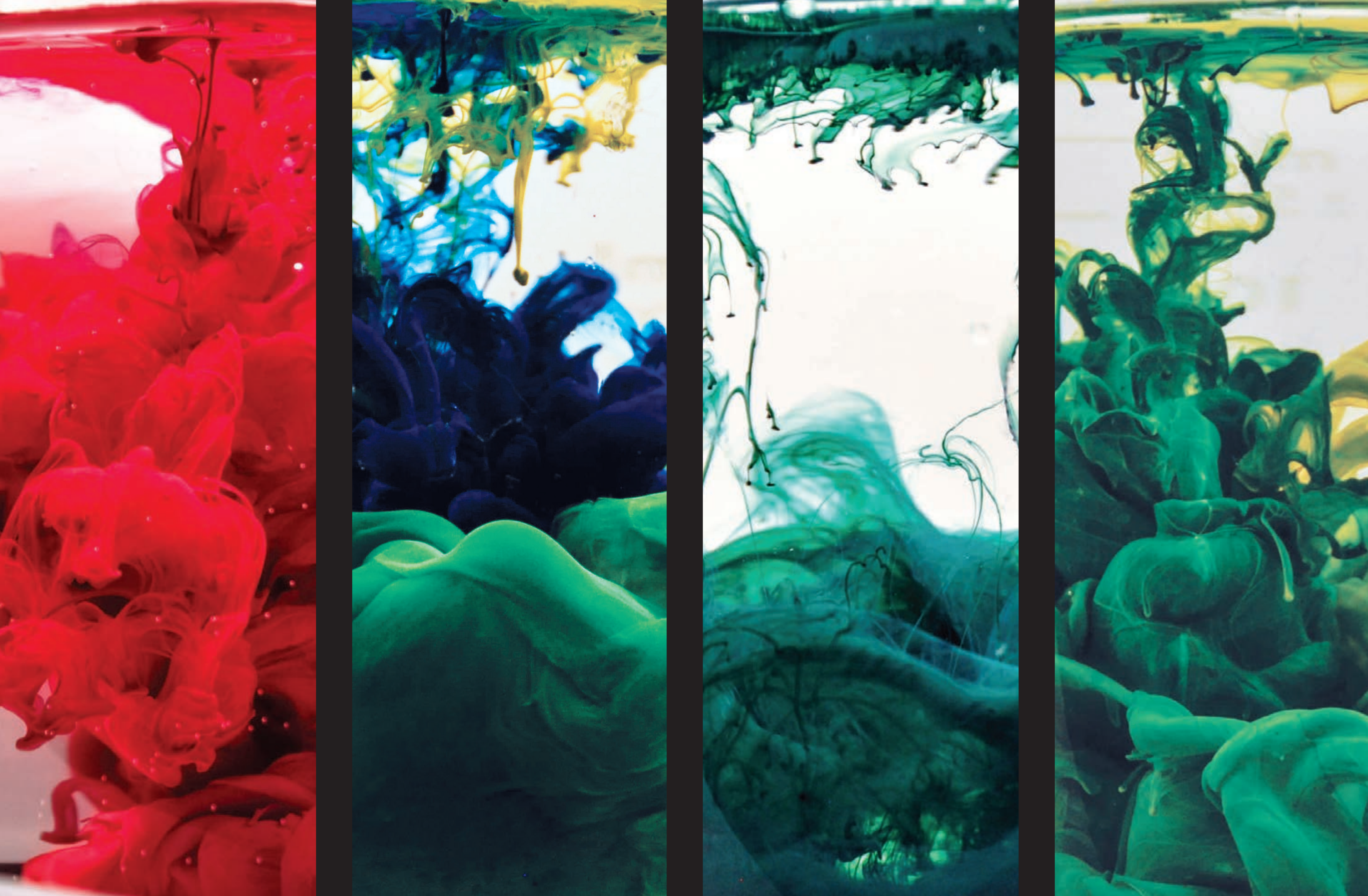
RYETAGA 2013



RYETAGA 2013

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A LETTER FROM THE FACULTY ADVISOR

DR. MARTIN HABEKOST

It is fun to see how the tension builds in the executive team as the deadline for the journal production gets closer and closer, and also the final preparations for the conference have to be done. I like the fact that the journal now contains more flexography related research carried out by students. This shows also that our school is moving strongly into this area and the recent donations of equipment and software to the school helps immensely.

This year we have an excellent executive team. From my point of view you all work together quite well. Our online presence is the most professional it has ever been.

Our fundraising efforts are going extremely well and many excellent ideas were put forward in this regard. The RyeTAGA calendar sold well. I like the fact that we had a “Platinum” edition.

This is now my 8th TAGA conference. I am looking forward to all the presentations and the social interaction that will happen between all the students that come to the conference. Take advantage of meeting leaders in research and industry and don’t be afraid to talk to them. You can establish connections that are invaluable to you in your future career.

Our journal looks great! I hope being on the west coast of the continent will lead to winning the cup, the grand prize.

Enjoy the conference and may the best journal win.

Martin Habekost, Dr. rer. nat.

RyeTAGA Faculty Advisor

THE PRESIDENTIAL ADDRESS

TRUNG NGUYEN
MARK BREJNIK

We are delighted to present the 2013 Ryerson University Student Chapter journal - our first journal with a strong relevance to flexographic printing. This year we bring 12 student representatives from Toronto, Canada to the 65th Annual Technical Conference in Portland, Oregon, USA. Upon conception of RyeTAGA in 2006, it has always been the goal to spread news about the talent of the student body at Ryerson's School of Graphic Communications Management. This journal is a tribute to the outstanding dedication and commitment to research of our students in these past 7 years.

All efforts put into the successful completion and delivery of this journal have been an immensely valuable and constructive learning experience for the entire team and student body. Your first impression is the manual debossing of matte black hard covers and artfully designed pages. Your second impression, carefully executed research and writing. Third, binding with a bright accent of color which brings together this journal, unrefined yet sophisticated, traditional yet avant garde.

We would like to thank our executive team and general member, our sponsors, the generous donations from the School of Graphic Communications Management, and the funding from the Project Funding Allocation Committee for Students (P-FACS). We could not have achieved our success without the help of Martin Habekost, faculty advisor, and Peter Roehrig.

We hope this journal enhances the learning experience and creates a greater understanding and connection between students and industry.

Trung Nguyen and Mark Brejnik

RyeTAGA Co-Presidents

PROOF-A-COLA

THE IMPORTANCE OF COLOUR ACCURACY FOR BRANDING ON DIFFERENT SUBSTRATES

SAMAR ALBAZZ

LINDA CHAU

COZETTE NGUYEN

JORDAN VAN OS

SCOPE

The following test investigates how colour is affected by common substrates used in packaging applications for purposes of brand colour consistency and management. Using the GretagMacbeth Color-Eye 2145 Spectrophotometer and GretagMacbeth ProPalette 5.2 computer program, colour consistency will be measured and evaluated between Canadian and American Coca-Cola package samples, as well as printed samples using similar substrates and PMS 186 C.

The purpose of this test is to assess packaging considerations for producing a consistent brand colour on multiple substrates. Substrates such as film and aluminum are different from the standard paper and paperboard products, which may affect the appearance of colour. Through testing we can deduct which substrates are the most difficult and which are the most accurate when reproducing colour. The test results will be evaluated for consistency, as well as compared to real world examples to deduct colour reproduction accuracy on varying substrates.

ABSTRACT

The execution of this test demonstrated the consistency of brand colour accuracy in Coca-Cola products printed on various substrates from Canada and the United States. Comparing the Coke samples to the United States and Canada, the iconic "Coke Red" looks visually consistent. However, when measuring the colour with the spectrophotometer, there were various ranges in the ΔE values. Similar results were gathered in the second stage of the test where flexographic ink was used to mix PMS 186 C, the PMS colour closest to “Coke Red,” and proofed on substrates closely matching those collected from the Coke samples. Our test lead us to the conclusion that the substrate on which an ink is printed has an important effect on the appearance of the colour. Since the appearance of a colour is dependent on its spectral reflectance, it is important that printers pay special attention when creating printed items such as plastic labels, printed paperboard, or aluminum cans since the colour of the substrate underneath can alter the results. In most cases, we found that colour accuracy can only be achieved if a white lining is used to prevent the colour of the substrate from interfering with the colour’s reflectance. Testing Coca-Cola products, we expected to find that the ΔE would be very small for items printed on similar substrates, despite their geographical differences. Here, we were not disappointed with our results. They showed that the ΔE value differences between the different country’s samples were less than 2 in most cases, meaning that they were able to maintain the colour accuracy on which Coke’s branding relies.

INTRODUCTION

In today's competitive market, branding is a fundamental method for any company's image to stand out from its competitors. Branding is a concept of consistent marketing and promotion, through the company's products, advertisements, and presence. Either through complex or simplistic packaging, branding is present on a diverse range of packaging as it plays a pivotal role in sustaining top-of-mind positioning.

Coke, the subject of our research project, is one of the most renowned brands in the world, relying heavily on its infamous red colour to be recognized amongst numerous competitors. From boxes to bottles to cans, "Coke Red" is always consistent as Coca-Cola invests millions of dollars to build and sustain their brand. To this point, inconsistency can be very costly for the company, both financially and in the marketplace.

Colour reproduction and management can be a difficult process, especially for packaging applications where multiple variables are present that may impact the final product. As Laurel Brunner (2012) of Output Magazine stated: "For printers of signs and displays, matching colours from print run to print run is an important part of their value added services. It's hard enough to manage colour, but ensuring that colours match to a specific brand formula is about more than adequate systems to ensure colour data accuracy".

The following test examines the effect that the substrate has on the final outcome and reproduction of a brand colour in packaging applications. Specific characteristics of the substrates, such as its colour or finish, must be considered when producing the colour and when printing it. Since the packaging industry is so diverse, using several types of substrates, colour management is vital to maintaining brand consistency.

TESTING PRINCIPLES

The GretagMacbeth Color-Eye 2145 Spectrophotometer and GretagMacbeth ProPalette 5.2 computer program measure the ink film colour on a substrate by measuring the amount of light reflected at different visible wavelengths. These wavelengths of the visible colour spectrum are represented as a spectral curve from which L*a*b* values can be derived (Adams, Sharma & Suffoletto, 2008). These values are used by the program to compare colours from different samples against the initial standard using the ΔE formula. By measuring the L*a*b* values and ΔE difference on printed Coca-Cola products, we were able to determine the deviation and the colour accuracy present in various products printed for the same brand.

Using spectrophotometry is a valid way to test colour differences because it measures the actual colour reflectance. As flexography is often used in packaging (Adams et al., 2008), we mixed flexographic inks to create the PMS 186 C colour and used the anilox hand proofer to simulate the flexographic printing process on our various substrate samples. With this process we were able to observe the performance of flexographic ink on the different substrates and determine how the printed colour compared on each sample.

Other methods of measuring colour include using a densitometer or visually comparing samples with our eyes. However, these methods are inappropriate to use for colour accuracy since densitometers only measure density, or the lightness and darkness of a colour by the amount of light being reflected, not the hue, and are used mainly for process inks (Adams et al., 2008). Using our eyes to measure colour difference is much too subjective and will not be as accurate as a spectrophotometer.

MATERIALS TESTED

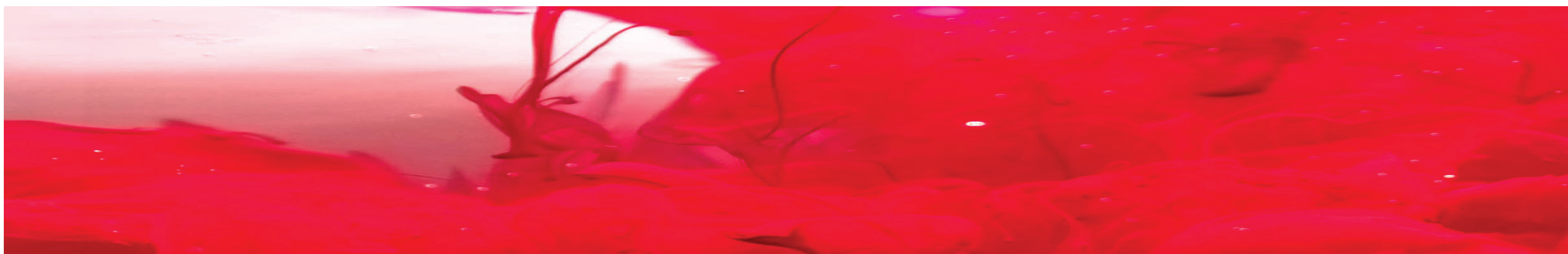
- PMS 186 C
- Wikoff Color Corporation Pantone Warm Red 73.9%
- Wikoff Color Corporation Pantone Rubine Red 24.6%
- PS+PRO Black FR 1.5%
- Self Adhesive Clear Gloss Film for Inkjet 706
- Aluminum Foil: MercArt USA Fine Crafts Materials
- Coated Paperboard

EQUATIONS

$$\Delta L^* = L^*\text{ Sample} - L^*\text{ Standard}$$
$$\Delta a^* = a^*\text{ Sample} - a^*\text{ Standard}$$
$$\Delta b^* = b^*\text{ Sample} - b^*\text{ Standard}$$
$$\Delta E^* = \sqrt{(\Delta L^2 + \Delta a^2 + \Delta b^2)}$$

EQUIPMENT USED

- Beakers
- Exacto knife
- Ink knives
- Stopwatch
- Water
- GretagMacbeth Color-Eye 2145 Spectrophotometer
- GretagMacbeth ProPalette 5.2 computer program
- Productolith Gloss 20X29 122M Offset
  - o Basis Weight: 100 lbs
  - o Grammage: 148 g/m^2
- Colmar Inks Pantone Formula Guide: Solid Coated
- Sheen #2 Zahn cup
- Little Joe Anilox hand proofer



PROCEDURES

PART 1: MEASURING GATHERED SAMPLES

Obtain 6 samples of Coke brand merchandise, 3 from Canada and 3 matching ones from the United States, printed on varying types of substrates.

- Coated paperboard
- Aluminum can
- Plastic film

PART 2: MIXING AND PRINTING SAMPLES OF A PANTONE COLOUR INK

1. Obtain unprinted substrates similar to those tested in Part 1.
2. Using the Pantone Formula Guide, mix 150 mL of the colour PMS 186 C using the available flexo inks.
3. Use a Zahn cup to check the viscosity, adding 5 mL of water to achieve a viscosity of 25 seconds.
4. Using the Little Joe Anilox hand proofer, test the ink on the chosen substrates.
5. All the samples to dry overnight.

PART 3: MEASURING AND COMPARING SAMPLES

1. Cut printed samples to an appropriate size to fit the GretagMacbeth Color-Eye 2145 Spectrophotometer
2. Use the GretagMacbeth Color-Eye 2145 Spectrophotometer along with the GretagMacbeth ProPalette 5.2 computer program to measure the colour of the first sample and record the results. Remember, the first sample measured will become the standard to which all other samples are compared. When measuring plastic film samples, place a sheet of Productolith Gloss paper behind the sample as a way of countering the transparent nature of the film.
3. Compare the following:
    - All Canadian samples against Canadian paperboard sample as standard
    - All U.S. samples against U.S. paperboard sample as standard
    - All printed samples against PMS 186 C from the Pantone Formula Guide

- All paperboard samples against Canadian paperboard as standard
- All aluminum samples against Canadian aluminum as standard

4. All plastic film samples against Canadian plastic film sample as standard Calculate the ΔE difference and compare the results

RESULTS & DISCUSSION

Colour accuracy is an intrinsic factor in the printing process, with specific stress on the reproduction of brand colours across a variety of different media. “Colour management is about recognizing and adopting an achievable objective through process control, monitoring the colour and adapting it to the predetermined target on an ongoing basis” (Fowler, 2007). Packaging materials create a unique problem, as the substrates used are inconsistent in essential colour management properties, especially their whiteness.

The samples were measured using a GretagMacbeth Color-Eye 2145 Spectrophotometer. Spectrophotometers work by emitting full spectrum light onto the sample where “some of the spectrum is absorbed by the sample [with] the remaining light exiting [and] striking the photodetector” (Dondelinger, 2011), with a D50 bulb acting as the light source and the photodetector as our eye. In our specific case, the colour that we measured (Coke Red or PMS 186 C) absorbed most of the spectral colours that make up the white light reflecting only the red portions back into the photodetector (Sabic, 2011). Our sample readings correspond with this, as the charts show the light spectrum spiking in the 625-740 nanometer range in which red is visible (Jones, 2012).

The method in which the spectrophotometer gathers data presents problems with the non-paper substrates used by Coca-Cola, specifically the plastic labels and aluminum cans. The information that the photodetector collects from the reflected wavelengths of light is converted to L*a*b* values. The L*, or lightness of the sample, ranges between 0 and 100, with 0 being black and 100 representing a perfect reflecting diffuser (HunterLab, 2008). "The perfect reflecting diffuser is completely matte and is entirely free from any gloss or sheen" (Hunt & Pointer, 2011). Thus, the high gloss plastic label and the reflective aluminum surface (which is completely absent of white) will inherently produce lower measurements in these areas.

Before considering the samples that we produced, we must first analyze the results of the collected pieces. There are two results to consider: The ΔE differences between different products from the same region, and the ΔE differences between products of the same substrate from different geographic regions.

We see a substantial difference between the three different substrates that we measured. Though visually they look very similar, when tested on the spectrophotometer they produce very different results. This is likely caused by the measurement system itself, as the spectrophotometer relies on reflected light to give it its information. Because aluminum does not have a white base like the plastic and paperboard, the spectrophotometer measures a much lower lightness in both the Canadian and U.S. samples. Without this consideration, the information conveys that the difference in colour between the aluminum cans and the paperboard is vastly different, and would be visually identified as a different colour entirely.

Plastic also faces possible inconsistency in measurement due to its high gloss, which also is a factor in lowering a sample's L* reading. It also may face inconsistency due to mounting it on a sheet of Productolith Gloss paper. Since the plastic labels are not fully opaque, we backed them with a white paper to ensure consistency. However, on a bottle, they would be backed with the dark syrup colour of cola, which the printers likely considered in process.

In analyzing Table 2, we can further conclude that the measurement system is likely the cause of the differences. While the numbers are way off from being a ΔE similar from one substrate to another, they are very similar on a region-to-region basis, with paperboard as an outlier. The similarity between regions means that this colour difference is either intentional, with the printing process calculating for the influence that light reflectance will have on the colour, or that the spectrophotometer

Table 1 ΔE difference between different substrates from the same region

	Aluminium	Paperboard	Plastic
Canada	31.57 ΔE	0.20 ΔE	4.91 ΔE
US	34.81 ΔE	0.10 ΔE	6.20 ΔE

Table 2 ΔE difference between the same substrates from the same region

	Aluminium	Paperboard	Plastic
Canada	0.76 ΔE	0.09 ΔE	0.82 ΔE
US	1.43 ΔE	9.39 ΔE	3.99 ΔE
ΔE	0.67 ΔE	9.30 ΔE	3.27 ΔE

Note: The spectrophotometer measures the samples under three light sources: the North American standard D50 lighting, incandescent illuminant A, and cool white fluorescence (CWF_2). For the purposes of our test we will preserve the North American standard and only look at the results produced by this light source!

Table 3 ΔE results for printed samples compared to PMS186 in the Pantone Formula Guide

	Aluminium	Paperboard	Plastic
Samples	38.54 ΔE	3.72 ΔE	18.35 ΔE

is not the proper instrument for measuring colour accuracy between disparate substrates. The difference in the paperboard measurements could be due to the effects of lightfastness, rub resistance, or poor process control; however, without a wider base of measurement we cannot conclude this with certainty.

Table 3 introduces our results. It is difficult to directly compare it to the industry samples because we did not proof with the exact same colour formula with which "Coke Red" is produced. It must also be considered that these results were not compared with the paperboard as the standard, but the PMS colour that we were hoping to achieve (PMS 186 C). However, what we can see is that our samples present some similarities to the results from Canada and the U.S. when looking at the ΔE differences.

The most distinct similarity is between the E of the paperboard and aluminum samples. Our results exhibit a 34.821 ΔE difference between these variables, where the U.S. presents a 34.712 ΔE, and Canada a 31.367 ΔE. This clear similarity leads us to conclude that there is limited colour adjustment made when printing on an aluminum substrate, as we were able to produce a similar difference without manipulating the colour formula. This could also be misleading, as we know that the measurement process is imperfect when dealing with the sheen of metal substrates.

Where we found a stark difference was in the plastic sample. We predicted that this would present the most skewed result, as we could not find a plastic film that was an exact match to the samples collected from Canada and the U.S.. The industry samples also had a white coat either printed or adhered underneath them, likely in order to improve the colour and opaqueness of the label. Our ΔE when compared to industry samples is around 4x higher, which means where their process was within acceptable tolerances, ours was not.

Although the paperboard sample had the smallest ΔE compared to aluminum and plastic, its results may be due to it being a white substrate. Because the paperboard was already white, the red appeared brighter and more accurate than the aluminum and plastic samples. If the paperboard were brown, like the inside of the Coke boxes, the red would not have appeared the way it did.

PRINTABILITY

INKS

In order to achieve accurate colour reproductions on varying substrates, the ink used requires some form of adjustment in order to fit its end use. Since flexographic inks may produce transparent films when printed, using them on substrates with varying colours can affect the way the colour is viewed. Ink suppliers provide printers with inks made up of strong colours. Specific pigments, concentrations, and ink film thicknesses are necessary when printing flexo, since the durability and ultimate success of the product being printed is dependent on the ink being used (Kular, 2011a). This is especially important when printing packages. Since the package acts as a form of marketing when placed on a shelf amongst a wide range of competitors, having a flawless print can make the difference between an item that is sold successfully and one that fails to intrigue the consumer.

When it comes to mixing the correct colour ink, it is important to consider the pigments being used. Ink pigments do not dissolve when mixed together in a vehicle. Instead, they intersperse within it (Kular, 2011a). This, as we noticed when mixing our PMS 186 C ink, can lead to patches of different colours if not mixed properly. Failing to notice this patchiness can again lead to an unattractive print on a package. Using different brands of inks to create a new colour can also lead to some printability issues. Different inks have different mileages and different fade resistances. If one of the pigments used fades away faster than the others, the colour of the product can change in appearance over time. Having a patchy print can lead the customer to believe that the product within the package is in some way imperfect as well. This, in turn, can lead them away from a sale.

SUBSTRATES

Printing on different kinds of substrates can result in different versions of the same ink due to the colour of the substrate which it is printed. The plastic film used by Coke is a combination of a transparent, printed film like the sample tested, and another, white film adhered to the back. This backing is important as it acts as a way of maintaining the brand colour despite the beverage's dark influence as it appears through the clear, plastic bottle. When measuring our own samples, we replicated this by placing a coated white piece of paper at the back of our plastic film samples to try and achieve a similar reflectance curve.

Using water-based inks can help combat the colour disparity existing between different substrates. Water-based inks are made with more pigment than water content so that drying time will be shortened (Kular, 2011a). Having more pigment can result in a more opaque colour finish, therefore eliminating the need for a white backing or undercoat on substrates such as aluminum cans. Substrates such as paperboard, on the other hand, require a bleached linerboard for better colour reproduction, since the interior of the board was made up of darker plies. Printing directly onto the paperboard will dramatically alter the colour of the ink, especially since the ink will be absorbed by the uncoated fibres, resulting in an unattractive, dull brown shade.

END-USE APPLICATIONS

Following the three purposes of packaging, Coke uses cans and paperboard boxes as a way of protecting the drink within while simplifying its transportation, and plastic labels as a way of conveying information on their clear, plastic bottles. Colour is an extremely important factor for all forms of printing, but especially pertinent for packaging applications and branding. “The bright, vivid colours in packaging are designed to capture the customers' attention...[creating] brand recognition and hence brand loyalty” (Sharma, 2006). The influence that colour has on a customer means that special attention must be paid to developing accurate colour on all products. Packaging is met with a unique problem, as unlike other printing it is possible for a single product to require multiple packaging substrates.

Achieving colour accuracy despite the different substrates used is crucial when it comes to trying to sell a product. This is especially true for a consumable product, such as Coke. Having a defect in the print, such as a box that is too dark a red or too orange a red, can confuse the customer, possibly leading them to think that since the package is defective, the contents must be defective as well. Coke, being the most recognized brand in the world (Interbrand, 2012), must maintain a consistent look in order to remain recognizable. This consistency must remain true on all of their packaging, even drink carriers where the foremost concern is durability. Creating a printed package that sustains both of these requirements is essential. For example, the colour must remain stationary on the can or label despite the use of the can. If water-soluble flexographic inks are used to print the can, these must dry to become water- insoluble in order to resist spills and saliva.

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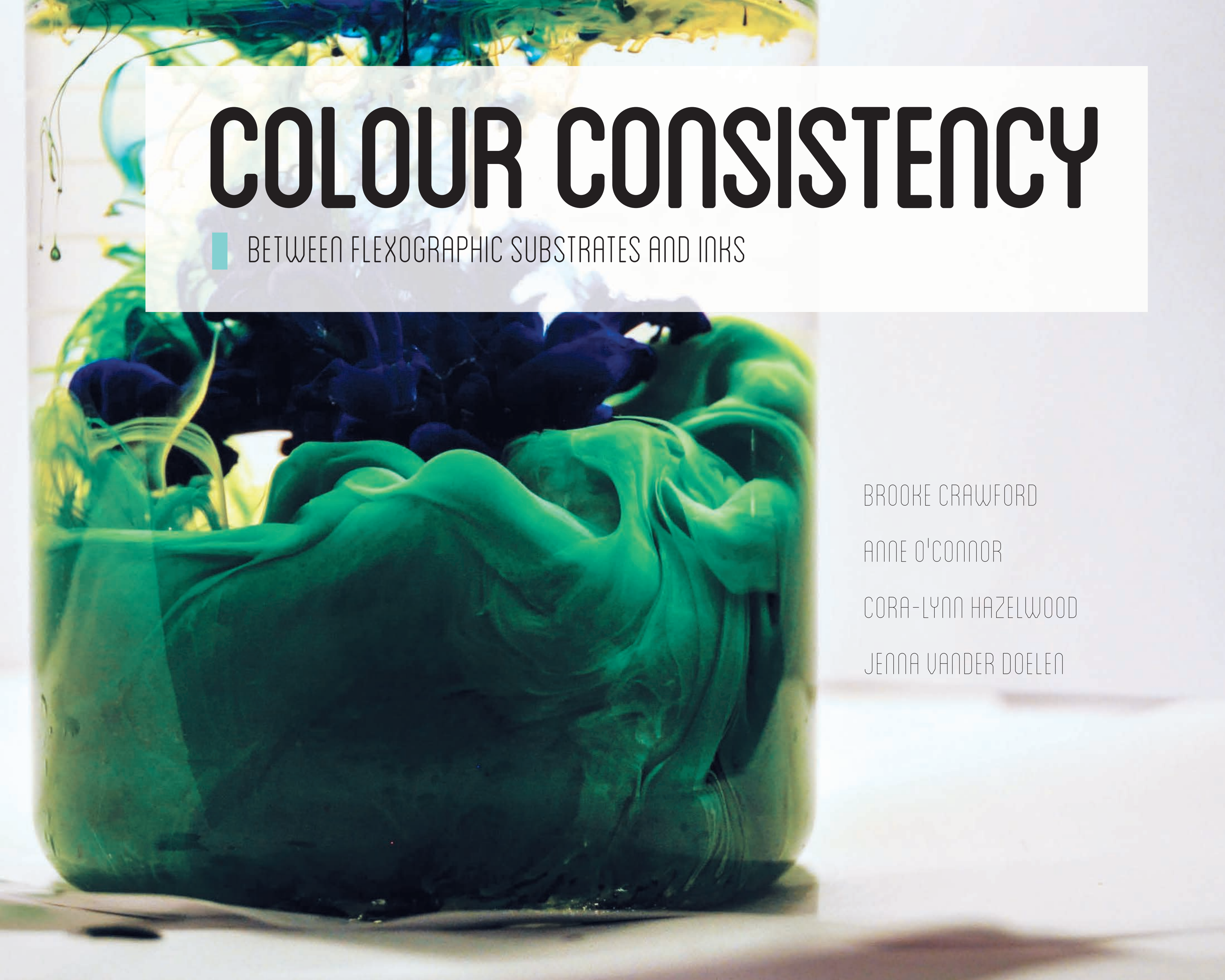


COLOUR CONSISTENCY

BETWEEN FLEXOGRAPHIC SUBSTRATES AND INKS

BROOKE CRAWFORD

ANNE O'CONNOR

CORA-LYNN HAZELWOOD

JENNA VANDER DOELEN

SCOPE

Brand awareness is a crucial part of allowing one's company to be identified amongst the competition. Derrick Daye (2011) of the Branding Strategy Insider states that, "The appropriate use of colour can increase brand recognition by some 80%, while also serving as an important brand identifier"(p.1). For example, Coca Cola uses brand recognition through a variety of different marketing materials such as the metal cans the soda is held in, the paperboard packaging, the plastic labels that wrap around their bottles, or in-store displays, just to name a few. It is imperative that all colours used to identify the company or products are consistent on all printed materials from brochures to product labels. However, not all substrates reproduce colour the same way. Likewise, the method used to achieve proper colour varies depending on the substrate being used. This test will determine the ways in which the printing industry maintains colour consistency across a wide variety of unique substrates in-terms of colour consistency.

ABSTRACT

Each of the substrates tested contained their own unique properties, and therefore, we found that they each had recommendations specific to them. There is no universal method or ink that consistently yields the best results for managing colour on press across different substrates. Therefore, it is extremely important to ensure that the right inks and printing methods are used, dependent on the substrate. The printing methods used to achieve proper colour, regardless of substrate, had their own recommendations as well. This is because each technique affected how the job is run through the press and therefore affected runnability in terms of cost, speed, and time. Though we tested several methods across five various substrates as well as three different colours of inks, our results found that with our chosen techniques, our samples yielded a 1:14 ratio of acceptable to unacceptable ΔE measurements. These were results that we had not anticipated, but learned from.

INTRODUCTION

Our "Colour Consistency Between Flexographic Substrates and Ink" instrumentation determines the best solution for achieving consistent colour and accuracy when printing with different substrates and inks in a flexographic environment. Larry Moore (2011), Director of Software Services at EskoArtwork states, "Flexography continues to be the production process of choice for packaging applications and presents a specific set of challenges, most notably the variety and complexity of substrates – as well as special brand colours" (p. 8). With flexography growing as large as it has, it is important that colour remains consistent and its colour results predicted before the final print.

According to Field (2004), "The ink and substrate are the printed product; however, it is possible to select a single set of inks and a substrate that will produce the highest quality results for all circumstances" (p.121). This test works to determine the substrate and ink factors that will create this ideal circumstance. Potential substrate factors that could influence our colour results are whiteness, brightness, and absorbency. Potential ink factors that could influence our colour results are transparency, pigment concentration and gloss. Through the use of three different flexographic inks and five different substrates, we will use three techniques to help improve the consistency and accuracy of the printed colours. The three techniques we will be using are an initial white printed film, a double drawdown of the ink and introducing a colour enhancer to the inks.

DEFINITIONS

Absorption: Soaking in or penetration of liquid components of the ink into the pores of an absorbent substrate (a type of physical drying, like evaporation) (Kipphan, 2001, p. 1115)

Brightness: The total reflectance of light from a substrate (Field, 2004, p. 98).

CIELAB Color Space: Device-independent colour space in which the CIE colour values Y, x, y have been converted into uniform chromaticity scale values L*, a*, b*. Where, L* represents lightness, a* is the red-green proportion, and b* is the yellow-blue portion (Kipphan, 2001, p. 1116).

ΔE: A Measure of overall colour difference between two samples. The different is expressed in MacAdam, NBS, or other units. Normally written as DE or E (Field, 2004, p. 346).

Density: An ink layer's imperviousness to light. Mathematically the logarithm of opacity in order to simulate the sensitivity of human seeing (Kipphan, 2001, p. 1117).

Whiteness: The absence of colour cast, or the ability to reflect equal amounts of red, green and blue light of a substrate (Field, 2004, p. 98)

TESTING PRINCIPLES

Through the completion of this test, we gained much information that gave us a valid means for managing consistency across multiple substrates. The test was completed by performing initial drawdowns for each of the ink colours on all five substrates. Secondly, thirdly and quarterly drawdowns were then completed with one of the three applied techniques to see if this improved the colour consistency and accuracy. By doing the physical drawdowns of the different inks as well as the applied technique we were able to do a side-by-side comparison of how the inks printed on the different substrates. This was the first and simplest way to look at all the different methods and determine which one produced the best result. Upon completion of the all of the printed samples, L*a*b* and density measurements were taken to achieve a more in-depth look at the colour difference between each technique and the standard printed swatch in the Pantone book. With the L*a*b* values, we calculated the ΔE values between the drawdowns and the Pantone book swatch. This showed us how close each printing technique was to the standard colour and whether or not the method produced a colour that was within acceptable printing ranges. Finally, with the density values of the ink, we determined the relationship the ink film thickness had with the colour results and whether the results were within the standard tolerances, as well as, how much ink the printing method required. This information was useful for runability and cost issues.

The drawdown blade worked by applying a predetermined amount of ink, in our case approximately 0.5 mL, onto the sample substrate and then hung up to dry. The samples were then used to determine the density and the L*a*b* values of the printed ink film using a densitometer and spectrophotometer.

The test was done in this method to remove any outside variables that could affect how the ink was printed onto the substrate. This included variables such as plate pressure and press speed. By removing these variables we were able to see how the ink and substrate interacted. This test could have also been conducted on a press or machine that simulates flexographic printing such as a perfect proofer. However, this method would increase cost, time and energy, especially to makeready the press each time for the different substrates, inks and printing methods. Another constraint that would have occurred if working with the perfect proofer is that certain materials (such as the cardboard, plastic and foil) poses a problem in actually working in compliance with the machine due to their structure and size.

MATERIALS TESTED

SUBSTRATES

- Earnscliffe Linen Bond (24lbs,122M, 90 g/m^2)
- Strathmore Bristol Smooth Surface (123 lb, 120M, 270 g/m^2)
- Single Wall Kraft Corrugated Board (35 lb. flute height 3/16”)
- Foil (9.5” Roll)
- White Heavy Grade Hexene Resin Plastic (0.9mm)

INKS & ENHANCERS

- WikoffColor HSHG NLF Pantone Running Reflex Blue
- KM-FX-1804 Pantone 804 Orange: G275
- WikioffColor HSHG NLF Pantone Rubine
- Environmental Inks and Coating PSPX3700 PS + Opaque White FR
- WikioffColor MWF-0128 Color Enhancer

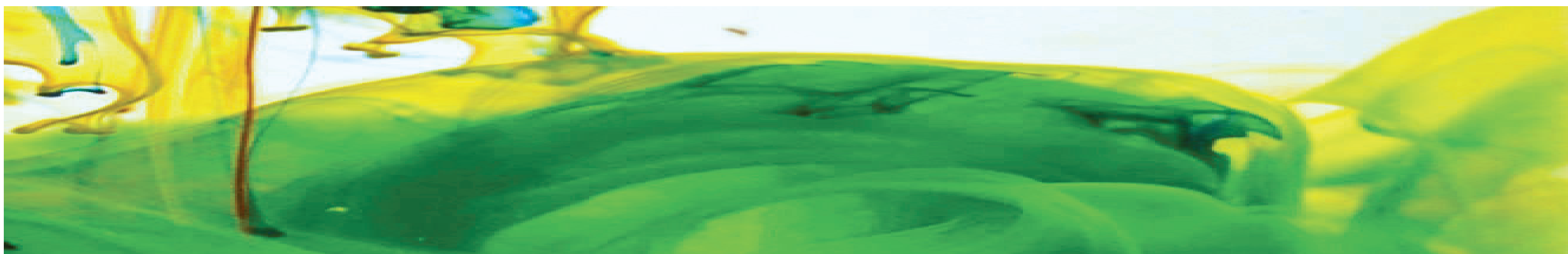
EQUIPMENT USED

- Draw Down Blade
- Glass Stir Stick
- Small Beaker
- X-Rite Spectrophotometer (ISOO Series) 011828
- IHARA R710 Densitometer
- Uncoated Pantone Book

EQUATIONS

CIE76 EQUATION:

$$\Delta E = \sqrt{(L_2 - L_1)^2 + (a_2 - a_1)^2 + (b_2 - b_1)^2}$$



PROCEDURES

INITIAL DRAWDOWNS

1. Gather all materials and equipment necessary.
2. Cut 15 samples each approximately 5.5″ x 8″ of corrugated board, plastic and foil. For the materials that are already sheeted (Earnscliffe linen bond and the paperboard) leave as they are. There should be 75 substrate samples total.
3. Begin with the Fluorescent Orange (Pantone 804).
4. Complete 5 drawdowns for the first substrate, using approximately 0.5mL of ink, once complete hang to dry.
5. Repeat step 4 for the remaining four substrates. Upon completion there will be 25 drawdowns completed.
6. Repeat steps 4 and 5 for Running Reflex Blue and Rubine Red. Upon completion of all of the drawdowns there will be a total of 75 printed samples.

TECHNIQUE 1: WHITE FILM DRAWDOWNS

1. Cut nine samples each approximately 5.5″ x 8″ of corrugated board, plastic and foil. For the materials that are already sheeted (Earnscliffe linen bond and the paperboard) leave as they are. There should be 45 substrate samples total.
2. Label each sample “white down”.
3. Using the Opaque White ink, complete the white film drawdowns using approximately 0.5 mL of ink on all 45 substrate samples.
4. Hang the samples and let the white films dry.
5. Once dry gather all of the white film samples.
6. Begin with the Fluorescent Orange (Pantone 804).
7. Complete 3 drawdowns for the first substrate, using approximately 0.5 mL of ink and printing directly overtop of the white film, once complete hang to dry.
8. Repeat step 13 for the remaining four substrates. Upon completion there will be 15 drawdowns completed.
9. Repeat steps 7 and 8 for Running Reflex Blue and Rubine Red. Upon completion of all of the drawdowns there will be a total of 45 printed samples.

TECHNIQUE 2: DOUBLE DRAWDOWNS

1. Cut nine samples each approximately 5.5″ x 8″ of corrugated board, plastic and foil. For the materials that are already sheeted (Earnscliffe linen bond and

the paperboard) leave as they are. There should be 45 substrate samples total.

2. Label each sample "double down"
3. Begin with the Fluorescent Orange (Pantone 804).
4. Complete 3 drawdowns for the first substrate, using approximately 0.5 mL of ink, once complete hang to dry.
5. Repeat step 4 for the remaining four substrates. Upon completion there will be 15 drawdowns completed
6. Repeat steps 4 and 5 for Running Reflex Blue and Rubine Red. Upon completion of all of the drawdowns there will be a total of 45 printed samples.
7. Hang all samples and let the "double downs" dry.
8. Once dry gather all of the "double down" samples.
9. Begin with the Fluorescent Orange (Pantone 804).
10. Complete 3 drawdowns for the first substrate, using approximately 0.5 mL of ink and printing directly overtop of the preexisting ink film, once complete hang to dry.
11. Repeat step 10 for the remaining four substrates. Upon completion there will be 15 drawdowns completed.
12. Repeat steps 10 and 11 for Running Reflex Blue and Rubine Red. Upon completion of all of the drawdowns there will be a total of 45 printed samples. Cut nine samples each approximately 5.5" x 8" of corrugated board, plastic and foil. For the materials that are already sheeted (Earnscliffe linen bond and the paperboard) leave as they are. There should be 45 substrate samples total.
13. Label each sample "colour enhancer".

TECHNIQUE 3: COLOUR ENHANCER DRAWDOWNS

1. Fill small beaker with 2 mL of Color Enhancer.
2. Add 18 ml of Fluorescent Orange (Pantone 804).
3. Using this ink mixture, complete 3 drawdowns for the first substrate, using approximately 0.5 ml of ink, once complete hang to dry.
4. Repeat step 3 for the remaining four substrates. Upon completion there will be 15 drawdowns completed.
5. Repeat steps 3 and 4 for Running Reflex Blue and Rubine Red. Upon completion of all of the drawdowns there will be a total of 45 printed samples.

MEASURING LAB & DENSITY VALUES

6. Gather all dried samples and separate them into their colour, substrate and technique.
7. Calibrate the spectrophotometer to the white point based of the machine.
8. Using the spectrophotometer, measure and record the L*a*b* values of each sample and the three colour swatches from the Uncoated Pantone Book.
9. For transparent substrates, such as plastic, place a plain white piece of paper underneath the substrate.
10. For samples that have a very light or inconsistent ink coverage, choose the medium to darker and more consistent area for measurement.
11. Repeat steps 37-39 using the densitometer.

RESULTS & DISCUSSION

PANTONE 804 FLUORESCENT

The L*a*b* values of the Pantone 804 fluorescent orange ink were very difficult to match. This difficulty meant that our tested values were relatively high compared to the standard of that referenced from the Pantone book. The average ΔE of one single drawdown on Earnscliffe linen bond paper was considerably higher than expected at an unacceptable value of 16.17. When a second drawdown of the same Pantone 804 fluorescent ink was added on top of the existing sample, the ΔE measurement jumped nearly 1.5 times that of the original single drawdown. Our lowest ΔE result with the fluorescent ink on Earnscliffe linen bond paper was derived from the addition of color enhancer to the ink itself before its application to the substrate. With this added step, we were able to achieve our best possible measurement of 12.61. From these findings we can determine that on matte pulp-based paper, adding color enhancer to the ink itself, while still at unacceptable differences, produces the best results. These results can be explained partly by the optical properties of the substrate itself. Earnscliffe linen bond contains the highest whiteness levels when both measured and visually compared to our other four substrates.

As well, when the bond paper is compared to our other two pulp-based substrates, it has the lowest absorptivity rating of paperboard, corrugated board and Earnscliffe linen bond. This meant that our drawdowns were left mostly on the surface of the substrate, keeping the brightness of the reproduced colour high.

When printing fluorescent ink on a paperboard substrate, our highest ΔE difference came from completing two drawdowns of the Pantone 804 fluorescent orange ink on the same paperboard sample. This resulted in a ΔE measurement of 19.23, which ruled out printing multiple ink layers as a beneficial way to maintain colour consistency. Once again, similarly to our Earnscliffe linen bond results, our best result on paperboard came from the addition of color enhancer to the fluorescent ink. The addition produced a ΔE of 3.18, which is considered to be a good match for most printing applications (Serwin, 2012).

We determined that color consistency of fluorescent ink is the most complicated to maintain on corrugated board. With all of our different testing methods of maintaining colour accuracy on different substrates, corrugated board produced the highest

ΔE measurements for fluorescent ink with all measured values being in the mid to high twenties range and our lowest reading averaging out to 23.00 with the use of the single drawdown technique. The most obvious reason for these extreme values is due to the brown-grey colour cast of the corrugated board. This cast produces much darker colours than expected once on press, making colour accuracy is particularly difficult. As well, the hills and valleys created by the structure of the corrugated board added extra difficulty in ensuring even coverage when applying the drawdowns of ink. These valleys created wells for the ink to settle into and the hills created peaks that were left with less ink coverage and therefore lighter and less dense areas of ink.

Upon testing the fluorescent ink on plastic substrate, it became clear through the ΔE values that the best way to print Pantone 804 fluorescent ink onto a plastic substrate is to first lay a drawdown layer of opaque white ink. This is apparent as our ΔE values for all other techniques range from 17.56 for a single drawdown to 23.74 for a double drawdown. However, when the white ink film was added prior to our fluorescent drawdown, we achieved a very acceptable ΔE of 1.87, which represents a difference not recognizable to the human eye when comparing our samples visually to the standard of the Pantone book (Serwin, 2012).

Table 1 Pantone 804 Fluorescent ΔE Summary

Substrate	Lowest ΔE	Highest ΔE
Earnscliffe Linen Bond	26.21 Single Drawdown	33.99 Double Drawdown
Paperboard	14.35 Colour Enhancer	38.24 Double Drawdown
Corrugated Board	39.08 Colour Enhancer	57.43 Double Drawdown
Plastic	11.12 Single Drawdown	27.97 Double Drawdown
Foil	18.08 Single Drawdown	38.59 Double Drawdown

Again, similar results were found when testing Pantone 804 fluorescent ink on a foil substrate. All ΔE values were relatively high ranging from 16.66 to as high as 33.03. However, the opaque white drawdown prior to the initial fluorescent ink drawdown stood out as most valuable process to maintain the fluorescent orange colour on a foil substrate. This technique produced a ΔE 8.78, which we considered acceptable for the purpose of this test, but technically it is still high and considered unacceptable for printing processes (Serwin, 2012). This is because, as Breede (2006) states, "There are two paper properties that have a major effect on this discrepancy between paper appearance and expected print quality are a paper's capacity to absorb ink and paper gloss" (p. 119). Not only is this true of pulp-based paper substances, but of foil as well.

PANTONE RUNNING REFLEX BLUE

Like the fluorescent orange ink, certain techniques worked better for specific types of substrates when working with the Pantone reflex blue ink. On the Earnscliffe bond stock, using no technique but just the original paper surface and a single drawdown yielded the best results with a ΔE of 8.65. All other techniques only hindered the results on this stock with ΔE values ranging from 13 to 21. This result can be explained due to specific substrate properties of the bond stock. The Earnscliffe bond paper had the highest whiteness level of all the stocks when comparing them side-by-side and contained an absence of a colour cast. Due to the substrates high whiteness level it also contained a high brightness level, which was influential to the results. In addition, the Earnscliffe bond had the lowest absorptivity of the three pulp substrates that was tested. The absorptivity of a substrate plays a major role in colour accuracy, and has been shown to influence shifts in the color of printed ink films (Field, 2004). That being said, the lower absorptivity of the Earnscliffe bond played an influencing role of our results to produce the lowest ΔE for the Pantone running reflex blue.

As a result of the similarities of substrate characteristics between the Earnscliffe bond and the paperboard stock,

Table 2 Pantone Reflex Blue ΔE Summary

Substrate	Lowest ΔE	Highest ΔE
Earnscliffe Linen Bond	8.65 Single Drawdown	21.20 Double Drawdown
Paperboard	11.60 Single Drawdown	21.99 Double Drawdown
Corrugated Board	21.46 White Drawdown	40.86 Double Drawdown
Plastic	13.60 Double Drawdown	38.99 Single Drawdown
Foil	3.98 Single Drawdown	32.58 Colour Enhancer

similar ΔE values resulted. The lowest ΔE value of the paperboard was 11.6 from a single drawdown and the other techniques producing results from the mid teens to the lows twenties. This increase in ΔE from the lowest ΔE values of the Earnscliffe can be explained due to the papers higher absorptivity factor. When comparing the results between the two different substrates it is apparent that the paperboard has a higher absorptivity due to the darker stain of the ink.

A colour cast was most notable in the corrugated board due to the natural colour of the pulp used in creation. As a result of this it was once again the hardest to maintain colour and produced low ΔE values. Not one of the techniques yielded results that lie anywhere within standards for this printing process. The technique that worked to produce the lowest ΔE values was technique 1, where an initial white ink film was printed before the colour. This produced a ΔE of 21.46. Even though the lowest results of the corrugated board is not ideal, the idea behind technique 1 of altering the substrates whiteness by applying a white ink film first proves to be the most effective when attempting to obtain the most accurate colour replication.

The plastic substrate also proved difficult for the Pantone running reflex blue. The worst technique was a single down with a ΔE of 38.99, and the best technique was to double print the ink with a ΔE of 13.6. Due to the transparent nature of the substrate, the plastics opacity played a major part in influencing the results. Field (2004) states,

Some substrates, are not perfectly dense, opaque materials; therefore, when light strikes the paper surface, or when it passes through the printed ink film, there is scattering among the materials that make up the substrate. Some of the light that passes through the ink film eventually emerges from the paper in an unprinted area and shifts colour of that area towards the color of the ink film (p. 101).

This explains why technique 2 (the double drawdowns) proved to create the lowest ΔE values. By applying a second coat of the blue ink the opacity of the ink film has been altered to be denser and allow less light to come through the substrate influencing the results of the color. This is clearly seen in the L* values of the single drawdown and double drawdown (Refer to Table 2). The single drawdown has a lightness/brightness of 65.63, as opposed to the double drawdown's L* value of 31.37. The double drawdown is letting less light through and more accurately represents the L* values of running reflex blue in the Pantone book. The tests done on the foil substrate produced a very clear method of printing to maintain colour consistency. Our single drawdown produced the lowest ΔE of 3.98, a highly acceptable value in the industry. All other techniques produced values from 11 to 32 with the addition of color enhancer providing the worst match. Breede (2006) states, "There are two paper properties that have a major effect on this discrepancy between paper appearance and expected print quality are a paper's capacity to absorb ink and paper gloss" (p. 119). This is not only true for paper but also with plastics and foils. Substrates with high gloss and low absorptivity produce the highest paper surface efficiency, which allows for the minimum distortion of the printed ink film colour by the substrate (Field, 2004). Metals and plastic have very high PSEs, which explains why the single drawdown of the blue ink on the foil produced the lowest ΔE value.

PANTONE RUBINE

Unlike the Pantone 804 fluorescent orange and Pantone running reflex blue ink, it is hard to make a distinction as to which technique proved to increase the colour accuracy of the Pantone rubine red between substrates. Each of the five substrates had relatively high ΔE minimum values, with none of them being in the acceptable range of colour accuracy. These large ΔE values are caused by an increase in the b* value, with a hue shift from red to green. The printed samples also have a decrease in in the L* value, meaning that it is not as bright/

Table 3 Pantone Rubine Blue ΔE Summary

Substrate	Lowest ΔE	Highest ΔE
Earnscliffe Linen Bond	26.21 Single Drawdown	33.99 Double Drawdown
Paperboard	14.35 Colour Enhancer	38.24 Double Drawdown
Corrugated Board	39.08 Colour Enhancer	57.43 Double Drawdown
Plastic	11.12 Single Drawdown	27.97 Double Drawdown
Foil	18.08 Single Drawdown	38.59 Double Drawdown

luminous as the pantone book standard. Due to these two factors the printed samples appear much darker .

This is most obvious on the corrugated board, which has a minimum ΔE of 39.08 using the color enhancer and maximum ΔE of 57.43 when using the technique of the double drawdown. Again the influence of the brown colour cast plays a role on the corrugated board. In addition, the board's porous nature causes the ink to absorb into its inner fiber structure. According to Breede (2006), "Uncoated papers and newsprint have a low ink holdout, and consequently their achievable print quality with respect to color saturation does not rate as high as coated papers, which have a higher ink holdout" (115). This can explain such a large colour difference between the sample and the standard from the uncoated pantone book. This can also be said to be true for the Earnscliffe linen bond and the paperboard, which are both uncoated substrates with higher absorbency levels.

As the materials have stayed consistent between each colour drawdowns we must assume that these large ΔE values are due to the composition of the Pantone rubine red ink. Factors such as pigment colour, transparency/opacity, and the tinctorial strength of the ink are potential factors that could be influencing our results. Tinctorial strength of an ink is a measure of the amount of ink per unit area required to produce a given strength of colour and is influenced by pigment selection and quantity of pigment used in the formulation (Field, 2004). That being stated, our results may be as high as they are because we used too high of a concentration of ink for the space that we completed our drawdowns on.

WEAKNESSES OF TEST

When testing the ink on the plastic substrate, an opposite problem occurred from the issue that occurred with the corrugated board. Due to the plastics composition it has very low absorbency, unlike the corrugated board, which soaked up ink as though it was sponge. With the plastic substrate, the ink would begin to flake once it was dry. This created an undesirable print and made testing each sample very difficult as ink was lost in certain spots of the sample. This could have altered our results for the plastic substrate's colour testing. A solution to this problem could be to apply a top coat/finish that would prevent the flaking from occurring. This could be effective but at the same time there is potential for the topcoat to alter the colour properties of the specimen being tested. An alternative to this solution could be to alter the way in which the ink was applied. Certain substrates, such as the plastic and foil were, at times, hard to apply ink using the drawdown blade and often an uneven coat was applied. Using a rubber roller could have been potentially more effective and replicated the actual printing process in a more accurate manner.

Another weakness that occurred during the completion of our test was the use of a normal spectrophotometer when testing the foil results. According to Moore, "it's not difficult to understand the printed result will be different when applying an ink on different specialized substrates. Making it even more challenging is that spectrophotometers can't accurately read reflective materials, such as foils" (p. 8). That being said, the results of our foil samples have the potential to be inaccurate due the high reflective properties of the material. Moore states, "When printing a brand color over a holographic foil, it is very difficult to capture the color data and represent it in a proof, which is why some suppliers have developed proofing devices that work with clear and metallic substrates and utilize white and metallic inks". Using a specialized spectrophotometer when reading the foil results would have be beneficial and provided us with more accurate results for those samples. However, do to availability and cost constraints, this was not a possibility.

RECOMMENDATIONS

PLASTIC SUBSTRATE

A big consideration for printing on plastic is its dyne level. The dyne level is based on a scale that measures the surface tension of the substrate. Higher dyne levels generally indicate better ink adhesion (Pad Printing Glossary, Common Terms Technical Bulletin from DECO TECH, n.d.). For printing on plastic substrates it is best to have a dyne level 38 and 50 with 40 being the ideal. However, the dyne levels in plastic tend to vary greatly (Oller, 2002). Dyne levels that are below 38 will cause the inks to not dry and peel off while dyne levels above 50 will create too much static and cause runability problems. It is best to acquire a sample of the plastic from the supplier, test the dyne levels and then send the samples to an ink manufacturer to formulate a ink that will be suitable. (Oller, 2002).

FOIL

When printing onto a foil substrate it is important that you are using the proper ink. This is because foils are generally wash-primed or coated, thus making it difficult for some ink to adhere to the surface. (Printing on Foil, 2005). By using ink that is not well suited for use on foils (ex. water based inks instead of UV inks) it will be harder get a consistent colour down and achieve the required result.

CORRUGATED BOARD

When printing onto a Kraft corrugated board, it is generally accepted that the right colour will not be achieved and the final product will look darker and less saturated than expected. This is because the inks used in flexographic printing are not opaque and therefore the brown colour of the corrugated board will tint the colour (Feltoe, personal communication. February 21, 2012). The printer may be able to get the colour close, but it will never be exact and thus guidelines and expectations and not as tight as other printing such as labels. Customers are usually shown swatches from the Flexo Color Guide that will show how close to the right colour the printer will be able to get (Feltoe, personal communication. February 21, 2012). To achieve proper colour on corrugated board, printers may put down a thin layer of opaque white ink and then print the coloured ink on top to help achieve the proper colour. As well, some printers have ink mixers on hand to mix and adjust the ink to compensate for the brown tint. For higher end printing that requires the ink colour to be exact, printers will print on fully bleached liners, which are then glued to the corrugated board (Feltoe, personal communication. February 21, 2012).

RUNABILITY

PLASTIC

Since plastic substrates have very low absorption, drying time is often an issue when using water-based inks. This means that the press will have to run at a slower speed to allow the inks enough time to properly dry between ink stations. Dryer time is also a major consideration and needs to be kept at an appropriate temperature so the plastic will not begin to melt to lose its shape. Often quick-drying or special light source inks like IR or UV inks are used so that less time is required in the dryers and these problems can be avoided.

FOIL

Foil substrates also have the same problem as plastic in terms of dryer time and temperature. UV or IR inks are usually used for foils as a quick drying method that does not require the press speed to be lowered.

END-USE APPLICATIONS

For this test, the end use is not how capable the substrates are of holding their contents, but rather if the substrate is able to effectively display special colours. If the substrate is capable of doing so, the companies' brand colours will be maintained, effectively communicating the brand and all it encompasses to the consumers. The key is to ensure the brand colours are made clear and identifiable to consumers. With the right techniques applied to different substrates, each one is very capable of properly displaying colour to the consumer. We found that when printing florescent colours, you must use additives with the inks or prep the substrate before printing such bright hues. Color Enhancer aided in maintaining fluorescent ink on matte paper substrates, while applying a white basecoat increased the colour match on packing substrates like corrugated board, foil and plastic. Matte general papers such as Earnscliffe linen bond, produced the best overall ΔE values with just a single drawdown. From this we can conclude that matte paper stocks are the easiest to achieve colour consistency, making it easier to print brand colours and have them be successfully recognizable by consumers.

Corrugated board, as it is when it comes off the press is not the best for maintaining colour consistency and therefore also not a worthy choice for broadcasting brand awareness, but it does have the capability to do so with extra work. We found that on average, colour was easier to match on corrugated board when a white layer of either ink or the possibility of being replaced with paper glued on first. This is due to the fact that you are altering the substrates whiteness, which intern increases the substrates brightness. The addition of this step could allow corrugated board to more accurately reproduce brand colours.

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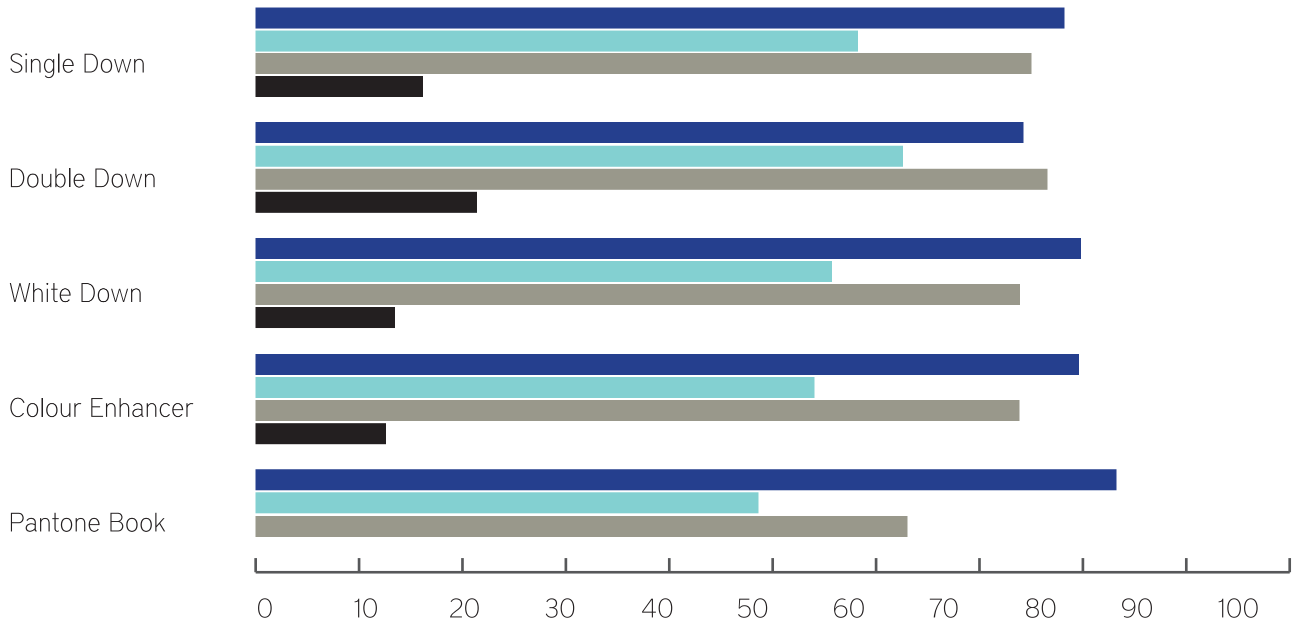
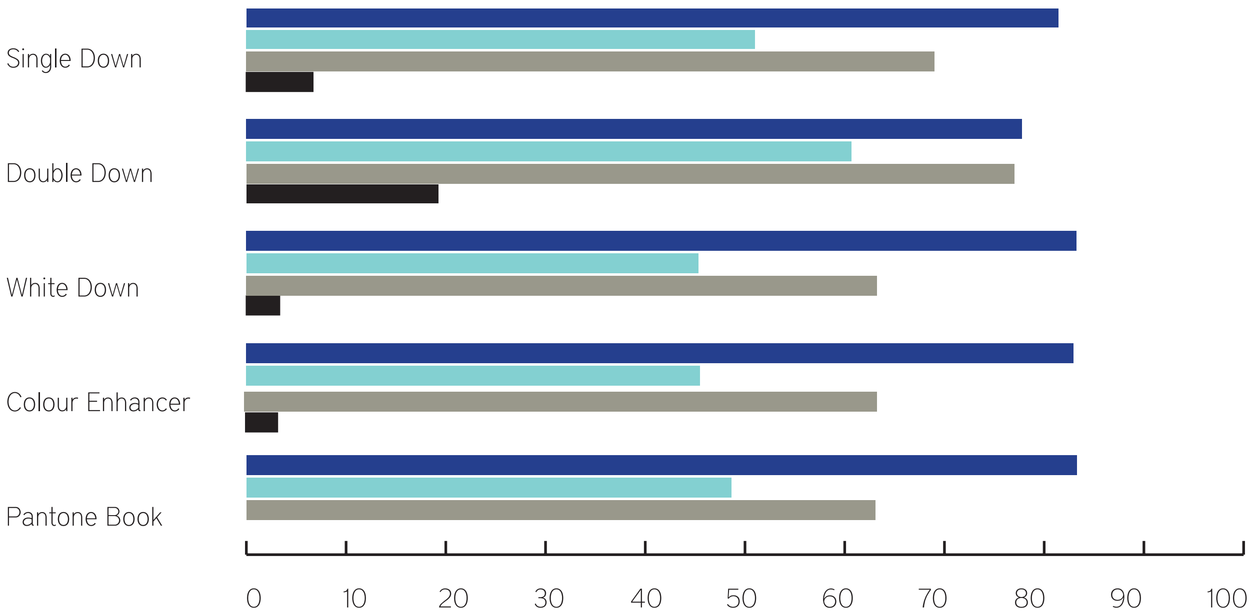
FLORESCENT INK ON EARNSCLIFFE LINEN BOND



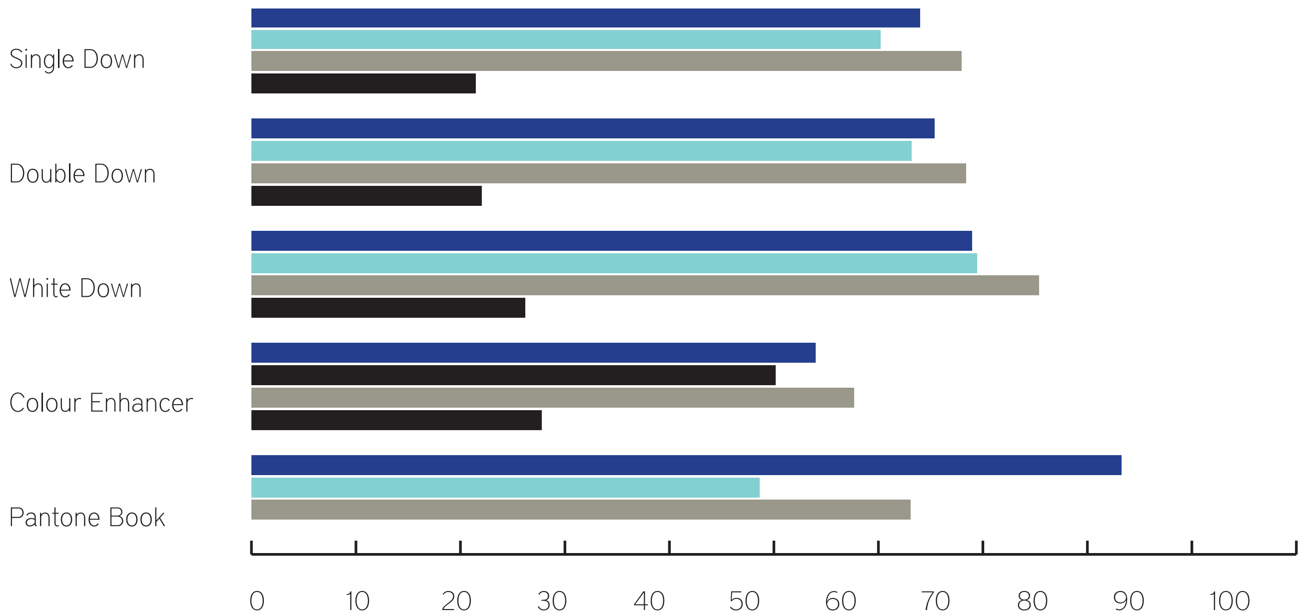
	L*	a*	b*	ΔE
Single Down	78.20	58.25	75.03	16.17
Double Down	74.28	62.60	76.57	21.41
White Down	79.80	55.75	73.93	13.46
Color Enhancer	79.64	54.02	73.87	12.61
Pantone Book	83.26	48.63	63.05	

FLORESCENT INK ON PAPERBOARD



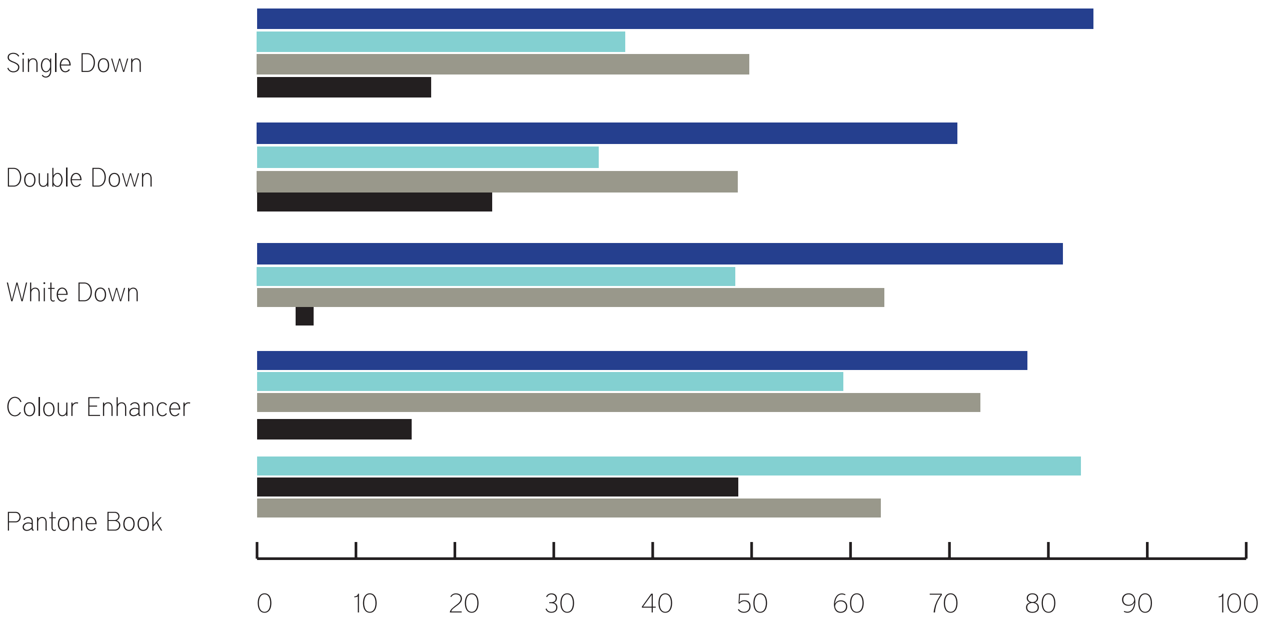
	L*	a*	b*	ΔE
Single Down	81.40	51.00	68.99	6.66
Double Down	77.78	60.69	76.99	19.23
White Down	83.24	45.31	63.24	3.32
Color Enhancer	82.95	45.49	63.46	3.18
Pantone Book	83.26	48.63	63.05	

FLORESCENT INK ON CORRUGATED BOARD



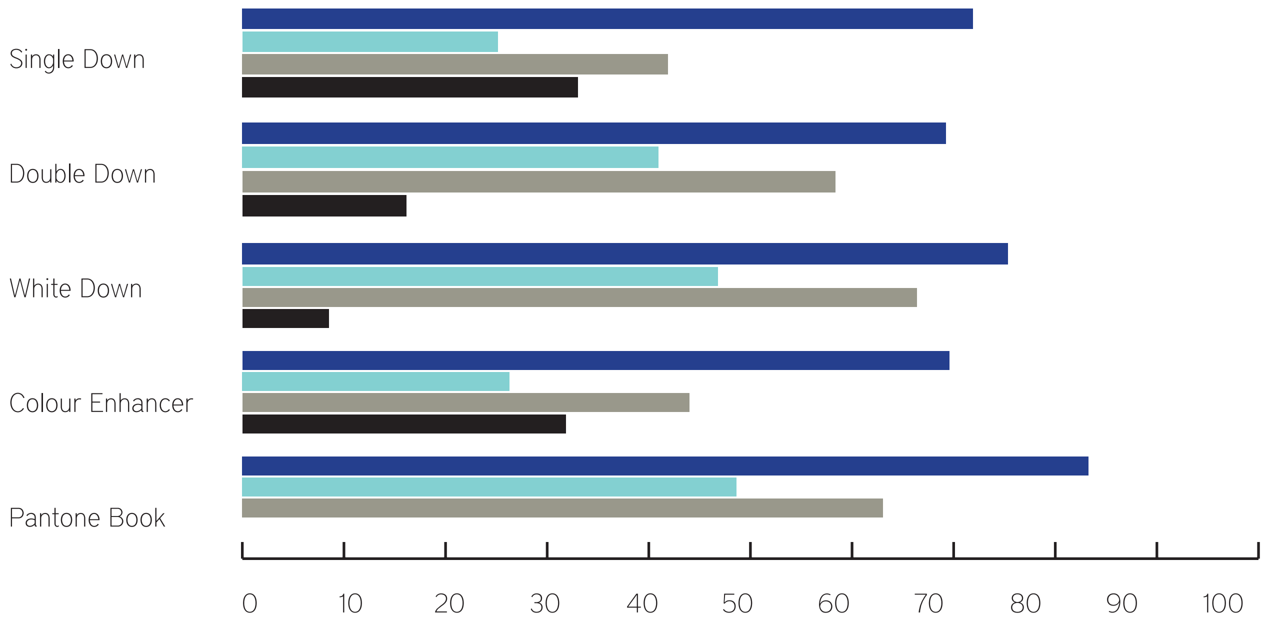
	L*	a*	b*	ΔE
Single Down	64.00	60.21	67.95	23.00
Double Down	65.38	63.15	68.37	23.64
White Down	68.94	69.43	75.35	28.09
Color Enhancer	54.00	50.16	57.67	29.79
Pantone Book	83.26	48.63	63.05	

FLORESCENT INK ON PLASTIC



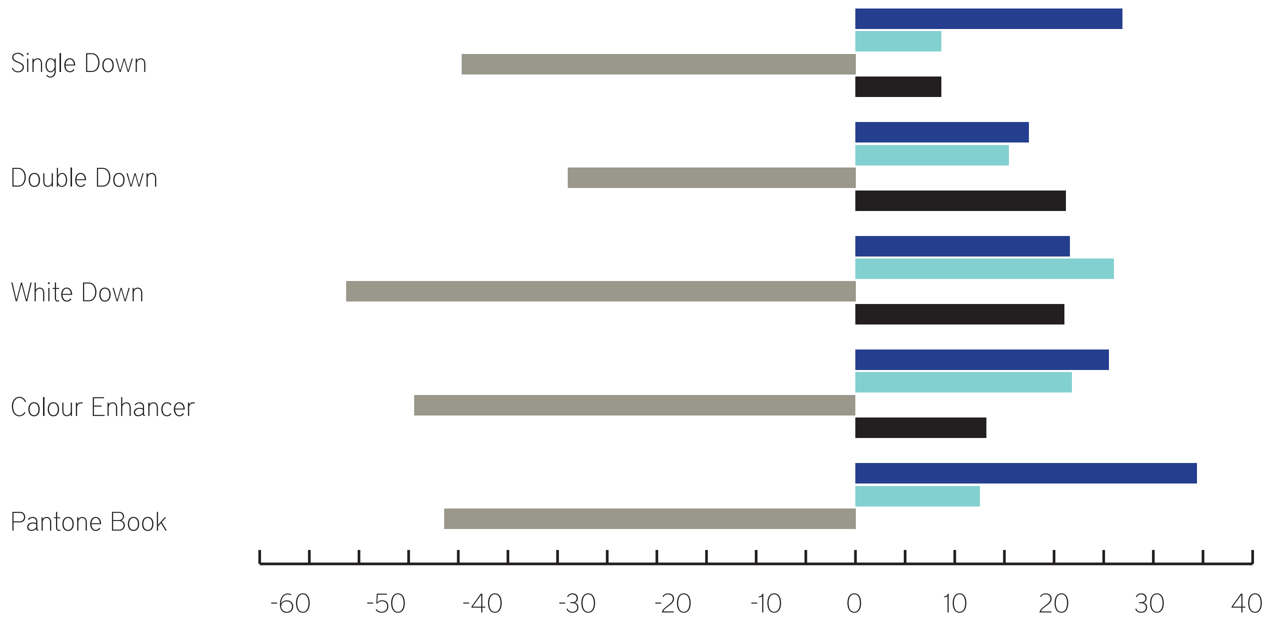
	L*	a*	b*	ΔE
Single Down	84.54	37.22	49.76	17.56
Double Down	70.80	34.52	48.60	23.74
White Down	81.45	48.35	63.39	1.87
Color Enhancer	77.85	59.24	73.12	15.61
Pantone Book	83.26	48.63	63.05	

FLORESCENT INK ON FOIL



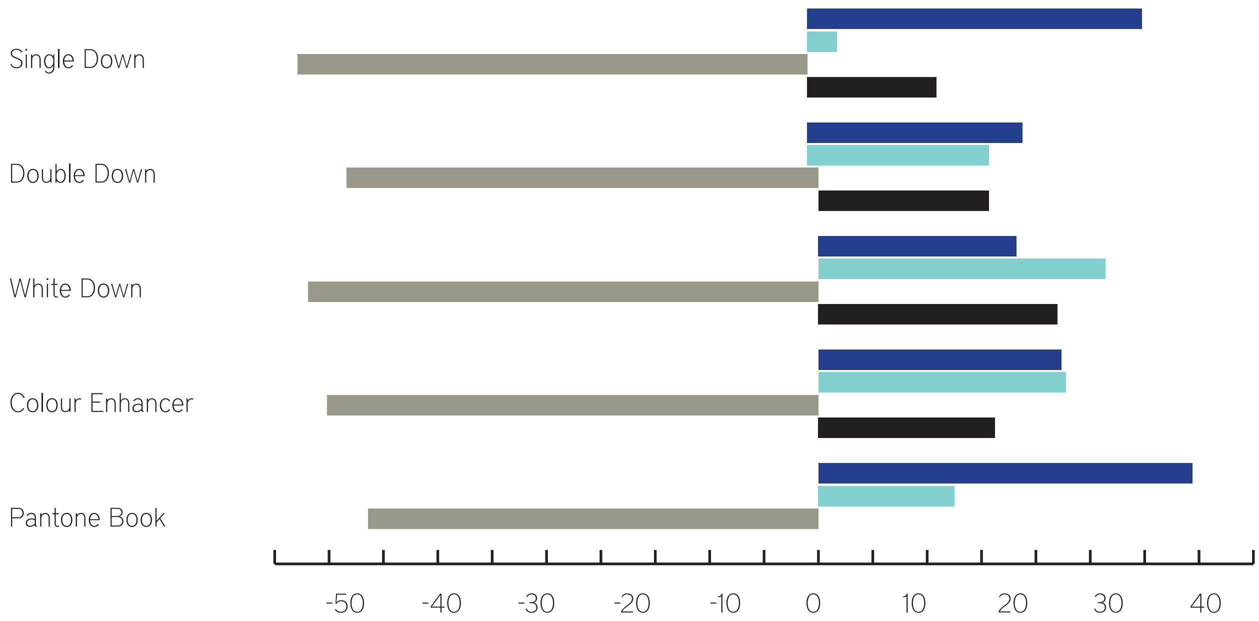
	L*	a*	b*	ΔE
Single Down	71.89	25.96	41.88	33.03
Double Down	69.24	40.95	58.35	16.66
White Down	75.34	46.77	66.36	8.78
Color Enhancer	69.56	27.16	43.97	31.82
Pantone Book	83.26	48.63	63.05	

REFLEX BLUE ON EARNSCLIFFE LINEN BOND



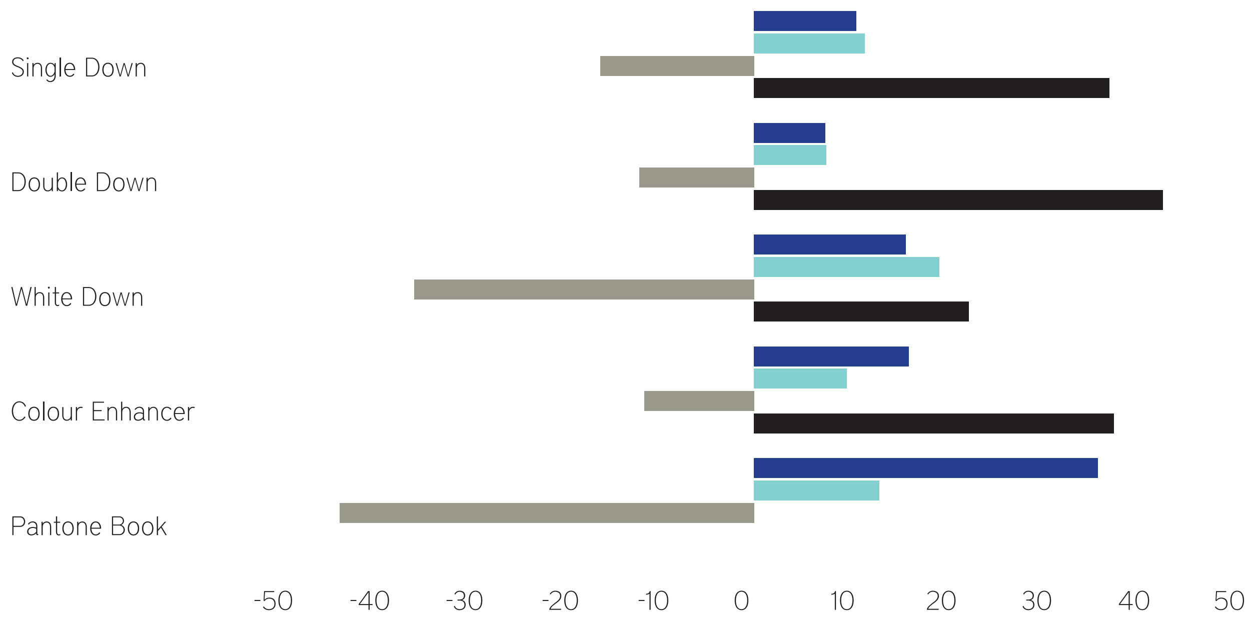
	L*	a*	b*	ΔE
Single Down	26.85	8.62	-39.67	8.65
Double Down	17.45	15.46	-28.99	21.20
White Down	21.60	26.00	-51.29	21.03
Color Enhancer	25.52	21.78	-44.41	13.16
Pantone Book	34.37	12.51	-41.42	

REFLEX BLUE INK ON PAPERBOARDS



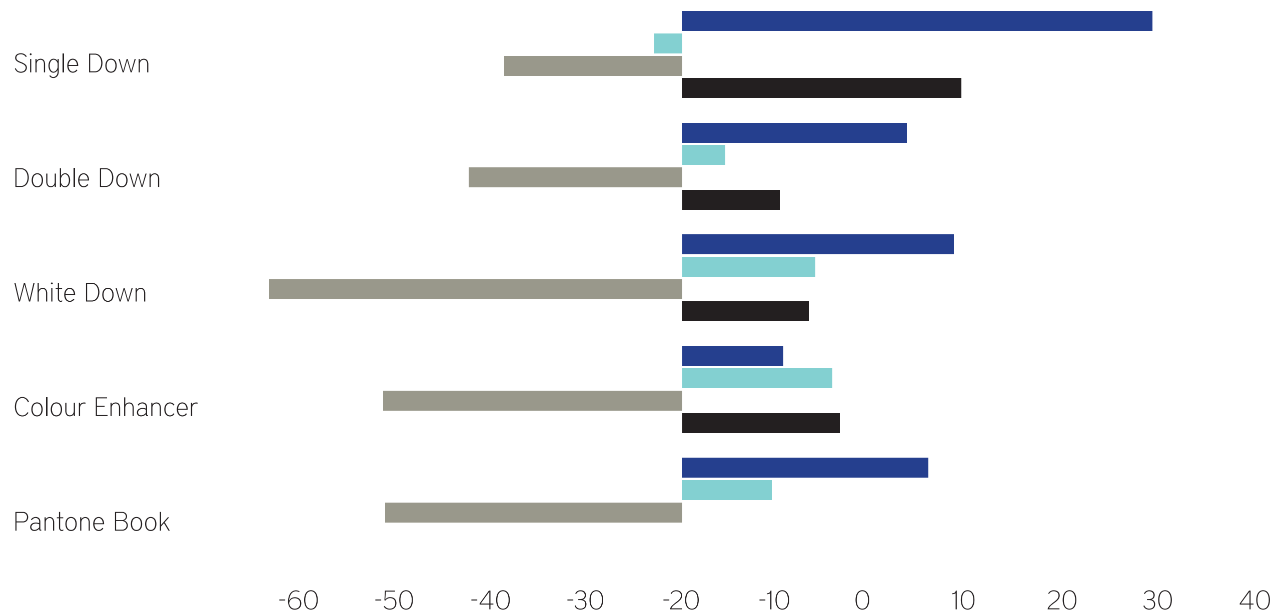
	L*	a*	b*	ΔE
Single Down	30.03	2.67	-45.76	11.60
Double Down	19.32	16.31	-43.39	15.65
White Down	18.21	26.37	-46.93	21.99
Color Enhancer	22.33	22.75	-45.16	16.24
Pantone Book	34.37	12.51	-41.42	

REFLEX BLUE ON CORRUGATED BOARD



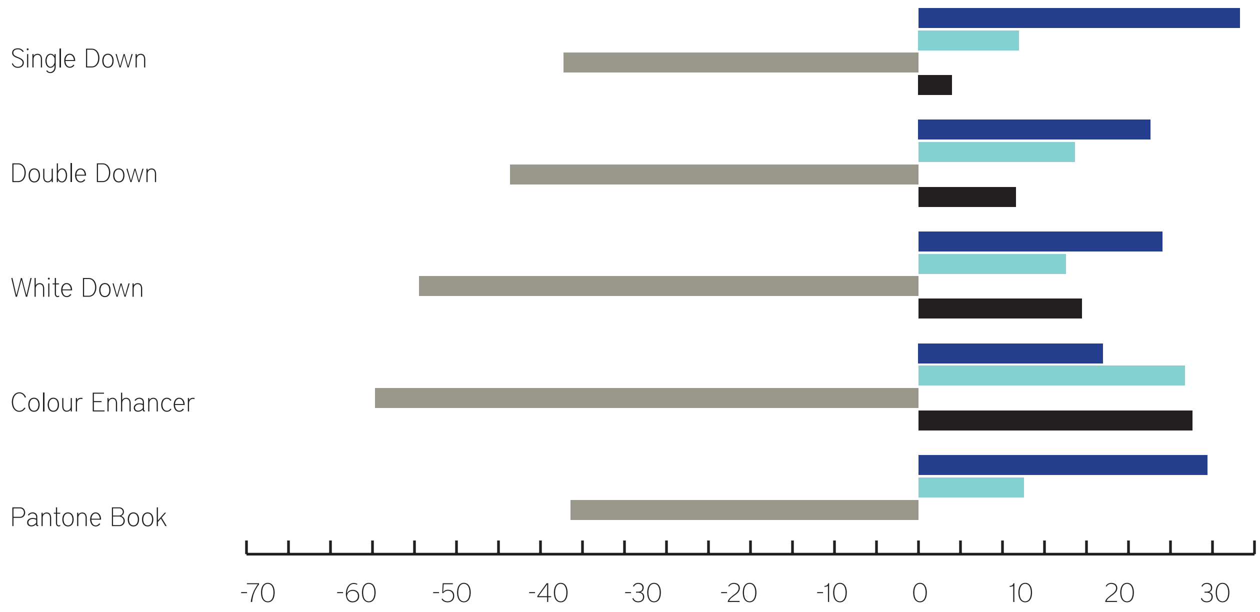
	L*	a*	b*	ΔE
Single Down	10.23	11.06	-15.37	35.54
Double Down	7.10	7.23	-11.46	40.86
White Down	15.16	18.50	-33.96	21.46
Color Enhancer	15.46	9.28	-10.99	35.97
Pantone Book	34.37	12.51	-41.42	

REFLEX BLUE INK ON PLASTIC



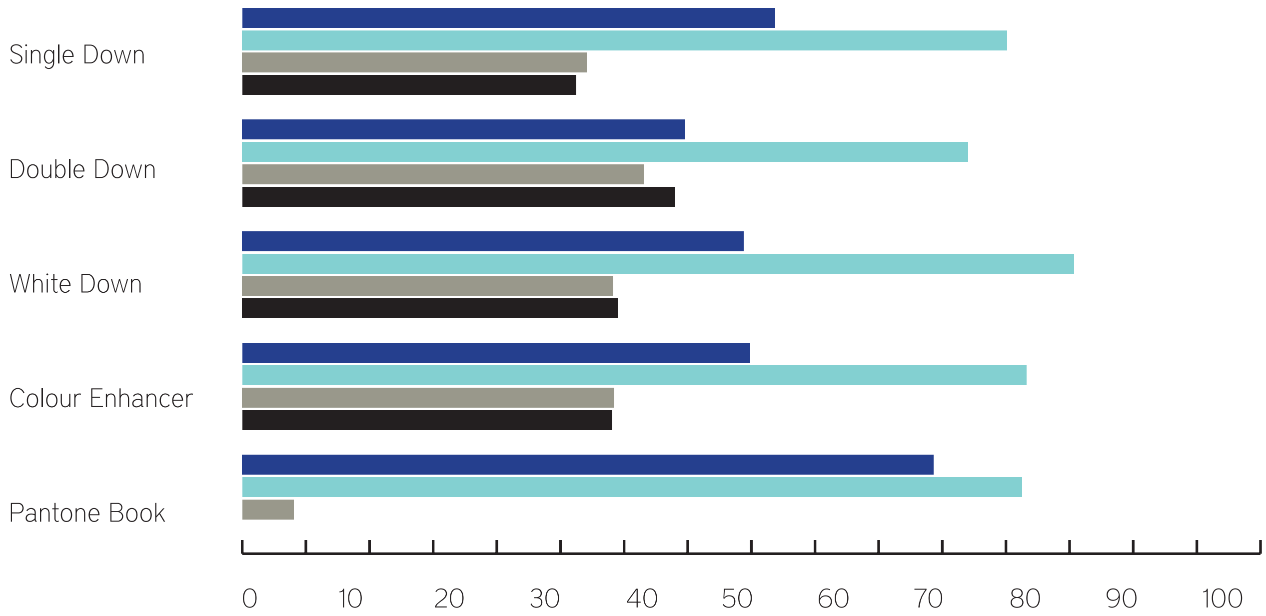
	L*	a*	b*	ΔE
Single Down	65.63	-3.84	-24.81	38.99
Double Down	31.37	5.97	-29.79	13.60
White Down	37.90	18.55	-57.66	17.68
Color Enhancer	14.09	20.93	-41.73	21.97
Pantone Book	34.37	12.51	-41.42	

REFLEX BLUE INK ON FOIL



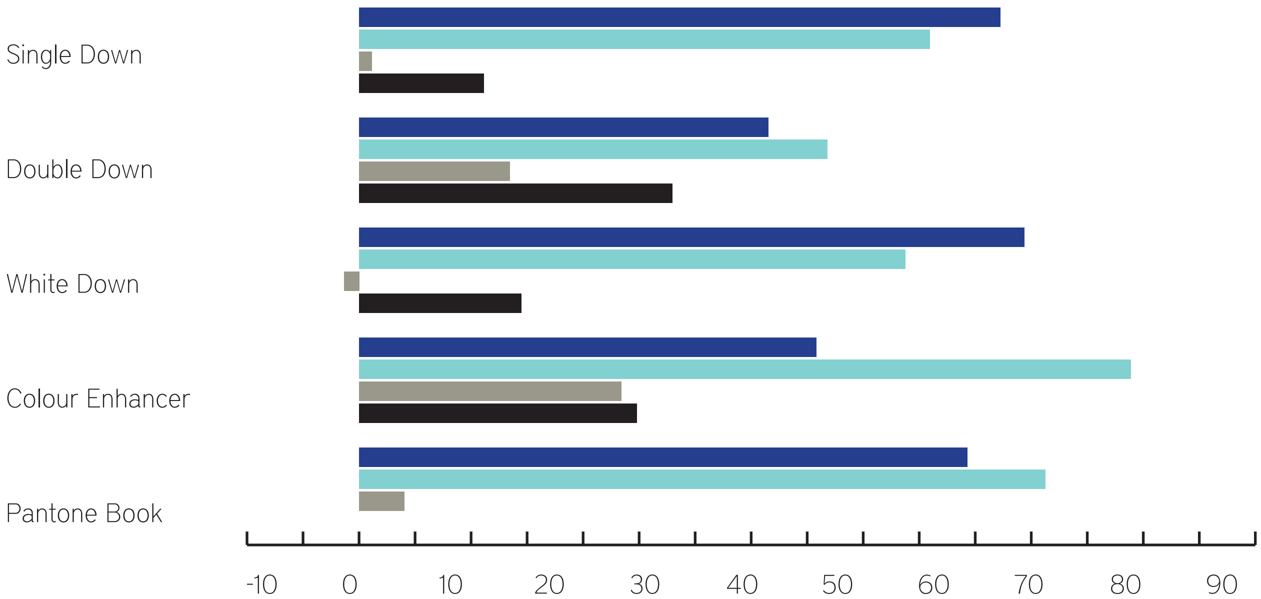
	L*	a*	b*	ΔE
Single Down	38.23	11.97	-42.23	3.98
Double Down	27.62	18.62	-48.61	11.60
White Down	29.03	17.54	-59.42	19.44
Color Enhancer	21.97	31.68	-64.66	32.58
Pantone Book	34.37	12.51	-41.42	

RUBINE RED INK ON EARNSCLIFFE LINEN BOND



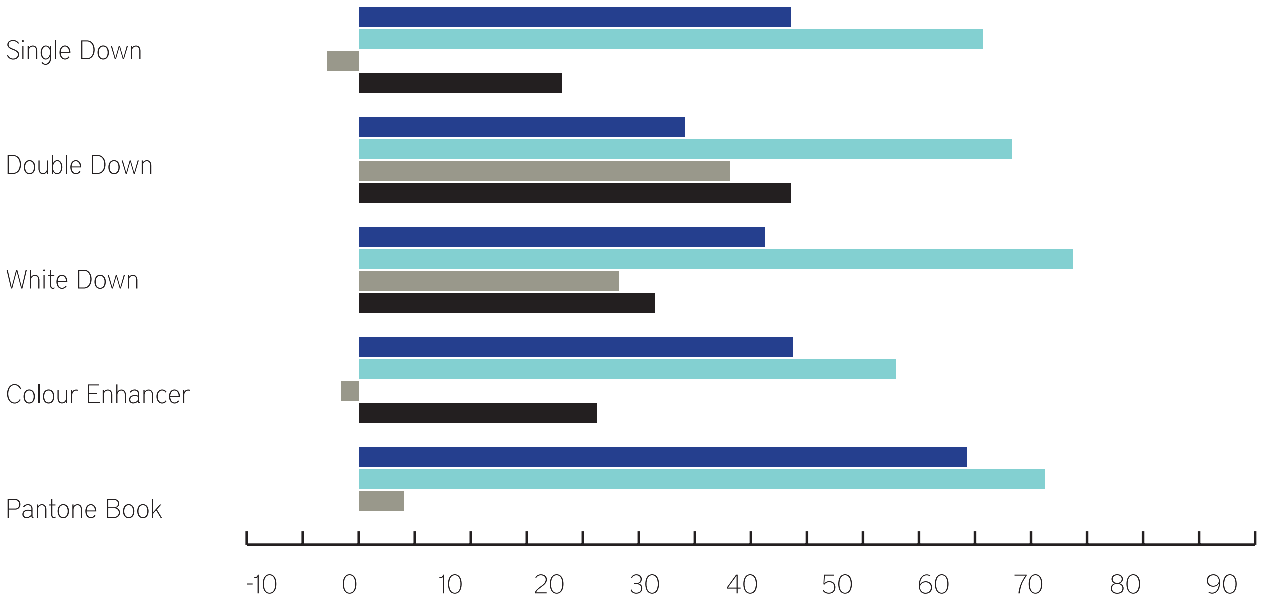
	L*	a*	b*	ΔE
Single Down	41.84	60.10	27.06	26.21
Double Down	34.79	57.03	31.53	33.99
White Down	39.40	65.33	29.15	29.49
Color Enhancer	39.88	61.60	29.23	29.05
Pantone Book	54.31	61.25	4.03	

RUBINE RED INK ON PLASTIC



	L*	a*	b*	ΔE
Single Down	57.25	50.93	1.12	11.12
Double Down	36.54	41.81	13.46	27.97
White Down	59.36	48.77	-1.34	14.50
Color Enhancer	40.80	68.87	23.40	24.81
Pantone Book	54.31	61.25	4.03	

RUBINE RED INK ON FOIL



	L*	a*	b*	ΔE
Single Down	38.53	55.66	-2.80	18.08
Double Down	29.12	58.25	33.11	38.59
White Down	36.20	63.75	23.16	26.46
Color Enhancer	38.73	47.96	-1.58	21.23
Pantone Book	54.31	61.25	4.03	

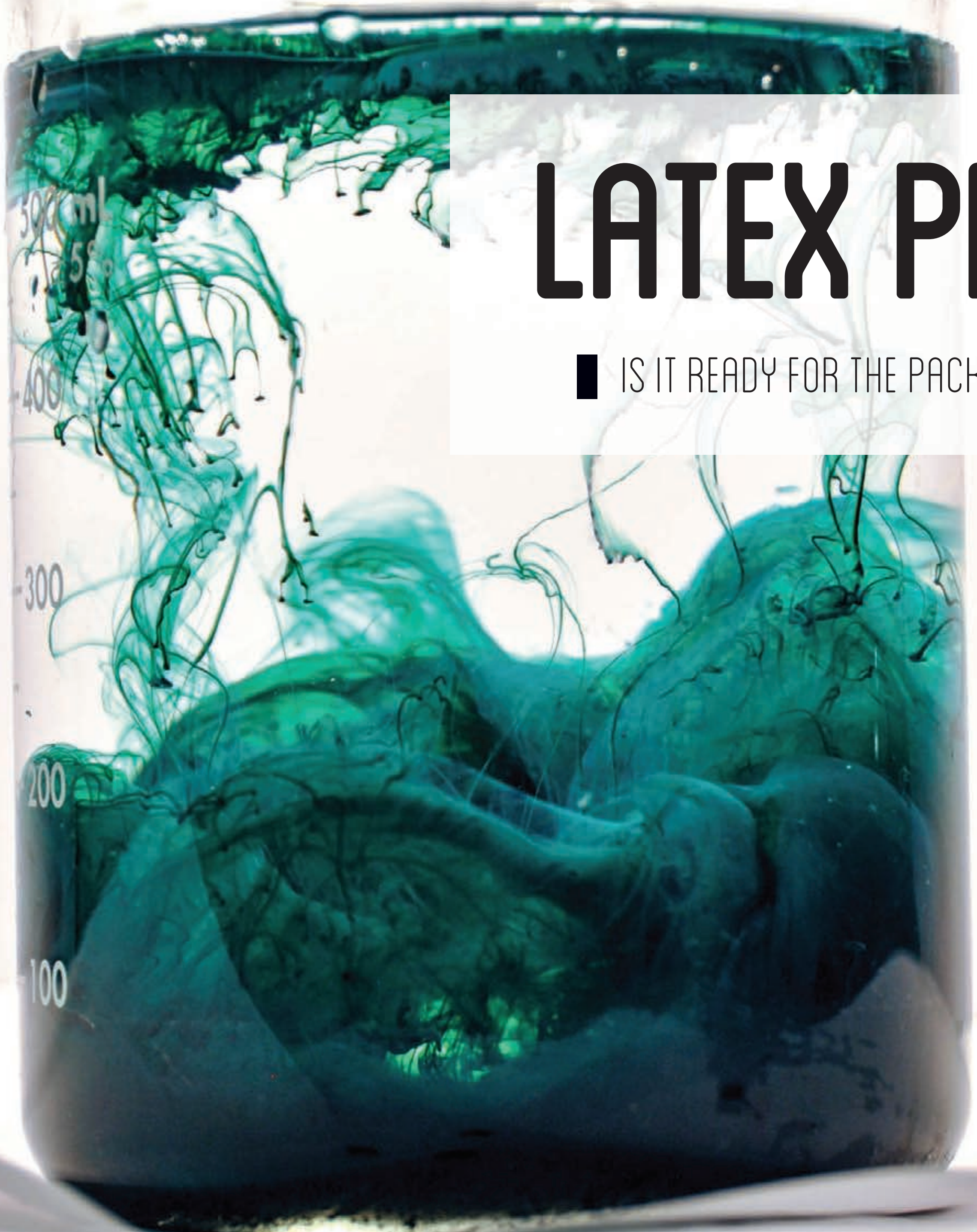
LATEX PRINTING

IS IT READY FOR THE PACKAGING INDUSTRY?

LEANNE FITZGERALD

MARCIN KORBUT

LARA VANDERHEIDE



SCOPE

The results from the series of tests completed by our team will hold valuable information on whether latex printing inks have the properties to effectively be used in the wide-format packaging industry. The latex used is described as a "stable, aqueous dispersion of microscopic polymer particles" (Hewlett-Packard Development Company, 2011). Our team will identify the strengths and weaknesses of latex ink in a number of diverse situations. Along with testing the performance of latex inks, we are testing how well Xerox and HP printed samples will perform. In order to reach a conclusive decision on how well the latex inks have bonded to the substrate, we must compare the results to other methods of printing. The properties that have been measured are: rub resistance, how well the ink bonds to the substrate and water resistance. By comparing the results, our team will be able to give an accurate and informed decision on whether or not latex inks have a place in the packaging industry.

ABSTRACT

Water and rub/smudge resistance were tested on three samples of paper; one printed with latex inks on a HP Design Jet L25500, one printed with toner on a Xerox Docucolour 7000, and one printed using standard ink jet inks on a HP9500. The purpose of the tests was to compare the durability of latex inks against standard printing inks. Latex inks are a fairly new technology within the printing industry. The test results show that the latex inks outperformed the other inks rub resistance but were very comparable in other testing areas.

INTRODUCTION

We researched the new wide-format printing technology of latex printing, developed by HP. The definition of latex is "describes a stable, aqueous dispersion of microscopic polymer particles" (Hewlett-Packard Development Company, 2011). Latex printing has proven to be a quick and efficient method of wide-format printing all while providing top quality. Latex printing "produces prints that come off dry, ready for lamination, packaging, shipping or display [...] giving users a competitive edge" (Graphic Arts, 2011). Latex printing inks are known to be more eco-friendly compared to solvent inks (Print Country, 2010). The development of this technology will continue in helping decrease the impact of the printing industry's carbon footprint in today's world and in the future.

TESTING PRINCIPLES

Our team has conducted and studied the results of the four tests to provide data on whether one printing process will be optimal. All of these tests replicate conditions that printed products may be in. It is vital that we understand how the samples will react to various amounts of external factors.

The experiments selected to test the properties of latex inks will provide our team with the data to make an informed decision on whether latex inks can be effectively used in the packaging industry. The first experiment performed tested the rub resistance of the three substrates. Using the Sutherland Ink Rub Tester, our team measured how well the samples would withstand handling and transportation. It is important for packages to have a high resistance to abrasion. The package may encounter prolonged rubbing, scratching and scuffing during shipping. The Sutherland tester will put the sample in a simulated situation to test the ink's ability to resist scuffing and scratching. By visually measuring the amount of ink rubbed off onto the blank substrate we can determine which sample has the highest resistance to abrasion.

Our team also conducted a smudge test, this concept is similar to that of the rub resistance test but it is preformed manually and uses a small amount of water. This will determine the rub resistance of each substrate under conditions that may allow a liquid such as water to be placed on the printed product. This test can be tied together with the rub resistance test to determine the optimal printing process to use for any condition.

The next test our team conducted was the tape test; this is used to determine the adhesion of the ink to the substrate. This will give our team a visual demonstration of how well the different inks bonded to the substrate.

We had originally planned to conduct a spray test to establish the water resistance of each sample. This was not the most appropriate method of measuring how resilient the samples are to small amounts of liquids. We decided to perform the Cobb test to more accurately measure the absorption level of the samples. The samples were measured before and after the test in order to precisely calculate the weight in grams that both the wire and felt side absorbed. This test will give us the results to establish how resistant latex inks are to any liquid that it may come into contact with.

These tests have been carried out the same way that we have studied in previous printing courses. This is important because it provides us with standard testing procedures in order to compare our results across the board. This information can be provided to give printers accurate results, which they can compare to the printing process that they currently use. This may be helpful if a printer is debating on whether or not to convert over to latex inks. An alternative test that would have been interesting to perform would be to test the eco-friendliness of the samples. This was one of the major advantages of latex inks, but it would be too complicated to carry out.

DEFINITIONS

Latex Inks: "Stable, aqueous dispersion of microscopic polymer particles" (Hewlett-Packard Development Company, 2011).

Rub Resistance: "The level of resistance to withstand repeated rubbing and scuffing" (Printingtips.com, 2012).

Cobb Test: "The surface water absorption over 60 seconds, expressed in g/m2" (Bilt Paper, 2003).

MATERIALS TESTED

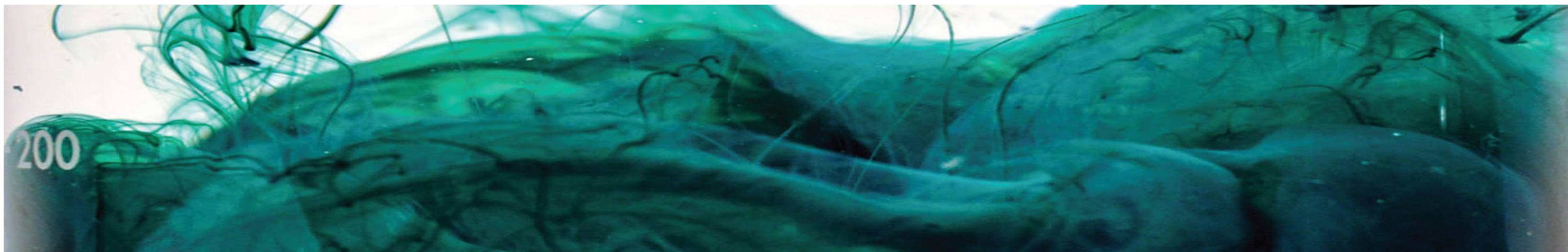
- Printed samples – HP latex, Xerox and HP toner
- Substrate – 170 g/m^2 Intellicoat matte coated heavyweight paper

EQUIPMENT USED

- Sutherland Ink Rub Tester
- Electronic Scale
- Cobb Tester
- Cloth
- Stopwatch
- Measuring cylinder
- Eyedropper
- Kimwipes
- Scotch Tape

EQUATIONS

$$A = (M2 - M1) \times 100$$



PROCEDURES

COBB TEST

1. Cut each sample to 125 mm x 125 mm from various parts of the sheet.
2. Use the electronic scale to weigh the samples to nearest 0.001 g.
3. Place the side desired to test up onto the base of the Cobb Tester, and then place the metal ring on top on the sample. Using the metal beam, secure the sample by tightening the wing nut.
4. Measure 100 mL of water, and then pour this on to the sample
5. Using a stopwatch, let the water sit on the sample for 60 seconds, then pour the water out, remove the sample and let it sit for an additional 60 seconds.
6. Weigh the sample on the electronic scale.
7. Repeat steps 3-6 with each sample, ensure you test both the felt and wire side.
8. Use the formula to calculate the water absorption of the samples in g/m2.

TAPE TEST

1. Collect a sample from all three printing methods.
2. Firmly press a strip of tape onto the printed sample.
3. Rub tape onto the sample to ensure there is no air bubbles.
4. Let stand for 30 seconds.
5. Quickly pull tape off of the printed sample.
6. Observe tape for any ink having lifted off of the printed sample.
7. Repeat for other areas of the print.

RUB RESISTANCE TEST

1. Cut each sample into the appropriate size.
2. Place printed samples on the Sutherland Ink Rub Tester.
3. Place an additional blank substrate on the Sutherland Ink Rub Tester.
4. Use the four-pound weight and set the tester to 110 rubs.
5. Turn on machine.
6. Observe the blank substrate for any traces of ink from the printed substrate.
7. Repeat each step with all 3 samples.

RESULTS & DISCUSSION

COBB TEST

Table 1 Latex Samples

Sample	Weight before H2O	Weight after H2O	Absorption
Sample 1 (Ink up)	2.8324 g	4.9438 g	211.14%
Sample 2 (Ink down)	2.8.002 g	3.9102 g	111%

Table 2 Xerox Docucolour 7000 Samples

Sample	Weight before H2O	Weight after H2O	Absorption
Sample 1 (Ink up)	2.8579 g	4.6992 g	184.13%
Sample 2 (Ink down)	2.8524 g	4.0489 g	119.65%

Table 3 HP9500 Samples

Sample	Weight before H2O	Weight after H2O	Absorption
Sample 1 (Ink up)	2.8793 g	3.8438 g	96.45%
Sample 2 (Ink down)	2.8678 g	5.1991 g	233.13%

For this test absorption of paper was tested using the Cobb Tester. Three samples were tested, one printed with latex ink on a HP Design Jet L25500, one printed with toner on a Xerox Docucolour 7000, and one printed using inkjet inks on the HP9500. The results show that 2 of the samples, the latex ink sample and the Xerox Docucolour sample, have more absorption on the ink up side. However, the HP9500 samples have more absorption on the ink down side. The sample with the highest overall absorption was the HP9500 samples. The sample with the lowest overall absorption was the Xerox Docucolour 7000 samples.

Latex inks claim to be water resistant with the ability to withstand weather conditions outdoors for up to 3 years un-laminated (Hewlett-Packard Development Company, 2011). This test did not confirm our expected outcomes as we predicted that the latex ink samples would have the least water absorption. However, this could be due to the type of substrate that our samples were printed on, making it more absorptive. Weaknesses from this test could have been from human error. It is possible that when completing the Cobb Test we did not correctly measure the amount of water used or misread the weight of the paper. These errors could have affected the overall results of the test.

TAPE TEST

In order from least ink pulled off (best performance) to the most ink pulled off (worst performance):

1. HP9500
2. Latex Ink
3. Xerox Docucolour 7000

For this test printing adhesion was tested using the Tape Test. A strip of tape was pressed firmly onto the printed sample and than quickly removed. The tape and sample was than observed for any ink removed. Three samples were tested one, printed with latex ink on a HP Design Jet L25500, one printed with toner on a Xerox Docucolour 7000, and one printed using inkjet toner on the HP9500. Of the three samples, the one that had the most ink removed was the Xerox Docucolour samples. The one that had the least amount of ink removed was the HP9500 samples.

HP latex inks claim to durable in that they are scratch-resistant (Hewlett-Packard Development Company, 2011). The test did not confirm out expected outcomes because we predicted latex inks to have the best adhesion and the HP9500 to have the worst. We expected the HP9500 samples to have the worst adhesion because they were printed using ink jet inks. Ink jet

RUB RESISTANCE

Table 4 In order from most rub resistant to least rub resistant

Test 1: 4 lbs @ 110 rubs	Test 2: 4 lbs @ 110 rubs	Test 3: 2 lbs @ 110 rubs
Latex Ink	Latex Ink	Latex Ink
Xerox Docucolour 7000	HP9500	HP9500
HP9500	Xerox Docucolour 7000	Xerox Docucolour 7000

inks are generally cheap inks commonly used in someone's home or office and not for commercial printing. The latex ink samples did not however have the worst results of the three samples and they were comparable to the ink jet ink samples. Weaknesses form this test could have been from human error. It is possible that when conducting the test we did not time each strip exactly to 30 seconds. We had two people conducting this test as well so it is possible that one person ripped the tape off much harder than the other.

For this test rub resistance was tested using the Sutherland Ink Rub Tester. Three samples were tested, one printed with latex ink on a HP Design Jet L25500, one printed with toner on a Xerox Docucolour 7000, and one printed using inkjet inks on the HP9500. The samples were tested using both a 2 lb weight and a 4 lb weight at 110 rubs. The results show that the samples printed with latex inks had the best rub resistance while the Xerox Docucolour samples had the worst rub resistance.

HP Latex Inks claim to be scratch and smudge resistant (Hewlett-Packard Development Company, 2011). The test did confirm our expected outcomes. We predicted that the latex ink samples would have the best rub resistance compared to the Xerox and HP9500 samples. The test results show that the latex ink is not completely rub resistant, however, it did perform exceptionally better than the other two samples. Weaknesses from this test could have been from human error. When completing the test using the Sutherland Ink Rub Tester, it is possible that we did not accurately set the amount of 110 rubs for each sample. This would make the test inconsistent and therefore skew the results of each sample.

SMUDGE TEST

For this test, water resistance was tested using the Smudge Test. Three samples were tested, one printed with latex ink on a HP Design Jet L25500, one printed with toner on a Xerox Docucolour 7000, and one printed using inkjet inks on the HP9500. Two drops of water were dropped onto the sample and than wiped away using a Kimwipe. The HP9500 samples had the most noticeable effects of smudging. The ink was completely removed on one of the samples tested. The latex ink samples and Xerox Docucolour 7000 samples were very comparable. Both samples showed little effects of smudging after the test.

HP Latex Inks claim to be smudge and water resistant compared to low-solvent inks (HP Scitex LX600 Printer, 2010). The samples did hold out very well against the smudge test. The test confirmed our expected outcomes. We predicted that the latex inks would have the best water resistance based on secondary research. Weaknesses in this test could have been from human error. When completing the test it is possible that on some samples slightly more water was used than on others. We also had two people completing the test. It is possible that one person wiped harder than the other when wiping off the water from the sample.

RECOMMENDATIONS

RUNABILITY

It is important to understand how the relative humidity in the pressroom can affect latex inks when printed. Although printed on a digital press, the moisture in the air can affect the print. The moisture can be absorbed through the paper causing the paper to expand, ultimately affecting the quality of the image printed (Dunn, 2004). The paper can then become wrinkly or wavy causing issues when running through the press. The paper could also have a static electricity affect that could cause feeding or jamming issues on press (Dunn, 2004).

END-USE APPLICATIONS

Using latex inks for packaging would not only be environmentally friendly but also appropriate. They proved to be suitable during the rub resistance test. It is important to test for rub resistance when testing for packaging because many printed packages are packed tightly together and have the tendency to rub against one another during shipping. When two packages rub against one another they can rub off the printed image, which leads to the package being unsuitable to display in stores. Rub resistance affects all types of products including magazines, newspapers, folding cartons, and any package in a grocery store (Penton Media, 2012).

Many packages are held together using tape after they are printed. However, when the tape is ripped off when being opened it can rip off some of the printed image. It is important to test how adhesive the ink is to the paper in order for the image to not be destroyed when the package is opened. Many packages can be bundled with tape during shipping. The customer will not want to purchase a package with the some of the image ripped off because they may think that the item inside is faulty or damaged at well.

Packages can be exposed to a variety of elements when being transferred from the printer to the company that needs to fill the package, to the store for selling and finally to the consumer. The package has to be able to withstand moisture to avoid warping the substrate it is printed on. Drops of water from rain can cause the ink to smudge especially if the packages are rubbing against one another when being transferred. Moisture that is sitting on top of the package substrate due to the ink not allowing moisture to absorb it can cause the substrate to warp.

It is important to understand how the type of ink used will affect the image printed on the package because customers will be unwilling to purchase a package where the image is destroyed. Testing printed ink to ensure it will withstand handling and transportation will eventually lead to a more environmentally friendly packaging system because the package will not have to be thrown away and reprinted if it is not destroyed upon arrival.

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BYE BYE ANILOX ROLL?

VERIFYING THE CLAIMS OF APEXS GTT INK METERING ROLLERS

MARK CORRIGAN

SOMMER JOHNSON

HANNAH PLAVNICK

ANDREW WONG

SCOPE

This test was conducted to determine whether a printed output on a narrow-web Comco Cadet flexographic press, when using channeled Genetic Transfer Technology (GTT) ink metering rollers, would result in reduced dot gain in detailed halftones and increased solid densities. The results are compared to a printed output using traditional 60° hexagonal cell anilox rollers. Related tests may include run-length (roller longevity), ink volume savings, solvent volume savings, and cleanup time.

ABSTRACT

Anilox rollers play an integral part in the quality of a printed image. They are designed to control the volume of ink that is transferred from the fountain roller to the plate during flexographic printing. Anilox rollers are generally etched with hexagonal cells, with specific cell counts and depths. The amount of ink transferred has a major effect on dot gain and density–two of the main properties that affect printed image quality. Among those in the flexo industry, it is a common frustration that different substrates and different types of images require the use of a range of anilox rolls with specific cell counts and depths to achieve optimal results.

In an effort to address the problem, Apex, a developer, producer and supplier of metering rolls to the graphic arts industry, has developed "intelligent" metering rolls that they call Genetic Transfer Technology (GTT). Unlike traditional anilox rolls, GTT uses "slalom" or wave-shaped canals instead of individual hexagonal cells. Apex claims their patent-pending design has the ability to print packages with both heavy solids, light halftones, and line work without the need to switch between anilox rollers as often (Apex, 2011).

This report attempts to rationalize the transition to GTT rollers over regular hex-celled rollers for flexographic printers by analyzing the GTT roller's effect on dot gain and density. Should we really say "Bye Bye" to anilox rolls, as Apex suggests?

Eight distinct samples are generated in this test: two Apex GTT rollers (XS and S) and two Harper anilox rolls (1000 LPI, 1.78 BCM and 800 LPI, 2.16 BCM) are tested, both on a clear poly laminate and a coated paper stock. Printed output was generated from a test form with a split 175 LPI and 150 LPI resolution, consisting of halftone screens and solids. This test focuses on single color printing, using cyan water-based flexographic ink. Printed samples were measured for dot gain and density. A Betaflex PRO 3 was used to measure dot gain. Density was measured with an Xrite 530 densitometer. Variability between each individual run was kept to a minimum whenever possible.

Our results indicate that the XS GTT roller has the lowest dot gain among all the rollers used. It also has an impressive ability to gradually fade to zero when printed on coated paper, as

demonstrated on the circle gradient located on our test form. No other roller was able to achieve this quality in the highlight areas. The XS GTT roller's ability to achieve good results among all target densities was very impressive.

It is important to note that the 800 LPI anilox with 2.16 BCM probably carries too much ink for a 150 LPI and 175 LPI image, so higher dot gain was expected for this roller. The S GTT shows similar dot gains in most areas, which leads us to believe that this roller is also intended for lower screen rulings. One exception for the S GTT is that is actually has lower dot gain than even the 1000 LPI anilox roll in dot areas of 60% or higher. The one clear advantage we can see from the S GTT is that it consistently produces higher densities.

Our results indicate that GTT ink transfer technology is not a set of "miracle" rollers that will print any given image perfectly. The XS GTT, for example, is capable of printing extremely fine halftone work, but a special bump curve would need to be created for its dot loss. For companies to switch to GTT rollers, extensive testing and press fingerprinting will need to occur. An increase in published research and standardization in this area will alleviate the hurdles associated with this transition, and may lead to increased adoption.

Foreseeable benefits from switching to GTT include being able to consolidate an anilox inventory, because each GTT roller can reliably cover a range of traditional aniloxes. They could also potentially decrease makeready times, for a number of reasons. If the GTT rollers cover a range of images (i.e. from detailed halftones to heavy solids), potentially fewer changeovers would be required. In addition, GTT rollers are easier to clean than traditional aniloxes, which means a slight decrease in washup time and cleaning solution volume.

INTRODUCTION

ANILOX HISTORY & DEVELOPMENT

Commonly referred to as the "heart of the flexo process," anilox rollers play an integral part in the quality of a printed image. Along with improvements to plate technology, they are a mainstay in the increasing development and popularity of the flexographic process. Starting back in the early 1900s, the aniline printing process, as flexo was originally known as, simply used two rubber rollers to transfer ink from the pan to the plate; the nip pressure controlled the ink film thickness (Trungale, 1997). The process was highly uncontrolled and produced poor quality results. Jumping ahead to 1939, the idea to mechanically etch cylinders to measure precise volumes of ink was introduced. It was largely based on the gravure process (Trungale, 1997).

Approaching the late 20th century, laser-engraving techniques began to replace mechanical ones. The patterns became more sophisticated and many variations were experimented. The wave pattern examined in this report is not the first in channel design. The concept was actually introduced in a high-walled engraving called Free-Flo® (Trungale, 1997). Other designs, such as the Roto-Flo, followed suit. The idea was to allow for more evacuation of ink from the roller so both process and line printing could be done on the same unit. These designs, however, were never widely adopted.

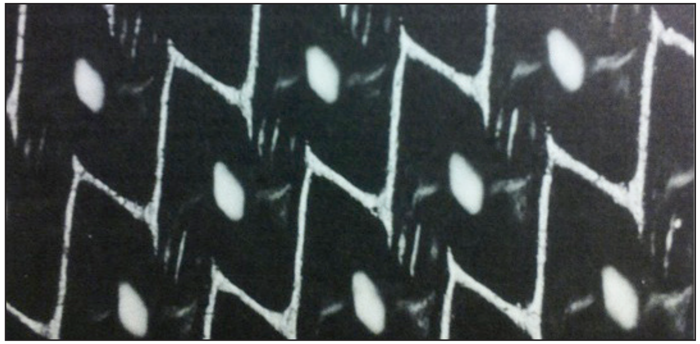


Figure 1 Roto-Flo®: example of an early concept in channel engraving based on a 26° angle (Trungale, 1997).

GENETIC TRANSFER TECHNOLOGY

Technological advances in the areas of plate imaging and roller engraving have led to widespread innovation and overall higher quality in the flexographic printing process over the last few decades. Better reproduction has thus led to further adoption of the process within the packaging industry and beyond. Among those in the flexo industry, it is commonly known that different substrates and different types of images require anilox rolls with specific cell counts and depths to achieve optimal results. Selecting the right anilox roller can be a difficult decision–often it is the experienced press operator who will make the final call. In an effort to solve this problem, Apex, a developer, producer and supplier of metering rolls to the graphic arts industry, has developed "intelligent"

metering rolls that they call Genetic Transfer Technology (GTT). Unlike traditional anilox rolls, GTT uses "slalom" wave-shaped canals instead of individual hexagonal cells. Apex claims their patent-pending design has the ability to print packages with both heavy solids, light halftones, and line work, without the need to switch between anilox rollers as often (Apex, 2011).

GTT technology could have a substantial impact on the flexographic industry; fewer parts and less task redundancy will provide cost efficiencies if GTT rollers are true to their claim. In addition, GTT technology promises higher quality printing, especially in areas that are typically problematic for traditional flexo printing. A new technology that can consistently deliver better print quality would only be beneficial to the industry. The Beginner Flexographer states that ink film uniformity "is the result of reducing the size of the spaces between [engraved] cells" (FTA, 1986, p. 47). A reduction in cell wall area is evident in the new GTT design.

In FLEXO magazine, Ed Emanus writes about the printability of photos on press. Not surprisingly, the first factor mentioned in the article is dot gain. "Dot gain flattens out and reduces contrast in [photographs], compressing the tones and highlights" (Emanus, 2011). One of the claims made by Apex mentions reduced dot gain–in fact, they say, "So long, pinholes, dot gain, mottling and haloing" on one of their marketing brochures (Apex, 2011). GTT is supposedly able to reduce dot gain because less ink volume is required and ink-to-plate transfer is more controlled (Apex, 2011).

GTT is a new technology and has not yet been widely adopted within industry. This report attempts to rationalize the transition to GTT rollers over regular hex-celled rollers for flexographic printers, through qualitative and quantitative testing measures. In other words, our aim is to put truth to the so-called "flexible nature" of GTT rollers. Should we really say "Bye Bye" to anilox rolls, as Apex suggests? Please see the included Apex marketing pieces for all GTT claims.

LINK TO PACKAGING AND EDUCATIONAL BENEFITS

Given the constantly changing nature of packaging, flexo technology must keep up at an ever accelerating rate. With the introduction of GTT, a great learning opportunity for students and industry professionals has presented itself in the form of an "all encompassing technology". As stated earlier, the GTT roller claims to eradicate many of the problems faced with traditional anilox rollers. Investigating these claims and learning about the purported benefits provides an enriched learning experience to students and industry members. If this technology is widely adopted by the industry, there is an opportunity to bring about many positive advancements in flexographic printing, in packaged products, and in related applications.

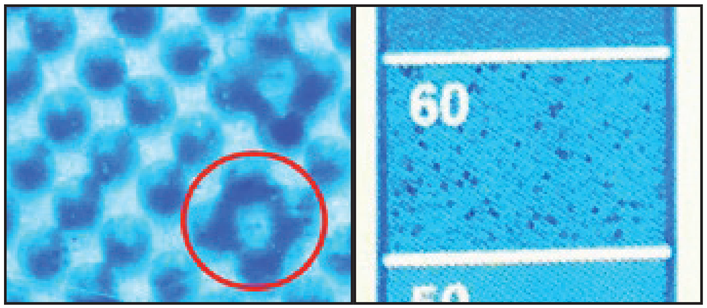


Figure 2 Dot bridging

DEFINITIONS

- *Bump curve:* Systematic adjustments made to the size of a plate's halftone dots prior to plate output. Adjustments are made in an effort to compensate for dot gain (loss) on press, i.e. to print linearly. This is especially important for flexo plates because of the compressible nature of rubber plate material.
- *Core:* The foundation of an anilox roll underlying the engraved, usually ceramic, surface layer. It is most often very durable and made of steel.
- *Conventional/traditional anilox rolls:* The most widely used type of ink metering roller at present. Rollers are engraved at 60° or 30° hexagonal cells, or 45° diamond cells.
- *Dot bridging:* The marriage of two closely spaced halftone dots on a printed output. Often caused by excess inking. The measures taken to avoid this print problem are key determinants in the anilox roll selection process.

- *Engraving:* The formation of cells or channels on the surface of a coated roller. There are two types of engraving: mechanical and laser. Instead of physically displacing the metal surface, laser engraving actually evaporates the surface, allowing for reduced spaces in between cells (walls) and a higher density of cells (FTA, 1986). GTT rollers use laser engraved "slalom" channels, while traditional anilox rollers use laser engraved 60° or 30° hexagonal cells, or 45° diamond cells.
- *GTT:* Genetic Transfer Technology. A new type of ink metering roller from Apex for the flexographic printing process. Roller types are categorized based on line screens; designated as either XS, S, M, L, or XL. As opposed to traditional 60° hex-cell-engraved anilox rollers, GTT rollers are engraved using a wave or "slalom" pattern.
- *Slalom channels:* As illustrated in the graphic on page 9, "slalom channels" are created using a wave-like engraving technique. These channels are said to reduce the stress cells put on ink, thereby "allowing ink to transfer evenly and consistently" (Apex, 2011). This is opposed to the inherent "aeration and turbulance [...] [and] uneven plate inking in convention anilox geometry" (Apex, 2011).

EQUATIONS

A= (M2-M1) X 100

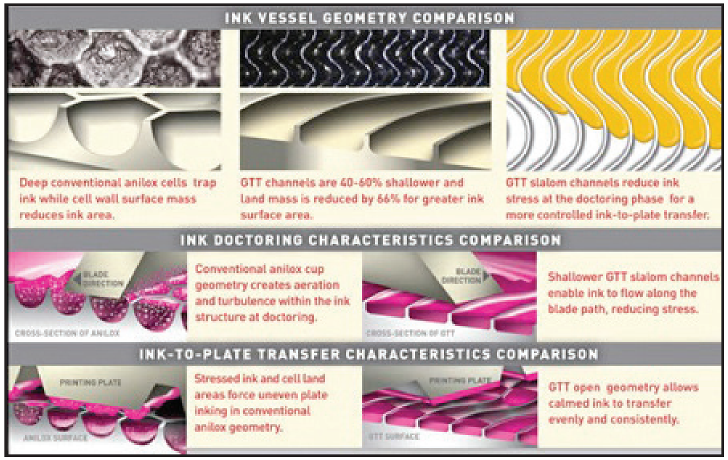
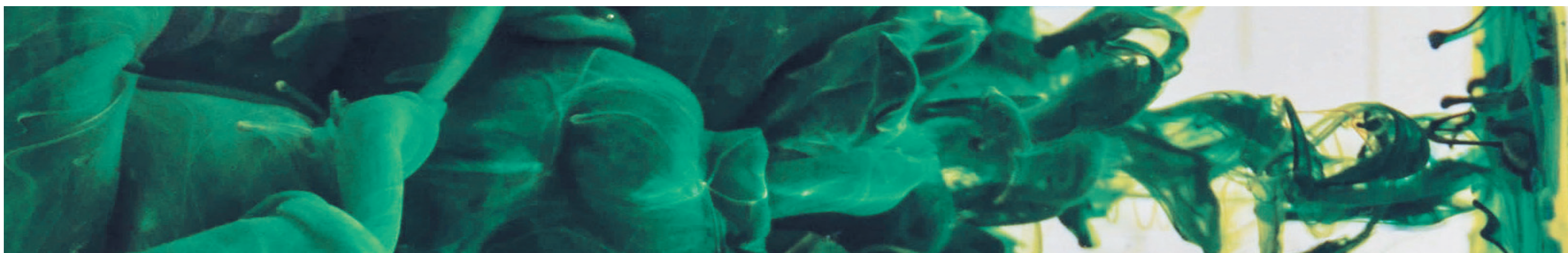


Figure 3 GTT roller anatomy from Apex's "Bye Bye Anilox" marketing website (Apex, 2011).



TESTING PRINCIPLE

Anilox roll selection plays a key role in the success of a pressrun. An essential requirement of an anilox roll is its ability to produce an image without dot bridging. Anilox roll selection is also fundamental to achieving desired colour strength (Malm, 2011). In order to produce high quality results, printers need to closely monitor the "tools and interrelationships that create a predictable, repeatable, controllable system" (FTA, 1986, p. 58). With controllable systems there is less waste and less downtime; this translates to a more profitable system (FTA, 1986).

This test primarily involves the measuring of dot gain. To measure dot gain, a Betaflex flexo plate reader is used to capture dot patterns on printed samples. The components of the reader include a macro lens, an imaging device, a light source, a base, a personal computer, and the Flex3 software. After inputting the line screen of the plate, the software is able to calculate the dot gain in a given tone patch. The resulting number indicates the % dot area of the sheet; it corresponds to the indicated tonal area. If, for example, a patch reads 53% in the 50% tone patch, a 3% dot gain can be inferred.

Betaflex measurement and analysis systems are among those highly regarded in the flexographic industry. They are used by numerous printers around the world. Using the device allows operators to observe both the original and reproduced dot pattern; both plates and printed substrates can be measured. This method is one of a few; densitometers utilizing the Murray-Davies formula can also measure the optical dot gain of a given patch (Lawler, 1997).

MATERIALS TESTED

- Apex S GTT 3.25-1.95 BCM, 650-1200+ LPI ink metering roller
- Apex XS GTT 1.90-0.95 BCM, 800-1500+ LPI ink metering roller
- Harper 1.78 BCM, 1000 LPI anilox roller
- Harper 2.16 BCM, 800 LPI anilox roller
- Poly substrate: Label Supply Extraclear TC LP-50 40# White Line
- Paper substrate: Label Supply Coated 60# Extrabrite/LP-205 (grain long)
- Ink: Wikoff Colour MWF-3660 HSHG LF PC Cyan (water-based)
- Plate: Thermal-engraved Dupont DPR, 2400 dpi (supplied by Agfa-Pitman)

EQUIPMENT USED

- #2 Zahn cup
- Hanna Instruments pH210 Microprocessor pH Meter
- Pentax K1WD Digital Camera with Carl Zeiss 6,3x (47, 50, 35) microscope
- PERET GmbH Flexo Plate Reader FLEX3 (Betaflex PRO 3)
- Xrite 530 Spectrodensitometer
- J.M. Heaford Video Plate Mounter
- Comco Cadet 700 7" narrow-web flexographic press

PROCEDURES

CONVENTIONAL ANILOX PRESSRUN PROCEDURE

1. Begin to prepare ink by pouring 800 ml of cyan into a beaker.
2. Test for pH. The target is between 9-9.5. The pH measured during this step was 9.2.
3. Using a Zahn cup, measure for viscosity. The target is between 25-30 seconds. 60 ml of water was added for a final viscosity of 28.1 seconds.
4. Take all necessary steps to makeready the press, including webbing and installing the inking system (ink trays, ink pans, fountain rollers, doctor blades, anilox rolls). For the first test, an anilox roll with a BCM of 1.78 and an lpi of 1000, and an anilox roll with a BCM of 2.16 and an lpi of 800 were used.
5. Measure and observe the dot shape of the plates using the Betaflex Pro 3.
6. Wash the back of the plate and plate cylinder with isopropyl alcohol for best adhesion.
7. Using a J.M Heaford Video Plate Mounter, mount all plates to plate cylinders with stickyback.
8. Install plate cylinders in the press.

9. Choose two substrates to run on press. In this instance, a Poly Extraclear TC LP-50 40# white liner (referred to throughout the report as "poly") and a Coated 60 Extrabrite/LP205 (re ferred to throughout the report as "coated") were selected for the run.
10. Splice the poly onto the web currently fed through the press.
11. Using the Comco Cadet 700 flexographic press, run the 800 lpi anilox first until optimal print quality is achieved.
12. Splice the coated substrate onto the press.
13. Run and adjust inking unit until optimal print quality is achieved.
14. Upon completing the first run, drain the ink and pour it into the 1000 lpi station (2nd unit).
15. Clean up the 800 lpi station (1st unit) to prevent spraying.
16. Run the 1000 lpi anilox, leaving the coated stock on press.
17. Once optimal quality is achieved, splice the poly substrate back onto the web.
18. Run the poly substate until optimal print quality is achieved.
19. Clean up the 1000 lpi station (2nd unit).
20. Analyze prints–discussed in Results.

GTT PRESSRUN PROCEDURE

1. Begin to prepare ink by pouring 800 ml of cyan into a beaker.
2. Test for pH. The target is between 9-9.5. The pH measured during this step was 9.2.
3. Using a Zahn cup, measure for viscosity. The target is between 25-30 seconds. 60 ml of water was added for a final viscosity of 28.1 seconds.
4. Take all necessary steps to makeready the press, including webbing and installing the inking system (ink trays, ink pans, fountain rollers, doctor blades, anilox rolls). For the second test,an XS GTT roller with a range of 1.90-0.95 BCM and an lpi range of 800-1500+, and an S GTT roller with a range of 3.25-1.95 BCM and an lpi range of 650-1200+ were used.
5. Measure and observe the dot shape of the plates using the Betaflex Pro 3.
6. Wash the back of the plate and plate cylinder with isopropyl alcohol for best adhesion.
7. Using a JM Heaford Video Plate Mounter, mount all plates to plate cylinders.
8. Install plate cylinders in the press.

9. Choose two substrates to run on press. In this instance, Poly Extraclear TC LP-50 40# white liner and Coated 60 Extrabrite/LP205 stock were selected for the run.
10. Splice poly onto the press.
11. Using the Comco Cadet 700 Flexographic Press, run the XS GTT roller first until optimal print quality is achieved.
12. Splice the coated substrate onto the press.
13. Run until optimal print quality is achieved.
14. Upon completing the first run, drain the ink and pour it into the S GTT roller station (2nd unit).
15. Clean up the XS GTT roller station (1st unit) to prevent spraying.
16. This time run the S GTT, leaving the coated paper webbed.
17. Once optimal quality is achieved, splice the poly substrate back onto the web.
18. Run the poly substate until optimal print quality is achieved.
19. Clean up the S GTT station (2nd unit).
20. Analyze prints–discussed in Results.

RESULTS & DISCUSSION

DOT GAIN CURVES

Readings were taken at the 1%, 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, and 90% tone scale patches.

FIGURE 4 DOT GAIN CURVES - 150 LPI ON POLY SUBSTRATE

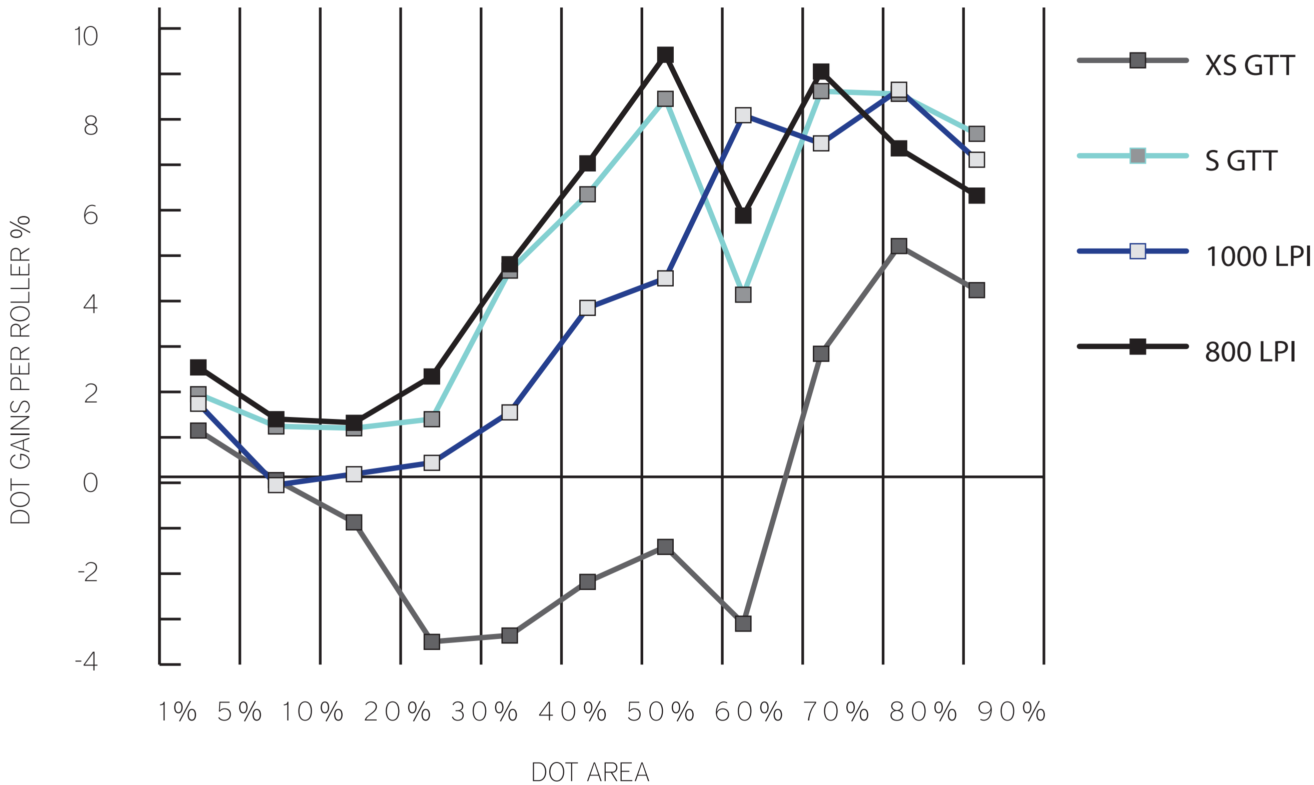


FIGURE 5 ACTUAL TONE REPRODUCTION VALUES - 150 LPI ON POLY SUBSTRATE

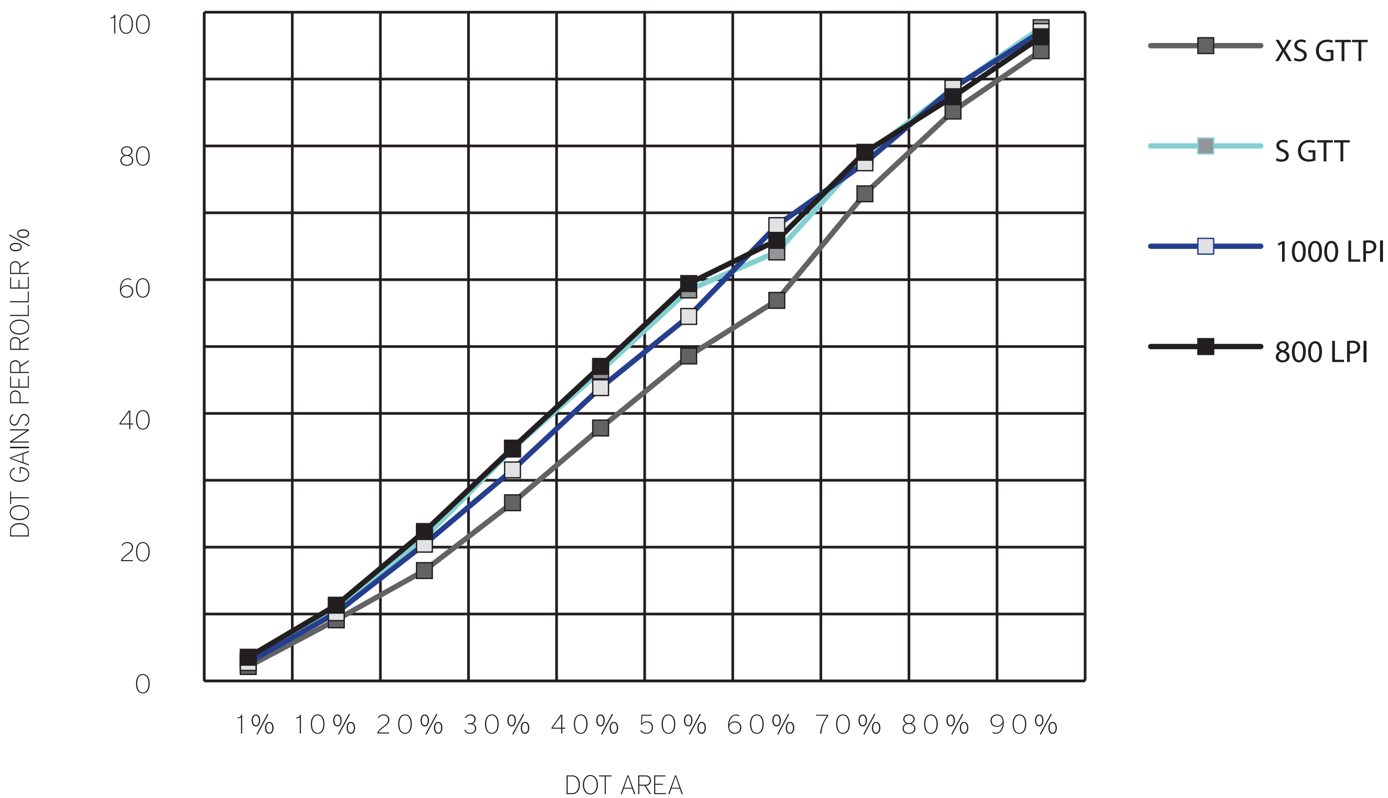


FIGURE 6 DOT GAIN CURVES - 175 LPI ON POLY SUBSTRATE

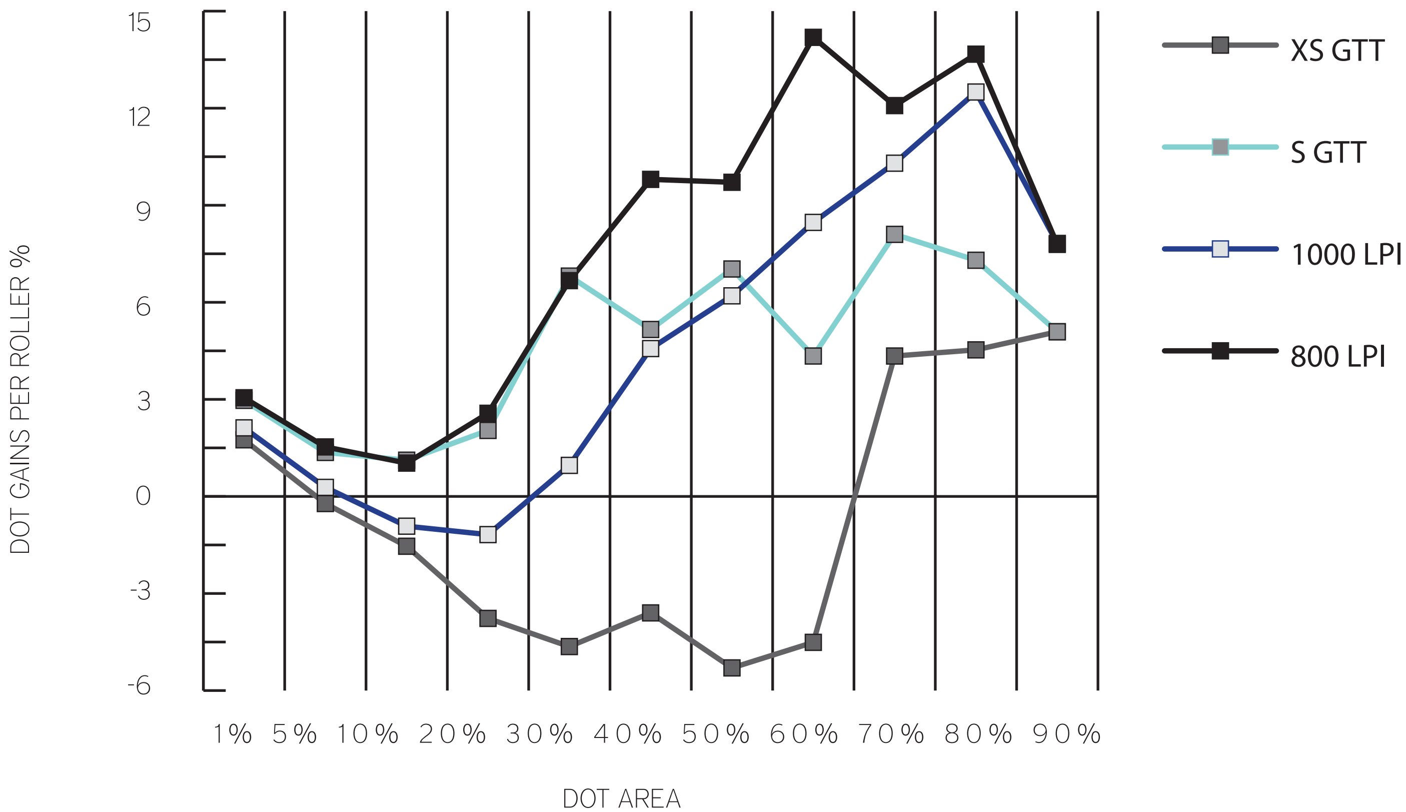


FIGURE 7 ACTUAL TONE REPRODUCTION VALUES - 175 LPI ON POLY SUBSTRATE

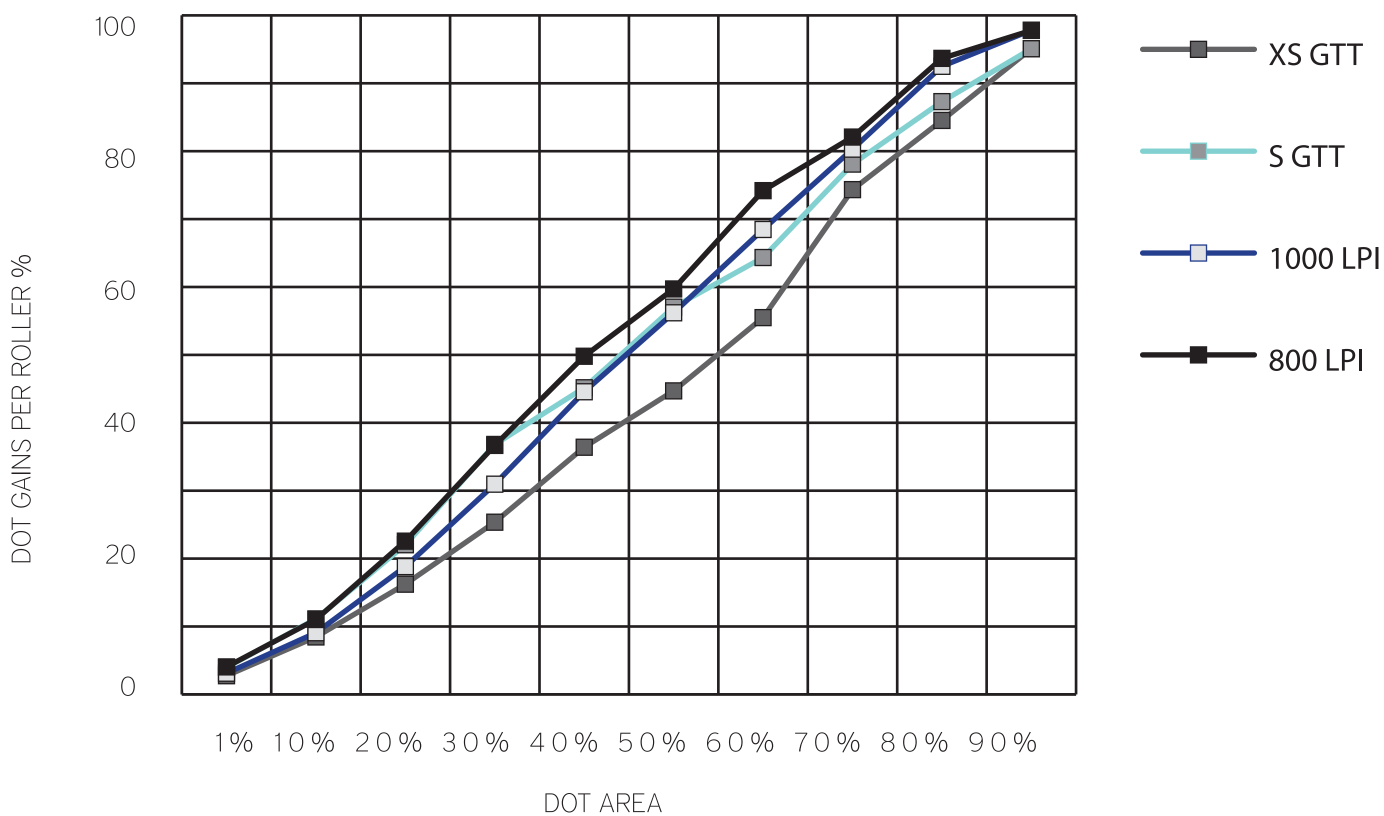


FIGURE 8 DOT GAIN CURVES - 175 LPI ON COATED SUBSTRATE

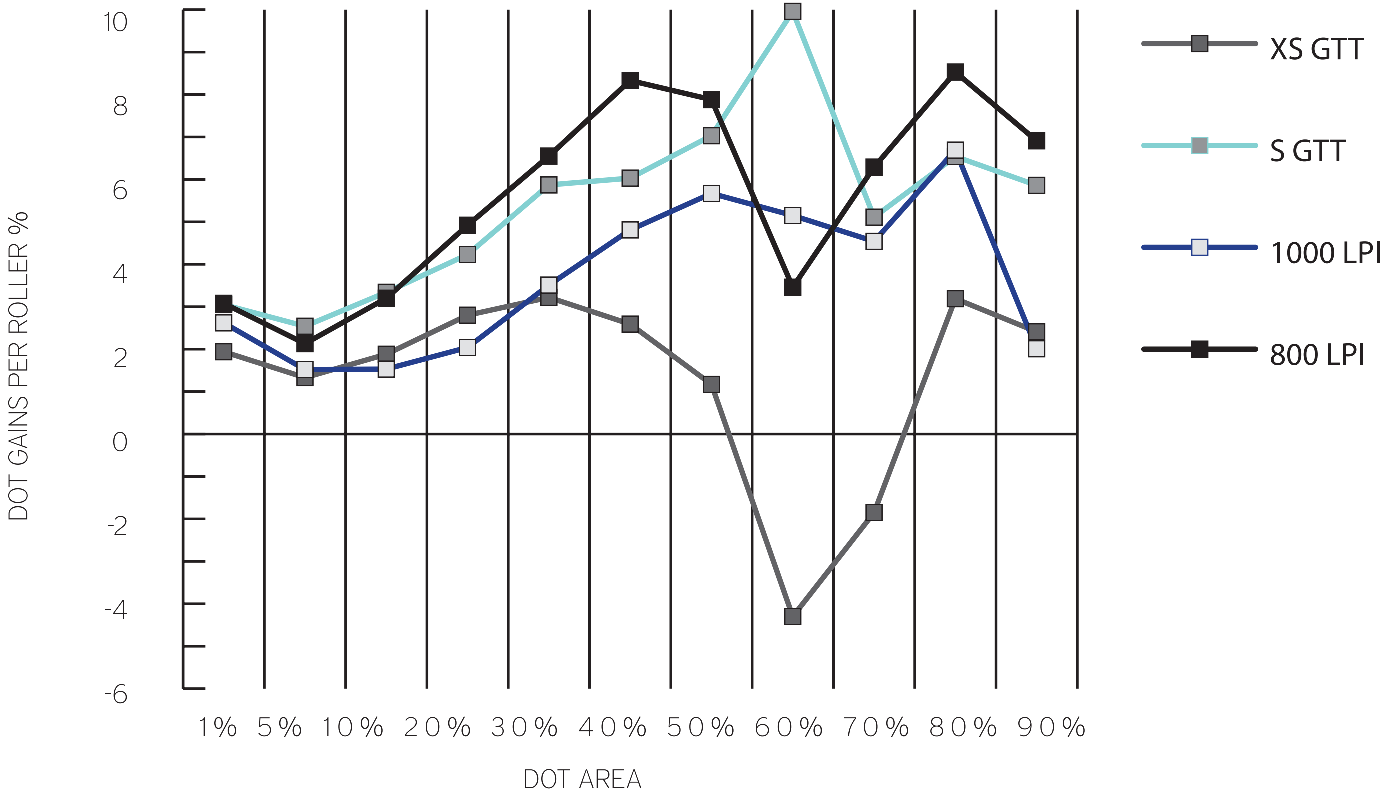


FIGURE 9 ACTUAL TONE REPRODUCTION VALUES - 175 LPI ON POLY SUBSTRATE

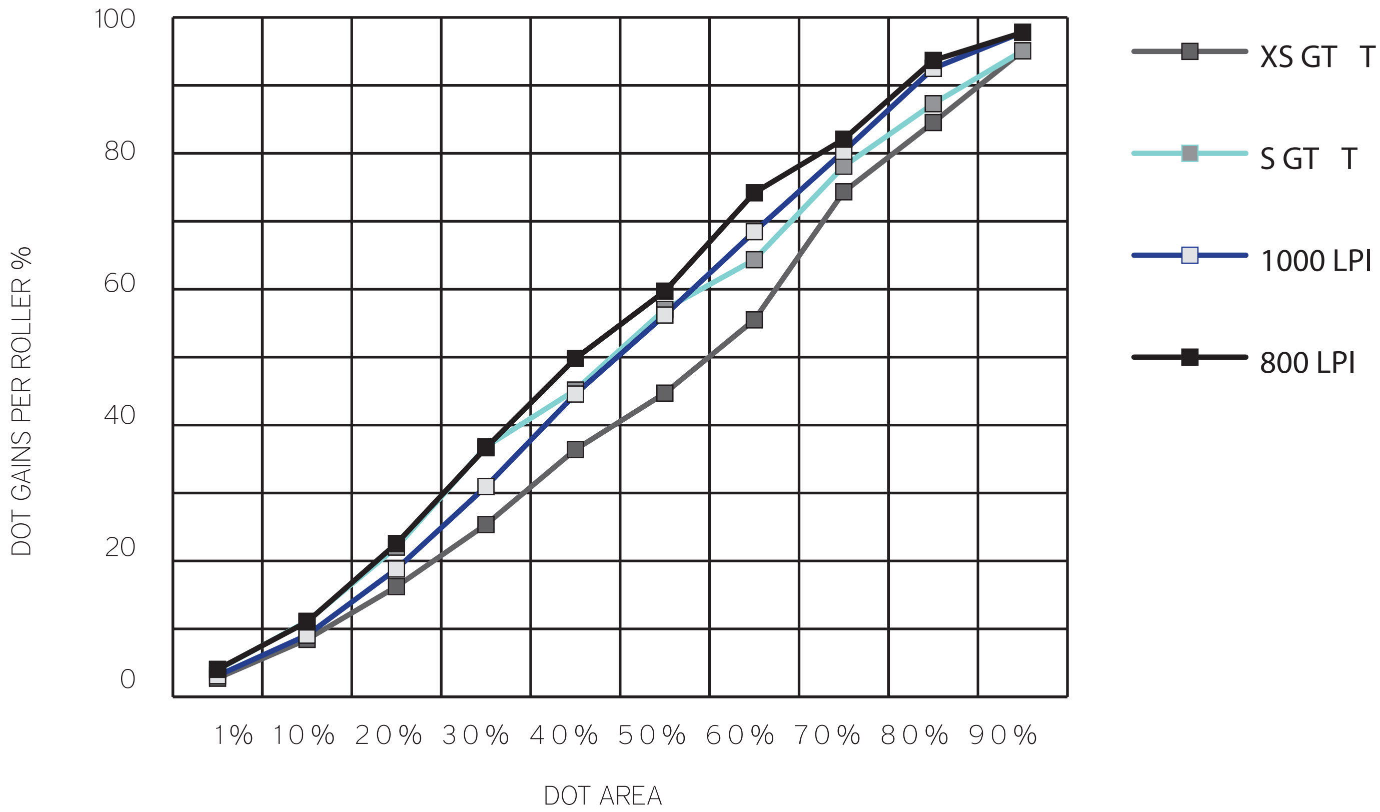


FIGURE 10 DOT GAIN CURVES - 175 LPI ON COATED SUBSTRATE

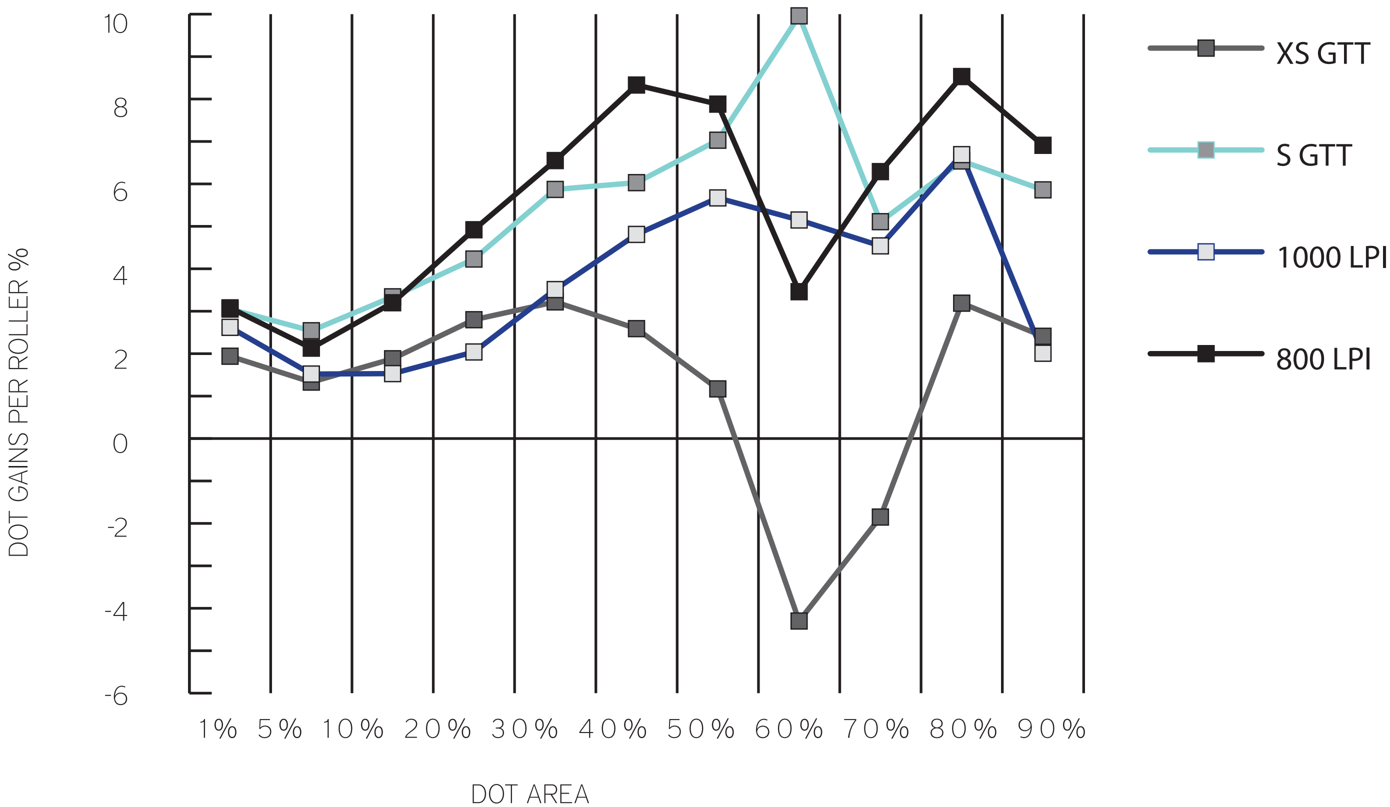


FIGURE 11 ACTUAL TONE REPRODUCTION VALUES - 175 LPI ON COATED SUBSTRATE

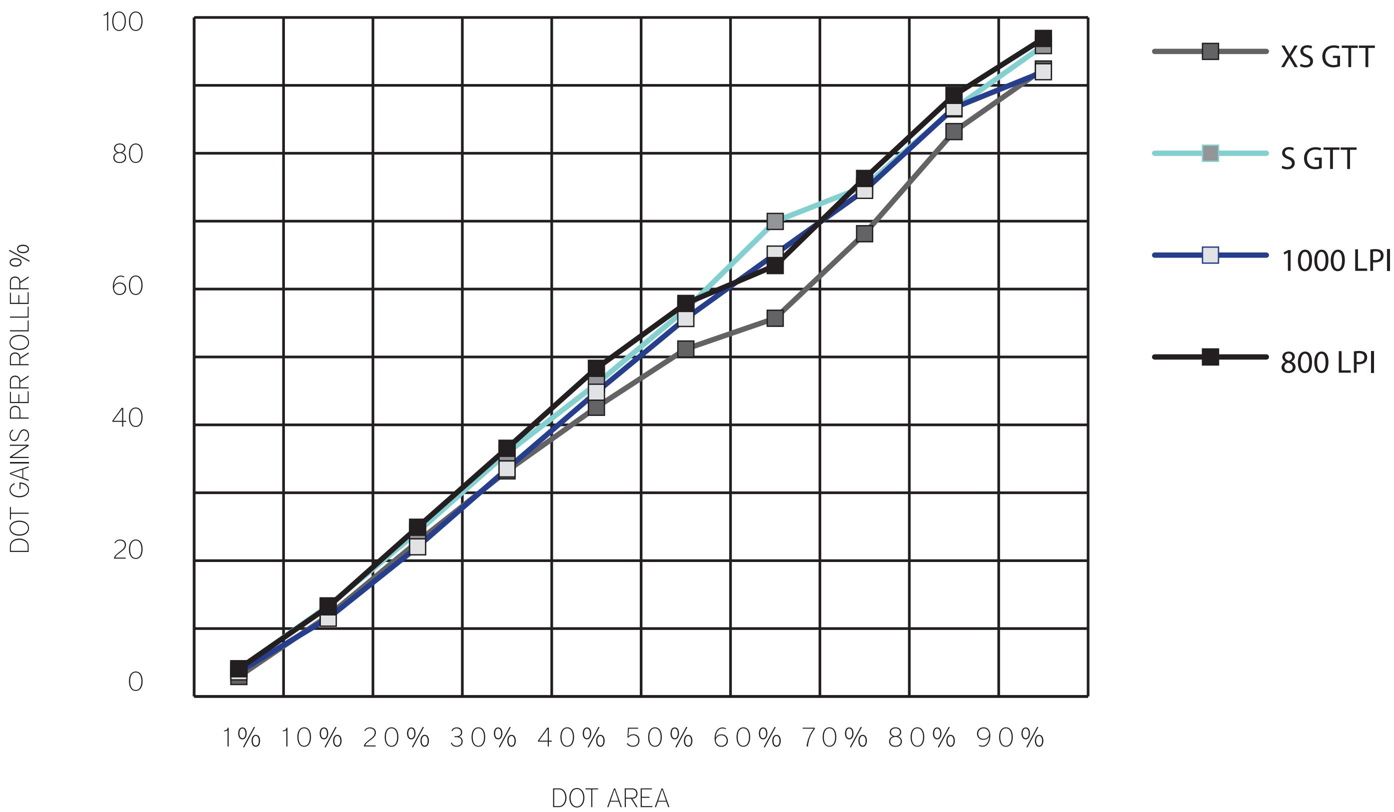


FIGURE 12 DOT GAIN CURVES - 150 LPI ON COATED SUBSTRATE

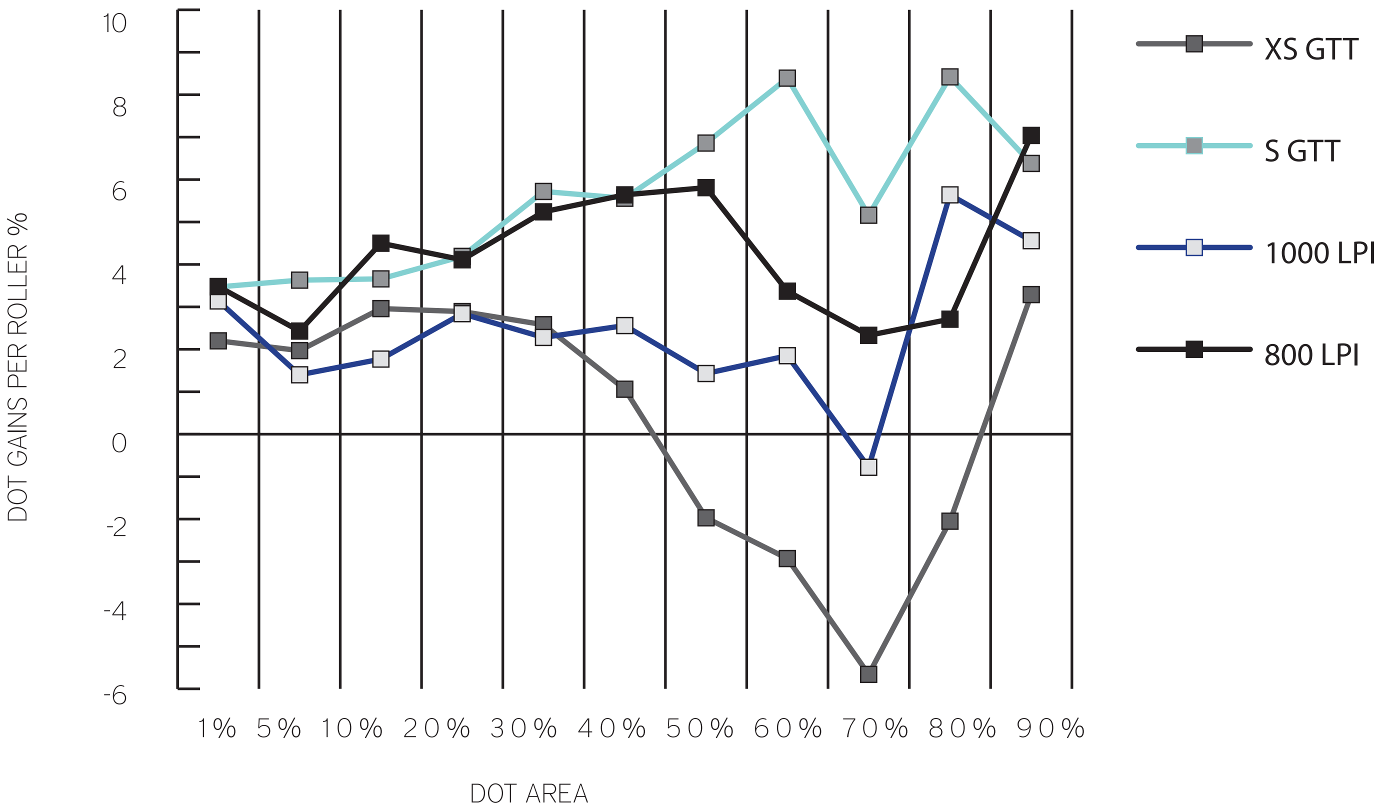


FIGURE 13 ACTUAL TONE REPRODUCTION VALUES - 150 LPI ON COATED SUBSTRATE

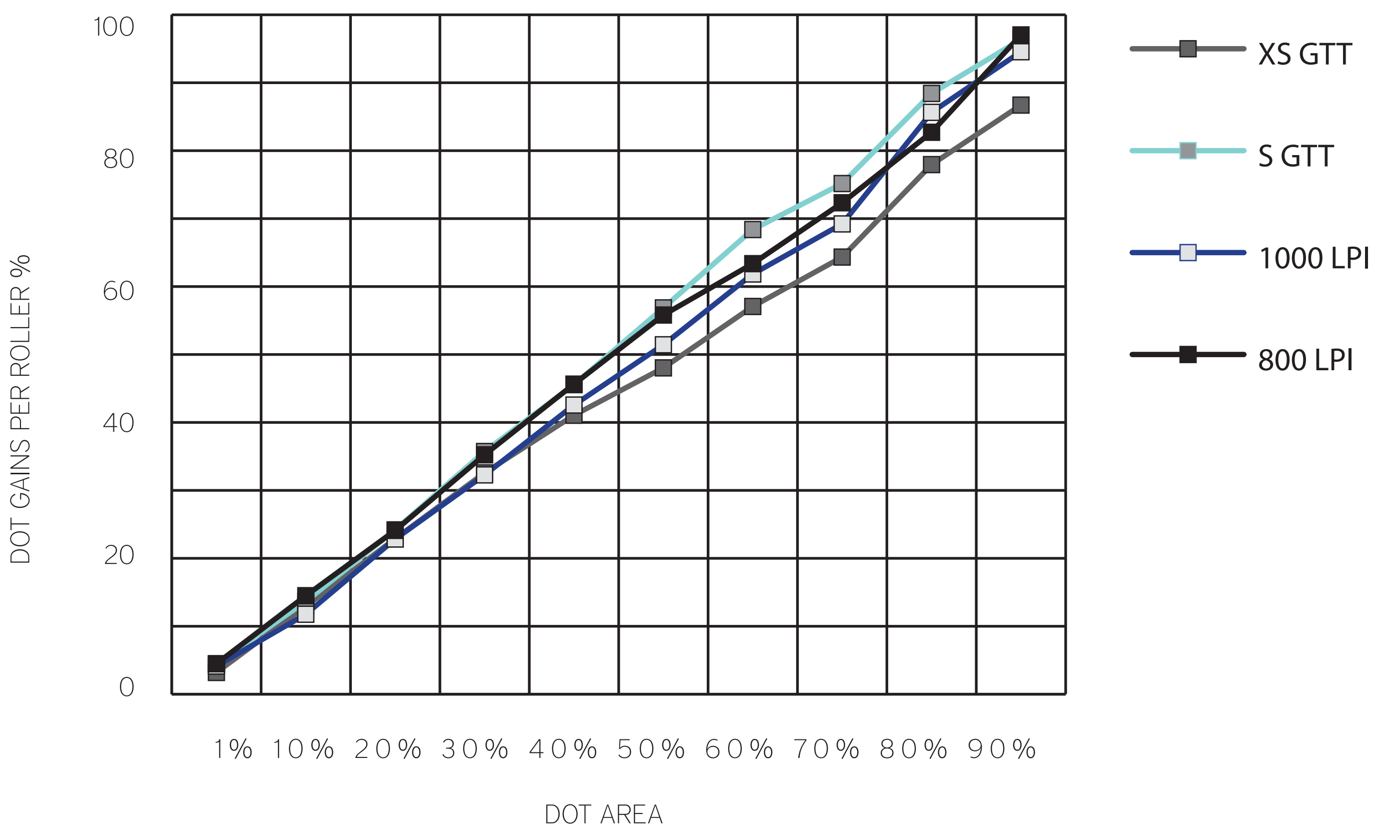


FIGURE 14 DENSITY READINGS

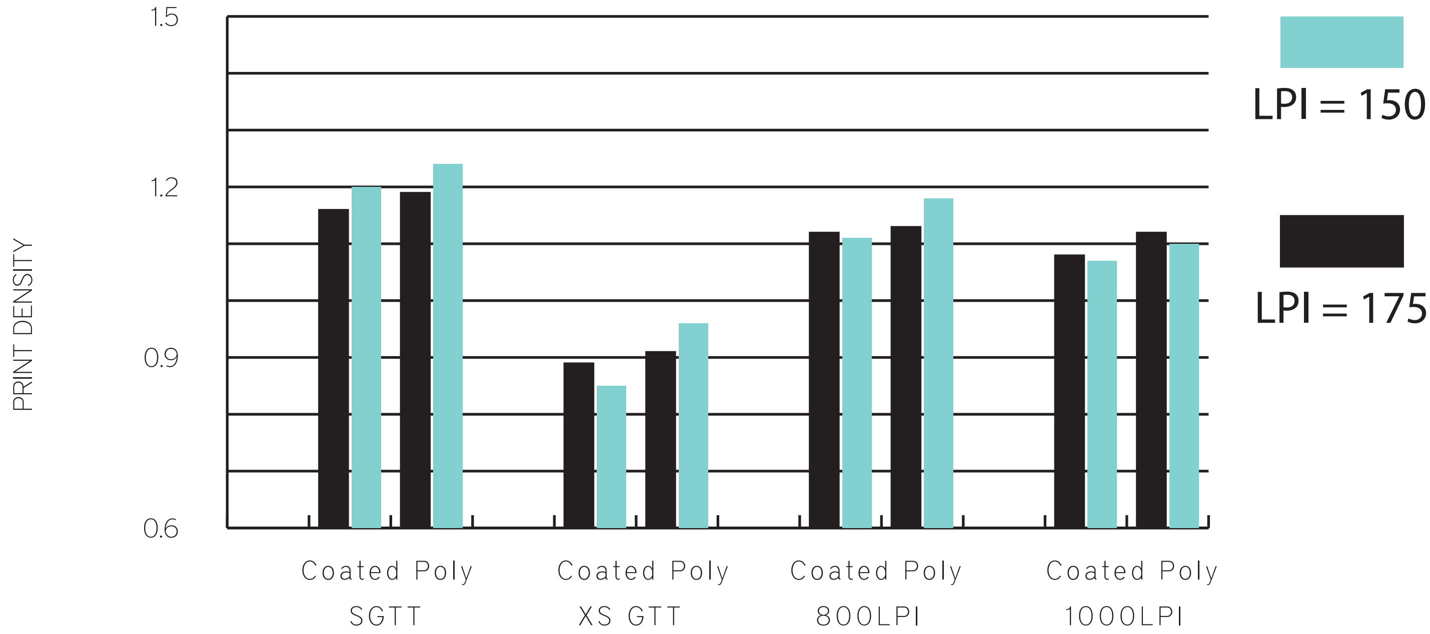


FIgure 15
Apex GTT "S" ink metering roller (6,3x magnification)

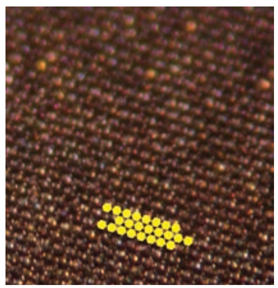


Figure 16
Harper 800 LPI, 2.16 BCM anilox roller (6,3x magnification)

On the coated paper substrate, we measured less dot gain in general than on the poly, as expected. In general, we were impressed with the visual performance of all of our tested ink transfer rollers. However, after conducting the test, we think that perhaps a 800 LPI anilox with a volume of 2.16 BCM is probably on the heavy side for 150 and 175 LPI plates. The S GTT roller also carried perhaps too much ink for the plates to transfer well. This can be observed most clearly in the 60% patch of the tint scale on both coated and poly substrates (see printed samples). This leads us to believe that the S GTT roller may be more suited for slightly coarser work. We would be very interested to see how the S GTT roller performs with a lower line screen plate–perhaps 120 LPI.

What impressed us about the S GTT roller is that it achieved the highest density ink film of all four rollers tested. In most cases, it was on par with the 800 LPI anilox in terms of dot gain. The only exception, surprisingly, was with the 175 LPI section of the plate on the poly substrate, where it achieved less dot gain than the 1000 LPI anilox in dot areas of 60% or higher (see printed samples).

Overall, the XS GTT roller is capable of printing very high quality work. The XS GTT roller consistently saw dot loss in the high midtones, which were typically the dot values where the other rollers had their highest dot gains. Perhaps one of the most impressive targets analyzed was the circle gradient. The XS GTT roller was capable of fading to zero phenomenally on the coated paper, given the other conditions and our press. All other tests created a harsh edge around the outside. Under magnification, we can see these outer dots being enlarged before zero.

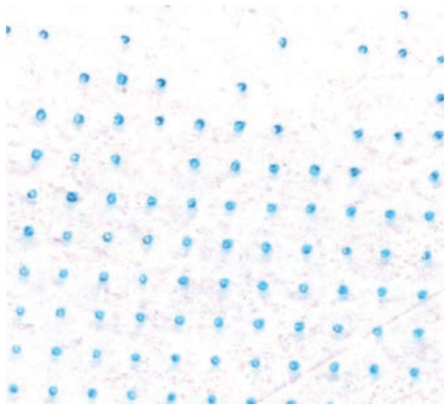


Figure 17 Enlarged dots before fading to 0%

SOURCES OF ERROR

Although our testing proved to be very informative and has given us insight into the possibilities for this new GTT technology, there are a few potential sources of error. We tested brand new GTT rollers against lightly used two-year-old anilox cylinders. In all practicality, the aniloxes were not as clean or in as peak condition as the freshly-engraved GTT rollers. This could mean that the actual volumes of our aniloxes were slightly less than the manufacturer's stated volumes. This in turn would change the amount of ink carried to the plate in our test.

Our test was focused primarily on how these different ink transfer rollers are able to reproduce fine halftone dots. We chose the stickyback accordingly: a 19 series tape from 3M, recommended for halftone dot reproduction. This tape is not the best choice for reproducing solids, as is very noticeable in our mottled solid patches. This mottle does not create the best surface for testing density, and does not tell us much about the ability of the ink transfer rollers to create dense solids. Testing this property, with the appropriate stickyback, would be an interesting next step.

RUNABILITY

Genetic Transfer Technology ink metering rollers proved to be advantageous to the flexographic printing process in our testing. Below is a list of benefits we noticed:

- Noticeably faster cleanup. While cleaning the rollers with flexo wash on the idling press, the solution tended to spread readily around the circumference. We can deduce this to the "open geometry" of the rollers; the solution flows more naturally down the channels than it would down rows of cells. Not only did this save cleanup time, less flexo wash was required, as well enlarged dots before fading to 0%
- Lighter rollers. While installing the GTT rollers into the Comco Cadet press, we found them slightly easier to handle. We took a minute to measure both types: the Harper rollers weighed about 11 lbs and Apex GTT rollers weighed about 7 lbs–a 4 lbs difference. unable to attribute this to the GTT engraving technique, however, since we were unable to verify the material of their cores. The core used in the manufacturing of our newly acquired rollers may be a recently developed material, and any conventional anilox roll could likely be manufactured from it, too. It would be an unsubstantiated conclusion to say GTT rollers weigh less than traditional ones.
- Fewer roller changes necessary. The S GTT roller proved to be able to print a combination of denser solids and higher-fidelity halftones than a single traditional anilox roller could. The graphic below from Apex's marketing website demonstrates the range comparison between traditional and GTT rollers.

RECOMMENDATIONS

PRINTABILITY

Apex claims their ink metering rollers help printers achieve a higher quality image. As discussed in Converting Today, Apex has actually gained "HD-Flexo certification from EskoArtwork for its patented GTT (Genetic Transfer Technology) and metering rolls developed especially for high definition printing. Apex is currently the only anilox roll manufacturer with this certification" (HD approval, 2011). "'Spectacular printing results' are said to have been achieved in numerous projects where Apex XS metering rolls and the new HD-Flexo technology were combined (HD approval, 2011). GTT-to-Anilox comparison guide from Apex's "Bye Bye Anilox" marketing website (Apex, 2011).

Below, we list our observations pertaining to the printability of GTT rollers:

- Quality of the S GTT roller. This is a versatile ink transfer roller that has high potential for the packaging industry. It has the widest range of capability of any of the GTT rollers. The XL and L GTT rollers, for instance, have a relatively limited target sector of extremely coarse line screens and high volumes of ink. The XS GTT roller is used primarily for fine line screens and halftone dots. The S GTT, however, is capable of delivering both a dense ink film and reproducing medium-fine line screens. This would make it a viable and reliable option for good print quality in the mainstream packaging industry.
- Quality of the XS GTT roller. As stated above, the XS GTT roller delivers great print quality for high line screen jobs. We foresee there being a definite market for these. For example, high-end labels like the wine and spirit labels would benefit from GTT technology due to the fine detail and quality measures required to produce them.

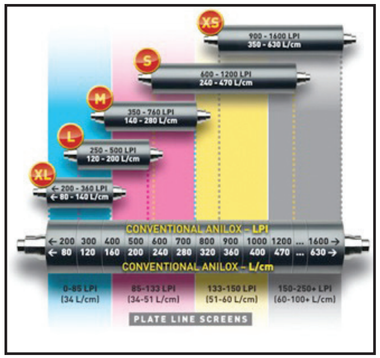


Figure 18 GTT-to-Anilox comparison guide from Apex's "Bye Bye Anilox" marketing website (Apex, 2011).

END-USE APPLICATIONS

Although the implications of GTT technology do not directly impact end-use, our group felt that through the integration of GTT technology, there is a possibility for increased rub-resistance. This is because slightly less ink is delivered to the substrate and, thus, less ink is available to rub off onto other packaged items. To support this claim, we referred to information in the graphic below, from the UK Wide Web Trial. In this study, testers noticed that the GTT technology used 27% less ink than a conventional anilox in the wide web printed samples. Tens of thousands of meters of substrate were run throughout the course of the trial.

CONCLUSIONS

The GTT ink transfer technology is not a set of “miracle rollers” that will do everything perfectly. It is still critical to evaluate the needs of a job with careful planning to get optimal results. There is a specific niche that we believe will eventually be dominated by GTT rollers, however. The XS GTT is capable of printing extremely fine halftone work, but a special bump curve would need to be created for its dot loss, and ink specially formulated for the thin ink film. For companies to switch over to using GTT rollers, extensive testing and press fingerprinting would need to be performed to know which rollers can be used in place of conventional aniloxes.

Foreseeable benefits from switching to GTT include being able to consolidate an anilox inventory, as each GTT roller can reliably cover a range of traditional aniloxes. They could potentially decrease makeready times as well, for a number of reasons. If the GTT rollers cover a range of needs, there would be potential to leave the same rollers in the press during changeovers. In addition, the GTT rollers are easier to clean than traditional aniloxes, which means a decrease in washup time and cleaning solution volume.

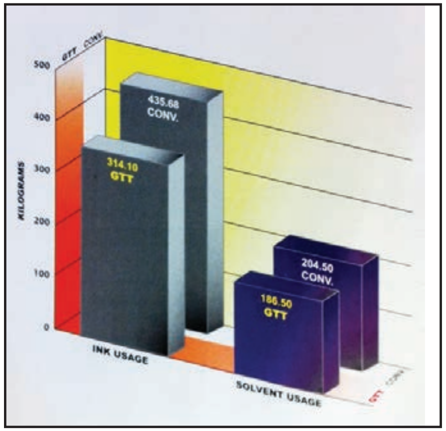


Figure 19 UK Wide Web Trial: GTT vs. conventional anilox roller testing in FLEXO (Fountain, 2011).

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CO-PRESIDENT

TRUNG NGUYEN

I have always been interested in digital media and print and it is my understanding that the industry is undoubtedly changing with the introduction, popularity, and interactivity of the digital landscape. Being involved with RyeTAGA has been one of the most challenging experiences in my undergraduate career. As co-president I could not ask for a better executive team and I am grateful for all the contributions of the general members.

With the successful completion of this journal, a milestone for us has passed, but I hope to further enhance my skill of exchanging diverse viewpoints and informed opinions in a professional context; this is a necessary skill in any sector of work. To me, this position was more than an agent for entering the field. It has trained me to analyze situations from multiple angles to lead an executive team into success. I am positive that the accomplishments we achieved this year will resonate for years to come.

CO-PRESIDENT

MARK BREJNIK

As a member since first year, RyeTAGA has not only been a great learning experience, but has also given me many opportunities to apply my education in a more practical environment.

I cannot begin to explain how much time and effort our team has put into the production of this years journal. As co-president, I would like to thank the RyeTAGA executive team for all their hard work and commitment. Commitment to each other has been a driving force for our team and it has given us the energy to create this amazing journal.

RyeTAGA would not be where it is today without the amazing support from the many members of our faculty, industry, and student body. I would like to sincerely thank all of our supporters, and I hope you enjoy reading our journal.

CREATIVE DIRECTOR

TRACY TA

Being involved with RyeTAGA this year has given me the opportunity to apply my creative visions to our organization's image through rebanding, designing and creating our sponsorship packages and promotional products as well as our main initiative - the technical journal. It has proven to be an incredibly challenging and rewarding experience. We're trying something a little different this year which is both a tad frightening and very exciting but with great risks comes great rewards and I hope that all our efforts are recognized at this year's conference.

MULTIMEDIA DIRECTOR

FARIS ABU-KWIEK

Being involved with RyeTAGA was a rewarding experience. I was able to apply the skills that I have gained from my previous education, prior to Ryerson University in multimedia design and production. As the multimedia director, my main responsibility was to give RyeTAGA a website that presents us with professional manner within the industry. One of my other responsibilities include controlling all of our social media outlets, which I enjoyed doing. Along with the help of my multimedia team, we will be exploring the opportunity of outputting an electronic journal so it can be viewed on various smartphones and tablets. None of this would have been possible without the support of our dedicated team.

PRODUCTION & EDITORIAL DIRECTOR

ALYSSA SZETO

RyeTAGA has been one of the most enriching experiences of my university career so far. I have learned how important it is to have a great team support a common goal in producing a journal we can all be proud of. My position of editorial and production director could not have been accomplished without the help of the other executives and especially all the general members who have put in many hours in the press lab and bindery. The whole process of this journal, from concept to finishing, was a challenging but extremely rewarding task. A lot of hard work has been put into this year's journal, and I am extremely proud of what RyeTAGA has been able to accomplish.

FINANCIAL DIRECTOR

STEPHANIE MURRAY

I am very grateful for my decision to join RyeTAGA last spring. Being able to work with such a great team of executives and general members has been a very valuable learning experience - personally and educationally. I learned skills in college that have played a part in my role as the financial director. I am responsible for recording meeting minutes, applying for grants and sponsorships, preparing our budget and financial plans, and planning travel arrangements. While a lot of this is independent work, I'm also working alongside all the other team members to produce a journal that we're proud of; we truly come together to run a great committee.

MARKETING DIRECTOR

SOMMER JOHNSON

The RyeTAGA team has worked incredibly hard to bring forth this publication. Many hours were put into all aspects of the creation of this journal through multimedia efforts, production considerations, creative layout and much more. My role throughout this process, in my fourth year of studies and as the marketing director, was to draw upon my knowledge and apply marketing principles and brand concepts to help further the RyeTAGA legacy. It is our pleasure to present this years technical journal. I sincerely hope you enjoy reading it.

FUNDRAISING DIRECTOR

ALINA ESMATYAR

I am a second year student at Graphic Communications Management, and have been honoured with being apart of RyeTAGA this year. Its been a pleasure to create this journal with my team! As the Fundraising Director, I have tried my best to help with events and implement them as best as I could. I make sure that the events are to let the GCM family know what RyeTAGA is and how they can help us out with creating this journal. As a member of RyeTAGA, there were times where the team has lost sleep to get through deadlines, but thats the greatest part of being a member of RyeTAGA, we work together and get things done.

FACULTY ADVISOR

MARTIN HABEKOST

Being the faculty advisor to the RyeTAGA student chapter is one of the perks of being a professor at the School of Graphic Communications Management. I enjoy seeing how the team grows together in the common goal of producing a fantastic journal. I also like the fact that student from all years of our program are in the student chapter. I look forward to the upcoming conference in Portland. It will be a rewarding experience.

COLOPHON

This journal was created by the students of Ryerson University Student Chapter of the Technical Association of Graphic Arts. RyeTAGA team members were an active part of every step of production. Industry assistance, facilities and equipment were employed in production where indicated below.

TYPEFACES

District
Blanch
News Gothic Condensed

STOCKS

Neenah Red 80lb cover
Zebra 100pt black binders board
Williamsburg 70lb offset

BINDING & FINISHING EQUIPMENT

Stahlfolder 1220E at Ryerson University
Polar 78 cutter, Heidelberg 137XT & 76 Cutter
at Ryerson University
Perfect bound with Heidelberg Perfect binder at RP
Graphics Group, Mississauga, Canada

SOFTWARE & EQUIPMENT

Adobe Creative Suite 5.5 and 6
Kodadk Preps 6
Kodak Prinergy
EFI Fiery
Nikon D90
Kodak Magnum 800 Platemaker at Ryerson University
Heidelberg PM74-4-P offset at Ryerson University
Xerox Docucolor 7000 at Ryerson University

SPONSORS

Kallima Paper

P-FACS

Don Black Linecasting

Emotional Photons

RP Graphics Group

Ryerson University

IAPHC

Fujifilm

PNH Solutions

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