M3 is for Controlling Metallics

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Abstract

The purpose of this research is to demonstrate that the M3 measurement condition should be used for controlling metallic inks on press. In this research, lithographic and flexographic metallic inks were printed with the Prüfbau Printability Tester and the Phantom Proofer. The tested inks were also printed on an offset press and on a flexographic label press.

Results showed that the X-Rite eXact and Techkon SpectroDens measuring devices, operating in the M3 mode, best capture the density values regardless of the color of the metallic ink being printed. Legacy densitometers with a polarization filter capture changes in the printed ink film thickness as well, but in future M3 mode compliant measurement devices should be used for controlling metallic inks on press.

The metallic inks were not only printed on coated paper, but also on cardboard stock to simulate the use of this substrate in the folding carton industry. The results demonstrate that the substrate does not influence on the measurability of the metallic inks.

A gloss water-based coating was applied to all printed samples to see if there is any influence on the measurement of the printed ink film density or colorimetric values. Since the results show that the coating has little effect on the measured densitometric or colorimetric values, the M3 mode can be used for controlling metallic inks on press, even with the application of a protective gloss water-based coating, like it is often done in the folding carton industry.

In addition, the ΔE values from the flexographic metallic ink press run illustrate that there were only small color variations between the coated and non-coated print samples. Thus, the application of a gloss water-based coating does not influence

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the density values and the M3 measurement conditions can be used to measure flexographic metallic inks as well.

The colorimetric values of the printed metallic colors were examined and the results show that the application of the water-based coating does not cause significant change in the L*a*b* values.

The main result from this study is, that a measurement device that is M3 measurement mode compliant, as outlined in ISO 13655, can be used for the control of metallic inks on press. Since modern spectrodensitometers capture the reflectance curve from the color sample, which in turn is converted mathematically into printed ink density, colorimetric values, mainly the L*-value of the sample, or the densitometric values can be used to measure and control metallic inks on press. The measurability of metallic inks is not influenced by the ink type, whether it is offset or flexographic ink.

The M3 measurement mode is the measurement mode of choice for controlling metallic inks on press.

Theory & Introduction

Metallic inks have been used in the graphic arts industry for quite some time, but it was not possible to control metallic inks on press like four color process inks can be controlled with the use of densitometer or spectrodensitometer. The graphic arts industry uses measurement devices that employ the 0/45 or 45/0 measurement geometry. This measurement geometry works very well with four color process inks, but not with metallic inks. The reason for this is the metallic flakes in the metallic ink. The metallic flakes give a strong reflection of light back to the measurement sensor, resulting in erroneous readings. Due to these erroneous readings, a regular densitometer cannot be used to measure metallic inks on press.

Many studies have been done in the past to see what kind of measurement instruments can be used to measure metallic inks on press. Mannig and Verderber (Mannig & Verderber, 2002) and Ploumidis (Ploumidis, 2006) came to the conclusion that a densitometer equipped with a polarization filter in the measurement head can be used to measure metallic inks on press. The polarization filter made the densitometer more sensitive to changes in the printed ink film thickness. Ploumidis (Ploumidis, 2006) also suggested to switch from status T filter to status I filters to increase the sensitivity of the densitometer.

In 2008, Breede and Sharma (Breede & Sharma, 2008) evaluated multiple instruments to see if they can be used to measure changes in the printed ink film thickness of metallic inks. The authors used a multi-angle gloss meter, a densitometer and a spectrophotometer. Their outcome of their research was that the gloss-meter cannot be used for tracking changes in the printed ink film thickness. An important outcome of their work was, that the L*-readings of the spectrophotometer can be used for controlling metallic inks on press. Breede and Sharma also stated that any of the density channels (C, M, Y, V) can be used to track the printed ink film thickness. The only drawback of their study was that only silver metallic ink was used.

In 2010 Habekost and Dykopf (Habekost & Dykopf, 2010) did a study of 25 metallic inks and three instruments for the evaluation of metallic inks on press. As in Breede and Sharma's study a glossmeter was used, but also a densitometer with a polarization filter and a sphere-geometry based spectrometer. The study had a few outcomes:
a.) gloss measurements taken at a 60º angle gave usable results, but the metallic inks needed to contain more than 50% of metallic content for meaningful results, and b.) the cyan density values from the densitometer with a polarization filter could be used to track the printed ink film thickness. The study also showed that there were visual differences between printed samples deemed acceptable and the measured ink density of the same color in the Pantone® metallic book.

In 2016 Habekost & Andino (Habekost & Andino, 2016) conducted a study on 9 metallic inks and used two spectrophotometers that could be switched to the new M3 measurement condition. The M3 measurement condition is defined in ISO 13655 (ISO 13655). The ISO 13655 lists four M-mode measurement conditions. These conditions are as follows:

- M0 – legacy mode (any illumination source, tungsten lamp commonly assumed);
- M1 – D50, UV-included mode (devices can use two different methods to achieve this mode);
- M2 – UV-cut mode (removes all UV light from the measurement system, below 400 nm);
- M3 – polarizing mode, same as M2 but with two orthogonal polarization filters. One filter is in front of the light source and one filter is in front of the measuring sensor. This mode can be used for the measurement of wet offset press sheets and effect inks.

The M-mode measurement conditions are well described in a white paper by Cheydleur & O'Connor (Cheydleur & O'Connor, 2017). The M3 measurement mode uses polarization filters the eliminate the influence of the metallic glare on the color measurement.

For this project four measurement devices were used. Two of the measurement devices were densitometers with a polarization filter and two devices were spectrodensitometers that could be switched to the M3 measurement condition.

This research work in this project was conducted to confirm the findings from the 2016 study, but also to see if flexographic metallic inks could be measured. The difference between offset and flexographic metallic inks is, that the metallic flake in the flexographic ink is much larger than in the offset ink, offering more possibilities to give a strong light reflecting back to the measurement sensor.

Another aspect of this project was also to find out if the substrate has a significant influence on the measurability of the metallic inks.

This project also aimed to find out how the measurements of the polarized densitometers correlate with the M3-mode capable instruments.

Experimental

Before the experimental procedures will be introduced and results analyzed, a list of the equipment and materials is shown.

List of equipment:

- Prüfbau Printability Tester
- X-Rite eXact
- Techkon SpectroDens
- Koeth Chameleon densitometer with polarizing filter
- X-Rite 528 with polarizing filter
- Heidelberg QM46-2 offset press
- Comco Cadet Model 700 flexographic label press
    - 3.52 BCM, 440 LPI
    - 4.21 BCM, 360 LPI
    - 3.57 BCM, 440 LPI
    - 4.52 BCM, 360 LPI
- Phantom Proofer with 7 anilox rollers:
    - 8.0 BCM, 260 LPI
    - 6.0 BCM, 260 LPI
    - 5.5 BCM, 360 LPI
    - 4.5 BCM, 360 LPI
    - 3.5 BCM, 440 LPI
    - 3.5 BCM, 360 LPI
    - 2.8 BCM, 550 LPI

List of materials:

- Paper for prints:
    - Supreme Gloss Offset 24 x 36 182M, 100lb, 148g/m2
    - Carolina C1S, 12 pt. 18 x 12 145lb, 235g/m2
- Background measurement paper:
    - Kromekote Offset 23 x 35 102M, 60lb, 89g/m2

- Inks:
  - P8203 Blue from Wikoff
  - P8682 Green from Wikoff
  - P8063 Pink from Wikoff
  - P877 Silver from ColorLogic
  - P874 Gold from Hostmann-Steinberg*
  - P8180 Blue from Wikoff
  - P8824 Purple from Wikoff
  - P8943 Orange from Wikoff
  - P877 Silver flexographic ink from Eckhart (Rotostar AQUA FP-06-40651)
  - P874 Gold flexographic ink from Eckhart (Rotostar AQUA FP-06-70454 874)
  - P8223 Blue (hand-mixed using 40% P877 Silver and 60% PANTONE Pro. Blue from Siegwerk)
  - P8283 Green (hand-mixed using 40% P877 Silver and 60% PANTONE Green from Siegwerk)
  - P8761 Blue (hand-mixed using 40% P874 Gold and 60% PANTONE Pro.Blue from Siegwerk)
  - P8723 Green (hand-mixed using 40% P874 Gold and 60% PANTONE Green from Siegwerk)
- Gloss water-based coating:
  - Flint General Purpose (XN913-1102)
- Pantone® Metallic Ink Book

  * = Hostmann-Steinberg is now known as hubergroup

List of software:

- X-Rite eXact DataCatcher (1.0 2580)
- Techkon SpectroConnect (Version 2.5.3)
- MS-Excel for PC/Mac
- PCs with Windows 7 & 10
- MacBook Pro with OSX 10.12.3

In this project four measuring devices were used - the Koeth Chameleon, an X-Rite 528 with polarization filter, an X-Rite eXact and Techkon SpectroDens. The first two instruments are legacy devices and the last two are devices that comply with the M3-measurement condition. There was a good reason for using the two legacy devices. The reason was to see how the measurements from these devices correspond with the measurements from the two newer devices. Another part of the study is also see how the application of a gloss water-based coating influences the L*a*b*-measurements and/or the density readings.

This study encompassed several parts. In the first part of the study, 8 lithographic metallic inks were chosen from the Graphic Communications Management basement lab. These colors were printed on coated paper using a Prüfbau printability tester. The target density of the colors were determined by measuring the Pantone® metallic book with the eXact M3 mode. After this was achieved, consecutive prints with declining ink film thickness were produced. Next, eight out of the nine previous inks were printed on cardboard substrate with the Prüfbau printability tester. The prints on coated paper and on cardboard were coated also with a general gloss water-based coating.

The metallic ink samples were half-covered with the gloss water-based coating used in this study. Then, the density values of the gloss coated and the non-coated sides of the printed samples were measured using the four devices (eXact, Techkon, Cameleon and 528).

In the second stage, silver, gold and two hand-mixed flexographic colors were printed on coated paper with the Phantom Handproofer. In addition, silver and one hand-mixed colors were printed on the cardstock substrate used in this study. Next, a water-based coating was applied to all of the printed samples. The density and colorimetric values of the coated and non-coated density values were measured using the eXact and the SpectroDense devices.

In the third stage, 4 flexographic metallic inks (Silver, Gold and 2 other hand-mixed colors) were printed on the Comco Cadet Model 700 press with anilox rollers that had a volume of approximately 4 BCM. The first press run was with the hard tape (3M, 18-series) and the second run was with soft tape (3M, 19-series). A water-based coating was applied to each colors and all the density and colorimetric values were measured using the eXact and Techkon devices.

In the fourth stage, the press sheets from the 2016 study were re-evaluated again with the four measurement devices used in this study. Six metallic colours, P874 gold, P877 silver, P 8203 blue, P 8682 green, P 8824 purple and P8063 pink. The six ink colors were measured using the four devices (eXact, SpectroDens, Chameleon and 528) for further density and colorimetric trend analysis.

Results

In the first part of the study, P 877 silver and P 874 gold were printed on coated paper and measured with four measuring devices (Chameleon, 528, SpectroDens and eXact). The visual comparison of these density measurements can be seen in figure 1 and 2.

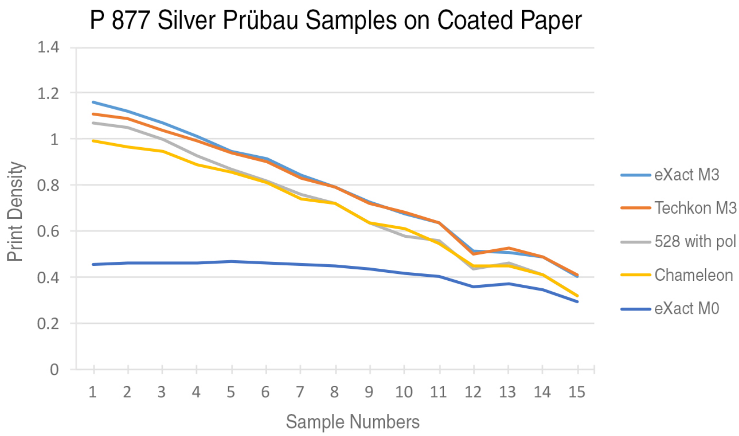

***Figure 1:** The density measurements of P 877 Silver Prüfbau samples with the eXact (M3, M0), SpectroDens (M3), 528 and Chameleon*

From figure 1 it can clearly be seen that the M0 measurement mode does not capture very well changes in the printed ink film thickness of the silver ink. It is interesting to see that the two legacy instrument capture quite similar density values. The two instruments using the M3 mode measure also quite similar, with the eXact measuring slightly higher density values than the SpectoDens, but both instruments capture the same changes in the printed ink density.

This figure shows a slightly different picture than the one before. The eXact in M0

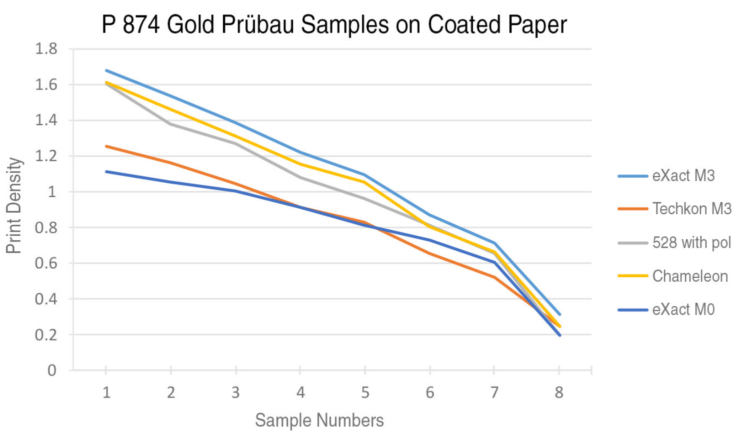

***Figure 2:** The density measurements of P 874 Gold Prüfbau samples with the eXact (M3, M0), SpectroDens (M3), 528 and Chameleon*

mode does not really capture very well changes in the printed ink density. This result is to be expected. The surprising result here is the difference in density values between the SpectroDens and the eXact in M3 mode. All the other instruments used in this study to record the printed ink density seem to be more sensitive than the SpectroDens.

Gloss coated and non-gloss coated density measurement comparisons on coated paper

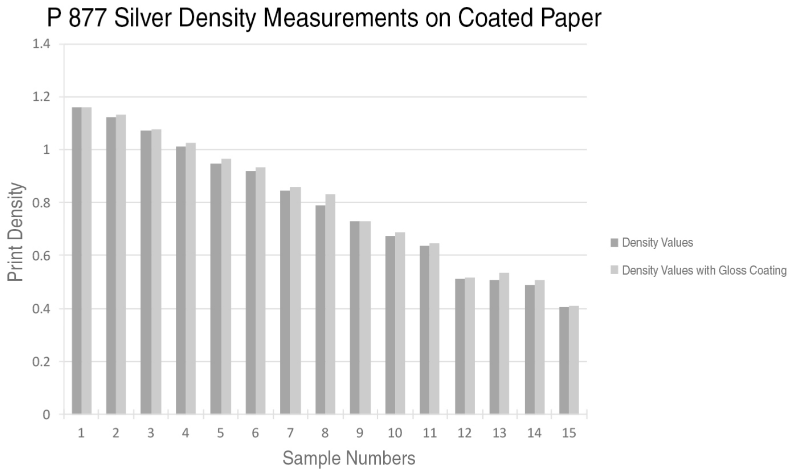

Figure 3: *A comparison of gloss coated and non-coated density measurements of P 877 Silver, Prüfbau samples, with the X-Rite in eXact M3 mode*

From figure 3 it can be seen that there is some increase in print density with the water-base coating on the silver samples. However, the growth of the print density values was not too dramatic across the print samples. In addition, from figure 4 below, a slight decrease in print density can be seen, when water-based coating was applied to the P874 Gold Prüfbau samples. Since the two graphs show different trends in the density measurements, we concluded that the water-based coating can have a small influence on the measured ink density of the printed metallic ink samples but no clear trend was observed.

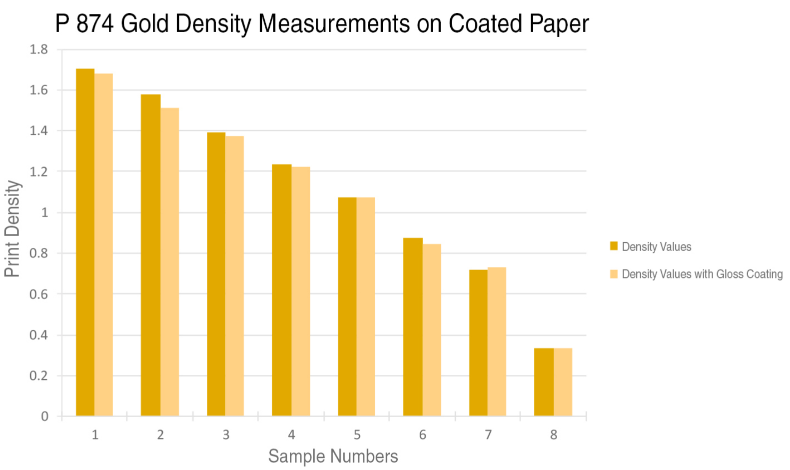

Figure 4: *A comparison of gloss coated and non-coated density measurements of P 874 Gold, Prüfbau samples, with the X-Rite in eXact M3 mode*

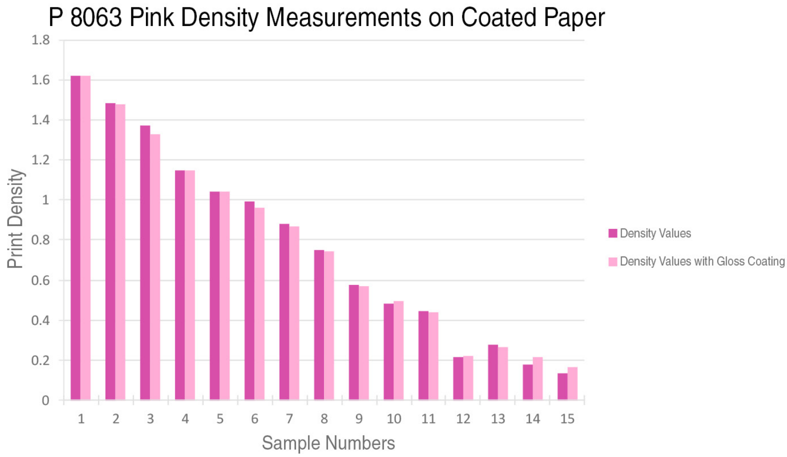

Figure 5: *A comparison of gloss-coated and non-gloss coated density measurements of P 8063 Pink, Prüfbau samples with the eXact in M3 mode*

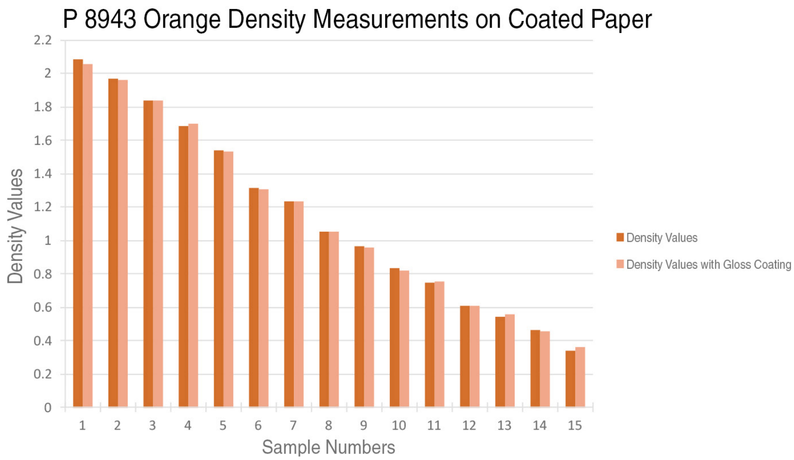

Figure 6: *A comparison of gloss coated and non-gloss coated density measurements of P 8943 Orange, Prüfbau samples with the eXact M3 mode*

Figure 5 and 6 show that there is no clear trend in regards to the density readings of the printed samples when a gloss water-based coating has been applied. The visual effect of a more intense looking color cannot be captured through density readings.

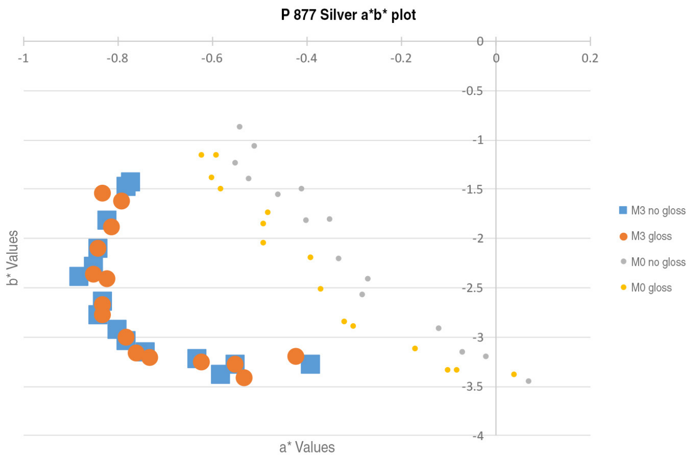

***Figure** 7: A comparison of gloss coated and non-gloss coated a* b* values of P 877 Silver, Prüfbau samples with the SpectroDens in M3 and M0 mode*

Figure 7 shows that there is no significant change in the a* and b* values for P 877 silver whether a gloss waterbased coating has been applied to the printed samples or not. The results were similar when an eXact measurement device was used. The a* and b* values of the tested metallic colors do not change significantly through the application of a gloss water-based coating. Also the L*-values differ not significantly between the samples with and without gloss water-based coating applied.

Measurements of the press sheets from the previous study

During the course of the study the press sheets from the 2016 study (Habekost & Andino, 2016) were re-evaluated using all four measurement devices. The press run was conducted as follows: The printed ink densities of the metallic inks were brought up to the printed ink density of the particular colour in the Pantone® Metallic book. Once this was achieved the ink ductor was shut-off and 200 sheets were printed. For the evaluation every 10th sheet was measured, resulting in 20 press sheets with a declining ink density.

In order to highlight the difference in the measurements the eXact instrument was switched to M0 mode. The results of the measurements can be seen in figure 8.

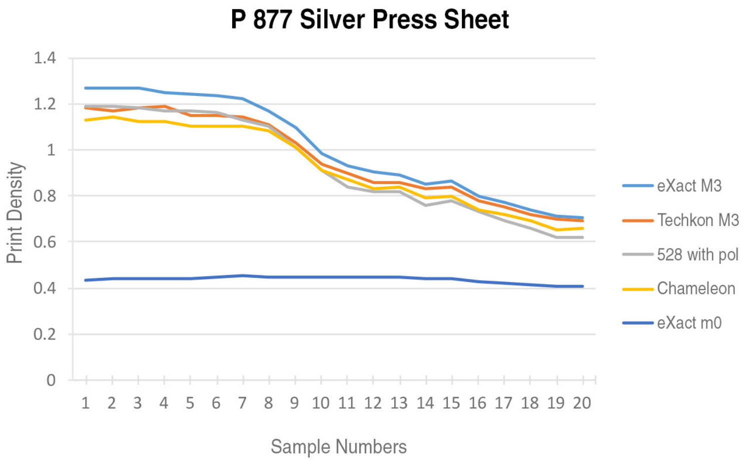

Figure 8: *Printed ink density measurements of the four devices of P 877 silver press run sheets*

Figure 8 shows clearly that the M0 or legacy mode is not capturing any printed ink density differences during the 200 sheet press run. The densitometers with a polarizing light filter capture quite well the changes in the printed ink density. Interestingly there is a slight density difference in the values captured with the eXact and the SpetroDens. The overall data trend is captured equally well by both M3-mode instruments.

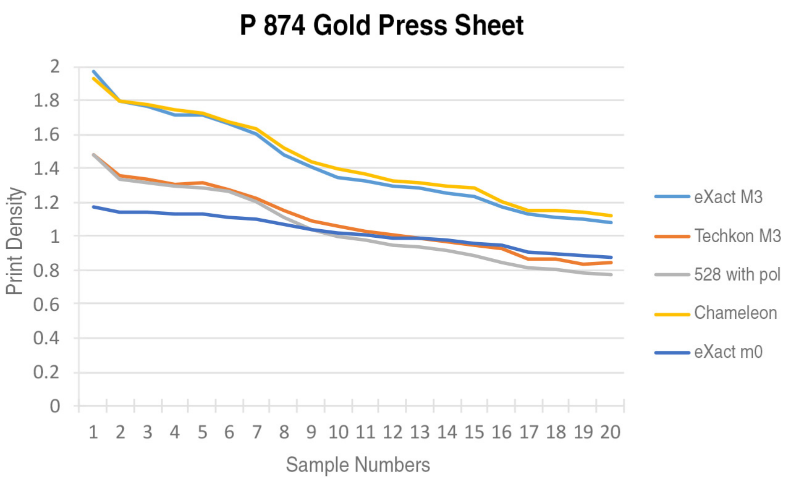

Figure 9: *Printed ink density measurements of the four devices of P 874 gold press run sheets*

The same measurements that were carried out for the P877 silver were also conducted for P874 gold. The eXact in M0 mode registers a slight decline in the printed ink density, while the polarized densitometers and the spectrodensitometers in M3 mode capture the changes in printed ink density quite well. As in previous test the eXact device seems to be a more sensitive in capturing printed ink densit.

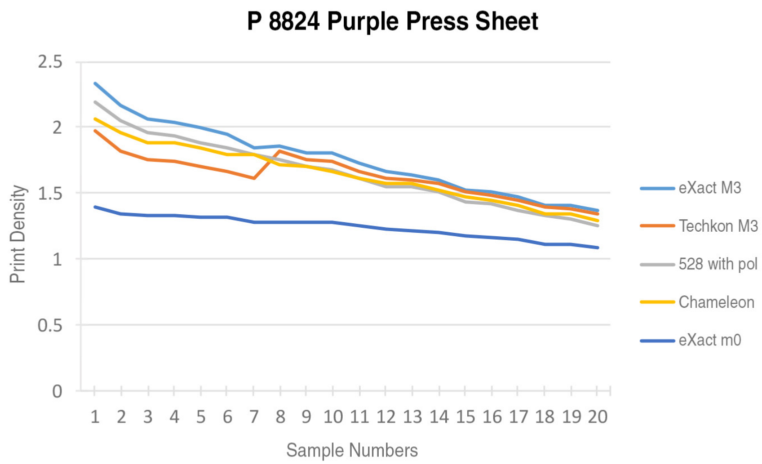

Figure 10: *Printed ink density measurements of the four devices of P 8824 purple press run sheets*

The measurements of the P 8824 metallic purple press sheets show a similar result than the previous two metallic colors. A measurement in M0-mode is registering only slight changes in the printed ink density, while the polarized densitometers or instruments in M3-mode register changes in the printed ink density quite well.

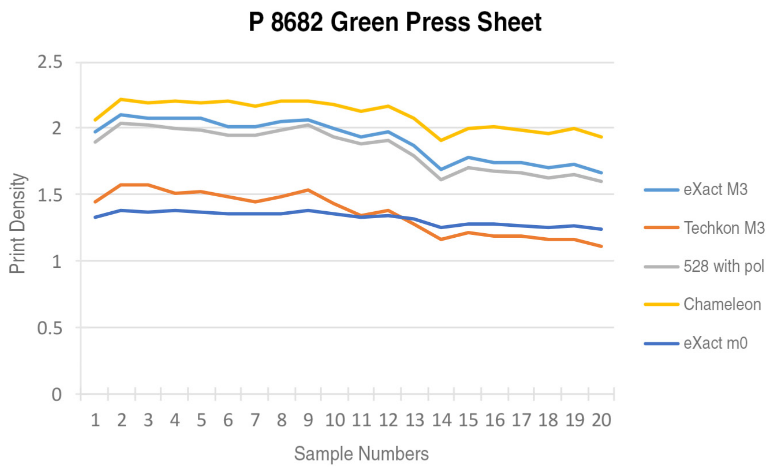

Figure 11: *Printed ink density measurements of the four devices of P 8682 green press run sheets*

This figure shows a similar result than figures 9 - 11. The legacy M0 measurement mode is not capable of capturing changes in the printed ink density of the 20 press sheets. The other instruments and the M3 measurement mode instruments are very capable of recording changes in the printed ink density, although the density numbers recorded from each instrument vary greatly.

Gloss coated and non-gloss coated density comparisons on cardboard

One of the goals of this study was to find out if the substrate has an influence on the measured density values of the metallic ink. A cardboard type substrate was chosen, since this type of substrate is often used to print consumer packaging like cereal boxes or folding cartons. The metallic effect is usually not as pronounced as on the coated substrate used in this study.

Two lithographic inks, P 8943 orange and P 8682 green, were printed on cardboard stock to see if the water-based coating has an impact on the printed ink density.

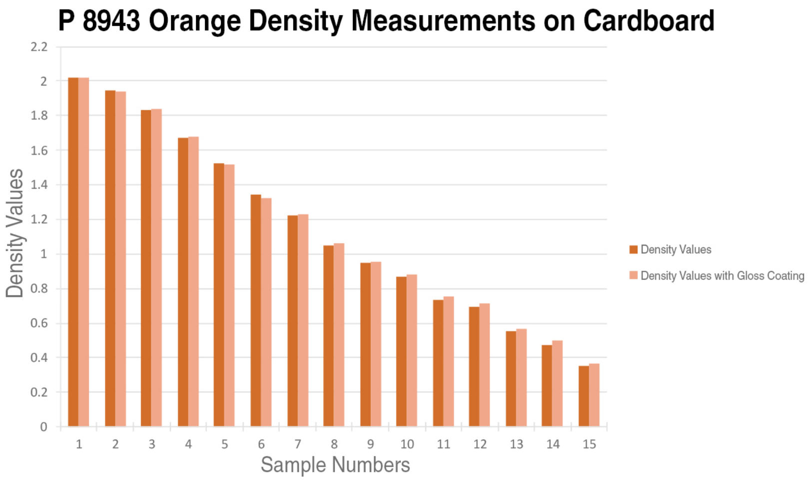

Figure 12: *A comparison of gloss-coated and non-gloss coated density measurements of P 8943 orange, Prüfbau samples with the X-Rite eXact M3 mode*

From figure 12 it can be seen that P 8943 orange on cardboard produces a similar density trend as P 8943 orange on coated paper. There is also a slight increase or decrease in print density values when water-based coating was applied to the printed samples. However, the influence of the gloss coating with regards to print density was small and unpredictable.

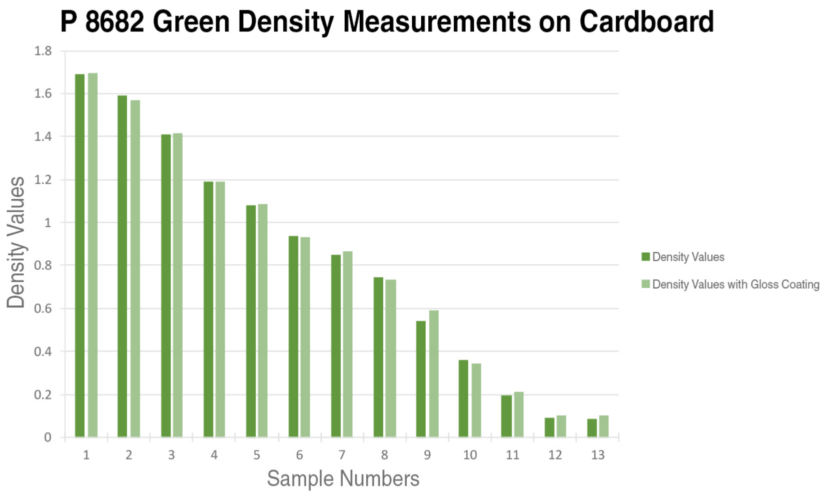

Figure 13: *A comparison of gloss-coated and non-gloss coated density measurements of P 8682 green, Prüfbau samples with X-Rite eXact M3 mode*

Furthermore, figure 13 also illustrates only small variations in print density values when water-based coating was applied to the P 8682 green Prüfbau samples. The variations are quite small especially in the first three print samples, which were printed around the target print density for P 8682 green.

Hand-proof of flexographic ink on coated paper

After conducting extensive tests on lithographic metallic inks, it was time to evaluate if water-based coating has an impact on flexographic metallic inks. Therefore, P 877 silver and one hand-mixed flexographic inks (P 8283 green) were printed on coated paper to see if any similar print density trend was observable, as it was with the lithographic metallic inks. It needs to be said that there were seven anilox rollers with different BCM volumes and linescreen rulings were available for this test.

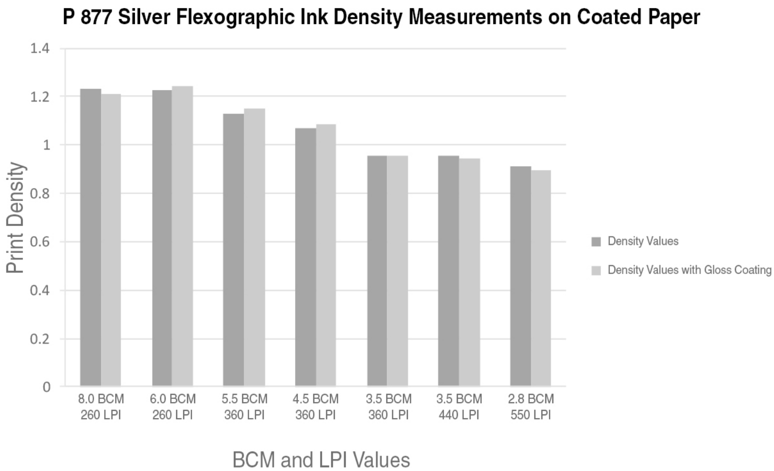

Figure 14: *A comparison of gloss-coated and non-gloss coated density measurements of P 877 silver flexographic ink samples with the X-Rite eXact in M3 mode*

From figure 14 it can be seen that there is no clear trend in regards to printed ink density readings whether a gloss water-based coating has been applied to the samples or not.

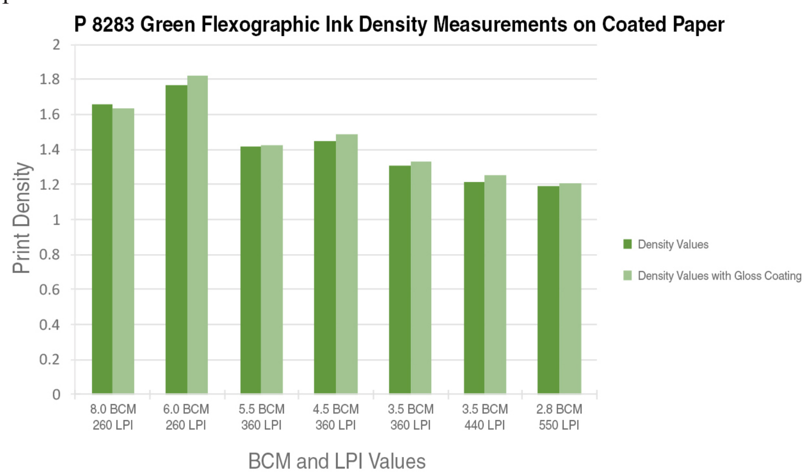

Figure 15: *A comparison of gloss-coated and non-gloss coated density measurements of P 8283 green flexographic ink samples with the X-Rite eXact in M3 mode*

Figure 15 shows similar results as figure 14. Again there is no clear trend in regards to the measured ink density in being influenced by the application of gloss-water-based coating to the printed samples.

Hand-proof of flexographic metallic inks on cardboard

For this part of the study two metallics were chosen as a representation of the all the metallic flexographic inks that were tested.

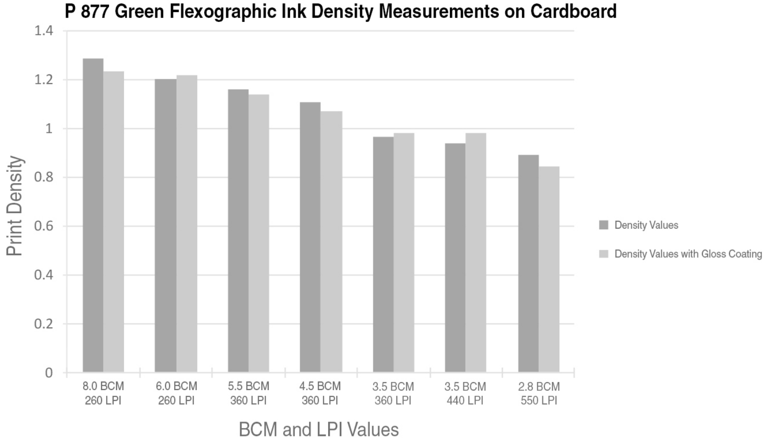

Figure 16: *A comparison of gloss-coated and non-gloss coated density measurements of P 877 silver flexographic ink samples with the X-Rite eXact in M3 mode*

From figure 16 it can clearly be seen again that there is no clear trend in regards to the influence of gloss waterbased coating on the measured density values. Sometimes there is a slight decrease in the printed ink density and other times there is a slight increase in the printed ink density values. This "trend" had been observed before with the lithographic ink samples.

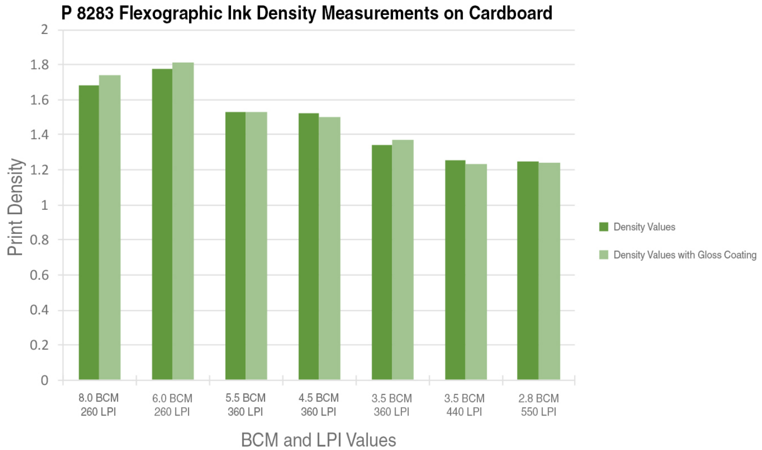

Figure 17: *A comparison of gloss-coated and non-gloss coated density measurements of P 8283 green flexographic ink samples with the X-Rite eXact in M3 mode*

Colorimetric comparison of the flexographic press run print sample

Since there is a visible difference between the gloss-coated and non-gloss coated samples it was tried if there is another way to capture this difference by other means than measuring the gloss at 60º. It was tried to see if there was a colorimetric difference between the gloss-coated and non-gloss coated part of the printed samples.

In the flexographic run, the prints with no coating were set as the standard values, while the ones with gloss waterbased coating were considered samples. The ΔE*(ab) comparison of Techkon and eXact M3 mode can be seen in figure 18 and 19.

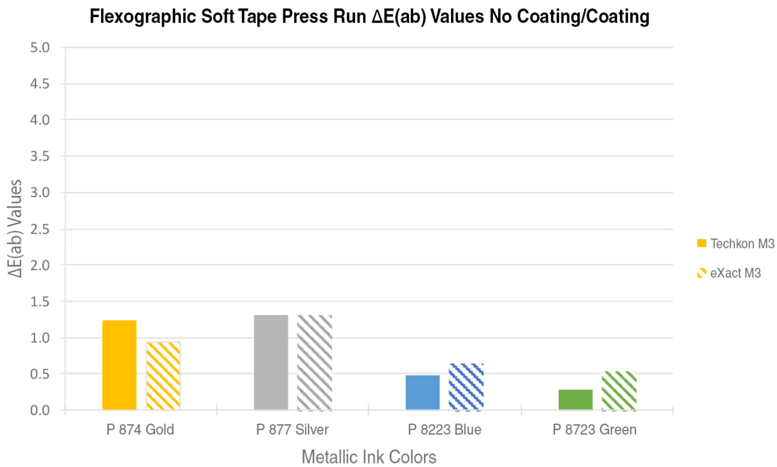

Figure 18: *A ΔE comparison of the SpectroDens in M3 and eXact M3 from the flexographic soft tape press run*

From figure 19 it is clearly visible that the water-based coating has little influence on the measured colorimetric values. The ΔE(ab) values of the four inks (gold, silver, blue and green) were all below 2.0 which shows that the color variations between the standard and sample values were small.

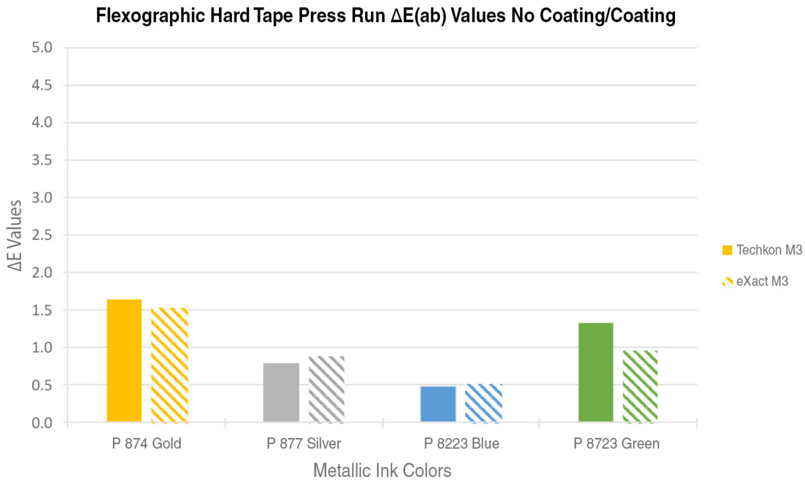

Figure 19: *A ΔE comparison of the SpectroDens in M3 and the eXact in M3 from the flexographic hard tape press run*

Figure 19 shows similar trend as figure 18. However, there is no clear trend in regards to which device provides a more accurate and stable measurements. Since the SpectroDens and eXact produces similar ΔE(ab) values, we concluded that both devices in M3 mode can be used to control the metallic ink.

In order to further prove that the gloss coating has little effect on the metallic print samples, the density values from the flexographic press run from both devices M3 capable devices were examined.

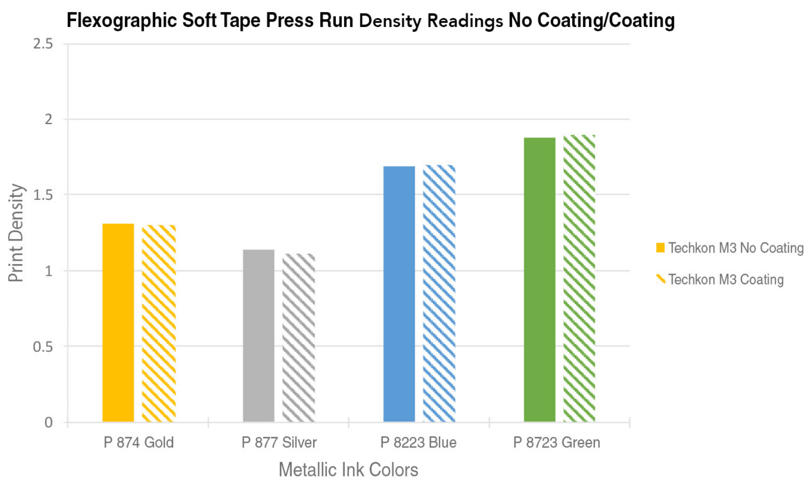

Figure 20: *A comparison of the gloss-coated and non-coated print density values from flexographic soft tape press run with the SpectroDens in M3 mode*

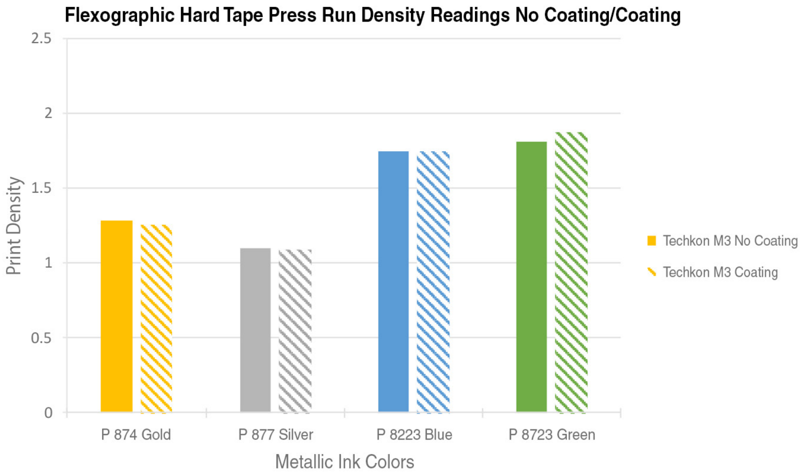

Figure 21: *A comparison of the gloss-coated and non-coated print density values from flexographic hard tape press run with the SpectroDens in M3 mode*

As can be seen from figure 20-24 there is small increase or decrease in print density when a gloss water-based coating has been applied. Since both Techkon and eXact in M3 mode measured similar density trend, we concluded that the gloss water-based coating has little influence on the measured print density.

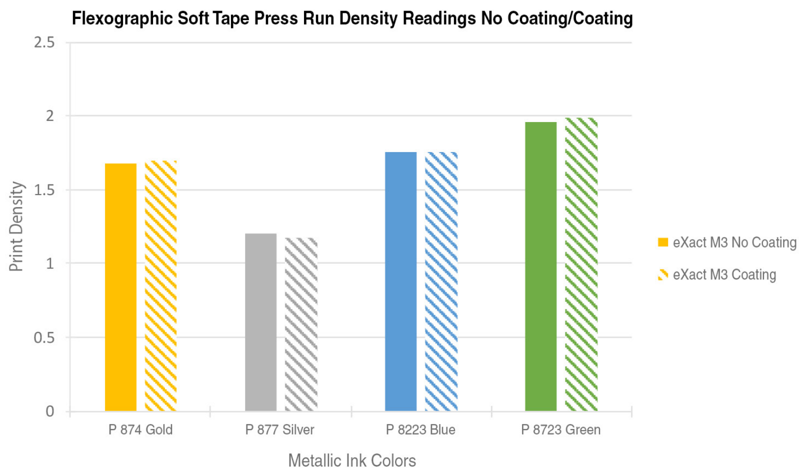

Figure 22: *A comparison of gloss-coated and non-coated print density values from flexographic soft tape press run with the eXact in M3 mode*

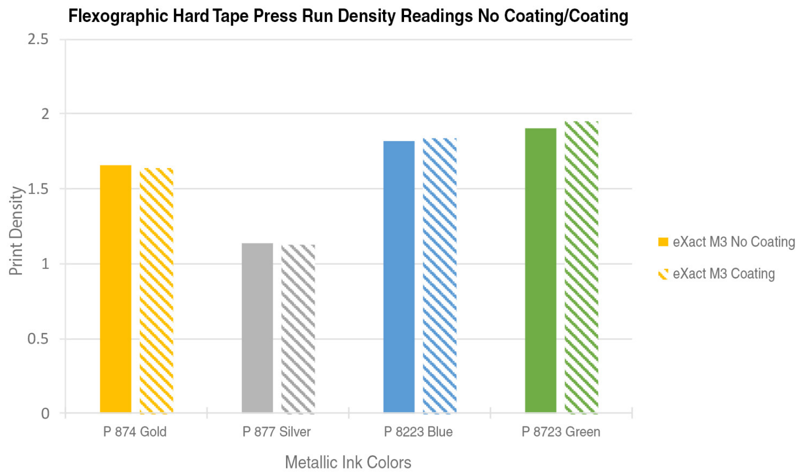

Figure 23: *A comparison of gloss-coated and non-coated print density values from flexographic hard tape press run with the eXact in M3 mode*

Colorimetric comparison of the lithographic Prüfbau samples

After analyzing the ΔE(ab) values of the four colors in the flexographic press run, a similar set of colors was chosen from the lithographic Prüfbau samples for further analysis.

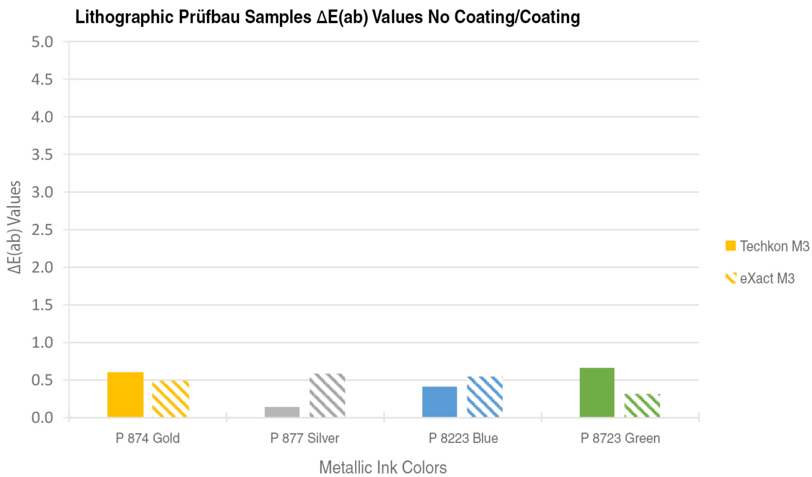

Figure 24: *A ΔE comparison of the SpectroDens in M3 and the eXact in M3 from the lithographic Prüfbau samples.*

From figure 24 it can be seen, that there is very little difference between to colorimetric values of the samples with and without water-based coating. The ΔE values are around 0.5 ΔE, which is below a ΔE of 1 which is considered a just noticeable difference.

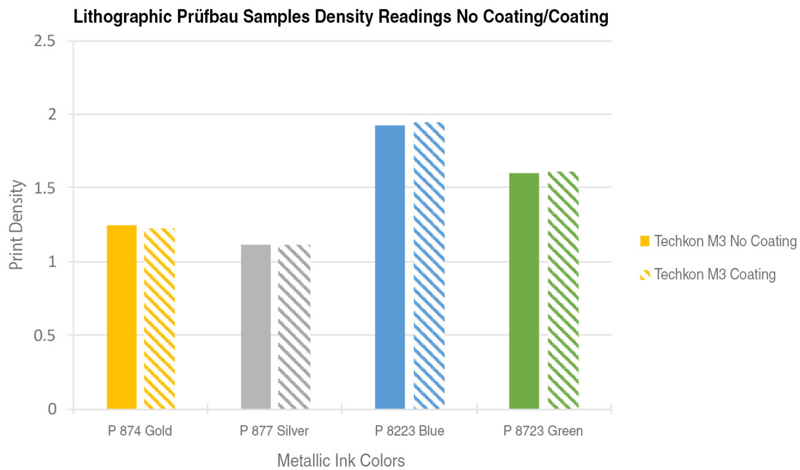

Figure 25: *A comparison of the gloss-coated and non-coated print density values from the lithographic Prüfbau samples with the SpectroDens in M3 mode*

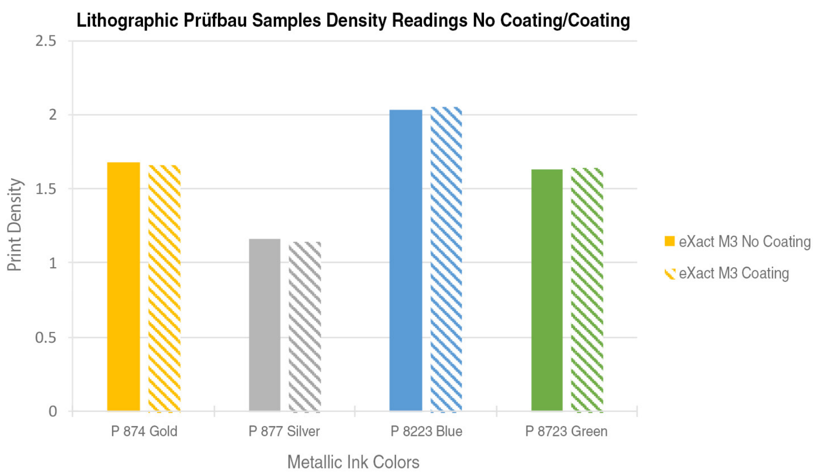

Figure 26: *A comparison of the gloss-coated and non-coated print density values from the lithographic Prüfau samples with the eXact in M3 mode*

A comparison of the overall trend in regards to the recorded ink densities between the eXact and the SpectroDens shows that both instruments show similar ink density values. At the end of the study a comparison between the printed ink density and the corresponding L* values was made.

From the tested colors P877 silver was chosen. It needs to be said that the order of the L*-values was reversed. The first printed sample has showed the highest recorded ink density and the corresponding L*-value would be low. For the lowest ink density value the L*-value would be higher than the initially recorded L*-values in this dataset. The reversal was done to see if both measurement values follow the same or a similar pattern. The result can be seen in the figure below.

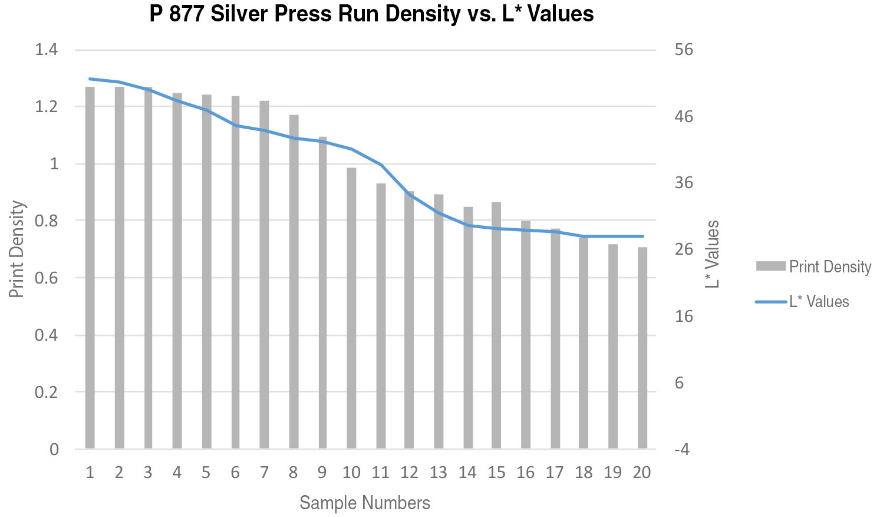

Figure 27: *A comparison of P 877 silver, press run density values vs. L* values*

Conclusions

This study has given a number of results. First and foremost that the M3 measurement condition can clearly be used to track the printed ink density of metallic inks on press. Second, it does not matter if the ink has of lithographic or flexographic quality. Third, the gloss coating cannot be tracked through either density or colorimetric differences between coated and non-coated samples of the same metallic ink. Forth, the paper does not have an influence on the measurability of the metallic inks.

Any print company involved in printing metallic inks for their customers should invest in a 0/45 or 45/0 measurement geometry device that can be switched to the M3 measurement mode. This measurement mode enables the press operator to track the printed ink density of the metallic ink(s) that is (are) used during the press run. As the title of this study says: “M3 is for controlling metallics”.

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