The Use of Colorimetric Values to Setup the Printing Press

Carlo Emilio Balestrini*

Keywords: Colorimetry, Densitometry, Measurement, Ink, Solid

Abstract: Since a few years, the family of ISO 12647 Norms have been updated specifying CIELAB color values parameters for normal process control thus obliging press operators to use spectrophotometry and densitometry in the same time. This system can present some difficulties when setting up and keeping under control production printing equipments. The object of this research, started four years ago, is that of finding out a methodology to obtain the correct ink values starting from the CIELAB references.

The densitometry is always the most common way to predict the amount of ink. Anyway no mathematical relationship can be done with the CIELAB measurements because both the densitometric and colorimetric values come from different sampling of the spectrum.

In this reserch different colorimetric coordinates belonging to the various CIE color spaces have been tested in different printing conditions with a number of inks, in order to verify which one is the more representative, useful and reliable to get the target colorimetric values with the minimun deltaE*

---

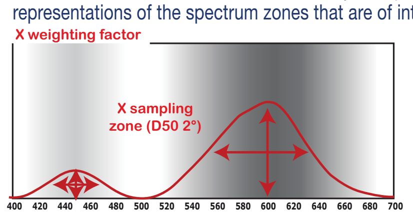
*TAGA Italia - RCS Periodici, Italy (carlo.balestrini@rcs.it)

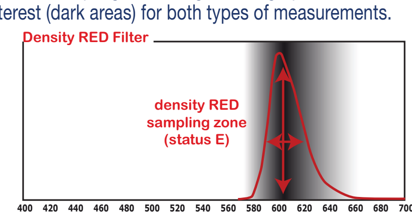
COLORIMETRY & DENSITOMETRY

In order to traduce the standard indications it is necessary to regulate the ink film thickness in the press setup using colorimetric values instead of those densitometric. The operation is quite difficult because the L*a*b* metric values are not intuitive when dealing with ink variations and so not too simple to use. Although there is a mathematic relation between the various CIE color space (ex: CIELab, CIEXYZ, CIELch). The aim of this research is to identify which of the three components of the various CIE color spaces is best correlated and useful for the optimum amount of ink that has to be used on the press in order to reach the reference values of the standards.

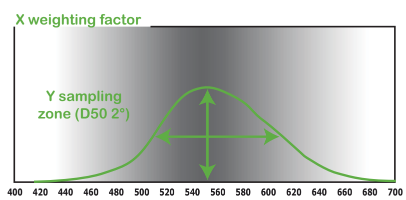
The main difference between densitometer and colorimetric measurements is that the first displays density values given by the logarithm of the reciprocal of a weighted average of the spectral reflectance factor. Colorimetric measurements display differently weighted averages of the spectral reflectance factor and can also frequently display various transformations from these values. One reason is the need to define a more uniform colour space such as CIELAB.

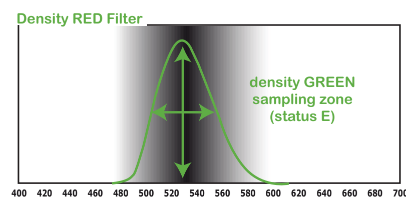
The first step necessary to face the subject is to analyze carefully the correlation between densitometric and colorimetric measurements obtained by the spectrum sampling. Following are the graphic representations of the spectrum zones that are of interest (dark areas) for both types of measurements.



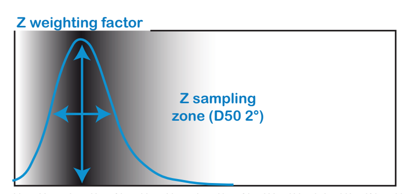


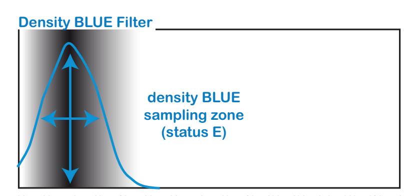
The X component of CIEXYZ results much less selective respect of the equivalent red filter. Consequently the computation of a Cyan ink will result very influenced by its colorimetric characteristics. On the other hand the related narrow band density measurements with a Red filter are almost immune of chromatic differences.





The same thing works for the Y and its equivalent Green filter. The first is a a wide sampling, the second instead is narrow. A quite interesting detail is that the Y of CIEXYZ represents the brightness that we can find in the L of CIELAB.

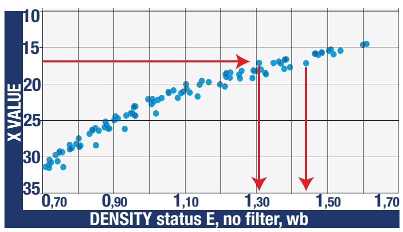


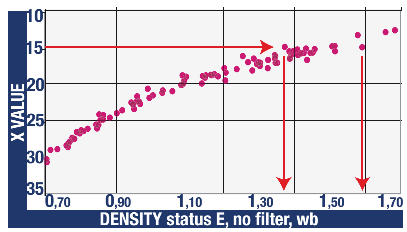


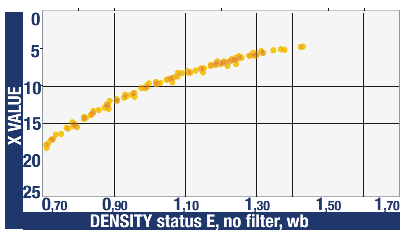
Regarding the Blue filter used in the yellow ink measurment, we can find a particular similarity with the weighting factor Z. Though they do not give an identical response, in the case we are using different inks.

Practically densitometric measurements universally adopted in the graphic arts are not absolutely accurate when matching colors. The next example evidences those limits: two color patches with the same density values but different colorimetrically, specially for the L value.

Relationship between Colorimetric coordinates & Density



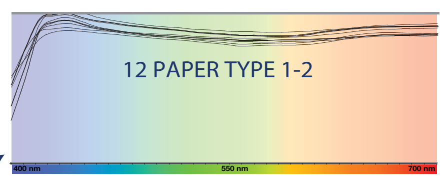


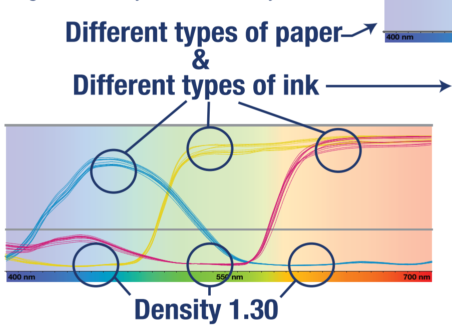


This are graphical representations of a few samples of prints in different sites and different conditions. The relationship between the specifical and single colorimetric component of the color space CIEXYZ is the densitometric measurement. We can notice a significant discard in both Cyan and Magenta inks.

Prints analyzed:

In the following charts we can observe the reflectance factor of 12 samples aligned exactly with a density of 1.30.





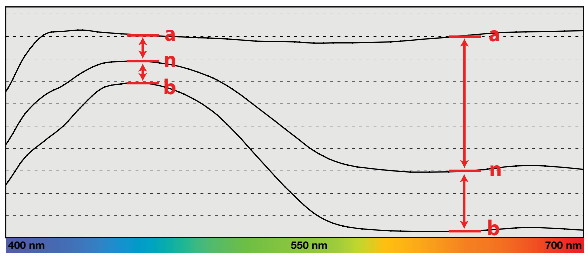
Huber 7000 Rapida
Huber 8510 Standard
Huber 7880 Hicos HD
SunChem Standard
SunChem High End HD
Maloberti Europarid HD
Colorgraf Excelsior HD
Flint Mach Standard
Eppele Aniva HD

TABLE 1 - INK TESTED ON 12 PRINT RUN

HOW TO DO

Since the testing on press has many difficulties in both timing and effective costs, we preferred developing a virtual lab. The main goal was to be able to simulate minimal spectral variations starting from real samples made under different printing conditions and with different types and brands of both ink and paper available on the market (see table 1).

In the fist place we looked for a mathematical formula that could describe an intermediate variation between the two spectral curves:



$$n=a(b/a)^f$$

where f<=0

n=a with f=0, n=b with f=1

From the beginning this formula turned out to be very accurate caused by known problems of "additivity failure" (Yule "Principles of Color Reproduction").
In order to obtain a more accurate result, like individually discarded in instrumental differences (ΔE<0,5) we had to do the following expedient:
a) choose some spectral samplings as close as possible between them (ex: like values between 40% and 60% in order to reach intermediate values with a ΔE under 0,2).
b) simulating solid values near the reference (table 2)

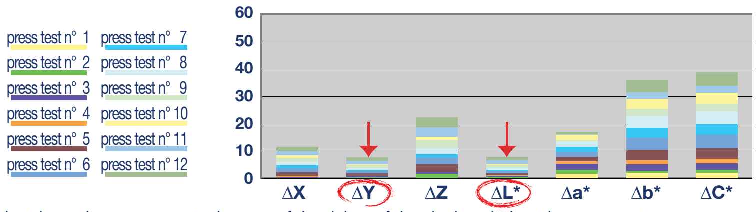
REAL MEASUREMENT		Calculated width the abrove formula		DELTAS WIDTH A REAL MEASUREMENT
1,25	→	1,45	=	ΔE^{76} 0,4
1,48	→	1,25	=	ΔE^{76} 0,7
1,23	→	1,66	=	ΔE^{76} 0,5
1,66	→	1,23	=	ΔE^{76} 0,4
0,88	→	1,26	=	ΔE^{76} 0,5
1,29	→	0,88	=	ΔE^{76} 0,7

TABLE 2

In the following pages we proceeded on simulating solid variations starting with measurement obtained in different printing conditions (site, press machine, paper, and ink).
The second step was that of analyzing ink variations in relation to various delta values, in particular XYZ that may help us individuate in a direct way the optimal reference value of the amount of ink necessary to reach the minimum deltaE.

CYAN ink

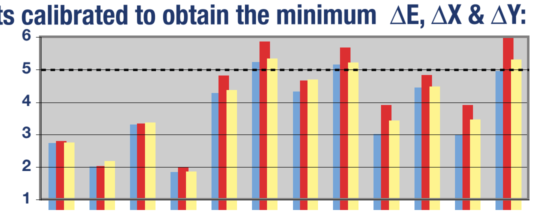
Cyan Ink, 12 samples calibrated during press in order to obtain the minimum ΔE in comparison to standard values:



The chart here above represents the sum of the deltas of the single colorimetric components: even though it is indicative, we can notice that the minimum deltaE corresponds to the minimum delta of Y (of CIEXYZ) and of L (of CIELAB).

Cyan Ink, 12 sample tests calibrated to obtain the minimum ΔE, ΔX & ΔY:

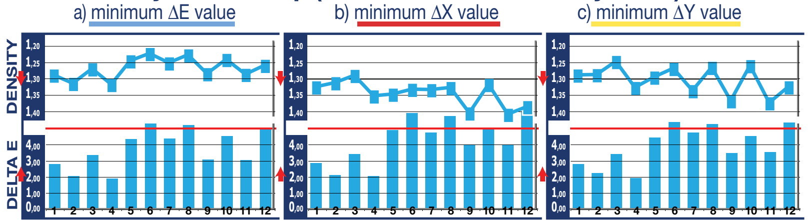
Three different scenes
In which we searched for:
a) minimum ΔE value
b) minimum ΔX value
c) minimum ΔY value



We found, through the analysis of these 12 press samples, that Y of CIEXYZ is a better way to calibrate the press with the colorimetric values, instead of the one based on X, the element used for the calculus of the dotgain that has always been considered the standard for Cyan, just like the Red filter use for densitometers. This detail represents in a something quite new, even though L of CIELAB, used for the setup, is obtained through Y.

ΔE & Density Relationship (3 different scenes with Cyan Ink)

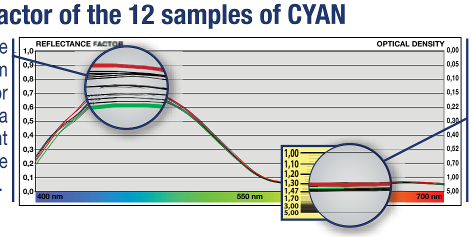
a) minimum ΔE value b) minimum ΔX value c) minimum ΔY value



Continuing through the analysis and verifying the remaining density values we can consider:
- an inversely proportional correlation between the values of ΔE and density values (left chart)
- that the alignment of the press machine in comparison to ΔE values in the analyzed cases does not prejudice the optimization of the density values.

Reflectance factor of the 12 samples of CYAN

The spectrum zone with maximum reflectance factor put in evidence a large misalignment between the samples.

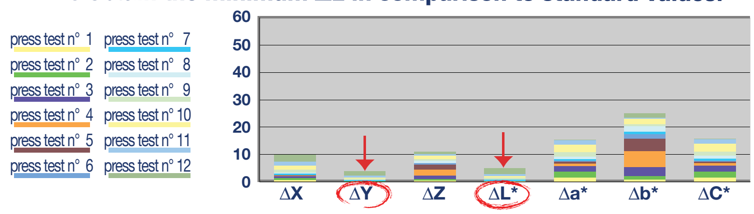


The spectrum zone with minimum values of reflectance put in evidence a perfect alignment between the samples.

It is evident that the research for the minimum ΔE value goes in the same way as the minimum delta of the ink thickness and so it is the best practice to calibrate a press setup to the aim values.

MAGENTA ink

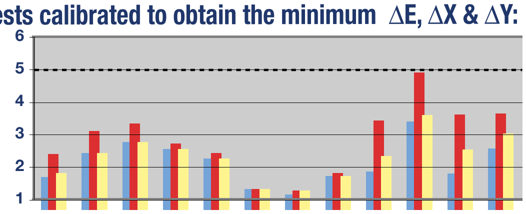
Magenta Ink, 12 samples calibrated during press in order to obtain the minimum ΔE in comparison to standard values:



Also, in case of Magenta ink, we can notice that the minimum ΔE value corresponds to the minimum delta of Y (of CIEXYZ) and L (of CIELAB). After the experience with Cyan we decided to align the setup with the X referrals obtaining worst results.

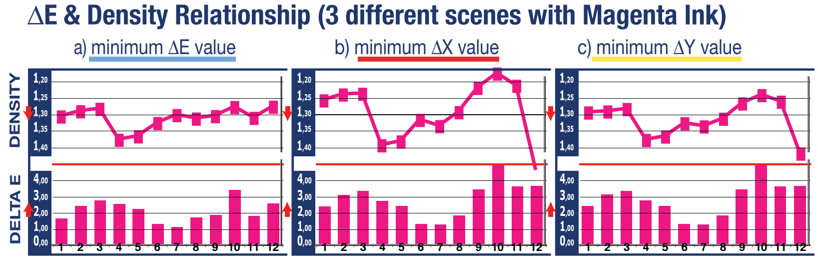
Magenta Ink, 12 sample tests calibrated to obtain the minimum ΔE, ΔX & ΔY:

Three different scenes
In which we searched for:
a) minimum ΔE value
b) minimum ΔX value
c) minimum ΔY value



While using the X value, in some samples (the last four) we had a misleading result. The Y of CIEXYZ did so confirm itself as a good reference on all samples. Observing the case history we can say that the L (of CIELAB) is a good reference and much easier to adopt rather than the more common Y.

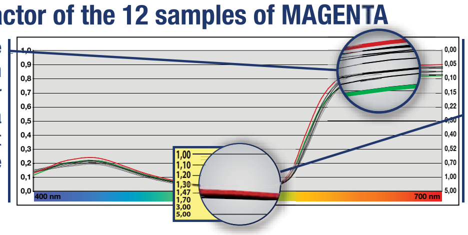
ΔE & Density Relationship (3 different scenes with Magenta Ink)



Continuing through the analysis and verifying the remaining density values we can consider:
- an inversely proportional correlation between the values of ΔE and density values (left chart)
- that the alignment of the press machine in comparison to ΔE values in the analyzed cases does not prejudice the optimization of the density values.

Reflectance factor of the 12 samples of MAGENTA

The spectrum zone with maximum reflectance factor put in evidence a large misalignment between the samples.

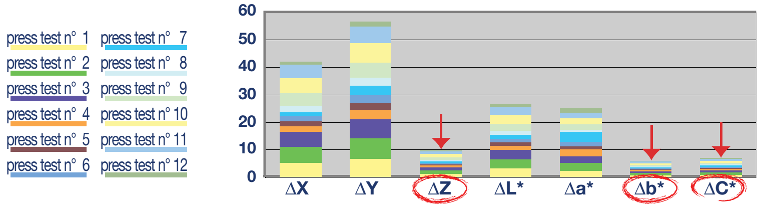


The spectrum zone with minimum values of reflectance put in evidence a perfect alignment between the samples.

It is evident that the research for the minimum DE value goes in the same way as the minimum delta of the ink thickness and so it is the best practice to calibrate a press setup to the aim values.

Yellow ink

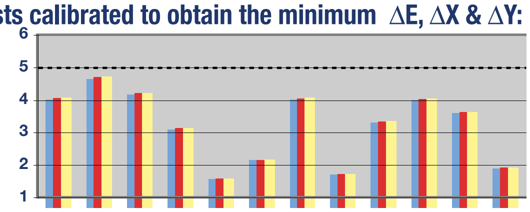
Yellow Ink, 12 samples calibrated during press in order to obtain the minimum ΔE in comparison to standard values:



In the above chart we can notice that minimum delta values are respectively found in the b (of CIELAB) , C (of CIELCh) and Z (of CIEXYZ) colorimetric coordinates.

Yellow Ink, 12 sample tests calibrated to obtain the minimum ΔE, ΔX & ΔY:

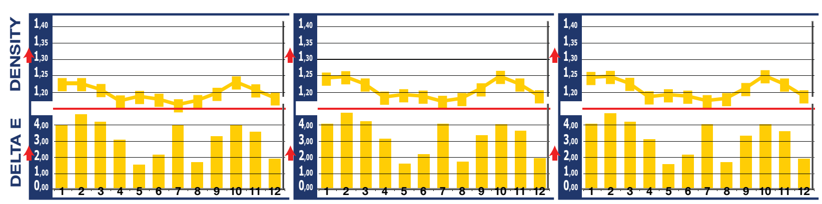
Three different scenes
In which we searched for:
a) minimum ΔE value
b) minimum Δa value
c) minimum ΔZ value



Even though the previous chat puts in evidence that the ΔZ value is higher that Δb and ΔC the results obtained during the test gave the exact same result. We found, through the analysis of these 12 press samples, that the yellow ink does not cause many problems and so it can be calibrated with different references like ΔE, Δb, ΔC and ΔZ. By adopting any of these reference values the minimum value of ΔE can be easily reached.

ΔE & Density Relationship (3 different scenes with Yellow Ink)

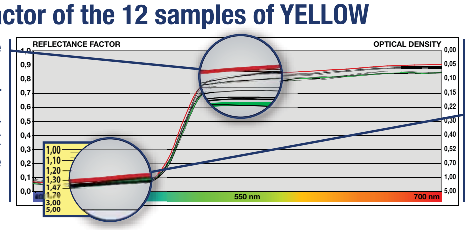
a) minimum ΔE value b) minimum Δb value c) minimum ΔZ value



After analyzing the chart using yellow ink we notice a very interesting point. While in the Cyan and Magenta we had an inversely proportional correlation between the values of ΔE and density values, in the yellow we found a directly proportional correlation.

Reflectance factor of the 12 samples of YELLOW

The spectrum zone with maximum reflectance factor put in evidence a large misalignment between the samples.

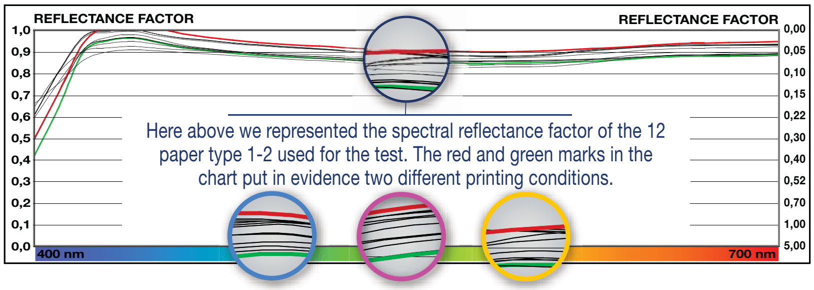


The spectrum zone with minimum values of reflectance put in evidence a perfect alignment between the samples.

It is evident that the research for the minimum ΔE value goes in the same way as the minimum delta of the ink thickness and so it is the best practice to calibrate a press setup to the aim values.

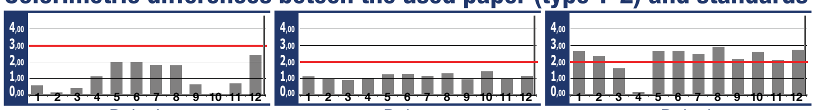
PAPER

Paper, 12 samples of paper used during press test the minimum ΔE in comparison to standard values:



In the three colors represented above, you can see that the principal gap is not due to the inks used but rather to the paper characteristics. It is common use to blame inks for the difference of ΔE rather than to the chromatic variations you may find in the paper.

Colorimetric differences beteen the used paper (type 1-2) and standards



Delta L | Delta a | Delta b

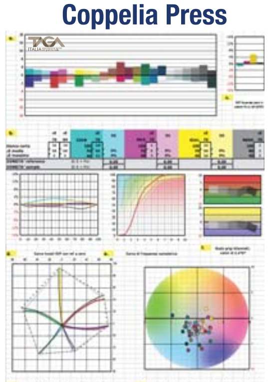
In conclusion we can draw say that:

1) Like in theory also in practice we found that there is not a stable relationship between densitometric and colorimetric measurements.
2) With the use of ISO2846 compliant inks the research of the minimum ΔE value takes to a fulfillment of an optimum setup
3) A high ΔE oppositely brings to a nonoptimal value in ink thickness.
4) Paper does influence very significantly and more than what we can imagine the ΔE on the solid.

More tools to setup the Press

On developing this research we found very useful representing with various charts the numerous variables related to the color management on the press. Practically we developed two Excel worksheets, the first able to calculate data on a control bar, the second that could elaborate a larger number of measurements like those of ECI2002 or the more recent IT8/7.4. At the end we noticed that it is not enough to evaluate single ΔE in order to diagnose and analyze color quality on the press.

Coppelia Press



Coppelia Digital