Alfred Eichler Colour Management

SunChemical®

Coates Screen Inks

OPACITY AND COLOUR SATURATION OF SCREEN AND PAD PRINTING INKS

Printers are often required to print a bright and saturated colour onto a dark substrate. A bright yellow on black, a bright orange on blue etc. This is easy on a computer screen, but almost an impossible task for screen and pad printers. What are the reasons for that problem? Where are the limits?

Transparency and opacity of a screen or pad printing ink directly correlate with the possibility to match "bright", highly saturated colour samples. Thus we should take a closer look at this correlation and recall the definitions of opacity, transparency and brightness of colour.

OPACITY

The term opacity of a pigmented coating describes its ability to cover the colour or colour differences of the substrate. The opacity criteria are either a defined colour distance (chromatic layers) or a defined contrast ratio (achromatic layers) between the contrasting areas of the coated substrate. The opacity is accomplished by scattering and absorption. Opacity of white pigments mainly derives from scattering whilst opacity of black pigments is a result of absorption ability. The opacity of printing inks defines whether an ink is in-transparent (opaque) or transparent.

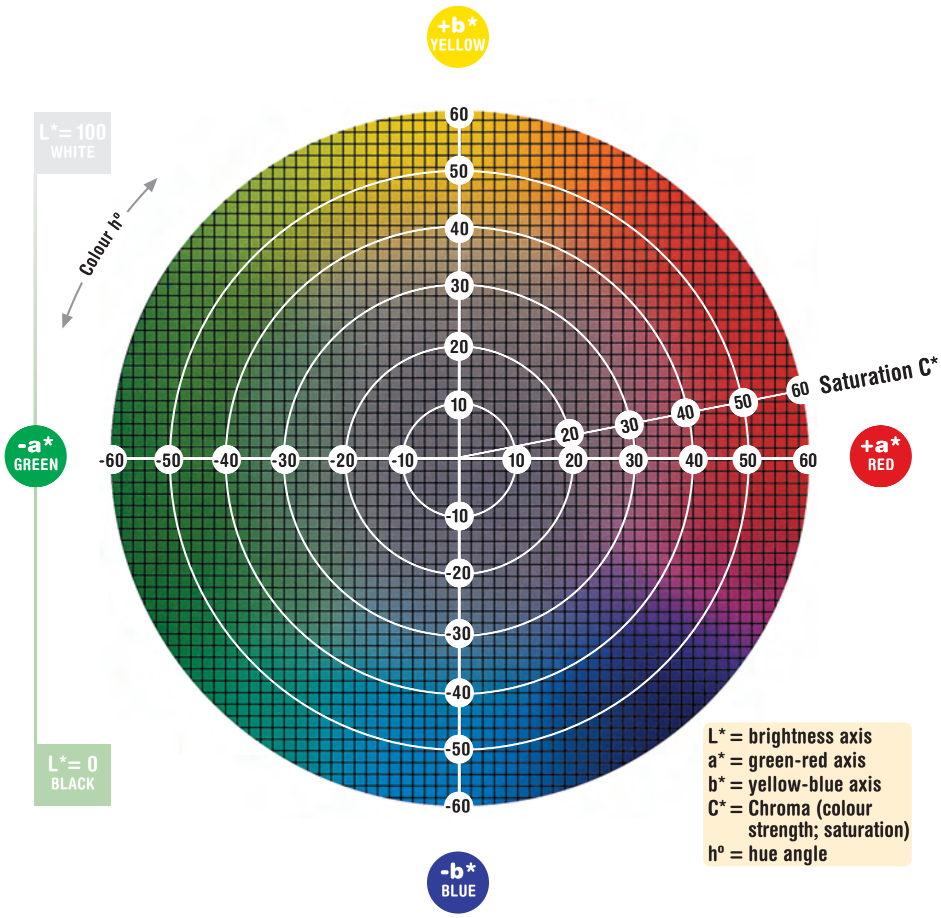
TRANSPARENCY

Transparency is the term used to describe the extent of translucency of coloured media. Translucency depends on the property to scatter radiated light as little as possible. If colour change seems small when looking at a test print on a black substrate, transparency is high.

SATURATION

Brightness or saturation of a colour describes its difference to a grey of the same brightness (achromatic) and is considered as colour strength. Definition in the CIELAB colour space is saturation (Chroma) C*. It describes the distance to the colour space centre, the "achromatic point". The higher the colour saturation the higher its brightness. When looking closer at this definition you will find that a high opacity (strong light scattering or absorption) will exclude a high chroma (saturation). The higher the opacity of a colour the more close it will be to the centre of the CIELAB colour space; in other words it will act in opposition to saturation C*. When matching "bright" colour shades this means that there is a physical border between opacity and chroma, i.e. the "brightness" of the colour. As usually the dry ink film of screen and pad inks is about 5-20µm, the opacity of prints applied onto coloured substrates is very important. When printing on white substrates opacity seems to play a secondary role and one can achieve a high "brightness" with transparent colours. However, as transparency increases, colour will be more and more dependent upon layer thickness. As numerous parameters have to be considered in the screen and pad printing process (degree of thinning, squeegee, squeegee position, printing speed etc.) there will also be differences of layer thicknesses applied.

The more transparent or translucent a screen or pad ink is, the higher the risk of colour changes due to printing parameters.



INFLUENCE OF PIGMENTS ON OPACITY AND COLOUR SATURATION

Opacity and colour saturation of a screen or pad printing ink mainly depend on pigmentation. Only a certain percentage of pigments can be blended into an ink system without changing its properties. This maximum concentration (pigment volume concentration) strongly depends on the pigment type (oil absorption) and absorption properties of the binder system.

In addition to the absorption coefficient of the pigment, the refractive indexes of pigment and binder, the degree of dispersion of the pigment, the layer thickness etc., the scattering coefficient of the pigment is very important. Just like the absorption coefficient it depends on the particle size. Scattering power will have a maximum value with defined particle sizes.

Despite of low scattering power opacity can be achieved due to high absorption ability. Pigments with a high absorption ability and low scattering power will achieve opacity with corresponding pigment concentration (layer thickness), however they seem very dark.

Therefore maximum opacity of a pigmented system can be achieved using a pigment with a maximum scattering power. The higher the scattering power is, the brighter the “colour” impression towards the maximum white and thus towards the “achromatic” axis of the defined colour space. The same happens when you use pigments with a maximum absorption ability, however in that case not in the bright colour space, but dark towards black.

MATCHING OF OFFSET SAMPLES SUCH AS PANTONE® OR HKS

When matching these colours there are limitations due to the colorants and the different printing technology. Offset colours, which are used to print the Pantone® Formula Guides contain other colorants with lower resistances and other spectral absorption abilities than screen and pad printing inks.

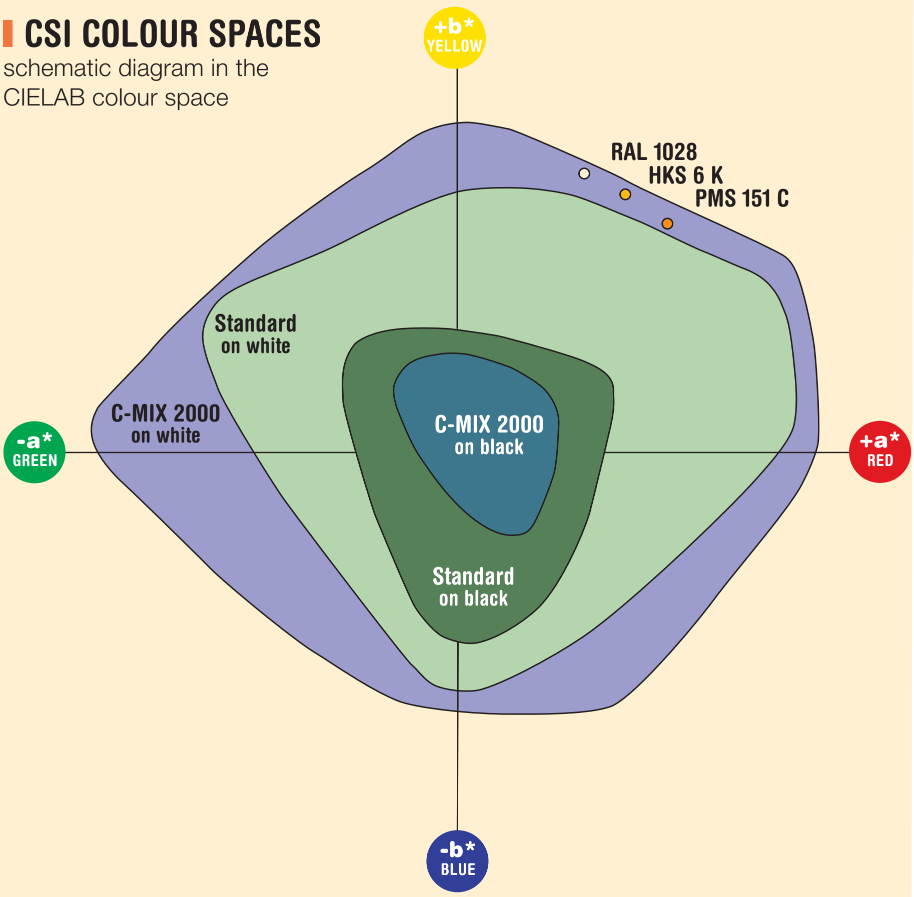
In addition much more saturated colours can be achieved with these printing inks printed on paper than with opaque systems. Taking a closer look at the Pantone® Mixing System you will find that not opaque white but transparent white (clear varnish) is added to brighten the colours. This way the bright white of the printing substrate is included und the achievable colour space is considerably expanded. If you would add opaque white (titanium dioxide) to these offset colours the saturation (chroma) would be considerably reduced. In the screen and pad process you will try to match a transparent system with an opaque system, often on coloured substrates. Inevitably you will experience problems and limitations.

REAL COLOUR SPACES OF SCREEN AND PAD PRINTING INKS OF COATES SCREEN INKS GMBH

To explain more clearly, based on laboratory prints the real colour space of our semi-transparent C-MIX 2000 colours and of the opaque standard colours was determined by evaluation of their brightness (L*) and chromatic (C*) values. The picture below shows a cross-section of the CIELAB colour space at brightness L = 50. The colour spaces on the outside show measurements on white substrates, the smaller ones show reduced colour spaces on black.

CSI COLOUR SPACES

schematic diagram in the CIELAB colour space



Note: the schematic diagram of the CSI colour spaces refers to a defined layer thickness (fabric 120-34) and was determined using screen inks HG (thinning degree 20%). Measurements were taken with a X-RITE 530 spectro-densitometer (0/45°: 3,4 mm diaphragm) at daylight D65 and an observation angle of 10°.

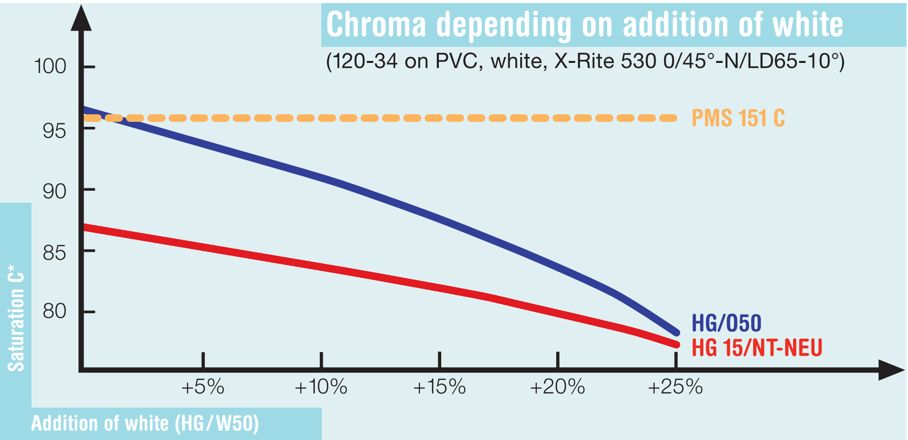
Printed on white the C-MIX-2000 colours achieve higher saturation values (C*) than the standard colours thus making it possible to match such “bright” colour shades like PMS 151C, HKS 6K and RAL 1028. On the other hand saturation values are considerably reduced on black. This is also the case with the more opaque standard colours, however not that much. Nevertheless this is not sufficient to match the bright colour swatches.

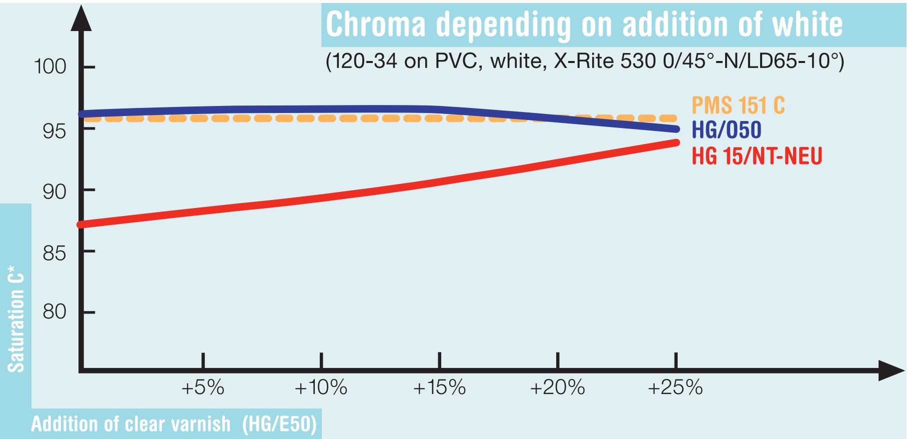
The following measurement values of individual colours and swatches will explain this:

COLOUR VALUES L* C*

X-RITE 530
3,4 mm/NLD65/10°/(0/45°)

Colour/Swatch	L*	C*	Substrate	L*	C*	Substrate
RAL 1028	73,93	99,83				
PMS 151 C	63,22	96,22				
HKS 6K	67,83	98,96				
HG/O50	58,88	94,86	Leneta, white	28,69	30,18	Leneta, black
HG 15/HD-NT-NEU	59,04	93,13	Leneta, white	42,95	53,80	Leneta, black
HG/Y30	86,81	111,41	Leneta, white	31,84	34,97	Leneta, black
HG 10/HD-NT-NEU	88,61	85,70	Leneta, white	67,71	53,45	Leneta, black





PRACTICAL IMPLEMENTATION

Not every colour shade can be matched with screen or pad printing inks. High opacity reduces high brilliance (brightness) and vice-versa.

If possible a double print, white pre-print or a coarse fabric are a solution. Otherwise you will have to make a compromise. In order to achieve a visually bright colour shade you have to adjust the colour to be a little brighter. Semi-transparent colour shades like C-MIX-2000 are especially suitable for matching of bright colours on white substrates. When printed on black substrates addition of white could result in increased opacity. As an alternative the C-MIX-2000 colours can be supplemented with more opaque standard colours or the highly opaque HD colour shades.

L*a*b* colour values as “colour sample”

Working regulations, quality management and standards being a daily requirement, in colour management we are also trying to substitute visual colour samples with mathematical values. The L*a*b* values are only suitable to a limited extent.

L*a*b* values without any additional information are not sufficient to define a colour. L*a*b values depend on the measuring geometry used, the light type, the standard observer, opening of measuring diaphragm, and the like.

To explain this in more detail please see below L*a*b* values of the C-MIX-2000 colour shade Y30 primrose taken with different adjustments. For each measurement we measured the same area of the print.

	Measuring parameters			**L***	**a***	**b***
	Measuring geometry	**Light type**	**Standard observer**			
1.	45/0°	D65	10°	88,10	-2,90	110,39
2.	45/0°	D65	2°	95,18	-0,86	109,81
3.	45/0°	D50	10°	89,43	1,90	110,20
4.	D/8°	D65	10°	89,33	-4,40	98,54
5.	D/8°	TL84	10°	92,56	-4,29	104,54

45/0° = X-RITE 530 with 3,4mm diaphragm
D/8° = Optronik Colorflash with 10,0 mm diaphragm

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