CerDeCure

UV Hardening in the Manufacture of Ceramic Decals

Introduction

What is ultraviolet light and what effect does it have?

Ultraviolet light is a part of natural light that is not perceived by the naked eye.

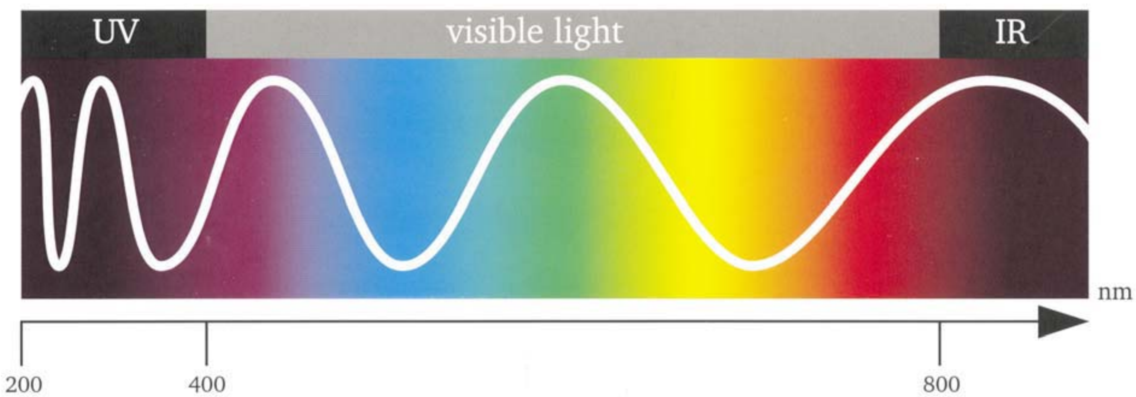


Diagram 1
Spectrum, visible and invisible light.

The main difference from conventional drying is that with UV drying the solvent-free printing pastes immediately "dry" completely when the decal undergoes UV radiation. In traditional silk-screen printing the solvents contained in the printing pastes normally have to be removed by air drying.

It is quite different with UV drying. With this method the liquid components of the binding agent cross-link within fractions of a second after the UV rays have taken effect to form a hard and dry film. The decal can be continued to be processed immediately.

How is UV light generated?

It is generated artificially by putting a quartz glass tube filled with inert gas and mercury under high voltage to produce an electric arc. In addition to UV light, visible light and infrared radiation, i.e. heat, are also produced during this process. The temperature on the outer wall of the quartz tubes is between 700 and 900 °C.

Ultraviolet light covers the spectral range of approximately 200-400nm. In this connection, it is normal to divide the range into the wavelengths UV-A, UV-B and UV-C.

Ferro GmbH
Color and Glass Performance Materials • BU Dinnerware Systems
Gutleutstraße 215 • D-60327 Frankfurt am Main • Germany
Tel: ++49 (0)69 27116-0 • Fax: ++49 (0)69 27116-333
E-mail: dinnerware@ferro.com
www.ferro.com

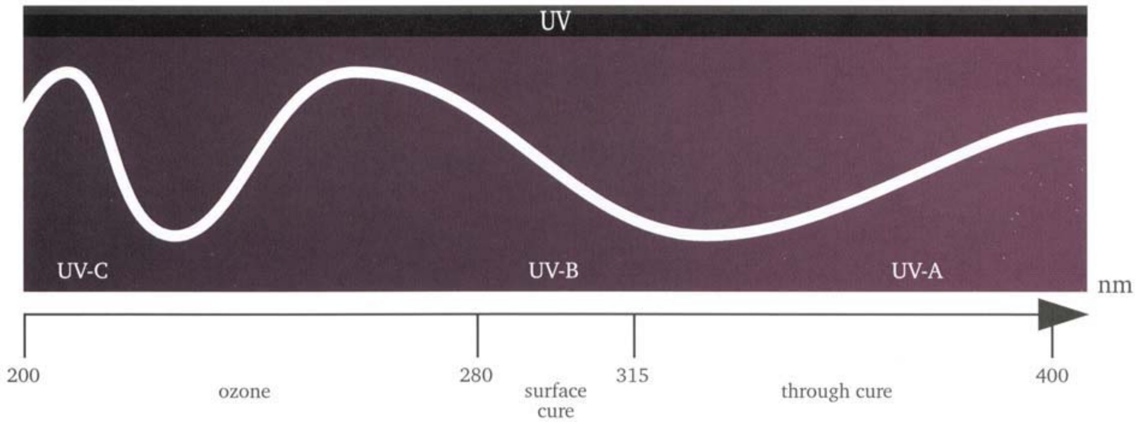


Diagram 2
Subdivision of a UV band and degree of curing through

UV-A is the long-wave part that directly adjoins the visible light in the spectrum. High wavelengths (= long oscillations) cause the substance to be penetrated more deeply. UV-A rays, therefore, are particularly important for the through-hardening of thick layers that are usual in screen printing.

UV-B light is important for surface hardening,

while **UV-C** , the high-energy part of the UV spectrum, besides contributing to a small part to surface hardening, mainly produces ozone. The ozone obtained by UV hardening has to be set free by means of suction, whereby it decomposes in seconds into harmless oxygen.

Equipment required

Printing can be carried out with any commercially available silk-screen printing equipment. The UV dryer (or better UV hardener), the **UV lamps**, respectively, must, however, meet two essential requirements. The thermal load of the decal paper must be kept below 35 °C, which is not possible without taking special measures in view of the surface temperature of the radiator of 700-900 °C. In addition, a noticeable shift of the emitted spectrum is particularly advantageous for UV-A radiation in comparison to that of standard UV lamps that are used in the graphic trade. This applies all the more as the layer to be hardened increases in thickness. In practice, the demands made of a radiator for four-colour printing with a fine screen are entirely different from those for flat-spread glass decals which are printed with a coarse screen.

The more simple and thus less expensive equipment is only suitable for four-colour printing, whereas with more expensive equipment the hardening of thicker layers, e.g. those that are usual in tableware décors, can also be achieved.
A current list of suitable UV hardeners is available on request.

Radiators with a capacity of 160 W/cm and above can be used. We recommend well-equipped radiators with a higher proportion of UV-A. Ferro provides assistance in selecting hardening equipment.

Besides the important question of the lamp, the reflector and cooling should also be given a brief mention.

Ferro GmbH
Color and Glass Performance Materials • BU Dinnerware Systems
Gutleutstraße 215 • D-60327 Frankfurt am Main • Germany
Tel: ++49 (0)69 27116-0 • Fax: ++49 (0)69 27116-333
E-mail: dinnerware@ferro.com
www.ferro.com

The reflector is made of metal and generally has an elliptical shape. Its task is to concentrate the rays and cast them onto the substrate (the transfer).

Cooling is necessary because of the fact that a large part of the expended energy is not converted into UV radiation but into visible light and infrared light, i.e. heat.

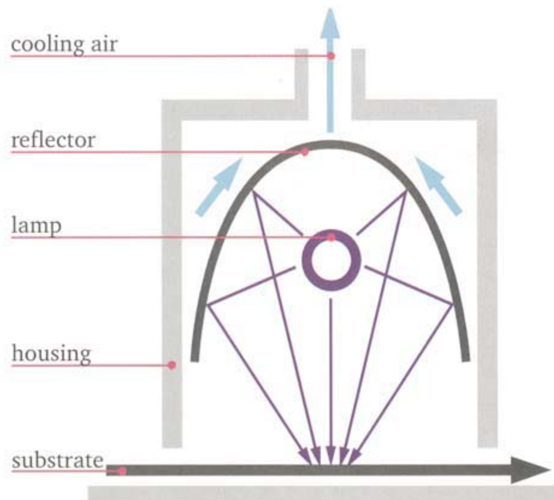


Diagram 3
Equipment required, simplified diagram

UV hardening in non-ceramic applications

Inks that can be hardened by means of ultraviolet light have been state of the art in non-ceramic screen printing and other printing techniques for many years.

The increasingly widespread use of UV printing inks is due to the fact that **solvent emission is reduced**, **time is saved**, **the occupational safety is improved** and a **quality of printing** that is almost unobtainable with other inks is achieved.

UV hardening in ceramic transfer printing

We want to comment in more depth on the subjects of saving time and quality, in particular for ceramic screen printing.

One feature of ceramic decoration is the variety of colours used for a motif and thus the number of printing cycles. The time saved by UV drying is directly proportional to the number of printing cycles. It is particularly noticeable when printing the small editions that are widespread today. Appropriate arithmetical examples are available on request.

Ferro GmbH
Color and Glass Performance Materials • BU Dinnerware Systems
Gutleutstraße 215 • D-60327 Frankfurt am Main • Germany
Tel: ++49 (0)69 27116-0 • Fax: ++49 (0)69 27116-333
E-mail: dinnerware@ferro.com
www.ferro.com

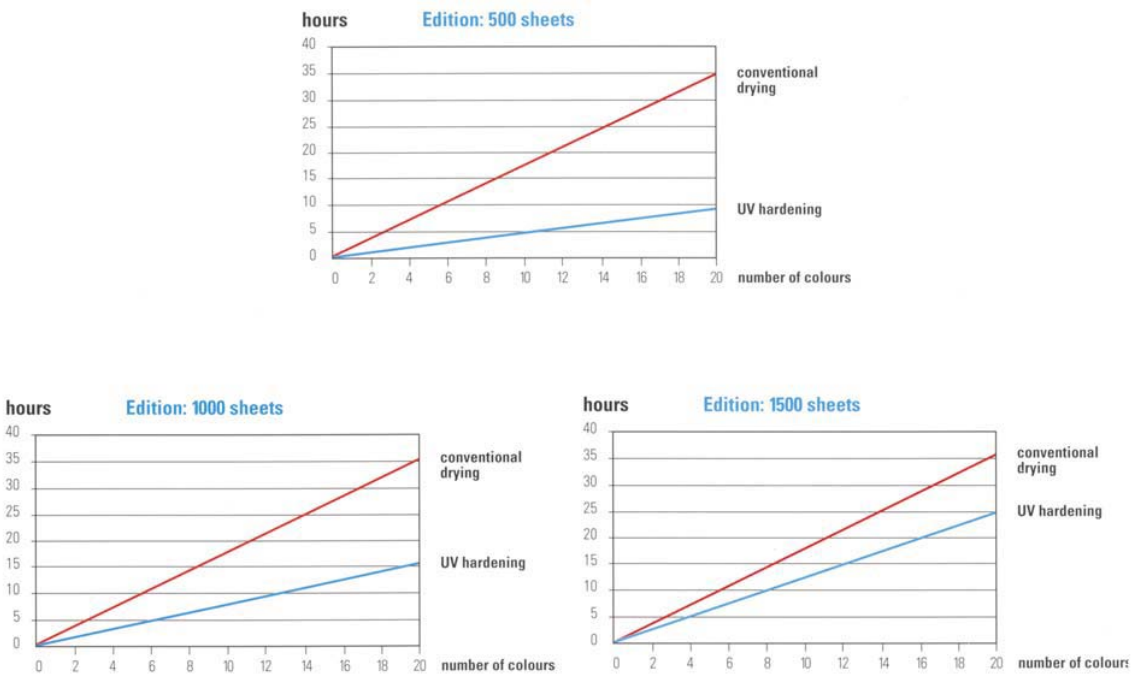


Diagram 4
Time gained with UV hardening

The quality of non-ceramic applications is demonstrated by characteristics such as a high degree of gloss, weather resistance and sharply defined reproduction. All these characteristics are improved by the use of UV inks. Sharply defined details, for example, are the result of the short period of time between printing and hardening which does not allow the ink to run.

This also applies to ceramic screen printing. Outside the field of ceramics, gloss and weather resistance result from the proportion of binder which, compared to inks containing solvents, is a good deal higher and envelops and protects the pigments. Whereas the solvent-containing ink loses around half of its medium through evaporation, UV ink retains all its medium and merely passes from a liquid to a solid state. These considerations also apply to ceramics, but although the consequences are different in this case, they are by no means less positive (see Diagram 8).

The well-known fact that a more organic matrix results in fewer firing defects is also valid for UV inks. The organic proportion of a hardened 100:50 dispersed UV paste corresponds to around that of a dried solvent-containing paste that is worked up at a ratio of approximately 10:10. This enormous advantage can be used for improved firing reliability and/or more intensity.

Ferro GmbH
Color and Glass Performance Materials • BU Dinnerware Systems
Gutleutstraße 215 • D-60327 Frankfurt am Main • Germany
Tel: ++49 (0)69 27116-0 • Fax: ++49 (0)69 27116-333
E-mail: dinnerware@ferro.com
www.ferro.com

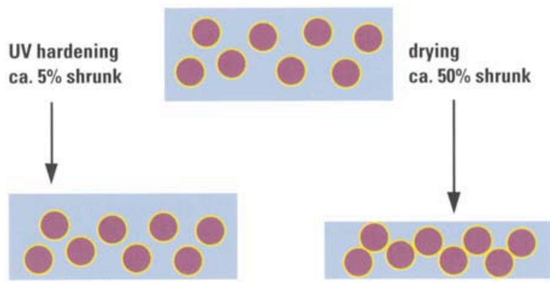


Diagram 5
Visual comparison of a traditional paste after drying (baked and agglomerated) with a UV paste after hardening (evenly dispersed and only minimally shrunk).

It is also possible to use this advantage not just to improve the intensity, but to economise on paste by taking finer screens, whereby the intensity is slightly reduced.

As already mentioned, UV inks do not lose any solvents while being processed on the screen. Thus, the viscosity of UV inks in the screen remains considerably more constant. As a result of this it is possible to retain the constancy of the print transfer over long periods, in particular when using fine screens in a 4-colour set, which represents a considerable gain in productivity.

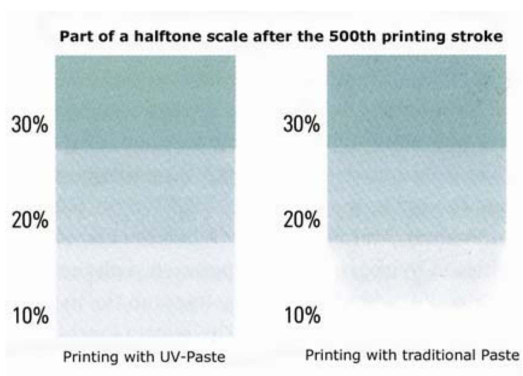
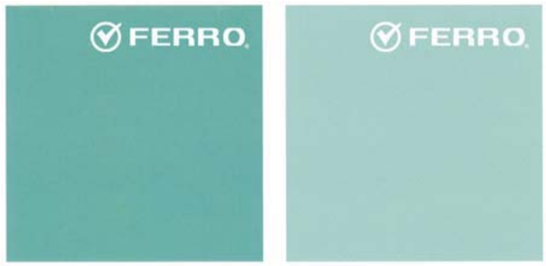


Diagram 6
Illustration of the better printing consistancy of a UV paste compared to a conventional paste.
Example: cyan green 11 1633
*Viscosity: 6 Pa*s*
Textile: Polyester 140 threads / cm

The constancy of the individual print layers also makes for an unchanging balance of colours when they are printed together, which is very important, especially in four-colour printing – think of the reproduction of skin colours.

Ferro GmbH
Color and Glass Performance Materials • BU Dinnerware Systems
Gutleutstraße 215 • D-60327 Frankfurt am Main • Germany
Tel: ++49 (0)69 27116-0 • Fax: ++49 (0)69 27116-333
E-mail: dinnerware@ferro.com
www.ferro.com

To sum up there is great potential for **shortening times of delivery, cutting costs in the printing process** and lastly achieving **a more constant quality**. The increase in intensity which is also possible has a positive effect, in particular for leadfree colours and glass colours.



Printing with UV-paste   Printing with traditional paste

Diagram 7
Comparison of intensity
*Example: cyan green 11 1633 (Viscosity: 6 Pa*s, Textile: Polyester 120 threads / cm)*

And the printing media?

CerDeCure UV media for ceramic decal printing differ considerably from media for direct printing, e.g. for automotive glass. Due to the paper, which is sensitive to temperature, they have to make do with 10-20 % of the UV intensity as UV light is always accompanied by heat (see above).

In this connection, an ideal medium is designed to match both the emission spectrum of the radiator and the specific UV absorption of the individual ceramic pigment. While the first can be achieved by appropriate cooperation with the producers of UV hardeners, adjustment to the individual colour causes difficulties. The reason for this is the great number of ceramic colours in combination with the variety of pasting ratios.

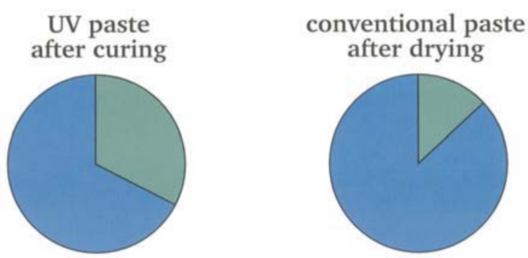


Diagram 8
Comparison of binder proportions of a paste, UV and traditional

Around 80% of Ferros decorative colors are of similar reactivity and can easily be handled with just one medium, or better, mediums with equal reactivity but different rheology.
For these colors a series of mediums with **standard reactivity** has been developed (see product literature).
For difficult to cure colors a series of mediums with **high reactivity** was developed.

Other colors cure very easily, the perfect match for those is our series of **low reactivity** mediums (see product literature).

Ferro GmbH
Color and Glass Performance Materials • BU Dinnerware Systems
Gutleutstraße 215 • D-60327 Frankfurt am Main • Germany
Tel: ++49 (0)69 27116-0 • Fax: ++49 (0)69 27116-333
E-mail: dinnerware@ferro.com
www.ferro.com

At first glance this seems to be an excess of mediums as the most reactive medium could of course cure all colors. In reality this only means that undercure would not occur. The more difficult to detect form of unsuitable degree of cure however is overcure, manifested by brittle, difficult to apply decals often leading to imperfect fired results.

While undercure is easy to detect as it results in a tacky print, overcure can only in very severe cases be seen directly after cure. Because of the so called "dark reaction" or "postcure", further embrittlement takes place during the first minutes to hours after cure, thus delaying the final judgement on proper cure by that amount of time. This is not acceptable in the light of technology geared at speeding up the printing process. Therefore, mediums suitable to the individual colors reactivity should be chosen in order to avoid overcure.

If no information on a colors reactivity is available, the safest approach is to start with the lowest reactivity medium and to move up the reactivity scale in case undercure occurs. In order to facilitate this approach, Ferro has determined the relative reactivity of various color palettes in order to indicate suitable medium/color combinations.

This is an ongoing process, the relevant literature is updated continuously (see brochure "**CerDeCure & the Ferro colour series**").

The ideal match of color to medium properties can only be realised with ready-to-print pastes that have already been ideally formulated during their production by means of an individually adjusted proportion of media. This is done in four-colour sets and for very common colours and is offered by Ferro on request.

Storage

CerDeCure UV media and printing pastes must be stored at a temperature of between 5 and 25 °C. Pastes must be stirred thoroughly before use. The guaranteed shelf life in an unopened original package is 12 months as of delivery. No guarantee can be accepted for opened packages and residual quantities (pastes) that have been bagged.

Stabilizing agent 80 4088 prolongs the shelf life of mediums and paste with only minor reduction of reactivity.

Handling

UV reactive materials can cause sensitive reactions on contact with the skin. It cannot be predicted whether sensitisation and thus skin reaction will occur in individual cases. It is advisable, therefore, to wear gloves when handling the materials. In addition to safety goggles, disposable gloves, in particular nitrile gloves, are to be worn when dispersing and printing. Neoprene gloves should be used when cleaning mechanical stirrers, rolls, containers and printing screens. Persons with sensitive skin are advised to wear cotton gloves under the other gloves.

Information on suppliers is available on request.

Particular reference is again made to the problem of cleaning in the Ferro product literature.

Ferro GmbH
Color and Glass Performance Materials • BU Dinnerware Systems
Gutleutstraße 215 • D-60327 Frankfurt am Main • Germany
Tel: ++49 (0)69 27116-0 • Fax: ++49 (0)69 27116-333
E-mail: dinnerware@ferro.com
www.ferro.com

Dispersion

In principle, dispersion is no different from the standard pasting with media that contain solvents. Care should be taken, however, to ensure that temperatures of over 40 °C **are not reached**, as the pastes otherwise become unstable. This is not a problem with a slow-running mechanical stirrer (e.g. a kneader). Metal abrasions should be avoided for the same reason. A triple roller mill with ceramic rolls, plastic jaws and ceramic knives is ideal. Ceramic knives, however, are expensive and fragile. In practice it has proved to be sufficient to combine ceramic rolls with metal knives or metal rolls with metal knives. The use of plastic jaws however is mandatory.

Just as for traditional pastes, the pastes should rest for 24 hours before printing.

Printing

The main difference from conventional screen printing is the prolonged period of time the paste stays open in the screen as compared with traditional pastes. Care is to be taken that UV radiation of lamps and windows in the area of the printing machines is kept to a minimum. UV filters are available in stores for most types of lamps.

Hardening

The hardening of a UV printing paste depends on the following factors:

1. The degree to which the medium is sensitive to the UV radiation emitted from the radiator
2. The permeability of the individual ceramic colour for this radiation
3. The ratio of medium to colour (pasting ratio)
4. Thickness of layer (screen cloth, thickness of emulsion layer and some printing parameters)
5. Dwell time under the radiator (belt speed)
6. Radiator capacity (can usually be controlled)

Factors 1-3 have already been taken into account when using ready-made UV pastes from Ferro. The printer influences the hardening via factors 4-6.

Factors 1-3 must also be considered when using self-made pastes.

It is not possible to employ just one radiation dose that is sufficient in all cases (very high) as thermal overloading of the dextrin paper and thus distortion and crazing occurs.

The printing paper should not undergo any large change in temperature. It has been shown in practice that high-quality dextrin-coated papers can take temperatures of between 20 and 35 °C without any loss of register accuracy. Higher temperatures can be tolerated during the last printing cycle of the last colour, ***but take care*** **– the 40 °C limit should really not be exceeded.**

Darker pigments heat up (and the paper) more strongly than lighter colours.

If the sheets are to be stacked, wait until they have reached room temperature as otherwise they might stick together.

If problems with hardening are experienced in odd cases, special media are available on request.

Ferro GmbH
Color and Glass Performance Materials • BU Dinnerware Systems
Gutleutstraße 215 • D-60327 Frankfurt am Main • Germany
Tel: ++49 (0)69 27116-0 • Fax: ++49 (0)69 27116-333
E-mail: dinnerware@ferro.com
www.ferro.com

FERRO

Environment and occupational safety

The handling of UV media and UV pastes is subject to certain matters regarding the environment and occupational safety. These are mentioned in our prospectus **Environment and Occupational Safety in UV Printing**.

Covercoat

Standard covercoats such as 83 450 or 83 2042 from Ferro have been tested. Unsuitable covercoats attack the print. This is noticeable either in the form of wrinkling directly after overcoating or in the form of large-scale firing defects after firing.

> **Important**: Attacks by the covercoat are a potential danger. Prints should be tested by pouring covercoat over a small part of the printed image after each color printed. This is important as even a covercoat tested by Ferro may lead to covercoat attack if the print is cured excessively altogether or the surface has been overcured.

Unsuitable paper (recommendations on request) may lead to the same effect.

Products

These are to be found in our current **product literature (CerDePrint Catalogue)**

Storage of decals

Ferro has succeeded in reducing the embrittlement of properly cured UV decals to such an extent that there is no noticeable difference from conventional transfers. At the most, a slight after-hardening can be determined in the first few days after production and can thus be calculated for. If the decals are brittle due to being stored too long, they can be made flexible again by applying the repair covercoat 80 961 if the embrittlement was not due to initial overcure.This is a time-tested method. Other application aids have also proved their worth in decoration with UV transfers. Please see our separate information brochure for details.

Summary

To sum up it can be established that UV hardening in ceramic transfer printing is a completely different technology from conventional drying.

Investments are incurred that, for a new acquisition, are naturally less significant than for converting production. Due to the fact that the raw materials are of a higher quality, the costs of UV media are also higher than those of conventional media. Particular attention should also be paid to matters of occupational safety and the shelf life of media and paste.

There is, however, an unmistakable **potential advantage for the user**.

The hardening speed is considerably quicker than for conventional drying due to the fact that "drying" takes place within fractions of a second.

Ferro GmbH
Color and Glass Performance Materials • BU Dinnerware Systems
Gutleutstraße 215 • D-60327 Frankfurt am Main • Germany
Tel: ++49 (0)69 27116-0 • Fax: ++49 (0)69 27116-333
E-mail: dinnerware@ferro.com
www.ferro.com

FERRO

As already described, noticeable **improvements in quality** can be achieved. To be mentioned here is a higher intensity, an improved dot reproduction curve (no running caused by "abrupt drying") and a distinctly **better print run constancy.**

In comparison to conventional drying there is **no solvent evaporation** (i.e. solvent emission) with UV hardening.

A significant feature of the UV system would be a **considerable reduction in the floor space** currently required to house large conventional dryers.

There is also a noticeable **cost saving**: much longer openness of the paste and thus potential savings in production and screen cleaning, the considerably reduced **material loss** connected with this (= paste and sheets) after cleaning the screen.

And not to be forgotten are the savings on the (expensively generated) conditioned air that is needed to dry the prints with conventional drying.

Ferro GmbH
Color and Glass Performance Materials • BU Dinnerware Systems
Gutleutstraße 215 • D-60327 Frankfurt am Main • Germany
Tel: ++49 (0)69 27116-0 • Fax: ++49 (0)69 27116-333
E-mail: dinnerware@ferro.com
www.ferro.com