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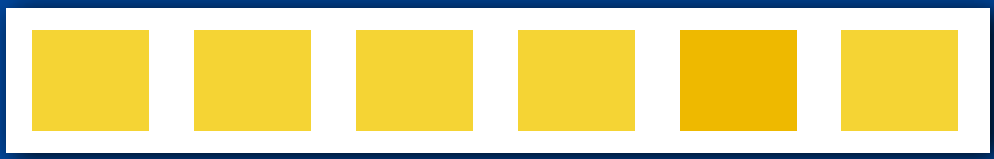
SCREEN PRINTING

FACTORS INFLUENCING COLOUR REPRODUCTION



One strength of screen (and pad) printing is the application of a huge variety of spot colours on different substrates. Usually without any problems, in most cases anyway. However, sometimes (avoidable) errors can be made in the hustle and bustle of order processing caused by overstepping tolerance limits for colour accuracy/colour reproduction specified by customers. The printed hue does not match the reference print made by the colour chamber; or the colour changes during printing; or the printer does not achieve the reference colour when mixing the colour for re-orders. These are just a few examples. In the following we explain all important factors influencing a reliable colour reproduction, so that in terms of colour you will always be on the safe side.

"LET THERE BE LIGHT" – BUT PLEASE THE RIGHT ONE!

Metamerism using the example of a Pantone Lighting Indicator card, which is part of every new Pantone Formula Guide.

The card shows 2 brown colour fields (divided horizontally) with two different formulations. The left picture shows the card illuminated with D65 or D50.

The image on the right (same card) is illuminated with F11 (TL85) and shows a considerable metamerism.

Colour is light! If you want to compare colour shades, e.g., the colour reference sample with the resulting print, you should always use the same lighting conditions. Depending on colour shade there will be metameric effects when viewing under different lighting conditions (the strongest effect will show with yellow, grey, and beige colour shades). Two colours, e.g., a PMS or a RAL template remixed with screen printing ink will be right under one illuminant (light source) such as daylight. They will, however, not seem right using another light source like warehouse lighting. Usually, colour shades are checked under "daylight" conditions. Since daylight varies a great deal depending on the time of day, position of the sun, clouds etc., there is a standard for daylight producing the most neutral "white" light possible.

In the screen and pad printing industry (and the coatings industry) we work with D65. Other printing processes (offset, flexographic, also digital printing) use D50. Differences are small. Compared to D50, the illuminant D65 is more blue-one-sided.

The so-called "warehouse lighting" standard F11 (before TL 84) which is used to show a common department store illumination is quite different. Out of fashion in Europe, but still relevant in other parts of the world, is standard illumination type A, the (yellow-red-sided) incandescent bulb light.

For screen and pad printing applications all colours are formulated, controlled, printed and compared under standard illumination D65, unless the client specifies other types of illumination.

COLOUR SENSITIVITY – A QUESTION OF CHARACTER

Just as with all other matters, you will have complicated and uncomplicated colours. The characteristic of a colour is the decisive factor. The human eye tolerates differences of rich reds or yellows more than those of grey shades. The richer, more intense, and opaque a colour is, the easier it is to print. On the other hand, the brighter and, above all, the more transparent the colour is, the more demanding will be the printing. When in addition you use a milky or clear substrate, which may also be backlit, then you will have a very demanding job.

Most RAL or NCS colour samples can usually be matched with opaque formulations. On the other hand, due to their high brilliance Pantone PMS-C or HKS-K colour samples often can only be matched and mixed with a high transparency, meaning a high varnish content and only few opaque colours.

THE FORMULATION OF A COLOUR – A QUESTION OF PRECISION

When creating a colour formulation, careful and precise work is required, especially for re-orders when you have to re-mix a formulation again and again.

THE 100 GRAMS/100% RULE

Ideally, when matching a colour formulation, you use the 100% principle. The sum of all components of the colour match always should result in 100 grams or 100%. That way you will have an accurate mixture for calculation of larger quantities for the print run. You will have a fast and safe percentage conversion for the required, possible also somewhat “odd” target quantity (e.g., 7.5 litres).

At first, mixing a formulation of 100 grams requires more time than simply adding colours until the colour-shade is finally right. That would usually be faster, but then the formulation ends in a total sum of 156 grams, or 312, or 64 or similar "odd" values. You can then always expect calculation errors when extrapolating to the quantity required for the print job.

It is also useful to separate other required additives such as thinners, retarders or hardeners from the actual 100 g colour formulation, these should be listed separately.

THE SCALE

Any formulation will only be as accurate as the scale used for weighing the components permits. Basically, the last digit shown in the scale display is the tolerance value. Actually, a scale with a 0.1-gram scaling will only weigh to 1 gram accuracy; not sufficiently accurate for mixing small amounts of <1 gram. Not to mention letter or kitchen scales which are used sometimes. Unfortunately, accuracy is a little expensive.

However, the investment of a precision scale with an accuracy of 0.01 gram will be worth the expense.

Left picture: Display of a precision scale with an accuracy of 0.01 gram.

Centre picture: Agitator of a dissolver for efficient mixing of ink components.

Right picture: Example: Colour changes of small additions of black to yellow. Yellow background is C-MIX colour Y30.
The left rectangle is Y30 with addition of 0.5% black N50. The right rectangle is Y30 with addition of 2% black N50.

FORMULATION

Although not always possible, try to use as few colours as possible for a formulation to get a better reproducibility. Also, try to avoid additions of <1gram as far as possible. Weighing and mixing an addition of e.g., 0.1 gram in a 100 grams formulation can be quite tricky. Even for an amount of 1 kilo that would only amount to 1 gram in 999 grams of other ink requiring a perfect and even distribution. It would be much better to mix such small amounts with another predominant colour of the formulation and then weigh this mixture.

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WEIGHING

Always start with the colour component with the largest quantity in the formulation, then in descending order the other colours.

MIXING

This part of the process is often underestimated. Least suitable are screw drivers, long nails or kitchen mixers. Also, for sensitive colours professional spatulas will be insufficient. Sensitive colours require efficient mixing equipment such as dissolvers, agitators. These are available in various sizes suitable for different container sizes allowing best-possible mixing by shear force. Otherwise, the final colour will only mix gradually during printing on the screen (or in ink cup of the pad printing machine).

THINNER

As far as viscosity of printing inks is concerned, screen and pad printers are downright individualists. Some prefer thinner (low viscosity) inks, while others rather print thicker (high viscosity) inks. Inks themselves tolerate different viscosities with no problem, but the hue doesn't. The more transparent the stronger the reaction due to the degree of dilution. The colour prints of inks with little amounts of thinner will be darker whereas the colour of inks with a high degree will be much brighter. Therefore, the required degree of thinning of the ready-to-print adjustment must be considered for the formulation.

PRINTING RECORD

"He who writes, remains."

All essential parameters are documented in a printing record (Example: Section of a record taken during a print run in our screen centre).

	Ink Type	Colour Name	Colour Shade	Thinner	Retarder	Fabric	Date	Print
				VD 60	VZ 25			
1.	CX	W 50	White	17%	5%	120-*34*	29.07.	JB
2.	CX	Y33/09	Primrose	10%	10%	120-*34*	29.07.	JB
3.	CX	R33/02	Signal red	6%	10%	120-*34*	30.07.	JB
4.	CX	32/70	Transparent blue	15%	5%	100-*40*	30.07.	JB
5.	CX	65	Black (Text)	15%	15%	140-*31*	30.07.	JB
6.	CX	E 50	Varnish	15%	5%	120-*34*	01.08.	JB

REFERENCE PRINT

Contrary to other physical values such as volume or weight it is difficult to describe the measurement values of colours. Thus, exact match of the colours will be difficult for re-orders. Therefore, anyone using colorimetric technology for colour matching will also document in the "old-fashioned way". A reference print is made under standard conditions and filed together with the formulation.

Any colour shade produced by Coates Screen Inks is printed on special test cards consisting of a transparent, a white and a black substrate.

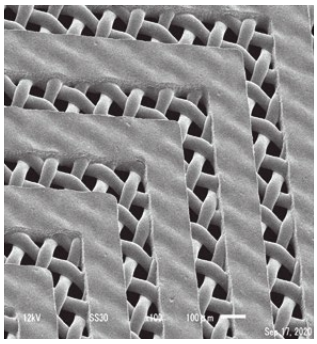
Example: Checking a reference print

SCREEN FABRIC – "THE SCREEN – AN OUTRIGHT MATTER OF FINENESS"

The screen fabric used for printing is one of the most decisive factors influencing the resulting colour or the print. All the more astonishing is that some tend to consider the screen fabric as secondary. A screen fabric is defined by the number of threads per centimetre and the thread diameter in µm (e.g., 120-*34*). The resulting fabric thickness and degree of screen openness are the calculation factors for the theoretical ink volume V_{th}. This practical value specifies the printed ink in cm^3/m^2. The following chart shows the differences of four different fabrics. When inks are printed with finer and then with coarser fabrics in repeated print jobs, it is only logical that you will have differences in colour shades.

Fabric count *	Theor. ink volume Vth	Absolute change	Percentage of change
120-*34*	14 cm³/m²	Reference	Reference
100-*40*	19 cm³/m²	+5 cm³/m²	+35 %
90-*48*	23 cm³/m²	+9 cm³/m²	+64 %
140-*31*	12 cm³/m²	- 2 cm³/m²	-14 %

* Fabric data in reference to *SEFAR PET 1500*



One Pot Sol C2. Picture of printing side of stencil.

STENCIL

Depends on printed motive. With solid motives the thickness (EOM = **E**mulsion **O**ver **M**esh) practically has no influence on the printed colour. The EOM will only influence the colour directly on the edge of the motive for a width of up to 1mm. Motives with dots or lines with a diameter of <2mm are influenced strongly by the stencil thickness and therefore also on the resulting colour. Again: the more transparent a colour shade is, the more visible will be the differences using various EOMs.

PRINT RUN – "A QUESTION OF ADJUSTMENT"

Printing equipment: Naturally snap off distance and screen lift (if available) have to be adjusted so that the screen fabric will always immediately detach from the printed ink layer after the squeegee has passed, i.e., there won't be any „trailing".

Screen printing machine

SQUEEGEE

Depending on hardness, angle, edge and printing speed there may be a sligh influence on the resulting colour. A small difference, however, a factor to be considered for strict tolerances.

PROCESSING CONDITIONS

Factors like number of prints, ink consumption and room climate play an important role. The longer you print, and the smaller the ink consumption is in an environment getting warmer and warmer around the press (room climate) the higher the risk, that the colour will "go astray". This is especially the case when printing solvent or water-based inks. UV-inks are more stable. Solvent (or water) based inks are physically drying inks, their solvent (or water) content evaporates, especially on the screen during the printing process. The higher the temperature is, the more solvents (water) evaporate. If, in addition you print motives only requiring small amounts of ink the viscosity in the screen quickly increases, the printed colour will become increasingly darker or more intensive. Therefore, it is essential to re-thin the ink in time to maintain a consistent colour.

SUBSTRATE

A printed colour will show differences depending on surface properties (e.g., rough, semi-gloss, high-gloss) and absorption properties of the substrate. A good example is the Pantone Formula Guide (see picture "Pantone 212C") comparing the colours PMS-C (smooth, coated material) with PMS-U (uncoated, absorbent material).

Printing on the reverse side of transparent material also has an influence on the colour of the material (even if hardly visible), especially when using very bright, whiteish colours.

PMS 212 U vs. PMS 212 C

FINISHING

Depending on the degree of gloss or matting, overprinting, lamination or coating of a printing ink will sometimes significantly change the colour. This effect also has to be taken into consideration when matching a colour.

SUMMARY: THE MOST DECISIVE FACTORS TO AVOID THAT COLOURS GO ASTRAY OR CHANGE

Colour control:	Consider light source (D65, D50, TL 84 etc.) to avoid metamerism.
Formulation:	100% rule, avoid colour components of <1%, documentation
Mixing:	Accurate weighing, efficient dispersion.
Reference print:	Easy reproducibility for re-orders.
Printing conditions:	Fabric, thinner addition, stencil thickness, squeegee etc.
Substrate:	Colour (white/black/coloured, translucent, transparent), surface, possibly absorption properties.