

SHEETFED UV PROJECT GROUP

UV

Edition N°2

GB

Optimised sheetfed UV

Best practice guide



Optimised sheetfed UV printing

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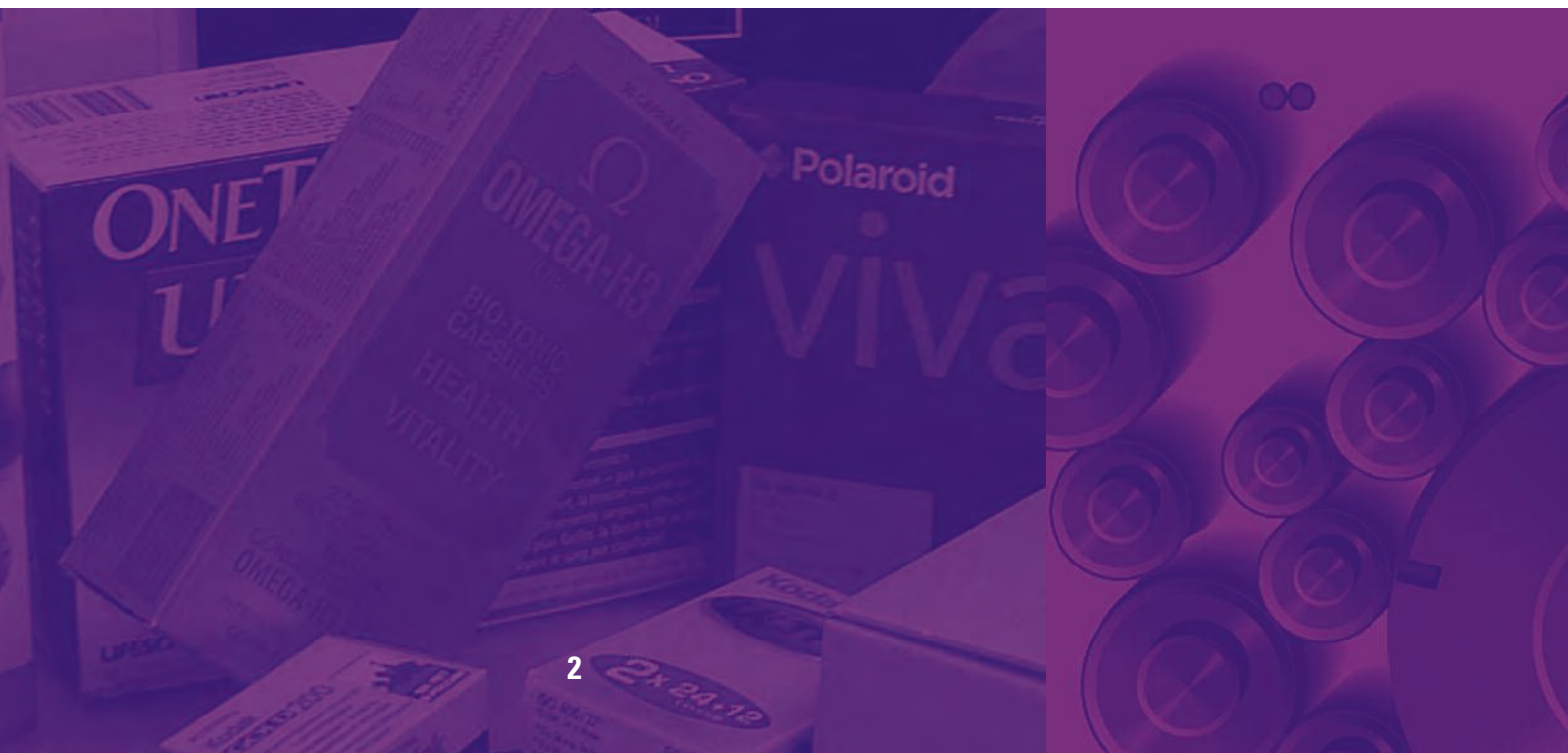
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Bibliography & further information:

"Print for Packaging — Low Migration Printing", 2006, Sun Chemical.

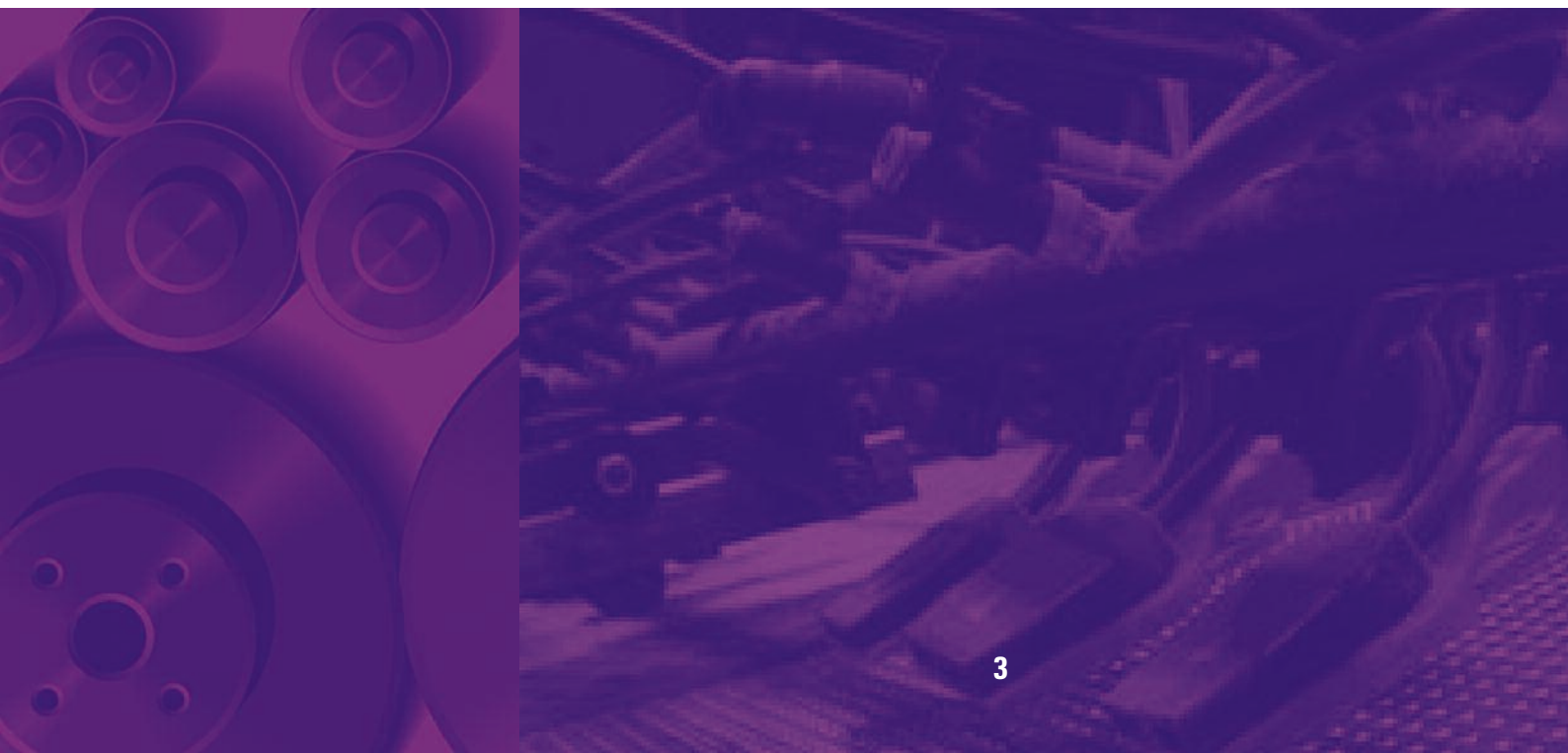
Additional UV best practice information from Sun Chemical

www.sunchemicalhelpdesk.com



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Glossary of technical terms

Absorption (setting)

The penetration of the thin phase from the ink or coating into the substrate.

Acrylate

Reactive raw material for the manufacture by photopolymerisation of acrylic thermoplastic synthetic resins. It is the basis for UV sheetfed ink chemistry.

Alternating (or combination) UV

Printing press specially equipped to allow alternating operation of both UV and conventional inks, one after the other, on the same press.

Aqueous coating (see Dispersion coating)

Classic UV

The mature and predictable UV system that has been in constant and growing use since the 1970s.

Coating (varnishing)

The application of a special covering layer onto a substrate or print by using a printing or coating unit. The covering layer can be functional, e.g. a protective coating, or decorative.

Combi or Combination

Special rollers and blankets for use with mixed production of UV and conventional inks and coatings on the same press (combination).

Combination dryer

Combines three drying methods, IR, hot air and UV.

Cross-linking

The process by which (small) reactive monomeric or oligomeric units present in a liquid mixture react irreversibly to create a solid matrix structure

Curing (drying)

The setting of inks and coatings using UV radiation.

Dedicated UV

Printing press that runs only UV 100% of production time — as opposed to alternating or mixed UV.

DIN 16524/16525

Tests for prints and printing inks: fastness to water, solvents, soaps, cleaning agents, foodstuffs, light.

Dispersion coating (Aqueous or WBC)

A coating material with the main ingredients of water, polymers and additives; dries by a physical process that can be accelerated by applying warm air.

Dryback (Drawback)

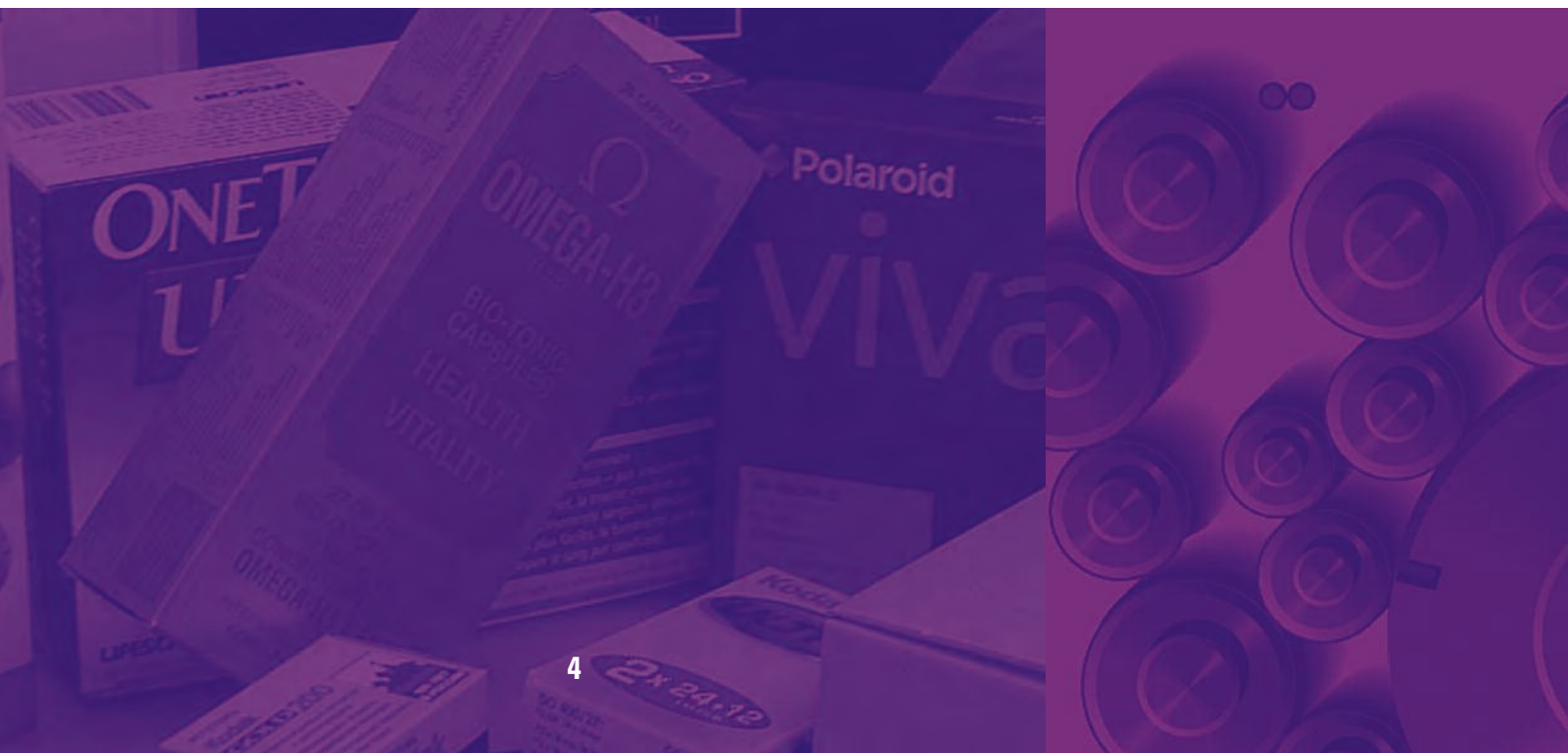
See gloss withdrawal

Edge blackening

Edges of UV lamps become black with use.

Effect pigment coating

Dispersion or UV coating containing effect pigments that provide Iroodin, metallic and other effects.



EPDM

Ethylene Propylene rubber made from non-polar bonded elements; suitable for polar additives such as the constituents of UV inks.

Gloss withdrawal (Dryback)

Oxidation drying of conventional inks and primer continues under a cured UV coating, leading to poor adhesion, low gloss and differential gloss between printed and non-printed areas.

Hybrid UV (see non-classic UV)

Hybrid effects

Special effects, such as matt-gloss or textured finishes, made from combining different types of coating (WBC, oil-based or UV).

Low migration (LM)

Products with a low potential to cause migration and give good results in testing.

Low odour

Products with a low potential for causing an odour problem.

Low taint

Products with a low potential to cause an off-taste or taint.

Migration

A term used to describe relocation of substances in different industrial products during drying. Migration is the transfer of substances from the packaging to the product it contains.

Monomer

Single molecule that can combine with itself or other similar molecules to form a larger molecule after exposure to a light source.

NBR

Nitrile Butadiene rubber with polar bonded elements used for inking and dampening rollers; suitable for use with conventional inks containing mineral oil and non-polar bonded constituents.

Non-classic UV (hybrid)

Combines UV curing ink technology with the ability to print and cure on a conventional sheetfed offset press fitted with end-of-press UV curing lamps. Performance is different to "classic" UV inks.

Orange peel effect

Too rapid IR (infrared) curing of dispersion coating before lower primer layer is set.

Oxidation drying

The networking reaction of conventional offset inks exposed to oxygen that generally takes several hours to one day, but can take several days.

Oxygen inhibition

High levels of oxygen enter the coating and diffuse into the ink layer and deform the surface. The effect also lowers the chemical reaction speed of the overall process.

Photoinitiator

An additive used in energy curing systems that forms reaction-capable products by absorbing UV rays; networked structures are

formed with the molecules of the binding agent.

Photopolymer

UV networked coatings.

Polar bonding

Polarity is the electrical forces between molecules that determine their bonding behaviour (similar to joining two bar magnets, which can only occur if opposite positive and negative ends are placed together); a form of element bonding where atoms become positive- or negative-charged ions that bond together. **Non-polar bonding:** The opposite to polar ion bonding where equivalent elements are bonded by homopolar linkage.

Primer

A special type of dispersion coating applied to the sheet after it is printed with conventional inks and when UV coating is to be applied over these inks.

Radicals

Chemically active atoms and molecules with a high energy level.

Tack

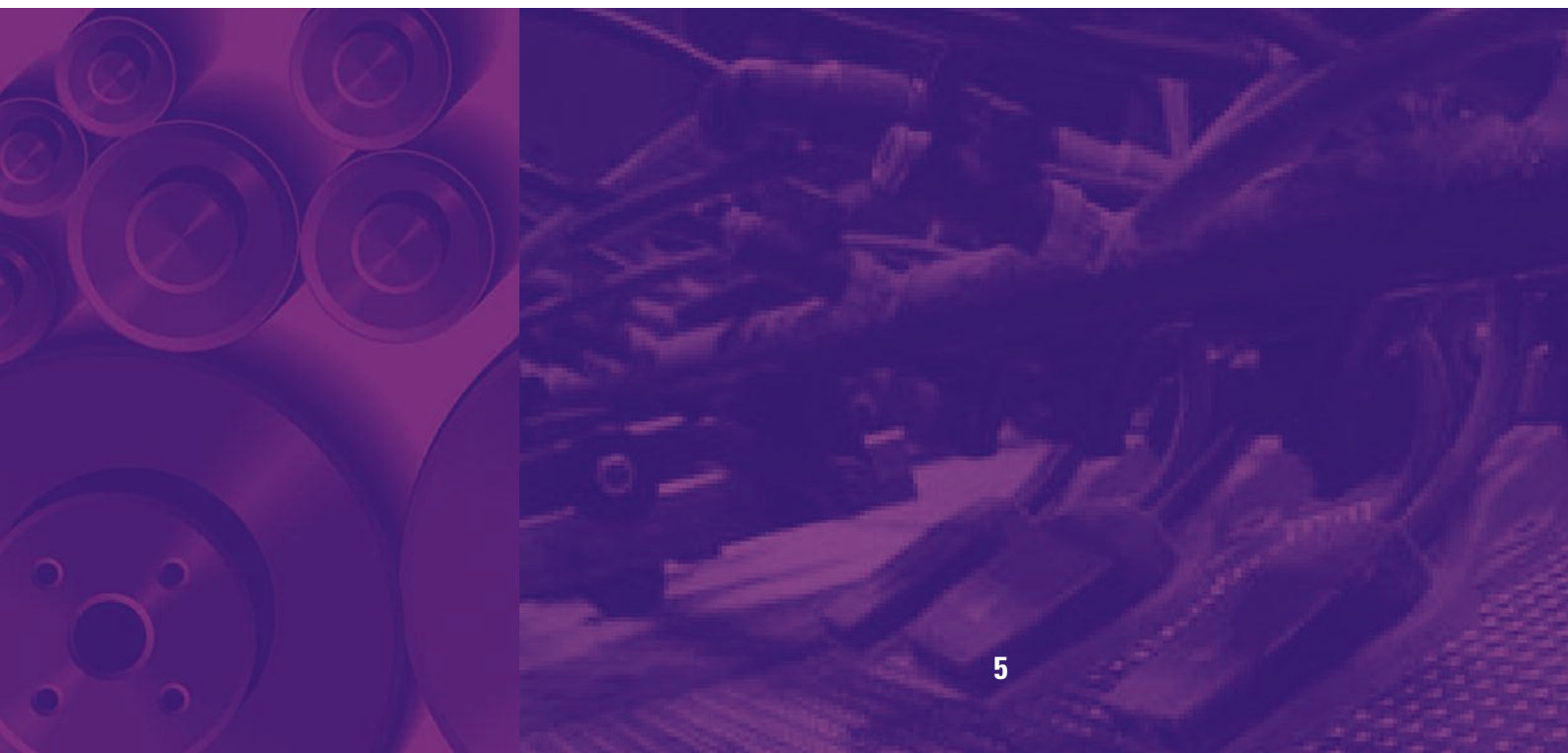
Stickiness of printing ink.

UV inks & coating

Energy curing that is activated by UV light energy and consists of vehicles, reactive thinners and photo-initiators; exposure to UV light hardens (cures) the ink and coating.

Water Based Coatings (WBC)

See Dispersion coating.





Best practice



Poor practice



Avoidable cost



Safety risk



Quality issue

*These symbols
are used
to bring attention
to key points.*



1

Introduction

The first edition of this guide was published in 2004 and is being used by thousands of printers around the world to help improve their understanding of the process and, consequently, productivity and quality. This is a fully revised edition, extended to include information on economics, food packaging and printing on non-absorbant substrates. UV printing and coating is a core technique for Value Added Printing, which provides the widest range of techniques on the widest range of substrates. The role of Value Added Printing is to increase differentiation of printed products to provide business opportunities for printers and their clients in the packaging, publishing and promotional sectors.

Continuing high growth for UV printed products is driven by demand in different markets for the unique attributes that the process can deliver. The demand for higher product quality and greater productivity is pushing both printers and their suppliers to select the right combination of equipment and consumable materials that will optimise the process and improve the skills of their production staff.

Optimal quality and productivity can only be achieved through effective co-operation between suppliers and printers, who benefit by pooling their skills and knowledge. The objective of this guide is to disseminate generic process knowledge to all the participants in the production chain.

Best practices are a tool to improve overall performance. Each contributing company has a role in an interrelated production chain; combining their expertise is a positive way of helping to improve overall process performance. The three priorities for high quality UV printing and productivity are:

- 1- Chemical compatibility of all consumables used in the process system:** roller covers and blankets for each ink type, coating and cleaning agents; ink and coatings selected to match the substrate, finishing and end use.
- 2- Ensuring that the press is appropriately configured,** correctly set up, regularly cleaned and maintained.
- 3- The prerequisite for high productivity UV printing** is thorough staff training.

IMPORTANT NOTE

A general guide cannot take into account the specificity of all products and procedures. We strongly recommend, therefore, that this guide be used in addition to information from your suppliers, whose safety, operating and maintenance procedures must take preference.

Frequently asked questions

Do UV inks have a higher dot gain (spread) than conventional inks?

Yes, but this is compensated in prepress by adjusting plate setter calibration curves.

Can UV printing meet current requirements in ISO12647-2 4-colour process printing?

Yes, but this must be specified when ordering UV 4-colour process inks.

Are there problems with stacking UV printed work?

No, provided that the sheets are cured when they arrive at the delivery then no set-off should occur. Attention to lamp efficiency and cleanliness are needed.

Are UV printed products recyclable?

UV printed matter can be disposed of in the same way as other printed waste in terms of heavy metal levels and biodegradability; even the most heavily coated sheets can be processed by modern re-pulping mills using a flotation process.

Can UV be used for toy packaging?

Yes, provided "toy packaging" is specified when ordering the UV inks so that the supplier can select appropriate pigments (same procedure as for conventional inks).

Are UV products suitable for food packaging?

Specific UV inks and coatings that have high consistency in odour and taint testing are available for food packaging. Consistent results require correct curing, careful controls and good procedures. However, the European printing ink industry recommends against any direct contact between printed surface and food. Even, if the risk of transfer or migration is very low, it should be avoided.

How does UV odour and taint compare to other products?

A specific advantage of UV is its rapid stabilisation in taint and odour levels as measured by approved standard test methods of food manufacturers. Properly monitored UV printing permits the short lead times between printing and packaging demanded by industry. Cured UV products have a very low potential for causing odour and tainting problems.

Is there a problem from ozone generation?

UV lamps are fitted with extraction systems and the low levels of ozone generated are extracted away from the workplace. The equipment used must be maintained correctly. Ozone is easy to detect and routine monitoring is recommended.

Does UV printing produce other air emissions?

Ozone is the only emission; it is produced by the lamps and each UV module normally has an integrated exhaust. In comparison to conventional printing, UV printing produces fewer VOC air emissions and can therefore be used as a control technology.

Is there a problem of ink mist on fast presses?

There are many factors that can influence the level of ink mist. Misting should be avoided or at least minimised since it can affect health, cleanliness and hygiene. High-speed presses should be fitted with mist extraction. Further reductions can be achieved by good press maintenance in roller, plate, and blanket cylinder pressures, press temperature control, effective exhaust and general ventilation.

Are UV products handled in the same way as conventional inks?

Energy curing products can be handled in a similar way to oil-based and water-based products while observing the same high standards of hygiene and working practice. Good housekeeping standards are required and care taken to avoid unnecessary contact with UV products. Always read the health and safety information provided by the supplier and follow the instructions carefully. Eye irritation can be caused by repeated or prolonged exposure to uncured UV products if the supplier's handling recommendations are not followed.

Are toxic materials used in UV inks and coatings?

UV products are formulated from materials other than those known to be toxic. Materials used in UV products are well understood from detailed scientific studies over many years. Spray powder and ink and coating solvents can be eliminated from the pressroom when UV technology is used. UV products are very press stable and this can lead to a reduction in the use of wash-up solvents.



Why use UV?

2005	
Overprint coatings	52%
Offset & Letterpress	25%
Screen	12%
Flexo	11%
Digital	1%
Gravure	0%

UV printing and coating is widely used for different printing processes in Europe.
Source: Cytec/Radtech.

The value added benefits of UV were first recognised for packaging, but its use has also grown in commercial and publication applications.
Photo: Sun Chemical.



UV and Value Added Printing

The competition for attracting point of sale attention to a product is intense – whether it is a packaged product in a store, a book on a display shelf, a magazine in a news kiosk, or a direct mail catalogue in the letterbox. The challenge is how to activate a perceived differentiation and positioning by the viewer from the product's shape, colour and effects. The role of Value Added Printing is to increase differentiation by combining several special elements. The design team's graphic elements and text can be enhanced by the selection of a corresponding substrate quality, then extended with the choice of inks, special effect or metallic pigments, foiling, coatings, and finishing. UV printing and coating provides the widest range of Value Added Printing techniques on the widest range of substrates including foils and plastics.

Growing UV demand

The UV market has been growing continuously over many years with an annual worldwide growth that is almost three times higher than the industry's average growth rate for printed products. UV has also grown strongly in sheetfed and in many flexo applications.

Process benefits for printed products

The growth of UV is being driven by its value-added attributes that can provide multiple benefits in publication, commercial, packaging and label market applications. The reasons for this are found in the increasing customer demands for:

- The use of a very wide range of substrates (in addition to paper and board) including low-absorption or non-absorption substrates (plastics, foil, metal and heat sensitive substrates).
- Very high gloss effects, sometimes in complex combinations with scuff and scratch resistance.
- A variety of special coatings for functional, tactile and special graphic surface treatments.
- High surface resistance (rubbing and scratching), especially for packaging and publication covers.
- Faster job completion, particularly for short runs, because UV printing can in many cases be immediately finished.

The key business advantage in the UV process is its application flexibility that delivers variable product features and special applications over a wide range of substrates and surface finishes. This provides printing purchasers with creative opportunities to differentiate their products and add functional features to them. Printers can achieve higher value sales to existing customers and attract new business.

In some cases, UV printing and coating reduces total production costs compared to other processes; in others, the higher selling price of UV products provides an improved return on investment even with higher UV production costs.

UV printing is now a dependable process. UV inks are considered to be environmentally friendly because they do not generate VOC (Volatile Organic Components) solvent emissions. For example, in the USA some conventional sheetfed ink distillates are classified as VOC and are subject to legislative control and restrictions – in these areas UV is often classed as the "best available process". In the EC, ink distillates for sheetfed printing are not classified as a VOC hazard.

Production process advantages

- Minimised printed waste – no smearing or set-off.
- Short turnaround time with almost immediate finishing from instant ink curing.
- Inline UV production also avoids separate offline coating operations (reduced waste levels and handling).
- Normally no spray powder is required; however, use of powder on highly static-prone substrates can improve their delivery performance.
- Reduced frequency of changing high delivery piles.

Production process constraints

- Higher equipment investment cost of 15-25% (depending on configuration).
- Replacement costs of UV lamps and reflectors that are replaced more frequently than IR lamps, which have a longer lifetime.
- UV ink and chemical costs may be higher than conventional inks in some world regions (like Europe) where the conventional inks used are of different quality/price than in other regions (like the US).

Production process comparisons

- UV ink consumption is equal to conventional 4-colour process printing; UV ink waste is less.
- Widespread European experience shows that average production output should be similar to conventional provided best practice is used (UV curing equipment configuration, ink and coating chemistries and correct operator techniques).
- Total energy cost of UV production is similar to that of the same press configuration equipped with IR/Hot air dryer. Tests show that UV draws 10% less lamp power than IR/Hot air. A comparative total energy running cost audit shows that UV costs about 30% less than IR/Hot air (using German energy costs). The energy necessary to start up a UV lamp is higher than that for an IR emitter that does not start by ignition, the kW rating of UV lamps is also normally higher than IR emitters.

What is UV curing ?

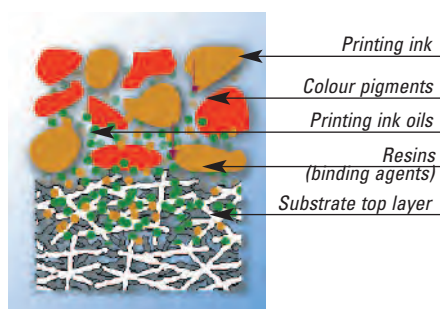
The main difference between UV curing and conventional ink drying lies in their binder ingredients and drying mechanisms. Conventional oil-based ink relies on the absorption of liquid materials into the substrate, where the ink sets and its resin materials dry by oxidation polymerisation to give a scuff resistant surface. This process can take many hours depending on variables like substrate, ink coverage, ink and water chemistry/balance. Assisted evaporation (IR and hot air with warm air exhaust) can accelerate drying of water-based coatings.

The UV ink curing process uses inks that contain a photoinitiator that is reactive to a specific bandwidth and intensity of UV light. After printing, the substrate is exposed to UV light (from lamps housed in the press) that initiates a chemical reaction of the photoinitiators and other UV-reactive components to cure (dry) almost instantly the ink-coating film.

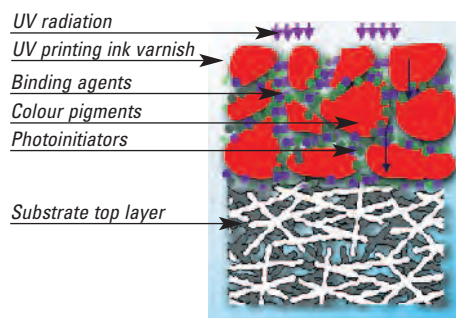
When catalysed by the combination of UV light and photoinitiator, the ink binders immediately react to give a dry ink film (UV ink binders include polymerisable monomers, oligomers and pre-polymers). Sheetfed UV ink and coating systems are based on acrylate chemistry and are generally used in four ways:

- Conventional inks + dispersion primer + UV coatings.
- Classic UV inks and UV coatings
- Non-classic UV (hybrid) inks and UV coatings
- Combination of UV and conventional ink systems and coating on same press for alternative operation.

Conventional drying (absorption)



UV chemical curing

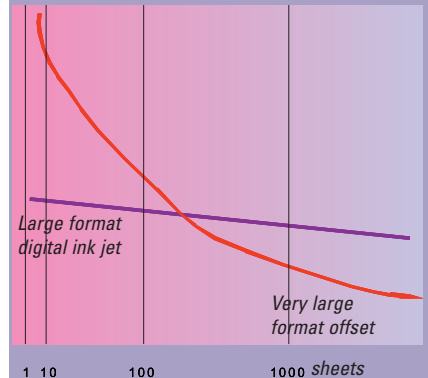


Source: Adphos-Eltosch.

UV Printing for sheet display

Very large format UV presses can now be economically competitive with UV screen and digital ink jet printing to cure thick non-absorbent substrates used for large format displays to deliver high definition, gloss, mechanical resistance and colour intensity.

Efficient makeready allows economic run lengths on large format offset presses to be reduced to a few hundred copies.



ISO12647:2 colour standard and UV

This international standard for 4-colour offset process printing is the basis for increased standardisation in Europe (Process Standard Offset) and in North America (GraCOL 7).

ISO compliance can be achieved using UV curing 4-colour process printing provided that a suitable substrate and inks are used.

The ISO standard uses reference measurements on some 'standard' papers. However, there is almost no restriction on the choice of substrate in UV, which means that care is needed in the choice of substrate before assessing compliance.

Care is also required in the level of resistance of the pigments used in the inks because the ISO standard is based on inks using pigments with a 'standard' resistance level on paper or board. However, in some cases the end-use requires additional light and chemical resistance; or UV printing on plastics, foils, laminates. To meet these demands UV inks must use highly resistance pigments but these may make ISO12647:2 more difficult.

Which UV ink system?

Characteristics	Ink system	
	Classic UV	Non-classic UV (hybrid-types)
Gloss coated paper printing	Excellent	Excellent
Matt or Satin coated & Uncoated papers	Excellent	Poor
Folding carton substrates	Excellent	Excellent
Plastic and foil substrates	Excellent	Unsuitable
Metallised substrates	Good	Unsuitable
Heat sensitive substrates	Good	Poor
Surface chemical resistance	Good	Good
Scuff and scratch resistance	Excellent	Excellent
Tactile and other surface effects	Good	Good
Overprinting varnishes and coatings	Excellent	Poor
Food applications (no direct contact)	Good	Unsuitable
Gloss quality	Good	Excellent
Coating	Optional	Inline obligatory
Coating quality and ease of use	Good	Good
Ink formulation	Standardised	Highly variable
Washing agents	Standardised	Highly variable
Ink rollers	Full or Mixed UV mode	Conventional or Mixed Mode
Blankets	Full or Mixed UV mode	Conventional or Mixed Mode
Ink/water balance	Sensitive	Better than classic UV
TVI (tonal value increase)	Higher than conventional inks	Lower than classic UV

The different operating characteristics of classic UV and non-classic ink systems. Source: PrintCity.

Two types of UV ink systems are available. Both can be used in either dedicated or alternating production with conventional oil-based inks. Both require the same health, safety and environmental procedures. However, each has different advantages and disadvantages.

Classic UV (or full, or traditional): Is a mature and predictable system that has been in constant and growing use since the 1970s. These inks can be printed with or without coating and are available for a wide range of applications including food packaging, non-absorbent substrates and printing on all paper types. Presses are normally specifically adapted for UV operation with devices to avoid degradation from heat or aggressive components in consumables. Established sets of consumables (washing agents, rollers and blankets) provide optimum and stable performance with low risk of damage over a long life.

Non-classic UV: Describes the complex array of other UV ink systems that have been introduced into the market in recent years and are often referred to as hybrid UV. These inks always need an inline UV flood coating to be cured (unlike classic UV). The original non-classic UV ink system was developed by Sun Chemical in 1999 called HyBryte™ (from which the generic term hybrid was derived). These systems were designed for occasional UV commercial printing on presses equipped with conventional rollers and UV dryers after the last print unit and the coater (it is now not uncommon for one or two inter-deck UV dryers to be fitted depending on ink coverage and speed requirements). Non-classic UV ink types tend to have less ink misting, better TVI and easier ink/water balance than many classic UV inks. However, they are normally unsuited to matt coated and uncoated papers, non-absorbent substrates, and food packaging applications.



As a generalisation, these inks have some of their UV medium replaced by other ingredients that are less aggressive to conventional rollers. However, the composition of non-classic UV (hybrid-type) inks has become highly variable and can represent a serious risk of roller, blanket and machine damage.



Before using any non-classic UV ink, always ensure it has been tested for compatibility with the rollers, blankets and washing agents to be used (see pages 38-40 for more information). The proportion of production time and frequency of changing between oil-based inks with non-classic UV can also have a significant impact on roller and blanket selection. Both classic and non-classic UV ink systems can be run in either dedicated or alternating modes.

Dedicated or alternating UV?

Dedicated UV production

The press is set up and equipped with dedicated consumables to print UV all of the time. The advantages are that consumables are optimised, there is no risk to their degradation from contamination, no cleaning downtime from changeover of ink types, and production and operator efficiency can be fine tuned for maximum productivity. The disadvantages are some higher UV costs (compared to conventional oil-based) for ink and consumables.



Best practice is to make a detailed comparative total cost analysis of dedicated vs alternating production. Be cautious on assuming that dedicated UV will always be more costly. Take into account particularly downtime during cleaning when making ink changeovers, higher risk of smearing and set-off in conventional production along with its longer manufacturing cycle time and work-in-progress costs.

Alternating (mixed) production with UV and conventional inks

Mixed mode production between conventional oil-based ink and any type of UV ink system on the same press requires attention to:

- 1. More roller adjustment** (than dedicated UV or conventional). All rollers swell and shrink — the key is by how much and when to adjust them to maintain quality. Motorised nip roller adjustment allows early and easy adjustment.
- 2. Cleaning:** Thorough cleaning of ink systems is essential when changing between ink types — even small traces of conventional ink, grease or oil will contaminate UV inks. Residual powder spray must also be cleaned.
- 3. Selected conventional inks:** Oils in some conventional inks may cause roller shrinkage and they should not be used in mixed UV production — check with your supplier.
- 4. Consumables:** Inks, coatings, washes, rollers and blankets must be selected as a set designed to function together — if not there is a high risk of deterioration of consumables and output.
- 5. Safety and environmental procedures:** Identical for all UV ink systems.

There are two approaches to alternating production, each with different advantages and disadvantages:

Combination (Combi): Combi presses are ideal for unrestricted commercial and packaging printing on all substrates. The flexible press configuration allows alternating production between oil-based, classic and non-classic UV (hybrid) inks and coatings. Equipment required includes: combi rollers, UV inter-deck dryers, end-of-press UV/IR/hot-air dryer for UV and dispersion coating, and printing units prepared for fast UV dryer changeover (see also page 24). Although capital costs are higher, operating costs should be lower, and risks from incompatible consumables more controlled.

Non-classic UV (hybrid-type) inks: Ideal for occasional commercial printing generally of low to medium area ink coverage. They can be used for limited periods on conventional offset presses equipped with conventional rollers — however, some ink types may require special Combi rollers and blankets. UV/IR/hot-air dryers are required after the last print unit and the coater — additional inter-deck dryers may be needed depending on ink coverage and speed.



The proportion of production time and frequency of changing between oil-based inks with non-classic UV (hybrid-type) can have a significant impact on roller and blanket selection.



Always ensure that any non-classic UV ink is chemically compatible with the rollers, blankets and washing agents to be used (see pages 38-40 for more information).

Which UV process?

A wide range of process options is available for value added sheetfed printing. These begin with conventional inks and inline aqueous coating to print on paper and board – where the final gloss is determined by the substrate. A higher gloss alternative is to apply a primer-sealer over conventional inks and then add UV coating. UV coating provides higher gloss and reduces waiting time for drying between the printing and postpress operations. The curing hardware for these options is the same; the variable is the number and position of the lamps.

1 - Conventional wet offset ink + primer + UV coating: The UV coating provides a scratch-resistant and high-gloss surface without changing proven conventional ink formulations on paper and board. The double coater and end-of-press combination dryer (IR/hot air and UV) allows a dispersion primer to be applied over conventional inks followed by UV coating. High gloss levels can be achieved with fast-absorption 4-colour process inks even with an area coverage of around 300% (similar to UV hybrid inks). The gloss level is influenced by the substrate as well as the configuration and efficiency of the drying system. This approach is common in Europe.

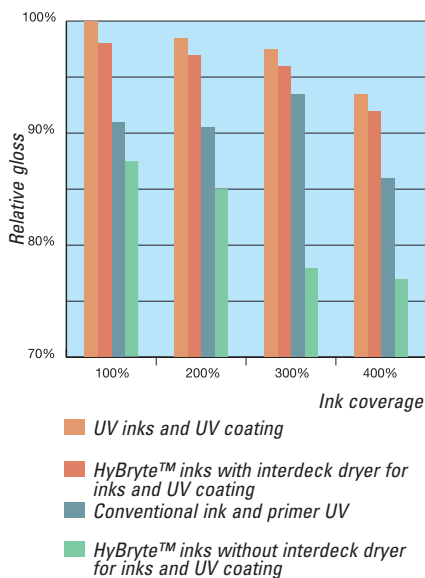
2 - Classic UV Offset (no coating): The essential process for non-absorbent surfaces. Gloss comes only from the inks and substrates. Value added surface treatment is possible by coating offline when the printing inks used are coordinated. Can also be used for time sensitive publication/commercial production of jobs requiring immediate postpress processing using either two press runs or perfecting.

3 - Classic UV Offset + Inline single UV coating: Provides a very good high-gloss finish with almost no change during the curing process. UV curing after the coating unit at the end of the press provides optimum gloss. Pre-heating the coating to about 40°C prior to application can help achieve higher gloss; to a lesser extent an IR inter-deck dryer before the coating module might also help.

Non-classic UV: Hybrid-type UV inks always need an inline UV flood coating to be cured (unlike classic UV). This means that the entire substrate surface is always covered. These ink types are normally unsuited to matt coated and uncoated papers, non-absorbent substrates, and food packaging applications.

4 - Classic UV Offset + Inline double UV coating: Allows a wider range of high value added surface finishes to be applied, including mixed matt/gloss coatings and special effect pigments. In Europe this approach is mostly used by specialists.

5 - Inline UV coating before classic UV offset printing followed by double inline UV coating: This "ultimate" press configuration permits applications to be combined inline to an extent not previously known. Applying opaque white or metallic effect coatings upstream of the actual printing units provides advantages for label and packaging printers who process non-absorbent substrates. A double-length drying path after the first coating module is extremely important for this process.



Each UV process combination has a consistent relative performance irrespective of ink coverage.

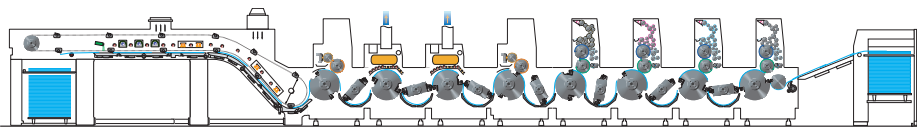
Overall gloss levels reduce as ink coverage increases. Gloss may vary due to the combination of ink, coating, paper, dryer settings.

Source: MAN Roland.

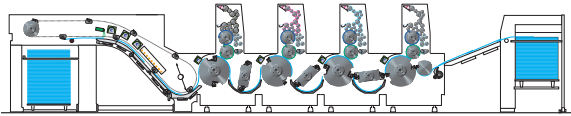
Printing Process	Wet offset+	Wet offset+	Wet offset+	Wet offset+	Non classic UV hybrid	Classic UV	Classic UV	ClassicUV	Classic UV
Coating	Inline single	Inline double	Primer +	Offline double	Inline single		Inline single	Inline double	Offline double
	WB coating	WB coating	UV coating	UV coating	UV coating	No coating	UV coating	UV coating	UV coating
Printing applications		WB coating		UV coating				UV coating	UV coating
Paper substrates	•••••	•••••	•••••	•••••	•••••	•••••	•••••	•••••	•••••
Folding carton substrates	•••••	•••••	•••••	•••••	•••••	•••••	•••••	•••••	•••••
Plastic and foil substrates	•••	•••	•••	•••	••	•••••	•••••	•••••	•••••
Metallised substrates	•••	•••	•••	•••	•	•••••	•••••	•••••	•••••
Heat sensitive substrates	•••	•••	••	•••	••	•••	••	••	••
Surface chemical resistance	••	••	•••••	•••••	•••••	••	•••••	•••••	•••••
Scuff and scratch resistance	•••••	•••••	•••••	•••••	•••••	••	•••••	•••••	•••••
Tactile and other surface effects	••	•••	•••	•••••	••	na	••	•••••	•••••
Overprinting varnishes and coatings	•••	••	•••	•••	••	•••••	••	•	•
Food applications (no direct contact)	•••••	•••••	••	•••	•	•••••	•••••	••	••
Gloss quality	•••	•••••	•••••	•••••	•••••	••	•••••	•••••	•••••
Coating quality and ease of use	•••••	•••••	•••••	•••••	•••••	na	•••••	•••••	•••••

Comparative performance:

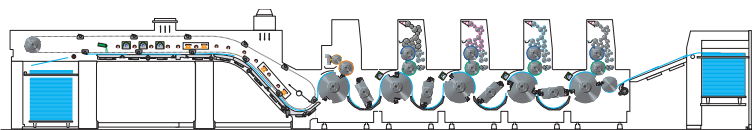
- Very good •••••
- Good •••••
- Satisfactory •••••
- Fair ••
- Poor •



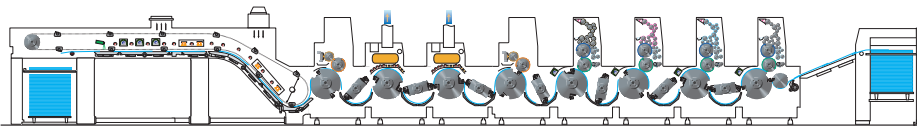
Conventional wet offset ink + primer + UV coating



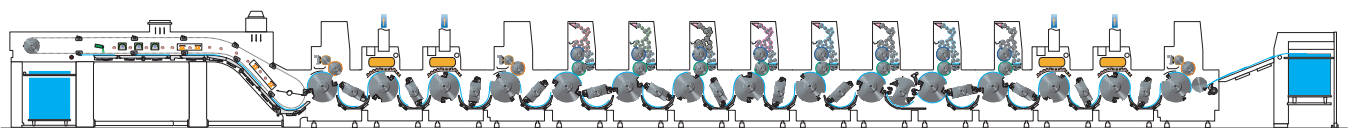
Full UV Offset



UV Offset + Inline single UV coating



UV Offset + Inline double UV coating



Inline UV coating before UV offset printing followed by double inline UV coating

Value Added UV

The competition for attracting point of sale attention to a product is intense – whether it is a packaged product in a store, a book on a display shelf, a magazine in a news kiosk, or a direct mail catalogue in the letterbox.

The challenge is how to activate a perceived differentiation and positioning by the viewer from the product's shape, colour and effects. The role of Value Added Printing is to increase differentiation by combining several special elements. The design team's graphic elements and text can be enhanced by the selection of a corresponding substrate quality, then extended with the choice of inks, special effect or metallic pigments, foiling, coatings, and finishing. UV printing and coating provides the widest range of Value Added Printing techniques on the widest range of substrates including foils and plastics.

The following pages are examples of Value Added UV printing and coating effects.

2

UV economics

Selecting the right process depends both on the substrates, the products to be printed, and the proportions of UV and conventional printing on the press. The economic impact of each option needs to be calculated as a total operating cost – investment, running costs, energy, consumables (ink, chemicals, rollers, blankets) over a range of jobs.

Direct cost comparisons with conventional wet offset can be misleading.

- UV printing is a value added process addressing wider markets that should generate higher sales revenues to compensate for any additional process costs.

- The elimination of waiting time between process steps is an economic and competitive advantage. In advertising-publication printing conventional inks often require a neutral coating to allow immediate reverse side printing or finishing. An alternative is to use UV inks without coating to allow immediate handling and preserve the paper's surface qualities.

To better understand these factors, the PrintCity UV project team in association with Eurografica, a specialised consultancy, made an economic evaluation of different process options to give potential UV users a clearer and realistic comparison of the alternatives.

Some of the key findings include:

- Classic UV without coating and conventional offset with coating have about the same cost level. The total UV energy consumption is about 50% less than with a conventional press.
- Total energy consumption of UV printing and coating is almost identical to conventional offset and coating.
- There is a negligible cost difference between conventional inks alternating with Classic UV on the same press; and for Non-classic (hybrid) UV alternating with conventional inks.
- Multi-purpose combination presses for alternating production are 3 to 4% more expensive than single-purpose processes but are more flexible.

Processes and Costs

Nine process variations of ink and coating types are modelled that correspond to 7 different press configurations. Classic UV (100%) means the press is completely dedicated to UV printing.

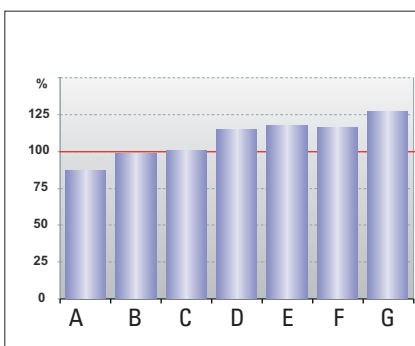
Process	Press - 70 x 100 cm
1 Conventional offset no coating	A: 5-colour press no coating unit
2 Conventional offset with coating	B: 5-colour press with coating unit
3 Classic UV offset (100%) no coating	C: 5-colour UV press no coating unit
4 Classic UV offset (100%) with coating	D: 5-colour UV press with coating unit
<i>Alternating production on the same press</i>	
5 Conventional offset with coating, and	E: 5-colour UV press with coating unit and additional equipment for alternating conventional with Classic UV inks
6 Classic UV offset with coating	
<i>Alternating production on the same press</i>	
7 Conventional offset with coating, and	F: 5-colour UV press with coating unit and additional equipment for alternating conventional with hybrid UV inks
8 Non-classic (hybrid) UV offset with coating	
9 Conventional offset plus primer + UV coating (primer UV)	G: 5-colour press with double coater plus special equipment

The annual production mix of the sample jobs is an average of 3 000 sheets per run for 35% of the year, 5 000 sheets for 45% of the year and 15 000 for 20% of the year.

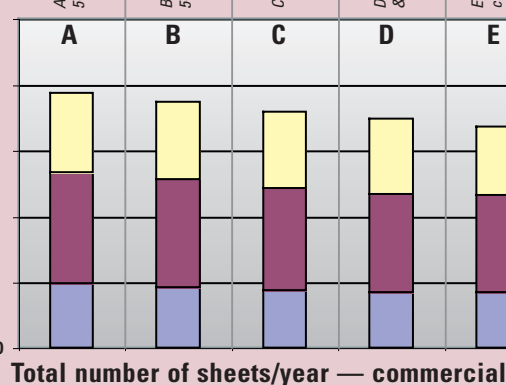
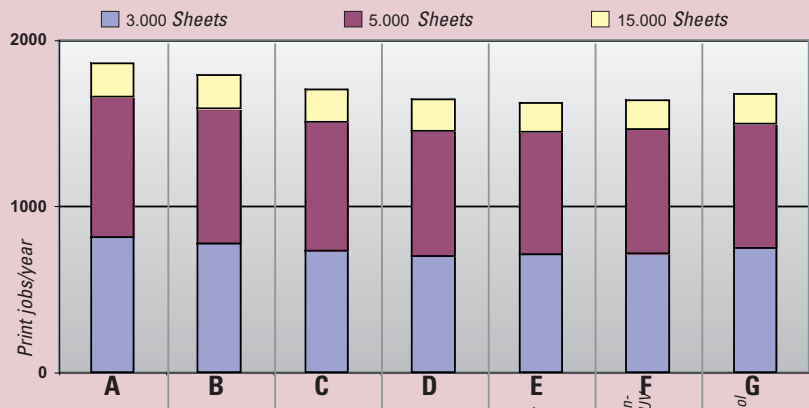
Two production shifts (3 750 hours/year) yield an annual job volume of 1 600-1 800 jobs, totalling 17-19 million sheets — depending on press and process.

Total investment cost

A 5-colour conventional press with coating (column 2) is the 100 % reference cost against which the costs of other configurations are compared.



Total number of jobs/year — commercial

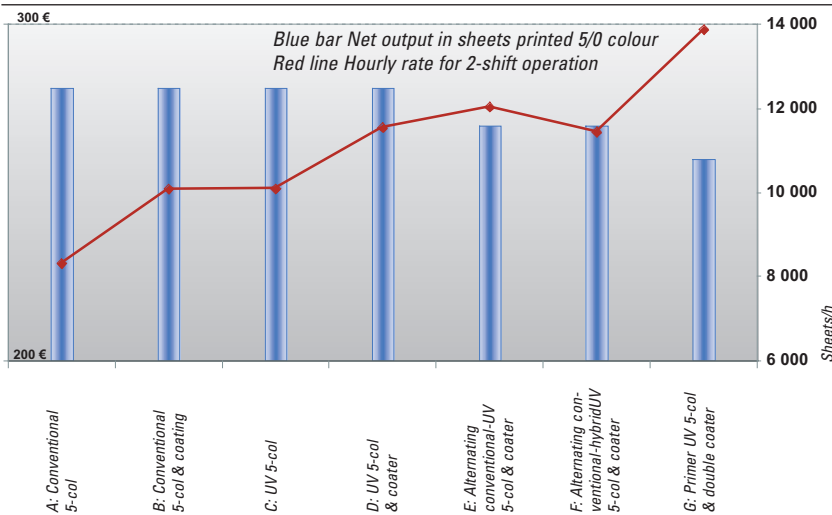


Print performance data

	Makeready time	Maximum sheets/hour	Production speed sheets/hour	Net performance sheets/hour
Conventional offset	25 min	16 000	14 000	12 500
Classic UV only	30 min	16 000	14 000	12 500
Alternating Conventional/UV	38 min	16 000	13 000	11 600
Primer UV	25 min	16 000	12 000	10 800

All presses are equipped to facilitate short makeready and high net production output. However, maximum output is influenced by the level of best practices, staff skills and motivation, and operating organisation. These example values are used in the analysis. Speeds for jobs with runs below 10 000 sheets were reduced accordingly.

Hourly rates and productivity



This chart compares net output in sheets per hour (bars and right scale) with the respective hourly machine rates (red line and left scale). The net performance includes start-up speed curve, stops and re-starts during production and intermediate cleaning. Manning is one printer and half of an assistant, with two operators during makeready. Depreciation and accounting methods are those from the German printers federation (bvdm); cost of electricity is based on average German rates.

		Replacement period	Time to replace
Dryer lamps	IR lamps	5 000 operating hours	Only minutes
	UV lamps	1 500 operating hours	
Rollers*	Conventional rollers	40 million impressions	8 hours for entire press
	UV rollers	30 million impressions	
	Combination rollers	20 million impressions	
Blankets	Standard blanket	2 000 000 impressions	0.8 hours for entire press
	Classic UV blanket	750 000 impressions	
	Combination blanket	750 000 impressions	

The economic modelling includes the different frequencies to change press consumables for each process and their relevant costs.

*Dampening rollers are usually replaced sooner than inking rollers.

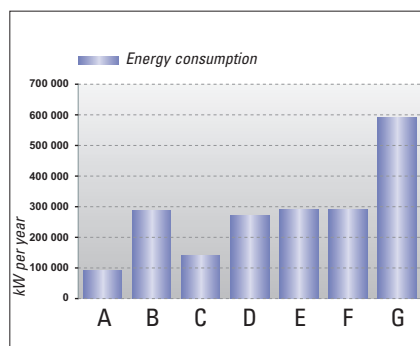
	Consumption	Cost index
Conventional offset ink	1.5 gsm	100
Classic UV ink	1.5 gsm	160
Non-Classic (Hybrid) UV ink	1.5 gsm	210
Water-based coating	3.0 gsm	25
UV coating	2.5 gsm	70
'Hybrid' UV coating	2.5 gsm	70

Ink and coating consumption values on coated substrates with their relative cost.

The evaluation's results are calculated as a cost price per 1 000 sheets for volumes of 1 000 to 100 000 in absolute values. For simplicity, a volume of 10 000 is used as reference value in these examples, and all figures are expressed as percentage values. Conventional wet offset printing with coating is the reference value (100%) for all calculations.

Two high quality print jobs were selected to represent packaging and publishing-commercial applications. Both jobs have a 70 x 100 cm format, the fifth colour is changed after each job, with a 100% blanket coating coverage. The packaging job is printed 5/0 colours with 250% ink coverage on a 250 gsm coated GD2 board. The publishing-commercial job is 5/5-colours on 135 gsm coated paper with a 150% ink coverage. Job costs include printing plates, but excludes postpress.

Important note: The comparative energy consumption data in this analysis is a general indication only. Sheetfed UV printing and coating energy consumption has a wide range of variables that need to be individually calculated to provide reliable results for a printer's specific job profile (ink coverage by colour, coating volume) and the press-dryer technology used.



Results and Comparisons

1 Process	Press	Cost level
1 Conventional offset no coating	A: 5-colour press no coating unit	94%
2 Conventional offset with coating	B: 5-colour press with coating unit	100%

1: The additional cost of using water-based coating in conventional offset printing is about 6%. The coating provides surface protection, faster finishing or converting, an improvement in gloss, and allows some special effects.

2 Process	Press	Cost level
1 Conventional wet offset no coating	A: 5-colour press no coating unit	94%
3 Classic UV offset (100%) no coating	C: 5-colour UV press no coating unit	100%

2: UV offset without coating costs about 6% more than conventional offset printing without coating. In both cases the surface properties of the paper are unchanged — particularly for matt coated paper. However, for conventional offset there is a risk of set-off and smearing of the printed image and a delay for postpress operations. The UV offset process does not have these limitations and delivers blemish-free printed images and allows immediate reverse printing and finishing.

3 Process	Press	Cost level
2 Conventional offset with coating	B: 5-colour press with coating unit	100%
3 Classic UV offset (100%) no coating	C: 5-colour UV press no coating unit	100%

3: Classic UV offset without coating and conventional offset with coating have more or less the same cost level. Conventional inks plus coating protect the paper surface but modify its visual appearance and feel. UV printed images have high resistance to marking, faster reverse side printing and converting, together with no detrimental impact on the paper surface. The dedicated UV press is less flexible than a conventional multi-purpose press with coating.

4 Process	Press	Cost level
3 Classic UV offset (100%) no coating	C: 5-colour UV press no coating unit	100%
4 Classic UV offset (100%) with coating	D: 5-colour UV press with coating unit	110%

4: Classic UV with inline coating costs about 10% more than UV without coating. UV coating achieves the highest surface gloss which explains its frequent use — however, flood coating may modify the paper's visual appearance and feel. This is not an issue for UV without coating because it has the same high rub resistance of the image and allows fast finishing — and at a lower cost. The press with coater is more flexible and can also be used to selectively coat large illustrations and graphics.

5 Process	Press	Cost level
2 Conventional wet offset with coating	B: 5-colour press with coating unit	100%
4 Classic UV (100%) offset with coating	D: 5-colour UV press with coating unit	110%

5: UV printing and coating costs 10% more than conventional wet offset with coating. The UV advantages are higher gloss, high rub protection and fast production, and a wider range of special effects.

6	Process	Press	Cost level
2	Conventional offset with coating	B: 5-colour press with coating unit	100%
4	Classic UV (100%) offset with coating	D: 5-colour UV press with coating unit	110%
	<i>Alternating production on the same press</i>		104%
5	Conventional offset with coating, and	E: 5-colour UV press with coating unit and additional equipment for alternating conventional with Classic UV inks	113%
6	Classic UV offset with coating		
	<i>Alternating production on the same press</i>		
7	Conventional wet offset with coating and	F: 5-colour UV press with coating unit and additional equipment for alternating conventional with hybrid UV inks	103%
8	Non-Classic (hybrid) UV offset with coating		114%

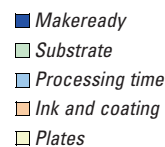
6: The direct comparison between conventional inks alternating with Classic UV (5+6); and for Non-classic (hybrid) UV (7+8) shows a negligible cost difference. Multi-purpose combination presses (5/6 and 7/8) are 3 to 4% more expensive than single-purpose processes because their ink system change over takes more time and the operating personnel have more tasks. However, multi-purpose presses have a much higher flexibility to print different types of jobs from various business segments.

7	Process	Press	Cost level	
			Advert.	Packag.
1	Conventional offset no coating	A: 5-colour press no coating unit	94%	96%
2	Conventional offset with coating	B: 5-colour press with coating unit	100%	100%
3	Classic UV (100%) offset no coating	C: 5-colour UV press no coating unit	100%	100%
4	UV offset with coating (UV only)	D: 5-colour UV press with coating unit	110%	106%
	<i>Alternating production on the same press</i>			
5	Conventional wet offset with coating and	E: 5-colour UV press with coating unit and additional equipment for alternating conventional with Classic UV inks	104%	102%
6	Classic UV offset with coating		113%	107%
	<i>Alternating production on the same press</i>			
7	Conventional wet offset with coating and	F: 5-colour UV press with coating unit and additional equipment for alternating conventional with hybrid UV inks	103%	101%
8	Non-Classic (hybrid) UV offset with coating		114%	109%
9	Conventional wet offset plus primer plus primer UV coating	G: 5-colour press with double coater plus special equipment	119%	111%

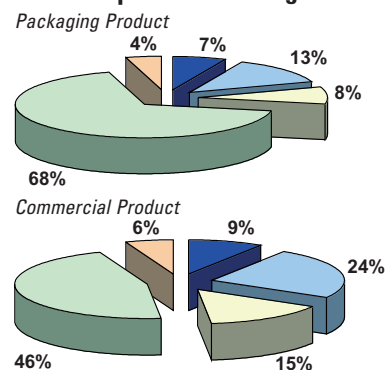
7: This overview shows the different values for advertising-publishing printing and for packaging — they show similar results for the economic evaluation of the different processes for both applications. For advertising-publishing, the cost differences between the alternative production processes has a range of 25% (94 to 119), and for packaging printing only 15% (96 to 111). This is caused by the much higher substrates costs for packaging. There is a significant shift of the cost proportion of the substrate and ink-coating related to the application and process.

The primer UV process (9) is 19% above the reference press costs. However, the double coater press offers a vast range of process combinations — wet offset, Classic UV and Non-classic (hybrid) UV — with the widest choice of finishes — gloss, matt, scented, effect, protection, barrier, blister, sealing and other special coatings.

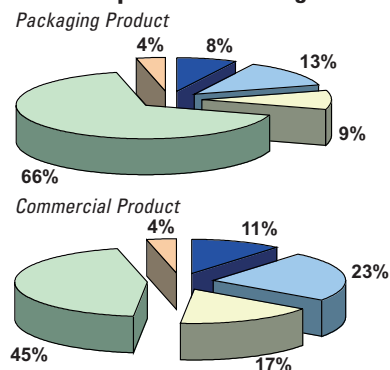
Production cost proportions



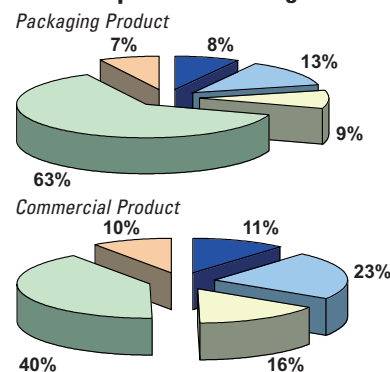
A - Conventional Offset 5-colour press & coating



C - Classic UV 5-colour press no coating



D - Classic UV 5-colour press & coating







3

Production system

Optimum performance is achieved by selecting the right components for the printing applications within a total processing environment with all of the consumables used.

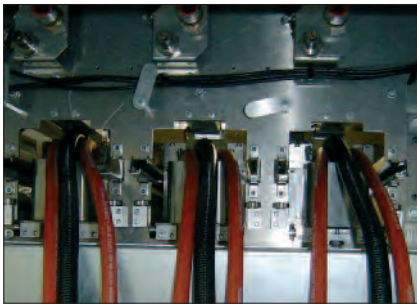
The best overall production performance is delivered by a press line in which all components required for UV processing are fully integrated and controlled as a single system. This includes the drying units, temperature control, heat and ozone exhaust, electrical supply, software control, washing devices and consumables.

Optimum printing performance requires chemical compatibility of all the consumables used in the process system. Plates, roller covers and blankets are made from materials that interact with the different chemical substances and fluids that they transport – inks, coatings and washing agents. There is an optimal roller, blanket and plate mix, along with dedicated washing agents, for any combination of inks and coatings.

Press equipment to enable and optimise UV production



Ink hood open to show ink fountain agitator that prevents high-tack UV ink from standing still in the ducts.
Photo: MAN Roland.

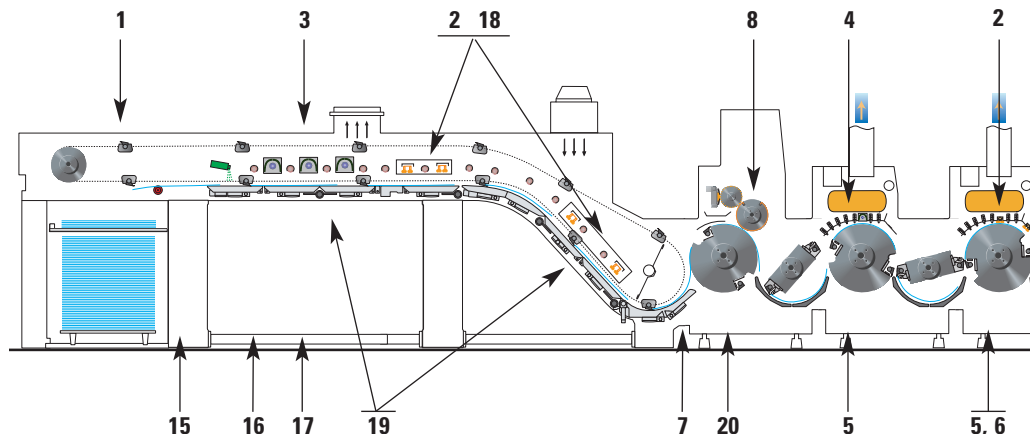


UV end-of-press lamp docking station.
Photo: MAN Roland.



UV inter-deck dryer on a Roland 700 press.
Photo Adphos-Eltasch.

- 1 Shadow-reduced grippers in the delivery gripper systems
- 2 Exhaust systems between print units and in the delivery to remove ozone, odours and humid air
- 3 Heat extraction system around UV lamps cassettes, between units and in the delivery Heat exchangers are standard components
- 4 UV inter-deck dryer between double coaters
- 5 Transfer modules between double coaters
- 6 Long UV coating flow track for best conventional primer-drying and UV curing results
- 7 Coating conditioners to pre-heat coating to 40°C to ensure even spread, obtain highest gloss and minimise foaming.
- 8 UV or combi blankets (for inking and coating systems)
- 9 Automatic ink supply and ink fountain agitators
- 10 UV inter-deck dryer between print units
- 11 Temperature controlled ink rollers (because of high tack of UV inks)
- 12 Convertible UV inking unit
- 13 UV or combi rollers (for inking and coating systems)
- 14 Ink mist exhaust device and inking unit blowing device
- 15 Extended deliveries for highest gloss
- 16 UV preparation of the printing press (mechanical, electrical, software)
- 17 Safety equipment (guards etc.)
- 18 Cassettes ("docking stations") in the delivery to accommodate IR dryers
- 19 End-of-press dryers – either UV only or combined IR + hot-air + UV
- 20 Non-contact pumps in the coating modules for fast coating changeover
- 21 Coating module with chambered doctor blade and anilox roller
- 22 Cassettes ("docking stations") between printing units to accommodate UV dryers
- 23 Roller washing device for UV
- 24 Additional washing tank system for combination presses alternatively running conventional and UV inks



Press components recommended for UV printing?

Press components for UV printing should satisfy two requirements:

1. Simplify the application to increase process stability and quality (e.g. UV inking unit, blowing devices, inking unit temperature control, and washing programmes);
2. Protect the working environment and make it safer for the production staff. Direct contact with the skin should be avoided when working with UV materials. Components that contribute to workplace safety include ink mist extraction systems, automatic ink supply and automatic wash-up units and programmes to eliminate manual post-washing.

1. UV inking unit: Improves printing with UV and hybrid inks. The window between scumming and streaking is smaller with UV and hybrid inks than with conventional inks. Therefore, it is important to print UV inks close to the smearing point and use the capabilities of the press to keep the water content in the ink as low as possible. If the direct contact between the damping unit and inking unit can be broken the printer has the possibility to control the water content in the ink — this is very important for images with low ink coverage because the less the ink emulsifies the less often wash-ups are necessary.

2. Inking unit blowing device: An aid to selectively counteract emulsification of UV inks by helping to ensure a precise ink/water balance (as does a symmetrical ink flow setting). Both devices have a positive influence on the rheology of UV inks that with many applications TVI is up to 5 % lower.

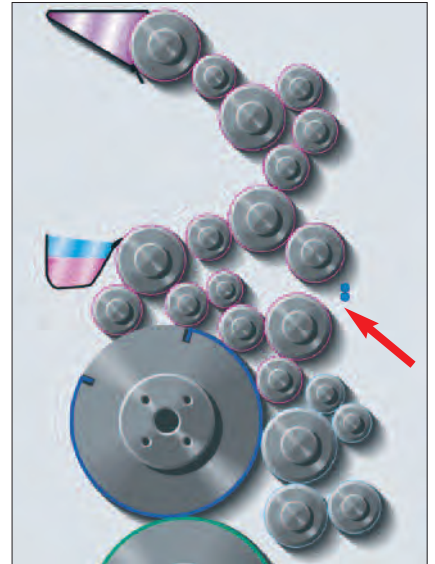
3. Inking unit temperature control: Stabilises the temperature of the UV inks in the inking unit to prevent scumming. Individual zone inking unit temperature control provides optimum results. The temperature of the distributor rollers and ink fountain rollers in every inking unit can be individually adjusted including different temperatures in different printing units if required — ideal for printing both UV and conventional inks in mixed operation inline and when printing waterless offset.

4. Ink mist extraction: Directly at the top of the inking roller train using filter mats to purify the exhaust air to ensure clean air in the pressroom and minimum soiling of the press.

5. UV wash-ups: Specific programmes for inking unit washing units with different need-related spraying durations. This makes wash-ups faster and ensures effective wash-ups with hybrid inks. It also improves working conditions and reduces makeready because manual post-washing is no longer required.

6. UV wash-ups in alternating operation: Fast changeover from one ink type to another is an important cost factor. Combi washing agents can be used for both ink systems but the results are often not comparable with those achievable from washing agents specifically formulated for each ink system. However, different washing agents must not come into contact with one another. Using several washing agent tanks and up to four washing agent pipelines per inking unit permits changeover between washing agents to UV washing agents at the press of a button.

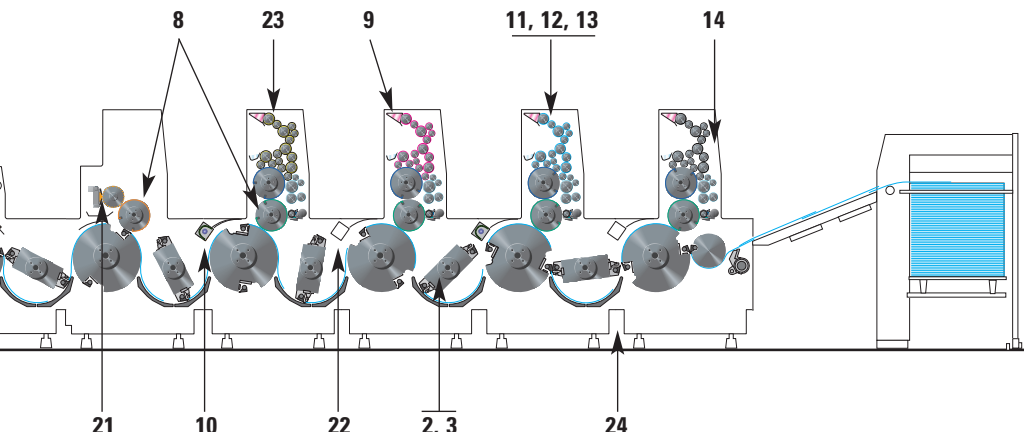
7. No waiting time after a UV wash-up: An option for many UV inter-deck dryers that pays for itself very quickly by saving several minutes per wash-up. It uses a brush-type washing system and suitable washing agents.



Ink flow direction change keeps the damping solution feed stable even with difficult UV inks.
Source: MAN Roland.



A blowing device combined with ink mist extraction.
Source: MAN Roland.





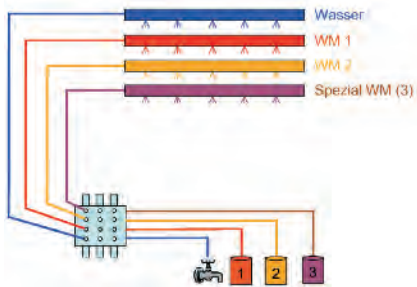
8. Automatic ink supply systems / ink agitators: Automated UV ink feed supply reduces costs by delivering only the ink needed at any time to the fountain, makeready time is reduced, and the ink does not settle. In addition, automatic ink feed reduces operator contact with UV materials. Ink can be supplied in cartridges with automatic ink feed to the fountain. This can be supplemented by fully automated ink supply lines and simple agitators for UV ink which tends to stiffen and settle in the ink fountain.

9. UV dryers: A distinction is made between conventional, heat-reduced and cold dryers. Currently only mercury vapour lamps are used and they have a surface temperature of 600°C-800°C. Heat radiation is highest when the lamp is positioned directly opposite the substrate referred to as conventional hot UV dryers. There are several ways to reduce heat stress on the substrate, one being the use of dichroitic-coated reflectors. This proven technology can be used without any problems in packaging and commercial printing.

Heat-reduced systems do not apply radiation directly to the substrate and the heat is filtered out by water pipes and mirrors to reduce heat build-up on the sheet by 20-30%. Mercury vapour lamps with their high surface temperature are used here as well but they are not positioned directly opposite the substrate. Heat-reduced UV dryers are used for commercial printing on thin substrates or label printing. With some constraints heat-reduced UV dryers can also be used for printing films.

10. Combination presses: To achieve optimum results from alternating production of conventional oil-based and UV inks it is recommended to install:

- A fast coating changeover system including conventional to UV washing agents (for the inking units, blanket and impression cylinder washing units).
- A standard inking unit temperature control system to control scumming of UV inks.
- Combination roller coverings are equally suitable for oil-based offset, full and hybrid UV inks.
- Inking unit blowing and ink flow direction change devices stabilise the ink/water balance.
- Inking unit cooling stabilises production.
- Fast washing agent changeover reduces makeready times.
- Preparation for running UV protects sensitive press components and provides better material compatibility.



A fast washing agent changeover system, as shown here with four circuits and spray pipes for water and three different washing agents, is recommended.
Source: MAN Roland.

Pipes and pumps:

- Avoid pipe systems containing copper because contact with UV products can initiate the hardening process.
- Ink pumps should use teflon bearings because UV products are not self-lubricating.
- Coating lines should use non-contact pumps (no bearing maintenance) that also allow fast changeover between different coatings without the cleaning required when using conventional pumps.





Ink agitators are recommended for UV ink which tends to stiffen and settle in the ink fountain.
Source: MAN Roland.

Curing & drying systems

UV inter-deck curing flexibility

Self-contained plug-in modules take 2-3 minutes to change and can be installed between units for flexibility and to give production back-up. They are positioned according to the needs of each job depending on ink colour, sequence and coverage. The maximum number of modules is a UV lamp for every printing unit. Fewer units can be used; the recommended minimum is one UV module for every two print units.

 Place an inter-deck UV dryer after opaque white, metallic colours, colours printed 15% above standard density, and dark colours (black, blue, green) and/or colours that cover more than 80% of the forme. Specially modified inter-deck dryers are available for opaque white.

 Always remove UV lamps from the delivery when using conventional inks and spray powder. To avoid surface contamination a dummy unit, without which the press will not start, is inserted in their place as a safety device.

Non-classic UV (hybrid) inter-deck: UV end-of-press curing alone may not be adequate for high ink coverage at high speed. Tests show that, for low ink coverage on high gloss paper, one inter-deck dryer after the last printing unit is sufficient but two are needed for mid-high ink coverage on low gloss substrates.

UV coating end dryer and cartridge: For best results, the UV end-of-press dryer should be as close as possible to the delivery to allow the coating to spread as evenly as possible prior to curing.

Complete production flexibility is available if all press units have a UV docking station. The variable positioning of available UV inter-deck lamps in these printing units depends on the requirements of a given job (colour sequence, brightness and coverage).

Combination IR + hot air + UV dryer systems

End-of-press dryer for printing presses with inline coating units and UV equipment that is used for alternating processes:

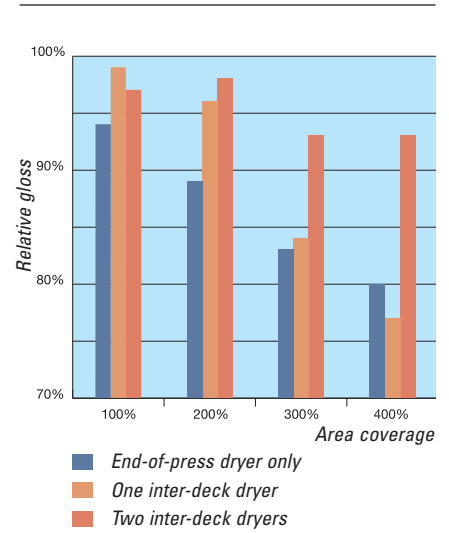
Hot air: For water-based coatings, IR (Infrared) lamps heat the aqueous content to create water vapour that is extracted by hot air knives and exhausted with a suction system.

IR segment: Helps reduce ink viscosity (of normal offset ink – not UV ink) for faster substrate absorption.

UV segment: Ensures final curing of UV inks (both full and hybrid) and UV coatings

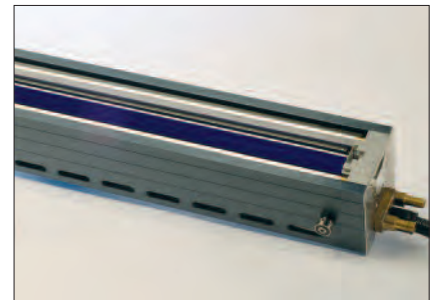
IR inter-deck

- IR inter-deck dryer before the first coating unit warms up the sheet to help more evenly distribute the coating film.
- IR inter-deck unit before the second coating module dries the first coating and warms the sheet to help prevent formation of an orange skin surface when using aqueous primer (caused by particles of water trapped in the primer layer leading to gloss draw back; too much energy sets surface only).
- IR inter-deck dryers accelerate oxidative drying.
- With the primer/UV process one can use an IR inter-deck dryer upstream of the primer application module to pre-warm the sheet, which helps the primer to dry.



The achievable gloss level of coating, when applied over different ink area coverage, is determined by the number of inter-deck dryers used with non-classic UV (hybrid) printing systems.

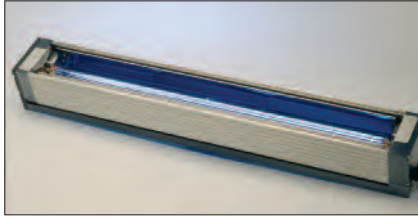
Source: MAN Roland.



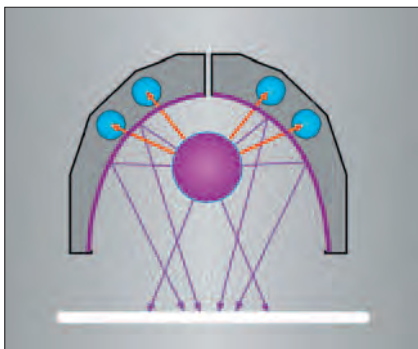
Heat reduced UV lamp module.

Source: Adphos-Eltosch.

UV lamps & reflectors



Standard UV module with shutter system.
Photo Adphos-Eltosch.



About 65% of lamp radiation travels indirectly from the lamp to the substrates. The properties of the reflective materials used in the reflector and its profile (elliptic, parabolic, variable, combi) significantly determine UV lamp efficiency.
Source: Adphos-Eltosch.



A new curing concept that combines two UV lamps in one module to eliminate heat problems associated with IR energy.
Source: Adphos-Eltosch.

UV lamps

UV emitters are typically a quartz tube containing mercury in an inert atmosphere. High quality quartz assures a transparency of up to 90% of UV radiation and resistance up to 800°C. Mercury is used because it emits radiation over a wide range of the spectrum to cure colours that are generally used in printing. For special applications (such as opaque white, high ink film weights and special colours) doped lamps may be required (cobalt, gallium, indium, iron, lead). UV lamps require a transformer to provide an electrical current of several thousand volts.

Mercury UV lamps are very reliable but their output declines continuously as they are used. Deterioration is related to (a) the number of operation hours (b) the number of times they are switched on and off (c) cooling system efficiency and the cleanliness of the tube and reflector. Generally, lamps have a guaranteed lifetime of 1000 - 1500 hours depending on supplier and type. A new generation of UV lamps using a circular halogen process largely avoids edge blackening (from corroded electrodes) and significantly postpones inner contamination of the whole lamp (electrode material deposits), giving them a very long lifetime if properly maintained.

High electrical lamp rating does not necessary mean that the system delivers high UV efficiency with a low level of heat generation at defined energy consumption. Efficiency depends not just on the power rating of the lamps but also on their quality and the system profile – this varies between suppliers and designs, and affects curing and energy efficiency, e.g.

- To reduce electrical stand-by costs and fire hazards the lamp system should include a shutter that automatically closes during a machine stop. An integrated shutter positions a lamp closer to the substrate and gives a 20% higher efficiency (it also needs less cooling and energy than other designs).
- The reflector profile should focus rays for highest intensity. The ideal is minimum direct radiation with highest intensity focussed into a narrow area.
- High intensity curing is preferred because it rapidly seals the ink surface in order to minimise oxygen inhibition effect (otherwise high levels of oxygen diffusion will deform the coating surface).
- Avoid pre-irradiation as this increases the power needed for main curing.
- Post-irradiation is only recommended for heat-sensitive substrates that may suffer from register problems resulting from heat generated during inter-deck curing.

Reflectors

Only about 35% of lamp radiation travels directly from the lamp to the substrates (primary energy). The remaining (secondary) energy is redirected onto the substrate by a reflector. Overall lamp efficiency is determined by the properties of the reflective material used and the reflector's profile. Reflectors should provide maximum UV radiation for curing at minimum energy consumption with minimal heat build-up. The decisive factor in curing is the amount of UV light that reaches the substrate. The UV module should be as close as possible to the substrate because UV intensity declines dramatically with increasing distance from the substrate surface.

UV reflectors are mostly made from aluminium or glass – which have almost identical reflective performance. Aluminium is preferred because users can change reflectors themselves when they are dirty (glass requires a specialist technician) and there is no risk of glass flying into the press should a reflector disintegrate. For heat-sensitive substrates a dichroitic reflective coating uses a selective mirror to reflect UV rays and to absorb most of the IR rays.

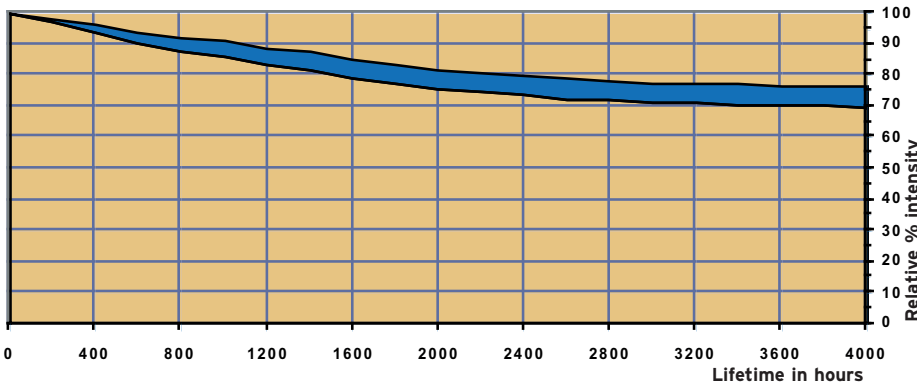
Modules

New generation UV modules have optimised elliptic and parabolic reflector profiles that improve intensity and minimise back reflection to reduce energy consumption (example Adphos-Eltosch LightGuide). Newer modules are easily moved between docking stations in less than one minute. Plug-and-play connections allow modules to be used as a UV inter-deck module for one application and an UV end-of-press module for another. UV lamps themselves can also have plug-and-play connections to allow lamp exchange in less than one minute without any tools.

Cooling

The surface temperature of UV lamps can be up to 800°C and effective cooling is required to avoid damage to either the substrate or the press system. Water-cooled systems filter out and absorb most of the heat generated by IR rays. It is essential that the cooling water is pure (demineralised) and free of bacteria.

Service life of UV lamps



Lamp lifetime is variable between different designs and suppliers. This example shows that UV lamps can achieve a life of 4 000 hours in the laboratory, but under tough practical conditions service life is around 1 000 - 1 500 hours – depending upon supplier and type. Longer service life is achieved by an optimised internal circuit process to make the lamp more durable and to ensure that the intensity at the lamp edges does not decline too quickly.

Source: Everclear Adphos-Eltosch..

Curing system control

Precise UV dosage should be matched for each ink colour at all press speeds. The control system should allow individual programmes of each UV lamp output module to achieve extremely fine dosing (particularly for heat-sensitive substrates) plus individual programming of each UV module in the end-of-press dryer. Other desirable features include step-less output regulation with dimmer; integrated shutter system to prevent radiation into the press during stand-by operation; immediate dryer power-up from standby to production; monitoring of cooling systems.

Special lamps/modules

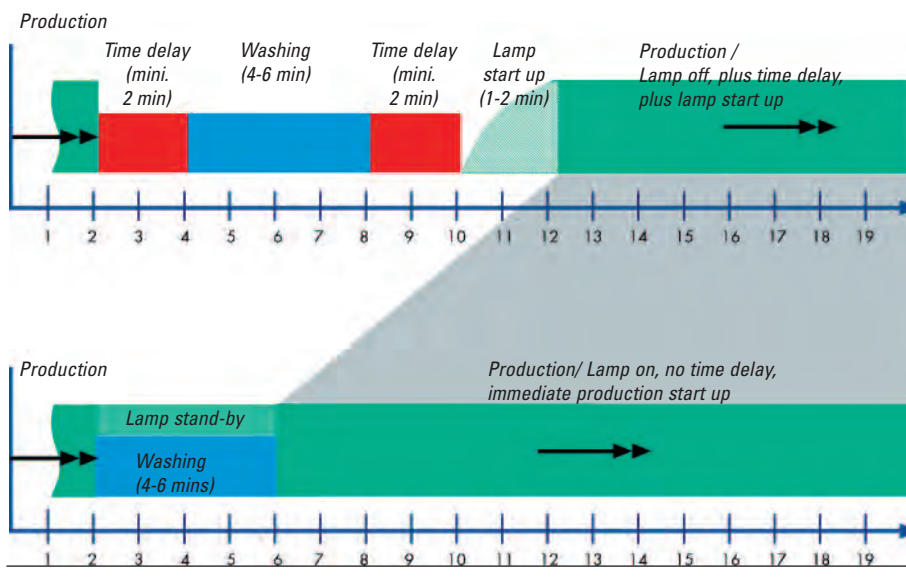
TwinRay: A new curing concept combines different UV lamps in one module to eliminate heat problems associated with IR energy including register, wavy sheets, high pile temperatures and stacking, as well as for heat sensitive substrates.

WhiteCure: UV opaque white ink used in printing plastic film has different absorption ranges than standard UV inks (white pigments absorb very well in a different range than standard pigments). This means that during curing they are in competition with the photoinitiators. A higher level of energy is often used to ensure curing but this can cause problems on heat-sensitive substrates. A special doped WhiteCure UV module (inserted in place of a standard lamp) can improve curing performance by up to 25% for opaque white ink.



UV module with plug-in UV lamps for quick lamp exchange without any tools. Source: Adphos-Eltosch.

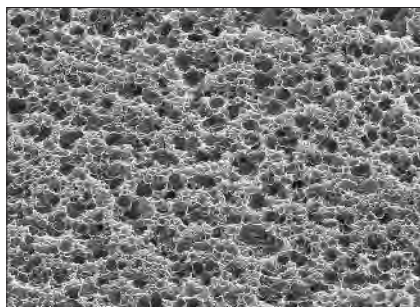
Increased production time by reducing downtime



The safety requirements for UV printing require that the UV inter-deck unit(s) must be switched off during the blanket washing cycle (volatile solvent explosive risk). This means that a washing cycle takes about 4 minutes. A recent innovation allows the dryer to run in stand-by during blanket washing (no slow-down and re-start) to reduce significantly total cycle time.

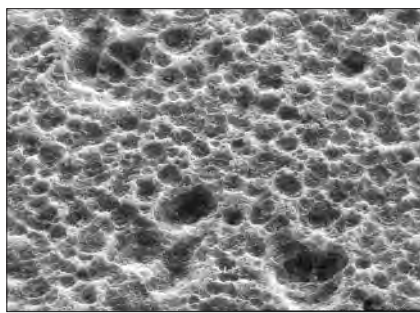
Source: Adphos-Eltosch.

Prepress & plates



Due to their finer pore structure Nitric-grained plates (above) carry more fountain solution than Hydrochloric surfaces (below).

Source: Agfa.



Optimum printing performance requires chemical compatibility of all the consumables used in the process system. Plates, roller covers and blankets are made from materials that interact with the different chemical substances and fluids that they transport – inks, coatings and washing agents. There is an optimal roller, blanket and plate mix, along with dedicated washing agents, for any combination of inks and coatings.

Offset plates for UV inks

UV inks take up less water and have less fountain consumption than conventional inks. The ink/water balance in UV printing is therefore more critical and the influence of the offset plate on the ink/water balance is more important.

The aluminium substrate, its graining and anodizing have an influence on the ink/water balance when printing with UV inks. In general, plates grained in nitric acid (HNO_3) carry more water or fountain solution due to their finer pore structure than plates grained in hydrochloric acid (HCl) which have a more open pore structure. Plates grained in hydrochloric acid are preferred because of their higher latitude on press. In practice, all types of plate substrate types can be used with UV inks – provided that the ink/water balance and the type of fountain solution are optimised for UV. However, the highly polar components of UV inks and blanket washes can damage the light-sensitive layers of the plates. The resistance of the plate to these components is more or less critical depending on the working principle of the plate.

Analogue negative working plates

Most analogue negative working plates are diazo based. Other types include photopolymer and hybrid systems (diazo-photopolymer combination). All negative plates have some resistance to UV inks and washes; however, their maximum run length in UV printing is lower than with conventional inks. Key points:

- Negative analogue and photopolymer plates can be used for printing with UV inks.
- Baking photopolymer plates doubles their run length stability.
- Run length is increased if higher plate exposure energy is used.
- Pressroom chemistries (washes, fountain solution, cleaners) that come into contact with the plate can have a significant influence on chemical resistance and run length. Always make a drop test with the chemicals in use.

Analogue positive working plates

Most analogue positive working plates are diazo resin based — there are some that have been specifically developed for use with UV inks. Assess the chemical compatibility of positive plates by making a drop test with all the pressroom chemistries used. Resistance against organic products (e.g. glycoether based) is lower than against water-based products. Key points:

- Special UV plates give higher run lengths than standard unbaked plates.
- Standard baked plates have far better run length than unbaked plates and special UV plates.
- Always make a drop test with the chemicals in use (washes, cleaners, etc). Fountain solution should be tested with a higher IPA concentration than usual (e.g. 15 %). Alcohol-free fountains (IPA substitutes) can be aggressive and should be tested. Baked plates are extremely resistant against all chemicals.

FM and other screening methods for UV printing:

If the ink - dampening balance is well controlled and the dot gain (TVI) is under control there are theoretically no limitations for use of FM screening. However, if using Sublima in UV printing for packaging applications it is advisable to limit the screen ruling to 240 lpi. When using FM screening it may be necessary to limit to 30 - 35 μ FM instead of 20 - 21 μ to ensure that calibrations remain stable.

Use of GCR, UCR, UCA

If there is no problem to print with thicker ink layers (mainly black) in UV printing there should be no problem in using these techniques.

Tests to assess plate suitability for UV inks, washes and cleaners:

Chemical compatibility:

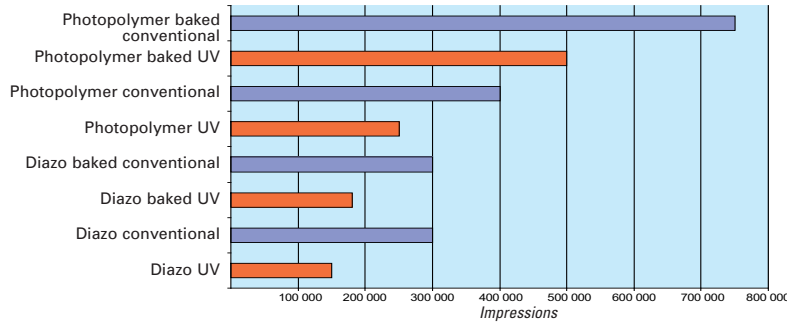
A drop of test fluid is placed on the plate and left for a certain time (between 1 minute and several hours depending on the type of chemical and its application (e.g. longer contact time for fountain solutions than for plate cleaners). Its affects are then assessed on the image areas (whether or not dissolved, ink receptivity, run length) and the non-image areas (damage of plate substrate).

Plate-print distortion:

Coat part of the image with the UV ink/coating and leave for 24 hours, clean the plate, then print test to ascertain any image distortion.

Plates

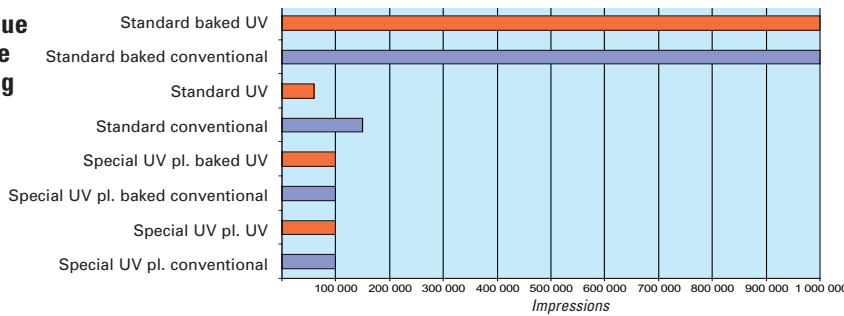
Analogue negative working plates



Run lengths of analogue negative working plates demonstrate that UV applications have less resistance than those using conventional ink. Baking photopolymer plates doubles their maximum run length.
Source: Agfa.

■ Conventional ink
■ UV ink

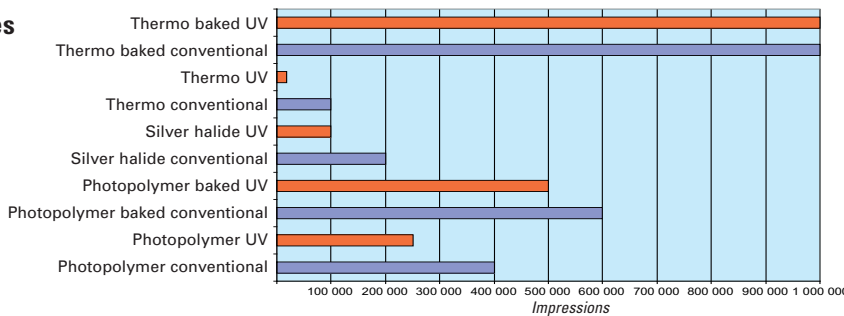
Analogue positive working plates



The run lengths (in thousands) of analogue positive working plates shows that special UV-plates are better than standard unbaked plates but that standard baked plates offer hugely superior run length.
Source: Agfa.

■ Conventional ink
■ UV ink

CtPlates



Run length of a digital plate based on silver halide technology (Lithostar LAP-V Ultra) is strongly influenced by different inks and fountain solutions. All of the fountain solutions in the test contain 10% IPA alcohol.
Source: Agfa.

■ Conventional ink
■ UV ink

CtPlates

In general the water demand and lithographic properties of digital plates are the same as analogue plates because their substrate graining and anodizing are very similar.

Digital positive working plates

Digital plates using silver halide technology are based on the DTR (Diffusion Transfer) principle. Run length of these plates is strongly influenced by different inks and fountain solutions. Optimisation of the ink-fountain combination improves roll-up properties as well as run length (up to about 50 % of the average run length achieved with conventional inks).

Digital positive working plates: Resin-based plates have the same lithographic properties and run length as analogue positive working plates. Their chemical resistance and run length can be improved by baking.

- Digital negative working plates: Photopolymer based plates have the same lithographic properties and run length as analogue negative working plates based on photopolymer technology. Their chemical resistance and run length can be improved by baking.

- Digital chemistry free plates are usually not as resistant as the other CtPlates. Some can be baked to optimise run length.

Digital negative working plates: Photopolymer-based plates have the same lithographic properties and run length as analogue negative working plates based on photopolymer technology. Their chemical resistance and run length can be improved by baking.

New plate developments for UV printing include: unbaked positive plates that give the same results with UV inks as with conventional inks; digital plates performance equal to analogue plates; improved resistance against all UV washes; optimised morphology of the light sensitive layers (because smoother surfaces have a higher chemical resistance); and better mechanical plate resistance from improved graining and anodizing.

Coating formes



Use blankets with open cell compressible layers to make stripping easier.
Photo Trelleborg..



Strippable blankets surface: the top printing face and non-printing black area are evident.
Photo Trelleborg..

Application	Flood	Knock-out	Spot
Coating formes	Coating	Coating	Coating
Sticky back blanket	●	●	-
Strippable blanket	●	●	-
Stripping blanket +PES	●	●	-
Sticky back PU film	●	●	-
Pre-cured polymer plate	●	●	●
Photopolymer plate	●	●	●

It is essential to select the coating and image carrier appropriate to the application:

Flood: Complete coating of a full sheet.

Knock-out: Geometric cut-outs of non-coated areas (glue flaps, book spines and ink-jet address panels).

Spot: Any image shape or size for selected areas with precise registration.

The surface properties required for reliable coating transfer are good wettability to ensure a constant thickness layer, consistent transfer, no coating accumulation, resistance to swelling, and easy cleaning. Some image formes are more appropriate than others – depending on the application, preparation method and type of lock-up system.

Strippable blanket: Used for flood and knock-outs. The fine elastomeric surface optimises coating transfer and most types are compatible for both UV and water-based coatings. Relief depth is typically 0,8-0,9 mm to avoid coating build-up and too frequent washing. The 1,95 mm carcass has layers of cotton, a thick compressible foam and an easy-to-peel stripping layer. Elastomers have good affinity with conventional ink but not with aqueous or UV coatings, and the quantity of coating transfer and gloss is generally inferior to a polymer plate. Newer stripping blankets use either a mylar carcass or a PES backing sheet to improve dimensional stability for better registration and are re-usable (about 10 times for overall coating and about 5 times for knock-outs). Mylar helps avoid deep cuts and carcass damage – for barred blankets the cotton canvas on the backside also helps ensure adhesion. Blankets can be stripped on- or off-press, either manually or by a CAD plotter.

Pre-cured polymer plate: Used for flood, knock-out and spot; is more accurate than a stripping blanket and can be used for repeat orders. Plates can only be processed out of the press (hand cut or CAD plotter) and the image distortion factor has to be taken into account. Plate type selection:

- Direct coating – Polyester base + polymer;
- Indirect coating – aluminium base plate + polymer; or Polyester base + compressible layer + polymer. PES is slightly more resistant than aluminium and a minimum 0,30 mm thickness is recommended. Pre-cured transparent polymer plates are a more recent option.

Plastic film + sticky backing: For knock-outs. Transparent film mounted on top of a developed offset plate.

Photo-imaged photopolymer relief plate: The best solution for precision spot and knock-out coating because of their fine detail, register precision and durability (about 1 million impressions). Solvent-washable flexo plates are recommended for UV coating (photopolymer on PES base, typical thickness of 1,14 mm). The processing of this plate requires a significant investment in equipment and they are usually imaged by specialist trade shops.

Sticky back blanket: Used on old presses for flood and knock-out coating from a printing unit.

- Indirect coating – the offset plate is replaced by a thin polymer plate or a sticky back blanket laminated on to an aluminium plate. The coating is transferred from the dampening system onto the polymer plate then transferred to the blanket and released onto the substrate.
- Direct – the print unit blanket is replaced with a coating blanket using a strippable blanket of 1,95 mm thickness.

Substrates

Paper and board

Economic aspects and technical suitability both need to be balanced when selecting the substrate, inks and coating to achieve a desired gloss. The properties of the substrate can influence gloss results by up to 30% (independent of the grade of coating on the substrate) depending on the amount of ink and coating applied.

Uncoated papers without a special preliminary treatment are not suitable for sheetfed UV printing. Coated paper surfaces can be roughly classed as gloss, silk or satin, and matt. Typical matt coated papers use coarse (preferably rhomboidal) multi-edged pigments to obtain the lowest possible reflection, but have negative characteristics of lower rub resistance and higher risk of marking. Gloss coated papers have a closed and even surface because their coating mostly consists of extremely fine pigments and the paper is also super calendered (pressure and friction). However, negative influences can be a lower delta gloss and the shiny surface may make readability less comfortable; because this paper is compressed it can be more sensitive to cracking during folding. Demi-matt (also known as satin or silk) is a good compromise between high gloss and truly matt paper qualities. The silky surface favours readability and has better rub resistance compared to matt papers and also provides better finishing performance. It is important to consider that classic and non-classic UV ink systems do not provide the same printing performance on all substrates (see table below).

Porosity and surface

The flatness of the surface and the paper coating absorption properties influence the coating results. Papers with a very smooth surface and/or a low porosity prevent high absorption into the sheet and are very suitable for UV coating. However, they may also affect ink holdout. On the other hand, papers with a rough surface and a low porosity do support ink holdout, but their rough surface may give rub resistance problems.

- High porosity can limit achievable gloss level as it allows the ink to sink into the substrate.
- High absorption of ink into the substrate surface may lead to an incomplete cure (photoinitiators and monomers sink into the substrate).
- Low porosity and very smooth surfaces (cast coated) can limit ink adhesion.
- High surface roughness improves adhesion but can reduce scuff resistance.

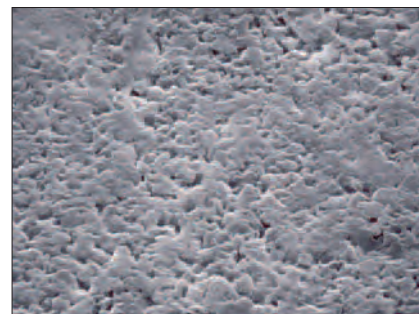
Influences of heat and light

Radiated heat increases the temperature in the printed pile. Potential side effects include blocking (sticking together of the sheets) and sheet flatness. Relative humidity can play a role when the temperature is too high and/or curing incomplete.

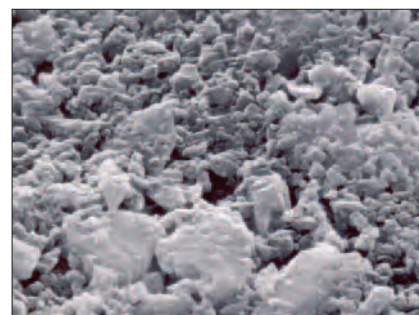
Paper discolouration (yellowing) may occasionally occur after UV coating or laminating on some substrates because optical bleaching agents as well as becoming active with daylight are also sensitive to UV light from curing. This effect gradually decreases under extensive UV radiation. It is important that the paper contains optical bleaching agents that are stable enough to undergo UV processing with only a small loss of brightness and without becoming yellow. Papers with a high basic brightness level of the pulp and fillers tend to be more resistant.

An undesirable odour can also be caused by a chemical process of some types of latex binders in the paper coating in combination with UV light.

Ink system	Classic UV	Non-classic UV (hybrid-types)
Substrate types		
Gloss coated paper	Excellent	Excellent
Matt or Satin coated & Uncoated papers	Excellent	Poor to moderate
Folding carton board	Excellent	Excellent
Plastic and foils	Excellent	Unsuitable
Metallised substrates	Good	Unsuitable
Heat sensitive substrates	Good	Poor



Surface of a gloss coated paper — raster electron microscope magnification 10.000 x.
Source: Sappi.



Surface of a matt coated paper — raster electron microscope magnification 10.000 x.
Source: Sappi.

Consultation

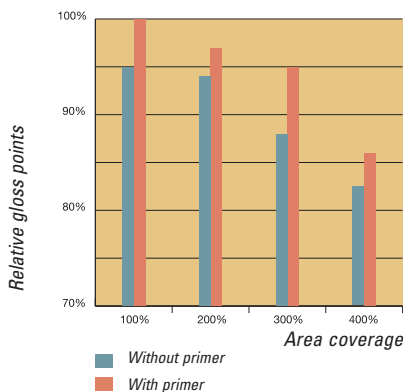
Many seemingly difficult applications of UV on paper substrates can be resolved with the selective use of materials and adapted procedures. When in doubt about the use of a product consult your supplier(s) for advice before committing yourself. See page 56 for non-absorbant substrates.

Classic and non-classic UV ink systems do not provide the same printing performance on all substrates.
Source: PrintCity.

Ink & coating selection

Coating application	Coating Unit		Coating type			Drying method		
	single	double	Aqueous	Oil-based	UV curing	Hot Air	Infrared	UV
Clear Matt								
Clear Gloss								
Clear Silk/semi matt								
Primer								
Protective Sealer/Neutral Coating								
Obliterating, Silver or other (Lottery)								
Encapsulated Perfume ('scratch and sniff')								
Metallic Effect								
Pearlescent Effect								
Cationic curing								
Blister pack (thermo bonding board/foil or board/board)								
Substrate pre-coatings								
Opaque white								
Pigmented coatings								
Functional Barrier (water, oil, grease)								
Optically Brightened								
Multi-unit perfecting								

Regularly used/readily available
 Possibly available but not regularly used
 Not usually used or not relevant



Gloss levels are improved by using a UV primer over dry non-classic UV (hybrid) inks prior to UV coating.
Source: MAN Roland.

The interactions between ink, coating and substrate along with the desired end-use characteristics determine the type of coating required – the type of coating unit is an additional factor. The choice of finished surface ranges from those that are brittle with high mechanical resistance to more flexible coatings with lower resistance properties.

- The surface smoothness of cured UV coating is influenced by the content of wax and silicone derivatives (slip agents). These additives impair mechanical and temperature resistance, glueing, deep-freeze resistance, wetting and spreading. After curing, slip agents rise to the surface and show fingerprints when the surface is touched.
- UV flood coatings need good elastic properties for trimming and die-cutting to ensure good quality edges.
- There is no universal ink or coating for all substrates.

Conventional inks + primer + UV coating

Conventional offset inks and UV coating have incompatible chemistries and an aqueous primer coating is used between them to allow a UV coating to be applied. A considerable amount of water is applied during primer coating and this must be removed by substrate absorption and accelerated evaporation prior to UV coating. Gloss is improved by using a fast drying primer suitable for the substrate. The properties of the substrate, ink film and coating thickness affect the gloss level. Achievable drying speed, flexibility, penetrability, trapping, viscosity, gloss and bonding depend on the base material and additives used. The ink composition and its affinity to the primer determine the bonding of the coating layer, which only becomes definitely stable several days after printing – gloss withdrawal may occur some time after the job is finished.

Consult your ink maker to select a UV coating adapted for use over conventional printing inks and the application equipment.

Advise the ink maker if UV coating will be applied offline to ensure that ink pigments are resistant to UV coating and to avoid using wax materials that may compromise the inter-coat adhesion and final flexibility of the job.



Some conventional inks are formulated to be slower setting and this can lead to serious gloss withdrawal after the primer and UV coating are applied (difference of gloss between printed and non-printed areas). Slow setting ink formulations for special colours are often selected when the printing sequence is not known in advance; however, some formulations are not suitable for primer UV operation – verify these with your ink maker.

UV inks + UV coatings

These produce the highest gloss level that does not change during curing. The gloss level of UV coating is strongly related to the type of ink selected and the volume of coating. Fast-absorption inks should be used to maintain gloss at a good level. However, the risk of mottling restricts the latitude for absorption (depending on the substrate and the end quality required). Optimum gloss requires foam-free coatings to avoid spots on the finished surface.

Non-classic UV (hybrid inks) + Inline UV coating

The low UV-content ink system uses a single coater to apply UV coating without primer – but the coating must be matched to the specific UV hybrid chemistry. For non-classic UV printing the compatibility of the hybrid UV inks with conventional rollers and blankets should always be checked with the suppliers. Some hybrid inks can be used with standard rollers and blankets for alternating printing with conventional inks. However, combi rollers and blankets are recommended for other more aggressive hybrid inks. Above this level there is an increasing risk of swelling and special combi rollers and blankets are recommended. There are significant differences between non-classic UV ink formulations (particularly between ingredients used in the USA and Europe) that can strongly affect ink/water balance stability and ink density required (ink cost is similar to full UV inks). Caution: not all conventional washing agents can be used on non-classic UV (hybrid) inks and some specific conventional blanket washing agents might encourage swelling.



Always test roller and blanket compounds prior to running non-classic UV. Provided correctly formulated hybrid UV inks are used, most blanket and roller problems are caused by incompatible washing agents or poor procedures.



It is important that the ink supplier knows which inks will be wet-trapped to ensure that the tacks are correctly set.

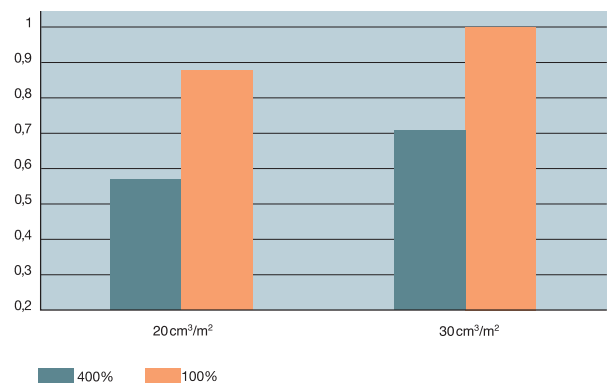
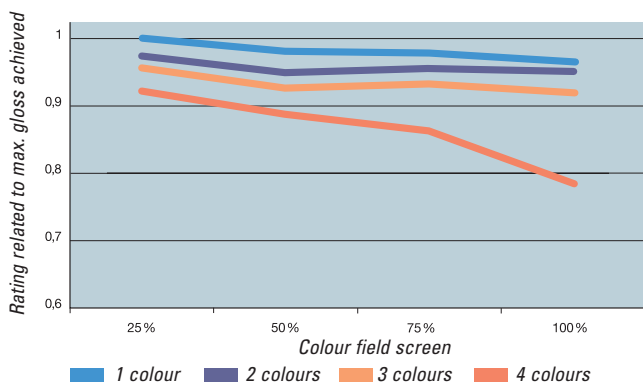
Using UV ink for special colours in the printing unit directly before an inter-deck dryer will achieve outstanding gloss because the coating is applied over a dry surface – which also reduces gloss dryback risk. Special surface effects can be created using a mix of hybrid and conventional inks with UV coating.

Primer: Provided inks and coating are correctly selected for good inter-coat adhesion there is no need for a primer to be used when printing offline UV coating over dry UV inks. UV primer can be used to seal (protect) the surface of conventional ink jobs when differences in absorption appear:

- If the substrate absorption is very high there may be significant absorption of coating in non-printed areas with a corresponding loss of gloss.
- Different thicknesses of ink layers (and between ink layers) and the non-printed areas can lead to differences in absorption of the sealer and be responsible for differences in gloss (drawback).

Neutral sealer: Gives functional protection to the printed surface to avoid marking in post-press processing and accelerated drying. It provides only a similar gloss to the substrate.

Pre-coating: This is used for different purposes including upgrading substrate surface and printing white opaque primer (wet-on-wet or wet-on-dry). Pre-coating is often made offline or as a separate first pass through the press.



When UV coating is applied over conventional oil-based inks the final gloss level is related to ink volume.
Source: MAN Roland.

UV gloss level over conventional inks and primers changes over time and it takes several days before hardening and drying is complete.
Source: MAN Roland.

UV & low migration printing for food packaging


Migration is the transfer of substances from the packaging to the product it contains. These traces may not always be detected in organoleptic testing of odour and taste, or when consumed, but may be found by sensitive chemical analysis. The terms "low odour" and "low taint" are synonymous with low migration.

Migration is not in itself harmful but there are more and more demands to minimise the risk of migration of packaging components into packaged food, beverage, pharmaceutical, medical, tobacco and other sensitive products. Reduced migration means reduced risk of any change in the nature, quality, organoleptic, colour, shelf-life or other important property of the packaged product.

Migration is time dependent and the longer the potentially 'migratable' components are in proximity to the package goods the greater the risk of migration. Migration is more likely when the viscosity is lower, the molecule smaller and the less branched the molecule. Examples of potential migrants are:

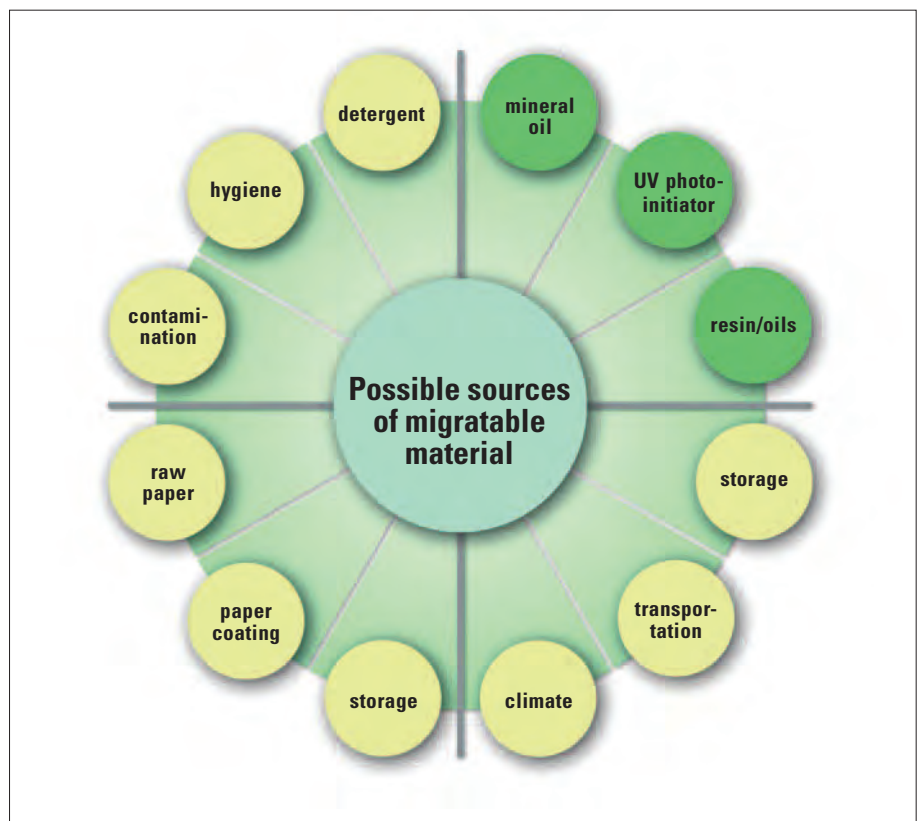
- Solvents, washes, cleaning chemicals, oils and grease,
- Plasticisers from plastics or inks,
- Monomers from plastics or coatings,
- Breakdown products from ink curing and drying,
- Low molecular weight components from substrates, adhesives and similar sources,
- Hydrocarbon distillates or mineral oils from conventional inks.



 Best practice requires a risk assessment from package design to the filling line. A risk may exist where printed ink, coating or adhesive are in close proximity to the packaged food and where there is no functional barriers between the packaging and its contents.

This analysis may indicate that migration testing is periodically required as part of the production specifications. Published standards identify suitable methods and frequency of testing, which can only be made by accredited laboratories using sophisticated equipment.

The determination of an 'acceptable' maximum level of migration is based on the toxicological profile of the migrant material and in some cases by expert assessment of the toxicological data. In all cases of migration, the migrants must be identified in order to carry out a risk assessment.



Source: Sun Chemical

Substrates

The substrate plays a key role in both the organoleptic result and low migration testing because the finished package is about 97% substrate, 0,5% ink and up to 1,5% coating. Pure cellulose board is preferred for low migration applications to those containing ground wood or recycled material. Paper and board are also very receptive to airborne migration of volatile materials and can easily absorb press washes or conventional inks in the atmosphere and therefore should be always be kept wrapped during storage or waiting during work in progress.

Low Migration (LM) systems

Best practice is to use LM consumables that are specifically formulated and tested for this application including inks, coatings, fountain solution, washing and wetting agents. These are made from materials that do not migrate under normal circumstances or foreseeable conditions of use. Very special care in product selection is required if the package is to be heated or used in a microwave oven. Ask your supplier to recommend consumables that are adapted for LM printing for the specific package specifications.

UV Low Migration systems

Radiation curing can be described as a 'best practice control process' for LM printing because they are dry at the end of the press — 100% solids, 0% VOC — ready for immediate converting, and are capable of being formulated to yield results of less than 10 ppb in migration testing. UV is the process that offers the lowest possible migration results in print testing along with excellent adhesion over a broadest range of substrates including paper boards, foils and plastics.

UV inks for LM can be used alone (or with an LM UV coating or a suitable LM water based coating) whereas conventional inks must always have an inline water-based coating over them to avoid risks of marking and set-off in the stack.

UV inks and coatings for LM are normally based on proprietary raw materials including high molecular weight oligomers and polymers, together with non-migrating polymeric photo-initiators. Formulations are normally 100% solids and should avoid low molecular weight raw materials and solvents, be highly cross-linking and fast curing.



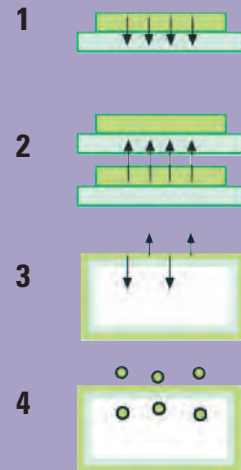
Best practice LM operation

- Test LM UV inks on difficult substrates such as plastics to assess adhesion and set-off risk that can be caused by an inappropriate product choice, inadequate curing or adhesion. Visual methods to ensure freedom from set-off are usually adequate but densitometric measurements on the reverse side can also be used.
- A clean press is absolutely essential. An LM press wash is unlikely to be as economic or efficient as a normal wash and cleaning procedures need to be changed to account for this. It is highly recommended to wipe the rollers and blankets dry of solvent wash after cleaning to reduce the risk of migration.
- Changeover procedures from normal to LM printing are onerous and generate waste — if possible a press should be dedicated 100% to LM work.
- Adhesives used in folder-gluer or laminator need to be LM products that meet food packaging regulations and provide good results in packaging migration testing.
- Audit production and storage areas to identify potential migrants and contamination risks, e.g from strong smells, vehicle exhaust fumes (including forklift trucks), floor cleaning and painting — good ventilation is essential.
- Always keep substrate wrapped in plastic to avoid airborne volatiles from printing, cleaning or painting.
- Maintain a low temperature in production and storage areas because migration is temperature dependant — risk doubles for every 10°C increase in temperature.



Storage of > 60% RH (Relative Humidity) avoids the growth of micro-organisms.

Methods of migration



There are four ways that migration can occur:

1 Penetration migration

Migration from the printed side through the substrate onto the unprinted side

2 Contact migration

Migration from the printed side to the unprinted side of another sheet in a stack or roll.

3 Evaporation migration

Migration due to the evaporation of volatile materials by heating (e.g. cooking, baking, or boiling frozen product in their original packaging).

4 Distillation migration

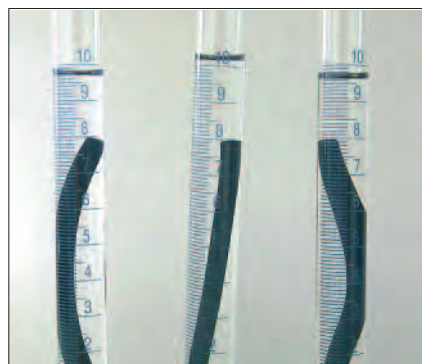
Migration through steam distillation during cooking, baking or sterilisation.

Source: Sun Chemical.



"Print for Packaging — Low Migration Printing" is a best practice guide available on request from Sun Chemical.

Cleaning agents



Swelling experiment:
Start of swelling experiment



Swelling experiment:
After 10 hours exposure time

This simple experiment illustrates the capability of aggressive washes to swell the rubber compound. Three samples of a rubber quality are exposed to 3 washes of increasing sharpness from the left to the right. After 10 hours of exposing time the sample in the right tube shows substantial swelling whereas the sample on the left remains almost unchanged.

Source: Boettcher.

Different inks require different washing solutions. Cleaning agents and chemicals for rollers, blankets and coating plates need to :

- Be chemically compatible.
- Conform to environmental and toxic standards.
- Clean effectively.

Mineral oil-based washing agents are used in conventional printing but the removal of UV-inks requires polar solvents (glycol ether). For mixed mode applications additional combination washes (suitable for UV and conventional applications) are available — it is also possible to use two separate systems, one for UV and one for conventional wash. Non-classic UV (hybrid) requires a specific wash.

1. Only use tested and approved washing agents.
2. Ensure that correct washing agent is used for the ink system (e.g. Conventional, UV, UV Hybrid)
3. Check any doubts regarding compatibility before use.

For all printing applications it is very important to use only the washing agents approved by the press supplier; and approved and Fogra certified washing agents for all sheetfed applications. Fogra tests the compatibility of washing agents with rubber rollers, blankets, washing unit and other parts of the press. These products are listed on <<http://www.fogra.org/>>

It is also important to select the correct washing programme and cycle time for the combination of materials being used (substrate, ink, blanket and roller coverings), the washing system (brush or cloth) and type of washing agent.

Printers running standard 4-colour ink set with few changes often find that one cleaner for the combined process is sufficient. However, with a wide variety of inks and frequent changes, some printers have two tanks – one for blanket cleaner and one for roller cleaner. Two additional tanks can be useful when running a 50/50 combined process for separate UV and conventional blanket and roller washing solutions.

Comparative washing agent efficiency

Findings from comparative washing agent efficiency tests show that agents for oil-based inks provide excellent results and satisfactory to good results for classic UV. The tested non-classic UV (hybrid) washing agents only achieved poor to just satisfactory results – however, ongoing development of washes for these inks might improve performance.

Summary of test results:

- **Conventional inks:** generally one wash is sufficient for good results using washing devices with most commonly-used washing agents.
- **Classic UV inks:** can be washed up quickly and effectively using the appropriate UV washing agents; combination washing agents also give good results with UV inks in washing devices with only one wash.
- **Non-classic UV (hybrid) inks:** Conventional washing agents or classic UV washes are not suitable to remove these inks from blankets or rollers. Specific hybrid washing agents are available which are mostly based on vegetable oil derivatives with a high flash point.


Ink type	Blanket cylinder washing device			Ink roller washing device		
	Conventional	Classic UV ink	Non-Classical UV	Conventional	Classic UV ink	Non-Classical UV
Washing agent						
Conventional	••••	••	•	••••	•	•
Combi type 1	••••	••••	•••	••••	•••	•••
Combi type 2	•••	•	•••	•••	••	•••
UV type 1		•••	••		•••	••
UV type 2		••••	•••		•••	•••
Vegetable oil derivative type 1	••••		•••	•••••		•
Vegetable oil derivative type 2	••••		•••	•••••		•
Vegetable oil derivative type 3			•••	•••••		•••

Comparative performance: Very good •••••, Good ••••, Satisfactory •••, Poor ••, Very poor • - Source: MAN Roland Expressis Technics N° 12.

Blankets & rollers

Consumable	Printing unit					Coating module	
	Blanket	Roller in the ink unit	Forme Dampening roller	Metering Roller	Washing Agent	Blanket	Roller
Conventional	Standard	Standard	Standard	Standard	Standard		
Conventional with aqueous coating	Standard	Standard	Standard	Standard	Standard	Standard & strippable/coating	EPDM 80°ShA
Conventional with UV coating	Standard	Standard	Standard	Standard	Standard	UV & strippable/coating	EPDM 80°ShA
Mixed Conventional / classic UV	Standard	Standard	Standard	Standard	Standard / UV Combi		
Classic UV	UV / EPDM	UV / EPDM	Combi	Combi	UV		
Classic UV with coating (disp)	UV / EPDM	UV / EPDM	Combi	Combi	UV	Standard & strippable/coating	EPDM 80°ShA
Classic UV with coating (UV)	UV / EPDM	UV / EPDM	Combi	Combi	UV	UV & strippable/coating	EPDM 80°ShA
UV - Metallic Inks	Combi	Combi	Combi	Combi	UV		
Non-classic UV (hybrid)	Combi	Combi	Combi	Combi	Hybrid Wash		


Sources: Boettcher, MAN Roland, Trelleborg.

 Compatible performance requires incompatible chemistry! Substances harmful to rubber migrate from cleaners, solvents and ink additives causing either swelling or shrinking. Incompatible polarity of materials has a very significant effect on migration and swelling. Ensuring opposite polarities of the ink system and the rubbers used for rollers and blankets is the key to their resistance:

- Conventional oil-based inks and washes are non-polar and are used with standard polar blankets and rollers (mainly nitrile polymers).
- UV inks and washes are polar and require rollers and blankets to be made from non-polar rubber materials (EPDM or butyl).
- Cleaning agents are the most critical part of the system and must be compatible.


Blankets


Performance in UV printing is influenced by blanket fabric quality, compressible layer, load development and surface finish. The key factor is the top rubber compound of the printing face, which requires good chemical stability without swelling when using UV inks. A nitrile top rubber compound can behave in a different way to EPDM or butyl top compound, which is why laboratory tests are needed to assess the top face of a dedicated UV blanket with common UV inks. UV blankets are available as 3-ply blankets with 1,70 mm nominal thickness and 4-ply blankets with 1,96 mm nominal thickness.

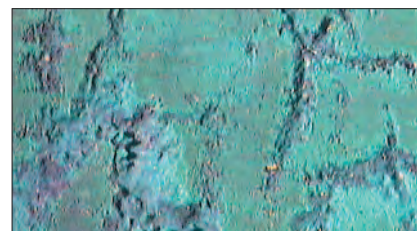
 Blanket choice is determined by the type of ink and coatings to be used:

Ink & coating type		Recommended blanket type
Classic UV ink only	>	Dedicated UV blanket
Classic UV and Conventional inks	>	Combi blanket
Non-classic UV (hybrid) ink	>	Combi or standard blanket
Conventional inks plus UV coating	>	Standard and strippable/coating blanket

Standard blankets are mainly manufactured with nitrile polymers that contain polar units and are used for non-polar oil based inks and washes – these chemicals will not dissolve or swell the blanket. Some standard blankets can be used for both conventional and UV inks on the same press.

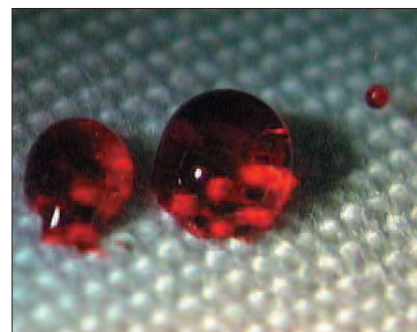
 If UV use is high, the lifetime of a standard blanket becomes shorter and is subject to swelling or bad print quality after a limited number of copies. Polar chemicals have a devastating effect on a polar nitrile blanket.

 A specialised UV blanket (with a face made from non-polar rubber EPDM or butyl) is needed when a large proportion of production is with UV inks. These are resistant to attack from polar solvents and inks, but can be severely damaged by non-polar solvents.



These two photographs show the compatibility and non-compatibility between the top rubber layer of the blanket and UV inks.

Photos Trelleborg..



Water solvent protection of blanket fabrics protects them against penetration by solvents, additives and other chemicals.

Photos Trelleborg..

Rollers

Chemical compatibility

Roller covers and blanket faces are compound materials that interact with the different chemical substances and fluids they transport. Therefore, they must be matched to the ink type, coating and cleaning agents used – if not, the blankets and rollers will swell causing a rapid decline in quality, productivity and will need replacing. For any combination of inks there is an optimal roller and blanket covering solution with specific washing agents.

Rollers

The chemical composition of UV inks differs significantly from that of conventional oil-based printing inks. Specific roller covering compounds have been developed for the particular requirements for conventional, UV, combination and hybrid sheet fed printing applications.

Rubber compounds must possess suitable physical and chemical properties to meet performance requirements for certain general and specific ink and dampening transfer and application functions. The specific combination of ingredients must ensure high resistance to inks and washing agents. The resistances of individual polymers in different media (inks, dampening and washes) depend on their respective polarities. Only substances of the same polarity will dissolve with each other; conversely, different polarities repel each other. Therefore, non-polar natural rubber (consisting of only carbon and hydrogen atoms) will swell in contact with non-polar oils composed of the same chemical building blocks, whereas it is resistant to polar liquids such as UV inks. It is therefore essential to adapt roller compounds to the respective media in order to avoid exerting a negative influence on the printing process.



Inking rollers

NBR (nitrile butadiene rubber) compounds have strong resistance to non-polar, oil-based inks and washes used for printing with conventional inks. In UV printing, preference is given to EPDM (ethylene propylene-diene) rubber compounds that have high resistance to polar UV inks and corresponding washes.

Compounds with sufficient resistance to both UV and conventional inks are available for combination printing. The new generation of new combination compounds do not need to be "run in" with conventional ink first to prevent them from swelling later on.

Conventional NBR roller coverings are suitable for a certain range of non-classic UV (hybrid) inks; however, combination compounds are recommended for other types of non-classic UV inks.



Dampening rollers

Conventional dampening roller compounds can swell from chemical reaction with UV inks and washes and therefore specific resistant rubber compounds are recommended for dampening form rollers. The metering rollers can remain in standard quality.



Rubber swelling and shrinkage

Roller rubber compound components have a greater or lesser tendency to swell or to shrink from interaction with inks and washes. Swelling means that ink or washing solution penetrates into the rubber matrix and increases its volume. Shrinkage means that ingredients of the rubber are extracted by either the ink or wash and decrease the volume of the rubber covering. This effect depends on how aggressive the inks and washes are to the rubber compounds and can lead to changes in roller geometry. This then leads to more frequent roller adjustment and reduced roller lifetime.

Therefore, for each specific application it is important to select the right rubber compound to ensure its compatibility with the inks and washes used. The chemical resistance of a rubber compound to a certain type of ink or wash can be assessed by a chemical resistance test. (The volume and the hardness of a defined rubber sample will be measured before exposing it to the contact medium for a certain time. Then the change in volume and hardness of the rubber sample gives the result of the chemical resistance.)

⚠ Rollers for non-classic UV (hybrid) inks

The variable chemical composition of non-classic UV inks means there can be large differences in the chemical reaction of rubber compounds to them. Tests of a wide range of these inks have shown that some of them react like conventional inks and others are very close to classic UV inks. This poses special requirements for roller coverings that are related to the composition of a specific ink. Laboratory swelling tests show that certain hybrid inks can be used in printing with conventional roller coverings, but others require the use of combination coverings to ensure sufficient swelling resistance. It is recommend to make a swelling test prior to using these inks to ensure that the roller covering is compatible.

Roller nip geometries after chemical attack



"Cigar shape" due to swelling of ink forme roller.



"Trumpet shape" due to shrinkage of ink forme roller.

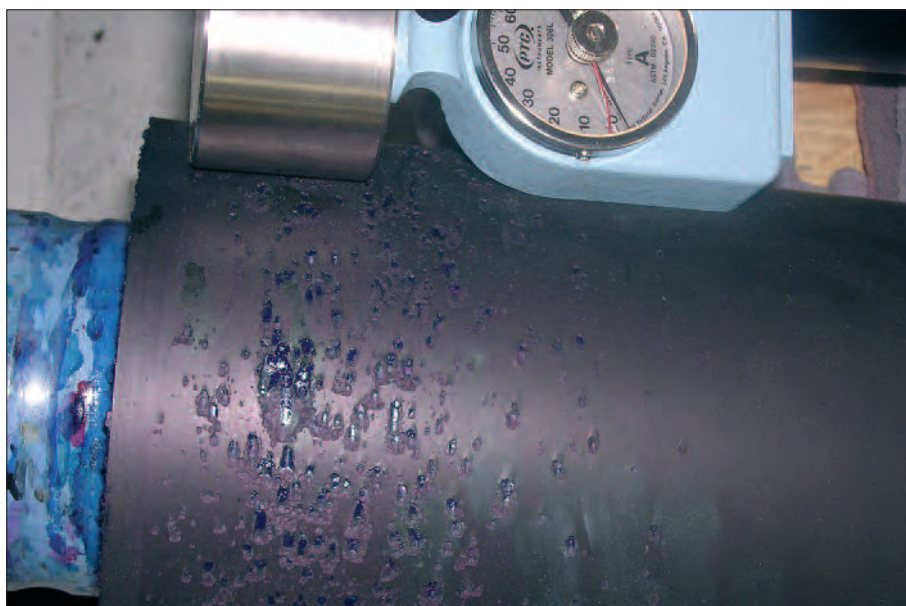
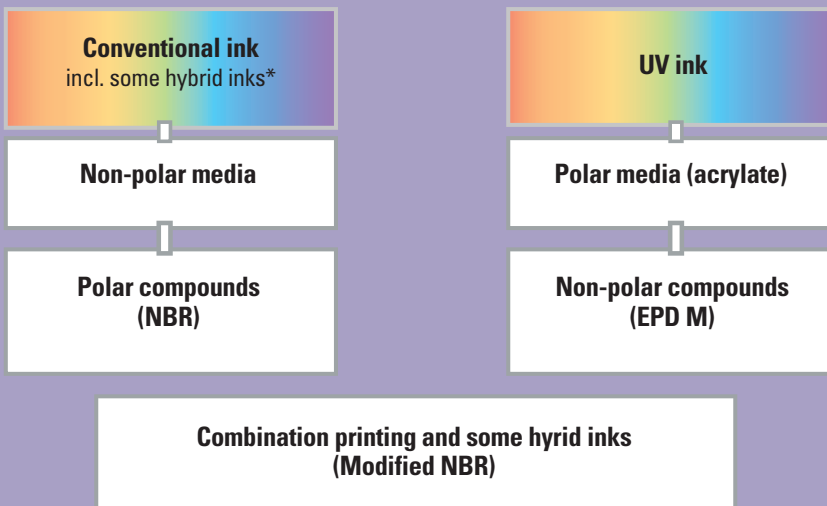
The use of aggressive inks and washes can lead to changes in roller geometry caused by chemical interaction with the roller covering and resulting swelling or shrinking.

Source: Böttcher

**Inks have to be tested before printing to ensure that they are compatible. It is essential that compatible washing agents, blankets and roller coverings are used for the specific inks, blankets and roller coverings. Make use of washes recommended by FOGRA and the press supplier that are compatible with the roller compounds.*

Source: Böttcher.

Overview of materials used in sheetfed offset printing



Damage caused by aggressive ink / wash.

Source: Böttcher





4

Best practices

High production quality and productivity requires that the total process is treated as an integrated production system. This includes optimising the use of all consumable materials and continues with adapted prepress, systematic maintenance, correct equipment settings and best practice operation.

Best practice starts with knowing and following safety, health and environmental recommendations and regulations.

Safety, health & environment

Best practice starts with knowing and following safety, health and environmental recommendations and regulations. The following are a selection of basic recommendations. However, local laws and regulations should always be given precedence. There is an increasingly regional approach in Europe with a common approach by organisations such as HSE (UK), CNAMTS (France) and BGDG in Germany.



Safety:

• Detailed information is given on material safety data sheets provided by consumable suppliers. Always refer to these before using any product.

- Follow the safety, operating and maintenance procedures recommended by equipment suppliers.
- Energy curing products are eye irritants; protective eyewear should be worn during dispensing.
- Never look directly at UV radiation or enter into a radiation zone.
- Never mix cleaning cloths for conventional and UV inks into the same bin. This can lead to cross contamination and make disposal unnecessarily complicated.

Materials handling: Energy curing products can be handled in a similar way to oil-based and water-based products while observing the same high standards of hygiene and working practice. See page 59 for materials storage.

Health: Suitable protective gloves should be worn during wash-up, especially if using solvent-based washes. Contaminated clothing should be removed and properly laundered before reuse.

Spills & Cleaning: Spills should be cleaned up immediately because energy curing products do not dry; if spilled they can easily be spread around the workplace creating a safety hazard.

First aid: In the case of accidental skin contact, the skin should be washed thoroughly with soap and water. Solvent-based washes should not be used to wash skin (they remove natural protective oils and so increase the risk of dermal absorption of energy curing products).

Environment: Energy curing has been designated the best available control technology to reduce atmospheric solvent emissions.

Waste wet ink & coating disposal: All inks are classified as 'controlled waste'. Energy curing products are considered as hazardous waste because they contain irritants to the skin and eye; and some ingredients are harmful to the environment. However, energy curing products are not considered corrosive, explosive, flammable or toxic to human health so they can be land-filled – taking into account local regulations. The best option for the disposal of wet energy curing products is controlled incineration.

Recycling: Waste material printed with UV inks can be recycled using existing techniques.

Operating environment

For optimum results, the press room temperature should be 20-30°C with a relative humidity of 50-60%. The environment should be as dust- and draught-free as possible. Production and quality performance will decline if these conditions are not maintained.



Key maintenance issues (different to those of conventional offset).

Dampening system maintenance: Due to high sensitivity of the UV ink/water balance it is essential to maintain the system frequently and thoroughly. FOGRA recommend a specific test plate for controlling and adjusting the dampening system on the press.

Cleanliness: Hygiene during coating changeover is very important to ensure high and stable quality. The press must be cleaned thoroughly when changing from conventional to UV inks, and vice versa, because of the chemical differences between these ink systems.

Ink mist: Caused by the fast revolution of ink rollers with highly viscous inks. The ink mist must be exhausted because it is a health hazard and contaminates the inking unit. When exposed to UV light (or daylight over a long period of time) the ink becomes cured and is difficult to remove. Minimise misting by reducing the dampening solution volume to the absolute minimum level. Specific equipment can be installed on the press to remove ink mist by using suction extraction. This is strongly recommended for prolonged running at high UV printing speeds.

Ink roller settings: These need to be monitored more frequently for mixed conventional and UV operation because of the risk of swelling.

- Rollers for UV printing should be set with a minimum bounce to the plate to avoid scum lines.
- Ink rollers for UV should be set 20-25% less than for conventional inks.

Dryer: Good curing production quality, productivity and lamp life are dependent upon system maintenance, cleanliness and temperature stability.

- Regularly check that water pipes are not restricted by build-up of scale; and clean air filters to ensure adequate airflow to maintain cooling efficiency.
- Clean dryer at regular intervals.
- Use soft tissues with alcohol to clean lamps and reflectors. Do not touch the quartz bulb with bare hands as traces of grease or dirt will burn on to the lamp and reduce its efficiency and shorten its life.
- Routinely test lamp status (e.g; Green Detex method of UV light sensitive tape).
- Change UV lamps as required. The normal lifetime is 1 000 - 1 500 hours depending on the mix of jobs and lamp cleanliness.
- The time needed to change a lamp is less than five minutes per module – once the lamp has cooled down and the machine panels are removed.
- Change reflector, usually between 5 000 - 10 000 operating hours depending upon cleanliness.

Lubrication: Use only heat-resistant grease.

Dampening system maintenance

Daily:

- Check temperature, conductivity, pH value and alcohol content.

Weekly:

- Clean solution tanks and pans for optimum water receptivity.
- Drain system pans, lines and tanks. Refill with hot water.
- Add prepared fountain system cleaner, and pump into pans to circulate.
- Maintain cleaning solution flow through system until only discoloration of the solution is visible and no large particles are left.
- When system is clean, drain, flush with clean water, drain, and wipe out pans and tanks.
- Change all filters before refilling with fountain solution.
- Before fountain solution is pumped into pans clean all damper rollers and etched chrome rollers.
- Desensitise roller surfaces by cleaning and etching them (rubber, chrome and ceramic rollers).
- Inspect system for bacteria growth.

Refresh dampening water:

- Every 2 weeks for alcohol-free solutions.
- Every 4 weeks for IPA alcohol solutions.

Annual maintenance:

- Empty the dampening system and remove all filters.
- Sufficiently fill the reservoir with cleaning solution to ensure a smooth circulation.
- Circulate 2 to 3 hours. (Turn off freezer unit and run warm whilst cleaning.)
- Empty the reservoir and rinse with water for at least 10 minutes.
- Re-empty the reservoir and rinse with water and 2,5% of fountain additive.
- Empty the reservoir and refill with dampening water, ready for use.

Prepress & plates

Reproduction

- UV inks have a higher dot gain (spread) than conventional inks. However, this can be compensated in prepress by adjusting plate setter calibration curves.
- UCR (Under Colour Removal) should be used during prepress to minimise ink film weight and consequently minimises dampening quantity – this has a significant affect on maximum printing speed.

Plates for UV printing

UV inks take up less water and consume less fountain solution than conventional inks. A plate's aluminium substrate, graining and anodizing all have an influence on the ink/water balance. In general:

- Negative plates are more stable than unbaked positive plates.
- Baking improves the run length stability of negative plates based on photopolymer technology and positive plates based on diazo resin technology.
- Special positive plates for UV printing are available for printing short runs without baking.
- CtPlates based on silver halide technology, photopolymer and thermal also perform very well with a lot of ink/fountain combinations.

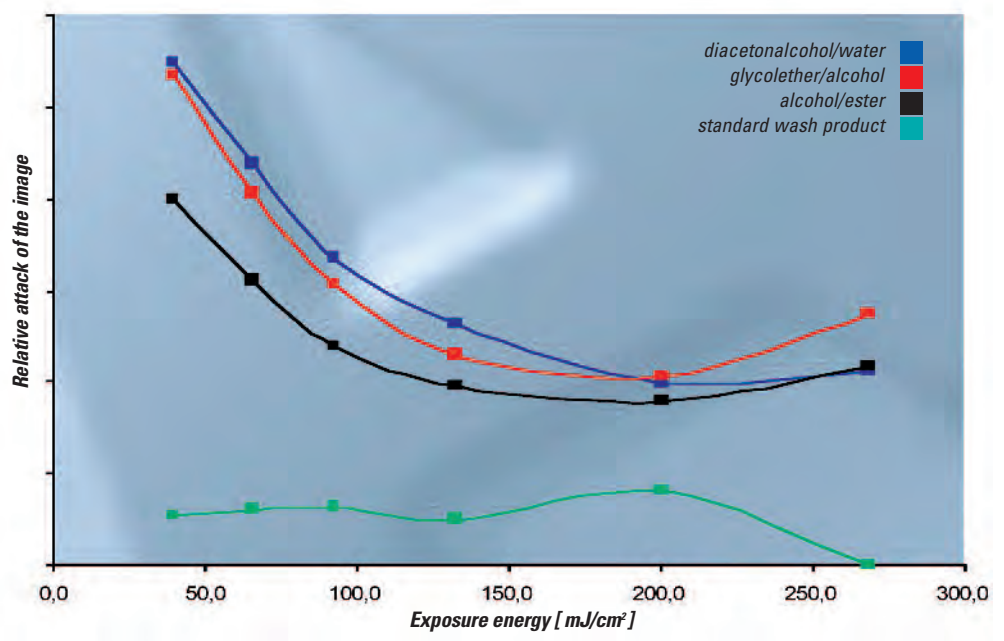


Improving plate run length

- Ensure chemical compatibility of plates with UV inks, washes and cleaner (see drop test page 30).
- The wear resistance of the image areas of negative plates depends on the exposure energy – the higher the energy, the better the resistance.
- Baking negative working photopolymer plates doubles their run length stability. Baking positive plates results in UV run lengths equal to conventional inks – it also provides excellent chemical resistance. However, baking adds a step to plate making and it must be assessed against the additional investment, energy and floor space required.

Resistance of negative plates (image-parts) depends on the exposure energy – the higher the energy the better the resistance.

Source: Agfa.



Coating formes

Selection of the coating and its image carrier (blanket or photopolymer plate) depends upon the application: (1) Flood, the overall coating of a full sheet, (2) Knock-out of simple non-coated areas (glue flaps, book spines and ink-jet address panels) or (3) Spot coating to selected areas with precise registration. See page 32.



Stripping blanket: For flood and knock-out coating.

- The blanket is mounted directly onto the cylinder and the image is printed onto it. It can then be either stripped on the cylinder or off press on a table. Carefully strip with a knife ensuring not to cut through the total thickness (or coating will penetrate the blanket and will reduce its dimensional stability).
- After stripping remove any threads left after the cut to avoid coating build-up.
- Compared to a polymer plate slightly higher pressure is required for an optimum coating transfer. Depending upon the cylinder undercut, some hard or soft packing may be needed.
- During production the blanket carcass becomes soaked with coating and will lose its dimensional stability. Therefore, to ensure register on repeat jobs it is recommended to make a new stripping blanket.



Elastomers have an affinity with oil-based ink but not with water-based or UV coatings. Therefore, the quantity of coating transferred and gloss is generally inferior to polymer plate.



Pre-cured polymer plates: Used for flood, knock-out, and spot.

- The polymer plate can only be processed out of the press; therefore, the image distortion factor (anamorphosis) must be taken into account, but the process is quite simple and does not require any special equipment or knowledge. Manual preparation types have a water-washable diazo top coating that can be developed using standard negative film in a conventional exposure unit. Once exposed, the non-coating areas can be easily identified.
- After washing and drying a special cutter and a metal rule is used to prepare image area. It is important not to cut or damage the PES base. Attention: the plate can be damaged from cracking at the bend before going in to the cylinder gap.
- Polymer plates are not compressible but can deform. Use a compressible underpacking to provide more pressure latitude and improve coating transport. A nip pressure strip of 6-9 mm is recommended.



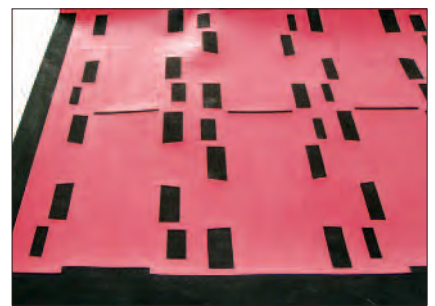
Plastic film with sticky backing: For knock-outs.

- Ensure plate is completely degreased and apply film carefully to avoid creating air bubbles.
- Remove the non-coating areas after cutting and fit the plate on to the cylinder.
- Before coating, it is recommended to set the "put impression" to 'on' in order to obtain complete adhesion of the film on to the plate.



Photopolymer plate: Precision spot and knock-out coating.

- Solvent washable flexo plates are recommended for UV coating.
- Correct pressure setting is important, because wear is the most frequent cause of plate damage. Pressure should be set to match print conditions (substrates, anilox roller). Soft underpacking is recommended for consistent and even coating transfer.



Strippable blanket with top face stripped from the open cell compressible layer.

Source: Trelleborg.



Sticky back blanket can be laminated on to an aluminium plate (see page 32). Source: Trelleborg.

Inks & coatings



Metallic inks:

- For frequent use of gold (bronze) and silver (aluminium) pigments use combi rollers on the printing unit.
- Some UV metallic inks contain low molecular components with a very low polarity that may cause swellings of EPDM roller covers; consult your ink supplier.
- Metallic particles in UV ink tend to reflect radiation, causing poor curing that leads to blanket build-up and more frequent cleaning. For this reason, some printers prefer to print conventional metallic inks on top of inter-deck cured UV inks to avoid trapping problems.
- Metallic and white inks tend to print better with a long ink path through the roller train. On some press types it is possible to lengthen the ink path and reduce water feedback into the ink duct by removing a roller. Attention: this may increase risk of ghosting.
- Metallic inks from 2-pack systems should be made up freshly as required in the smallest amounts, the duct should be replenished frequently. This is especially important for 'silver' colours made from aluminium.
- If metallic ink pigments are used frequently on the same print unit, equip it with combi rollers – even if the press runs 100% UV. For many inks non-polar oils protect the metallic pigment against corrosion – which can affect EPDM covered rollers.

Inks



Combination presses: UV and conventional oil-based inks are totally incompatible and should never be mixed. Double wash rollers when changing from one ink system to another.



Cool weather: A UV reducer can lower ink tack and improve flow. Use only 1% at a time in carefully measured doses to ensure that curing performance is not affected. Overcome low temperature start-up by running the press with impression 'off' to pre-heat ink rollers.

Coating application

Gloss level is dependent on the substrate coating, ink coverage (the higher the ink film thickness and coverage, the lower the obtainable gloss), printing speed, the drying/curing system, coating method (and roller type), the coating substance, the temperature of the coating and the substrate. High gloss UV coatings require high carrying capacities for both flood or spot coating.



Optimise the coating and film weight for each substrate for the best cost-to-gloss performance (excessive film weight can cause insufficient flexibility and if folded may have poor adhesion in the folded areas; it is also uneconomic). Only apply the film weight necessary for maximum gloss and mechanical resistance. Exceeding this level gives little or no increase in gloss.



Variations in the level of gloss are particularly noticeable on large flood coated areas; therefore, coating must be applied very evenly to ensure uniform gloss across the entire image.



Conventional inks + Primer + UV coating

- Ink composition and its affinity to the primer determine the bonding of the coating layer, which only becomes definitely stable several days after printing.
- Print with as little water as possible to minimise blanket ink build-up and reduce the risk of mottling. If very fast-absorption inks are used in the first printing units, then ink splitting on the blankets in the subsequent printing units may cause mottling.
- Use specially adapted inks to avoid risk of colour change when applying UV coating over conventional inks that contain non-solvent proof pigments (HKS 13, 25, 33, 43, PMS warm red, rhodamine red, purple, blue 072, reflex blue).



Gloss withdrawal is a negative interaction between ink and coating layers that affects gloss some time after the job is finished (see opposite page).



UV coatings + UV inks

These produce the highest gloss results with minimal change during the curing process. Increasing the amount of UV coating applied can improve gloss level.

- Optimum gloss results require foam-free coatings – otherwise spots may appear on the finished surface. Spills into the press can be caused by foaming, leading to additional cleaning time. Minimise this by ensuring the coating system does not become too agitated (entraining too much air). Foaming often causes poor supply return and can increase the level of coating in the pan. Use de-foaming agents.
- Good coating flow becomes more difficult when applying high volumes (depending on viscosity). Heating the coating to 40°C has a positive effect on flow properties and this can also increase gloss.
- The geometry of the anilox screen rollers strongly influences coating flow.



Offline UV coating

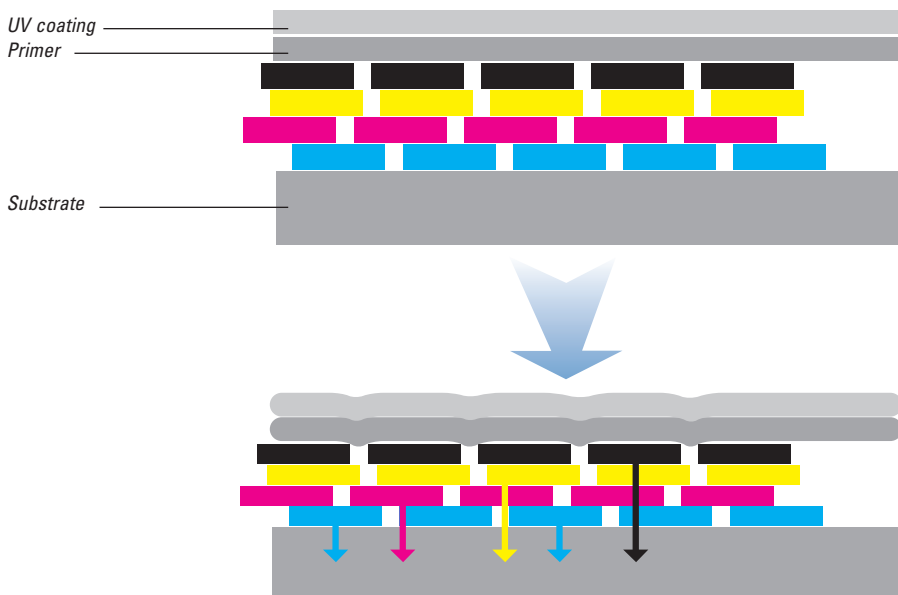
UV coating over dry conventional inks can lead to trapping difficulties. Lack of adhesion of the dried coating may result in orange peel effect or crater formation. Ensuring the right combination of materials throughout the production chain will avoid or minimise this risk.

- Too much spray powder negatively affects adhesion – use only the minimum quantity on an uncoated grade.

- Minimise excessive ink film weights and multi-colour builds that can cause excessive accumulation of ink distillates and additives at the ink surface during drying and which also reduces surface tension.
- Conventional inks must be completely dry prior to coating (minimum delay is about 48 hours).
- Avoid a long delay between printing and coating. After 72 hours, there is a risk of poor adhesion due to surface crystallisation and hardening with reduced surface tension.
- Apply the optimum coating film weight for maximum gloss and mechanical resistance.
- To avoid discolouration clean thoroughly when changing from pigmented coating to clear coating.

Oxygen inhibition: This mainly occurs with low-viscosity UV coatings. It shows up after hardening in the form of a greasy film on the coating surface – when this film is wiped off, the coating surface below is glossy. The cause is high levels of oxygen that enter the coating and diffuse into its surface. The solution is high intensity curing to rapidly seal the ink surface to minimise oxygen entry.

Gloss withdrawal (dryback). The negative interaction between ink and coating layers, which can affect gloss some time after the job is finished. This is caused when oxidation drying of conventional inks and the primer continues under the cured UV coating, leading to differential gloss between printed and non-printed areas, less gloss and poor adhesion. The effect can be seen in the double coating process and occurs mainly when printing substrates with high or medium recycling content along with high ink area coverage (>200%) and when UV coating is applied over a primer. The gloss level can decrease by several points in areas with high area coverage. There are different proposed explanations for the effect: one is that in areas with high area coverage the inks absorb into the substrate immediately and in other cases take minutes or hours to dry. Both lead to a loss of volume in the ink that causes the layers of primer and UV coating on top of it to collapse. This changes the light refractions on the UV coating surface and results in lower gloss.

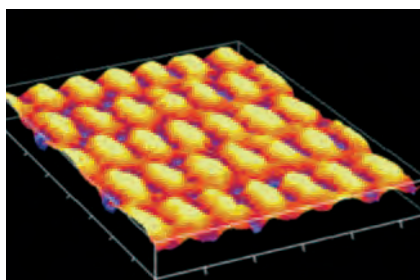


! Black ink and high colour build (>300%) to make a black can be a cause of severe dryback even in UV printing.

✌️ Keep black Optical Density below 2.0 (ideally O.D. 1.8) to reduce the risk. Consider using a 40-50% screen of cyan under the black to minimise black film-weight and dryback. This also has a positive effect of ink cure, flexibility and adhesion.

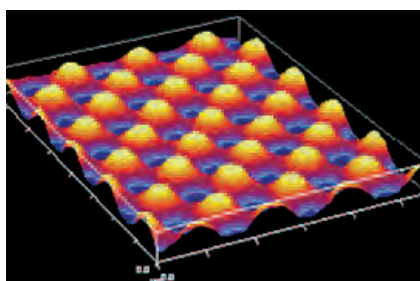
The volume of primer applied over conventional inks has an influence on the final gloss level of the UV coating.
 Source: MAN Roland.

Effect pigments



Anilox Reverse Technology (ART) are the most suitable to reproduce halftones with effect pigments. An open cell structure in the anilox roller minimises bubbles in coating.

Source: MAN Roland.



Thin Ink Film screen.

Source: MAN Roland.

Application of effect pigments in coatings

Application	Roller structure	Coating volume gsm	Screen Angle	Lines/cm
UV clear coating	ART	20	60° or 45°	80*
UV effect coating	Cell structure	13	60°	80
Primer + UV: Coating unit 1	Cell structure	13-18	60°	80
Primer + UV: Coating unit 2	TIF	25	75°	40

*Finer screen lining with lower coating volume

TIF: Thin Ink Film

ART: Anilox Reverse Technology



Effect pigments can be applied in water-based UV primers or coatings depending on the preferred type of pigment or effect. The screen ruling depends on the particle size of the pigment.

Selecting the correct etched roller and photopolymer plate is crucial to achieve an optimum effect and for problem-free printing and coating. The cell geometry of the etched roller should be matched to the applied effect pigment according to the table above. Suitable photopolymer plates include BASF Nylocoat® Gold A 116 and Seal F 116 and DuPont Cyrel® CL2 and CL4.

Ensure an even coating pressure between the roller and polymer plate. It is highly recommended to put continuous roller support strips (7 mm wide) along each outside edge of the plate. Separate (not overlapping) strips are required for multiple coating.

The development of new types of etched rollers improves pigment transfer behaviour and allows use of effect pigments in halftone applications. Selecting the correct etched roller depends on the ratio between particle size, screen ruling and theoretical dispensing volume. Autotypical halftone screens (ART) with a screen ruling of 21 lines/cm (52 lines/inch) are the most suitable to reproduce halftones with effect pigments. FM screens are not recommended because of the platelet structure of the effect pigments.

Effect pigments of different particle sizes

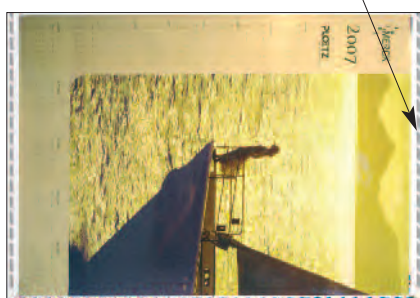
Colorstream® - multicolour effect pigments, with a smooth flowing gradation across many colour tones.

Miraval® - dramatic glitter with colorful highlights – like small diamonds or “rainbow crystals”. UV coating is the ideal method to apply these pigments due to their particle size (up to 200 µm). Compared with other effect pigments low concentrations allow satisfaction / glitter effects. Good print results are not possible with water based coatings. Ideally use rollers with a high ink transfer volume.

Iridin® - pearlescent, iridescent, shimmering, glittering effect pigments. Iridin Pearlets® are a new type of Iridin pigment for simple preparation of effect printing inks, inline and overprint coatings. Iridin in the water based primer followed by a transparent UV topcoat reproduce high gloss metallic effects of car paints.

Iridin Pearlets® effect pigments offer: Significant savings in time; easy achievement of the unique Iridin® effect; optimised ink manufacturing; due to the better wetting of the pigments more even print image is possible.

Iridin Pearlets® are superior to conventional powder pigments in several ways: Much smaller volume; ease of handling; dust-free operation; precise metering; prevention of remaining quantities of ready made ink; optimum dispersibility; optimised sedimentation and re-dispersion properties; minimal foaming; low de-aeration required.



Coating roller support strips (7 mm wide) along each outside edge of the plate.

Source: Merck.

Blankets



The three absolute priorities for high quality and productivity are:

- 1 Chemical compatibility of all the consumables in the process system with inks and coatings matched to the substrate, finishing and end use.
- 2 Correct press and dryer settings and the production line regularly cleaned and maintained.
- 3 The key to efficient UV printing is to keep dampening water to a minimum to obtain maximum production speed.

It is essential to ensure correct compatibility of polar and non-polar UV blankets rollers, inks and washing agents. (See also pages 38-40.) For each blanket type a specific washing agent is required, otherwise blankets will be severely damaged.

Some common blanket issues



Ghosting – when the black text of the previous job is visible in the screen areas when switching to a new job. This may be caused by blanket swelling from using a blanket incompatible with the UV ink (or washing solution).

Use appropriate blankets with a top face compatible for UV inks and clean with correct washing agents.



Swelling on standard blankets when UV and conventional inks are used on the same press is caused by the incompatibility between the washing agent and blanket face.

Use the correct solvent to clean the blanket without swelling the top face; use combi materials.



Blanket delamination can be caused by swelling over the whole surface that generates too high indentation and friction.




Ensure compatibility between blanket, inks and washing agents; or consider using combi blankets.



No special care is needed to handle or mount UV blankets on the press.


Follow the supplier's instructions to store, tension and clean correctly. Use only appropriate chemicals.


Operational Modes

	 NBR	 HNBR (Combi)	 EPDM
Blankets & Ink Rollers			
Washing agents	Non-Polar	Polar Non-Polar	Polar
Inks	Conventional Inks	Alternating Conventional & UV-Hybrid inks	Classic UV Inks

Roller & press operation

For any combination of inks there is an optimal roller covering solution and washing agent. See also pages 38 and 40.

 The consequences of an unfavourable materials combination include swelling that can impair the function of the rollers so badly that printing cannot continue.

 The cleaner and the solvents for the ink systems are critical to the performance of the rubber compound. Different ink system and rubber roller polarity is the key to the resistance of the rubber roller. Ask your ink and washing agent suppliers for information on compatibility of their products with NBR, Combi NBR and EPDM rollers.



Best practice for ink -and dampening rollers

- Use conventional rollers only for conventional printing inks – no UV inks on conventional rollers.
- Use mixed mode rollers for combination printing and non-conventional UV inks.
- Use EPDM rollers for 100% UV printing.
- Rollers for UV printing should be set with a minimum of bounce to the plate to avoid scum lines.
- Ink rollers for UV should be set 20-25% less than for conventional inks.
- There is a link between the ink axial oscillation movement and printing problems of ghosting and dot gain. If ghosting is a problem, then oscillation may be too low; however, increasing oscillation may increase dot gain – and vice versa – therefore, the goal is to find the right balance.
- Clean rollers regularly with an adapted washing agent to maintain their settings longer and extend the life of the coverings.
- In mixed UV/conventional production, regularly monitor and adjust the setting of the throw-on of rollers.
- If metallic ink pigments are used frequently on the same print unit, equip it with combi rollers – even if the press runs 100% UV. For many inks non-polar oils protect the metallic pigment against corrosion – which can affect EPDM covered rollers.

Minimum dampening is essential!



Printers running their first UV jobs often set the water much too high, leading to over emulsification, water marks, toning in the ink free areas and ink misting. The only solution is to stop the press and wash the ink unit.



UV systems need much less dampening than conventional inks. A 'drier' ink train allows faster printing without ink misting. Minimum dampening is the prerequisite to obtain maximum production speed, reduce ink misting, and avoid emulsification with low ink coverage.

- Ensure dampening is set just above the point of ink catch-up on the plate, but always with ink marking on the plate's leading edge.
- If the potentiometer speed is 70% for conventional inks, a UV job should be started with 40%. The running free point of 55% is much easier to reach by increasing the water. With conventional inks the speed of the dampening unit can be decreased to achieve the correct ink/water balance, but this is nearly impossible with UV ink because it stores the water (and leads to further problems).
- If there is still too much water (or ink wash-out) when printing with the lowest dampening unit potentiometer speed, then reduce the nip setting between ceramic duct and water forme roller to reduce water to the plate. *(This nip has the highest influence to regulate the dampening unit speed range and it reacts differently to all other nips in the press. The forme damper runs with the same speed as the plate but the ceramic and the metering rollers are nearly four times slower causing the plate damper to rub the water from the ceramic roller. A narrower nip reduces water transfer to the plate damper and the ceramic roller must run faster to deliver enough water for the running free point.)* Make the opposite adjustment if the speed is too high (over 90%) and increase the nip setting to increase water carried by the plate damper.
- Too great a speed difference between pre-dampening and normal dampening leads to too much water and increases printing waste. Either reduce the pre-dampening speed or increase the ground speed of the dampening unit (by reducing the nip between ceramic and plate damper).
- UCR (Under Colour Removal) should be used during prepress to minimise ink film weight and consequently minimise dampening quantity.
- The dampening solution must be carefully metered and the system perfectly maintained.



Some additional skills are required for printing with UV inks as their properties and drying behaviour are fundamentally different from conventional inks. Source: MAN Roland.

Curing system

Operation

- Do not touch the lamps or their housing because of their high temperature! Ensure they are adequately shielded and light tight.
- Using alcohol regularly clean dust and lint from lamps and reflectors.
- Do not allow sheets to become trapped inside lamp housings – they are a fire hazard.
- Maximise lamp life by avoiding unnecessary press stops and starts as this reduces lamp life. When starting a new job, first run some sheets through to verify smooth sheet travel and delivery; only then switch on the lamps.



Use the correct procedure to maximise productivity and avoid inadequate curing of UV inks and coatings:

- Correctly match press speed and lamp power because ink and coating curing resistance is directly related to UV exposure. Because of the many different types of lamps available, there are no general rules; therefore, contact the supplier for the correct speed/lamp power for your configuration. Running at too high a speed with underpowered lamps will lead to inadequate energy available to cure the ink or coating.
- Optimise ink and coating film weight to the lowest level for good printing (this also makes economic sense). Excessive film weight will not lead to any perceptible increase in gloss but will increase the risk of ineffective curing and consequent costs.
- Lamps and reflectors need to be properly maintained and kept adequately clean to work effectively. Use an appropriate biocide to avoid biological contamination of water filtered lamps.
- When changing from one type of ink to another ensure press rollers are not contaminated and are completely clean.
- Some plastics contain plasticisers and/or anti-oxidants that can adversely affect curing or can re-soften the cured film after printing. Test them in advance of use.
- Remove UV modules during conventional printing.



Incorrect UV exposure may lead to:

- Under-cured ink that remains liquid.
- High surface tack or less durable surface.
- Partial surface cure but with poor substrate adhesion.
- Over-cured brittle surface with poor over-printing performance.
- Poor solvent or mechanical resistance, or lack of slip.
- Poor odour and/or taint.
- Poor gloss.



Causes within the UV curing system may include:

- Insufficient power supply.
- Unsuitable lamps.
- Ageing lamps.
- Excessive cooling of lamps preventing them reaching peak radiation.
- Dirty reflectors or glass covers.
- Lamps with burnt-on contamination.
- Lamps too far from substrate.
- Water-cooled lamps with incorrect or unclean water.



Causes outside of the UV curing system may include:

- Residue of washing agent in the ink system.
- Conventional ink or washing residues in the system when changing over to UV production.
- Too much reducer, varnish or water in the ink; or insufficient photoinitiators.

Post curing refers to a very slight improvement in mechanical resistance and surface 30 minutes after printing as the film 'relaxes' following shrinkage during curing. However, 'post cure' should not be relied upon and any doubt about curing should be validated by testing (see UV ink and coating testing on page 54).

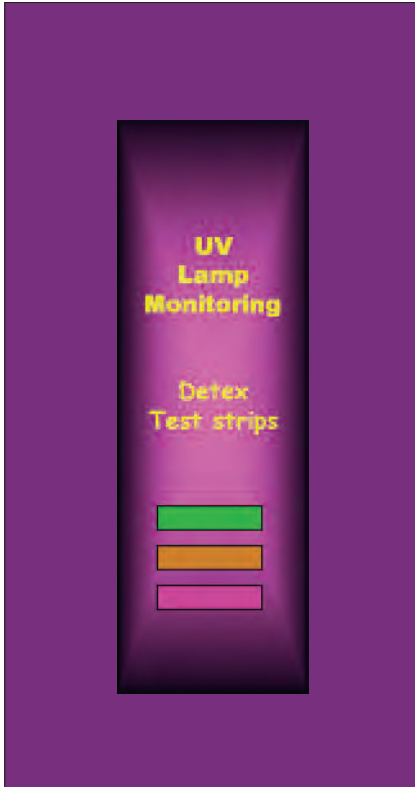


At high printing speed it is more difficult for the sheet surface to be sufficiently cured and to keep heat at an acceptable level. This can result in interactions between the top and bottom sides of sheets in the delivery, leading to set-off or blocking. Poor lamp curing efficiency may result in a localised adhesion problem in areas with strong dark colours or heavy superposition that strongly absorb UV light. If the print feels soft, or the ink smears in the delivery, then stop the press to check for possible poor curing.

Tests for UV lamps, inks and coatings

UV Lamp efficiency

Detex test strips can be used to record the efficiency of UV lamps. The strips are attached across a sheet of paper which is then passed through the press with the UV lamps on and the colour changes of the strips will indicate the profile of lamp efficiency.



Colour changes of the strips indicate lamp efficiency. Source: Sun Chemical.

Adhesion tape test

The adhesion of an ink or coating to a substrate can be assessed using adhesive tape. The principal is that if the tape adheres more strongly to the ink or coating surface — than the ink or coating to the substrate — then the tape will remove ink or coating. Tapes with various levels of adhesion are used and care is needed to select the most appropriate tape for the purpose. Commonly used standard tapes include:

- Moderate adhesive strength: Commonly used by printers and also to test the foil adhesion in foil blocking. 3M Scotch™ range (<http://solutions.3m.com>) product 3M 616 is made in the USA.
- Moderate to strong adhesion: Used by ink makers to test inks and coatings on paper and board. Scapa red tape H101 (www.scapa.com/products).
- Strong adhesion: Testing adhesion of UV inks and coatings to plastics. TESA blue tape code 4104 (www.tesa.co.uk)

Method

1. Lay the print on a hard flat surface (a thick glass slab is ideal) and stick a 5 cm length of the selected tape to the surface with firm thumb pressure.
2. Peel the tape away immediately, quickly, cleanly and smoothly at 90° to the print.
3. Study both the print and the adhesive side of the tape.
4. Make an estimate in % terms regarding the amount of ink/coating that is adhered to the tape.



Always ensure reels of tape are properly stored at ambient temperature (out of direct sunlight and away from sources of heat) and respect use-by dates: adhesive tape deteriorates with age.



Health and Safety first: Throughout the tests wear appropriate clothing (overalls or a laboratory coat), protective glasses and protective gloves (made of vinyl or nitril rubber) during cleaning.



Environment: Ensure all waste products, solvents and cleaning materials are disposed of correctly in proper waste bins. Do not mix materials between bins and keep solvents, paper and plastic waste separate.



Care is needed to selecting the most appropriate tape adhesion strength. Source: Sun Chemical.

When is UV “dry” or “cured”?

A UV cured ink or coating is considered to be dry when it is fully fit-for-purpose with regard to print finishing and subsequent end use. There are no simple quantitative or objective tests to determine whether a UV product is ‘fully cured’ or not. The criterion is fitness-for-purpose.

- No build-up on subsequent blankets after UV inter-deck dryer.
- The printed product allows “reasonable” handling (slitting, folding, binding, packing, shipping and use). Excessive friction or pressure on the ink surface must be avoided in “reasonable” handling.

On some jobs there may be post-curing effects where the surface takes some minutes to fully cure, but this normally has no impact on quality of stacking or set-off.

Change of colour: Coating may change the ink colour. It may be necessary to overcoat proof prints to anticipate the potential colour change.

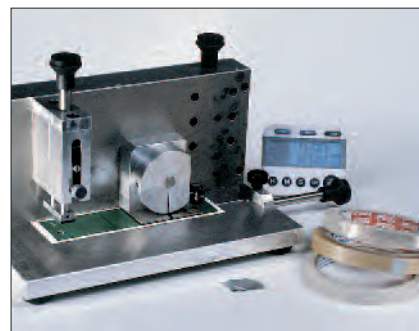
Reflected light as a gauge for gloss: A gloss meter measures light reflected from a set angle. The angle is important because pigments that lie deeper have a scattering effect and the human eye reacts more strongly to gloss on a dark background. The angle must be constant so that the values provide reliable information on gloss variations. Different wave lengths and viewing angles are used in North America and Europe (60%).

Solvent resistance of UV ink and coating: Printed sheets can be tested to see that they have been adequately cured. The traditional method compares resistance to solvent attack between a printed sample and a standard test sample. This is a simple and effective guide that with experience is repeatable and reliable. The procedure is: 1– Place the test print and the standard on a suitable hard surface; 2– Dip a cotton bud into the test solvent until wet (inks only use Isopropanol and for UV coatings use MEK methyl ethyl ketone); 3– Rub the tip gently over both prints 20 times or until the film becomes visually damaged. The results should be recorded as (a) number of rubs to failure and (b) whether better, equal to, or worse than the control standard. FOGRA have developed a simple test device (ACET) using acetone to make this assessment easier with more reliable results under well-defined conditions.

Scratch resistance: Testing of scratch resistance and bonding properties is an important aspect in finishing operations and verifies the durability of the printed product. The bonding of WBC primer to the UV coating layer is only stable several hours (if not days) after production as the inks dry by oxidation. This can lead to cleavage products settling between ink and coating, which spoils the bond. This should be checked some time after the run is completed. The traditional nail and adhesive tape tests depend on the individual user’s judgment. The FOGRA LHT test has mechanised the adhesive tape test to measure values automatically. The FOGRA Institute (www.fogra.org) also recommends test devices for scuff and blocking resistance. Resistance of printing can be tested in accordance with DIN 16524 and DIN 16525.



*ACET is a simple to use solvent resistance test device developed by FOGRA.
Source: FOGRA.*

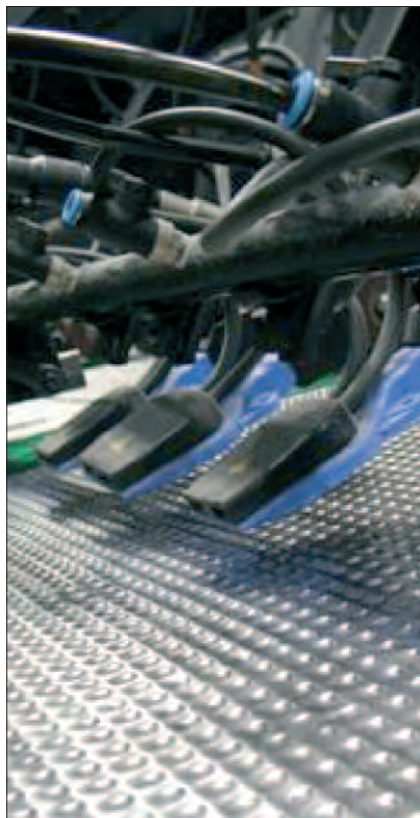


*FOGRA's LHT adhesive tape scratch resistance test measures values automatically.
Source: FOGRA.*



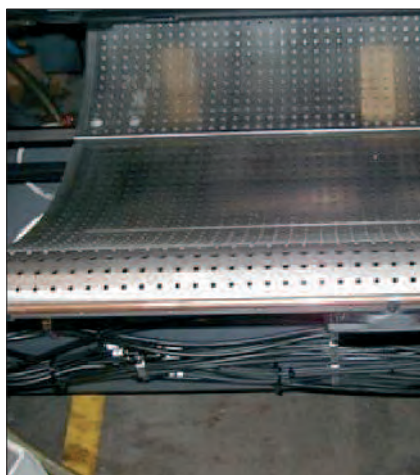
*The traditional method to test if printed sheets have been adequately cured compares resistance to solvent attack between a printed sample and a standard test sample.
Source: Sun Chemical.*

Printing on non-absorbent substrates



Conidur sheet metal plate suction feedboard surface with blowing air for air pillow effect improves sheet travel of sensitive substrates.

Source: MAN Roland.



Sheet guiding below the transferer improves sheet travel.

Source: MAN Roland.

Plastics and special substrates

The use of synthetic substrates printed with UV continues to grow in a wide range of applications. Substrates can be transparent or coloured, flexible or rigid, single materials or complex combinations of materials. These include:

- ABS Acrylonitrile-butadiene-styrene copolymer
- PC Polycarbonate
- PE Polyethylene
- PETP Polyethylene Terephthalate
- PLA Polyactic acid
- PP Polypropylene PS Polystyrene
- PVC Polyvinyl chloride
- Aluminium foil-Paper board
- Metallised polyester-Paper board (generally requires a special coating pre-printing)
- Multi-layer complex substrates (composites)
- PE coatings-Paper board

Some complex and synthetic substrates are subjected to corona treatment in order to improve the adhesion of ink to their surface by oxidation. Measurement of the surface tension indicates the effectiveness of the treatment and if it is suitable to be printed. Consult your ink supplier for optimum selection of inks for substrates.

Non-absorbent substrates printing challenges

1. Sheet travel through the press (surface scratching, electrostatic problems)
2. UV curing on heat sensitive substrates
3. Ink adherence
4. Ink/water balance

Best practice solutions



Sheet travel — substrate scratching

- Avoid or minimise by using transparent PET or Hard PVC materials; problems decrease by using thinner and more flexible substrates.
- Preferably use a press with a suction feed board and sheet guiding device along with additional tapes made from adapted materials like velour or billiard cloth.
- Electrostatic forces may prevent sheet separation from the feeder or the suction feed board. A powerful antistatic device can help overcome this problem.



UV curing on heat sensitive substrates

To cure heat sensitive substrates (like OPP for IML with 57 or 75µm) minimise the power of the UV inter-deck dryer to as low a setting as possible. Minimise curing difficulties by avoiding:

- Higher ink densities of opaque white or black
- 100% surface coverage
- Direct post-press or second run through the press to print back side.
- Use heat reduced UV drying systems
- Find the right balance between press speed and UV curing output!
(Cool air together with UV inter-deck and UV final dryer are expensive and less effective.)

Special UV lamp systems

Heat-reduced systems do not apply radiation directly to the substrate and the heat is filtered out by water pipes and mirrors to reduce heat build-up on the sheet by 20-30%. Mercury vapour lamps with their high surface temperature are used here as well but they are not positioned directly opposite the substrate. Heat-reduced UV dryers are used for commercial printing on thin substrates or label printing. With some constraints heat-reduced UV dryers can also be used for printing films.

UV opaque white ink used in printing plastic film has different absorption ranges than standard UV inks (white pigments absorb very well in a different range than standard pigments). This means that during curing they are in competition with the photoinitiators. A higher level of energy is often used to ensure curing but this can cause problems on heat sensitive substrates. A special doped WhiteCure UV module (inserted in place of a standard lamp) can improve curing performance by up to 25%.



Ink adherence

The surface energy of the plastic must be above 38 mN/m (dynes) or ideally 10mN/m above the ink which is about 32-35 mN/m. Some plastics can have low surface tension (some, but not all, e.g. PP, PVC, A-PET, GAG-PET) and trial printing should be made before the full printing run. Adhesion can be improved using:

- Corona treated or primed (Primelt) substrate from the plastic supplier; or
- Corona treatment for some materials prior to printing increases surface tension and so aids adhesion (note that surface tension from Corona treatment can diminish with time).
- Alternatively for some plastics it is possible to use a primer on the first printing unit prior to printing.
- Always use a dedicated ink formulation with correct ink film weight that is fully cured.
- Correct coating selected

A suitable UV curing coating is often essential to provide correct mechanical and product resistance and ensures good ink adhesion. Ink and coating need to work together with the substrate to ensure the best printed result. This only works when the difference in surface energy between ink and substrate is about 10 mN/m.



Ink / water balance

Constant control of the UV ink system is a prerequisite. This can be assisted by using an ink unit temperature control and ink unit blowing device.

Establish the optimum dampening solution volume — as low as possible and as high as necessary.

Types of adhesion

The different mechanisms for ink and coating adhesion are complex and care is needed when selecting substrate and surface treatment:

	<p>1: Mechanical: Two materials may be mechanically interlocked when the ink or coating 'hooks' into a microscopically rough surface. The strength of the cured ink layer determines adhesion and mechanical resistance.</p>
	<p>2: Chemical: The two materials form a compound at their intersection. The best adhesion comes where some atoms or electrons are shared — corona treatment increases this interaction.</p>
	<p>3: Dispersion: The surfaces are charged but do not share electrons, this is a form of adsorption.</p>
	<p>4: Electrostatic attraction: Some conducting materials pass electrons and create a difference in electrical charge at the join.</p>
	<p>5: Diffusive: Some materials merge at the joint when the molecules of both materials are mobile and inside each other. The ends of the chains diffuse into the substrate.</p>

Special inks for plastics have a surface tension of 32-35 mN/m (milli-Newton/metre) when they are dry and the surface tension of the substrates needs to be about 10 mN/m higher to assure bonding. The surface tensions of synthetic materials is increased to this level by corona treatment.

		mN/m
PE	Polyethylene	31
PP	Polypropylene	29
PS	Polystyrene	32-35
ABS	Acrylonitrile-butadiene-styrene copolymer	33-36
PVC	Polyvinyl chloride	39-40
PLA	Polylactic acid	38-39
PC	Polycarbonate	46
PETP	Polyethylene Terephthalate	43

Substrate adhesion and flexibility for UV printing

This table shows the adhesion and flexibility of a typical sheetfed offset full UV ink for use in packaging of cosmetics, liquor, pharmaceuticals, personal hygiene and similar products (it is not a 'confectionary' ink for paper and board only nor a full UV ink for rigid and semi-rigid plastics).

Coated papers	100
Coated Boards	100
Polyethylene	100
Polyester	100
Acrylic and PVdC coated	100
Polystyrene	75
Coated Thermal paper	100
Metallised Polyester	100
Synthetic Papers	80
PVC	100
Polypropylene	75
Acetate	50
PET/APET	50

Ratings:

100 = excellent adhesion.

75-80 = normally excellent adhesion but new substrate qualities should be tested with the inks and coatings to be used.

50 = normally acceptable adhesion but care must be taken and pretesting is essential.

Improving UV production

- **Spray powder:** Should not normally be used because it migrates to the UV lamp surfaces and reduces their power output, lowering their curing efficiency and operating life. Remove UV-end-of press and inter-deck modules when running conventional inks with, or without, powder to prevent reflectors and lamps being contaminated with powder.
- **Piling when printing UV?** If the curing is too hard, the ink becomes brittle and piles on the blanket one or two units later. Reduce the UV power on the unit where piling originates. Slightly increase water in the unit where ink is piling to decrease ink hardening (but ensure that the leading edge of the plate is still inked). Switch on the blowing device to avoid emulsion problems.
- **Absolutely avoid over-emulsion of the ink unit.** There is less tinting with alcohol. Tinting is a severe constraint with regard to decreasing alcohol content in the UV process. Tinting leads to ink build-up on the non-printing area of the blanket and impression cylinder. The cured hardened UV ink deposit is difficult to clean and the build-up can change the pressure between impression and blanket cylinders. Ask your supplier for an improved fountain solution. If possible, avoid curing with the inter-deck; if this is not possible, then try to improve the shadow to the blanket cylinders.
- **Improving combi printing process with low alcohol.** Use a good fountain solution and alcohol reduced to 5% with water temperature maintained at 16°C. Use the blowing device when necessary. Increase the ink chilling device temperature to 2°C above the condensation point on the ink duct (around 23°C).
- **Improving UV printing at high speeds.** Absolutely minimise the water in the ink unit (but ensure that the leading edge of the plate is still inked). Increase ink chilling device temperature to 2°C above the condensation point on the ink duct (around 23°C). Use the blowing device when necessary to avoid emulsion problems and ensure efficient exhaust operation. Optimise the consumables (rollers and blankets) consistent with the proportion of UV production.
- **Only use the UV lamp power required for the job:** To save energy and reduce costs.
- **Optimise UV ink and coating products:** Provide your supplier full details of the intended printing application to select the most appropriate consumables.
- **Training and education:** The keys to help realise the full benefits of UV printing. Adequate and thorough training of production and sales teams is an ongoing part of company best practices.
- **Ensure that all the consumables work together as a set:** Ensure the right rubber roller and blanket compounds are used for the ink system used; that press chemicals are compatible with the rubber compound (resistance test); and use only recommended and approved washes.
- **Correct maintenance and cleaning:** Ensures correct curing and highest printing quality. A comprehensive preventative maintenance programme and cleaning routines should be in place in all aspects of production.
- **Clean lamps and reflectors regularly:** Prevent decline in curing system efficiency.
- **Clean air filters:** Regular cleaning of cabinet filters ensures efficient cooling.
- **Monitor roller settings:** These need to be monitored more frequently for mixed conventional and UV operation because of the risk of swelling. Adjust to the recommendations of the press supplier to maintain print quality.
- **Ensure an even coating:** Put continuous roller support strips (7 mm wide) along each outside edge of the polymer plate to ensure even pressure between the plate and roller. Separate (not overlapping) strips are required for multiple coating.
- **Improve plate run length:** Ensure chemical compatibility of plates with UV inks, washes and cleaners.
- **The wear resistance of the image areas of negative plates depends on the exposure energy – the higher the energy, the better the resistance.**
- **Baked plates:** Baking negative working photopolymer plates doubles their run length stability. Baking positive plates results in UV run lengths equal to conventional inks.
- **Cool weather:** A UV reducer can lower ink tack and improve flow. Use only 1% at a time in carefully measured doses to ensure that curing performance is not affected. Overcome low temperature start-up by running the press with impression 'off' to pre-heat ink rollers.
- **Coating flow:** Is more difficult when applying high volumes (depending on viscosity). Heating the coating to 40°C has a positive effect on flow properties and this can also increase gloss.

Storage & handling of UV consumables

Consumable materials	Storage conditions							
	Storage position	Keep in packaging	Sensitive to sunlight	Sensitive to artificial light	Sensitive to ozone	Max storage time/months	Temperature °C	Humidity % RH
Plates	On pallet	•	•	•		6	20-25	50-55
Paper	On pallet	•	•			6	20-25	45-60
UV inks	Closed container	•	•	•		12+	5-25	
UV coatings	Closed container	•				12+	5-25	
Blankets	Flat < 14-high	Unroll	•		•	12	20 +/- 5	50-65
Rollers	Verti./Horiz.	•	•		•	12+	20 +/- 5	
Chemicals	Vertical	•	•		•	3-6	20 +/- 5	

Inks and coatings

To prevent premature polymerisation of UV inks and coatings, do not expose them to direct sunlight when in open buckets, ink ducts and rollers. Premature ink polymerisation can occur under levels of high heat and shear. If UV inks or coatings are pumped to ducts, all seals joints and hoses should be opaque and resistant to UV chemistry (PTFE is widely used for seals together with stainless steel piping) except if non-contact pumps are used.

Never put UV inks into transparent container or cartridges

There is a high variation of storage time between UV inks and coatings; therefore, consult your supplier for storage duration. Storage of coatings under 10°C may cause crystallisation. Do not exceed 30°C.

Uncontaminated press returns can be stored under the same conditions as unopened inks and should be reused within three months of being returned to stock.

Blankets


Must be unrolled immediately on delivery and stored flat face-to-face to avoid surface damage. Stack no more than 14 in a pile otherwise their weight will permanently distort blankets at the bottom of the pile.

Ink rollers

Leave the rollers in their paper wrapping and store them either in the original roller box or in adapted racks to avoid any surface pressure on the roller covering.

Protect rollers against humidity and extreme temperature changes.

Storage area should be ventilated and consumables should be kept out of direct sunlight.

 Avoid storing consumables near electric motors and cabinets that produce ozone and can cause deterioration.



Blankets should be immediately unrolled on delivery and stored flat face-to-face.
Photo Trelleborg.

Post-press processing

UV printing and coating allows almost immediate finishing. However, because of the wide variety of coatings available it is important to check that the product used is compatible with post-press operations and end-use.



Always pre-test new consumables combinations for finishing compatibility.

Die-cutting & Embossing: Requires a flexible UV coating with a controlled film weight. Avoid scoring and folds in dark image areas as any scaling faults will become more visible.

Hot-foil stamping: Use a coating formulated for the purpose with optimised film-weight and curing. Ensure little or no slip agent in the coating that will impair foil keying to the surface and use only the minimum quantity of spray powder.

Folding and scoring: Good substrate adhesion is essential for maximum tensile strength for folding and scoring (avoid brittle finishes). The loss of moisture caused by heat in the UV curing process and the presence of a coating layer makes the printed product slightly harder and more brittle.

- It is important that the selected UV coating retains sufficient elasticity.
- Avoid scoring and folds in dark image areas as any scaling faults become more visible.
- Any scoring required on a job should be done after the sheets have been coated and not before.
- Scoring is strongly recommended for substrates over 150 gsm.
- Excellent condition and setting of post-press equipment is a precondition to process UV material.

Glueing: Applying glue over UV coating is unpredictable. Leave a coating-free strip for glueing; if this is not possible, then test the suitability of the coating and required curing conditions for the glue – conventional hot melt and EVA adhesives can be used. Check with a specialist glue supplier to get the right formulation.

Perfect bound book covers: If the outside of the cover is coated then so should the inside to prevent the cover from warping. It is essential to leave a coating-free strip for glueing the text block back and sides to the cover. Coated or laminated covers should be scored in the spine and side glueing area. The paper grain direction of the cover should always be parallel to the book spine, even if the content has signatures running in the wrong direction.

Laser overprinting: Normally there is good adhesion of overprinting except on UV varnishes containing slip agents. However, there is a risk of build-up on the fusing roller from the high temperature – certain ink colours with low heat resistance may discolour.

Ink jet overprinting: Because these inks can be either water- or solvent-based it is extremely important to pre-test their adhesion onto a UV coating; alternatively, leave a coating-free area for overprinting. UV ink jet using digital delivery is a recent development.

Heat sealing: UV coating is generally only resistant with PP (polypropylene); do not use XS films. MAST cellophane may be suitable but should be pre-tested.

Production diagnostics

SYMPTOMS

PRIMARY CAUSES

Tone value increase

1. The ink is absorbing too much water or the ink/water balance is incorrect.
2. Incorrect damping solution composition – check the alcohol content (7.5-8% is recommended). Experience shows that too high pH value contributes to tone value increase.
3. Ink build-up from too much water absorption (among other cause).
4. On film substrates, printing pressure is too high (max. 1/10 mm).
5. Cylinder rolling incorrect (check cylinder dressings and whether plate inking rollers and blankets are swollen). Incorrect blankets; check carcasse condition of blanket. Foil underpacking beneath the blankets might help.
6. Plate exposure/tone value curve incorrect.
7. Ink tack is incorrect leading to ink splitting problems.
8. Ink feed too high (check intensity/density).
9. Faulty curing (“blotting paper effect” on very absorbent substrates, binding agent depletion).

Ghosting

1. Poor ink distribution.
2. Pigmentation of ink is too low.
3. Ink distribution in the ink roller train not balanced (too much ink on forme rollers 3 and 4 compared to 1 and 2).
4. Check oscillation timing of ink distributors.
5. Switch on oscillation mode of ink forme rollers.
6. Rollers in poor condition.

Ink not sufficiently cured

1. Ink/water balance incorrect; or too much ink and water leading to ink film thicknesses that cannot harden.
2. Surface inhibition of lacquers.
3. Unsuitable exposure; drying disturbed by shadows (or something else).
4. Insufficient dryer output.
5. Unsuitable lamps; the lamp emission does not harmonise with the sensitivity spectrum of the photoinitiators.
6. Too-high lamp temperature shifts emitted wavelengths.
7. Over-cooled lamp reduces radiation intensity.
8. Old lamps with inadequate radiation emission. Lamps should be changed after 1 000 – 1 500 operating hours.
9. Lamps/reflectors are soiled, e.g. lamp output diminished by paper dust.
10. Printing speed too high; not enough time for the lamps to be effective.
11. The photoinitiators are not harmonised or insufficient.
12. The substrate is soiled, reactions with foreign matter on the sheet.
13. Residue of conventional binding and washing agents on the rollers Curing disturbance only occurs when printing starts and disappears very quickly if traces of conventional ink or washing agent are in the inking unit.

Ink specks on the sheet

1. Too much water.
2. Check temperature variations.
3. Incorrect ink flow.

Inks become lighter in colour

1. Insufficient ink feed. Ink gets stiff in ink fountain (solution is an ink agitator).
2. Too much water or wrong ink / water balance
3. Ink build-up on the blanket.
4. Poor ink trapping (subject accepts too little ink, inks clog).
5. Coating dissolves the ink (see magenta test); the coating slightly etches the ink films, which then slightly stains the coating.

Low rub resistance / scratch resistance

1. Films not pre-treated; insufficient surface tension prevents the ink from bonding well to the substrate. Either apply a primer or corona treatment. Surface tension on plastic film can be easily checked with a special test ink. Recommended surface tension should be 40 mN/m or, even better, 44 mN/m.
2. The ink used is unsuitable for the substrate; contact your ink supplier.

Poor ink transfer

1. Substrate surface tension is too low.
2. Pre-polymerisation of the ink, ink splitting is disturbed.
3. Ink is too tacky – see previous point.
4. Excessive washing of the rollers/blankets; washing agent residue remains on the rollers. This problem resolves itself during printing.
5. Incompatible roller covering or blanket surface.
6. Damaged rollers or blankets surfaces from incompatible washing agents.
7. Incorrect ink/water balance
8. Deposits on inking rollers due to calcium in the damping fluid.

Odour formation

1. Odour may come from the paper coating if it is sensitive to UV exposure.
2. Inks with a high percentage of low molecular binding agents and initiators tend to produce an odour.

Roller streaks

1. Plate inking rollers that are too hard; recommended roller hardness is 25° - 30° Shore.
2. The rubber rollers are too smooth.
3. The ink is accepting too much dampening solution.
4. The water feed to the printing plate is too high.
5. Check the inking and damping roller settings; set the plate inking rollers with less pressure to the distributor and the plate.
6. Ink charge is too high due to too low ink pigmentation.
7. Poor ink splitting; unfavourable ink consistency, water runs into the inking unit.

Smearing

1. Roller swelling; incorrect roller material causes dimensional change and thus changes the plate-to-inking roller contact settings.
2. Wrong washing agent can also cause roller swelling.
3. Washing agent in the inking unit.
4. Residue of conventional inks or washing agents.
5. The contact pressure of the plate damping rollers is too high.
6. Worn roller coverings contribute to poor water feeding.
7. Roller coverings are dirty.
8. Ink feed is too high.
9. Incorrect washing of the coverings.
10. Not enough alcohol additive in the dampening solution, which causes the surface tension of the solution to rise (7.5% is recommended).

Scumming

1. The pH value of the dampening solution is incorrect (4.8 – 5.2 recommended).
2. Roller hardness and/or contact settings incorrect.
3. Plate inking rollers set too firmly to the ink distributor.
4. Plate inking rollers contact setting.
5. Unsuitable dampening solution additive.
6. Printing pressure is too high.
7. Unsuitable plates.
8. Washing agent residue in the inking unit and/or dampening unit.
9. Swollen plate inking rollers impairs rolling.
10. Poorly mixed additives not spread evenly through the ink.
11. The ratio of water feed to ink feed is incorrect (as little ink and water as possible).
12. Inking unit temperature is too high causing the dampening solution to evaporate.
13. Incorrectly baked plates because gumming of the plate was not thoroughly cleaned off before exposing the plate.

**Emulsification, unstable
ink emulsification**

1. Higher risk with black, spot colors and white.
2. Water feed is too high contributing to the dampening solution “migrating” into the inking unit.
3. Unsuitable dampening solution additives. Surface tension-reducing additives increase the risk of emulsification.

Print image not sharp

1. Wrong plate-blanket packing.
2. Ink too thin or too short causes poor transfer to the substrate.
3. Incorrect substrate surface tension (dot contracts or spreads on the substrate).

Uneven surface hardness

1. Soiled lamp; paper dust or similar prevents the ink film from drying evenly.
2. Too much water in the ink. Contact your ink supplier.

Blanket / roller swelling

1. Incorrect roller or blanket material.
2. Incorrect washing agent.
3. Incorrect ink.



Adphos-Eltosch

Eltosch is a world leader in drying systems that guarantee optimal results in the most demanding applications. Eltosch pioneered radiation technologies and provides single-source expertise for UV, IR and NIR radiation and hot air drying technologies. Innovative milestones include plug-in technology, Dichroselect-S for cooler UV, Inert UV for sheetfed presses and the new WhiteCure UV module. Constant feedback provides the basis for technical innovation that has been essential to develop the UV/IR/HA dryer system for inline coating using cross-linking, silicon curing and coating techniques. Founded in 1967, Eltosch was acquired by Adphos AG in 2001 and is based in Hamburg; the company provides worldwide sales and service. www.adphos.de



Böttcher

Böttcher GmbH & Co. KG — project associate

Böttcher is the world's number one manufacturer of rubber covered rollers for the printing industry. Böttcher-developed washes, cleaning pastes, fountain additives as well as the BöttcherTop blanket series completes the product range for printing applications. The presence in more than 80 countries, with 17 production facilities as well as 30 sales and service units, makes Böttcher a global player. As OEM supplier for many press manufacturers Böttcher underlines its leading position as technology partner and system supplier. www.boettcher.de



MAN Roland Druckmaschinen AG

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Sun Chemical Corporation

Sun Chemical, the world's largest producer of printing inks and pigments, is a leading provider of materials to packaging, publication, coatings, plastics, cosmetics, and other industrial markets. With annual sales over \$3 billion and 12,500 employees, Sun Chemical supports customers around the world and operates 300 facilities throughout North America, Europe, Latin America and the Caribbean. The Sun Chemical Group of companies includes such well-known names as Coates Lorilleux, Gibbon, Hartmann, Kohl & Madden, Swale, Usher-Walker and US Ink. Additionally, Sun Chemical has many joint ventures, with the largest being its \$1.5 billion Kodak Polychrome Graphics joint venture with Eastman Kodak. www.sunchemical.com



Trelleborg

Trelleborg (Vulcan from Reeves) is one of the world's largest manufacturers of offset printing blankets with the most comprehensive product line on the market. Vulcan offset printing blankets have been manufactured and distributed all over the world for more than 80 years. Trelleborg keeps on investing in their plants in Italy and the USA, and now has also formed a majority owned joint-venture company in China with the purpose of manufacturing and selling blankets in this fast growing market. Vulcan technology and know-how is a real cost-competitive advantage for end users. Trelleborg's skilled application specialists and their partnership with their distributors help to provide printing quality around the world to ensure immediate assistance to printers whenever and wherever it is required. www.trelleborg.com/vulcan



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