half of the 11 million tons of paperboard packaging produced in the U.S. in 1993, folding cartons are being examined for their potential recyclability (this 11 million tons does not include corrugated boxes, but does include folding cartons, foodboard, chipboard, core and tube stock, etc.). As prices for recovered paper grades such as OCC and ONP rise to unprecedented levels, recycled paperboard mills themselves may be the best candidates to use old folding cartons, particularly in lower-grade types of recycled paperboard, such as chipboard.

A. Current Collection and Recycling of Folding Cartons

The only postconsumer paperboard currently being recycled on a large scale in the United States is from grocery stores where the paperboard is used as inner dividers in corrugated boxes. In these cases, the paperboard is baled with the OCC, accounting for a fraction of the OCC furnish. In general, when making recycled paperboard, old boxboard is a better ingredient when density and smoothness are required and, because of its longer fibers, OCC is preferred when stiffness and strength are required.

With current high prices for recovered paper, many communities are adding residential mixed paper to existing curbside recycling collection programs. This improves collection efficiencies and takes advantage of a collection infrastructure that is already in place.[63] Paperboard packaging is one component of the residential mixed paper stream. Mixed paper, including folding cartons, is collected at curbside in mercer County, NJ, and is used to make Homasote, a non-structural construction board product. OCC is collected separately in this case.[64] A few towns in DuPage County, IL collect folding cartons, except for wet-strength board. It is either marketed with OCC or sorted out and sold as mixed paper.[65] In Vancouver, WA, folding cartons are placed in a bin along with household fine papers and telephone directories. ONP is placed in a separate bin and OCC is bundled separately.[66]

Numerous municipalities in Ontario now have a few years experience in collecting paperboard packaging. These efforts began as “the Quinte Project,” an experimental recycling program in Quinte County, Ontario, initiated in 15 municipalities in September, 1990 as a joint venture between a coalition of 15 municipalities, the Ontario Multi-Material Recycling Institute (OMMRI), and the Ontario Ministry of the Environment. The Paper and Paperboard Packaging Environmental Council (PPEC) is also involved through the participation of its member mills.[67] Currently there are 600,000 household in Ontario that have the option of recycling paperboard packaging, along with magazines, phone books, newspapers, paper bags and corrugated boxes, through curbside collection programs. The PPEC is promoting the “Paper Box,” a large bin with a divider in the middle, as the collection container for paper materials. Newspapers, phone books and magazines are placed on one side of the containers, and all other collected types of paper on the other side.[68]

Developing markets for postconsumer paperboard is one of the main goals of the "Paper Box" initiative. The outcome of these efforts should help Ontario's "blue box" curbside recycling program, which is being expanded to the rest of the province and which may begin recycling OCC and paperboard. To date, six Canadian producers of recycled paperboard are using paperboard collected from Ontario households: Paperboard Industries, Strathcona Paper, Cascades Inc., Fraser Inc., Daishowa Forest Products Ltd. and Sonoco, Inc.[69]

B. Potential Use of Folding Cartons and other Paperboard Packing by Recycled Paperboard Mills

The presence of contaminants and the uncertain fiber composition of paperboard packaging collected from homes are two major concerns listed by recycled mills that have run this mix in their systems. Stickies are the contamination problem most commonly named by makers of clay-coated paperboard and other recycled paper grades, because they can poke through the coating and cause blemishes, or "hickeys," in the printing surface. Bits of metal foil can have the same effect, and can also tear off the box and stick to the printing press at the converting plant, marring each box that makes contact with the press. In addition, high levels of plastic tape, wax or polyethylene coatings can overload screening and cleaning equipment and increase residual disposal costs. For the same reasons, large quantities of clay in fiber sources are also not desirable.

Recycled paperboard, chipboard, and core and tube stock may also be able to absorb fiber recovered from virgin and recycled paperboard. However, for the recycling of paperboard packaging back into paperboard to be viable, several common contaminants will have to be reduced at the source or sorted out before shipment to the mill. These include hot melt glues, paperboard made using wet-strength compounds (e.g., beer carriers), nylon tear tapes (incorporated into boxes for easy opening) and nylon handles (such as those used on large boxes of laundry detergent). Polyethylene and foil coatings used on food packaging are also potential problems. Many of these contaminant materials are intrinsic to packaging as currently designed, and reducing them at the source will be a challenge. One change that packaging designers may be able to make would be to use aqueous (water-based) varnishes in place of UV-cured plastic resins, which are more difficult to recycle.

To address the difficulty in recycling paperboard made with wet-strength additives, Mead Corp. has developed a repulpable wet-strength additive. The new additive provides a high-quality functional carrierboard that can be repulped along with OCC.[70] Adoption of this technology across the CUK and folding carton industry is not yet certain.[71]

Uncertainty about the type of fiber in a recycled pulp makes it more difficult to predict how the pulp will behave (e.g., drain water) on the paper machine. When forced to shift from OCC to the less predictable commercial mixed paper grades in the past, manufacturers have installed monitoring equipment to detect increases in the amount of shorter fiber in the pulp. Larger chests and drums used for pulp storage also help reduce the variability of average fiber length in the pulp. To compensate for an increase in short fibers, the paper machine can be run at a slower speed, allowing water to drain more thoroughly. All paper makers seek to avoid such reductions in output; one manufacturer using mixed paper found that machine speed adjustments could be avoided by other techniques.[72]

Mills producing recycled paperboard have in the past added detrashing equipment, pressurized and vibrating screens and centrifugal cleaners to their stock preparation systems. However, this was done primarily to upgrade the quality of the product made from their existing fiber furnish, rather than to facilitate the use of a lower grade of recovered paper.

Paperboard mills are theoretically candidates for fiber fractionation. Fractionation allows a mill to direct short and long fibers to different plies of paperboard. Short fibers are desired in multi-ply paperboard products in two areas. In the inner layers they add inexpensive bulk to the board. In the outer layers the short fibers help to mat together the longer fibers, which are added for strength. The combination results in a more even finish.[73]

APPENDIX A. PAPER TASK FORCE WHITE PAPERS

Paper Performance

Functionality Requirements for Uncoated Business Papers and Effects of Incorporating Postconsumer Recycled Content (White Paper 1)

Functionality Requirements for Coated and Uncoated Publication Papers and Effects of Incorporating Postconsumer Recycled Content (White Paper 8)

Functionality Issues for Corrugated Packaging Associated with Recycled Content, Source Reduction and Recyclability (White Paper 6A)

Functionality Issues for Folding Cartons Associated with Recycled Content, Source Reduction and Recyclability (White Paper 6B)

Recycling and Used Paper Management

Economics of Recycling as an Alternative to Traditional Means of Solid Waste Management (White Paper 2)

Lifecycle Environmental Comparison - Virgin Paper and Recycled Paper-Based Systems (White Paper 3)

Economics of Manufacturing Virgin and Recycled-Content Paper (White Paper 9)

Forest Management

Environmental Issues Associated with Forest Management(White Paper 4)

Economic Considerations in Forest Management (White Paper 11)

Pulp and Paper Manufacturing

Environmental Comparison of Bleached Kraft Pulp Manufacturing Technologies (White Paper 5)

Economics of Kraft Pulping and Bleaching (White Paper 7)

Environmental Comparison - Manufacturing Technologies for Virgin and Recycled-Content Printing and Writing Paper (White Paper 10A)

Environmental Comparison - Manufacturing Technologies for Virgin and Recycled Corrugated Boxes (White Paper 10B)

Environmental Comparison - Manufacturing Technologies for Virgin and Recycled Coated Paperboard for Folding Cartons (White Paper 10C)

Comparison of Kraft, Sulfite and BCTMP Pulp and Paper Manufacturing Technologies (White Paper 12)

Nonwood Plant Fibers as Alternative Fiber Sources for Papermaking (White Paper 13)

ENDNOTES

[1] *1994 Pulp & Paper Factbook*, San Francisco: Miller Freeman, 1994, p. 278.

[2] Joseph Hanlon, *Handbook of Package Engineering*, 2nd Edition, Lancaster: Technomic Publishing Co., 1992, p. 6-2.

[3] American Forest & Paper Association, *1995 Statistics; Paper, Paperboard and Wood Pulp*, Washington, DC: AF&PA, 1995, pp. 22.

[4] Joseph Hanlon, *Handbook of Package Engineering*, 2nd Edition, Lancaster: Technomic Publishing Co., 1992, p. 6-21.

[5] American Forest & Paper Association, *1995 Statistics; Paper, Paperboard and Wood Pulp*, Washington, DC: AF&PA, 1995, pp. 22.

[6] American Forest & Paper Association, *1995 Statistics; Paper, Paperboard and Wood Pulp*, Washington, DC: AF&PA, 1995, pp. 22-25.

[7] As part of its research, the Task Force examined specifications on different grades of paperboard provided by a number of different manufacturers. This comparison of specifications provides part of the support for the findings presented in the paper. However, these specifications themselves are not published in the paper for several reasons. First, paperboard specifications are closely related to folding carton performance, but will not correlate 100% for all types of packaging produced under all types of conditions. Second, these specifications are used in sales and marketing by the individual companies that provided them, and are not appropriate for publication in a paper of this type.

[8] Franklin Associates, Ltd. *Evaluation of Proposed New Recycled Paper Standards and Definitions*, prepared for the Recycling Advisory Council, November 25, 1991, Table A-2. The table estimates that 17% of new paperboard used in converting "boxboard and other paperboard" is generated as scrap at the converting plant, 88% of which is recycled. This is an estimate for 1995 developed in 1991; given recovered paper markets, the actual number may now be higher.

[9] Joseph Hanlon, *Handbook of Package Engineering*, 2nd Edition, Lancaster: Technomic Publishing Co., 1992, p. 6-3.

[10] American Forest & Paper Association, *1995 Statistics: Paper, Paperboard and Wood Pulp*, Washington, DC: AF&PA, September, 1995, p. 22, 26.

[11]"Boxboard: Steady growth expected," Pulp & Paper, January, 1990.

[12] American Forest & Paper Association, *1995 Statistics; Paper, Paperboard and Wood Pulp*, Washington, DC: AF&PA, 1995, pp. 22-25.

[13] *1994 Pulp & Paper Factbook*, San Francisco: Miller Freeman, 1994, p. 279.

[14] *1994 Pulp & Paper Factbook*, San Francisco: Miller Freeman, 1994, p. 278.

[15] *1994 Pulp & Paper Factbook*, San Francisco: Miller Freeman, 1994, p. 278.

[16] Clyde Eckhart, "Paperboard," in Alex Glassman, ed., *Printing Fundamentals*, Atlanta, GA: TAPPI Press, p. 226.

[17] Clyde Eckhart, "Paperboard," in Alex Glassman, ed., *Printing Fundamentals*, Atlanta, GA: TAPPI Press, pp. 223-225.

[18] Paper Task Force tour of James River Corp. Kalamazoo, MI mill, November, 1993; *Pulp & Paper Week,* September 17, 1990, p. 2. Production estimate from 1995 *Lockwood-Post's Directory*; 800 tons per day at 355 days per year. 1990 *Pulp & Paper Week* article gives production capacity as 320,000 tons per year.

[19] *1994 Pulp & Paper Factbook*, San Francisco: Miller Freeman, 1994.

[20] Clyde Eckhart, "Paperboard," in Alex Glassman, ed., *Printing Fundamentals*, Atlanta, GA; TAPPI Press, p. 226.

[21] *Walden's Handbook for Paper Salespeople & Buyers of Printing Paper*, 2nd ed., Oradell, NJ: Walden-Mott Corporation, 1981, p. 239.

[22] This section from:

American Forest & Paper Association, *A Buyer's Guide to Recycled Paperboard*, Washington, DC: AF&PA, 1994, pp. 4-12

Joseph Hanlon, *Handbook of Package Engineering*, 2nd Edition, Lancaster: Technomic Publishing Co., 1992, Chapter 2.

James River Corp., written response to questions asked by Johnson & Johnson staff, Paper Task Force meeting, June 2, 1995.

[23] Gary Smook, *Handbook for Pulp and Paper Technologists,* Second Edition, Vancouver, BC: Angus Wilde Publications, 1992, p. 307.

[24] Literature on "Robustness," provided by Mead Coated Board Division, Paper Task Force meeting, Atlanta, GA, April 4, 1994.

[25] American Forest & Paper Association, consolidated comments on White Paper No. 6B Draft, July 13, 1995.

[26] Joe Hart, division manager, mechanical packaging/structural design, Jefferson Smurfit Corp., Paper Task Force meeting and tour of folding carton plant, Valley Forge, PA, April 21, 1995.

[27] *1994 Pulp & Paper Factbook*, San Francisco: Miller Freeman, 1994, p. 271.

[28] Tom Scott, Mead Coated Board Division, personal communication, March 13, 1995.

[29] *1994 Pulp & Paper Factbook*, San Francisco: Miller Freeman, 1994, p. 271.

[30] American Forest & Paper Association, consolidated comments on White Paper No. 6B Draft, July 13, 1995.

[31] Ric Hirst, Technical Services Manager, Gerstman + Myers, Inc., Personal communication, June 20, 1995.

[32] American Forest & Paper Association, consolidated comments on White Paper No. 6B Draft, July 13, 1995.

[33] Ric Hirst, Technical Services Manager, Gerstman + Myers, Inc., Personal communication, June 20, 1995.

[34] American Forest & Paper Association, consolidated comments on White Paper No. 6B Draft, July 13, 1995.

[35] Marylin Bakker, editor-in-chief, *Encyclopedia of Packaging Technology*, New York: John Wiley & Sons, 1986, p. 147.

[36] James River Corp., written response to questions asked by Johnson & Johnson staff, Paper Task Force meeting, June 2, 1995.

[37] John Dayton, Director of Technology, Temple-Inland Forest Products Corp., Personal communication, March 13, 1995.

[38] Joe Carothers, manager, product development, Bleached Board Div., Georgia-Pacific Corp., Paper Task Force meeting, Atlanta, GA, April 4, 1995.

[39] James River Corp., written response to questions asked by Johnson & Johnson staff, Paper Task Force meeting, June 2, 1995.

[40] Joe Carothers, manager, product development, Bleached Board Div., Georgia-Pacific Corp., Paper Task Force meeting, Atlanta, GA, April 4, 1995. American Forest & Paper Association, consolidated comments on White Paper No. 6B Draft, July 13, 1995.

[41] Nelson Eldred, "Printing Developments and the Papermaker," in Alex Glassman, ed., *Printing Fundamentals*, Atlanta, GA: TAPPI Press, 1985, pp. 320-23.

[42] Russell Currey, executive vice president, Rock-Tenn Co. Interview and tour of folding carton converting plant, recycled paperboard mill and recovered paper processing center, Dallas TX, July, 1994.

[43] Joe Hart, division manager, mechanical packaging/structural design, Jefferson Smurfit Corp., Paper Task Force meeting and tour of folding carton plant, Valley Forge, PA, April 21, 1995.

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[50] Joe Hart, division manager, mechanical packaging/structural design, Jefferson Smurfit Corp., Paper Task Force meeting and tour of folding carton plant, Valley Forge, PA, April 21, 1995.

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