Coatings have evolved from a simple protective layer of gloss to an attractive design medium for accentuating spots or solids. The creative use of coatings gives rise to products whose visual and tactile properties make them stand out from the pack. And print providers can exploit coating as a value-added service to differentiate themselves from their competitors. Sumptuous matt/gloss effects can be created on hybrid or two-coater presses, metallic and lustre coatings impart unusual optical effects, scented coatings appeal to our sense of smell, scratch-off coatings introduce an element of surprise, blister and adhesive coatings give packaging rigidity, UV coatings enhance the inherent properties of folding cartons, plastic film and cards...

For many applications, inline coating has long since become established as a high-quality, cost-effective alternative to offline coating in special coaters or screen-printing machines. More than half the medium- and large-format sheetfed presses shipped today are configured with at least one coater. And print providers experienced in inline coating are becoming ever more adventurous. One consequence of this is that coating specialists are focusing more and more on applications that cannot be implemented offline.

If the customer so specifies, Koenig & Bauer can equip its small-, medium-, large- and superlarge-format Rapida press and its small-format Performa and Genius S2UV presses with auxiliaries for coating to the highest quality standards. The most popular types of coating, in conjunction with an extended delivery, mobile plug-in interdeck and end-of-press dryers and automatic coating change, are:

- aqueous or UV coating in commercial and packaging presses fitted with one coater,
- overprint varnish and UV or aqueous coating in hybrid presses fitted with one coater,
- aqueous plus UV or special-effect coating in a press fitted with two coaters.

Special configurations also allow perfect coating or the application of a primer and/or special-effect coating prior to impression. The coater version of the 74 Karat has now become the standard configuration. KBA even offers the option of integrating non-KBA coating modules in its Compacta commercial web offset and TR publication rotogravure presses.

The various types of coating interact with inks and substrates in different ways. How they interact has a direct bearing on the type of dryer that should be used. This is just one of the many practical issues discussed in detail on the following pages. Others include the optimum coating viscosity, recommended anilox rollers and coating formes, and diverse aspects of process technology. In this context, reference is made throughout this publication to the findings announced at the coating seminar which KBA held last year in Dresden. There is also a wealth of practical tips. The extensive know-how and in-depth experience in inline coating that KBA and its partners bring to the table have been summarised in a compact and easily comprehensible form. As in previous issues of KBA Process, we strive to maintain an objective presentation of the process technologies, their benefits and drawbacks, and the potential savings, quality gains and range of applications that are possible.
Exploit hybrid to raise your profile

Since the first publication in 2002, KBA Process has been a source of knowledge and information on technologies, processes and markets relating to sheetfed applications that are outside the mainstream. Previous issues discussed direct offset on corrugated, environmentally friendly waterless offset and hybrid finishing with UV- and oil-based inks and coatings – a technology that KBA has successfully launched on the market following intensive post-Drupa 2000 development work.

In issue number 4 of KBA Process we discuss the subject of inline coating in much greater detail. This is because alongside the hybrid process there are many other options for hitting the mark among customers and consumers alike with superbly finished products. The authors have done their best to present this highly complex subject in a compact and practical form that is also comprehensible to non-chemists. A wealth of charts, tables, graphics and illustrations furnishes an in-depth yet wide-ranging insight into the current state of the art in coating, the consumables available on the market, the technologies involved and the practical and theoretical knowledge gained, interspersed with invaluable advice. This publication also draws on the findings of a coating seminar which KBA held in Dresden in 2006, and which attracted a record 800 print professionals.

With editorial assistance from trade journalist Dieter Kleeberg we have created a comprehensive coating compendium with useful tips for all those who wish or need to delve more deeply into the subject of coating, whether with a view to installing a new press, addressing a new market or enhancing the daily production routine, or as part of a training programme.

We shall continue to keep you updated on the steadily proliferating options available for inline finishing, occasionally making our own contribution towards advancing the technology. And we aim to continue actively promoting the strengths of printed products well beyond our 190th anniversary. We would be delighted if some of the ideas and advice contained in this publication were to find applications in your own business operations.

Yours,

[Signature]

Ralf Sammeck, executive vice-president sheetfed sales, Koenig & Bauer AG

In a society heavily exposed to advertising on an unprecedented scale, the opportunities for promoting the image of printed products such as business reports, luxury magazines and catalogues, displays and, more particularly, point of sale packaging lie in creating an eye-catching visual impact, a certain texture, a tantalising interplay of contrasting gloss and matt effects, an unusual form and, increasingly, an appealing scent or aroma appropriate to the content. As the market leader in large format, KBA is well positioned in the packaging and display sectors. Not only that: we provide the technology for inline coating on paper, board or plastic in just about every press format. Few manufacturers can compare with us when it comes to engineering customised coating and finishing equipment for sheet sizes ranging from small to superlarge.
Overview of coating types

A coating for every purpose – that just about sums up manufacturers’ prolific offerings. At first glance printers are spoilt for choice, but on closer inspection the options are narrowed down by the technology used to apply the coating, the system used to harden it and the specific demands made upon the finished product. Inevitably, interaction among the properties and functions listed on the label will not be confined to the desirable ones for which they were formulated, so the printer must always be on the watch for unexpected ‘side effects’ that may impact on coating compatibility and finishability.

Coatings are distinguished both by their composition and, deriving from this, the principle by which they harden: physically (drying) and/or chemically (curing, polymerisation). Aqueous coatings and UV-cured coatings are the most common, while solvent-based coatings – are found solely in flexo and gravure production. In recent years overprint varnishes – non-yellowing versions of which have been available for some time now – have experienced a renaissance, particularly in conjunction with a UV or aqueous gloss coating. Aqueous coatings boast the broadest range of applications. For traditional high-gloss finishes, however, UV coatings are the prime choice.

Water-based coatings (aqueous coatings)

Water-based coatings form a film physically, through the evaporation or absorption of the carrier (water) and the precipitation of the particles dispersed (suspended) in it, which coalesce on the substrate. The particles are predominantly acrylate polymers; hardening by polymerisation is anticipated, as it were, during manufacture. Film formation is facilitated by hydrosols – resins and other substances dissolved in water – which cement the polymer particles together and enhance their ability to adhere to the substrate. Other substances contained in the coating improve its processability: anti-foam agents prevent foaming on the anilox roller in the doctoring system, while surfactants help ensure that the substrate or inked image surface is properly wetted by reducing the surface tension or, in the case of the primer, that the aqueous coating is properly wetted by the subsequent UV coating. Retardants can improve coating spread if the delivery is short. Other additives serve to intensify desirable properties. They are usually dispersed wax particles (to counteract abrasion, scratching and set-off and to enhance gloss, mattness, sealability, UV-coatability etc), though they can also take the form of special-effect pigments (pearl gloss, metallic) and aromatic substances.

Earlier aqueous coatings were applied via the dampening duct, and the quality was correspondingly poor. And there are still some presses around that are fitted with two-roller coating units. But KBA customers have long since switched to specifying anilox coaters, which deliver the best possible coating quality and support a wider range of applications.

Unfortunately, the benefits of such a wide range of applications are offset by the energy-intensive drying methods that aqueous coatings demand. This is because, unlike radiation-cured coatings and oil-based varnishes, they contain nowhere near 100 per cent solid matter. In practice, this means that not all the substances contained in the aqueous coating remain on the substrate. As we have already mentioned above, the water applied with the rest of the coating must be made to evaporate, which entails an excessively high input of energy. On top of this, alongside infrared radiation units it is necessary to install a...
## Coatings | Composition, properties

### Properties and possible applications of commonly used coatings

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Aqueous coating</th>
<th>Radical UV coating</th>
<th>Cationic UV coating</th>
<th>Overprint varnish</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cost efficiency:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Price</td>
<td>budget</td>
<td>dearer than aqueous coatings</td>
<td>dearer than radical UV coatings</td>
<td>same as conventional varnish</td>
</tr>
<tr>
<td>Method of application</td>
<td>doctor blade recommended</td>
<td>doctor blade recommended</td>
<td>doctor blade required</td>
<td>in final offset printing unit</td>
</tr>
<tr>
<td>Press handling</td>
<td>scarcely dries on coating forme</td>
<td>does not dry on coating forme</td>
<td>does not dry on coating forme</td>
<td>like ink; can be run with ink</td>
</tr>
<tr>
<td>Drying/curing input</td>
<td>very high energy input, possibly hot-air knife, vapour extraction</td>
<td>either long dwell section or high energy input</td>
<td>short dwell section, low energy input</td>
<td>no specific dryer input</td>
</tr>
<tr>
<td>Emitter life</td>
<td>infrared emitters and hot-air knife; relatively long</td>
<td>UV lamps; relatively short, drift from UV-C to UV-A</td>
<td>UV lamps; relatively short, drift from UV-C to UV-A</td>
<td>—</td>
</tr>
<tr>
<td>Range of applications</td>
<td>very broad (mainly in sheetfed offset)</td>
<td>broad (mainly sheetfed offset, screen and flexo)</td>
<td>broad (mainly flexo, narrow-web offset, rarely sheetfed offset)</td>
<td>abrasion protection (sheetfed offset); gloss contrasts (hybrid, strip-off)</td>
</tr>
</tbody>
</table>

### Drying (physical), curing (chemical):

- **Principle:**
  - Aqueous coating: dries by evaporation
  - Radical UV coating: radical UV radiation curing
  - Cationic UV coating: cationic UV radiation curing
  - Overprint varnish: cures by oxidation, dries by penetration

- **Film-forming agent:**
  - Aqueous coating: pre-polymerised particles suspended in water
  - Radical UV coating: mainly acrylic resins (AC) that polymerise when exposed to UV radiation; 100% solid matter
  - Cationic UV coating: epoxy (EP) and special resins that polymerise when exposed to UV radiation; 100% solid matter
  - Overprint varnish: hardened and alkyl resins react with oxygen-bridge bonds; 100% solid matter

- **Initial reaction:**
  - Aqueous coating: water evaporation through heat radiation and vapour extraction
  - Radical UV coating: photoinitiators split negatively charged organic radicals when exposed to UV-C radiation
  - Cationic UV coating: photoinitiators release positively charged cations when exposed to UV-C radiation
  - Overprint varnish: impact of atmospheric oxygen

- **Setting time:**
  - Aqueous coating: short (1 s)
  - Radical UV coating: very short (1/100 s)
  - Cationic UV coating: very short (1/2 s)
  - Overprint varnish: very long

- **Film-forming process:**
  - Aqueous coating: polymer particles and hydrosols coalesce
  - Radical UV coating: only while exposed to radiation (UV-8 maintains curing reaction, UV-A acts deep in layers)
  - Cationic UV coating: single radiation pulse (UV-C) initiates chain reaction culminating in complete curing
  - Overprint varnish: only while exposed to atmospheric oxygen

- **Facilitating factors:**
  - Aqueous coating: maintains prescribed minimum temperature for film formation
  - Radical UV coating: inert nitrogen atmosphere, waste heat from UV lamp
  - Cationic UV coating: waste heat from UV lamp
  - Overprint varnish: heat, absorbent substrate

- **Inhibiting factors:**
  - Aqueous coating: cold air flow
  - Radical UV coating: atmospheric oxygen
  - Cationic UV coating: moisture; low temperatures, alkaline paper coating
  - Overprint varnish: cold, moisture

- **Economical use of excimer emitter:**
  - Aqueous coating: —
  - Radical UV coating: inert chamber or HF generator, special photoinitiators and prepolymer needed
  - Cationic UV coating: inert chamber or HF generator, special photoinitiators and prepolymer needed

### Runnability:

| Viscosity | low; suitable for pump and doctoring systems | low; suitable for pump and doctoring systems | very low; highly suitable for pump and doctoring systems | relatively high to pasty |
| Tendency to spread | high; beneficial for high gloss, combats shrinkage during curing | high; beneficial for high gloss, combats shrinkage during curing | low; despite low viscosity; detrimental to gloss formation, beneficial for structured effects | low; beneficial for structured and matt effects |
| Tendency to mist | relatively high, restricts press speed | relatively high, restricts press speed | relatively high, restricts press speed | low |
| Thin layers | poor, ie spotty | poor, ie may not cure right through | cure fast right through | like ink |
| Thick layers | dry sufficiently well and uniformly | cure slowly | cure right through even faster, cause brittleness | not possible |

### Printability and finishability:

| Adhesion on absorbent materials | very good | good | primer advisable for alkaline paper coatings | very good |
| Adhesion on synthetic film and metallic foil | only special types of aqueous coating | with prior static elimination good on PE and PP | very good on all films and foils | very poor |
| Compatibility with laminate/glue | specifically seal-on, blister coatings etc | average; gloss coatings better than high-gloss coatings | good | good |
| Compatibility with scoring/folding/embossing | relatively poor, because layer is brittle | relatively poor, because layer is brittle; good printability | good, because layer is elastic; good printability | very good, because thin layer is elastic; good printability |

#### Emissions and migration:

- **Ozone emission:**
  - Aqueous coating: none
  - Radical UV coating: high (multiple powerful UV lamps; ozone extraction required)
  - Cationic UV coating: low (few weak emitters)
  - Overprint varnish: none

- **Heat emission:**
  - Aqueous coating: very high (delicate), high (lamp housing cooled)
  - Radical UV coating: high (lamp housing cooled)
  - Cationic UV coating: high (lamp housing cooled)
  - Overprint varnish: none

- **Odour emission:**
  - Aqueous coating: possibly ammonia during impression; none when dry (suitable for food packaging)
  - Radical UV coating: inherent coating odour and ozone odour during impression; low or none when cured
  - Cationic UV coating: minimal ozone emission during impression; none when cured (ideal for food packaging)
  - Overprint varnish: same as conventional ink

- **Migration:**
  - Aqueous coating: none (suitable for food packaging); barrier coatings available to combat migration
  - Radical UV coating: only fully cured or migration-free coatings should be used for food packaging
  - Cationic UV coating: none, because coating cures right through (ideal for food packaging)
  - Overprint varnish: yes
Selection of coatings according to their visual and functional properties and offset compatibility

<table>
<thead>
<tr>
<th>Selection criteria, specification</th>
<th>Aqueous coatings</th>
<th>Radiation-cured coatings</th>
<th>Overprint varnishes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gloss (microstructure, based on spread characteristics):</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High gloss</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>Gloss</td>
<td>yes (primer also)</td>
<td>yes (primer also)</td>
<td>yes</td>
</tr>
<tr>
<td>Neutral</td>
<td>yes (primer also)</td>
<td>overprint pastes only</td>
<td>yes</td>
</tr>
<tr>
<td>Silk matt</td>
<td>yes</td>
<td>yes (overprint pastes also)</td>
<td>yes</td>
</tr>
<tr>
<td>Matt</td>
<td>yes (primer also)</td>
<td>yes (overprint pastes also)</td>
<td>yes</td>
</tr>
<tr>
<td>Dull matt</td>
<td>yes</td>
<td>yes (overprint pastes also)</td>
<td>yes</td>
</tr>
<tr>
<td><strong>Macrostructure (special coatings):</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Structuring, granulating coating</td>
<td>no</td>
<td>yes</td>
<td>yes (offline also)</td>
</tr>
<tr>
<td>Contour coating</td>
<td>no</td>
<td>yes (mainly offline)</td>
<td>no</td>
</tr>
<tr>
<td>Relief coating</td>
<td>no</td>
<td>yes (only offline)</td>
<td>no</td>
</tr>
<tr>
<td><strong>Gloss contrast (special coating combination):</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hybrid coating (UV high-gloss coating on matt/granulating overprint varnish)</td>
<td>no</td>
<td>yes (full-solid)</td>
<td>yes (partial)</td>
</tr>
<tr>
<td>Drip-off coating (aqueous gloss coating on matt/granulating overprint varnish)</td>
<td>yes (hot, full-solid)</td>
<td>no</td>
<td>yes (partial)</td>
</tr>
<tr>
<td>Twin effect coating (aqueous gloss coating on matt/granulating overprint varnish)</td>
<td>yes (cold, full-solid)</td>
<td>no</td>
<td>yes (partial)</td>
</tr>
<tr>
<td><strong>Smoothness (special coatings):</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glide-effect coating (for automated high-speed packaging machines), playing card coating</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>Non-slip coating, non-slip coating</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td><strong>Physical stability:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abrasion- and scratch-free when dry or wet</td>
<td>yes (suit for labels)</td>
<td>yes (basically all UV and EB coatings)</td>
<td>yes (special overprint paste)</td>
</tr>
<tr>
<td>Heat- and frost-resistant</td>
<td>yes</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>Form-stabilising, anti-curl</td>
<td>yes (for label stock)</td>
<td>no</td>
<td>yes (for thin paper)</td>
</tr>
<tr>
<td>Non-crack, non-crack</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td><strong>Chemical stability (non-reactive, antimigratory):</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UV-resistant, slow aging</td>
<td>yes (non-brittle, non-yellowing)</td>
<td>yes (non-brittle, non-yellowing)</td>
<td>yes (non-yellowing formulae available)</td>
</tr>
<tr>
<td>UV filter (enhances light-resistance)</td>
<td>yes</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>Alkali-resistant (eg for cosmetics)</td>
<td>yes</td>
<td>yes (basically all UV and EB coatings)</td>
<td>no</td>
</tr>
<tr>
<td>Acid-resistant</td>
<td>yes</td>
<td>yes (basically all UV and EB coatings)</td>
<td>no</td>
</tr>
<tr>
<td>Barrier against fat, oil, water (vapour*)</td>
<td>yes</td>
<td>yes (basically all UV and EB coatings)</td>
<td>no</td>
</tr>
<tr>
<td>Low-odour (irrespective of ink and paper coatings)</td>
<td>yes (suitable for food packaging)</td>
<td>yes (radial UV)</td>
<td>yes (special overprint paste)</td>
</tr>
<tr>
<td>- suitable for food packaging</td>
<td>yes, in general</td>
<td>no direct contact with packaging, ITX-free</td>
<td>no</td>
</tr>
<tr>
<td>Odour- and migration-free (irrespective of ink and paper coating)</td>
<td>yes (suitable for food packaging)</td>
<td>yes (cationic UV and EB)</td>
<td>yes (special overprint paste)</td>
</tr>
<tr>
<td>- suitable for food packaging</td>
<td>yes, in general</td>
<td>+ cationic UV and EB always, radical UV from some manufacturers, ITX-free</td>
<td>yes</td>
</tr>
<tr>
<td>Compliant with pharmaceutical codes**</td>
<td>yes</td>
<td>yes (often EB coating)</td>
<td>yes</td>
</tr>
<tr>
<td><strong>Microbiological stability:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fungicidal and antibacterial</td>
<td>yes</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td><strong>Incorporating special-effect pigments (possibly with protective top coating):</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Incorporating interference pigments (pearlescent gloss, colour change)</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>Incorporating gloss and glitter pigments (metal oxide, bronze)</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Incorporating fluorescent pigments</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>Incorporating counterfeit-proof pigmented features</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>Primer for special effects</td>
<td>yes</td>
<td>yes</td>
<td>yes (eg MetalFX Base ink)</td>
</tr>
<tr>
<td>Incorporating aromatic substances</td>
<td>yes</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td><strong>Incorporating specific functional properties:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Can be heat-sealed ( blister coating)</td>
<td>yes</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>Bonds with water-based or hot-melt glue (skin coating)</td>
<td>yes</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>Can be sealed by ultrasound</td>
<td>yes</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>Can be embossed (for hot-stamping foil and thermal transfer printing)</td>
<td>yes</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>Flexible (for scoring and grooving)</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Can be laminated with thin synthetic film</td>
<td>yes</td>
<td>unusual</td>
<td>unusual</td>
</tr>
<tr>
<td>Can be used as release coating (pre-print application for rub-off inks)</td>
<td>yes</td>
<td>no</td>
<td>no</td>
</tr>
</tbody>
</table>

* Water vapour and condensation thresholds as per MVTR (moisture vapour transmission rate);
** eg FDA Code (US Food & Drug Administration), PQG Code (UK Pharmaceutical Quality Group), Leitfaden Gute Herstellungspraxis Pharma-Verpackung (Germany/Switzerland)
Coatings | Composition, properties

Vapour extractor and maybe also a hot-air knife. If thermal drying is too rapid it can cause the coating to craze (crackle), especially on areas with a lot of ink laydown. Twin-tube carbon emitters have a higher level of efficiency, and are integrated in KBA's VariDry dryers for the Rapida press series. High-frequency drying is about to enter the beta testing stage at a prominent manufacturer of emitters: the wavelengths only excite the water molecules and cause them to evaporate, while the polymer molecules remain unaffected – the substrate and the surroundings are not warmed in the process. The drawbacks are that aqueous coatings must be used, which are low in resin-based solvents that also vaporise. Furthermore, this method is unsuitable for substrates that are foil-laminated or feature metallic strips or pigments.

**UV-cured coatings (UV coatings)**

Ultraviolet light is the dominant form of radiation used to cure coatings. In practice, applications entailing conventional, ie radically curing UV coatings, outweigh all others. Epoxy resin-based, cationically cured UV inks and coatings,

---

**Selection criteria, specification**

<table>
<thead>
<tr>
<th>Aqueous coatings</th>
<th>Radiation-cured coatings</th>
<th>Overprint varnishes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Interaction:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adhesion on ink</td>
<td>on oxidative inks</td>
<td>on UV and hybrid inks (after intermediate UV curing)</td>
</tr>
<tr>
<td>Compatibility with other coatings for inline applications</td>
<td>with other aqueous coatings and as primer with UV coatings</td>
<td>with other UV coatings and on aqueous primer</td>
</tr>
<tr>
<td><strong>Runability:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low viscosity (for pumps and doctor blades) no</td>
<td>yes (as a rule)</td>
<td>no</td>
</tr>
<tr>
<td>Higher viscosity (for roller distribution) no</td>
<td>seldom as overprint paste</td>
<td>as overprint varnish/paste</td>
</tr>
<tr>
<td>Foaming</td>
<td>very little</td>
<td>very little</td>
</tr>
<tr>
<td>Temperature range</td>
<td>relatively small, depends on coating formula</td>
<td>small (heating module advisable)</td>
</tr>
<tr>
<td>Base well wetted</td>
<td>key option</td>
<td>key option</td>
</tr>
<tr>
<td>Dwell section</td>
<td>short one is adequate</td>
<td>as long as possible</td>
</tr>
<tr>
<td>Fast drying/curing</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>No blocking or set-off when wet or dry</td>
<td>key option</td>
<td>key option</td>
</tr>
<tr>
<td><strong>Method of application:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inline</td>
<td>via coater or auxiliary unit</td>
<td>via coater or ink duct</td>
</tr>
<tr>
<td>• wet-on-wet, one side</td>
<td>• yes (primer also)</td>
<td>• yes</td>
</tr>
<tr>
<td>• wet-on-wet, both sides (perfect coating)</td>
<td>• yes (primer also)</td>
<td>• yes</td>
</tr>
<tr>
<td>• wet on dried ink</td>
<td>• unusual</td>
<td>• yes</td>
</tr>
<tr>
<td>• wet on dried coating</td>
<td>• yes (two coatings or on special-effect coating)</td>
<td>• yes</td>
</tr>
<tr>
<td><strong>Offline</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wet-on-dry</td>
<td>in flexo, screen or sheetfed gravure printing</td>
<td>calender, screen printing</td>
</tr>
<tr>
<td>• yes (possibly primer)</td>
<td>• yes</td>
<td>• yes</td>
</tr>
<tr>
<td><strong>Inline print production:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coating applied in wet offset</td>
<td>sheetfed offset, heatset</td>
<td>sheetfed offset, heatset, narrow web</td>
</tr>
<tr>
<td>Coating applied in waterless offset</td>
<td>sheetfed offset, 74 Karat</td>
<td>sheetfed offset, narrow web</td>
</tr>
<tr>
<td>Coating form</td>
<td>rubber blanket or photopolymer flexo plate</td>
<td>UV/hybrid-compatible blanket or flexo plate</td>
</tr>
<tr>
<td><strong>Substrate (irrespective of ink already applied):</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paper, cartonboard, corrugated cardboard (direct): yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Highly absorbent paper and cardboard</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>Plastic film</td>
<td>special</td>
<td>yes</td>
</tr>
<tr>
<td>Metallic foil</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>Sheet metal</td>
<td>yes (bakable)</td>
<td>yes</td>
</tr>
<tr>
<td><strong>Environmental impact:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Positive</td>
<td>odour- and migration-free, generally VOC-free, non-hazardous, biologically degradable</td>
<td>always VOC-free</td>
</tr>
<tr>
<td>Negative</td>
<td>high energy input for drying, de-inkable only with additional application of water</td>
<td>ozone emitted during curing, poor de-inkability</td>
</tr>
</tbody>
</table>

The KBA Rapida 105 6-colour two-coater press at Italian printer Vimer in San Giustino primarily prints displays for manufacturers of cosmetics brands. Not only can it apply a UV gloss coating over primer, but thanks to its modular drying system it can also combine a gloss with a matt aqueous coating.
which first hit the market in the 1980s, offer a raft of benefits, first and foremost the fact that they cure all the way through – albeit slowly – and are suitable for food and drug packaging.

UV coatings consist of synthetic resins with an embedded photoinitiator. The free radicals or cations released upon exposure to UV-C radiation trigger the hardening process in the synthetic resins. Developers of UV coatings for pharmaceutical and food packaging take care to use photoinitiators which, when split, do not release products that migrate or are hazardous to health (see chapter on migration-free packaging on pages 19-21). If energy-saving excimer lamps are to be the source of radiation, then UV inks and coatings must be used in which the photoinitiators are specifically formulated for UV-B and only react with specific synthetic resin prepolymers. Synthetic resins in which the photoinitiators trigger polymerisation when they split are composed of reactive organic molecules – some monomolecular (monomers), some pre-cross-linked on a low level (oligomers, prepolymers).

Because cationic coatings contain photoinitiators formed from organic acids, they are unsuitable for alkaline substrates (eg paper whose coating includes calcium carbonate) since there is a risk that the sheets will block and gloss be impaired. If the emphasis is on coating properties and quality rather than cost efficiency then a cationic coating will require a prior application of primer to seal the substrate. Radical coatings consequently have a broader, more differentiated range of applications than cationic ones – among them hybrid production in conjunction with a matt or granulating overprint varnish.

UV coatings are predominantly used as clear high-gloss coatings, less often as matt or metallic-effect coatings. They can easily be combined with UV-curable inks, provided the inks are cured in an inter-deck dryer prior to coating. If a UV coating is to be applied to conventional inks then a water-based primer must be applied in advance to seal the surface, and this primer must be dried immediately. Two-coater presses were designed specifically for such applications. With hybrid inks there is no need for this energy-intensive intermediate application of primer because a UV coating can be applied directly. No primer is normally needed if a UV coating is applied to conventional inks offline. If UV coatings are applied inline, the 8µm (0.3 thou) thick coating layers deliver a high degree of gloss because the coating has excellent flow characteristics. Offline coating machines can apply even thicker layers of coating and thus deliver gloss levels of 100 with ease. Both methods represent a viable alternative to lamination.

Electron beam-cured coatings (EB coatings)

Unlike UV coatings, EB coatings require no photoinitiator to trigger the initial reaction. This is because electron beams – just like the adjacent x-ray and nuclear radiation beams in the spectrum – are “hard” beams or, more correctly, ionising beams, which means that they can split and release reactive free radicals in the coating resin without the stimulus provided by a photoinitiator.

The electron beams, which are equally destructive for human cells and micro-organisms, are generated in a high vacuum by a tungsten wire cathode, accelerated by high voltage through a ring anode and applied to the substrate through a titanium foil beam hole in an inert gas atmosphere. Because of the health hazard posed by the electron beams, and by the equally dangerous x-rays that are generated when the electron beams are slowed in the coating, the system must be securely encapsulated and personnel regularly checked with a dosimeter. The technical input is also substantial, though for packaging printers not excessive. The most expensive EB systems are to be found in the furniture industry. While the systems available for printing presses cost little more than a complete UV package, the running costs should not be underestimated. The biggest item is the nitrogen required for the inert gas chamber that prevents the atmospheric oxygen from ionising. Energy consumption, by comparison, is almost negligible.

Electron beam curing does, in fact, offer a raft of beneficial properties:

- It is antimicrobial and generates neither odours nor migratory substances – EB-cured inks and coatings are therefore ideal for sterile folding cartons made of cardboard or compounds (eg Tetra-Pak drinks cartons), or foil packaging for the pharmaceutical and food industries.

- For flexo printers in particular, an EB coating is an economical alternative to laminating with oriented polypropylene (OPP) film.

A fine example of the gloss contrasts possible with hybrid coating: a granulating overprint varnish was applied as a spot coating on hybrid inks, followed by a full-solid UV gloss coating which was repaired by the OVP. The two-dimensional coating effect can compare with three-dimensional embossing.

*For flexo printers in particular, offer a raft of beneficial properties:

- It is antimicrobial and generates neither odours nor migratory substances – EB-cured inks and coatings are therefore ideal for sterile folding cartons made of cardboard or compounds (eg Tetra-Pak drinks cartons), or foil packaging for the pharmaceutical and food industries.

- For flexo printers in particular, an EB coating is an economical alternative to laminating with oriented polypropylene (OPP) film.

The cost savings exceed 10%.

- The deep impact of EB radiation and its ionising capability (as much as 50% of solid matter) can be set via the voltage (150 to 250 kilovolts), so curing is always fast and completely thorough. EB radiation is even effective on ultrathin layers of coating – an asset which furniture makers are not alone in appreciating – and through the substrate, so perfect-coated paper, carton and synthetic films need only be irradiated on one side in order to cure the coating on both sides in a few microseconds.

- The energy input required is roughly one-third of that for UV curing and just one-sixth of that for IR drying. Yet the efficiency level is high: between 90 and 95% of this energy is utilised, compared to just 50% with UV.

- EB radiation is “cold”– the electron beam curtain generates no heat, so even heat-sensitive substrates can be coated with ease, provided the radiation has no direct detrimental impact at the molecular level.

- The same acrylate binding agents are used as in radically-cured UV coatings, but without the costly photoinitiators, so EB coatings are cheaper to manufacture than UV coatings (the price is influenced more by the limited demand). And because they contain no photoinitiators that tend to decay, EB coatings have a longer shelf life than UV coatings.
Oil-based varnishes
Oil-based overprint varnish (OPV), which is basically nothing more than a pigment-free ink, both dries and hardens. It dries as a result of the binding agent penetrating the substrate, though on multi-coated cartons and paper this scarcely plays a role. If applied to the ink while this is still wet, OVP penetrates the ink film and thus adheres firmly to the moist ink by the time the sheets are delivered to the pile.

Oxidation has a much bigger impact on film formation. More precisely, this is a chemical hardening induced by what are known as oxygen-bridge bonds. Reactive oxide ions, which are formed when the molecules of atmospheric oxygen are split in the siccative (oxidising agent) contained in the coating, settle among the molecules of the mineral- or vegetable-based binding agents.

Oxygen absorption by the resin molecules is enhanced by catalysts. Nonetheless, in a pile the oxygen will naturally take a while to work its way from the edge to the centre of the sheet, which substantially delays the curing process.

Oil-based inks and coatings used in image- and solids-rich promotional and packaging printing can therefore hardly be expected to cure completely as long as the substrate is stacked in a pile. The judicious addition of a siccative in the ink feed facilitates curing, as does better pile ventilation, eg by adding a fine dusting of powder and blowing air into the pile while it is being formed.

IR emitters can be plugged in to support both drying and curing processes.

Although OVPs are now formulated to eliminate yellowing (with the exception of overprint paste for abrasion protection) and would thus be suitable for full-solid varnishing, in practice very little use is made of this option because an increasing number of printers are shifting to the enhanced quality of inline aqueous coating with an anilox coating unit. OVP is no longer even used to stabilise lightweight uncoated stock. But its inherent virtues are being exploited as never before: because this type of coating, like conventional printing ink, is transferred in an offset printing unit in which the aluminium plates are dampened and the coating applied to the substrate in precise register via the blanket, overprint varnishing can be used for even the most delicate coating patterns and screened spot coating. Partial applications of matt or granulating OPV is also part of the hybrid production sequence (in conjunction with a UV coating) as well as in dip-off and twin-effect coating processes (in conjunction with an aqueous coating).

By combining coatings such as these it is possible to achieve some highly sophisticated gloss contrasts.

Solvent-based coatings
Solvent-based coatings consist of resins dissolved in a blend of organic solvents. Like the solvent particles in graviure and flexo inks, this mixture must be appropriate for the type of substrate used and/or the specified drying speed.

Single-component coatings dry physically, purely through vaporisation of the solvent mixture. The main coating solvent they contain is nitrobenzene, familiar perhaps from the nitro paints that were in use at one time. Nitrobenzene is low-boiling and therefore a volatile organic compound (VOC). It vaporises at almost the same speed as toluene, namely 6.5 times slower than either. As environmental awareness has become more widespread there has been a substantial decline in the use of this highly flammable and carcinogenic substance, and not just for offline coating. In gravure and flexo print production, not even the addition of hot-air dryers and extractors with post-combustion for inline coating systems has mitigated the universal condemnation. The maximum permitted workplace concentration for nitrobenzene vapour is a mere 1 cm³/m³ (263 ppm), compared to 200 cm³/m³ (52,600 ppm) for toluene!

The use of two-component coatings is less critical. They dry not by vaporisation but by curing, or to be more precise as a result of the solvent mixture cross-linking with the resins. The coating should be prepared no sooner than 24 hours prior to printing. It consists of liquid resins and a curing agent (in a ratio of approximately 5:2) along with alcohol acetates that act as a thinner and retardant.

So in practice the coating is already partially cross-linked when it is applied, but the coating does not form a firm surface film until the sheets enter the hot-air dryer. Although solvent particles vaporise in hot air, none are as hazardous as nitrobenzene. The advantages of two-component coatings are that they harden all the way through and are resistant to heat and numerous chemicals. The drawback is that the cross-linking process, and thus complete curing, can take several days.

Two-component coatings are used in gravure and flexo printing on polyethylene (PE) and polypropylene (PP) films and on aluminium foils and compounds coated in nitrocellulose (NC). They function both as an overprint varnish (with resins and curing agents in a ratio of approximately 10:4) to improve the chemical and physical resistance, and as a pre-print coating (approximately 10:1) for nitrocellulose-rich inks.

Powder coatings
Synthetic resins can be used as an alternative to viscose coatings. They are applied as a fine, pre-polymerised powder. This method, which is already well proven in the literature and furniture industries, has now been adopted by the printing industry in the form of gloss and security toners for electrophotographic digital printing systems (HP’s Indigo press, Kodak’s NexPress, Xerox’s iGen). The resin particles are applied to the paper as a spot or solid coating via a photoconductive subcarrier, just like normal toner, and then mixed. Upon exposure to heat they instantly melt and bind together to form a surface with the desired properties. This can be an amazingly high gloss or matt finish, an imitation watermark or some other security feature.

Coating powder can even be used to create a printable layer on a type of paper that is otherwise unsuitable for digital printing.

Dieter Kleeberg
Technologies for drying and curing offset coatings

The choice of coating applications, curing and drying principles, print characteristics and substrate properties is so prolific that it must be possible to find a coating whose film-forming speed and quality are appropriate for each individual print job. The technology used is constantly advancing, with KBA at the forefront.

General specifications for coatings, dryers and substrates
Coatings must meet the same specifications as inks in that they must neither block nor smear in the delivery pile. In addition they must be compatible with the inks they coat, ie they must offer uniform wetting, firm adhesion and be chemically inert. It follows that the form of radiation used to dry or cure the coating must not impair the drying or curing process for the ink. Conversely it also means that the ink may have to be dried prior to coating so as to provide a firm base to which the coating can adhere.

As far as the drying process is concerned, the level of radiation emitted must not cause the substrate to overheat and overdry; some synthetic substrates cannot tolerate the heat emitted by IR emitters and UV lamps. So the substrate must be compatible with the type of radiation used. UV curing, in particular, can give rise to odours in the paper coating. If the UV coating is cured cationically, the paper coating must not be alkaline. The radiation must not cause any undesirable substances to be released in the coating. Some UV coatings contain photoinitiators that split when exposed to UV radiation and create problematical by-products such as isopropyl thioxanthone (ITX). If the coating is to be used for food and drug packaging it must be migration-free.

In general, the emitters must have a high level of efficiency. The energy input should have a maximum impact on film formation, yet heat the substrate and the environment as little as possible. Gloss coatings need time to spread and form a smooth, even surface. This dwell time is much longer for UV coatings than for aqueous coatings. To avoid any loss of productivity it is customary to extend the dwell section instead of reducing production speed. Presses in which coatings are applied inline should therefore have an extended delivery. In most presses it is twice as long as the standard delivery and on high-speed presses very often three times as long. In recent years aqueous coatings have been developed that contain a higher percentage of water, and as a result a double extended delivery is rapidly becoming the norm for this type of coating as well.

Will high-frequency dryers be developed for printing presses?
Physicists have been working for a long time on developing high-frequency dryers that are more efficient than twin-tube carbon IR dryers at making water evaporate. HF dryers function in a selective manner similar to that of a microwave oven, but in a different wave band and much faster. While it would be a good idea to use HF dryers on printing presses because the substrate stays cold, at present it is not possible to say whether this will actually happen because it would entail reformulating aqueous coatings. The hydrosol content would have to be drastically reduced or eliminated entirely so that the solid particles would disperse in water but not dissolve, and would precipitate out and form a deposit as the water evaporates — rather like salt crystals in a desalination plant. So it is not just an issue for physicists: coating manufacturers would have to develop a totally new product. Whether this would be as good and versatile as existing aqueous coatings is debatable.

Technologies for drying aqueous coatings
Aqueous coatings dry by penetrating the substrate and through water evaporation, with extraction of the vapour-laden air. In sheetfed printing, heat is applied with the aid of one or more infrared emit-
ters. But there are different types of IR radiation. In practice, fast-switching medium-wave IR radiation (fast MIR, FMIR) is often combined with slow-switching short-wave IR radiation (SIR) because their respective spectral emission spreads (intensity curves) complement one other in the maximum absorption area for water of 3000 nanometres. This combination, however, is not very effective.

As an alternative KBA recommends Heraeus Noblelight’s twin-tube carbon IR (CIR) emitters, which have an intensity curve maximum of 2000nm. Although the 2400nm maximum for medium-wave IR (slow MIR, SMIR) emitters is much closer to the ideal, they react much too slowly to switching signals and have only a low level of radiation density. In contrast, CIR lamps switch at a speed of just 1 to 2 seconds, almost as fast as FMIR emitters, and in addition have such a high, stable and homogeneous radiation density that format widths of up to three metres (10ft) can be covered with a radiation power of 60 to 80 watts/cm (144 - 203W/in). CIR emitters are therefore the most effective of all IR radiation systems and can be operated cost-effectively with a low input of energy. Because less heat is applied, and at a wavelength of 2000 nm it is primarily the water molecules in the coating that are made to vibrate (a selectivity similar to that utilised in a microwave oven), this has the added advantage that the substrate does not heat up to the same extent as with other types of IR emitter, so more sensitive materials can be passed through the dryer. A similar principle is applied in high-frequency drying (see box.)

To enhance their efficiency IR emitters are often combined with hot-air knives. Like the blowers at the end of an automated car-wash they direct a blast of hot air onto the sheets through slit-type nozzles and blow away the moisture that has evaporated from the coating. In heatset web offset, the days of gas-flame blowers are long gone. Modern flotation dryers blow the hot air onto both the upper and lower sides of the web. The dryer’s impressive length is a compromise between web speed and the maximum reasonable surface temperature. Nonetheless, a lot of papers become so excessively dry they must not only be cooled but also remoistened. On some heatset presses, additional modules are inserted at the dryer infeed to apply rub-off ink or remoistenable glue. However, they could also be used to apply an inline aqueous coating. The volume of water vapour generated does not impair the suitability of the solvent-laden exhaust air for generating energy through post-combustion, eg for the chill rollers.

Technologies for curing UV coatings

As a rule, UV-cured coatings require lamps that cover the spectral range from UV-C to UV-B. However, it is not possible to dispense entirely with UV-A because the colour pigments in UV and hybrid inks absorb UV-B/C radiation differently, depending on the hue.

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**Practical tips from KBA’s coating seminar: dryer handling and maintenance**

1. **Keep it clean**
   - Dryers are particularly prone to contamination from powder and paper dust via electrostatic charge, warm-air convection and stabilising air-blasts during sheet transport. So the lamps, reflectors and sensors must be regularly cleaned, otherwise the loss of radiation could rise into a double-digit percentage.
   - KBA’s recommendations for VariDry dryers: UV modules should be removed once a week, IR modules removed once a month from the interdeck and end-of-press dryers, the lamps (easily broken!) and reflectors (surface easily scratched!) cleaned with a cloth soaked in white spirit, checked for mechanical damage and changed if necessary.
   - The filters on the blower/suction systems must be cleaned regularly to prevent the radiation units from becoming contaminated prematurely. Both dust and ozone must be extracted efficiently from the UV dryers.

2. **Test for ageing**
   - Lamps that are in continual use and switched on and off repeatedly will lose their efficacy. So the elapsed time counter at the console must be read regularly and compared to the manufacturer’s specifications. Once the specified service life has expired the lamp should be changed, even if it is still functioning. The transparency of the quartz glass should also be checked since the milky spots that can arise during UV radiation are radiopaque.

3. **Check output**
   - The output of IR emitters can be checked by using a metal probe and a contact thermometer to test the difference in temperature for any given input of energy. Drying tests conducted with defined thicknesses of aqueous coating film at specific dryer settings can, if carried out regularly, reveal a lot about the output and the “true” age of the IR emitter. A temperature sensor only determines the radiation energy; it is therefore unsuitable for taking absolute measurements. In addition to some more or less reliable hardening tests (see “Is the UV coating hard enough?”, pages 22-23) UV lamps can also be tested directly with a UV dosimeter, which allows the level of radiation set to be compared to the level actually delivered.
The only system used to cure UV coatings is an end-of-press UV dryer. In order to extend the dwell time as much as possible the three-lamp UV module is positioned right at the end of the extended delivery. The standard form of UV systems are medium-pressure mercury lamps – quartz glass lamps filled at medium pressure with mercury vapour. At present excimer lamps (see box) are not a viable alternative for sheeted offset because they require special photoinitiators which are only contained in the inks and coatings formulated for flexo printing.

In a conventional UV radiation unit there are two lamps in front of the reflectors, which usually double as water-cooled shutters that shield the substrate and adjacent parts from the lamps during press standstill. To filter out disruptive IR radiation a dichroic coating is applied to the surface of the reflectors (“cold lamps”) or to semi-permeable mirror glass (“cold mirror”). An optional quartz glass disc can also be fitted. The quartz glass of the lamps itself filters out a lot of IR radiation.

Nitrogen, an inert gas, is sometimes used to enhance efficiency because it provides a protective atmosphere that accelerates the curing process by preventing atmospheric oxygen from reaching the substrate. This is a good idea if heat-sensitive substrates are being printed and lamp power must be reduced to avoid excessive heat radiation. Fitting a nitrogen chamber to promote curing substantially reduces the amount of radiation energy required, cutting heat generation by as much as 80% and the temperature of the delivery pile by up to 15°C. Not only that, the unit also allows production speed to be increased because it reduces the length of time that the sheets must be exposed to UV radiation. The technical input required in sheeted offset is much higher than in

4. Check spectrum

IR emitters have a constant radiation curve with no peaks and just one single maximum that gradually rises and falls. As the lamp ages this curve flattens out, ie the level of intensity decreases, but the mode of operation does not change. So checking the age is perfectly adequate.

UV mercury lamps have several peaks in their metal halide spectrum, and these play a major role when curing various substances (coating, ink, opaque white) and during reaction sequences (start, deep impact, curing right through). In order to target these substances (lowest-possible absorption through coloured or white pigments) or to support specific links in the reaction sequence, individual lamps may have to be exchanged for special ones which are more appropriate. This is because in specially dosed lamps, eg for opaque white or cationic photoinitiators, doping the electrodes with metals (indium, gallium, iron) weakens disruptive peaks and strengthens beneficial ones.

A UV radiometer can be used to determine which UV particles are present and in what volume. Portable radiometers merely take an integral measurement of the dosage in the UV-A, UV-B and UV-C range: the location and height of the peaks can only be determined with laboratory measuring devices. So it would be a good idea if portable radiometers for the press room had this capability as well, since the radiated spectrum changes as UV lamps lose power with increasing age. More specifically, during the service life of the lamp the spectrum and all its peaks drift from UV-C towards UV-A. Even if the level of radiation is high, this wavelength drift can seriously impair film formation in the layers of coating and ink.

The press operator must make sure that the UV-C is regularly “refreshed”. When changing a lamp it is therefore advisable to position the UV lamps in the end-of-press dryer according to their age: first, the new lamp (because it will have a high level of the UV-C radiation needed to initiate action by the photoinitiators and cure the coating), second, the lamp that was previously in first position and finally, the lamp that was previously in second position.

Grafix dichroic UV dryer module. The casing (1) is protected by a thermal shield (2) from the UV lamp (3), which can heat up to 800°C. The two shutters (4) are open when in operation (top), otherwise they are closed (bottom). A dichroic coating on the inside surface of the shutters allows the IR radiation to pass into water-cooled pipes (5), which conduct the heat out of the module. A quartz glass disc (6) filters out the heat radiated directly from the lamp while allowing UV radiation to pass through.

The TwinRay UV radiation unit made by Adphos-Elfroch has a unique design in that it incorporates two separate UV lamps with a rotating dichroic shutter between them that reflects light either onto the substrate (top) or away from it (centre). The shutter is no longer a hindrance when the lamps need replacing, since they can be accessed by simply opening the side panels (bottom).

Metal halide spectrum of a medium-pressure mercury discharge (Hg) lamp. Individual Hg peaks can be flattened or heightened by adding indium (In), gallium (Ga) or iron (Fe). Wavelength drift from important, but inconspicuous UV-C towards UV-A can seriously impair curing of UV coatings. Sources: Primarc Fogra; UV guidelines issued by the German industrial safety council’s working committee on UV printing.

Film formation | Technologies for drying and curing
Effective electromagnetic spectra for film formation on diverse coatings

<table>
<thead>
<tr>
<th>Wavelength</th>
<th>Wave band, application</th>
<th>Appropriate coatings</th>
<th>Reaction, effect</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Radio-wave/high-frequency radiation:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• 10 m (corresponds to frequency of 300 MHz)</td>
<td>high-frequency (HF) dryers</td>
<td>non-/low-hydrosol aqueous coatings</td>
<td>electron-spin alignment in magnetic field causes water to evaporate; substrate and environment remain cold</td>
</tr>
<tr>
<td>• 1 cm (corresponds to frequency of 100 GHz)</td>
<td>microwave radiation units</td>
<td>aqueous coatings</td>
<td>rotation of water molecules causes water to evaporate, but too slowly</td>
</tr>
<tr>
<td><strong>Optical radiation:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>IR general</td>
<td>Vibration of water molecules</td>
<td></td>
</tr>
<tr>
<td>• 10 000 - 780 nm (depending on source of IR radiation, including gas flames)</td>
<td>evens</td>
<td>metal-decorating coatings</td>
<td>causes water to evaporate, bakes coating film on</td>
</tr>
<tr>
<td></td>
<td>hot-air dryers</td>
<td>heat-set-off/water-based coatings</td>
<td>causes high-boiling mineral-oil particles to vaporise</td>
</tr>
<tr>
<td></td>
<td>hot-air knives</td>
<td>solvent coatings</td>
<td>causes solvents to vaporise</td>
</tr>
<tr>
<td></td>
<td></td>
<td>aqueous coatings</td>
<td>supports the IR emitters with a flow of hot air that carries away the water vapor</td>
</tr>
<tr>
<td></td>
<td>3000 - 1400 nm</td>
<td>IR-B, medium-wave IR (MIR)</td>
<td>Ideal wavelength for water absorption: 3000 nm</td>
</tr>
<tr>
<td></td>
<td>2400 nm maximum, continuum via IR-A/B/C</td>
<td>slow MIR (SMIR) radiation units</td>
<td>causes water to evaporate rapidly with minimum energy input, slow-switching, low radiation density</td>
</tr>
<tr>
<td></td>
<td>2000 nm maximum, continuum via IR-A/B/C</td>
<td>twin-tube carbon IR (CIR) radiation units</td>
<td>causes water to evaporate rapidly with minimum energy input, fast-switching, low radiation density</td>
</tr>
<tr>
<td></td>
<td>1500 nm maximum, continuum via IR-A/B/C</td>
<td>fast MIR (FMIR) radiation units (often combined with SIR unit)</td>
<td>causes water to evaporate with medium energy input, fast-switching</td>
</tr>
<tr>
<td></td>
<td>1400 - 780 nm</td>
<td>IR-A, short-wave IR (SIR), near IR (NIR)</td>
<td>supports oxidation and prompts functional groups (eg —OH) to cross-link</td>
</tr>
<tr>
<td></td>
<td>380 - 380 nm</td>
<td>UV curing</td>
<td>promotes UV-induced polymerisation</td>
</tr>
<tr>
<td></td>
<td>380 - 315 nm</td>
<td>UV-A, long-wave UV, near UV</td>
<td>maintains radical polymerisation, deep impact on UV coatings</td>
</tr>
<tr>
<td></td>
<td>315 - 280 nm</td>
<td>UV-B, medium-wave UV, Dorno radiation</td>
<td>causes water to evaporate, bakes coating film on</td>
</tr>
<tr>
<td></td>
<td>280 - 100 nm</td>
<td>UV-C, short-wave UV</td>
<td>activates radical and cationic polymerisation by splitting the photoinitiators (from approx. 200 nm and above), most important for UV coating</td>
</tr>
<tr>
<td></td>
<td>380 - 200 nm</td>
<td>UV-1, &quot;quartz UV&quot;</td>
<td>Energy-intensive radiation splits molecules</td>
</tr>
<tr>
<td></td>
<td>365 nm maximum, continuum via UV-A/B/C</td>
<td>medium-pressure mercury-discharge lamp</td>
<td>UV coatings</td>
</tr>
<tr>
<td></td>
<td>308 nm line</td>
<td>XeCl* lamp (xenon-chloride excimer discharge lamp)</td>
<td>special UV coatings, foil-laminated paper</td>
</tr>
<tr>
<td></td>
<td>according to dosage and pressure</td>
<td>xenon pulse-discharge lamp (flash lamps)</td>
<td>special UV coatings, UV inkjet inks</td>
</tr>
<tr>
<td></td>
<td>200 - 100 nm</td>
<td>UV-2, &quot;vacuum UV&quot;</td>
<td>activates radical and cationic polymerisation by splitting the photoinitiators and supports polymerisation</td>
</tr>
<tr>
<td></td>
<td>continuum according to dosage and pressure</td>
<td>medium-pressure mercury-discharge lamp</td>
<td>UV coatings during drift</td>
</tr>
<tr>
<td><strong>Ionising radiation:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>100 - 0.0001 nm</td>
<td>X-ray UV, X-radiation and gamma radiation</td>
<td>coatings for photoresistant components</td>
</tr>
<tr>
<td></td>
<td>0.0024 nm (Compton wavelength of electron)</td>
<td>cathode-ray tube (tungsten cathode)</td>
<td>EB coatings</td>
</tr>
</tbody>
</table>

An inert UV module developed jointly by KBA, AdPhos-Eltosch and the Saxon Institute for the Printing Industry (SID) was first fitted in a Rapida 72 at Belgian plastics printer Creaf. Fitting a nitrogen chamber to promote curing substantially reduces the amount of radiation energy required and cuts heat generation by as much as 80%, so the temperature of the pile is up to 15°C lower. Not only that, the unit also allows production speed to be increased because it reduces the length of time that the sheets must be exposed to UV radiation. The technical input required in sheeted offset is much higher than in narrow-web offset because the substrates printed are thicker and the gripper bars run through the inert chamber at high speed, disturbing the density. Twin tubes like those used in carbon IR emitters are rarely found in UV curing because the lamps have a higher output. Nonetheless, some manufacturers do offer narrow-web offset because the substrates printed are thicker and the gripper bars run through the inert chamber at high speed, disturbing the density.
systems with tubes arranged in pairs (see Adphos-Eltosch’s TwinRay, page 11). What is more important is the geometry of the reflectors. In sheetfed offset, irregularly curved reflectors are the preferred choice because they diffuse the light so that it even reaches the parts of the sheet that are shaded by the grippers. Different geometries are to be found in web printing: beams reflected by parabolic reflectors run parallel to one another, which is good for fine layers but not for coatings. Elliptical curves focus incidental light and therefore concentrate power on a smaller strip.

If UV inks and coatings and/or hybrid inks are used, an ozone extractor must be positioned at the end-of-press dryer. Ozone gas, which is odour-intensive and hazardous to health, is generated when UV beams cause diatomic atmospheric oxygen molecules to react with triatomic oxygen. Another essential is an opaque radiation shield to protect personnel, since the high energy density of the UV radiation used can cause burns and skin cancer.

Film formation when two or more coatings are applied

In two-coater presses an aqueous coating forms a dry primer for the subsequent high-gloss UV coating. The primer is needed to allow the moist oxidative inks to be UV-coated online. It is also possible to apply two aqueous coatings, with special-effect pigments (metallic, pearlescent etc) in the first layer. Since this first layer of coating must be completely dry before the second is applied, it is customary to position two interdeck dryers, each with two IR emitters and hot-air knives, before the final coater.

The end-of-press dryer section in the extended delivery will feature UV or IR/hot-air modules, depending on the second type of coating applied. The film-forming components in overprint varnishes (OVPs) are basically formulated like conventional inks and need neither radiation nor an extractor system to form a film. In hybrid coating, a matt or granular spot overprint varnish is applied to the hybrid inks while they are still moist, followed by a full-solid application of UV coating. Interdeck UV-A dryers are positioned after the first printing unit (to stabilise the ink instantly on coated paper or carton board) and after the final printing unit (ie after the overprint varnish has been applied). The heat emitted during end-of-press UV curing also accelerates the oxidation process in the overprint varnish. But what is decisive is the contact with atmospheric oxygen on the sheet surface or in the pile, and here the air-blasts that stabilise the sheets as they are transported and

Dryer configuration on a KBA two-coater press: the final printing unit (1) is followed by an anilox coater that applies an aqueous coating to the oxidative inks. The water in the coating is evaporated by IR emitters and hot-air knives in two interdeck dryers (3, 4). There follows a second anilox coater (5) which applies a high-gloss coating (usually a UV coating, more rarely an aqueous coating). The extended delivery houses the end-of-press IR and hot-air dryer modules (6, 7), the UV-A/B/C radiation unit (8) and extraction units for ozone and water vapour. The ACS air-cleaning system (9) above the delivery pile extracts any residual ozone and powder.

Standard configuration of a KBA hybrid press with VariDry drying system. Hybrid inks, which dry by oxidation and cure under UV radiation, are applied in the first four printing units (1) and partially dried by a plug-in UV-A interdeck dryer (2). In a typical hybrid production sequence, oxidative matt or granule-effect spot overprint varnish is applied instead of ink in the final printing unit (3). A second UV-A interdeck dryer (4) hardens the hybrid ink beneath the overprint varnish. The anilox coater (5) applies a full-solid high-gloss UV coating which only adheres to the exposed hybrid ink and is repelled by the overprint varnish. This creates a contrast in gloss levels. The end-of-press IR/hot-air dryers (6, 7) are only used if conventional inks are applied followed by an aqueous coating. The end-of-press UV-A/B/C dryer (8) is positioned at the end of the UV coating dwell section. Here, too, an ACS air-cleaning system (9) is a recommended option. A pure UV press, which must be fitted with UV-compatible rollers and blankets, dispenses with the IR and hot-air dryers but not with the extended delivery.
Are excimer radiation systems an alternative?

For flexo printing the answer is a resounding yes. But as far as sheetfed offset is concerned, the absence of suitable UV inks and coatings prevents KBA, for one, from pursuing this avenue. And although MAN Roland unveiled its Secomatic Blue excimer system on a halfsize press at Drupa 2004, no other manufacturers have followed suit. Would an excimer system really be such a good idea?

1. Excimer lamps have a surface temperature of just 30°C, as opposed to 600°C on conventional UV lamps. This would allow heat-sensitive substrates to be printed, which is ideal for flexo. Furthermore, when the press is brought to a halt the lamps can be switched off to conserve energy, since they are operational as soon as the press starts up again. And they can be cooled directly, which is less complicated.

2. Excimer helium gas discharge lamps have a very narrow radiation range – around 308 nanometres (xenon chloride excimer) in flexo printing and in the Secomatic Blue. At 308nm there are no unpleasant odours caused by ozone generation and decomposition of the paper coating. Nor is there any UV radiation that is hazardous to humans. So there is no need for extractors or protective shields.

However, these benefits are offset by a number of drawbacks:

- An excimer lamp has a lower radiation output along its length than a mercury vapour lamp – at present a maximum of just 50W/cm (127W/in) or one-fifth. So its effectiveness would have to be improved, which may make it more complex and costly. One option would be to use five excimer lamps instead of one conventional lamp, though lack of space makes this impractical. Another would be to create an inert gas atmosphere to banish oxygen, though nitrogen storage and the inert chamber needed would push up costs. Secomatic Blue enhances efficiency by using twin lamps, special reflectors and a high-frequency 15 to 25kW power supply.
- Only a few specific photoinitiators will react at 308nm, so the resins in the coatings and inks would have to be blended with special pre-polymers (dimers); the term excimer is in fact derived from “excited dimer” and indicates the crosslinking mechanism involved. So the standard UV coatings and inks that react to UV-C, UV-B and UV-A could not be used.

How does coating harden in a metal-decorating press?

Following KBA’s acquisition of Bauer+Kunzi in 2003 and LTG-Mailänder in 2006 the two subsidiaries were merged to form KBA MetalPrint, the global market leader in metal-decorating presses. Even before its acquisition by KBA, Bauer+Kunzi used modified printing units and other modules from KBA Rapida presses in its production line.

An opaque white coating is usually applied to the metal sheets to prevent the metal surface shining through, or to simulate a label, and this also improves ink adhesion. No such coating is applied if gold, silver or copper tones are to be simulated. A clear, scratch-proof coating: hotair tunnels to dry and bake aqueous coatings, and UV lamps for curing. The tunnel ovens are longer than hot-air dryers, and the metal sheets are transported through them upright to give the coating a full 20 to 30 minutes to dry thoroughly and harden at normal production speeds. There are dedicated passes for both preprinting and finishing. Because UV inks form a film so rapidly, UV coatings can be applied inline, which takes up less space and time than thermal drying. As a result, metal-decorating specialists are increasingly opting for a UV system. An interdeck UV dryer cures the inks directly prior to coating. A normal end-of-press UV dryer follows a dwell section that is just five metres (16ft 5in) long. Prints can be checked immediately.

Dieter Kleeberg

stacked are very helpful. While a powder sprayer aids the air flow by spraying the sheets with powder particles that act as “spacers” in the pile, powder should be applied as sparingly as possible when coating, so as not to impair the gloss; if possible it is best to dispense with powder entirely.

Gloss contrasts can also be created with OVP by combining it with a pre-warmed drip-off coating or normal temperature-controlled twin-effect coating. Like the UV coating during hybrid production, these two special gloss coatings are repelled by the OVP and run or drip off it, but are water-based and therefore require end-of-press IR/hot-air dryers. And they cannot compare with the high UV gloss levels, diverse effects and finer detail possible with hybrid technology.

KBA has already shipped a number of Rapida presses with special configurations. These include presses for perfect inline coating with an interdeck dryer before and after the perfecting unit, and two end-of-press dryers. The speed at which the coating forms a film means that coating set-off on the impression cylinder during perfecting is not an issue with this technology. Some specialist presses for applying two end-of-press coatings also allow the inline pre-application of a special-effect coating or opaque white primer, which requires interdeck dryers before the first printing unit.
What can KBA VariDry do?

KBA started developing an in-house range of infrared/thermal air (IR/TA) and UV dryers in 2003. We can now offer a complete programme for the medium-format Rapida 105 and are planning to expand this eventually to all our other Rapida models. But why do we offer our own drying systems alongside those of established vendors? KBA Process 4 provides some answers.

Apart from ensuring that all systems function as billed, development work on this new range of dryer modules focused on two primary objectives: to maximise flexibility for the benefit of the user, e.g. by ensuring that UV emitter modules could be plugged in at any position, and to facilitate handling by providing console displays and controls for all key parameters.

Infrared/thermal air dryers
A double extended delivery for a Rapida 105 can accommodate up to eighteen infrared and thermal air drying modules in a ratio of seven to eleven. Within the drying section these modules can be positioned freely according to production requirements, affording total flexibility in how the sheets are dried. For perfect printing or work and turn there are optimised hot-air knives that allow coatings to be dried with the maximum possible air volume and thus with no reduction in production speed.

The IR emitters routinely used in the VariDry system are Heraeus’s twin-tube carbon infrared (CIR) emitters with an intensity of 60W/cm (152W/in). The spectrum of CIR emitters coincides more closely with the absorption curve for water than does the spectrum of other shortwave (SIR) or fast medium-wave (FMIR) emitters (see diagram). As a result CIR emitters function more effectively at a very low temperature.

IR modules and hot-air knives can be removed from their slip-in ports without using tools, which makes for faster, simpler servicing and maintenance work. If an IR emitter needs to be changed it can be removed from the press by simply unscrewing two screws and pulling the emitter out of the module. Plug-in connections mean that anyone can make the change - no specialised knowledge is necessary. For special applications it is possible to use fast medium-wave twin-tube emitters or hybrid emitters (twin-tube emitters with one carbon and one short-wave component). Sheet travel can be monitored at any time through inspection windows in the swan neck and the extended delivery. The intensity of the IR emitters is regulated by measuring the temperature of the pile and adjusting the emitter temperature accordingly.

T o facilitate monitoring the relevant parameters are displayed at the console.

Intensity curve $I(\lambda)$ for three types of IR emitter – shortwave (SIR), fast medium-wave (FMIR) and twin-tube carbon (CIR) – standardised according to the surface-related drying power. The small blue diagram superimposed on the chart shows the degree of absorption $\alpha(\lambda)$ of the aqueous coating (maximum at a wavelength of 3,000nm) and reveals that CIR is more effective than the other IR emitters at evaporating water (pale blue infill beneath the CIR curve). CIR achieves the maximum effect with the minimum energy input (just 1,200°C) (Source: Heraeus Noblelight)

Hot-air knife (l) and CIR emitter (r) for the VariDry. Using parallel light tubes is the only way to deliver the necessary output of 60W/cm across the entire 1,050mm format width in one single emitter module. The carbon filaments heat up to 1,200°C and the heat is reflected with virtually no loss at all by the gold lining on the inside of the tubes.

The UV modules are easy to exchange. The photo shows the last three slip-in ports for an end-of-press UV dryer configuration: the left-hand UV module is plugged in, connected and operational. The centre module has been partially extracted. The right-hand module has been removed and the connecting plug “parked” beneath the empty port.

Left: KBA VariDry can accommodate seven CIR emitters, three of which are shown here.
The tremendous flexibility afforded by our VariDry system will be enhanced still further by new, complete drying units. Pure IR/TA and UV modules are already in operation along with quick-change units in which an IR module with three emitters can be exchanged for a UV module. Since the drying elements in the drying unit can be increased by adding inter-deck UV dryers, the production options are virtually unlimited.

As an option, or in the press formats for which VariDry is not yet available, we shall continue to offer familiar and proven products from other manufacturers such as Grafix, IST Metz etc.

Peter Patzelt, Martin Dänhardt
Choosing suitable photoinitiators

When inks and coatings are exposed to UV radiation, radical photoinitiators interact with the binding agents. The type of photoinitiator determines the type of radicals released, which in turn can cause differences in curing. One of the main tasks in formulating and using UV inks and coatings is to optimise key properties whose impact may be contradictory: good runability and spread, rapid reactivity and flexibility yet good adhesion with minimal colour and sensory impairment.

Interaction with radiation energy
Radical photoinitiators absorb the radiation energy generated by UV lamps only within specific segments of the UV spectrum. The intensity of the radiation depends on the pigments in the UV inks, since these absorb some of the UV radiation. They therefore have a considerable impact on the efficiency with which radicals are created, ie on the ‘reactivity’ of UV inks, and thus on the efficiency of the curing process. If UV rays encounter pigment particles, three different forms of interaction may be observed: a relatively small proportion of the radiation will be reflected at the pigment surface (remission) and can be utilised by the photoinitiator to generate initiator radicals. Depending on the absorbent properties of the pigments involved, a larger proportion will generally be absorbed by the pigment and will therefore no longer be available to the photoinitiator for the creation of initiator radicals. The proportion of radiation that is neither reflected nor absorbed (transmission) can be absorbed by the photoinitiator and converted into chemical energy in the form of initiator radicals (photo fission).

To cure UV coatings, photoinitiators that primarily absorb radiation in the shortwave UV-C spectrum (200 to 280 nanometres) are generally adequate, since in the absence of pigments the reduced penetrating strength of the energy-rich UV-C radiation does not impair curing. If, for example during inline preprinting, the coating competes with pigments to absorb radiation, then photoinitiators capable of absorbing UV-B and, above all, UV-A radiation must be used, since radiation in this wavelength range has greater penetrative power even though it has a lower energy level.

As has already been explained in the practical tips on pages 10-11, ageing in UV lamps primarily manifests itself in a substantial drop in UV-C radiation, which can impair surface hardening and thus cause stickiness.

Task sharing
In general, shortwave radiation, which only penetrates the surface, triggers curing and the formation of a (superficial) film, while longwave radiation, which penetrates further, cures the deeper layers and causes the coating to adhere to the substrate. Printing inks are usually formulated to include a photoinitiator for each of these two functions – eg alpha-hydroxyketone (AHK) for surface hardening and alpha-aminoketone (AAK) or daylight-sensitive bisacylphosphinoxide (BAPO) for deep curing. Other modern photoinitiators for printing inks are Ciba’s Irgacure 369 and 379, isopropyl thioxanthone (ITX), trimethylbenzoyl diphenyl phosphinoxide (TPO) and monoacetyl phosphinoxide (MAPO). Benzoin ether, which tends to yellow, was initially replaced by benzyl derivatives such as benzyl dimethyl ketal (BDK). These were subsequently succeeded by acetophenones such as alpha-hydroxycyclobutene, which along with benzophenone (BP) is now commonly used to cure clear coatings.

When exposed to UV radiation, photoinitiators create radicals via two main reactions: fragmenta-
tion and hydrogen abstraction. Most initiators fragment (“decompose”) instantly into reactive radicals with free electrons. The others, among them BP and ITX, require the presence of amines or amine-modified acrylates as so-called synergists, which can create reactive radicals when hydrogen atoms are split. In addition ITX can function as a sensitisier for other photoinitiators (eg certain AAKs; usually in conjunction with Ciba’s Irgacure 907), to enhance the curing process.

Care with food packaging
Every item of packaging makes different demands on the printing inks, depending on which products it must hold. Packaging for aggressive products like household cleaning agents primarily demand chemically resistant components if there is a likelihood that ink and coatings could come into contact with the contents. One essential for food and semi-luxury goods is that inks and coatings must be neutral from the sensory point of view, ie odour- and taint-free. This applies not only to the cured binding-agent film but also to the unconverted photoinitiators and their fission products. Migration,
hydroxy/alpha-amino acetophenone (3) decomposes into two radicals with one free Fragmenting photoinitiators: benzyl ketal (1: electron apicel, benzoin ether (2) and alpha-hydroxyalpha-amino acetophenone (3))

Hydrogen-abstracting photoinitiators: benzophenone (1: in conjunction with a hydrogen atom from a synergist it creates the radical benzhydrol, the synergist becoming a radical in the process) and ITPX (2)

**Interaction with binding agents**

The choice of photoinitiator depends, as ever, on how well it can be worked into a coating or ink. **Liquid photoinitiators** (eg blends of BP and specific AHPs) have the edge because they dissolve or disperse easily in the binding agent. **Powder-based photoinitiators** (eg TPO) must be dissolved prior to blending. In radically curing coatings, acrylic resins are not suitable as binding agents for every application. While **epoxy acrylates** are highly reactive and resistant to chemicals, they are also highly viscous and the coating film will become correspondingly hard. **Polyester acrylates** have a relatively low level of viscosity and create a flexible coating film, and their low price and good adhesion make up for their average reactivity. **Polyurethane acrylates** are highly resistant to chemicals, adhere well to substrates and create a flexible coating film, but are generally more expensive. **Polyether acrylates** typically have a very low viscosity and a relatively high reactivity. Silicon acrylates are reserved for special applications, or function as an additive. Their reactivity is comparatively low and they are generally expensive. The properties of acrylates, eg reactivity, viscosity or their potential to irritate, depend in many cases on their chemical structure. For example, some polyester acrylates have a whole range of the properties mentioned.

**Odour development**

Upon exposure to UV radiation the above-mentioned photoinitiators create fission products which may emit more or less perceptible odours; some are virtually odourless. In general it may be said that needlessly high quantities of photoinitiators lead to high concentrations of fission products, which may make their presence felt by causing the ink or coating to emit powerful odours. Here it should be emphasised that unreticulated acrylate binding agents may have a characteristic odour that diminishes after polymerisation. Improved acrylates have been available for some years that were developed expressly to reduce odour and skin irritation. Unpleasant odours can also be caused by the paper coating, which in the absence of UV inks or coatings can develop a perceptible odour during exposure to UV radiation. This may be limited by radiating the unprinted sheet. Often odour generation is indicative of too high a radiation level, a more obvious indication being a brittle paper coating. This issue is discussed exhaustively in KBA Process No. 3, Quality enhancement with hybrid production. From all the variables it may be deduced that in UV and hybrid offset printing it is vital to achieve an optimum balance between the level of radiation, photoinitiators and substrate sensitivity. And, of course, UV coatings must be compatible with UV or hybrid inks.

**Ask your supplier**

In the end it is the manufacturer who decides which components are used in UV inks and coatings. Hazardous ingredients are listed in the material safety data sheet. Ink manufacturers in the European Printing Ink Association (EuPIA) undertake to dispense with the toxic and environmentally hazardous raw materials contained in an exclusion list.

As a matter of principle, tests should be conducted on the toxicity of coatings, inks and substrates when in contact with foodstuffs. Coatings and inks should only be applied to the outer surface of food packaging and must comply with EU directive 82/711/EEC. Typical raw materials for manufacturing synthetics must not exceed a specified migration limit (SML); however, for common raw materials used in inks and coatings there are no official SML values. To avoid unpleasant surprises it is advisable to obtain details from the supplier of UV inks and coatings. If in doubt all the materials used should be tested in a real production environment.

**Dieter Kleeberg**

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Sources

Frank, Dr Erich: UV print production. – presentation, X355 Print Solutions (Flint Group), Stuttgart, December 2005 (illustrations).


Kartonverpackungen. Stellungnahme Nr. 044/2005Arbeitskreis UV-Druck der BG Druck and Der Praxisleitfaden für alle Druckverfahren. – presentational.
Migration-free packaging printing

Over the past two years consumers and packaging printers alike have been rattled by incidents reported in the media of carton packaging contaminating the contents, most notably drinks and baby food. One of the hazardous substances detected, isopropylthioxanthone (ITX), migrated to what would eventually be the laminated interior of the carton when the freshly printed substrate was rewound following production. But photoinitiators such as benzophenone and substances such as texanol 2-isobutyrate (TXIB), produced when photoinitiators in UV inks and coatings decompose, are just as hazardous to health. To minimise all risk of contamination the Vegra group, based in Aschau am Inn, Germany, developed migration-free binding agents and coatings. But first the causes of migration, in other words the interaction of all the substances involved in the printing process, had to be determined. It was found that even traces of residue in recycled substrates and in the press itself can contribute to chemical migration into food packaging.

Product development and tests
Theoretical premises were tested by producing UV-reactive binding agents and coatings in the laboratory and applying specific procedures to check for pre-polymer and monomer migration. None of the photoinitiators used contained benzophenone or produced TXIB.

The coatings were analysed in a special laboratory using headspace (or vapour space) chromatography, a form of gas chromatography (in which the vapour phase is analysed as an indication of concentration in the liquid phase) combined with mass spectroscopy. A comparison was then made with the standard coating formulae currently in widespread use. The aim was to blend the pre-polymers, monomers and photoinitiators in such a way as to create UV binding agents and coatings that polymerise with maximum speed and efficiency, are odourless and contain no low-molecular compounds that may migrate into the packaged contents.

The coatings formulated in the laboratory were applied to sample substrates at a speed of 12,000 sheets per hour during multicolour production on a KBA Rapida 105, and cured by lamps with different power settings. The substrates tested were:

- foil-laminated, recycled GD2 cartonboard,
- standard recycled GD2 cartonboard,

1 Impact of DPM wash on migration-free UV coatings and binding agents. Phenol from the triphenyl phosphite stabiliser was detected in every layer. Some coating formulae (VP102-67, -95, -98, -98b) contained between 0.3 and 0.6 % DPM, the rest contained none.

2 Determining acrylate residues in non-hardened applications of migration-free coating VP10299 MF (radiation by three lamps at 100 % and 50 % power output). All three substrates were contaminated by diacetone alcohol (DA), which is not a component of VP10299 MF.
Interaction | Migration

- virgin cellulose GC1 cartonboard.

Between coating applications the coating system was cleaned using a competitor’s standard wash based on diacetone alcohol. Immediately after being coated the sample sheets were wrapped in aluminium foil and analysed in the headspace chromatograph. An uncoated blank was analysed as a control.

Findings

The analyses of the uncoated areas exposed to UV radiation in the press revealed that:
- the foil-laminated, recycled GD2 cartonboard contained clear traces of Surfynol 104 (a surfactant), TXIB and benzophenone;
- the standard recycled GD2 cartonboard contained, as was only to be expected, solvents from irremovable ink residue (alkane

3 Although UV coating VP10295 is free of benzophenone and TXIB, both substances were detected following print production on GC1 and GD2 cartonboard and 50 % radiation power. They originated from old ink and coating residues on the press rollers and migrated to the samples via circulated air.

4 An analysis of migration-free UV coating VP10299 MF on all three substrates after being cured at 100 % radiation power. The benzophenone content presumably migrated from wash residues in the recycled components of GD2 cartonboard and the traces of TXIB from a poorly cleaned coater.
C14, C15, C16, C18, C19 and C20) in the recycled pulp, an ester (Estisol 242) and traces of benzo phenone, TXIB and softeners; the virgin cellulose GC1 cartonboard contained minimal quantities of benzophenone, TXIB and softeners.

The results of the chromatographic analyses are shown in the diagrams.

**Discussion**

The tests indicate that the benzophenone content in the foil-laminated, recycled GD2 cartonboard and virgin cellulose GC1 cartonboard originated from residues of washes, coatings and other substances on the coating rollers. Traces of ink oils on the standard recycled GD2 cartonboard stem from the original substrate. This is because it is not yet possible to extract these oils and other ink components from the pulp during the recycling process. The level of contaminants in the virgin cellulose GC1 cartonboard may be considered negligible.

Since Vegra coatings contain no Surlynol 104, benzophenone or TXIB, it follows that any traces of these substances found in the samples must be foreign bodies and cannot have originated in the Vegra coatings used in the laboratory experiments. And since they were present in the uncoated board they can only have migrated from contaminated pulp or rollers during processing or printing. Diacetone alcohol washes decompose when exposed to UV radiation, and one of the products, benzaldehyde, was found to migrate from the packaging to the contents.

**Recommendations for printing food packaging**

- Choose substrates that are non-hazardous to health and contain no substances that may migrate from the packaging to the contents.
- The print production environment (press) should be confined to one process, UV, to exclude the possibility of contamination from conventional consumables.
- Washes must be effective enough to remove all traces of ink and coatings, and must themselves contain no contaminants, thus ensuring that no contaminants can migrate to the packaged contents.
- Precautions must be made to ensure that no substances such as benzaldehyde are produced on the substrate as a result of decomposition during UV radiation.
- UV lamps must be scrupulously maintained and their power output set high enough to trigger maximum polymerisation of the applied inks and coatings so that they will pass the MEK or acetone test, 15 double rubs. The printing inks used must, of course, also be based on a blend of binding agents and photoinitiators that would not contaminate packaging.

While aqueous coatings do not normally contain any migratory components, if they are used the same precautions should be taken as for UV coatings:

- Choose suitable substrates and ensure that the print environment is free of contaminants.
- Choose washes with no migratory components.

**Conclusion**

Tests revealed that Vegra’s new, migration-free UV coatings, identified by the suffix MF (migration-free) to the product name, eliminate all risk of food contamination from migratory components in the coating.

Albert Uhlemayr,
president of the Vegra group,
Aschau am Inn, Germany
www.vegra.de

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An analysis of the three GC1 cartonboard samples, printed with coating VP102-66, -97 and -99, following UV radiation at identical power settings (three lamps, 100%). The benzaldehyde content may be attributed to the diacetone alcohol wash.

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Is the UV coating hard enough?

This is a question that frequently occupies press operators. How fast and thoroughly a UV coating cures, and how well it adheres to the underlying ink, aqueous coating and/or overprint varnish, depends on the press and dryer settings, which thus have a decisive impact on the quality of coated prints and the time delay before they can be finished. Usually the operator must fall back on tests whose parameters are not defined with the degree of accuracy required. This is why Fogra has devised more standardised methods for testing the hardness of radically cured UV coatings and inks.

Testing for hardness in the press room

One property of radically curable consumables is that the cross-linking sequence continues only as long as it is exposed to UV radiation. Unlike cationic polymerisation, which is completed in a single triggered chain reaction but is not yet used in sheetfed offset, radical UV cross-linking requires some means of checking the hardness of the film. At present the simple tests that can be carried out directly at the press by printers or finishers do not deliver reliable results. There are currently two methods for testing hardness at the press:

Tape test, Scotch tape test or adhesive test: this entails pressing a strip of adhesive tape onto the print and peeling it off again. If any coating or ink film is pulled off with it this indicates that the coating is not yet hard enough. Acetone test: here acetone is applied to the coating or ink film and the image surface subsequently rubbed. If the solvent fails to loosen the surface of the layer and cause it to shift then the coating or ink is considered to be adequately cured.

However, both methods have their drawbacks: the informational value of the tape test heavily depends on the force with which the tape was applied and removed, and on the properties of the tape itself, which in some circumstances may vary. On top of this it cannot be used on uncoated paper. To make the tape test more reliable Fogra has developed a coating adhesion testing device known by its German initials of LHT. It standardises the force, the speed and the angle at which the tape is peeled off.

Following changes in the formulation of radically cured UV consumables the acetone test is no longer reliable. Most of the UV inks and coatings currently in use cannot be loosened and removed with acetone even if the layers have not yet cured completely. A universally applicable solvent that allows the difference between well hardened and insufficiently hardened layers to be determined has not yet been developed. Nonetheless, it is still possible to monitor the curing process by testing solvent resistance at the press – namely when the ink or coating supplier recommends another solvent that can be used. To conduct such a test Fogra has developed an acetone testing device, or ACET, which can be filled with any type of solvent.

A new testing device was unveiled at the Fogra User Forum on UV Printing in Munich on 8 November 2006. Developed in collaboration with Ushio, this UV curing tester was designed for the purpose of checking whether UV inks (but not UV coatings!) have cured right through on paper and cartonboard. The printed sheets are inserted in the tester with a sheet of contact paper on top, and subjected to a predefined pressure and temperature. Ink set-off on the contact paper at the end of the test indicates that curing is incomplete; if the contact paper is clean, curing is complete.

All three devices – the LHT, ACET and UV curing tester – can be obtained from Fogra (www.fogra.org). Other simple, familiar testing methods described in the relevant literature as a means of determin-
ing the curing status are mechanical in principle and should only be used on hard, incompressible substrates. Some examples are the microhardness test as defined in DIN 55676, the pendulum damping test as per DIN 53157 and tests in which the surface of the samples is bombarded with cone points or falling bodies. Abrasion tests such as scuffing tests, the Taber abraser or the fingertip test are of limited use in checking whether UV-curable ink films have cured right through. The same applies to the talcum-powder test, set-off tests and the measurement of gloss or roughness.

**Testing for hardness in the laboratory**

The development of a process for monitoring the hardness of UV-curable inks and coatings in the laboratory is also a work in progress. In the past, the following different physical and chemical methods were used to determine the extent to which UV or EB-cured layers had hardened:

- Fourier transform infrared (FTIR) spectroscopy,
- Near-infrared (NIR) spectroscopy,
- Raman spectroscopy,
- Atomic force microscopy,
- Ion mobility spectroscopy,
- Dielectric spectroscopy,
- Heat-measuring processes,
- Ultrasound propagation,
- Pulse radiolysis,
- Evaluation of rheological and/or mechanical changes due to UV radiation,
- Measurement of penetration by radioactively marked liquids,
- High-performance liquid chromatography (HPLC) and
- Headspace gas chromatography.

No universally applicable standard method has yet been distilled from the plethora of investigative techniques currently in use. The result of a series of tests conducted by Fogra shows that HPLC and ATR (attenuated total reflectance) infrared spectroscopy

-in the case of printing inks) and confocal Raman spectroscopy (for radiation-curable coatings) can deliver reproducible chemically analytical data on the curing status of these layers.

Dr Wolfgang Rauh, Fogra Graphic Technology Research Association, Munich

**Bibliography**


Anilox coaters are the state of the art

Over the past twenty years the range of inline coating options available on the market has improved out of all recognition. In sheetfed offset, the raft of benefits delivered by anilox coaters has made them the most popular choice. KBA has systematically promoted anilox coating technology for a number of years now, initially for its Rapida and 74 Karat presses and, more recently, for its Performa presses. While a roller-type coating unit is occasionally requested as an alternative in VLF format, and is also available as an option with KBA-Metronic’s B3 (20-inch) Genius 52UV, only Performa presses offer the option of coating via the dampening duct.

Inline coating with offset technology

In standard sheetfed offset, applying overprint varnish via the inking unit, plate and blanket in the final printing unit is the only coating system that still utilises offset technology. In conjunction with hybrid consumables it has attained a new status as an option for creating sophisticated gloss/matt contrasts.

With KBA-Metronic’s OC 200 it is also possible to apply UV coatings via the inking unit, plate and blanket when printing individual plastic cards in sets of two with waterless UV offset inks. Since the OC200 has keyless inking units with temperature-controlled screened metering rollers, and the dwell section after the final printing unit is adequate, the quality of the gloss coating delivered is exceptionally high. The same system can be used to apply a UV primer that is cured immediately, before the first colour is printed. One of the more common methods in the 1990s was to apply a water-based coating via the dampening duct and blanket, but nowadays this is confined to users who seldom have to apply a coating and are therefore prepared to accept the attendant quality impairments. There are still a few coating manufacturers who offer optimised aqueous coatings, or dampening-duct coatings as they are known. In place of dampening-duct metering one press manufacturer offers a modular doctor-blade attachment, which on an offset press can be positioned where the blanket washing system is usually found. This well-meaning approach, intended for medium-format presses which are rarely used for coating, is not one that KBA is planning to adopt. The reason is obvious: the presses concerned are normally not equipped with an adequate number of IR and thermal dryers, so the water-based coating is generally not dried as well as it should be, particularly if the attachment can only apply a solid coating. So the claim that inserting one such attachment in the first printing unit prior to the first colour, or two attachments for perfect coating with no intermediate drying, seems reckless, to say the least. For aqueous coatings KBA recommends a dedicated coater (with which it is also possible to apply spot coatings) plus the appropriate drying technology. From the economic point of view that is perfectly justifiable because coating, far from being the exception, has long since become the rule, and allows prints to be finished much sooner.

Inline coating with coater

It is only possible to achieve a superior, consistently reproducible quality with an inline application of aqueous and/or UV coating if one or more dedicated coaters are used. These can apply a much larger volume of coating than other systems, and also meter it more uniformly on the coating forme. For solid applications it is customary to use a smooth blanket, for spot coatings a stripped coating blanket or photopolymer letterpress plate. Initially roller-type coaters, which are available in a choice of versions, were the most common coaters used. The simplest design is the two-roller coater, which is still the preferred choice in web printing, basically on account of its simplicity, its trouble-free application at high web speeds and the frequently changing applications for which it is used. This is because gloss coatings are used relatively rarely compared to rubber coatings, gluing, rub-off ink or scented coatings. Two-roller coaters typically consist of a rubber-coated dip roller that rotates in a coating pan, a chromium-plated coating forme roller and a coating forme cylinder. Two-roller coaters for sheetfed presses have been transmuted into what are known as squeeze coaters. The rubber roller has been replaced by a chrome roller and the coating is applied through a slit in a tank positioned above the roller nip. The volume of coating applied is controlled by adjusting the size of the roller nip, so exceptionally thick layers of coating can be applied. The rollers
Roller-type versus anilox coaters

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Roller-type coaters</th>
<th>Anilox coaters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness of coating film that can be applied</td>
<td>very thick</td>
<td>generally thinner, but with special screen roller thicker</td>
</tr>
<tr>
<td>Specified coating thickness</td>
<td>can be set fast by changing the roller nip or speed and direction of roller rotation</td>
<td>reproducible thickness can be set by using a screen roller with a predefined pick-up volume</td>
</tr>
<tr>
<td>Impact of production speed</td>
<td>Changes in speed cause fluctuations in the volume of coating applied</td>
<td>none (volume always constant)</td>
</tr>
<tr>
<td>Adjustment to suit substrate</td>
<td>limited (solely via volume)</td>
<td>precise (by using a screen roller with the corresponding engraving)</td>
</tr>
<tr>
<td>Application of pigmented coating</td>
<td>poor</td>
<td>good in conjunction with a screen roller specially engraved for larger pigment particles</td>
</tr>
</tbody>
</table>

Coating quality

| Solid | Homogeneity depends on speed | Always homogeneous |
| Spot  | Blurred edges | Outstanding reproduction of type and fine details |

Handling

| Cleaning | With a roller-washing device | Automatic washing within the coating circulation system, very efficient with sealed doctor chamber |
| Changing components | Seldom necessary | Insertion of new screen roller (at large-format presses with the aid of a crane); regular replacement of worn blades and seals |

Four printing units plus an anilox coater: that is the standard configuration for the Rapida 74 G, which like the 74 Karat consumes waterless offset inks and aqueous coatings.

The Swedish pilot user, Inplastor, wanted to avoid having to use an offline coating system for the plastic cards it prints, and opted for an anilox coating system with a variety of screen rollers. Nonetheless, anilox coaters are the present state of the art for sheetfed presses. Because they are based on flexography, a letterpress process, the quality of the coating delivered is much better than in offset with regard not only to the homogeneity of full solids but also to detail reproduction in spot coatings. Anilox coaters consume on average 15% less coating than roller-type coaters. While it is true that anilox coaters are unable to apply an infinitely adjustable coating film, coating application is more consistent and reliably reproducible because it is influenced solely by the pick-up volume and the engraved screen roller – speed is irrelevant. As a result anilox coaters require less skill on the part of the press operator than do roller-type coaters, and also less monitoring.

With anilox coating it is possible to apply not only aqueous and UV coatings but also metallic and pearlescent coatings and opaque white. The volume of coating applied can be defined and reproduced at any time with the utmost precision.

Purchasers of Rapida and Performa 74 presses equipped with coater(s) can choose systems from either Harris & Bruno or Tresu, both of which also offer automated systems for changing the coating. (See pages 32 to 35: “Technologies for automating changes of coating.”)
Anilox systems from Tresu are installed in KBA’s two waterless offset presses, the 74 Karat and Rapida 74 G, with technotrans systems available as an alternative. Coating change systems are optional with the 74 Karat and Rapida 74 G, because most users tend to use just one type of aqueous coating; a change of coating would only be necessary if pigmented coatings or opaque white were applied, and if paper were printed instead of plastic film.

Doctoring chambers can either be swivelled (Tresu) or shifted sideways (Harris & Bruno) to allow access to the screen roller, the two doctoring blades and the seals (see “Technologies for automating changes of coating”). In both cases the blade chamber can be thrown on and off manually and is exceptionally easy to operate.

Dieter Kleeberg

Supersize press: even the Rapida 205 boasts anilox technology. In this instance the customer opted for a two-metre (78-inch) wide blade from Harris & Bruno

The buyer has the choice: the doctor blades in the Rapida 105 pictured at the top of this page are from Tresu, those in the Rapida 142 above are from Harris & Bruno

No compromise: an anilox coater – like the one here from Harris & Bruno – is a routine feature on the Performa 74. Roller-type coaters are considered old hat in small and medium formats because the quality they deliver is inferior

Consumable parts: the sealing and doctoring blades must be changed at regular intervals along with the seals

Photo: Tresu

Screen roller and coating forme cylinder: on this Rapida 105 there are no streaks in the coating
# Offline gloss coating options for sheetfed products

<table>
<thead>
<tr>
<th>Coating application</th>
<th>Aqueous coatings</th>
<th>Other coatings</th>
<th>Gloss inks</th>
<th>Possible coating finish</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full-solid or spot with inline coater (as separate pass)</td>
<td>all types (gloss and metallic, metallic and lustre, spot and scratch-off, gumming, blister and sealant coatings; primer)</td>
<td>gloss and matt UV coatings</td>
<td>(metallic and lustre inks are applied inline in printing units)</td>
<td>sheeted printing (additional pass), blind and hot-foil stamping</td>
</tr>
<tr>
<td>Full-solid, strip or spot with roller-based coater</td>
<td>all types</td>
<td>gloss and matt UV coatings</td>
<td>—</td>
<td>high-gloss calendering (inline or offline), blind and hot-foil stamping</td>
</tr>
<tr>
<td>Full-solid with hot calender</td>
<td>—</td>
<td>hot-melt plastic</td>
<td>—</td>
<td>inline high-gloss calendering is part of the process</td>
</tr>
<tr>
<td>Full-solid or spot with flatbed or rotary screen-printing press</td>
<td>gloss and matt, metallic and lustre, gumming and adhesive, blister and sealant coatings</td>
<td>gloss and matt UV, relief and contour UV coatings</td>
<td>metallic and lustre inks, holographic and mirror inks</td>
<td>high-gloss calendering (offline), blind and hot-foil stamping</td>
</tr>
<tr>
<td>Full-solid with sheetrock gravure press</td>
<td>—</td>
<td>gloss and metallic UV, solvent-based gloss coatings</td>
<td>metallic and lustre inks</td>
<td>sheeted printing, blind and hot-foil stamping</td>
</tr>
</tbody>
</table>

**Film lamination**

<table>
<thead>
<tr>
<th>Consumables applied</th>
<th>Possible film finish</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full-solid with wet laminator</td>
<td>first aqueous or UV adhesive, then film</td>
</tr>
<tr>
<td>Full-solid with dry laminator</td>
<td>first solvent-based, hot-melt or polyurethane adhesive or wax, then film</td>
</tr>
<tr>
<td>Full-solid with thermal laminator</td>
<td>film with pre-applied hot-melt adhesive</td>
</tr>
</tbody>
</table>

## Excursus: offline gloss coating

It is worth applying an offline gloss coating to the substrate if the surface must demonstrate specific visual, tactile or mechanical properties – or if additional finishing processes such as stamping, punching or flocking are to follow. An inline combination with other materials, e.g. hologram-like film, is simply not possible. Screen printing, being a common process, is often the most versatile offline finishing option, even though the production speeds of rotary screen-printing presses are, at best, only 70 to 80 per cent as fast as roller-based coating machines, which can have maximum speeds in excess of 10,000 sheets per hour.

In contrast to inline coating, which is typically applied wet on wet, offline coatings are usually applied once the ink has dried or cured. It is therefore generally possible to apply a UV coating to oxidation-dried ink without the need for a primer. Basically, this will also function on a printing press, provided it is used for a separate coating pass after the ink has dried. Instead of a printing unit some coating specialists use a roller-based coater capable of applying both a full-solid and a spot coating. It is even possible to fit photopolymer coating plates, which reproduce detail better than an inline roller-based coater. Detail reproduction with screen-printing presses is also good.

Film adheres well to all types of inks once they are dry. Film-laminating machines are normally equipped with a cleaning system that removes powder and paper particles prior to lamination. Whether a coating or a film should be used is primarily determined by the proposed function or purpose of the printed product in question. Visually, extra-thick layers of gloss coating, smooth-calendered for additional shine, are just as good as a gloss film. Polypropylene (OPP, PPVK), polyester (PET), polyvinyl chloride (PVC, PVDC) and cellulose acetate (CA) film are the most popular types currently in use. Prestamped or pre-embossed film is also available, and this dispenses with the need for stamping or embossing after the film has been applied. Structured embossing generally simulates the tactile properties of linen, parchment or leather and is frequently used for presentation files and for books (eg reference books and textbooks). More conspicuous visual effects can be created by using coloured and metallised film. Laminating film is generally between 10 and 100µm (0.4 to 4 thou) thick. Although hot-melt film does not boast the same wide range of properties as other types of coating, and the prior application of adhesive makes it more expensive, it is becoming increasingly popular because it is easier to apply. Film-laminating machines for sheetfed prints currently have a maximum throughput of 10,000 sheets per hour. The speed is reduced if laminating is combined with embossing or lamination of the reverse side of the sheet.

Dieter Kleeberg
Anilox rollers are a product of the flexo printing process. The very name anilox indicates its provenance, since it was originally used to apply aniline-based flexo inks. In the interim anilox rollers have evolved into a highly technical and complex component.

KBA’s long history of expertise in short-train inking means that it is the only press vendor worldwide with the know-how required to manufacture anilox rollers in-house. The rollers made at its Radebeul facility are primarily destined for keyless, waterless short ink trains. Anilox rollers for KBA’s inline coaters are supplied by two specialists, Praxair Surface Technologies and Zecher.

Types of engraved screen
The entire surface of an anilox roller is engraved. The classic engraved screen consists of cells. Previously the indentations were pyramid-shaped and arranged like a chess board. Later a hexagonal shape with spherical indentations in a honeycomb pattern was adopted. While closed structures such as hexagons are currently the pattern of choice for metallic pigment coatings, for other applications there has been a gradually shift towards open structures. For some years now a hachure, or hatched engraving that resembles a screw thread or line screen, has proved to be the most efficient structure. Although hachures have the advantage of preventing foam formation, problems may occur with more complex coating images as centrifugal forces drive the coating along the grooves to the edge of the roller. This shift in coating application may result in ghosting, though this can also be caused by improper wetting or an insufficient volume of coating in the doctor chamber. Ghosting caused by patchy coating, on the other hand, can be eliminated by adopting a ratio of 1:1.5 for the diameters of the anilox roller and the coating form cylinder.

The most recent type of engraving pattern to be developed is cross-hatching, which creates as it were “islands” or “pillars”. Here, too, the two sets of hatched engravings are applied at right-angles to each other. If the angle of the cross-hatch is reduced to just 75°, the structure is distorted in one direction. Stretching the pillars causes them to flatten, so that virtually the entire surface of the roller is covered in coating. When transferred to the substrate the coating therefore takes less time to spread. Despite the ultra-flat engraving and thus shallow depth of coating on the anilox roller, the fact that the coating is more or less pre-spread upon application means that there is no further thinning of the film so it retains its maximum thickness. This type of cross-hatching is known as an ART-TIF engraving (Thin Ink Film). It is applied to anilox rollers used for high-gloss coatings and can deliver a gloss level that is up to 5 points higher than with ART.

Key parameters
On an anilox roller, the screen resolution in repro corresponds to the screen ruling in lines per centimetre or lines per inch (1000pc = 250lpi, 100lpi = 40lpc). It ranges from 40 to 180lpi (100 to 460lpi). The fineness is determined by the...
The coating film transferred from a TIF roller (blue), is thinner at maximum elasticity than the coating film from an ART roller (grey). But although it is thinner, it is smoother so the volume of coating applied is higher than with an ART roller. In this illustration the difference is exaggerated.

If rollers are to be used efficiently they must be clearly identified. A tag (eg Zecher) or an identity strip on the roller (eg Praxair) are two accepted methods.

Choosing the right type of anilox roller

The volume of coating transferred by the anilox roller is constant and uniform across the entire format width. The total volume applied can only be changed by changing the roller, zonal metering is not possible. So where production entails various coating applications, it is essential to choose the anilox roller with the screen and pick-up volume best suited to the type of coating and substrate being used for the job in hand (see table).

It is not just the volume of coating transferred that is influenced by the screen structure: where a pigmented coating is used the cells, grooves or interstitial columns must also be large enough to accommodate the pigment particles. Metallic pigments range in size from 7 to 17µm, interference pigments (eg Merck’s Iriodin as individual flakes or encapsulated as pearlets) and scented capsules can measure between 5 and 200µm, depending on specifications. By comparison pigments in standard printing inks are just 1 to 3µm across. Even if the cells and grooves are large enough, not all the pigment particles will disappear into them: the residue will be pressed against the walls by the doctoring blade, accelerating surface abrasion. This is one reason why pearlescent coatings should be applied with ART rollers.

Most printing plants generally use a variety of anilox rollers. To avoid confusion, roller data must be easy to identify. As a rule, anilox rollers should be stored together with their specifications in containers or on shelves. In case of doubt it is best to check the roller with a volumeter.

Unfortunately, a lot of anilox rollers still have non-standard markings that are stamped or vibration-etched into the steel side faces. This has the drawback of making them hard to read at the press. For some time now both Praxair’s standard and customised rollers have featured an ID strip which provides roller data that can be read at a glance, even in the coater. This ID strip, whose width varies according to roller size and customer specs, is engraved at the edge of the cylindrical surface, outside the screen structure. The data are generated by computer and engraved in the ceramic surface along with the screen structure. The strip is as hard-wearing as the engraved surface.

Surface and engraving quality

The surface of anilox rollers consists of a ceramic layer into which the screen structure is engraved by laser. Ceramic is particularly hard and resistant to abrasion. The ceramic layer should also adhere firmly to the metal roller body, protect it from corrosion, contain no foreign particles and be laser-encravable to a high quality standard. But its most important quality is low porosity, so the surface must be totally smooth and sealed. The smoother the surface, the lower the interfacial tension relative to the coating. And the lower the interfacial tension, the easier it is to empty the screen of coating during transfer and cleaning. Praxair guarantees that the proportion of micropores (pinholes) in its roller surfaces does not exceed 3%, even though with ART and TIF screens the impact of these pinholes is negligible.

A special surface treatment can be used to lower interfacial tension or set it to a precise value. Praxair’s iridescent layer which combines the benefits of good detail reproduction and a uniform application to deliver the matt and gloss values...
### Specifications and recommended applications for anilox rollers used for inline coating

<table>
<thead>
<tr>
<th>Screen ruling</th>
<th>Engraving</th>
<th>Pick-up volume</th>
<th>Volume applied wet*</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Aqueous coatings</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>120 lpi (300 lpi)</td>
<td>Praxair ART</td>
<td>n/a</td>
<td>9 g/m²</td>
<td>coated paper up to 170 g/m²</td>
</tr>
<tr>
<td>120 lpi (300 lpi)</td>
<td>Praxair ART</td>
<td>n/a</td>
<td>13 g/m²</td>
<td>coated carton</td>
</tr>
<tr>
<td>120 lpi (300 lpi)</td>
<td>Praxair ART</td>
<td>n/a</td>
<td>13 g/m²</td>
<td>coated paper in two-coater press</td>
</tr>
<tr>
<td>100 lpi (250 lpi)</td>
<td>Praxair ART-TIF</td>
<td>n/a</td>
<td>16 - 20 g/m²</td>
<td>high gloss coatings</td>
</tr>
<tr>
<td>160 lpi (400 lpi)</td>
<td>hachure</td>
<td>6.5 cm³/m² (4.2 BCM)</td>
<td>16 - 2 g/m²</td>
<td>coated paper</td>
</tr>
<tr>
<td>160 lpi (400 lpi)</td>
<td>hexagon 60°</td>
<td>7.5 cm³/m² (4.8 BCM)</td>
<td>16 - 3 g/m²</td>
<td>coated paper</td>
</tr>
<tr>
<td>140 lpi (350 lpi)</td>
<td>hexagon 60°</td>
<td>8.7 cm³/m² (5.6 BCM)</td>
<td>2.1 - 3.5 g/m²</td>
<td>coated paper</td>
</tr>
<tr>
<td>120 lpi (300 lpi)</td>
<td>hexagon 60°</td>
<td>9.2 cm³/m² (5.9 BCM)</td>
<td>2.3 - 3.6 g/m²</td>
<td>coated paper</td>
</tr>
<tr>
<td>110 lpi (280 lpi)</td>
<td>hexagon 60°</td>
<td>10.2 cm³/m² (6.6 BCM)</td>
<td>2.5 - 4.5 g/m²</td>
<td>coated paper</td>
</tr>
<tr>
<td>100 lpi (250 - 250 lpi)</td>
<td>hexagon 60°</td>
<td>11 cm³/m² (7.1 BCM)</td>
<td>2.8 - 4.6 g/m²</td>
<td>coated paper</td>
</tr>
<tr>
<td><strong>UV coatings</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>120 lpi (300 lpi)</td>
<td>Praxair ART</td>
<td>n/a</td>
<td>9 g/m²</td>
<td>coated paper up to 170 g/m²</td>
</tr>
<tr>
<td>120 lpi (300 lpi)</td>
<td>Praxair ART</td>
<td>n/a</td>
<td>13 g/m²</td>
<td>coated carton</td>
</tr>
<tr>
<td>100 - 80 lpi (250 - 200 lpi)</td>
<td>Praxair ART-TIF</td>
<td>n/a</td>
<td>16 - 20 g/m²</td>
<td>high gloss coatings</td>
</tr>
<tr>
<td>80 lpi (200 lpi)</td>
<td>Praxair ART-TIF</td>
<td>n/a</td>
<td>16 - 20 g/m²</td>
<td>high gloss coatings in two-coater presses</td>
</tr>
<tr>
<td>160 lpi (400 lpi)</td>
<td>hachure</td>
<td>6.5 cm³/m² (4.2 BCM)</td>
<td>16 - 2.6 g/m²</td>
<td>coated paper</td>
</tr>
<tr>
<td>160 lpi (400 lpi)</td>
<td>hexagon 60°</td>
<td>7.5 cm³/m² (4.8 BCM)</td>
<td>16 - 3 g/m²</td>
<td>coated paper</td>
</tr>
<tr>
<td>140 lpi (350 lpi)</td>
<td>hexagon 60°</td>
<td>8.7 cm³/m² (5.6 BCM)</td>
<td>2.1 - 3.5 g/m²</td>
<td>coated paper</td>
</tr>
<tr>
<td>120 lpi (300 lpi)</td>
<td>hexagon 60°</td>
<td>9.2 cm³/m² (5.9 BCM)</td>
<td>2.3 - 3.6 g/m²</td>
<td>coated paper</td>
</tr>
<tr>
<td>110 lpi (280 lpi)</td>
<td>hexagon 60°</td>
<td>10.2 cm³/m² (6.6 BCM)</td>
<td>2.5 - 4.5 g/m²</td>
<td>coated paper</td>
</tr>
<tr>
<td>90 - 100 lpi (250 - 250 lpi)</td>
<td>hexagon 60°</td>
<td>11 cm³/m² (7.1 BCM)</td>
<td>2.8 - 4.6 g/m²</td>
<td>coated paper</td>
</tr>
<tr>
<td><strong>Gold and silver coatings</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>180 lpi (460 lpi)</td>
<td>hexagon 60°</td>
<td>6.5 - 7 cm³/m² (4.2 - 4.5 BCM)</td>
<td>n/a</td>
<td>linework, fine fonts and logos</td>
</tr>
<tr>
<td>140 - 160 lpi (350 - 400 lpi)</td>
<td>hexagon 60°</td>
<td>7 - 9 cm³/m² (4.5 - 5.8 BCM)</td>
<td>n/a</td>
<td>large texts, large solids</td>
</tr>
<tr>
<td>120 - 140 lpi (300 - 350 lpi)</td>
<td>hexagon 60°</td>
<td>7 - 10 cm³/m² (4.5 - 6.4 BCM)</td>
<td>n/a (on the primer)</td>
<td>in two-coater press</td>
</tr>
<tr>
<td>110 lpi (280 lpi)</td>
<td>hexagon 60°</td>
<td>7 - 10 cm³/m² (4.5 - 6.4 BCM)</td>
<td>n/a (on the primer)</td>
<td>in two-coater press</td>
</tr>
<tr>
<td>80 lpi (200 lpi)</td>
<td>hexagon 60°</td>
<td>15 cm³/m² (9.7 BCM)</td>
<td>3.8 - 6 g/m²</td>
<td>n/a</td>
</tr>
<tr>
<td>60 lpi (150 lpi)</td>
<td>hexagon 60°</td>
<td>17 cm³/m² (11 BCM)</td>
<td>4.3 - 6.9 g/m²</td>
<td>n/a</td>
</tr>
<tr>
<td>55 lpi (140 lpi)</td>
<td>hexagon 60°</td>
<td>21 cm³/m² (13.5 BCM)</td>
<td>5.3 - 8.4 g/m²</td>
<td>n/a</td>
</tr>
<tr>
<td>160 lpi (400 lpi)</td>
<td>hachure</td>
<td>n/a</td>
<td>7 - 8 g/m²</td>
<td>n/a</td>
</tr>
<tr>
<td><strong>Pearlescent coatings</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>180 lpi (460 lpi)</td>
<td>Praxair ART</td>
<td>n/a</td>
<td>8 g/m²</td>
<td>pigment size &lt; 15 µm, screen</td>
</tr>
<tr>
<td>160 lpi (400 lpi)</td>
<td>Praxair ART</td>
<td>n/a</td>
<td>12 g/m²</td>
<td>pigment size &lt; 15 µm, solid</td>
</tr>
<tr>
<td>140 lpi (350 lpi)</td>
<td>Praxair ART</td>
<td>n/a</td>
<td>12.5 g/m²</td>
<td>pigment size &lt; 25 µm, solid and screen</td>
</tr>
<tr>
<td>100 lpi (250 lpi)</td>
<td>Praxair ART</td>
<td>n/a</td>
<td>13 g/m²</td>
<td>pigment size &lt; 60 µm, solid and screen</td>
</tr>
<tr>
<td>100 - 80 lpi (250 - 200 lpi)</td>
<td>Praxair ART</td>
<td>n/a</td>
<td>16 - 22 g/m²</td>
<td>pigment size &lt; 100 µm, solid</td>
</tr>
<tr>
<td>80 lpi (200 lpi)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>120 - 70 lpi (300 - 180 lpi)</td>
<td>hachure</td>
<td>17 cm³/m² (11 BCM)</td>
<td>6 g/m²</td>
<td>pigment size &lt; 15 µm, solid</td>
</tr>
<tr>
<td>120 - 60 lpi (300 - 150 lpi)</td>
<td>hachure</td>
<td>11 - 19 cm³/m² (7.1 - 12.1 BCM)</td>
<td>6 - 13 g/m²</td>
<td>pigment size &lt; 25 µm, solid and screen</td>
</tr>
<tr>
<td>60 - 40 lpi (150 - 100 lpi)</td>
<td>hachure</td>
<td>22 - 30 cm³/m² (14.2 - 19.4 BCM)</td>
<td>6 - 19 g/m²</td>
<td>pigment size &lt; 60 µm, solid and screen</td>
</tr>
<tr>
<td>55 lpi (140 lpi)</td>
<td>hexagon 60°</td>
<td>21 cm³/m² (13.5 BCM)</td>
<td>5 - 7 g/m²</td>
<td>blister and skin packaging</td>
</tr>
</tbody>
</table>

* *ABR recommendation: Since the inline coatings applied by anilox rollers have a low viscosity and a density similar to that of water, for wet applications 1 g/m² is roughly equivalent to 1 cm³/m².*
Practical tips from KBA’s coating seminar: how to handle anilox rollers

1. Cleaning discipline
- The pick-up volume determines the coating thickness. In the interests of accurate metering, the press operator must ensure that the anilox roller is kept free of dried coating residue. The anilox rollers must therefore be cleaned after every job.
- After inline cleaning (warm water is recommended) the rollers should first be thoroughly wiped by hand with a damp cloth and then dried with a fresh cloth until all traces of moisture have been removed.
- The anilox roller should be cleaned immediately following the application of special-effect coatings containing, say, metallic or pearlescent pigments, blister coatings and opaque white. Gold and blister coatings justify the connection of an additional warm-water circuit.

2. Checking the pick-up volume
- Quality assurance procedures should specify regular maintenance that includes the microscopic examination and measurement of anilox rollers to facilitate roller selection, promote cleaning discipline and monitor roller abrasion.
- Depending on the process used, the pick-up volume and other parameters can be monitored with greater or less accuracy either at the printing plant or the roller manufacturer using roller impressions. Under ideal conditions interferometric, ie three-dimensional, volume measurements taken directly on the roller can reduce the error tolerance to ± 3%. With indirect optical and interferometric volume measurement using an anilox strip the error range is between +4% and -7%.
- Major fluctuations are mostly caused by interference from:
  - contamination by coating residue (measurement can also provide proof of contamination),
  - irregular engraving with excessive pinholes,
  - faulty roller impression on the paper,
  - errors in the interferometric evaluation of the strip impression.
- The engraving depth is not normally logged, since sizeable local fluctuations can be misleading. What is important is that the pick-up volume should be tested on a large enough section of the roller.
- Streaking normally has nothing to do with fluctuations in the pick-up volume. If streaking occurs, check the rigidity and abrasion of the two doctoring blades on the anilox roller.

3. Changing the anilox rollers
- KBA recommends using a crane to change the anilox rollers on large-format presses. This avoids the risk of damage caused by manual handling and excessive force. The rollers for small- and medium-format presses are light enough to be changed by hand.
- The roller must be removed from the press prior to being deep-cleaned and checked for signs of abrasion.

Left: The pick-up volume can be checked quickly and directly, but not with any great degree of accuracy, with a manual measuring device like the URHI II (Ucarlox Roll Measuring Instrument) available from Praxair and other vendors. Right: The pick-up volume can be determined indirectly by rolling a paste with defined force into the screen structure, taking impressions on paper and sending them to Zecher for measurement.

Direct interferometric examination using a Wyko microscope of the structure and volume of an anilox roller with various test engravings. Photos: Zecher

Media blasting. An ultrasonic system is available from KBA, or alternatively a CleanMobil can be hired by the hour from Zecher. Properly used, it is outstandingly effective, but uncontrolled intensity can destroy the ceramic. Laser cleaning employs a relatively weak laser beam to evaporate coating residue. The thoroughness is determined by the length of time the laser acts on the roller.

Jürgen Veil, Dieter Kleeberg
Technologies for automating changes of coating

Changing from one type of coating to another is no longer a time-consuming business, thanks to automation. Users of KBA sheetfed presses can choose between single-circuit pumping systems from Harris & Bruno or dual-circuit systems from Tresu. As KBA has found in tests, both systems deliver essentially the same results – but the level of automation and the manual input involved vary, as do the benefits and the underlying philosophies.

The coater and feed system must be cleaned at the end of each shift and when switching from one type of coating to another (eg from UV to aqueous, or from aqueous with special-effect pigments to aqueous without). Changes of coating are all part of the routine with hybrid and two-coater presses, but can also occur with any other type of coater press. They should take a minimum of time and require a minimum of input from the press operator.

Manual cleaning is time-consuming and gives rise to lengthy down times. An average cleaning cycle using simple coating pumps and doctor blades that are not embedded in the feed system takes between 20 and 25 minutes per coater, with the press operator fully occupied for the duration. By contrast, automated feed systems like those from Harris & Bruno clean all the coating-specific components thoroughly in just a few minutes, depending on the type of coating used, the press format and the degree of automation. This was not always the case, because for a long time the automation levels available for inline coaters could not compare with those for offset printing units.

Harris & Bruno systems: one coating circuit

A Harris & Bruno automated coating feed system is cleaned immaculately in just three to eight minutes, depending on the coating type and the press format. Since the cleaning process is actuated by push-button and runs automatically, the operator can turn to other tasks within a matter of seconds.

Preconditions for total automation

Automation levels can vary substantially. Total automation means that all coating-specific components – even the hoses back to the drums – are cleaned at the touch of a single button, with no manual pumping, valve switching or subsequent cleaning necessary. For completeness it should be possible to switch from one type of coating to another in a single feed system. Using a single circuit avoids the need to manually switch the hoses or valves, thus eliminating the risk of accidentally mixing the coatings.

As a precondition the doctoring system must be fully embedded in the controls, and the filling and draining valves for the doctor chamber controlled automatically. This is the case with our HydroComp doctoring system, which is a standard feature of H&B feed systems. To avoid mixing different coatings in one circuit, one part of the cleaning process must be carried out in what is known as purge mode (an H&B patent). This entails using the new coating to squeeze any residual cleaning agent or coating out of the system and into the waste container.

Two options are available for optimising automatic operation. An inline heating module is especially useful for warming UV coatings to their optimum viscosity, with the temperature at the anilox roller measured continuously by a sensor. There is also a special coating circulator, SCC, which includes cooling and agitation to make rheologically problematical coatings workable.

Single- and dual-circuit systems: the pros and cons

Previously, if cross contamination was to be avoided, two separate coating circuits were indispensable. While changeover times are shorter than with basic manual systems, Harris & Bruno believes that this gain comes at the expense of automation, since hoses must be re-attached or additional valves switched. What is more, it requires twice the number of pumps and valves, which in turn doubles cleaning and maintenance input and makes the system more prone to malfunctions and operating errors, thus pushing up costs.

In a single coating circuit there is no risk of cross-contamination if the system has a patented purge mode capability. If this is the case it is possible to automate the system completely and minimise operator intervention, so that make-ready and press down times are shorter than with two circuits. A system that is half the size of another system requires 50% less maintenance and is vulnerable to fewer operator errors. Nonetheless, a separate coating feed system, or to be more precise an SCC, may be advisable or nec-
Tresu offers a complete portfolio comprehensive concept that also change are just two aspects of a press during cleaning and changes doctoring blade can remain in the ings. With this system, too, auto circuits for aqueous and UV coat presses, uses two separate coating technology for inline coating in sheetfed and in 1992 adapted this technol for flexo presses in the late 1980s started making doctoring systems Danish vendor Tresu, which two coating circuits Tresu systems: two coating circuits

Danish vendor Tresu, which started making doctoring systems for flexo presses in the late 1980s and in 1992 adapted this technol for inline coating in sheetfed presses, uses two separate coating circuits for aqueous and UV coat ings. With this system, too, auto mated sequences mean that the doctoring blade can remain in the press during cleaning and changes of coating. Coating feed and change are just two aspects of a comprehensive concept that also addresses typical flexo issues. Tresu offers a complete portfolio for transforming a standard coater into an advanced coating system for specific applications.

Dedicated or dual-purpose circulators

Tresu users are offered a choice between a dedicated coating cir culator – the L10 Aqua (for aqueous coatings) or L10 UV (for UV coatings) – and a dual-purpose system, the L30 Combi. The L10-Aqua circulator can be programmed for several different cleaning cycles. The simplest uses hot water and should be reserved for quick cleans between two job. A more intensive cycle which uses hot water and a cleaning additive is recommended for cleaning the doctor chamber, hoses and circulators at the end of a shift or prior to a change of coating. The ability to program the cleaning mode and duration as well as the water volume and temperature means that all traces of contamination are removed from the doctoring blade and the anilox roller. Instead of a hot water cleaning system the L10 UV has a built-in solvent tank from which the solvent is distributed to the doctor chamber, the hoses and the circulator. Both the Aqua and the UV circulator have a purge function.

The L30 Combi, which has one circuit for aqueous coatings and one for UV, has four compressed air membrane pumps – two for each type of coating.

Quicker coating changes with two circuits

With two circuits, all traces of coating must be removed only from the doctor chamber – not from all the pipes and valves in the circulator. So less time is needed to empty and clean the system and less coating is used in the process. This delivers both time gains and cost savings – and any danger that different types of coating may mix during production. At the KBA coating seminar it was made clear that this is a topic to which many printers pay too little attention.

The pumps used

More than 80% of all anilox coating and inking systems are powered by membrane pumps which in most cases function with compressed air. This type of pump is still the best compromise in respect of flow volume, reliability and price. The biggest drawback of membrane pumps is pulsation, though this has no impact on modern, stable doctoring systems. On the contrary, pulsation can actually have a beneficial impact during cleaning. The high consumption of air is also criticised as a drawback. Pumps with the appropriate power level fill the doctor chambers in the coating circuit at a very low speed. With Harris & Bruno’s system this is around one stroke per second, which pumps around 9 litres per minute. This is more than adequate for the maximum take-up volume of approximately 3.6 litres per minute for full-solid coating in large format. At this speed, air consumption by the pump is equivalent to around 0.3 kilowatts, which is comparable to the energy consumed by electrical pumps for the same flow rate.

Conclusion

The biggest benefit delivered by a well-designed automatic feed system for inline coaters on offset presses is the reduction in press down times.

Gerhard Palinkas,

Harris & Bruno Europe,

Schwäbisch Gmünd

In Harris & Bruno’s HydroComp doctor chamber the hydropneumatic blade-pressure control (1) is located on a shaft (2) and acts at several places across the format width, thus ensuring that blade pressure is uniform and the blades cannot flex during linear adjustment.
Sticky manual cleaning is generally more effective than an automatic cleaning system. Elsewhere it has long since become the norm.

An automatic cleaning system is not entirely problem-free. To avoid or eliminate undesirable effects the following must be checked.

1. More effective circuit cleaning
   - An inline heating system can be used not only to control the temperature of UV coatings but to heat the water for flushing out aqueous coating systems. This method of cleaning is much more effective because pumping hot water through the system removes even the most obstinate residue.
   - An agitator module in the coating circuit makes UV coatings more workable, and this is why agitators are a standard feature on Rapida presses sporting a UV capability.
   - A dedicated coating circuit is recommended for special high-viscosity coatings. Although this option is less common in the USA, elsewhere it has long since become the norm.
   - An automatic cleaning system is generally more effective than manual cleaning at removing sticky blister coatings with a viscosity of 100s or more (DIN run-out cup) from the anilox roller. Even so, it may be necessary to finish cleaning the roller manually, which is why – as with all special applications – the roller should be given a careful post-wash inspection.

2. Choosing and setting the coating pump
   - Low-viscosity coatings are pumped by H&B systems, for example, at a speed of 1 stroke per second (approximately 9 litres per minute). Depending on the press format, coating take-up varies between 1.6 l/min (Rapida 105) and 3.5 l/min (Rapida 205), ie the pumped volume and the return volume are much higher than the take-up volume. If the feed volume is too high it can cause excessive pressure within the doctoring chamber, forcing out some of the coating.
   - If high-viscosity coatings are used on a regular basis it is best to obtain advice on which type of coating pump to buy. Coatings with a viscosity of around 200s push the pumps to the limits of their mechanical capabilities and cause excessive wear and tear. A modification to the pump is possible for coating viscosities of 150s or more, but even so membrane pumps have proved to be less suitable.
   - Return pumping is possible for a residual volume of no more than 1.5 litres. Since air is pumped back as well, it is fatal to pump back costly metallic coatings as the metallic pigments would rapidly oxidise.

3. Undesirable effects at the Doctoring blade
   - The coating feed systems built by Harris & Bruno and Tresu differ in the design of the integrated doctoring systems. Tresu’s doctoring blade is pivoted above the upper blade so that it can be raised and lowered. The throw-on angle is thus determined equally by the pressure of the two blades. The blade pressure, which results from the torque of the relatively heavy chamber, is therefore always uniform and unaffected by blade abrasion. With H&B’s chamber, on the other hand, the throw-on/throw-off movement is linear.
   - As a result the chamber is always applied at the same angle to the anilox roller. The blade throw-on pressure is controlled hydropneumatically, either at a standard 2 bar (2000 hectopascal) or another prespecified value, with the blade automatically adjusted to allow for abrasion.
   - Nonetheless, chamber operation is not entirely problem-free. To avoid or eliminate undesirable effects the following must be checked.

With Tresu’s pivoting doctoring system the chamber is always full and the sealing blade (1) is above the doctoring blade (2). With this patented E-Line chamber the optimum torque is set by a torsion rod (3) via a lever (4). The torsion rod creates a uniform blade pressure across the entire width, thus preventing blade deflection.
Pigmented coatings
As an option the X10 can be fitted with an agitator to ensure that the particles in pigmented coatings are distributed evenly. Depending on their size and structure, pigment particles also increase viscosity. While this can easily be remedied by reducing the concentration of pigments, it naturally impairs the overall quality of the coating and the optical effects created. Pigmented spot coatings are normally applied in a coater using a polymer flexo plate. They are prone to build up at the edges of the spots. The press operator must keep a sharp watch if he is to maintain a consistently high coating quality, because he must clean the coating plate at the first sign of build-up. Tresu’s Printing Plate Cleaner (PPC) – a system that cleans the flexo plate during print production – was developed specifically for this purpose. A “turbo” version can be used during press standstill.

Anti-foaming agents
Air that could cause the coating to foam does not stand a chance in an E-Line doctoring system. The chamber is always full of coating, so there are no air pockets, and the coating is pumped through at a high flow speed. If air is applied with high-viscosity coatings, which can happen, this can escape via a siphon valve that can be actuated on demand.

Patented torsion rods in E-line chamber
To eliminate all risk of excessive or uneven abrasion that could necessitate a premature change of blade, and to ensure that the coating is doctored uniformly across the entire width of the roller, the doctoring blades in Tresu’s E-Line system are thrown on at a uniform torque via a torsion rod. The rod replaces the conventional chamber in which several screws had to be tightened simultaneously. A blade can be changed in a matter of seconds by simply loosening the torsion rod.

Hans Henrik Christiansen,
Tresu Production, Bjert (Denmark)

• Leakage from the doctoring chamber can have three basic causes:
  - Insufficient throw-on pressure can leave a minute gap between the blade and the anilox roller, as a result of which too much coating remains on the roller and is therefore applied to the plate, and coating leaks out during press standstill.
  - One or both blades, and maybe also the seals or blade clamps, may be worn and/or contaminated. They should be checked once a week and cleaned if necessary. If no coating is applied for any length of time the chamber should be tipped up and the seals lubricated. If blade abrasion is excessive it may be better to use a different type, eg synthetic, long-life or ceramic ones or – if quality standards allow – unsegmented blades. Causes of wear and tear that should be avoided are abrasive coating pigments (eg titanium oxide in aqueous opaque white; UV opaque white is a possible alternative) and anilox rollers with inappropriate surface finishes or abrasive engraved patterns.
  - Press speed may be too high, causing the blades to be pushed back for a split second by coating turbulence and cavitation (the formation and collapse of regions of low pressure in a flowing liquid).
• Trail doctoring is a phenomenon that can occur at both the upper and the lower blade, even if the seals are tight and blade pressure sufficiently high. Leakage is not the cause.
  - If the blade throw-on pressure is too high, the two doctoring blades will bend along their length so that one side of the blade is in contact with the roller instead of the edge. Increasing throw-on pressure to try and remedy what appears to be a loose line of contact will only exacerbate the problem.
  - Open anilox-roller engravings (ART, ART-TIF) have no cell walls and therefore cannot form a tight seal with the doctoring blade. So low-viscosity coatings may leak out even when the press is at a standstill.
  - Excessive pressure inside the doctoring chamber (filling pressure) can force coating out of the chamber.
• Centrifugal drift can occur on hachure rollers, especially with screen resolutions of less than 50lpc and low-viscosity coatings. Centrifugal forces drive the coating along the endless groove, causing it to build up on one side. Here it is advisable to use a different engraving and/or a coating with a higher viscosity.
• Ghosting can occur if the ink is not wetted properly by the coating or if there is insufficient coating or an uneven level of coating in the doctoring chamber, which will result in a patchy application of coating even if the blade is in the correct position.

![Image](Process_4_d_e.qxd:Seite 24-35 19.11.2007 12:43 Uhr Seite 35)
Flow and wetting properties of coatings

Viscosity and other rheological properties have a major impact on the storability, preparation and application of coatings. But many press operators are confused by the fact that the reference values and measuring processes specified are inconsistently defined. This chapter seeks to clarify the terms and procedures relating to flow properties and interfacial tension.

What is viscosity?
Consistency is a generic term for the solidity or fluidity of materials. In relation to printing inks and coatings it is the flow properties, the rheology, that is of particular interest. And, as with printing inks, the most important rheological characteristic of coatings is their viscosity, also called strength or tack. Synonyms for highly viscous are gummy, thick, thick-bodied, pasty, strong or stiff; the opposite is thin, thin-bodied, soft, runny or liquid. Overprint varnishes are not as stiffly viscous as sheetfed offset inks because they contain no pigments that could increase viscosity. UV and aqueous coatings have a low level of viscosity – while not as low as flexo inks, they can be transferred using a screen roller in an anilox coater. Ink with too high a level of viscosity does not split well on the rollers, and this is noticeable when taking ink out of the drum with a palette knife. Inks and coatings with too low a level of viscosity are prone to mixing, such inks lead to a higher dot gain. Viscosity can be reduced by adding thinners in the form of a special additive for UV coatings, and water or ammonia for aqueous coatings. The optimum level of viscosity depends on the specific application.

Inks and coatings are what are known as non-Newtonian or anomalously viscous fluids – ie fluids whose viscosity is changed by external influences. Mechanical influences are stirring in storage containers or agitation in the doctor chamber and – which partly depends on printing speed – shear forces and shear stress in the roller nip caused by rolling and lateral oscillation. Thermal influences are heating or cooling. Strong mechanical stress also causes heat emission. The higher the temperature increase and/or mechanical stress, the lower the viscosity. This is known as structural viscosity. The use of mechanical influences alone to lower viscosity is called thixotropy (when referring to printing inks, overprint varnish, aqueous and some UV coatings) and to raise viscosity rheopexy (a lot of UV coatings). Such mechanical influences include relaxation, the fact that after being subjected to mechanical influences inks and coatings recover and seek to restore their original viscosity. During the coating process a rapid thixotropic or rheopexic reaction is desirable: firstly it enables as near a complete film of coating as is possible to be transferred from the coating form to the substrate, secondly it enables gloss coatings to form a smooth, homogeneous surface instead of an orange-peel texture or droplets; UV coatings need a longer dwell section. In both cases there is a visible link between viscosity and wetting properties.

How is viscosity measured?
In practice, different procedures must be used to measure viscosity because inks and coatings can vary in consistency from liquid to paste. Depending on the measuring procedure either the dynamic or the kinematic viscosity is measured using a rheometer, otherwise known as a viscosimeter. But the same tenet applies for both types of viscosity: the higher the viscosity, the tackier the ink or coating. Viscosity is determined by adhesive and cohesive forces acting on the molecules in the liquid components. These forces can only be measured when the fluid is in motion (dynamic). Imagine that the fluid is formed in layers, then as it flows one layer will slide across another – a so-called shearing movement takes place. The term dynamic viscosity is used to describe the slide or flow resistance that occurs as the quotient of shearing stress and shearing speed. In UV and overprint varnishes it is the binding agents and photoinitiator molecules, in aqueous coatings the water molecules with the suspended resin molecules that determine flow resistance, and this in turn can be boosted by adding pigments. The whole process can be described neatly by the term internal friction. To overcome this internal friction, ie to make the transition to a fluid movement, certain forces – shear forces – are required. Rotating and oscillating rheometers, which are suitable for sheetfed offset, heatset and coldset inks as well as overprint varnishes, directly measure the flow resistance that is overcome. Since it counteracts the torque of a rotating or reciprocating body. DIN 53019 specifies rheometer
Rheological properties of coatings

<table>
<thead>
<tr>
<th>Rheological property</th>
<th>Symbol</th>
<th>SI units</th>
<th>Non-SI units</th>
<th>Definition</th>
<th>Measuring devices used in the print industry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dynamic viscosity</td>
<td>( \eta ) (Greek ( \eta ))</td>
<td>Pascal second (1 Pa s = 1 kg m/s²)</td>
<td>Centipoise (1 cP = 0.001 Pa s)</td>
<td>Resistance of a fluid to deform under shear stress, resistance to flow in fluids; shear stress divided by shear speed</td>
<td>for all coatings and inks: rotating or oscillating rheometers, also in viscosity-regulating feed systems</td>
</tr>
<tr>
<td>Flow curve</td>
<td>( \eta' (T) ) (eta of tau)</td>
<td>Pa s</td>
<td>cP</td>
<td>Dependence of dynamic viscosity on agitation time</td>
<td>for all coatings and inks: rotating rheometer, stopwatch</td>
</tr>
<tr>
<td>Kinematic viscosity</td>
<td>( \nu ) (Greek ( \nu ))</td>
<td>m²/s</td>
<td>Centistokes (1 cSt = 0.0001 m²/s)</td>
<td>Dynamic viscosity divided by material density</td>
<td>for UV/aqueous coatings and low-viscosity inks: drop-ball or drop-rod rheometer, capillary rheometer, run-out cup, coriolis rheometer</td>
</tr>
<tr>
<td>Temperature-dependent run-out time</td>
<td>( t(T) ) (run-out time)</td>
<td>s</td>
<td>m</td>
<td>The time it takes for a volume of fluid at a specific temperature to run out of a standardized receptacle</td>
<td>for UV/aqueous coatings: measuring cup with a 4-mm nozzle in the base, fluid thermometer (T = 20°C), stopwatch</td>
</tr>
<tr>
<td>Solids content</td>
<td>c</td>
<td>%</td>
<td></td>
<td>Concentration of solid matter in an aqueous solution</td>
<td>for aqueous coatings: scales, desiccator</td>
</tr>
<tr>
<td>Tack</td>
<td>tack</td>
<td></td>
<td>m/kg</td>
<td>Film-splitting resistance, adhesive force per surface (adhesive tension)</td>
<td>for inks and overprint varnishes: rotating tackmeter; glass plate, finger</td>
</tr>
<tr>
<td>String formation, length</td>
<td>s</td>
<td>[string break-off length] m</td>
<td>inch (1 in = 2.54 cm)</td>
<td>Flow properties of higher-viscosity fluids under impact of tensile stress</td>
<td>for inks and overprint varnishes: palette knife, glass plate, finger, substrate</td>
</tr>
<tr>
<td>Flow</td>
<td>s</td>
<td>m</td>
<td>inch</td>
<td>Distance travelled in 10 minutes by a specific volume (1 ml) of vertically flowing ink</td>
<td>for inks and overprint varnishes: metering device, vertical flow surface, length scale, stopwatch</td>
</tr>
<tr>
<td>Flow limit</td>
<td>( t_s )</td>
<td>s</td>
<td>m</td>
<td>Moment of transition when a specific volume of fluid stops spreading of its own accord (circle diameter)</td>
<td>for inks and overprint varnishes: metering device, horizontal flow surface, length scale, stopwatch</td>
</tr>
<tr>
<td>Flow path as per the spread method</td>
<td>s</td>
<td>m</td>
<td>inch</td>
<td></td>
<td>for oxidative printing inks and overprint varnishes: metering device, steeply inclined flow surface, length scale</td>
</tr>
<tr>
<td>Immobilisation point</td>
<td>t</td>
<td>s</td>
<td></td>
<td>Time taken for a stable coating film to form in the dryer</td>
<td>for UV coatings, UV inks and aqueous coatings: stopwatch</td>
</tr>
<tr>
<td>Dwell section</td>
<td>s</td>
<td>m</td>
<td>inch</td>
<td>Distance between coating application and dryer in a printing press or coater</td>
<td>for UV coatings: length scale</td>
</tr>
<tr>
<td>Dwell time</td>
<td>t</td>
<td>s</td>
<td></td>
<td>Dwell section, divided by sheet transport or web speed</td>
<td>for UV coatings: stopwatch</td>
</tr>
<tr>
<td>Minimum film-forming temperature</td>
<td>MFT</td>
<td>Kelvin (K)</td>
<td>°C, °F, °R</td>
<td>Temperature below which an applied aqueous coating remains fluid, ie cannot form a film</td>
<td>for UV and aqueous coatings: fluid thermometer</td>
</tr>
<tr>
<td>Interfacial tension between surface and air, surface tension</td>
<td>( \sigma ) (Greek ( \sigma ))</td>
<td>Millinewton per metre (1 mN m⁻¹ = 0.001 kg m s⁻²)</td>
<td>1 dyn cm⁻¹ = 1 mm H₂O</td>
<td>Change in energy (needed to enlarge the surface) divided by change in surface</td>
<td>for all coatings and inks: optical measurement of wetting angle at drops of fluid on a base with known surface tension</td>
</tr>
</tbody>
</table>

**Geometry, DIN 53018**

The run-out time is a measure of the viscosity of coatings during inline processing in sheetfed offset. It is the quotient of the dynamic viscosity and density of the fluid and is also temperature-dependent. Because drop-ball and drop-rod rheometers (ISO 12644) – which measure internal friction by measuring the time taken for test bodies to drop a prespecified distance – and capillary rheometers are so complicated to use, for ease and speed printing plants tend to measure the run-out time from a normed cup: the longer the duration, the tackier the fluid. The viscosity of doctor-compatible UV and aqueous coatings is determined at a liquid and ambient temperature of 20°C using a run-out cup with a 4mm nozzle in its base. Although national norms such as DIN 53211 and ASTM D-4212 were superseded back in 1996 by ISO 2431, German coating manufacturers still cling to DIN cup 4, whose geometry differs from the ISO cup. As a result DIN and ISO values are not comparable! In any case, the cup method is fairly imprecise because the starting and finishing points are not clearly perceptible, which is why DIN values, which are generally higher, are considered more exact. This is also the reason why a run-out sequence is not considered reliable if it lasts less than 25 seconds. Instead of kinematic viscosity only the run-out time is normally specified on a coating drum, and even then only for the condition in which it is delivered and stored (when viscosity is mostly higher and the viscosity window bigger) and for the processing condition (a lower viscosity and narrower viscosity window). In viscosity-regulating feed systems like those used for inks and coatings in gravure and flexo printing, coriolis rheometers – based on the patented contact-free Heimann process – are a new and better substitute for the customary error-prone rotating rheometers. The parameters measured are the density of the material (with ultrasound), the flow volume (with a pump) and the righting moment of a horizontally clamped U-shaped tube. The lower the viscosity, the lower the density and the greater the flow volume and the radial acceleration in the tube, which

---

**The run-out time \( t \) depends on the percentage of thinners in an aqueous coating. Ammonia reduces the viscosity (run-out time) more than water, but has little impact on solids content \( c \). Source: Sun Chemical**
under the impact of what is known as the coriolis force will impact at a right-angle to the direction of flow, thus causing a measurable righting of the tube.

What is tack?

Tack is the surface-specific force (ie a mechanical tension) with which a fluid film counteracts splitting. Tack is thus a measure of how well an ink or coating film will split. The higher the tack of an ink, the stronger its adhesion to the printing plate and blanket (when the tack value inevitably increases from that set in the factory), waterless inks require some form of temperature control in the inking unit. This is why the inking-unit temperature is specified on the ink drum. If this temperature is exceeded the tack will be too high and can cause toning. The higher the tack, the greater the heat emission when the ink is applied to a reflective. The point of transition from viscosity to plasticity, and the surface becomes textured or smooth and reflective. The point of transition from viscosity, ie the point at

35°C (in the case of particularly large temperature windows).

How is tack measured?

ISO 12634 specifies the parameters for measuring tack. These include what is known as a rotating tackmeter comprising a temperature-controlled system-driving roller and a distribution roller with a measuring roller resting on it. The deformation of the measuring roller at a specified speed or rolling distance per time unit indicates the tack value. While these tack values (inko, tacko) vary from

IGT’s Tacktester measures tack

one device manufacturer to another (eg Prüfbau Inkomat, IGT Tacktester), there is a correlation. The median tack value is generally considered to be around 12 inko. Experienced operators in the press room resort to other proven aids, because the possible impact of additives on tack is even more significant than numerical values. Tack is also evident in adhesion, so that it is possible to test the ink or coating by dabbing it with a finger on a glass plate. A closely associated phenomenon is string formation. When a fluid is stretched – scooped out or dabbed on a surface or two test bodies (eg fingers) which are then drawn apart – it forms either a long, stable string or a short one that tears. The longer the string, the stronger the traction, ie the higher the tack, the stronger the adhesion on the paper or carton. Long-stringing ink flows well into the ink duct and can be pumped in ink-feed systems. Having said that, UV and aqueous coatings can all be pumped even though they do not form a string. Thin long-stringing ink runs easily off the palette knife and has a high tack when dabbed onto paper. Thick long-stringing ink is hard to scoop out of the drum. Short-stringing ink adheres weakly, but is not prone to misting. Thin short-stringing ink is soft and gel-like and runs slowly off the palette knife. Thick short-stringing ink sticks to the palette knife and several strings break simultaneously. Long, tacky ink and, to an even greater extent, UV and aqueous coatings, have a high yield strength. This can be determined by timing how long it takes for a defined volume of ink to stop spreading when applied to a smooth surface. Flow is determined by measuring the distance a millilitre of ink or coating travels vertically in ten minutes. Even inks with a higher viscosity should have a flow rate of no less than four centimetres.

Rheology and film formation

As inks and coatings form a film their consistency changes, their viscosity transmutes into elasticity and plasticity, and the surface becomes textured or smooth and reflective. The point of transition from viscosity, ie the point at
Coating transfer and application | Rheology

Surface tension

<table>
<thead>
<tr>
<th>Consumable</th>
<th>Surface tension</th>
</tr>
</thead>
<tbody>
<tr>
<td>Offset process:</td>
<td></td>
</tr>
<tr>
<td>Dumpling additive isopropl alcohol (IPA)</td>
<td>21.7 mN/m</td>
</tr>
<tr>
<td>Water with 20% IPA</td>
<td>38 mN/m</td>
</tr>
<tr>
<td>Water with 10% IPA</td>
<td>44 mN/m</td>
</tr>
<tr>
<td>Water with 5% IPA</td>
<td>52 mN/m</td>
</tr>
<tr>
<td>Offset ink, wet (hydrophobic)</td>
<td>30 - 36 mN/m</td>
</tr>
<tr>
<td>Offset ink, dry (hydrophobic)</td>
<td>35 - 40 mN/m</td>
</tr>
<tr>
<td>Light-sensitive plate coating, blanket (oleophilic)</td>
<td>36 - 38 mN/m</td>
</tr>
<tr>
<td>Electrochemically roughened aluminium oxide (hydrophilic)</td>
<td>&gt;50 mN/m</td>
</tr>
</tbody>
</table>

Substrates:

- Polypropylene (PP) with no prior corona treatment: ca. 28 mN/m*
- Polyethylene (PE) with no prior corona treatment: ca. 36 mN/m*
- Paper, carton, board: 38 - 42 mN/m
- Polyvinyl chloride (PVC): ca. 38 - 45 mN/m
- Polyurethane (PS): ca. 43 mN/m
- Polyester (PET): ca. 47 mN/m

Inline coating:

- Matt/granular coatings for contrasting gloss effects: max. 25 mN/m
- Flexo ink, UV/aqueous coatings: 28 - 30 mN/m
- Chrome anilox roller in coater: 34 mN/m
- Coating blanket, photopolymer coating plate: 36 - 38 mN/m

* Preliminary corona discharge treatment is necessary for good printability.

Aqueous coatings with – and to a lesser extent without – special-effect pigments flow best when agitated.

Photo: Opti-color

which the coating forms a film and is considered to be dry, is called the **immobilisation point**. It is reached in a matter of seconds, while the sheets are passing under the dryer in the press. It does not depend on the completion of the curing procedure for UV coatings or water absorption in aqueous coatings.

Printing, inks and overprint varnishes can start drying by oxidation or water absorption in aqueous varnishes. The temperature should not exceed 30°C. At the other end of the temperature scale the storage temperature is generally around 5°C, for some coatings 10°C. At the other end of the temperature scale the storage temperature should not exceed 30°C.

**Rheology and wetting**

How well a coating spreads on and adheres to a substrate or ink film does not depend solely on its viscosity and tack: the **interfacial tension relative to air** (or surface tension for short) of the relevant materials also plays a major role because the receptiveness of the printed surface to wetting naturally impacts on coating spread and adhesion. More specifically, the surface tension of the coating must be lower than that of the ink and substrate. Since the ink should adhere to the substrate, the substrate must have the highest surface tension of the three consumables. Differences in surface tension cause the ink film on the rubber blanket or the coating film on the coating forme to split. Wetting is thus directly influenced by tack.

The surface tension of paper and cartonboard primarily depends on the chemical composition of the coating if they are coated and on the roughness if they are uncoated or recycled. Substrates with too low a surface tension – particularly PP and PE film – require **preliminary corona discharge treatment**. This causes ions to be ejected from the film surface, creating a microscopic roughness that raises the surface tension and thus improves wetting. A corona unit is included in the film-printing package offered with KBA’s Rapida presses.

Gloss contrasts are created by applying a matt or granular spot coating followed by a solid gloss coating. To create this effect the surface tension of both coatings must be set so that the gloss overprint varnish either cannot adhere to the matt or granular spot coating and runs off, or is not split on the spots. The surface tension of the matt coating first applied must therefore be lower than that of the gloss coating, irrespective of whether they are applied wet on wet (UV gloss coating on matt/granulating overprint varnish in hybrid production, aqueous gloss coating on OPV in drip-off or twin-effect process) or wet on dry (gloss UV coating on matt UV coating in pure UV production, gloss aqueous coating on matt aqueous coating in two-coater press).

Dieter Kleeberg

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Example of poor wetting by the coating

Photo: Schmid-Rhyner

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Surface tension during inline coating. Above: the substrate (1) always has the highest surface tension, the ink (2) the second highest, the coating (3) the lowest. Below: With gloss-contrast coatings, the spot matt coating (3) has a lower surface tension than the final solid high-gloss coating (4).

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How a fluid (2) spreads on a solid body (1) at different surface tensions. Top: no spreading (droplet formation); centre: poor spreading; bottom: good spreading (wetting).
Quality specifications for coatings and coating application

The quality of inline coating is defined by the degree to which the desired optical, haptic, mechanical or chemical effect is achieved. This chapter summarises the most important factors that impact on gloss formation, wetting capabilities and workability.

Gloss quality
A level of gloss ranging from high to matt, clear transparency and the absence of yellowing are the optical properties, a smooth or finely structured surface the haptic properties most commonly specified. Gloss is the visual impression that indicates the smoothness of a surface. It is created by the reflection of light. Diffused light is less intensive than directed light that falls within the gloss angle, ie the angle of reflection, which is equal but opposite to the angle of incidence. Diffuse light diminishes if the cavities in the rough surface topography are filled by a homogeneous medium (eg a coating) or completely covered.

Gloss intensity is measured with glossmeters (reflectometers) at different angles: ISO 2813 (DIN 67530) stipulates 20°/20° for high-gloss surfaces, 60°/60° for standard and 85°/85° for matt surfaces. For some years now the printing and packaging industry has preferred to use 45°/45°, though 60°/60° is also often used for checking coated prints. So the angle used should always be specified with the measured values. The measured values are the same as the reflectometer values, gloss levels or gloss values. They lie between 0 (totally diffuse reflection, totally matt) and 100 (totally directed reflection, totally glossy) given either as a percentage or with no unit of measurement. Less common in practice is the visual gloss figure (DIN 16537), which lies between 0 (matt) and 10 (glossy). In the US the haze value is commonly determined (ASTM D 4039). This is the difference between gloss at 60° and at 20° (H = R60 – R20). It measures haze more accurately, particularly on standard and high-gloss samples.

But taking measurements on a freshly coated print alone reveals very little: it is better to measure the gloss on the actual substrate used for the print run, printed using a KBA gloss test form (64 large measuring fields) and inline coated with the specified coating, eg at four different intervals: copy no. 5,000 immediately and after 72 hours and copy no. 10,000 immediately and after 72 hours. The four resulting gloss curves allow deductions to be made regarding the gloss quality that may be expected, so that steps can be taken if necessary to influence the outcome by changing the substrate, the inks, the coating or the anilox roller. Gloss curves should also include the gloss value for the unprinted, uncoated substrate, since this provides an initial reference for enhancing or diminishing gloss levels.

The primary factor impacting on coating gloss is the substrate and its inherent gloss. The coated inks enhance the gloss provided that they do not react chemically with the coating (draw-back effect). If coating viscosity supports spreading, then a dwell section can be inserted in the extended delivery to prolong the dwell time and thus promote gloss formation without having to compromise on production speed. Lowering the pile temperature to slow the drying process also enhances gloss. Conversely, a higher pile temperature brings the risk of gloss impairment through blocking. Other factors and phenomena are detailed in the table and in the practical tips.

Wetting quality
The key parameters for wetting the substrate properly with the coating, so as to create an intact coating film instead of an “orange-
Gloss phenomena during coating, and their causes

<table>
<thead>
<tr>
<th>Gloss phenomenon</th>
<th>Cause, description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Desirable</strong></td>
<td></td>
</tr>
<tr>
<td>High gloss</td>
<td>Light reflection with a very high proportion of directed light from a smooth, unbroken coating surface; gloss levels 90 to almost 100</td>
</tr>
<tr>
<td>Gloss</td>
<td>Light reflection with a high proportion of directed light from a smooth, intact coating surface; gloss levels 65 to 90</td>
</tr>
<tr>
<td>Matt/dull gloss</td>
<td>Light reflection with a high proportion of diffuse light from a microscopically uneven to rough but unbroken coating surface; gloss levels 20 to almost 0</td>
</tr>
<tr>
<td>Graining</td>
<td>The formation of three-dimensional reticulated grains in the coating film that reduce gloss and make the substrate appear more matt</td>
</tr>
<tr>
<td>Spot</td>
<td>Partial application of coating (images or image areas, text, graphic elements) to form a contrast with the surroundings through a high or matt gloss surface, graining or special-effect pigments</td>
</tr>
<tr>
<td>Gloss contrast</td>
<td>Differences in reflection of two types of coating with contrasting gloss properties, eg high-gloss UV coating on a matt or grainy overprint varnish (hybrid coating) or high-gloss aqueous coating on a matt overprint varnish (drop-off/twin-effect coating)</td>
</tr>
<tr>
<td><strong>Undesirable</strong></td>
<td></td>
</tr>
<tr>
<td>Gloss impairment</td>
<td>Impairment of a smooth, unbroken coating surface, eg as a result of the coating reacting chemically with the ink (draw-back effect) or the paper coating, oversprayed drying or blocking in the delivery pile</td>
</tr>
<tr>
<td>Pin holes</td>
<td>Small holes in the coating surface caused by foaming prior to or following coating application</td>
</tr>
<tr>
<td>Cracking</td>
<td>Cracks in the coating surface (primarily on thick layers of ink) caused by heat shocks during drying</td>
</tr>
<tr>
<td>Streaking</td>
<td>The accidental formation of streaks on the coating surface resulting from uneven application</td>
</tr>
<tr>
<td>Banding</td>
<td>Periodic streaks in the coating surface resulting from an uneven application</td>
</tr>
<tr>
<td>Mottling</td>
<td>Spotty, uneven coating that may also be grainy. Caused by poor wetting or insufficient dwell time</td>
</tr>
<tr>
<td>Cloudiness</td>
<td>Random streaks in the coating surface due to irregular spreading</td>
</tr>
<tr>
<td>Moiré</td>
<td>The apparently periodic appearance of specularities or streaks in the coating surface caused by the optical resonance of the spot coating screen and the print screen</td>
</tr>
</tbody>
</table>

Workability
Detailed product-specific properties are listed in the tables on pages 4 to 6. This section focuses on the general handling of coatings.

Problems with handling begin with correct storage. Frost primarily damages aqueous coatings, while UV coatings must be stored in light-proof containers. Aqueous and UV coatings with special-effect pigments blended in cannot be stored as long as standard coatings without suffering a loss of quality.

Conditioning, prior to and during impression includes preparing the coating in accordance with the manufacturer’s specified parameters. These include temperature, viscosity and — for aqueous and special-effect pigment coatings — the even distribution of solid particles through thorough, foam-free agitation. Special-effect pigment coatings should even be stirred during print production. With the proper conditioning, a coating will be easy to pump, will neither foam nor mist and will have the desired surface tension. Aqueous coatings may sometimes dry slightly in the coater through evaporation if production is interrupted for any length of time.

The volume of coating applied should always represent a compromise between the desired effect, frugal coating consumption and minimum radiation input. Applying a thicker film of coating than necessary not only results in an excessive consumption of coating and energy but can also have an undesirable impact on the substrate and impair drying or curing, which in turn can lead to set-off and blocking in the delivery pile. Applying thinner layers of coating generally eliminates the need for powder, which would impair the quality of the coating. And, of course, a thin application is important when perfect coating. Iridescent, metallic and blister coatings cause more contamination in the coater, especially around the anilox roller.

The choice of coating also influences print finishing. Many coatings combine several functions, though specialised...
Coating transfer and application | Coating quality

Practical tips from KBA’s coating seminar: troubleshooting

Compiled from various discourses and discussions, and from instruction manuals issued by Actega Terra, IS Druckerei Service, Jänecke-Schneemann, Schmid Rhyner, Sun Chemical, Vegra and Weilburger

Coating transfer
- KBA recommends Planeta universal clamping bars or Ternes clamping bars for coating blanketks, and automatic clamping bars with no underpacking clamps for varnish plates.
- The throw-on pressure between the anilox roller and coating forme cylinder should be as low as possible.

Overprint varnishes
- According to Fogra, ghosting caused by the oil particles in the ink reacting with the reverse side of the substrate in the delivery pile can be prevented by applying an aqueous coating. Overprint varnish is not recommended as this would only exacerbate ghosting.
- Granular overprint varnish has a much higher boundary surface tension than gloss coatings, so this must be taken into account when choosing the substrate.

Aqueous coatings
- Only use solvent- and alkali-proof printing inks that comply with DIN 16524 (if necessary, check using Schmid-Rhyner’s SRAG testing solution). Do not use drying-retardant or scratch-proof inks, or anti-abrasion pastes. Fresh and overnight inks are also unsuitable.

Inks should contain no surfactants such as wax or silicone; in waterless offset, coating silicone-oil-free inks is a standard procedure.
- The ink film will crack if it is dried too fast after being applied to a thick layer of ink. This can be remedied by reducing dryer power or printing at a higher speed, increasing the volume of coating applied, adding retardant or using a different coating.
- During perfect coating, ink may build up on the coating forme. This can be remedied by increasing the coating volume.
- With some images, coating may build up on the coating forme, so a manual clean may be necessary. Matt coatings are particularly prone.
- Streaking in matt coatings caused by mineral components can be remedied by agitating them. Conversely, if the coating does not relax properly, add a surfactant.
- An orange-peel skin forms if the coating is worked below the minimum film forming temperature. This can happen if the coating is stored at too low a temperature or not conditioned properly, or if the air blown onto the coating film is too cold.
- Poor abrasion resistance (nail test, laboratory abrasion carriage) indicates that the dryer was on too low a setting, so no film could form. Run the prints under the dryer again. Generally the radiator power should be increased if the coating does not dry right through.
- Poor scratch-resistance is manifested in a brittle coating film. The answer is to use a more flexible coating. If inks containing silicone or wax are the cause, use different inks.
- If an aqueous coating is not agitated thoroughly,agitte it again. Any sheets that were coated too thinly should be coated again.
- Foam need not be caused by the anilox roller or the doctor chamber. So check whether the pumping system is drawing in air, and maybe add a suitable defoamer.
- If the substrate is too absorbent, use a primer to seal the surface before applying the specified coating in order to achieve the desired level of gloss. Of course, it is better to choose an appropriate paper in the first place.
- Always allow for the loss of viscosity caused by the increase in temperature at high press speeds. If the initial coating viscosity is set at the lower limit of 25s (DIN 4 cup) there is no reserve. However, in conjunction with high-speed inline coating too high a viscosity will cause splashing. Viscosity can be kept constant with a rotational viscometer.
- Blocking in the pile indicates that the pile temperature is too high because the sheets were under the dryer for too long — perhaps the coating contains too much additive to stop it cracking. Blocking can also occur if a gloss coating formulated for perfect coating is used for single-sided coating, causing a glass-plate effect (where a vacuum is created between the sheets, pressign them firmly together).
- During prolonged down times the coater should continue to run so as to prevent the coating from drying out.
- Blocking in the pile is a standard procedure.

UV coatings
- During hybrid operation with aqueous coatings, a second coating circuit will eliminate the risk of contamination with water, which would prevent the UV coating from curing.
- If blocking or odour in the delivery pile is a recurrent problem this indicates that the coating is not curing properly (test hardness). The reasons may be too high a print speed, contaminated/damaged reflectors or ageing lamps.
- If the coating fails to spread even though the dwell section is adequate, the UV coating may be too thick because it is too cold. Warming it should help — either via a heater in the coating circulation system or IR radiation in the dwell section. Another cause may be that the sheet pile was stored at too low a temperature. If the volume of coating applied is too high this can cause cloudiness and hinder spreading.
- As with aqueous coatings, if the substrate has too low a surface tension this can be countered with the appropriate coating additive and by avoiding the use of inks with surfactants.
- If sheets printed with standard inks are to be UV coated separately, the powder must be removed. If the ink is not dry enough a primer must be applied prior to UV coating.
- On two-coater presses the primer and UV coating should always be obtained from the same supplier.

Properties such as slippage in packaging lines are best created using high-slip or playing-card coatings rather than a standard gloss coating. Measuring the slippage angle on two sheets placed one on top of the other at an incline will reveal the coating’s suitability or otherwise for this type of application. And not all gloss coatings are equally scratch- and rub-resistant. In doubt test the material, for example to see whether the aqueous coating film is compatible with a specific adhesive or whether a UV coating film can subsequently have a hot-stamping foil added.
When selecting a coating, printers and their customers must increasingly consider environmental criteria, eg whether the coating is non-hazardous and whether coating residue and prints can be recycled and/or are biodegradable.

Dieter Kleeberg
**Blister coatings**
- Blister coatings are generally water-based and are therefore compatible with the same inks as aqueous coatings. They can be used with all the above-mentioned recommended types of ink, which have a similar thermal sensitivity. Occasionally solvent-based blister coatings are used that heat-seal faster.
- Blister coatings can be heat-sealed only on hard elastic types of film, e.g. PET (G, A) or PVC.

**Recycled board** is the best type to use. (Tape test on raw material: board coating must tear off down to the board fibre, since the coating should penetrate right down to the fibres.) The suitability of board for blister coating should be confirmed by the supplier.

- To ensure that the coating film seals properly with the plastic film the volume applied should not exceed 6 to 8gsm. For some highly absorbent cartonboard, or board-to-board heat-sealing, two applications of coating may be needed. In such cases it is more economic to use a primer for the first coat because this is cheaper and also seals the board surface more effectively than a blister coating.
- A lower level of IR radiation must be used to ensure that the blister coating is not “heat-sealed” in the press.
- Blister coatings have a tendency to clog the anilox roller surface and coating feed, so the system must be cleaned thoroughly after the print run. The anilox roller should also be cleaned if production is interrupted for any length of time. The same applies to special-effect coatings.
- The ideal storage temperature and relative humidity for cartonboard prior to the print run and blister cards after printing and coating are 18-25°C (64-77°F) and 55% respectively. Weilburger has found that in conditions such as these blister cards with its Senolit-WL blister coating will remain workable for up to two years. Even if storage conditions are not ideal, blister cards can usually be processed with no trouble if they are aclimatised beforehand.
- Packaging machines are used to heat-seal the blister cards onto the skins. Heat-sealing quality depends on the temperature, throw-on pressure and plane-parallelism of the sealing tools and the length of heat contact (machine timing), which is set according to board thickness, the length of the sealing tools, the type of film and the thickness of the coating.

**Special-effect pigments and aromatic coatings**
- Special-effect pigments can be blended into both aqueous and UV coatings, aromatic coatings are always aqueous. The particle size must be considered when selecting an anilox roller. Iridescent pigments (up to 200µm) and scented capsules (up to 30µm) require a cell aperture that is 1.5 times the size of the cell aperture on the anilox roller.
- Special-effect pigment coatings must be well agitated when worked, aromatic coatings must also be cooled.
- Aromatic coatings are very expensive (1kg can cost as much as €500), but can be applied sparingly and thinned without difficulty. It is advisable to consult the coating manufacturer on the best way of handling and applying the coating. As an option, “spacers” can be blended into aromatic coatings to prevent the minute capsules from being crushed during coating application and in the pile.

**Resources and alliance partners**
We wish to express our thanks and appreciation to all those whose keen commitment, active participation and invaluable support contributed in no small part to the success of KBA's inline sheetfed coating technology and high attendance at the KBA coating seminar in March 2006.

**Consultants, certifying institutes**
- Berufsgenossenschaft Druck und Papierverarbeitung, D-Wiesbaden (www.bgdp.de)
- Druck & Beratung D. Braun, D-Mülheim/Ruhr (www.wlvw.de)
- Fogra Forschungsgesellschaft Druck e.V., D-München (www.fogra.org)
- **Coatings, special-effect pigments, additives and washes**
  - Actega Terra Lacke GmbH, D-Lehde (www.terralacke.de)
  - Ciba Specialty Chemicals Inc., CH-Basel (www.cisc.com)
  - Eckart GmbH & Co. KG, D-Farth (www.eckart.de)
  - Eppler Druckfarben AG, D-Neusiedl (www.eppler-druckfarben.de)
  - Jänecke+Schneemann Druckfarben GmbH, D-Hanover (www.js-druckfarben.de)
  - Merck KGaA, D-Darmstadt (www.merck-pigments.com)
- SunChemical Hartmann Druckfarben GmbH, D-Frankfurt am Main (www.sunchemical.com)
- Schmid Rhyner AG Print Finishing, CH-Altstätten (www.schmid-rhyner.ch)
- Siegwerk Group, D-Siegburg (www.siegwerk-group.com)
- Werner Tippl, A-Vienna (tippl@point.at)
- Vegra GmbH, D-Aschau am Inn (www.vegra.de)
- Weilburger Graphics GmbH, D-Gerardsrofen (www.weilburger-graphics.de)
- Zeller+Gmelin GmbH & Co. KG, D-Erlingen (www.zeller-gmelin.de)

**Coating and fount solution management**
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**Coating plates/blanks, post-press and repro services**
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- FLEX Service Rüschee-Anstalt Jaehde, D-Berlin (www.jaehe.de)
- Folex GmbH, D-Cologne (www.folex.de)
- Hessmann GmbH, D-Lahr (www.hessmann-lackierplatten.de)
- Streb GmbH, D-Dreieich (www.streb.de)

**Anilox rollers and roller materials**
- Felix Bötcher GmbH & Co. KG, D-Cologne (www.boetcher.de)
- Praxisurface Technologies, D-Schuchtern (www.praxair.com)
- Zecher GmbH, D-Paderborn (www.zecherm.com)

**Coating feed and doctor blade technology**
- Harris & Bruno Europe GmbH, D-Schwabisch Gmünd (www.harris-bruno.de)
- Tresu GmbH, D-Celle (www.tresu.com)

**Dryer and radiation technology**
- Grafix GmbH Zerstaubungstechnik, D-Stuttgart (www.grafix-online.de)
- Heraeus Noblelight GmbH, D-Hanau (www.heraeus-noblelight.com)
- Dr. Hönle AG UV Technology, D-Gräfelfing (www.hoenle.de)
- IST Metz GmbH, D-Wurtingen (www.ist-wc.de)
- RadTech Europe, NL-Den Haag (www.radtech-europe.com)

**Consultants, certifying institutes**
- Harris & Bruno Europe GmbH, D-Schwabisch Gmünd (www.harris-bruno.de)
- Tresu GmbH, D-Celle (www.tresu.com)
- Dryer and radiation technology
- Grafix GmbH Zerstaubungstechnik, D-Stuttgart (www.grafix-online.de)
- Heraeus Noblelight GmbH, D-Hanau (www.heraeus-noblelight.com)
- Dr. Hönle AG UV Technology, D-Gräfelfing (www.hoenle.de)
- IST Metz GmbH, D-Wurtingen (www.ist-wc.de)
- RadTech Europe, NL-Den Haag (www.radtech-europe.com)

**Substrates**
- M-real Technical Sales and Marketing, D-Hamburg (www.m-real.com)
- Sappi Deutschland GmbH, D-Hanover (www.sappi.com)
- Schneidersöhne Unternehmensgruppe, D-Ettlingen (www.schneidersoehne.de)
- UPM-Kymmene Sales GmbH, D-Hamburg (www.upm-kymmene.com)
Coating with no limits: 15-unit Rapida 105 at Graf-Poz

Last year, at Ipex in Birmingham, Polish printer Graf-Poz signed up for one of the longest sheetfed presses in Europe: a B1 (41-inch) Rapida 105 with a grand total of fifteen printing, coating and drying units. After that, everything went quiet for a while – but now it’s here!

The seemingly endless UV press line made its debut at the end of March this year.

30 metres long
The giant Rapida at Graf-Poz consists of a Corona static eliminator, a coater for applying opaque white, two dryers, seven printing units, a second coater, two more dryers and a third coater followed by a triple extended delivery. Wow! It is hard enough to say all that in one breath, but then this 30-metre (98-foot) Rapida 105, which comes complete with CX cartonboard capability, is the longest Rapida installation in Europe. Thanks to its triple extended delivery it is longer than a similar press with the same number of units at Swiss print enterprise Model PrimePac. And if the Graf-Poz press line had just one more printing unit, it would be the longest in the world!

The answer is blowing in the wind
The Rapida’s technological capabilities with regard to inline print production and finishing are pretty awesome. When production is in full swing there are more than 40 sheets running through the press at any one time. Following acceptance tests Graf-Poz put the Rapida into operation, printing a broad spectrum of packaging products. But manufacturer and buyer agree that there is even more to this press than meets the eye, and that it will take some time for the operating crew to learn all its secrets and exploit its full potential. Until then, Graf-Poz is taking things one step at a time and looking forward to each new discovery that will enable the company to further enhance its profile in one of its core markets, packaging.

At present the awesome Rapida press line is the sole occupant of a brand new, dedicated press room. “We’re still considering our options for filling the rest of the available free space,” says proprietor Marek Przybylski. And there is plenty to think about — the Rapida 105 is the first KBA press the company has ever owned and there is ample room in the new hall for a few more installations...

One of the biggest print providers in Poland
Proprietor Marek Przybylski, who is a qualified printer, established the company exactly twenty years ago, in 1987. At first he struggled to survive because in the controlled economy of those times there were frequent shortages of paper and other consumables, so that running a business according to market principles was well nigh impossible.

Since then, Graf-Poz has grown into one of the biggest print providers in Poland and has moved up to the pole position in the packaging sector. At present it employs more than 150 staff. Packaging is printed in new, well-equipped production halls with just under 2,000m² (21,500ft²) of floor space. Graf-Poz’s warehouse is equally large.

Although the company’s main claim to fame is as a specialist printer of labels (including self-adhesive labels) and solid board...
Blankets, plates and films for coating

A certain level of experience is demanded on the part of an offset printer when selecting the best materials for making coating forms and using them in inline coating processes. This is because the transfer of low-viscosity coatings from the coating forme to the substrate is a letterpress process that is subject to its own specific laws.

The following observations apply to the transfer of low-viscosity, ie thin-bodied, UV and aqueous coatings with and without special-effect pigments. They do not apply to imaged offset plates for spot coating with pasty overprint varnishes.

Coating forms for the direct and indirect application of coatings

As a rule low-viscosity coatings are applied directly. Nowadays this occurs with the aid of an anilox coater, whereas previously roller-type coaters were used. Both types of coater are based on direct letterpress technology which is perhaps more akin to flexo. Located in the coater is the coating forme cylinder on which the coating forme – the coating blanket or coating plate – is generally clamped or, more rarely, glued.

Low-viscosity coatings can also be applied indirectly, though the coating quality will not be as good as with a direct application because the film of coating applied is thinner. As with the application of overprint varnish, the coating forme is mounted on the forme cylinder in the printing unit – with the difference that for low-viscosity coatings a letterpress forme is used. While this principle is very similar to indirect letterset, photopolymer letterset plates are only suitable for the most basic type of spot coatings. It is better to use hard PVC film on a carrier plate, or special photopolymer plates.

Coating forms for low-viscosity coatings

Rubber blankets are the only type of coating blankets used. There are two basic types:

- strippable offset blankets (which may, but need not be, designated as coating blankets by the manufacturer) with a sealed or open-weave layer of fabric (carcass) on the backing for clamping on the coater cylinder;
- strippable coating blankets with an adhesive backing for attaching to the coater cylinder.

Coating plates usually have a metal backing, which makes them stiffer and less prone to distortion than coating blankets. There are several types:

- strippable coating blankets with a polyester (PET) or aluminium backing, mounted on the coater cylinder;
- strippable coating blankets with an adhesive backing for attaching to a polyester carrier or either a raw or used aluminium plate, mounted on the coater cylinder;

Examples of the structure and stencil depth of Duco coating blankets. With the fabric-backed Superstrip FB (top) the knife cuts through the rubber and fabric layers and into the easy-strip compression layer. With the Superstrip PB (centre) it penetrates down to the cut-proof polyester backing. With the self-adhesive Superstrip SB (bottom) even the adhesive layer is cut out to expose the metal cylinder underneath.

Continued from page 44

Continued on page 46
Coating transfer and application | Coating formes

- cuttable transparent coating films with an adhesive backing for attaching to an aluminium plate (exposed with the spot coating image as a template), mounted on the plate cylinder for indirect coating;
- cuttable transparent coating films with an adhesive backing for attaching to an aluminium plate or polyester film, mounted on the coater cylinder;
- cuttable PVC plates with an aluminium or polyester backing, mounted on the plate cylinder for indirect coating;
- special photopolymer or flexo plates with a polyester or aluminium backing, mounted on the coater cylinder;
- photopolymer letterset plates with a polyester or aluminium backing, mounted on the plate cylinder for indirect coating.

Photopolymer coating plates are usually thin, around 1.15mm (0.04in) or less. DuPont and Flint are the leading suppliers in Europe, MacDermid (NAPP) is a major player in the USA, Toray in Japan. Kodak’s Flexcel plates are not designed for coating applications, Asahi only offers plates up to a maximum of B2 (29in) in various gauges.

Underpacking, auxiliaries and handling

KBA offers a choice of clamping systems suitable for coating forme cylinders. Two coating forme punch patterns available from Grapho-Metronic and Bacher Control function as universal plate register systems.

The two types of clamping system differ in their mode of operation. With the quick-action clamping system the plates are clamped via a toggle lever with a mandrel and then tightened pneumatically. However, only two coating plates – albeit with different carrier materials – can be used, no blankets.

With the universal clamping system the coating forme is clamped using bars that are screwed on and must be tightened manually. In contrast to quick-action clamping systems it is possible to use coating blankets that have no prefitted bars, and coating plates with different backings. Polyester and, more particularly, aluminium carriers not only enhance the register stability of the coated image, they also make it easier to clamp on coating formes. KBA has found that polyester-backed coating blankets are more likely to slip than other coating formes if the polyester does not have a matt surface. Aluminium carriers are bent at the rear edge, which can cause jumping at the edge if the anilox roller is thrown on too forcefully, and when clamped the front edge follows the curve of the coating forme cylinder. Coating formes with prefitted bars or bent edges can be stored and used for repeat jobs.

Coating formes usually have to be combined with underlay sheets or blankets to ensure optimum rolling. Polyester and polyurethane films, and also compressible blanks, are available in various gauges, depending on whether the coating forme is already compressible or not. Coating without a compressible structure is otherwise only practicable for simple spot and glue knock-outs. Underlay materials are available from coating forme manufacturers, coating plate manufacturers and specialist suppliers.

The hardness gauge used in the overview on pages 47 and 48 is degrees shore A, as this indicates the hardness of the entire coating forme and allows a direct comparison between adhesive-backed rubber blankets and plates, and photopolymer plates. Impression pressure is even more crucial to an optimum transfer of coating film than compressibility and hardness, which tend to have a higher impact on dot gain in half tone flexography. The pressure must be set to kiss impression, the lightest possible contact between the coating forme and the substrate. The coating forme is barely deformed and the coating image remains free of dot fringes. A compressible layer in the coating forme sandwich broadens the kiss-printing zone. Basically, with compressible rubber blankets and plates a slight increase in the impression pressure has no impact on the print length, while with flexible photopolymer formes the print lengths must be corrected via the distortion factor. Even the anilox roller, which determines the pick-up volume and thus the volume of coating transferred, should be set with the minimum possible pressure relative to the coating forme. A contact strip 4mm (0.15in) wide is recommended for the anilox roller relative to the coating forme.

A key criterion when selecting the coating forme is the maximum stencil depth required to avoid coating build-up on the raised image elements. However, the deeper the recession the less stable the profile, particularly on delicate, slender elements. With photopolymer plates, delicate free-standing lines and dots are not an issue as far as coating is concerned; since the elements are not as fine as in halftone flexography there is less of a compromise between the image area, the flank angle, the base and adequate spacing between elements. The case is different with coating formes that are cut out and

Since the thickness of the coating formes and calibrated underlay materials are given in the manufacturers’ data sheets, it is easy to calculate the total thickness of the coating cylinder packing. Tolerances, rounding errors, compression and expansion, however, may cause the actual thickness to deviate from this. So it is best to check the thickness of the entire coating cylinder packing (see practical tips).

Stencil profile and stability

In practice a distinction is made between two types of stencil profile: full-solid and partial. Even a coating forme for a full-solid application of coating has a stencil profile, since the coating applied must be contained at the edge by deeper recessions. Partial coatings are either spot coatings or knock-outs. Spot coatings are a design tool and are generally used on selected page elements, eg solids, images, text (6 points minimum), logos or lines and guilloches, either to enhance the gloss or matt contrast compared to the substrate or other page elements or to emphasise them using pigment effects. When creating contrasting gloss effects with overprint varnish on hybrid inks it is even possible to create spot screens in images. Knock-outs in full-solid coating formes are primarily restricted to areas that will later be glued (folding cartons), imprinted or stamped.

A key criterion when selecting the coating forme is the maximum stencil depth required to avoid coating build-up on the raised image elements. However, the deeper the recession the less stable the profile, particularly on delicate, slender elements. With photopolymer plates, delicate free-standing lines and dots are not an issue as far as coating is concerned; since the elements are not as fine as in halftone flexography there is less of a compromise between the image area, the flank angle, the base and adequate spacing between elements. The case is different with coating formes that are cut out and
### Overview of coating forms

<table>
<thead>
<tr>
<th>Product name</th>
<th>Coating form</th>
<th>Features</th>
<th>Stencil cutting</th>
<th>Gauge (mm)</th>
<th>Stencil depth (mm)</th>
<th>Shore A hardness</th>
<th>Coatings</th>
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<tbody>
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<td>Ashi Photoproducts</td>
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<td>small-format photopolymer plates</td>
<td>film copy, washed off</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gerber Innovations SectorCoat DG</td>
<td>aluminium-backed photopolymer plate</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Gerber Innovations SectorCoat Poly</td>
<td>aluminium-backed photopolymer plate</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Printec Coater</td>
<td>aluminium-backed photopolymer plate</td>
<td></td>
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<tr>
<td>Printec Coater Tac-M-Coat</td>
<td>aluminium-backed photopolymer plate</td>
<td></td>
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<tr>
<td>Printec Dual</td>
<td>aluminium-backed photopolymer plate</td>
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<tr>
<td>Printec Natural</td>
<td>aluminium-backed photopolymer plate</td>
<td></td>
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<tr>
<td>Printec Polyester-back 115/135</td>
<td>aluminium-backed photopolymer plate</td>
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<tr>
<td>Printec Polyester-back 184/194 Sun Ultra Strip GRL</td>
<td>aluminium-backed photopolymer plate</td>
<td></td>
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</tr>
<tr>
<td>Folocoat Easyspot</td>
<td>aluminium-backed photopolymer plate</td>
<td></td>
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</tr>
<tr>
<td>Folocoat LP-P-Comp</td>
<td>aluminium-backed photopolymer plate</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Folocoat plus LP-D</td>
<td>aluminium-backed photopolymer plate</td>
<td></td>
<td></td>
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<tr>
<td>Folocoat plus LP-D</td>
<td>aluminium-backed photopolymer plate</td>
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<tr>
<td>Folocoat plus LP-D</td>
<td>aluminium-backed photopolymer plate</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Folocoat plus LP-D</td>
<td>aluminium-backed photopolymer plate</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Product name</td>
<td>Coating forme</td>
<td>Features</td>
<td>Stencil cutting</td>
<td>Gauge (mm)</td>
<td>Stencil depth (mm)</td>
<td>Shore A hardness</td>
<td>Coatings</td>
</tr>
<tr>
<td>--------------</td>
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<td>-------------------</td>
<td>------------------</td>
<td>----------</td>
</tr>
<tr>
<td>Folacor plus LT-P</td>
<td>polyester-backed rubber plate</td>
<td>plotter</td>
<td>manual</td>
<td>1.15</td>
<td>n/a</td>
<td>n/a</td>
<td>aqueous</td>
</tr>
<tr>
<td>Folacor UV LT-D</td>
<td>polyester-backed rubber plate</td>
<td>plotter</td>
<td>manual</td>
<td>1.15</td>
<td>n/a</td>
<td>n/a</td>
<td>aqueous</td>
</tr>
<tr>
<td>Folacor UV LT-P</td>
<td>polyester-backed rubber plate</td>
<td>plotter</td>
<td>manual</td>
<td>1.15</td>
<td>n/a</td>
<td>n/a</td>
<td>aqueous</td>
</tr>
</tbody>
</table>

**Graphitone**

<table>
<thead>
<tr>
<th>Product name</th>
<th>Coating forme</th>
<th>Features</th>
<th>Stencil cutting</th>
<th>Gauge (mm)</th>
<th>Stencil depth (mm)</th>
<th>Shore A hardness</th>
<th>Coatings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stripper A</td>
<td>polyester-backed rubber plate</td>
<td>manual/plotter</td>
<td>manual/plotter</td>
<td>1.70; 1.95</td>
<td>n/a</td>
<td>n/a</td>
<td>aqueous</td>
</tr>
<tr>
<td>Stripper UV</td>
<td>polyester-backed rubber plate</td>
<td>manual/plotter</td>
<td>manual/plotter</td>
<td>1.70; 1.95</td>
<td>n/a</td>
<td>n/a</td>
<td>aqueous</td>
</tr>
</tbody>
</table>

**Hydro Dynamic Products**

<table>
<thead>
<tr>
<th>Product name</th>
<th>Coating forme</th>
<th>Features</th>
<th>Stencil cutting</th>
<th>Gauge (mm)</th>
<th>Stencil depth (mm)</th>
<th>Shore A hardness</th>
<th>Coatings</th>
</tr>
</thead>
<tbody>
<tr>
<td>HDP Stripper UV</td>
<td>polyester-backed rubber plate</td>
<td>compressible</td>
<td>manual/plotter</td>
<td>n/a</td>
<td>0.50</td>
<td>82°</td>
<td>UV</td>
</tr>
<tr>
<td>HDP Stripper Blanket</td>
<td>polyester-backed rubber plate</td>
<td>compressible</td>
<td>manual/plotter</td>
<td>0.95; 1.05</td>
<td>n/a</td>
<td>87°</td>
<td>pearl gloss (M)</td>
</tr>
</tbody>
</table>

**Kinyo**

<table>
<thead>
<tr>
<th>Product name</th>
<th>Coating forme</th>
<th>Features</th>
<th>Stencil cutting</th>
<th>Gauge (mm)</th>
<th>Stencil depth (mm)</th>
<th>Shore A hardness</th>
<th>Coatings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air-Tack Type J SH400</td>
<td>self-adhesive rubber blanket on cylinder</td>
<td>manually developed for narrow web</td>
<td>manual/plotter</td>
<td>0.53; 0.68</td>
<td>0.80; 1.00; 1.00</td>
<td>&gt;100°</td>
<td>UV</td>
</tr>
</tbody>
</table>

**Kruse**

<table>
<thead>
<tr>
<th>Product name</th>
<th>Coating forme</th>
<th>Features</th>
<th>Stencil cutting</th>
<th>Gauge (mm)</th>
<th>Stencil depth (mm)</th>
<th>Shore A hardness</th>
<th>Coatings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Varnilack</td>
<td>self-adhesive film on offset plate</td>
<td>for indirect coating always with VarniComp</td>
<td>manual/plotter</td>
<td>1.15; 1.35; 1.55</td>
<td>0.80; 1.00</td>
<td>&gt;100°</td>
<td>UV, aqueous, oil</td>
</tr>
<tr>
<td>Varnilack Plate</td>
<td>polyester-backed elastomer plate</td>
<td>always with VarniComp, underlay for indirect coating</td>
<td>manual/plotter</td>
<td>1.15; 1.35; 1.55</td>
<td>0.80; 1.00</td>
<td>&gt;100°</td>
<td>UV, aqueous, oil</td>
</tr>
</tbody>
</table>

**MacDermid (Rollin, NAPP)**

<table>
<thead>
<tr>
<th>Product name</th>
<th>Coating forme</th>
<th>Features</th>
<th>Stencil cutting</th>
<th>Gauge (mm)</th>
<th>Stencil depth (mm)</th>
<th>Shore A hardness</th>
<th>Coatings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elastostrip</td>
<td>fabric-backed rubber blanket</td>
<td>compressible</td>
<td>manual/plotter</td>
<td>1.95</td>
<td>n/a</td>
<td>77°</td>
<td>UV</td>
</tr>
<tr>
<td>Highlight (US only)</td>
<td>self-adhesive rubber blanket on cylinder</td>
<td>compressible</td>
<td>manual/plotter</td>
<td>1.70; 1.96</td>
<td>n/a</td>
<td>77°</td>
<td>UV</td>
</tr>
<tr>
<td>PCResal (US only)</td>
<td>polyester backed rubber plate</td>
<td>compressible</td>
<td>manual/plotter</td>
<td>1.04</td>
<td>n/a</td>
<td>77°</td>
<td>UV</td>
</tr>
<tr>
<td>PolyBlanket adhesive b. (US only)</td>
<td>polyester backed rubber plate</td>
<td>compressible</td>
<td>manual/plotter</td>
<td>1.14</td>
<td>n/a</td>
<td>74°</td>
<td>UV</td>
</tr>
<tr>
<td>Polystr</td>
<td>fabric-backed rubber blanket on self-adhesive rubber</td>
<td>compressible</td>
<td>manual/plotter</td>
<td>1.24</td>
<td>n/a</td>
<td>74°</td>
<td>UV</td>
</tr>
<tr>
<td>RCU/RCA (US only)</td>
<td>self-adhesive rubber blanket on cylinder</td>
<td>compressible</td>
<td>manual/plotter</td>
<td>0.95; 0.95</td>
<td>0.89</td>
<td>75°</td>
<td>UV</td>
</tr>
<tr>
<td>RCU/RCA/SGT (US only)</td>
<td>polyester-backed rubber plate</td>
<td>compressible</td>
<td>manual/plotter</td>
<td>1.70; 1.96; 1.96</td>
<td>n/a</td>
<td>78°</td>
<td>UV</td>
</tr>
<tr>
<td>NAPCoat CBF (US only)</td>
<td>aluminium-backed photopolymer plate</td>
<td>compressible</td>
<td>manual/plotter</td>
<td>1.70; 1.96; 1.96</td>
<td>n/a</td>
<td>78°</td>
<td>UV</td>
</tr>
<tr>
<td>NAPCoat GLX (US only)</td>
<td>aluminium, steel- or polyester-backed photopolymer plate</td>
<td>compressible</td>
<td>manual/plotter</td>
<td>1.14; 1.70</td>
<td>n/a</td>
<td>78°</td>
<td>UV</td>
</tr>
</tbody>
</table>

**Meiji**

<table>
<thead>
<tr>
<th>Product name</th>
<th>Coating forme</th>
<th>Features</th>
<th>Stencil cutting</th>
<th>Gauge (mm)</th>
<th>Stencil depth (mm)</th>
<th>Shore A hardness</th>
<th>Coatings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perfect Dot MX</td>
<td>fabric-backed rubber blanket</td>
<td>compressible</td>
<td>manual/plotter</td>
<td>1.96</td>
<td>n/a</td>
<td>80°</td>
<td>aqueous</td>
</tr>
<tr>
<td>Perfect Dot QR</td>
<td>fabric-backed rubber blanket</td>
<td>compressible</td>
<td>manual/plotter</td>
<td>1.96</td>
<td>n/a</td>
<td>81°</td>
<td>UV</td>
</tr>
</tbody>
</table>

**Nessmann**

<table>
<thead>
<tr>
<th>Product name</th>
<th>Coating forme</th>
<th>Features</th>
<th>Stencil cutting</th>
<th>Gauge (mm)</th>
<th>Stencil depth (mm)</th>
<th>Shore A hardness</th>
<th>Coatings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spot Coat 50 TR</td>
<td>self-adhesive film on offset plate or polyester backing</td>
<td>for indirect coating</td>
<td>manual</td>
<td>0.50</td>
<td>0.50</td>
<td>115°</td>
<td>UV, aqueous, oil</td>
</tr>
<tr>
<td>Spot Coat TR 50 WM</td>
<td>self-adhesive film on offset plate or polyester backing</td>
<td>for indirect coating</td>
<td>manual</td>
<td>0.50</td>
<td>0.50</td>
<td>85°</td>
<td>UV, aqueous, oil</td>
</tr>
<tr>
<td>Spot Coat 100</td>
<td>self-adhesive film on offset plate or polyester backing</td>
<td>for indirect coating</td>
<td>manual</td>
<td>0.80; 0.95</td>
<td>0.90</td>
<td>75°</td>
<td>UV, aqueous, oil</td>
</tr>
<tr>
<td>Strip Plate S1</td>
<td>aluminium-backed photopolymer plate</td>
<td>for indirect coating</td>
<td>manual</td>
<td>1.70; 1.96</td>
<td>n/a</td>
<td>75°</td>
<td>UV, aqueous, oil</td>
</tr>
<tr>
<td>Strip Plate 13 KR</td>
<td>aluminium-backed rubber plate</td>
<td>for indirect coating</td>
<td>manual</td>
<td>1.96</td>
<td>n/a</td>
<td>75°</td>
<td>UV, aqueous, oil</td>
</tr>
</tbody>
</table>

**Novurania**

<table>
<thead>
<tr>
<th>Product name</th>
<th>Coating forme</th>
<th>Features</th>
<th>Stencil cutting</th>
<th>Gauge (mm)</th>
<th>Stencil depth (mm)</th>
<th>Shore A hardness</th>
<th>Coatings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spot 303 Revolution</td>
<td>fabric-backed rubber blanket</td>
<td>compressible, isotrop. torsionally stable</td>
<td>manual/plotter</td>
<td>1.15; 1.35; 1.55</td>
<td>0.80; 1.00; 1.20</td>
<td>&gt;100°</td>
<td>UV, aqueous, oil</td>
</tr>
<tr>
<td>Pavan</td>
<td>self-adhesive film on offset plate</td>
<td>fabric-backed rubber blanket</td>
<td>manual</td>
<td>1.95</td>
<td>n/a</td>
<td>85°</td>
<td>UV</td>
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</tbody>
</table>

**Prisco**

<table>
<thead>
<tr>
<th>Product name</th>
<th>Coating forme</th>
<th>Features</th>
<th>Stencil cutting</th>
<th>Gauge (mm)</th>
<th>Stencil depth (mm)</th>
<th>Shore A hardness</th>
<th>Coatings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Priscoith Conti-Air Crystal</td>
<td>fabric-backed rubber blanket</td>
<td>compressible</td>
<td>manual/plotter</td>
<td>1.69; 1.95</td>
<td>ca. 0.5</td>
<td>78°</td>
<td>UV</td>
</tr>
</tbody>
</table>

**Reeves, Gans Ink**

<table>
<thead>
<tr>
<th>Product name</th>
<th>Coating forme</th>
<th>Features</th>
<th>Stencil cutting</th>
<th>Gauge (mm)</th>
<th>Stencil depth (mm)</th>
<th>Shore A hardness</th>
<th>Coatings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vulcan UV</td>
<td>polyester-backed rubber plate</td>
<td>compressible</td>
<td>manual/plotter</td>
<td>1.70; 1.96</td>
<td>0.76; 1.02</td>
<td>n/a</td>
<td>UV</td>
</tr>
<tr>
<td>Vulcan UV</td>
<td>polyester-backed rubber plate</td>
<td>compressible</td>
<td>manual/plotter</td>
<td>1.70; 1.96</td>
<td>0.76; 1.02</td>
<td>n/a</td>
<td>UV</td>
</tr>
<tr>
<td>Vulcan 714 Strippable</td>
<td>polyester-backed rubber plate</td>
<td>compressible</td>
<td>manual/plotter</td>
<td>1.70; 1.96</td>
<td>0.76; 1.02</td>
<td>n/a</td>
<td>UV</td>
</tr>
</tbody>
</table>

**Sava Tech**

<table>
<thead>
<tr>
<th>Product name</th>
<th>Coating forme</th>
<th>Features</th>
<th>Stencil cutting</th>
<th>Gauge (mm)</th>
<th>Stencil depth (mm)</th>
<th>Shore A hardness</th>
<th>Coatings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advantage EPDM Red/Black</td>
<td>fabric-backed rubber blanket</td>
<td>compressible</td>
<td>manual/plotter</td>
<td>1.69; 1.95</td>
<td>n/a</td>
<td>n/a</td>
<td>UV</td>
</tr>
<tr>
<td>Advantage UV dual</td>
<td>fabric-backed rubber blanket</td>
<td>compressible</td>
<td>manual/plotter</td>
<td>1.69; 1.95</td>
<td>n/a</td>
<td>n/a</td>
<td>UV</td>
</tr>
</tbody>
</table>

**SFI Hybrid**

<table>
<thead>
<tr>
<th>Product name</th>
<th>Coating forme</th>
<th>Features</th>
<th>Stencil cutting</th>
<th>Gauge (mm)</th>
<th>Stencil depth (mm)</th>
<th>Shore A hardness</th>
<th>Coatings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smitomo ST-800</td>
<td>fabric-backed rubber blanket</td>
<td>film copy, washed off with water</td>
<td>manual</td>
<td>1.14</td>
<td>n/a</td>
<td>n/a</td>
<td>UV</td>
</tr>
</tbody>
</table>

**Toray**

<table>
<thead>
<tr>
<th>Product name</th>
<th>Coating forme</th>
<th>Features</th>
<th>Stencil cutting</th>
<th>Gauge (mm)</th>
<th>Stencil depth (mm)</th>
<th>Shore A hardness</th>
<th>Coatings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toreflex LT-14/DIR</td>
<td>polyester-backed photopolymer plate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


n/a: no data in the internet documents, OW: opaque white; (M) recommended by Merck; where a manufacturer's product range does not specifically include coating blankets, strippable printing blankets have been listed.
stripped: vertical cuts can destabilise the more delicate elements so that they are unable to withstand the shearing forces for any length of time, and deform or crumble. So it is best to ensure that the flanks are angled slightly, at least when cutting by hand on rubber.

Creating a stencil profile
Cutting and stripping (lifting, releasing) are two processes in which the outlines for the application of coating are cut and coating-free areas on the blanket or plate removed either manually or using a computer-to-plate system and a cutting plotter. Basically, any blanket can be cut and stripped to a more or less acceptable quality. Whether a blanket is suitable for coating does not just depend on the ease with which it can be stripped; other key criteria are the ability of the liner to accept and transfer a coating, and its swell-resistance relative to oil-based inks, diverse coatings and washes. The compressible layer in a rubber blanket plays a decisive role during stripping; if it is necessary to cut through compact layers, stripping the cut-out areas can be quite difficult. Open cell structures, however, make stripping easier. Stripping is also easier if it is possible to cut down to the polyester or aluminium backing, which is usually the case on thinner blankets. Some manufacturers recommend incompressible coating blankets that can be cut deep, in tandem with a compressible underlay. Others use the compressible layer in the coating blanket as a separating layer from which the cut-out sections can easily be stripped. There are tools available for manual cutting, and hotplates to facilitate stripping. But first of all the coating image must be copied onto the opaque rubber liner to create a template. It is easiest to do this with the aid of a light-sensitive diazo film on the rubber, which can be exposed and developed just like an analogue printing plate through a diapositive film. Transparent films that are to be glued onto aluminium carriers should be mounted on aluminium plates imaged with the coating pattern.

Cutting plotters are controlled with CAD data generated eg in packaging design software or from layout data. But even here the cut elements must be removed manually. Some dedicated plotter-cuttable blankets and plates are protected by a non-scratch or non-stick film which must be removed after plotting.

Photopolymer plates are mostly imaged through a template using UV radiation, cleaned with water or solvent and re-exposed. There are also photopolymer coating plates that can be imaged digitally with a laser, though laser engraving is not yet available. And, as in offset CTP, coating is also possible with chemistry-free plates (eg DuPont’s Cyrel FAST) which require UV imaging followed by dry thermal developing.

DIY or made to order?
While it is customary to create the profile on rubber and film formes in-house, and the coating forme is often cut on the cylinder by the press operator himself, photopolymer coating formes are manufactured almost exclusively by specialist companies. For printing plants it is not usually cost-effective to invest in a device for imaging and developing photopolymer plates, as it most probably will not be utilised to the full. Printers all too rarely include the in-house labour input in their calculations when comparing the prices of different coating formes. A rubber or polymer forme delivered ready to use may be more expensive than a coating blanket stripped in-house, but the substantial length of time required for transferring the image and cutting and stripping the blanket should also be factored in. If the image is complex, additional labour may be required, so it is worth checking whether in-house production is always the most cost-effective method. More and more printers have reviewed their procedures and switched to ready-to-use coating plates, which include a growing number of photopolymer plates. And photopolymer plates are no longer used solely for particularly delicate coating images demanding precise registration but also for simpler work such as knock-outs for adhesive.

Dieter Kleeberg
Calculating the distortion factor for coating images

When creating the stencil profile on a coating forme — whether manually, on a plotter or using UV or laser imaging — image distortion must be factored in. This is because the curve of the cylinder makes the profile fan out in the direction of rolling, so the coating image must be shortened accordingly. The larger the sheet size, the smaller the relative distortion, but even so the bigger cylinder circumference increases the absolute difference between the coated and the printed image.

**Target values:**
K (in mm): curvature, distortion value
D (in %): distortion factor, relative distortion, foreshortening of coating image

**Variables:**
s (in mm): stencil depth
u (in mm): coating forme cylinder circumference
d (in mm): coating forme cylinder diameter
π: ratio of cylinder circumference to cylinder diameter (3.14…)

**Formulas:**
K = 2πs
u = πd
D = (K / u) · 100%
D = (2πs / πd) · 100%

**Consequence:**
The length of the coating image must be shortened in the direction of cylinder rolling by distortion factor D, eg from 100% by D = 0.5% to 99.5%. The substrate thickness and the total thickness of the coating forme including all underpacking exert an influence via the cylinder diameter d that is not mutually eliminated and can therefore minimally alter distortion factor D. With photopolymer plates the impression pressure also increases the distortion factor. In practice, mean values are often used for calculations: half- and medium format 0.7%, large format 0.6%, superlarge format 0.5%. Extreme values range from 0.2 to 1%.

**Problem-free cutting and stripping**
Special knives and awl-like lifting tools are used for manual cutting and stripping. For straight edges it is advisable to use a metal rule. In rectangular knock-outs the cuts must meet in the corners so that no rubber tags remain after stripping. The material to be removed is peeled off slowly at an acute angle, and always away from the corners and edges so as to avoid accidentally lifting the remaining layer(s). Mistakes can be remedied with special repair adhesives such as Folaglue’s Folaglue.

**Servicing the coating forme cylinders**
These should be serviced once a week. Push up the protective grid and use the keyboard to rotate the plate-clamping bars so that they are visible (1). Secure the press to prevent a restart. Clean the clamping bars and spray lightly. Clean the setting screws (2) and other movable parts through the gaps in the covers, and spray lightly. Carefully remove excess lubrication. Use sprays VI (with aqueous coatings) or VII (with UV and mixed production) — see KBA lubrication guide 8-1 to 8-4.

**Measuring the thickness of the packing on the coating forme cylinder**

Outside the press with a measuring device. Insert the entire sandwich and measure with a defined sensor pressure; it is even possible to measure individual components.

**Servicing the coating forme cylinders**

Servicing the coating forme cylinders

**Problem-free cutting and stripping**

Problem-free cutting and stripping

**Servicing the coating forme cylinders**

Servicing the coating forme cylinders

**Calculating the distortion factor for coating images**

Calculating the distortion factor for coating images

**Problem-free cutting and stripping**

Problem-free cutting and stripping

**Servicing the coating forme cylinders**

Servicing the coating forme cylinders
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Perfect kiss prints (top) with the correct impression pressure, dot fringes (bottom) with too high a pressure — this is demonstrated equally clearly with a spot coating (left) and gold varnish (right), both applied using photopolymer plates Photos: Flint Group

3. The pressure between the anilox roller and the coating forme is too high because the underlay is too hard or too thick.

The anilox roller jumps:
1. Incorrect cylinder rolling.
2. The pressure between the anilox roller and the coating forme is too high. The roller stripe width should be a uniform 4mm (0.15in) wide.
3. A compressible underlay or coating forme helps counteract this problem right from the start.

The coating image contains imperfections:
1. The impression pressure of the coating forme cylinder is too low, ie it is lighter than the setting for a kiss impression.
2. The coating forme is too thin. Thicken the underlay.
3. The coating is too thin. This may be due to a contaminated roller or an anilox roller that is unsuitable for the pick-up volume required, or the anilox roller may have too little contact with the coating forme; on large-format presses the anilox roller may not be sufficiently rigid. Or the coating transfer properties of the coating forme (eg with blankets that are intended only for ink transfer) may be the culprit.
4. The carton is of poor quality. This may be reflected in a high thickness tolerance.

Ink builds up on the coating forme faster and more frequently:
1. Impression pressure is much higher than for a kiss impression, so the load on the fresh print is too high and ink rubs off. Reduce impression pressure and stabilise if possible with a compressible underlay.
2. The coating is too thin (see above).
3. The volume of ink is too high, the ink too thick, or highly pigmented or metallic inks were used. Poorly or non-absorbent substrates such as parchment, metallised or foil-coated paper impair ink adhesion.
5. When coating coarse carton, the pressure in the coater often has to be increased and this encourages ink build-up.

Coating builds up on the coating forme:
1. The stencil cut is too shallow.
2. The coating has the wrong viscosity.
3. The coating is applied too thickly.
4. At print start the coating forme slams the forme roller against the polymer layer. Check rolling and if necessary exchange hard components for compressible ones.

Underlay composition
If the coating forme is too hard, dot fringes may occur even with the correct impression pressure. Experts therefore recommend including a compressible layer in the coating forme or underlay. For example Folex, Kruse and Nessmann offer compressible underpacking, so the coating forme comprises just a polyester backing, a cut-proof polyester laminate and a polymer surface layer that can be cut right down to the laminate. If a compressible coating forme is used there is no need for compressible layers in the underpacking. Not all materials are suitable for use as compressible underlay sheets, since these must have a specific thickness. Calibrated underlay sheets were developed for this purpose. They can consist of paper or, most recently, an extruded, lightly compressible sandwich of polyurethane (PUR) and polyester (PET) (available from Finito in Italy).

Choosing the coating forme
Simple disposable coating formes or self-adhesive polymer films are often perfectly adequate for short print runs. For longer runs it is best to use either rubber blankets or plates with a compressible component, or photopolymer plates. Depending on the distribution of coating-free areas and thus the concentration of the mechanical load, the service life of a compressible coating forme can be 2 to 3 million impressions, spread over several repeat runs. Photopolymer plates have a similar lifespan. Compressible coating formes reduce the consumption of coating — provided an anilox roller with a finer profile is used — because they hug the substrate. They also absorb wrinkles or folds in the substrate without deforming.

There is no alternative to photopolymer plates when coating complex images. And they are almost always a viable alternative even with simple images, since buying them in is often cheaper than cutting them by hand or with a plotter, or manually stripping a rubber forme.

Gloss also depends on the coating forme
Coating formes with a high-gloss rubber surface, ie smooth and unroughened, can enhance gloss, particularly when combined with high-gloss UV and special-effect pigment coatings. The surface tension of the rubber should exceed 32mN/mm. The plan parallelism of the coating forme also plays a role, since the contact surfaces should be as uniform and even as possible.
Aqueous and UV coatings in waterless offset

Waterless offset with conventional and UV-curing inks delivers a high-quality printed image. It is often combined with other high-end technologies such as frequency-modulated screening and an expanded colour gamut. Here, too, inline coating can be the crowning glory.

KBA: pioneering waterless

Waterless offset with inline coating became an established technology many years ago – in principle at the same as inline coating units for wet offset were developed. KBA and its subsidiary KBA-Metronic were among the first to pioneer both waterless offset and inline coating. Screen rollers were adopted even before anilox coaters in offset inking units, which is why the inking units are so compact and require no key-setting elements. Keyless inking technology for waterless offset was utilised back in the early 1990s – along with UV inks and coatings – in the OC100/OC200 single-card printing presses developed by Metronic prior to its acquisition by KBA. OC presses predominantly print PVC/ABS (acrylonitrile-butadiene-styrene) mono plastic cards such as prepaid telephone cards.

In the meantime waterless offset with UV inks (WLUV) and inline UV coatings has been adopted for a variety of applications. This applies – generally with “long” ink trains – to sheetfed offset on board for folding cartons and displays, to printing on plastic and foils and to narrow-web offset, which is often used to print labels. One press that operates solely with keyless inking units is the Genius 52, which is available only as a UV version marketed by KBA-Metronic. The Genius 52UV’s most striking feature – apart from its user-friendliness and space-saving footprint – is the wide range of substrates it can print, which include paper, carton and plastic up to 0.8mm thick.

The first Genius 52UV to incorporate a UV coater with squeeze rollers and an extra-long dwell section was installed at prominent Swedish plastic print specialist Inplastor. Both these features promote an exceptionally high level of gloss: the squeeze rollers allow the optimum thickness of coating to be applied, while the six-metre-plus (20ft) dwell section allows the thick layer of coating to develop its maximum smoothness.

As a result the gloss of the printed and coated cards delivered closely approaches the gloss level and rub-resistance of laminated cards. Inplastor uses this configuration to print smart cards of all kinds, including debit and credit cards that are produced in a high-security environment. Smart cards – plastic cards with digital storage capabilities and functions, in association with electronic systems – are a booming market.

The four-colour 74 Karat Di offset press, which consumes waterless inks that dry by oxidation and penetration, is now shipped almost exclusively with an aqueous coater. This configuration was developed in response to a demand by Karat users for faster finishing to keep pace with tight delivery deadlines.

Coating quality benefits from waterless process

The use of coatings in waterless offset processes involving oxidation-dried or UV-cured inks has a number of advantages, since there is no water or isopropyl alcohol present. The mere absence of fount solution imparts a higher degree of gloss to the inks used. It follows that the coating will also benefit from this higher basic gloss level. The gloss levels are around 3 to 4% higher than in inline coating in wet offset.

Since there is no transfer of fount solution to the substrate prior to coating, the coating can wet the substrate and ink much more...
Coating applications | Waterless offset

Process 4 | 2007

In waterless offset print production, in particular, dispensing with fountain solution delivers additional benefits: the coating can adhere and dry faster and more thoroughly, so there are fewer problems associated with drying in the pile, thus minimising the risk of blocking. In narrow-web label printing, waterless UV with inline coating has been a common practice for some years now because the fountain solution would be a major issue during printing and finishing. Since seven- or eight-colour presses are commonly used, the volume of fountain solution applied would be twice that required for a four-colour sheet-fed press.

Essentially the usual coatings

In waterless offset print production with inks that dry by oxidation/penetration or UV curing, perfectly normal aqueous or UV coatings are used. Coating manufacturers designate their products as suitable for both wet and waterless offset. Here the decisive criteria are the solvent- and alkali-resistance of the waterless inks and the absence of surfactants such as wax or silicone. Since waterless inks today generally contain silicone oil substitutes, special coatings are no longer necessary. One exception is if oxidation-dried waterless inks are used to print plastic film. For example, for printing on plastic the 74 Karat is run exclusively with Zeller+Gmelin’s Toracard TF inks. Toracard TF is silicone-free, so it is only the peculiarities of the plastic surface that create the need for a special aqueous coating. Basically, polystyrene (PS), PVC, ABS, polyester (PET) and polycarbonate films are suitable for printing, but polyolefins such as polypropylene (PP) are not. Vienna-based coating specialist Werner Tippl manufactures Tipadur-Printcoat aqueous coatings specifically for printing plastic on the 74 Karat.

Detlef Braun,
Druck & Beratung (www.WLUV.de),
European Waterless Printing Association
(www.ewpa.org)

For some years now virtually all the 74 Karat presses KBA has shipped have featured an anilox coater for aqueous coatings, so as to reduce the delay between printing and perfecting or finishing and thus minimise turnaround times.

One of the Drent-Goebel narrow-web waterless UV offset presses that have been printing and coating in triple-shift operation for many years at X-label in Erfurt. In the foreground, Harris & Bruno’s LithoCoat coating feed system can be seen at the second, active coater from which the dwell section rises up to the UV radiator.

Photo: Braun
Coating applications | Choosing substrates

How paper and board interact with coatings

The various types of coating available on the market harden by different processes, so the properties of the paper and board that they coat must differ accordingly. This chapter summarises the recommendations, based on past experience, made by paper manufacturers and vendors Sappi, Schneidersühne and UPM at KBA’s coating seminar.

Papermakers enhance their products on an ongoing basis. As a result paper has been transformed from a basic vehicle for information to a crucial and sophisticated tool for product differentiation. Choosing the right combination of consumables, and maintaining close communications with the technology vendors involved in the process, have enabled printers to achieve some stunning results in the field of coating applications and hybrid finishing.

Optimising the interplay of substrates, inks and coatings can visibly enhance the overall impact, because not every permutation is equally good. If a customer chooses a substrate that has not been proven, the result may come as a nasty shock. So for printers the important thing is to work with paper manufacturers and vendors to find the best possible substrates for any specific coating.

But the act of applying and drying a coating, in itself, demands a certain level of knowledge and skill on the part of the press operator. When changing to a different coating it is important to test its compatibility with the substrate and with any other form of finishing that has been specified. It is also important to make sure that substrate acidity does not retard the drying or curing process. Nowadays paper and board are generally pH neutral because calcium carbonate is a cheap alternative to fillers and coatings. In an acid medium, calcium carbonate would decompose and carbon dioxide bubbles cause the ink and coating to foam.

Aqueous coatings

Most of the water contained in aqueous coatings is absorbed by the paper or board, even if the surface is coated. When the sheets pass under the IR dryer and hot-air knife, water evaporates not only from the coating but also from the substrate. Since the amount of moisture absorbed by the substrate increases with the volume of wet coating applied, it follows that thin substrates should only receive a thin application of coating.

It is only possible – and advisable – to drive a certain proportion of water out of the substrate. For one thing evaporation is hindered by the dried or cured coating and for another excessive drying would cause the paper to warp. So the only answer is to adjust the volume of wet coating to suit the thickness of the substrate. This can be done by choosing the appropriate screen roller. Water evaporation produces a cooling effect that is beneficial to the delivery pile, which tends to be hot. This allows more room for manoeuvre as far as dryer output is concerned.

If drip-off or twin-effect aqueous coatings and matt overprint varnish are to be used then it is advisable to test substrate compatibility in advance. KBA recommends switching to hybrid coating since this has a much greater visual impact.

UV coatings

Paper and board with an extremely smooth surface and/or low level of absorbency are a good choice for UV coating as they impair penetration. Substrates with a rough surface but a low level of absorbency will require less ink for the same level of cover, but surface roughness can reduce rub-resistance. Highly absorbent substrates are totally unsuitable because they seriously impair gloss and, since the photoinitiators may escape UV radiation by penetrating the substrate, can even prevent the coating from curing completely. One disadvantage of a smooth surface (particularly with cast-coated stock) and poor absorption is that the ink and coating may not adhere properly.

Although modern UV lamps largely exclude the IR spectrum, the delivery pile still becomes very hot. This may frequently lead to blocking and distortion, because the temperature-dependent loss of substrate moisture may destabilise the sheets – a phenomenon that may also be observed when aqueous coatings are dried by IR radiation.

Optical brighteners in the substrate can cause discoloration (yellowing) when exposed to UV radiation, though this is only visible after several hours. When selecting substrates for UV printing and coating it is therefore best to make sure that any optical brighteners they contain are sufficiently stable. Paper in which the pulp and fillers have a high inherent whiteness will yellow the least.

One example often quoted of the aesthetic benefits of spot UV coating is reflection-free, easily readable text on matt-coated paper.

Die-cutting and stamping require a flexible UV coating film. The key
to this is to reduce the volume of wet coating applied.

For folding and scoring, the coating film must not only be flexible and elastic, but must also withstand tensile stress and adhere well to the substrate. A brittle surface caused by moisture loss through heat during UV curing is therefore undesirable if the coating is to remain pliant and crack resistant. Even so, it is best to avoid positioning folds and grooves in dark images because any cracking or flaking in the ink or coating would be much more noticeable. The higher the surface mass of the paper, the higher the risk that the coating will crack; with weights of 150gsm (40lb bond) or more we strongly recommend scoring prior to folding.

If finishing is to include hot-foil stamping it is best to use a coating that contains no anti-friction agent. Here, too, the volume of wet coating applied must be appropriate for the UV curing process. Powder impairs adhesion by the foil.

If glue areas cannot be left bare during coating, they should be roughened if possible.

Ask the manufacture for suitable water-based, hot-melt or ethylene vinyl acetate (EVA) adhesives and be sure to test them for adhesion on the UV coating. Polypropylene film is ideal for heat-sealing, MSAT (moisture-proof, sealable by heat, anchored coating, transparent) and XS (polymer-coated, sealable) films are not.

Inks and coatings with a small proportion of low-molecular binding agents and photoinitiators tend to generate odours. The tendency of decomposition products (gaseous monomers) from the UV inks to accumulate on the binding agents in the coating colour may be another source of odours. Odours can also arise if just the paper coating reacts to the UV radiation. At KBA’s initiative Fogra has been examining this issue in association with a number of paper manufacturers.

Smooth, UV-coated paper, particularly if it is perfect coated, is typically prone to a type of blocking known as the glass-plate effect, in which all the air between smooth paper sheets in the delivery pile is forced out, creating a vacuum like that between two plates of glass. Preventive action can take the form of a light dusting of powder or trimming the pile while it is still warm and full of air.

**Overprint varnish**

Overprint varnish dries by oxidation and by absorption. However, the proportion that is absorbed by the substrate should be smaller than with printing inks, since otherwise the intended coating effect, especially gloss, will fail to materialise. So the substrate should only absorb a small proportion of the overprint varnish, which is the case with most types of coated stock.

The absorbency of uncoated paper can be reduced by a prior application of overprint varnish. Calendered uncoated stock is more suitable because its surface is sealed. As with aqueous and UV coatings, overprint varnish is most effective if the substrate has a low level of absorbency.

**Hybrid technology**

This was discussed in detail in an article by the Schneidersöhne group entitled "Substrates for hybrid applications" on pages 24 and 25 of KBA Process 3: Quality enhancement with hybrid production.

Since hybrid finishing includes a final UV gloss coating, when combining and working substrates and coatings essentially the same specifications apply as for UV coatings. The choice of substrate is therefore guided by UV-relevant criteria (high-gloss coated types are the best), wettability and odour generation, as well as by the impact on adhesion, scratch- and rub-resistance.

If contrasting gloss effects are to be created, then the hybrid inks that are cured with interdeck UV dryers must receive an additional partial application of matt or granulating overprint varnish prior to the full-solid UV coating. Whether the effect succeeds with a different choice of materials should be tested in advance.

Printers can obtain a lot of useful advice from the websites of the above-mentioned companies.

[www.sappi.com](http://www.sappi.com)
[www.schneidersoehne.de](http://www.schneidersoehne.de)
[www.upm-kymmene.com](http://www.upm-kymmene.com)
Coating and finishing underpin success of KBA users

KBA is the global technology leader when it comes to inline coating in sheetfed offset. Evidence of this is provided by the numerous printing presses with standard or customised coaters that have been installed by satisfied users the world over. Not only that: KBA has accelerated the adoption of anilox technology in offset, developed hybrid coating to perfection and also offers other systems for coating board and film in UV and waterless offset.

Coatings on the advance
Printers throughout the world are taking inline coating on board. This is because product and brand manufacturers must continually come up with new design elements in order to differentiate their products and raise their competitive profiles in the global marketplace. This differentiation is achieved by exploiting every possible option that printing technology offers with regard to substrates, ink application, coating and finishing. The ability to print and coat in one pass can deliver vital competitive advantages.

KBA feels the pulse of this trend via customer specifications for new presses. For some years the proportion of small-, medium- and large-format KBA presses shipped with a coating facility has varied between 40 and 60%. The folding carton and display sectors have the highest rate of adoption worldwide, with 80 to 85% of presses in the industrialised world featuring inline coating. There follows label printing (64 - 77%), commercial and book sectors, while spot coating is the preferred choice in the folding carton and display sector. Spot line and screen coating is more popular among book printers. According to a survey of European printers by Weilburger Graphics, in recent years there has been a continual increase in the proportion of UV coatings and inks relative to total consumption, and this has been most marked in the UK and France. However, the majority of the printers surveyed

One of KBA’s many innovations is the ability to create a hidden image within a coating. With the aid of hybrid technology it is possible to conceal counterfeit-proof images in dark solids on packaging and not just in the screen structures. They can only be read with a special decoder lens.

Full-solid coating is the most popular form in the label, commercial and book sectors, while spot coating is the preferred choice in the folding carton and display sector. Spot line and screen coating is more popular among book printers. According to a survey of European printers by Weilburger Graphics, in recent years there has been a continual increase in the proportion of UV coatings and inks relative to total consumption, and this has been most marked in the UK and France. However, the majority of the printers surveyed

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still use overprint varnishes and aqueous coatings. Among packaging printers aqueous and UV coatings have been widely adopted, largely because of their outstanding quality, which is due in no small part to anilox technology. The key function of a coating, according to print professionals, is to protect the freshly printed image from damage due to mechanical impact, thus eliminating the risk of process-related down times while ensuring that the product can be finished as specified. But while ever tighter delivery deadlines mean that production time plays an increasingly major role, the companies surveyed place greater emphasis on product quality.

Business models for inline coating

The substantial installed base of KBA presses with coating capabilities reflects a strong focus by printers on sophisticated coatings for all kinds of products. This indicates that overprint varnish, which can be applied in a wet offset printing unit without the need for a coater, is often no longer capable of fulfilling the more challenging demands placed on gloss coatings. And because it takes so long to dry, it is also less suitable as a protective shield for prints to allow them to be finished without delay. However, it has acquired a new field of application in the creation of contrasting gloss effects with matt and granulating coatings in hybrid production, which is being adopted by a rising number of print providers. Hybrid inks in conjunction with a spot overprint varnish and full-solid high-gloss UV coating have proved to be a genuine alternative – both from the aesthetic and the economic point of view – to coating with two-coater presses. With hybrid presses it is also possible to apply conventional inks and aqueous coatings. But it is not only hybrid technology which proves that all kinds of options are possible with just one (anilox) coater. Many printers have recognised, for example, that full-solid or spot applications of aqueous coatings, which offer far more functions than just protection and gloss, are a valuable tool for enhancing their print portfolio with value-added products. Gloss contrasts can even be achieved using drip-off or twin-effect coatings (conventional inks plus spot overprint varnish plus full-solid aqueous coating), though these are less impressive than with hybrid consumables.

The case is similar in UV printing: many companies have found that applying a pure UV coating instead of two coatings can give folding cartons a greater visual impact. Moreover, UV printing and coating capabilities have become a major source of income for a growing number of plastic and film printers. KBA-Metronic addresses this highly specialised sector with systems that can print and coat directly on plastic cards (the OC200) or print plastic along with paper and board (the Genius 52UV, an increasing number of which are being configured with a UV coater). The Rapida 74 G, which has waterless and keyless inking units, has already been...
Coating applications | Examples

Selection from the broad product spectrum of London-based large-format printer Augustus Martin. Every year the company’s products win awards – for example from the SPA in the categories plastic printing, large-format printing and non 3D POS in 2004. The press fleet includes one Rapida 105, two Rapida 162s and one five-colour Rapida 205. Many displays that could previously only be printed in one piece using screen or inkjet systems can now be printed on the large-format sheetfed offset presses at a much higher speed and in a better quality shipped with a UV capability, as well as with two coaters for printing and coating short runs of packaging and promotional products. But two-coater presses are still the most versatile. Their ability to apply a primer means that they can print conventional inks followed by a high-gloss UV coating, or apply a special-effect coating plus a high-gloss coating. Some printing plants have even put presses into operation that feature an additional coater plus dryer modules ahead of the first printing unit. This allows them to apply opaque white or special-effect primers, which can then be printed over and given a second coat for added brilliance.

On top of all this, the complexity of the coating process makes it harder for packaging to be counterfeited. At the same time coatings can be combined with additional counterfeit-proof features such as concealed image technology (CIT). KBA has developed this technology for use with hybrid coatings, as a result of which it is now possible to position the hidden image not just in the screen structure of the colour separations but anywhere in the coated image. Again and again, KBA offers its customers new approaches to inline coating, and these are not confined to the coating itself. For example, the coater – like the final printing unit – can now be used for other mechanical finishing processes such as die-cutting, by mounting the relevant die-cutting forme on the forme cylinder so that it is thrown against the impression cylinder in the coater.

KBA will continue to focus on expanding press applications through product enhancement and value-added advances – and not just in inline coating processes.

Jürgen Veil, Martin Dänhardt, Dieter Kleeberg

A five-colour Rapida 205 with coater and dryer that came on stream in 2006 at Redditch-based SP Group, the POS arm of prominent UK print group St Ives, can print plastic film as well as 1.2mm (48pt) packaging and microflute at a rate of 9,000 sheets per hour, and apply conventional and UV inks plus water-based and UV coatings

Chinese greetings cards and wrapping paper specialist Glory Moon in Yingde has three five-colour KBA presses – a Rapida 142, a Rapida 105 universal and a Performa 74 (pictured here) – each with a coater and extended delivery

KBA’s coating seminar in 2006 included a demonstration in the Radebeul R&D centre of rotary die-cutting in the coater of a Rapida 105. It was the first ever demonstration of inline kiss die-cutting on self-adhesive stamps, enabling the off-cuts to be pulled off cleanly leaving the stamps intact on the silicone backing. To surface die-cut the printed elements the screen roller was removed and a die-cutting forme mounted like a coating plate on the forme cylinder.
KBA Process

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