Tech INFO

Marabu

Fade and Weather Resistance of Printed Products

Aw/enk
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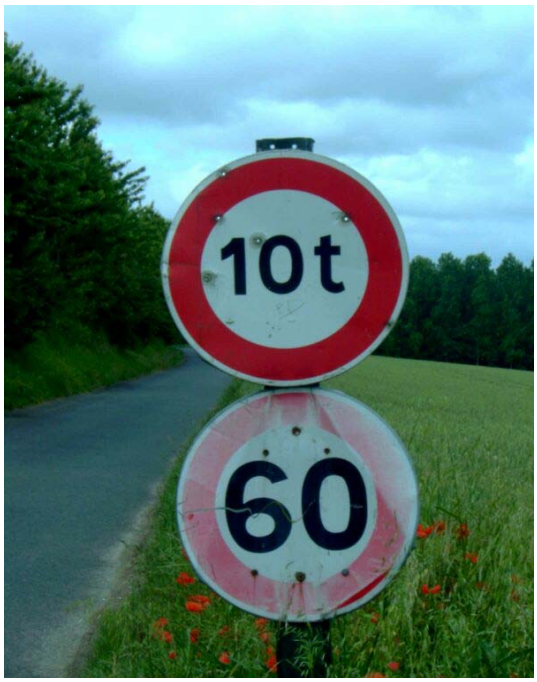
Printed outdoor advertisements have increasingly become attractive and already today, there is no means of transport such as busses, trains, trucks, and taxis without any advertising on them. To avoid loss of attractiveness or quality of an outdoor print due to colour fading or shifting, a background regarding fade and weather resistance of printed products is essential.

The reason for varying colour shifts of the 4-colour process prints is that the four basic colours Yellow, Magenta, Cyan, and Black behave very differently in their pigment decomposition when exposed to the sun (UV light). What exactly happens? What leads to colour fading? How is it possible to extend the life time of printed products used outdoor? These are elementary questions which will be examined in this article.



Content

1.0 Theory

In the coloured world of printing inks, there is a clear awareness that every organic pigment and binding agent – i.e. every screen printing ink – is subject to an ageing process due to the absorption of direct or indirect sun rays (UV light). This causes a fading effect and as a consequence, a decrease in colour. During this process, the molecules oscillate against each other. In the following fatigue phase, the molecular bond of the pigment cracks and the pigment no longer appears coloured – it is destroyed. The decisive question is therefore:

How resistant is the printing ink in use and when does the colour shade start to change?

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1.1 Global radiation

Global radiation means all sun rays impinging onto an area, mostly referred to as one square meter. It consists of direct and diffuse radiation. The atmosphere, together with possible cloudiness, reduces the intensity of global radiation as part of the UV rays will be reflected, diffused, or absorbed.

If the sky is clear, the energy is composed of the direct radiation power outside the atmosphere (solar constant) minus the energy loss of ca. 53% during its way through the atmosphere (towards the earth). In the case of a cloudy sky, there are no direct sun rays and on such days, only a slightly diffused and sunburn-free UV radiation will happen. The filtering effect of the atmosphere cannot be considered as a constant factor since also here changes due, for example, to the decomposition of the ozone layer are possible.

Furthermore, the amount of global radiation varies as to the geographic positioning. The power of sun rays in the African deserts, the Middle East up to India, Australia, and the southern part of the USA (the so-called sun belt of the earth) is twice as much as in Central Europe (e.g. Germany) while the subject "cloudiness" has here not even been considered by.

Today, the following average radiation values are taken into account:

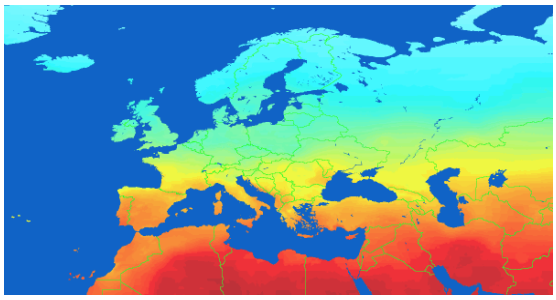
North/Central Europe 600 – 900 kWh/m²
Canada, North of USA
(45th degree of latitude, north)

Central/Southern Europe 900 – 1200 kWh/m²
Central USA, parts of South
America, Northern China,
Japan, and New Zealand
(between 40th and 45th degree of latitude)

South. Europe/North Africa 1200 – 2000 kWh/m²
Middle East, South Africa
(between 35th and 40th degree of latitude)

Africa, Southern USA, 2000 – 2500 kWh/m²
Central and parts of South
America, Arabian peninsula,
India, Australia
(between 35th degree of latitude north and south, equatorial area)

It can clearly be recognized that global radiation varies according to the geographic location. This is important to bear in mind, especially when advertising campaigns are placed worldwide. With this statement, further influences on the printing ink such as elevated temperatures have not yet been included.



1.2 Fade resistance

Fade resistance means the resistance of printed products to the impact of day light without any direct influence of the weather. For defining the fade resistance, there are standardised test methods and weathering machines which simulate and accelerate the exposure process in order to achieve a test result within an acceptable period of time.

DIN 16525 part 1 describes the standard fade resistance test for prints and printing inks to daylight. Part 2 also contains the guidelines for an exposure test with weathering machines. This guideline has meanwhile been further developed and is now called ISO 12040.

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1.3 Scale for the fade resistance of an ink

The fade resistance of a printing ink depends upon the quality of binding agent and organic pigment in use. The pigments are classified and described in the so-called blue wool scale with quality levels from 1 (very low) to 8 (excellent).

Therefore, the higher the value, the better the pigment quality whereas the increase by one point means the approximate doubling of the outdoor quality. The following blue wool scale values are given in the technical literature:

Level 1	very low
Level 2	low
Level 3	medium
Level 4	fairly good
Level 5	good
Level 6	very good
Level 7	superb
Level 8	excellent

This concretely means that for a high-quality screen printing ink at medium to long-term outdoor use (3-5 years), only pigments of blue wool scale 7 to 8 are to be used. Usually, these pigments are more expensive (especially for yellow and red) and due to this, Marabu offers special highly-fade resistant colour shades in the Marastar SR and Libraspeed LIS ink series. By doing this, the customer is free to choose the quality level he requires.

2.0 Factors influencing fade and weather resistance

Generally seen, the screen printing process with its many different binding agents (i.e. variation possibilities) and the high ink film thickness is clearly an advantage to other printing processes when a medium to long-term outdoor use is demanded.

It goes without saying that only ink series with weather resistant binding agents must be used. Below we will list some additional factors influencing outdoor behaviour:

2.1 Sun rays

It is a matter of fact that direct exposure to the sun has the greatest effect upon outdoor fading (almost 90%). This is due to the rather low percentage of UV rays in the sun light. There is, thus, a clear dependence between the length of exposure and the degree of colour fading or yellowing. As the strength of the sun is unequally distributed over the earth's surface, differing results must locally be reckoned with.

2.2 Water and temperature

A frequently occurring direct contact with water or a permanently high humidity of air combined with elevated temperatures and direct sun exposure also affects the printed ink negatively and may soon lead to a chalking process. In this case, the binder decomposed migrates to the surface in the form of a white powder and leads thus to an inevitable colour shift. This white layer, however, can be removed by cleaning the surface with water and the original colour will re-appear.

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Colour shades mixed with white (pastel or grey shades) strongly risk to chalk since the titanium dioxide is able to accelerate the decomposition process through photochemical actions.

A further negative aspect is the possible increase in temperature fo up to 80°C in the case of an intensive exposure to the summer sun. All inks contain thermoplastic binders which must not allow any decomposition process at such extreme temperatures. Beyond this, there is a significantly higher deterioration of the ink in places with a saline atmosphere (near the sea) compared to inland.

The power of sun rays onto water drops on the surface is much higher due to the fact that they simulate a magnifying glass effect and therefore focus the sun light onto only one point.

2.3 Environmental influences

The climatic influence on printed products of outdoor use is often further increased by industrial exhaust gases such as sulphur dioxide, soot, cinder, etc. but also by agrochemicals. This strongly varies from place to place and can thus not be defined in detail.

2.4 Positioning of prints

All prints positioned towards the sun (northern hemisphere – southern direction) exhibit a significantly higher deterioration effect due to direct exposure. Positioning angles like 90° vertically, 0° or 45° horizontally also affect the life time of an outdoor print whereas in Central Europe, there is an approx. 30% higher ink deterioration at 45° compared to 90° vertically.

If printed products are placed in altitudes exceeding 1000 m, colour fading is consequently accelerated since the filtering effect of the atmosphere is decreased. It is further decisive if the print is in a fixed position (e. g. signs) or if it is variable with always changing positions like vehicle marking. UV-resistance of prints on "movable" means is on the average twice as long as for "immobile" applications.

2.5 Print side

A further influencing factor is the print side of transparent materials. If printed onto the rear side, the substrate can absorb damaging UV light already before the ink is exposed to full radiation. Due to this, applications on the reverse side of the material are always of advantage if the correct ink type has been selected.

2.6 Substrate

The substrate choice as well as its own colour will lead to differences in the weathering result. Not only the printed colours are affected but also a great number of substrates (see picture, yellowing of PS).

A white foil will display the slightest colour shift on outdoor use as a big part of the UV light is reflected. Due to this, the substrate's temperature will be lower by ca. 10°C ca. compared to a black foil.

Metallic substrates are clearly more difficult (even if only used as a base for foils) since metallic parts store a higher amount of heat and will pass it on to the printed product. This also leads to an accelerated colour fading.

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2.7 Colour shades

The choice of colour shades is also strongly influencing the future weathering result. As standard shades, black and blue have a much higher fade resistance compared to yellow, orange, yellow-pigmented gold and/or red shades. For a medium to long-term outdoor use of such shades, the best pigment quality available must always be chosen.

Pure (mono-pigmented) shades basically achieve better outdoor results than ink or pigment mixtures. However, if a mixture of colour shades is to be used (which cannot be avoided), the percentage of the single components should not be less than 5%.

Furthermore, it is important to know that pastel shades containing high amounts of white (50-95%) will change their colour shade much faster with outdoor use than pure shades. Transparent shades with a high percentage of varnish also display poor UV-resistance since the pigment content has been reduced with the addition of varnish and deteriorating pigments will be noticed sooner in the form of a colour shift. So colour shade is not colour shade, and attention must be paid.

2.8 Highly fade-resistant colour shades

The following table compares the pigment quality of the highly fade-resistant SR and LIS shades to the standard shades. The increase by one figure approximately corresponds to a doubling in outdoor quality.

Marastar SR/ Libraspeed LIS	standard	highly fade-res.
Lemon 020/720	7	(7-8)
Medium Yell. 021/721	7	(7-8)
Light Yellow 026/ 726	7	(7-8) + 8
Yellow Orange 022/722	7	(7-8) + 8
Scarlet Red 031/ 731	7	7 + 8
Carmine Red 032/ 732	(7-8) + 7	(7-8) + 8
Bright Red 035/ 735	7	8
Yell. Green 064/ 764	(6-7) + 7	8

2.9 Over-varnishing

Generally seen, a full area over-varnishing always leads to an improved UV-protection of the underlying colours shades and should therefore be applied automatically in the case of outdoor use.

For such applications, we recommend special absorber varnishes (not standard varnishes!) which have been enriched with UV-absorbing additives. In this case, the varnish layer plays the "victim role" for the aggressive UV rays and protects the coloured pigments from being affected by fading.

2.10 Ink deposit

A further possibility to protract creeping colour fading due to radiation is to increase the ink layer thickness by choosing the correct mesh. The following fabrics are usually used:

Solvent-based inks

Standard printing : 77 to 90 threads/cm
Full area printing: 54 to 77 threads/cm
4-clr. process printing: 100 to 120 threads/cm

UV-curable inks

Standard printing: 120 to 140 threads/cm
Full area printing: 120 to 140 threads/cm
4-clr. process printing: 140 to 150 threads/cm

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2.11 Further additives

For the adjustment of an ink which must withstand a long-term outdoor use, neither matt colour shades nor glossy shades mixed with matting paste or powder should be used. This decreases fade and weather resistance in all cases. Other additives such as plasticizers or levelling agents are not as critical as matting auxiliaries, but also affect the drying of the ink film as far as the compact and resistant ink built-up is concerned. Due to this, they should never be added without any good reason.

3.0 Marabu ink recommendations

Besides good adhesion as well as mechanical and chemical characteristics, the colour range is also decisive for the choice of the suitable ink type. If only white, black, green, and blue shades are used, no special highly-fade resistant shades are necessary as these are always highly fade-resistant.

Colour ranges like yellow, red, yellowish green as well as the 4-colour process shades Yellow and Magenta are more critical. For a medium to long-term outdoor use (3-5 years), highly fade-resistant shades (HFR) must always be used. Marabu gives the following recommendation for such differentiation:

Ink series without HFR shades

(List of all ink series having a good binder but no additional highly fade-resistant shades for the ranges yellow, red, and yellowish green):

Libragloss LIG
Libraprint LIP
Marapur PU
Ultrastar UVS
Ultraflex UVF

Ink series with HFR shades

(List of all ink series having a good binder as well as a high-quality pigmentation or additional highly fade-resistant shades for the ranges yellow, red, and yellowish green):

Libraspeed LIS
Marastar SR
Ultragraph UVAR
Marapoly P
Ultraform UVFM

Ink series with HFR 4-clr. process shades

For a long-term outdoor use of 4-colour process prints, we recommend:

Libraspeed LIS (plus Yellow LIS 476 97 429)
Ultraform UVFM
Ultragraph UVAR

Over-varnishing

Prints destined for a long-term outdoor use must be full-area coated with a suitable overprint varnish (+ UV absorber). Such varnishes are available as standard products:

Libraspeed LIS 911
Marastar SR 911
Maragloss GN 911
Marapur PU 911

All these recommendations safeguard an optimum protection of “sensitive“ printing inks and guarantee best print results.

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