Consistency of the Xerox 700 across Mid to Long Press Runs

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Keywords: digital printing, color consistency, GRACoL, DE2000, color registration

Abstract

The digital printing sector is becoming more and more prominent in the printing industry and yet there is no defined standard to evaluate the quality of the printed work provided by digital presses. The IDEAlliance Digital Press System Certification Program aims to provide certification to presses which have consistently demonstrated the ability to meet certain printing tolerances as outlined by certification. A test has been designed using test procedures and tolerances from this certification program in combination with custom ones to evaluate the Xerox 700, a press which is considered to be certified. This test aims to see if certain aspects of its certification can be repeated and to evaluate the overall consistency the press by comparing printed characteristics to tolerances outlined by IDEAlliance, GRACoL printing tolerances, and the manufacturer's specifications. The main parameters evaluated were solid ink densities, color difference using the CIEDE2000 equation, front-to-back registration, and color-to-color registration. In the end, the data showed that the Xerox 700 was able to reproduce and meet IDEAlliance and GRACoL's tolerances in regards to color difference, color-to-color registration, and solid ink densities respectively. The press's front- to-back registration however varied drastically throughout the press run and often bypassed the tolerance that the manufacturer had set for its own printer.

1. Introduction

Consistency is valued and recognized with the use of international standards in the graphic art industry; however, the development of a standard for the digital print sector has yet to exist despite its many technological advances. The digital print sector has begun to stabilize and mature; thus, the lack of standardization brings to question as to how viable digital printing is as an alternative to conventional printing. Because of this, it is important to determine the competencies of digital printers. The absence of a printing plate in digital printers means frequent variations in the

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overall print, especially in regards to properties such as color, registration, and overall image quality. Although there is no established standard, IDEAlliance provides a Digital Press Certification Program containing color specifications that can be used as an indication for color reproduction and registration on a digital press.

This paper aims to evaluate a Xerox 700 (xerographic) Digital Color Press in determination of how well it is able to maintain a quality print over a medium-to-long press run. A test has been designed to assess the different print characteristics of numerous sheets printed on the press through a medium-to-long press run. It will determine how consistent these properties are relative to the other sheets printed within the same press run, in comparison to values outlined by the IDEAlliance Digital Press Certification program, and specifications of other printing processes. Based on the IDEAlliance Digital Press Certification Program, there are already many digital presses that are considered certified and able to consistently produce high quality work and meet printing standards. IDEAlliance has certified several Xerox presses, and the Xerox 700 is one of them (IDEAlliance, 2013). This means that the Xerox 700 should be able to meet the standards outlined in the certification program; however, the certification was awarded to the Xerox 700 using a Fiery DFE. The Xerox 700 that is being tested uses a FreeFlow DFE; therefore, it is possible that there will be some deviations from the certification program.

The predicted outcome is that there will be a fair amount of variations across all of the measured properties. However, it is likely that the variations may be greater for some properties than others. This is mainly attributed to the fact that there is no printing plate or fine-tuning adjustments. The image is produced through digital means, being cached and re-used by the Raster Image Processor (RIP) with every copy printed. This allows for variations, as digital information is very dynamic and not static compared to a physical printing plate. Because so many different parameters are being evaluated for this test, it is difficult to say whether the press, overall, is consistent or not. Instead, each parameter will be addressed individually based on the results. If a parameter is generally unable to meet tolerances outlined by the IDEAlliance Digital Press Certification Program or other specifications, that specific parameter will be considered inconsistent. However, if the parameter consistently conforms to tolerances outlined by the certification program or another specified printing specification, then that parameter will be considered consistent.

2. Definitions

- **CIELAB Color Space:** "The 1976 CIE color space transformation with the dimensions L*, a*, and b*, in which equal distances in the space represent approximately equal color differences" (Field, 2004, p.346).
- **Delta E:** The overall measured difference between two colors in the CIELAB color space represented as ΔE (efi, n.d). Several variants of the Delta E equation exist and each consider different variables of color difference.

- **Solid Ink Density (SID):** The measure of perceived darkness based on the light absorption or reflectance of a solid ink patch on the printed sheet, as well as the paper underneath. (Breede, 2006, p.107).
- **Front-to-Back Registration:** The alignment of graphics on one side of the sheet relative to the graphics

on the other side of the sheet (Kipphan, 2001, p.309).
- **Color-to-Color Registration:** The alignment of overlapping colors in multi-color printing (Kipphan, 2001, p.278).

3. Testing and Evaluation Principles

The design of this test is to measure color consistency using the specifications in the IDEAlliance Certification as a benchmark for colorimetric measurements. Consistency in registration will also be evaluated on a visual approach and compared to the capabilities of the press as outlined by the manufacturer. In order to accomplish this task, a test form was specially created so that all elements that we intend to measure are present. This included some color measurement tools and elements as outlined by the IDEAlliance Digital Press System Certification. This will ensure that we have the means to compare to this certification, as well as others we deemed necessary based on our intention to evaluate registration and overall consistency. To ensure validity in our colorimetric test results, the press was calibrated before the press run using the i1 Spectrophotometer and a printed test chart generated from the Xerox 700. Calibrating the press beforehand is important in creating a consistent printing environment (IDEAlliance, 2011).

This test was completed by printing 500 test forms on the Xerox 700. Whilst the amount of sheets printed is half the amount that was used in the IDEAlliance Digital Press Certification Program, a larger number of the sheets were evaluated. In the certification program, 1000 sheets were printed, but only 10 sheets were measured (IDEAlliance, 2011). With such a small sample size compared to total number of sheets printed, a lot of changes in the variables could be missed. In order to more accurately evaluate the consistency of the Xerox 700, we decided to measure 50 of the 500 sheets printed instead. The larger sample size allows us to see more differences and changes in the variables throughout the entire run. Also, the certification program only measures 5 sequential sheets (IDEAlliance, 2011). The problem with the small sample size is once again present, making it an unviable representation of such a large press run. In order to counteract these issues, a larger sample size within our 500 printed sheets was evaluated. Out of those 500 sheets, 50 random and 20 sequential sheets were quantified for color consistency, and evaluated for registration. The purpose of conducting measurements for these two sets of sheets is to observe how the variables change over the entire production of the 500 sheets in comparison to smaller consecutive portion of the press run. The 50 sheets that were pulled for evaluation were randomly generated in Microsoft Excel. The range of consecutive sheets, which were to be evaluated, was also randomly generated in Microsoft Excel. In regards to registration, 10 sheets were pulled from the 500-sheet pile in a random but somewhat consistent intervals in order to measure the change or consistency along the entire press run.

The solid CMYK and overprints were measured with a spectrophotometer for L*a*b* and density values. Both density and L*a*b* values are measured due to the relationship between the two. A change in density will often also result in a change in L*a*b* values. It should also be noted that a single spectrophotometer, the X-Rite® 530 Series Spectrophotometer (Serial Number - 051480), was used to conduct all measurements. This is because of inter-instrument agreement and instrument repeatability. Despite the accuracy of an instrument, there will always be some variation between measurements made by 2 separate instruments of the same model. The variation for consecutive measurements by the same instrument is always a lot lower than the variation between 2 different instruments (X-Rite, 2012). In order to minimize the amount of variation in our measurements, the same device was used for the entire process.

Registration will be measured through use of a digital microscope called the Dino-Lite® Digital Microscope. For front-to-back registration, a light source would be put under elements that are supposed to back up to each other perfectly and the amount of offset or deviation will be captured and measured with the digital microscope. For color-to-color registration, 4 registration marks, 1 from each corner of the test form, will be viewed and measured with the digital microscope. The 4 values will then be averaged to be representative of the color-to-color registration of the page. However, if any of these registration marks breaks past IDEAlliance's tolerance of 0.1mm, then that value will be used as the representation for that sheet (IDEAlliance, 2011).

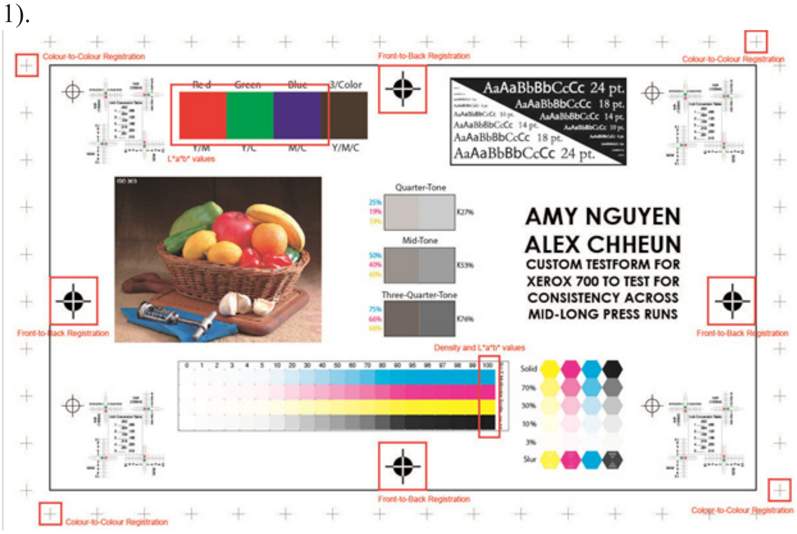


Figure 1: *Custom test form with indications of where the color and registration measurements were taken for test.*

To determine how consistent the Xerox 700 is, the data we collected will be compared to the IDEAlliance Digital Press Certification program as well as standards and specifications outlined for other printing processes in the graphic arts industry. As actual standards or specifications do not exist for digital presses, the certification program acts as the main measure or benchmark of the press's performance. For parameters that are not outlined in certification program, specifications from other printing processes will be used as a benchmark. Also, in regards to registration, the data will be compared to the capabilities of the press as outlined by the manufacturer. In accordance to these premises, our parameters will be compared to the following benchmarks:

- Density will be compared to GRACoL specifications in which the solid ink densities are outlined as follows with an allowable ±0.1 tolerance (IDEAlliance, 2007):
  - K: 1.60
  - C: 1.30
  - M: 1.40
  - Y: 1.00
- Color consistency will be compared to the IDEAlliance Digital Press Certification Program in which it states that the maximum ΔE*00 between any solid patch and the average L*a*b* of that patch throughout the entire press run should not exceed 2.0 (IDEAlliance, 2011).
- Registration will also be compared to the IDEAlliance Digital Press Certification Program in which it is indicated that color-to-color registration should be within 0.1mm (IDEAlliance, 2011). Front-to-back registration will also be evaluated and compared to Xerox 700's manufacturer's specifications in which it is said that the press can achieve registration of 1mm or less in front-to-back applications (Xerox, 2009).

There are some considerations when collecting the data for evaluation. The use of ΔE*00 is vital when comparing the color data to the certification program, as there are many versions of the ΔE formula. The values in the certification program are based on the ΔE*00 equation. Each equation has different considerations and will result in a different value, so if the ΔE*00 equation is not used, then the press would not be evaluated properly. ΔE*00 is the most recently formulated equation which is considered to be most accurate due to its utilization of variables that address shortcomings in the human eye, making it the most accurate representation of the human eye's perception of color difference (Habekost, 2013). When evaluating the registration of the printed sheets under a microscopic camera, a scale should be present because it provides a basis of measurement in the enlarged image, as one cannot accurately measure the distance between objects viewed under a microscope due to the change in proportions. This ensures that whatever is being viewed can be perceived in an aspect that allows for proper measurement.

4. Materials Tested

- Domtar Opaque - Plainfield 11” x 17”

50/20lbs, 19.68M, 74g/m2, 96 brightness, 150 whiteness

5. Equations

- CIEDE2000 Equation

$$\Delta E_{00}^* = \sqrt{\left(\frac{\Delta L'}{k_L S_L}\right)^2 + \left(\frac{\Delta C'}{k_C S_C}\right)^2 + \left(\frac{\Delta H'}{k_H S_H}\right)^2 + R_T \frac{\Delta C'}{k_C S_C} \frac{\Delta H'}{k_H S_H}}$$

6. Equipment Used

- Xerox® 700 Digital Color Press
- X-Rite® 530 Series Spectrophotometer (Serial No. - 051480)
- X-Rite® i1 Spectrophotometer (Serial No. - 3.278-611601-2)
- Dino-Lite® Digital Microscope

7. Procedures

Part 1 - Creating the Test Form

1. Create a new 11” by 17” (tabloid) landscape file on Adobe Illustrator.
2. Place all required testing elements such as: a color bar on the art board containing solid and tint color patches; grays patches made from CMY and from K; small and large text; a graphic image; and registration marks along the border of the art board.
3. Export the test form as a PDF file.

Part 2 - Warming up and calibrating the Xerox 700

1. Send the PDF of the test form to the Xerox 700’s Freeflow DFE.
2. On the DFE, adjust the properties of the job to the following:
   - 50 sheets
   - printed on 11” x 17” tabloid stock
   - printed in color
   - duplex
3. Apply the changes and release the job.
4. After the press has finished printing the 50 sheets and has warmed up, select the calibration option from the DFE and follow the steps as outlined by the DFE to calibrate the press, making sure to use the X-Rite i1 Pro Spectrophotometer calibration method as opposed to the Xerox scanner method.

Part 3 - Printing the Test Form

1. Adjust the properties of the test form job to print 1 sheet and release the job.
2. Visually evaluate the front-to-back registration of the printed sheet and make positioning adjustments through the DFE to achieve the best registration possible.
3. Print another copy of the test form to evaluate the results of the adjustments.
4. Repeat steps 1 to 3 until adequate front-to-back registration is achieved.
5. Adjust the properties of the test form job to print 500 sheets and release the job.

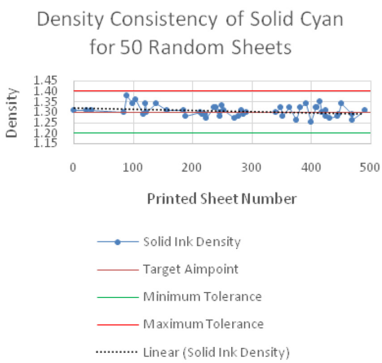
Part 4 - Measuring the Test Form

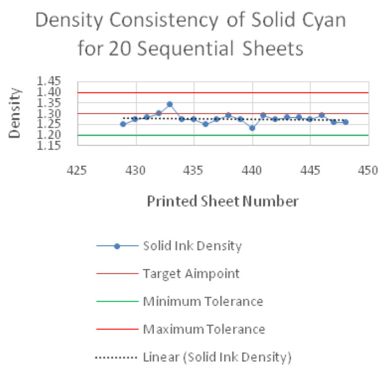
1. Measure the all L*a*b* values of the Solid colors using the X-Rite 530 series spectrodensitometer.
2. Record all values in Microsoft Excel.
3. Average the L*a*b* values of each color.
4. Calculate the ΔE*00 of each solid color using the averaged L*a*b* values as the reference/second color.
5. Graph the results with indication of the averages, aim points, tolerances, and trend lines.
6. Visually inspect the registration and front-to-back registration under a microscope over a light table.

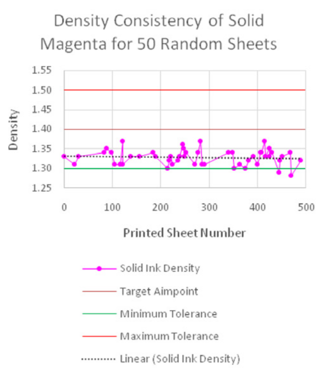
8. Results

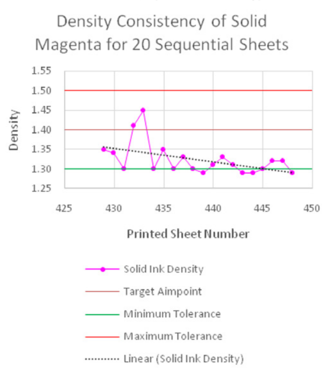
8.1 Solid Ink Densities of CMYK (50 Random vs. 20 Sequential)

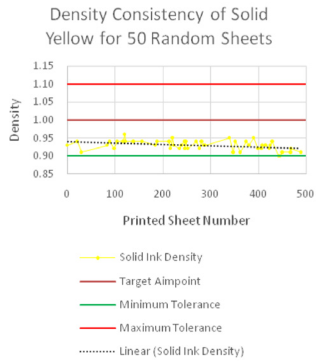
In comparison of the density data for the 50 random sheets and the 20 sequential sheets, some general trends are seen consistently between the two; however, there are some properties which are unique to each set of measurements as well. In both instances, the cyan SID lies within the tolerances around the 1.30 density target aim point. The data points for the 50 random sheets appear to fluctuate around the aim point and to quite a large degree. The data points for the 20 sequential sheets, however, tend to lie below the 1.40 density aim point. There is less fluctuation present in the 20 sequential sheets as well, as indicated by range of data points compared to the 50 random sheets. Both sets of cyan solid ink density data also have a very subtle negative trend line. For the magenta SID in both sets of data, almost all data points lie below the 1.40 density target aim point. There are also several points in both instances that lie either on the minimum tolerance or below it. There is also a much greater amount of fluctuation present in the 20 sequential sheets than the 50 random sheets. While the trend line for both sets of magenta SID data are negative, the trend line for the 20 sequential sheets are a lot more drastic and noticeable than that of the 50 random sheets. In terms of the yellow SID, all data points lie below the 1.00 density target aim point. Most points are around the minimum tolerance, with several lying right on it or even below it. Both sets of data have approximately the same level of fluctuation and both contain a very subtle negative trend line. The black SID data points for the 50 random sheets are generally within the tolerances with a few points that lie above the maximum tolerance. In both the 50 random sheet and 20 sequential sheet data, most black SID data points are between the 1.60 density target aim point and the maximum tolerance, although there are a few that lie below the target aim point. The data points also seem to progressively get closer to the target aim point as the press run goes on. The highest amounts of fluctuation between all colors are present in the black SID. Both black SID trend lines are negative, although the trend line for the 50 random sheets is slightly more drastic. Overall, the SID of all the toners tend to be decreasing throughout the press run, although this trend is most noticeable in the data for magenta in the 20 sequential sheets and for black in the 50 random sheets. Fluctuation also exists in all colors to varying degrees. Additionally, the overall average of the densities is higher in the 50 random sheets compared to the 20 sequential sheets. Finally, the cyan SID appears to be the color that is closest to meeting the GRACoL specifications, while yellow SID deviated greatly from the GRACoL target aim point.

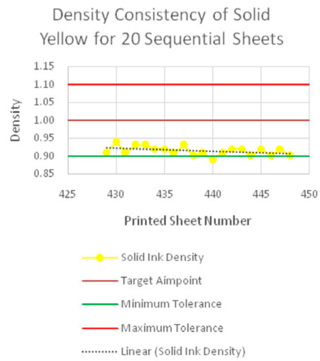


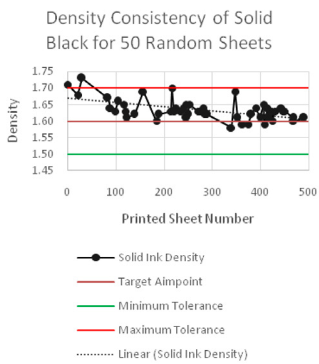


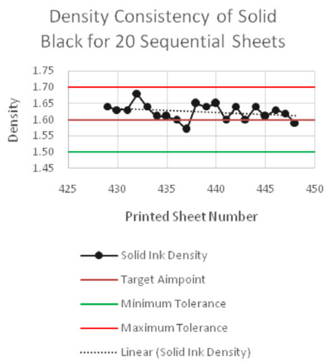












ΔE*00	Cyan	Magenta	Yellow	Black
Average	0.77	0.58	0.70	0.45
Minimum	0.25	1.30	0.37	0.04
Maximum	1.39	1.10	1.41	1.45
Range	1.14	0.97	1.12	1.41

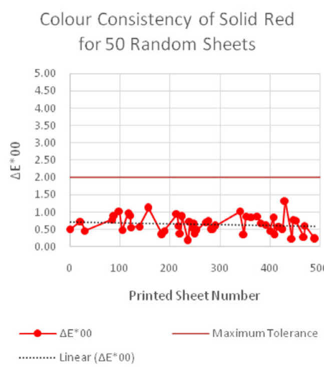
Table 3: *ΔE*00 of Solid CMYK for 50 random sheets printed on the Xerox 700.*

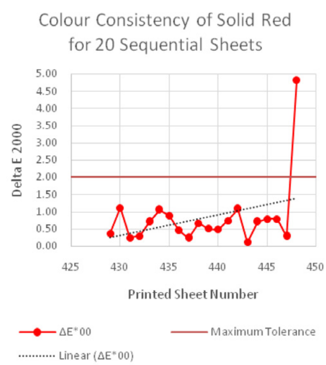
ΔE*00	Cyan	Magenta	Yellow	Black
Average	0.53	0.69	0.51	0.42
Minimum	0.19	0.23	0.20	0.09
Maximum	1.00	3.09	1.05	1.05
Range	0.81	2.89	0.85	0.96

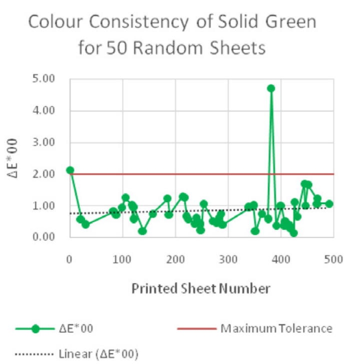
Table 4: *ΔE*00 of Solid CMYK for 20 sequential sheets between pages 429 to 448 printed on the Xerox 700.*

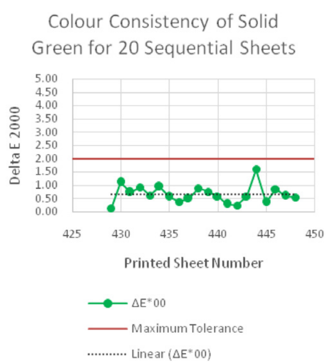
8.2 CIELAB values of RGB (50 Random vs. 20 Sequential)

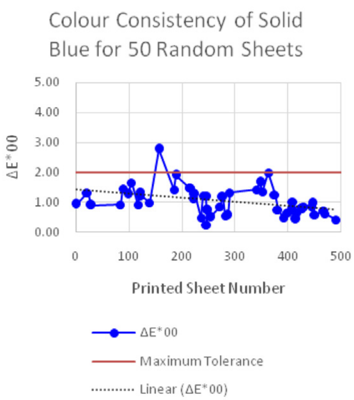
The RGB overprints generally appear to be able to meet the tolerances outlined by the IDEAlliance Digital Press Certification Program with the exception of some sheets, but there is a lot of fluctuation within the data points. The red overprints between the 2 sets of sheets resulted in an average ΔE*00 of approximately 0.70. However, in the 20 sequential sheets there is one point which resulted in a ΔE*00 of 4.82. The drastic difference between this point and the rest suggest that this point may possibly be an outlier, however, an assignable cause cannot be determined, so it is included in the final data. The green overprints averaged around 0.75 ΔE*00 between the 2 sets of sheets. Like the red overprints, there appears to be 1 point which is drastically different from the others that it should be deemed an outlier, but with no assignable cause, it is a data point that has to be considered. Additionally, in the 50 random sheets, there is a single point at the start which lies right above the maximum tolerance. The level of fluctuation in the green overprints is quite high. Green is also the only overprint with a positive trend line. The blue overprints averaged around 0.80 ΔE*00 between the two sets of sheets. One point lies above the maximum tolerance in the 50 random sheets, however, the difference is not drastic enough to be thought of as an outlier. High levels of fluctuation exist for the blue overprints as well. Overall, most overprint data points are within the tolerance level of 2.00 ΔE*00. There is a small amount of points that lie outside the tolerance and even some evident outliers present in the data, but the lack of assignable cause makes them permissible. There is also significant amounts of fluctuation among all of the overprints, as shown by the many dramatic peaks and valleys in all of the overprint graphs in both the 50 random and 20 sequential sheets. In these set of colors, it is difficult to determine whether there is a recurring pattern between the red, blue, and green throughout the press run. The graphs show no indication of a clear trend such as like the recurring pattern for the solid CMYK color data points; the steadily decreasing ΔE*00 values.

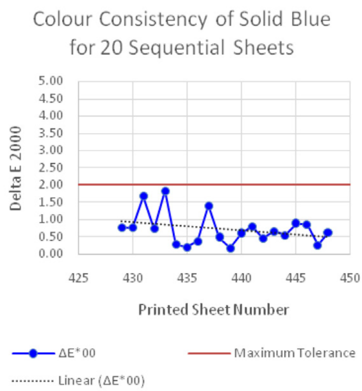












ΔE*00	Red	Green	Blue
Average	0.64	0.85	1.04
Minimum	0.18	0.15	0.25
Maximum	1.34	4.71	2.77
Range	1.16	4.56	2.52

Table 5: *ΔE*00 of Solid RGB for 50 random sheets printed on the Xerox 700.*

ΔE*00	Red	Green	Blue
Average	0.82	0.66	0.71
Minimum	0.11	0.14	0.16
Maximum	4.82	1.60	1.82
Range	4.71	1.46	1.66

Table 6: *ΔE*00 of Solid RGB for 20 sequential sheets between pages 429 to 448 printed on the Xerox 700.*

8.3 Front-to-Back and Color-to-Color Registration

In terms of front-to-back registration, the pages near the beginning of the press run had tighter front-to-back registration than the ones near the end. There were a few instances of the registration breaking past the 1mm tolerance that was indicated by the manufacturer. The nonconformity to this tolerance starts relatively early in pages at the end of the 100's. Although there was some fluctuation in the measurements, the general trend line shows that the registration was progressively getting worse. For color-to-color registration, all measured sheets were well within the tolerances set by IDEAlliance. There was a small amount of fluctuation, but the steady trend line shows that color-to-color registration may likely never break through the tolerances.

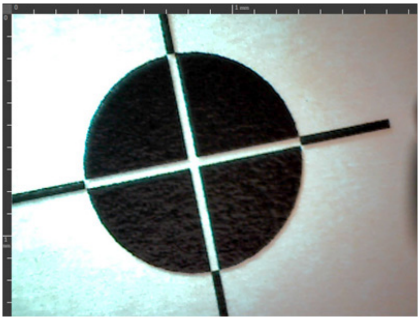


Figure 2: *Front-to-back registration on page 48 with a very small deviation of 0.14mm.*

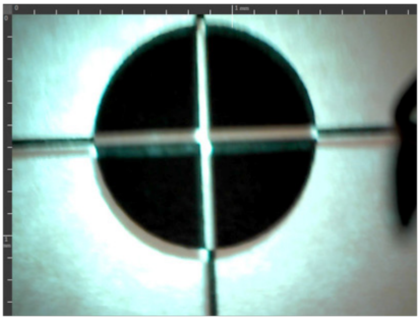


Figure 3: *Front-to-back registration on page 134 deviates to the left and downwards by 0.46 mm. This deviation is within tolerances.*

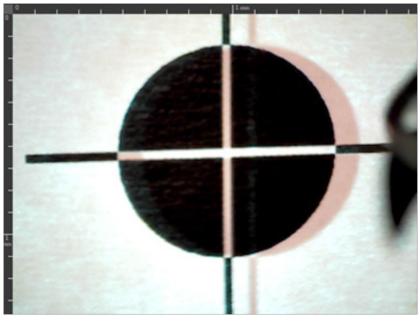


Figure 4: *Front-to-back registration on page 331 deviates to the right by 1.09 mm, which is outside of the 1mm tolerance in the IDEAlliance Certification.*

Figures 5 to 8 shows the four registration marks evaluated at each corner of one test form. All sheets measured had perfect registration similar to the registration marks depicted in the figures.

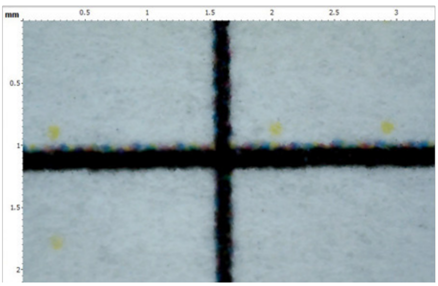


Figure 5: *Color-to-color registration mark at the top left corner of the test form.*

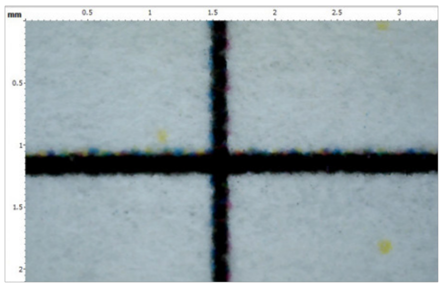


Figure 6: *Color-to-color registration mark at the top right of the test form.*

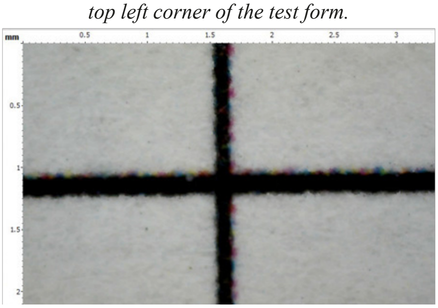


Figure 7: *Color-to-color registration mark at the bottom left of the test form.*

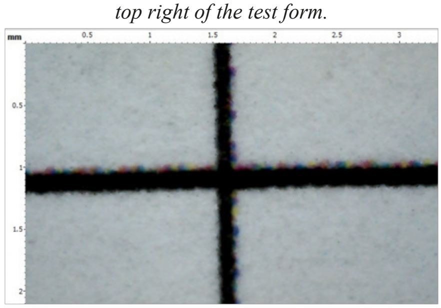
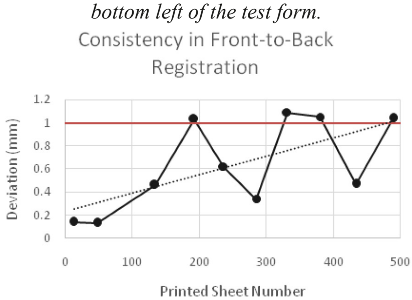
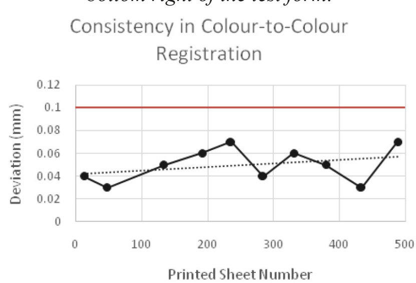


Figure 8: *Color-to-color registration mark at the bottom right of the test form.*





9. Discussion/Conclusion

The sporadic fluctuations in the cyan SIDs as well as its overall ability to consistently meet the GRACoL SID target aim point might be a result of Optical Brightening Agents (OBA) within the paper. The substrate that this test was performed with is categorized as “Britewhite,” with brightness and whiteness readings of 96 and 150 respectively. These 2 properties are generally measured on 100 scale, so values at the higher end of the spectrum and even beyond it are indicative of OBAs being within the substrate (Xerox, 2005). Based on this, it is likely that the tested substrate has OBAs present within it, thus affecting how printed colors are perceived by spectrophotometers. The presence of OBAs makes substrates appear whiter and a blue tint, especially when viewed under UV light settings. Spectrophotometers do not take the reflectance of UV light into account when taking measurements, and in turn, just interprets it as blue light being reflected; thus, resulting in higher readings for colors such as cyan (Chaikovsky & Garrison, 2012).

The use or lack of color management during the press run could have also contributed to the results we acquired. Use of color management on a DFE tends to prioritize an accurate reproduction of color through the use of multiple colors without considerations for things such as density or grey balance (A. Sharma, personal communication, April 2, 2014). Without color management, colors are printed with more purity, using only the respective color to print (A. Sharma, personal communication, April 2, 2014). Color management was not used in our press run and as such, colors remained pure but the accuracy is questionable. Despite this, color consistency was relatively good overall. The press was capable of mostly achieving ΔE*00 values of under 2.00. Using color management may have resulted in even better ΔE*00 values; however, the additional mixture of colors may have consequently affected the densities, thus causing more fluctuation and inaccuracies.

The large amount of fluctuation could also be the result of the paper being uncoated. Uncoated paper is believed to have low ink holdout and can negatively affect the toner adherence to the paper and the way light reflects off the color (MacMillian Graphics, 2003). Considering the level of accuracy of a spectrophotometer, small variations could affect the results including the particle size of the toner and its distribution when printed. Toner is uneven and angular particles of various shapes; thus, when printed, the distribution would not be completely uniform (Xerox, 2013).

While the SID of the process colors were all within the GRACoL tolerances, they did not necessarily meet the target aim points. This may be due to the pigments/colorants that were used to produce the toners. The different composition between offset lithography inks and toner affect how color is reproduced and whether or not certain density values can be achieved by each of the compositions. This provides some explanation as to why the yellow and magenta SIDs were generally lying closer to the minimum tolerance limit, as the difference between toner and ink for these colors could be drastically different. This makes it difficult for the toner to meet GRACoL tolerances.

A general trend that was observed was that as density decreased, the ΔE*00 decreased as well. This indicates that even though most densities at the start and end of the press run were within the GRACoL tolerances, they were still too high; thus, resulting in larger color differences. As the press run continued, density started to subtly decline. This could be attributed to the strain put on the press due to the continuous run length. At the same time, this pattern shows how tolerances from 2 different specifications do not integrate into the same test effectively (Vogl, n.d.). In this test, lower densities are required to minimize color differences, however, most density values are not even meeting the GRACoL specification aim points. A compromise or balance of these two parameters will then need to be made. One can either ignore the density aim points in order to achieve optimal color consistency or try to achieve the density aim points at the expense of some color consistency.

A lot of our results are in accordance with published information. GRACoL specification outlines a set of densities that should be met for offset lithographic printing and these aim points and tolerances were used to evaluate the Xerox 700's ability to remain consistent in relation to these values. Although these are 2 completely different printing processes, the values represent a level of quality within a printed piece and comparison to these values not only gives a benchmark to measure consistency from, but also indicates, to some degree, the amount of quality that the Xerox 700 can produce. Given that the SIDs of all the colors, with the exception of only a few data points, fall within the tolerances outlined by GRACoL specification, it can be said that in terms of SID, the Xerox 700 was able to meet GRACoL specifications.

According to the IDEAlliance Digital Press Certification Program, the maximum ΔE*00 between any solid patch and the average L*a*b* of that patch throughout the entire press run should not exceed 2.0 (IDEAlliance, 2011). Most of our data is within this indicated tolerance, with the exception of a small number of points which might be outliers, thus indicating that the press was generally able to meet IDEAlliance's tolerances. IDEAlliance also indicates that the maximum tolerance for color-to-color registration should be 0.1mm and all of our data was able to meet this tolerance.

The manufacturer of the Xerox 700 states in one of its specification brochures that the Xerox 700 is able to achieve front-to-back registration of 1mm (Xerox, 2009). Our data indicates that while this is achievable, there is absolutely no consistency in the press's ability to stay within this tolerance. After having optimally adjusting the front-to-back registration on the DFE, the front-to-back registrations on the prints were nearly perfect. However, after approximately 190 sheets, fluctuation in this parameter became really sporadic and drastic. The amount of deviation starts to gradually increase at this point and never return to registration that was as optimal as when it had been freshly adjusted. Out of the 10 sheets that were measured for front-to-back registration, 4 of the sheets were unable to meet the 1 mm tolerance. If the same ratio was applied to the entire press run, then there would be 200 sheets that do not back up to each other adequately. So whilst the press is technically able to achieve a front-to-back registration of 1mm, this may only be applicable to shorter runs, as this parameter starts to deviate greatly after a certain number of sheets.

The results contradicted our preconceived assumptions on the Xerox 700's color and registration consistency throughout a medium-to-long press run. Our data shows that while there is some fluctuation in the data for density, color consistency, and color-to-color registration, all 3 of these parameters were able to meet tolerances outlined by IDEAlliance and GRACoL, with only some minor exceptions. It is inevitable that there will always be some data points that do not meet the tolerances, as no printing process is absolutely perfect. That means that the data points that slightly breakthrough tolerances are attributed to this while those that drastically break tolerances are due to the high possibility of them being outliers. Additionally, we measured a much bigger sample size in comparison to the certification program, so the odds of finding data that do not meet the tolerances is a lot greater. Despite this, the amount of points we found that do not meet the tolerances is really small. Had all testing been done in accordance to the certification program, it could have been possible that no data points that are out of tolerance been discovered at all. Under such presumptions, it was concluded that by being more lenient with the requirements set up for the test, it would hold true that the Xerox 700 is consistent in terms of density, color, and color-to-color consistency.

The same cannot be said about front-to-back registration, as this is the sole parameter in which our hypothesis was confirmed. The data shows that out of only 10 sheets, almost half of the sheets did not meet the front- to-back registration values outlined by the manufacturer. The registration started out really well, but then it began to drastically drift out of the tolerances with no signs of returning back to its initial position. This parameter's overall inconsistency and inability to reproduce values meets our requirements in support of the hypothesis.

Weaknesses exist in every experimental test and the same holds true for this test. Calibrating the equipment and instruments to collect our data, along with the use of excel functions and equations helped minimize validity issues; however, there are still a number of factors which could have influenced our results. The test forms were printed duplex; thus, colorimetric measurements could have been affected by the show-through of the second form on the other side of the sheets. It was also difficult to quantify the deviation of color registration and front-to-back registration accurately using the ruler on the DPM program. Front-to-back registration was particularly difficult to capture using the microscope because a light table was needed to see the registration marks on the second form to compare to ones on first form. Moreover, the 500 sheets were not measured the same day they were printed. It's unsure whether the pressroom was properly conditioned and whether it affected the sheets while they were stored there. In addition to this, repeatability of the X-Rite® 530 Series Spectrophotometer (Serial No. - 051480) is best on a short-term basis. Even though the same device was used for all the measurements, the sheets were measured days apart, which to some degree, affects the repeatability of the instrument. For this test, only 500 sheets were printed instead of 1000 sheets, which is specified in the IDEAlliance Digital Press Certification. 1000 sheets would've given a more accurate representation of consistency throughout a long press run. Also, a lot more sheets were measured in our test than IDEAlliance's certification program. These 2 factors could have both positive and negative implications for the test. Measuring a smaller sample of a larger population means that the odds of detecting errors or anomalies is lower. This could falsely indicate that a press is more consistent than it actually is. By measuring a large sample in a smaller population, a better representation of the press run is being recorded. Although this means better detection of changes, it could actually affect whether or not the press is able to meet certification requirements.

Overall, the intended purpose of this paper is to evaluate how viable digital printing is without an official standard. This viability is evaluated based on a press's consistency and ability to meet existing tolerances or specifications even though they may not be intended for digital presses. It also specially evaluates certain aspects of the Xerox 700 in greater detail than the IDEAlliance Digital Press Certification Program. We intended to discover trends and patterns in regards to consistency for the Xerox 700 to see if its ability to meet IDEAlliance's certification requirements can be repeated. Repeatability of a press's abilities to meet the certification requirements indicate the overall consistency of the press, thus suggesting that standards could be met if they were available.

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