

# Evaluation of Offset Prints on Recycled Carton Substrates

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***Abstract:** Paper and carton materials containing recycled fiber are economical and ecological to use in production. The recycled content of these materials is increasing with the emergence of novel technologies in paper industry. The competitiveness of the recycled material can be preserved by keeping quality measures, physical and optical properties in the range of consumer expectations. Printing of the substrates requires runnability and printability properties to keep up to industry standard values.*

*We used four types of folding cartons in our experiments, two of the substrates contained recycled material. Prints were produced on a 4 color sheet-fed offset press. Optical properties were determined using a CMYK test chart. The chart was printed in production, as part of a real print job. Along with the colorimetric properties physical properties were also determined, the physical properties were stronger indicators of the presence of recycled fibres in the substrate.*

***Keywords:** paperboard; recycling; offset print*

## 1 Introduction

In the 1940's, when older, idled, smaller capacity paper mills returned to service by processing secondary pulp, it was the beginning of the history of recycled boxboard. The otherwise inefficient mills produced low strength and low quality boxboard [1]. Paper and paperboard represent the largest portion of all packaging recovered for recycling. In comparison with 100% virgin board, paperboard with recycled content uses less wood, energy and water, reduces emissions of greenhouse gases and air and water pollutants, and cuts the amount of trash sent to incinerators and landfills. This industrial segment have experienced a reasonable growth over the past decades.

Multilayer coated boards have a wide range of application in packaging industry, in general it has higher creasing and folding performance than single ply. The top layer physical and optical properties are designed to improve whiteness,

smoothness and gloss for better printing quality, other layers support the structure and contribute to tensile properties. Chromo carton has a smooth coating on one side and with a light intermediate ply of wood pulp and a wood-free ply on one or both sides. Duplex carton is a multilayer carton with a gray intermediate ply, gray back and wood-free or almost wood-free coat on one side. In the case of triplex cartons layer structure is similar to duplex, with 2 additional layers on the back side (Figure 1).



Figure 1

Multi-layer carton layer structure: 1. - coated front 1.1 mechanical pulp 2. intermediate ply 3. mechanical pulp 3.1. back cover. The above structure holds for triplex cartons, for duplex only three layers (1-1.1-2) apply [2]

The aim of the study was to evaluate the properties of four different types of paperboard for a company that produces folding boxes for packaging industry using sheet fed offset presses.

## 2 Experimental

Two of the four substrates included in this study contained recycled material. The two glazed chromo (GC-2) paperboards were from two different manufacturers, the recycled substrates were a duplex (GD-2) and triplex (GT-2) type from the same manufacturer. The GC-2 boards have a pressure groundwood layer sandwiched between two layers of bleached chemical pulp, with a double pigment coating on top. Grammage of the traditional substrates was 290-295 g/m<sup>2</sup>, the recycled boards were heavier: 350 g/m<sup>2</sup>. A five unit offset press was used to make the test prints, a varnishing unit was added to the four process color units, to enhance the appearance of the prints with a glossy dispersion varnish. A series of measurements were performed to obtain mechanical and colorimetric properties of the four printed substrates.

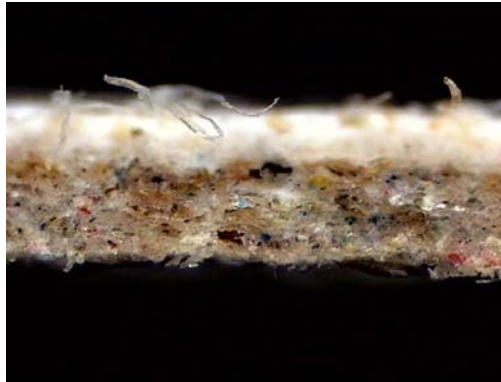


Figure 2

Microscopic view of substrate cross section: the recycled layer contains pigmented secondary fibers

## 2.1 Mechanical Properties

We performed mechanical measurements for the comparison of recycled and virgin fibre substrates [3]. Bending properties are important in the manufacturing of folding cartons. A Lorentzen & Wettre 2 point bending tester was used for measurement, 15° deflection was set. Bending stiffness was measured in machine direction, cross machine direction, to wire side and felt side. The printed packaging product is subject to surface wear. Therefore accelerated wear testing was performed, abrasion resistance was measured using a Prüfbau Quartant abrasion tester.

The Dennison wax test was used to characterize the substrates' pick resistance, or surface strength. The test consists of a set of calibrated, progressively adhesive wax sticks. The sticks are melted onto the surface of a paper sample and, after cooling, pulled quickly from the surface. The "strength number" is the highest-number wax stick that can be melted on and pulled from the paper without marring its surface. Paper thickness (caliper) was tested using a Lorentzen & Wettre micrometer; area of the specimen was 2cm<sup>2</sup>, the pressure applied was 98,06kPa.

For the evaluation of measured bending stiffness values of substrates with different grammage a relative stiffness value ( $S_{sp}$ ) was introduced:

$$S_{sp} = \frac{\text{stiffness}}{\text{grammage}} \left[ \frac{\text{mNm}}{\text{g}} \right] \quad (1)$$

## 2.2 Colorimetric Properties

Optical characterisation of the printed substrates focused on obtaining spectral data. Evaluation of the printable gamut is important in case of prints. A CMY test chart was printed on the substrates. Ideal inking parameters were adjusted for all four substrates using the same ink set in the offset press. Samples of the test chart were measured with a spectrophotometer. Based on the measured samples of the test chart an ICC device (printer) profiles were created. The profiles containing the interpolated measurement data were used as the input to Gamutvision, a software that is capable of visualizing the gamut and calculating the gamut volume in CIELAB units. Paper whiteness is also a crucial property regarding both the perceived visual quality of the substrate and the range of printable colors.

## 3 Results

### 3.1 Mechanical Properties

Measured relative bending stiffness values are summarized in table 1. As expected, the recycled substrates are weaker than the ones produced of virgin pulp (Table 1). The Dennison wax test was performed using a set containing 25 wax sticks, 15 minutes were allowed for cooling (Table 2). Paper thickness (caliper) measurement values were in good agreement with manufacturer data.

Abrasion resistance was found adequate for all four substrates, the density decrease was well below the threshold  $\Delta D=0,1$  after the 50 rub cycles specified for varnished offset prints.

Table 1

Relative bending stiffness values expressed in percentages of the best performing among the measured traditional (T1 and T2) and recycled (R1 and R2) boxboards in machine (MD) and cross machine directions (CMD)

	T1 290g/m <sup>2</sup>	T2 295 g/m <sup>2</sup>	R1 350 g/m <sup>2</sup>	R2 350g/m <sup>2</sup>
MD felt side	100%	90,23%	81,79%	78,30%
MD wire side	100%	96,16%	78,82%	76,10%
CMD felt side	100%	87,20%	49,46%	47,07%
CMD wire side	100%	84,81%	47,92%	47,46%

Table 2

Results of the wax test in case of the traditional (T1, T2) and recycled substrates (R1, R2)

	T1 295 g/m <sup>2</sup>	T2 290 g/ m <sup>2</sup>	R1 350 g/ m <sup>2</sup>	R2 350 g/ m <sup>2</sup>
strength number (felt side)	11	8	7	6
strength number (wire side)	18	16	7	6

### 3.2 Colorimetric Properties

Surface color properties were measured using an XRITE Eye One spectrophotometer. The unit applies 45/0 measurement geometry with ring illumination. In order to determine the printable gamut on the substrates with the offset press the i1 CMY 1.1 test chart with 323 uniform colour samples were placed outside the page area of a real print job. The test chart measurement provides a sampling of the maximum achievable color solid. The application software generates an ICC device profile based on the measurement data. The profile was used as input to the processing software which calculated the gamut volumes (Table 3). It is apparent that the substrates containing recycled material can reproduce a wider range of colors.

Table 3

Computed gamut in the CIELAB color of the traditional (T1, T2) and recycled (R1, R2) substrates. The values are given as percentages relative to the sRGB color solid.

sRGB gamut = 100%	T1	T2	R1	R2
Test chart gamut (%)	35,88%	34,62%	36,60%	36,48%

The human visual system can adapt to different chromaticities in case of white colors (this feature of our vision is modeled by “white balance” adjustment in digital cameras), color coordinates of the substrate may influence color reproduction significantly. Instead of using whiteness and tint formulas, the measured substrate color was compared to the white point of the CIELAB color space using the  $\Delta E^*_{ab}$  color difference formula (Table 4). The  $L^*$  values also indicate that the traditional substrates appear lighter to a normal observer.

Table 4

Measured CIELAB values of the traditional (T1, T2) and recycled (R1, R2) substrates. The last column indicates calculated color difference between the color space with the point and the sample.

	$L^*$	$a^*$	$b^*$	$\Delta E^*_{ab}$
T1	94,8	0,4	3,4	6,22
T2	96,2	0,2	4,2	5,70
R1	92,1	-0,2	2,6	8,34
R2	92,4	-0,2	1,7	7,81

Paper cost is an important factor for printing companies when evaluating different substrates. A price comparison was made based on available public pricelists (Table 5). For some compromise regarding the physical properties, the cost effectiveness of recycled paperboard makes it a profitable choice.

Table 5

Comparison of retail prices of the traditional chromo (T1, T2) and recycled (R1, R2) paperboards.

Values are given in percentage of the highest cost.

	T1	T2	R1	R2
Relative cost	100.00%	95.25%	57.68%	62.93%

**Conclusions**

Analysis of the results of the measurements have shown that the comparison of physical properties of multilayer paperboards reflect whether recycled pulp was used during manufacturing. Optical characteristics of the top coated layer allow for a larger gamut in case of the duplex and triplex boards, however with recycled substrates only lower lightness values are achievable.

**References**

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