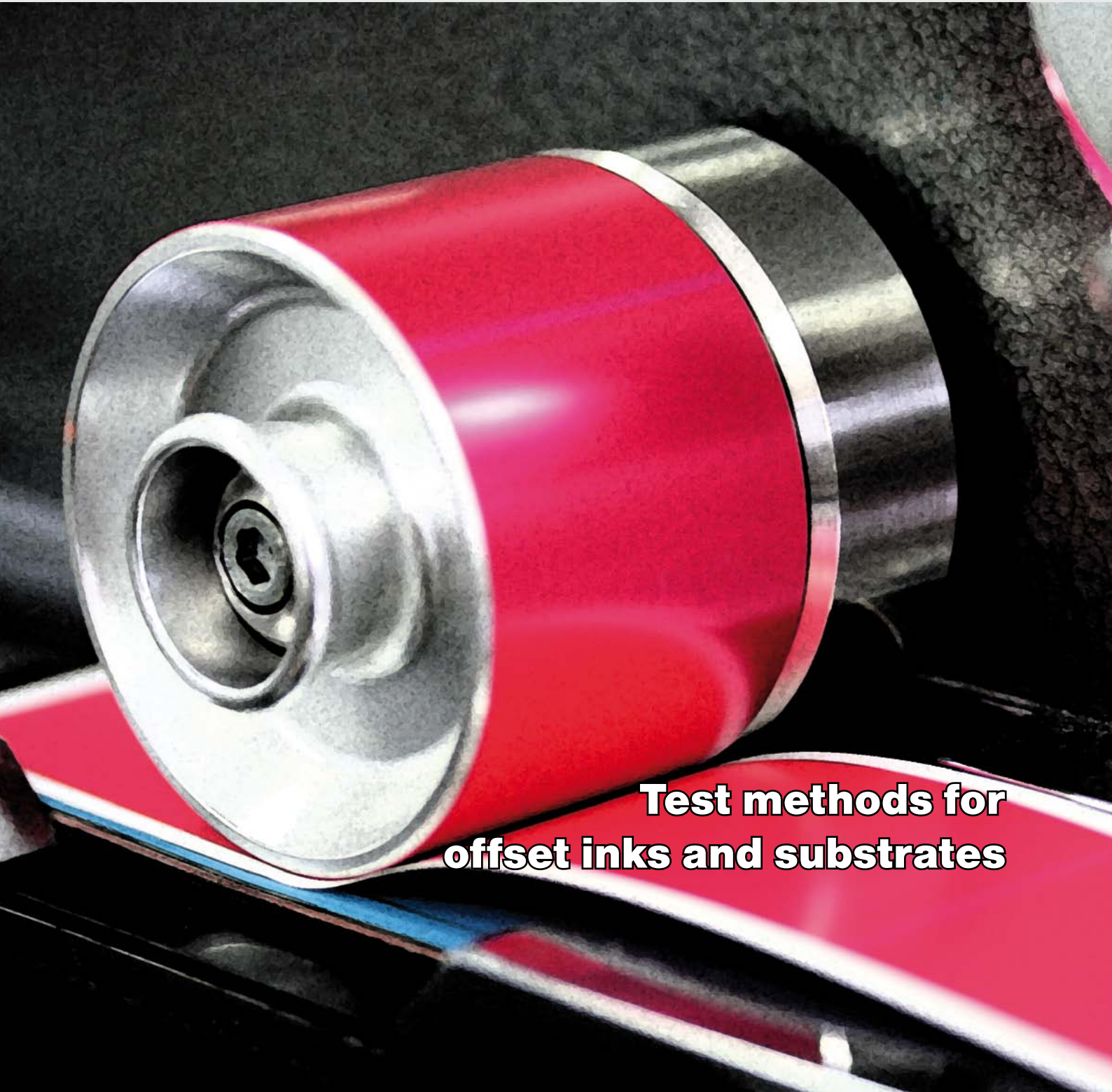


INK **K**FORMATION



**Test methods for
offset inks and substrates**

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Test methods for offset inks and substrates

Introduction

Offset is a very complex printing process in physical terms. Although offset is extremely versatile while plate production costs are low, some processes and interactions, which have not been subject to scientific exploration so far, are still involved. Realistic testing methods are an essential tool for research, development and applications-related problem solving in order to predict results in offset printing.

The **huber**group has helped to develop many testing methods, especially those concerning the interaction between ink and print substrate. Some of them are used in the printing and paper industry, and in order to respond the large number of inquiries we prepared this new compilation.



The descriptions and procedures of the test methods are indicated by this pictogram.

Fundamentals

Two important parameters governing the printing characteristics of offset inks are rheology and drying characteristics.

Like other ink properties, these parameters depend on the particular formula, especially on the vehicle composition. In this context, we refer to conventional offset inks and don't consider energy-curing systems.

Conventional offset inks may contain the following constituents:

- Colouring agents: Pigments, organic as well as certain inorganic pigments
- Vehicles: Hard resins, alkyd resins, vegetable and mineral oils
- Auxiliaries: Waxes, drying agents, fillers, inhibitors, etc.
- Thinners: Mineral and/or vegetable oils

Various types of these individual components are used in different quantities depending on the application.

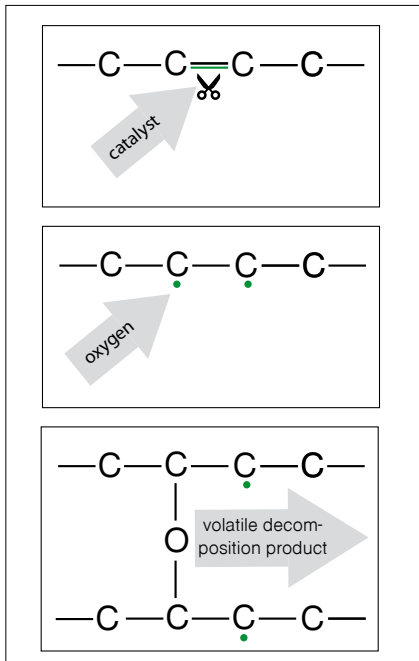


Fig. 1: Oxidative drying breaks a double bond and forms an oxygen bridge between the fatty acids

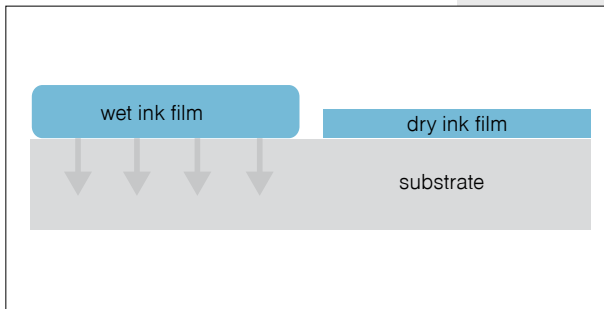


Fig. 2: Physical drying in conventional offset printing

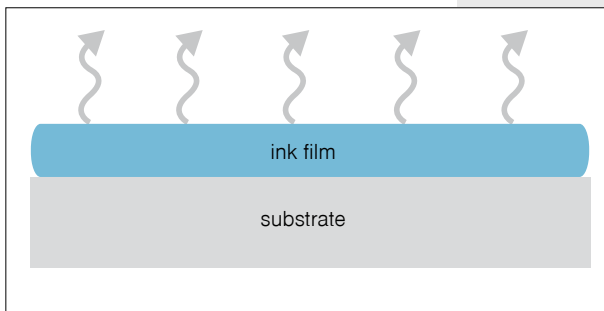


Fig. 3: Physical drying in web offset-heatset

Drying of offset inks

Chemical drying

Most modern ink vehicles are a composition of filmforming resin components and drying vegetable oils. Especially in sheet-fed offset inks mineral oils are used less often, whereas this raw material is still common in web offset inks.

Vegetable oils and alkyds have an important characteristic: when exposed to atmospheric oxygen they polymerise to form a tough, elastic film which fixes the ink on the stock. This process is generally referred to as “oxidative drying”, which represents the most common form of chemical drying (Figure 1).

Chemical drying of inks can be described as cross-linking of components and it takes many hours, until the ink is fully cured. The drying time depends on the formulation and is commonly accelerated by adding catalysts. Catalysts, in printing inks often referred to as drying agents or siccatives, are metal salts that accelerate the initiation of the drying process. An ink with drying agents that can be easily converted within six hours may show bad rub resistance after 72 hours if no drying agents are added.

Physical drying

Mineral oils and many esters of vegetable oils do not polymerise when exposed to air as drying oils do, but they penetrate into absorbent substrates and separate from the other ink constituents. To be more precise, any oil of low molecular weight and small structure will penetrate, as long as the substrate is absorbent. This specific form of physical drying is called “setting” (Figure 2).

In the web-offset heatset drying process, part of the incorporated oils evaporate from the ink, while a part absorbs into the substrate (Figure 3).

The absorption process is an interaction between ink and printing substrate. Several characteristics of the substrate govern the absorption of printing inks:

- Absorptivity

The total volume of liquid (i.e. oil from the binder) that can be taken up by the substrate is generally referred to as its absorptivity. Since this value depends on the free pore volume of the substrate, it can involve either a few large-diameter pores or a large number of pores with very small diameter. The absorptivity therefore indicates nothing about pore diameter. That diameter, however, has a substantial influence on separation effect and absorption rate, which are highly significant parameters in the absorption of inks.

- Separation effect

The separation effect results from the capillary structure of paper. Just like a sieve filled with a mixture of particles, which allows only those smaller than the sieve mesh to pass through and retains the rest, the surface characteristics of the paper allow parts of the oil to separate from the other components of the ink. In this case the sieve mesh corresponds to the average pore or capillary diameter. If that diameter is small enough, only the oil penetrates into the paper, while the pigment and the rest of the vehicle remain on the surface. If the diameter is too large, pigment and vehicle will also penetrate, leading to reduced colour strength in the printed ink.

- Absorption rate

It's easy to figure how a natural sponge with large pores would be soaked a lot quicker than a synthetic one with small pores, even though ultimately the same amount of liquid was absorbed. Adding to that, the same sponges, which soaked up water so easily, would take much longer to mop up a spilt of viscous oil. These relations do also apply for the absorption rate of paper, which strongly influences the setting process.

Displayed in a graph (Figure 4), we find that the absorption rate is extremely high at the beginning of the absorption process and decreases over time. For example, doubling the pore radius results in approximately five times the absorption rate, while multiplying the pore radius by five increases the absorption rate by a factor of about 60.

Viscosity, however, has much less of an influence: decreasing the viscosity by 50% results in a 40% higher absorption rate, while a 100% increase produces a 30% lower rate.

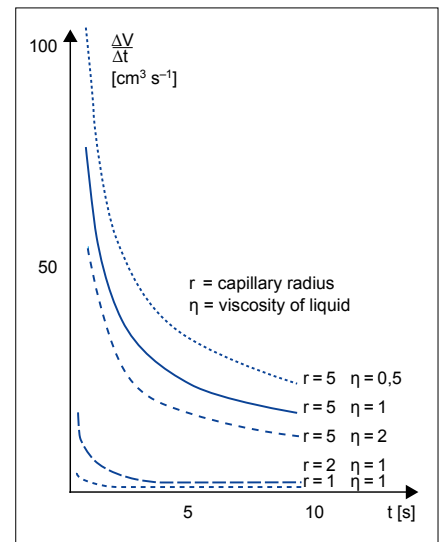


Fig. 4: Relationship between absorption rate and time, capillary radius and liquid viscosity

The absorption rate can be described essentially by a simple physical relationship, the Hagen-Poiseuille capillary flow law:

$$Q = \frac{V}{t} = \frac{\pi r^4}{8\eta} \times \frac{\Delta P}{l}$$

It states, that the quantity of fluid V delivered per unit time through a cross section with radius r is proportional to the fourth power of the cross-sectional radius and to the pressure differential ($\Delta P/l$) and inversely proportional to the viscosity of the fluid. The pressure differential in the paper capillaries is generated by the capillary pressure which results from wetting. If you replace pressure differential and volume of the capillaries with their calculation formula, the following formula for non-linear absorption rate is the result:

$$\frac{dV}{dt} = \frac{\pi r^2}{4} \times \sqrt{\frac{r\sigma \cos \alpha}{\eta}} \times \frac{l}{\sqrt{t}}$$

It also depends on the capillary radius r, the wetting tension ($\sigma \cdot \cos \alpha$) of the liquid with the surface tension σ , the wetting angle α and the viscosity η . So if viscosity η and surface tension σ are the characteristic parameters for the liquid, and pore radius r for the paper, while the value $\sigma \cdot \cos \alpha$ characterises the interaction between liquid and paper.

Requirement profiles for paper and ink

From these properties – absorptivity, separation capacity and the absorption rates – we can derive the following substrate and ink requirements for optimum ink absorption:

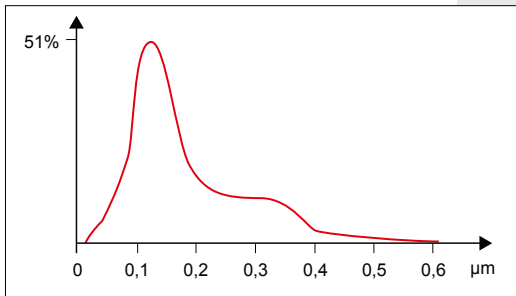


Fig. 5: Distribution graph of the pigment size in an offset process ink

- Capillary diameter

Absorption rate rises with increasing pore diameter, while separation capacity decreases. With large pores, portions of the pigment and the high-viscosity vehicle components will penetrate into the paper and separation will be incomplete. The optimum pore diameter is defined primarily by the pigment particles in the ink. The pigment particles size (*Figure 5*) for the offset ink from the example spreads across a distribution curve mainly between 0.1 and 0.2 µm (variable with the pigment and its grade of grinding). So to ensure that the pigment remains on top of the paper, its surface pore diameter should be just less than 0.1 µm. A maximum number of capillaries per unit area results in faster penetration of the low-viscosity constituents.

- Wetting characteristics

The better the wettability of the substrate, the faster a liquid can penetrate. This important factor is expressed in the Hagen-Poiseuille law by the product of the cosine of the contact angle and the surface tension of the liquid. Good wetting of the paper by the ink means that a hydrophobic (water-repelling and therefore oil-compatible) paper coating must be present. The paper manufacturer encounters limitations here. If a hydrophobic coating would completely reject the fountain solution, a thin layer of water could prevent the ink to adhere to the paper surface. Offset inks must have the property to cover the paper surface well, and must possess both a certain water uptake as well as a certain stability regarding the fountain solution. This limits taking influence on the wetting behaviour and the options for increasing penetration rate of the ink's liquid vehicle components.

The lower the viscosity, the faster a liquid can penetrate into a capillary system. The viscosity of the oils usable for offset and letterpress inks ranges between 3 and 7 mPa · s. Unfortunately the options for modifying the setting speed of a printing ink are very restricted, as explained in the derivation of *Figure 4*.

- Separation characteristics of the vehicle

The desired separation of oil from the other vehicle components and the pigment is greatly influenced by careful selection of qualified vehicle components. In general terms, components that are difficult to mix already have a certain tendency toward separation. The less compatible they are, the more rapidly these components will separate.

Vehicle production therefore involves finding a mixing ratio for selected resins and oils that produces a strong tendency toward separation but keeps the ink from “falling apart”. On absorbent substrates the printing ink will compact very fast due to decreasingly low viscosity components, making the print become resilient within a short time.

To wrap it up, the analysis of the absorption process has shown that it depends on the following ink and paper properties:

- Absorption capacity of the paper
- Pore diameter and number of pores per unit area of the paper
- Wetting of paper capillaries for low-viscosity components present in the ink
- Viscosity of ink constituents that are being absorbed
- Separation behaviour of ink vehicle

Effects

Absorption begins as soon as the ink is applied onto the substrate. The ink in fact begins to change as it is transferred and on its way toward downstream printing units (*Figure 6*). Release of the low viscosity vehicle components changes the viscosity of the ink film and the tack of the ink increases rapidly.

The absorption process influences the following parameters:

- Stacking characteristics
- Chemical drying
- Ink trapping
- Picking characteristics
- Mottling
- Rub resistance
- Ink piling in downstream units

If the ink is absorbed too quickly into the substrate, the stickiness of the ink will increase very rapidly. As a result, there will be a more than normal back-splitting of the ink printed in the initial units onto the blanket of following print units. This effect is of course more noticeable the longer the press is.

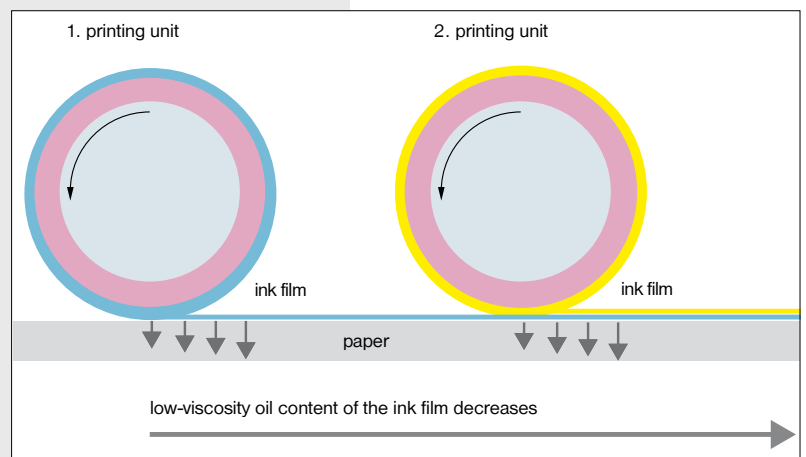


Fig. 6: Absorption during the printing process

Viscosity and flow properties of offset inks

Viscosity and flow are both vital for the performance of paste-like offset inks in the press. Viscosity is a measurement for the body of the ink (consistency). Viscosity is due to the attraction forces between neighbouring parcels of the fluid that are moving at different velocities (inner friction). The so called shear viscosity is determined by a rheometer.

Ink is applied into a gap between a fixed, constantly tempered plate and a mechanically powered cone (with defined angle of its tip). Due to a rotative motion of the cone the ink is exposed to shear stress (*Figure 7*). The measurement is indicated in *S.I. units* [Pa*s].

Viscosity is defined by the force (transverse strain [Pa]), with which a fluid resists the relative motion with constant speed (shear speed [1/s]). Time (duration of measuring programme) and temperature (product and measuring environment) are kept constant.

The higher the effort and the resulting measurement values, the thicker (less willing to flow) is the ink; the lower the value, the thinner the ink. Under the same ambient conditions, the thinner ink would flow faster.

SI unit: The international system of physical units or SI (from French: *Système international d'unités*)

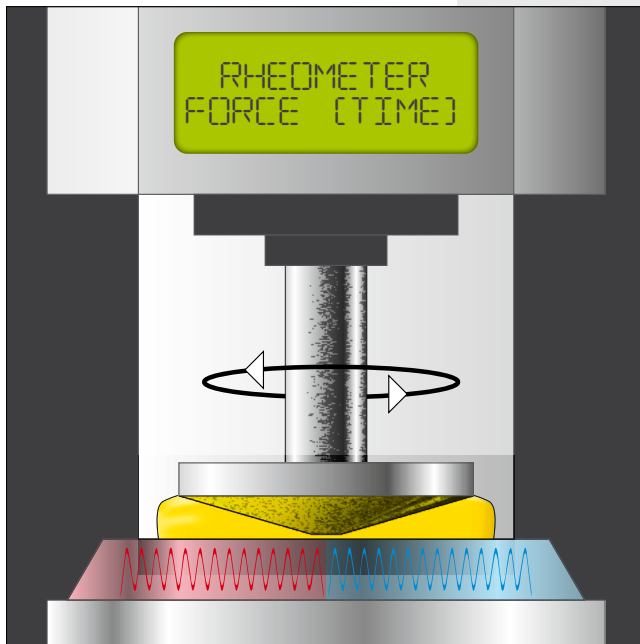


Fig. 7: Layout of a cone-plate-rheometer with temperature control

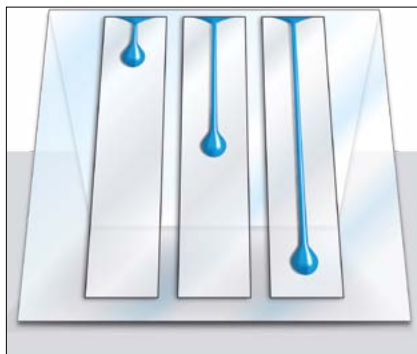


Fig. 8: Flow plate: on the left high, on the right lower viscosity value

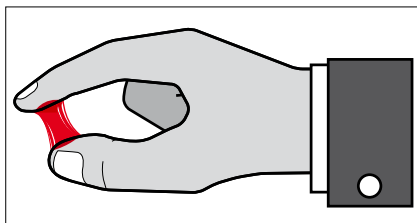


Fig. 9: Finger test for tack. The harder the fingers separate from another after a slight pressure on the ink, the tackier is the ink. Only empiric experiences allow an evaluation.

If the viscosity is too high, the ink is too pasty, and transfer from the duct into the ink train can cause problems. If the viscosity is too low, the ink could literally drip from the rolls or from the ink fountain.

The resulting measurement values can be variably influenced by different measuring geometries – therefore target values would make no sense if the conditions aren't chosen with care. Only if reference values exist, measurement is a means of quality control; but values can't be interpreted globally and independent from their relation as an absolute quality criterion.

In relation to the flow properties especially the term flow limit is important. Flow limit is the force that is needed to bring the ink from its resting state to motion (i. e. the pressure to press out tooth paste from a tube).

Whether an ink flows properly or backs from the duct can be investigated with the help of a flow plate (Figure 8). The inner structure of a defined quantity of ink during rest is manually destroyed and the rebuilding of the structure is evaluated with a flow plate. Therefore the ink is applied on a pad which stands in a defined angle. If the resulting track is very short, the ink might tend to back away from the ink duct (gain distance from the ink fountain ball). A very long track hints to an insufficient structure though.

Tack in offset printing inks

The tack of a printing ink plays an essential role in a number of imprintability tests, for example the picking test. "Tack" means the tensile forces occurring during the printing process as the ink splits between two surfaces.

The rheological properties of an ink, embracing a variety of properties – viscosity, tack, and others – in some cases depend on one another. An ink specialist uses the terms "thin" and "thick", "short" and "tacky" to describe consistency; both a thin and a thick ink can be either tacky or short. The printer uses the "finger test" (Figure 9) to determine whether an ink is short or tacky. Tack can be measured quantitatively using a tack tester.

The first tack tester, the inkometer, was developed in 1938 by R. F. Reed at the Lithographic Technical Foundation (LTF), New York. The inkometer (*Figure 10*) measures the force which occurs when two inked rollers rotate together at a constant roller pressure, film thickness, and temperature. A specific quantity of ink is applied to rollers A and M. When roller A is driven and roller M is transported in the direction of the arrow, a traction force develops where the ink splits at the diverting roller surfaces which can be measured at the deflection of roller M.

Measured tack values incorporate instrument constants such as applied pressure, roller hardness and diameter, and rotation speed. Values measured on an inkometer do not have a definable measurement unit; the terms “inko units” or “tack units” are commonly used. In addition to a determination of tack, the misting characteristics of printing inks can also be assessed.

Various manufacturers offer different devices based upon this measuring principle. In order to effectively compare the measured values, the use of identically constructed devices is advised. The standard ISO 12634:1996 defines a test method which determines the tack of pasty inks or binders. It is based on the common rotary measuring systems.

What effect does the tack of a printing ink have on the printed product?

Higher tack results in:

- less increase in tonal value (dot gain)
- better water stability in the ink
- more ink transfer
- greater tensile forces on the paper surface as the ink splits, hence a greater danger of picking and a greater risk of curling with lightweight papers.

Tack also plays an important role with respect to ink trapping. It is one of the few ink properties the printer is able to influence, at least in one respect; he can reduce the level of tack of an ink (*Figure 11*) by admixing small quantities of print oils or pastes.

Apart from this, a major reduction in tack is likewise obtained through increasing the temperature. This should especially be considered when printing with high-speed presses (*Figure 12*), which are not tempered.

Tack can also be reduced by fountain solution that is picked up during the printing process. The interaction processes between ink and fountain solution are so complex, that their impact on tack is only one single aspect in a whole chain of changes. Therefore it is difficult to globally describe what direct effects are caused by a change in the ink/water emulsion.

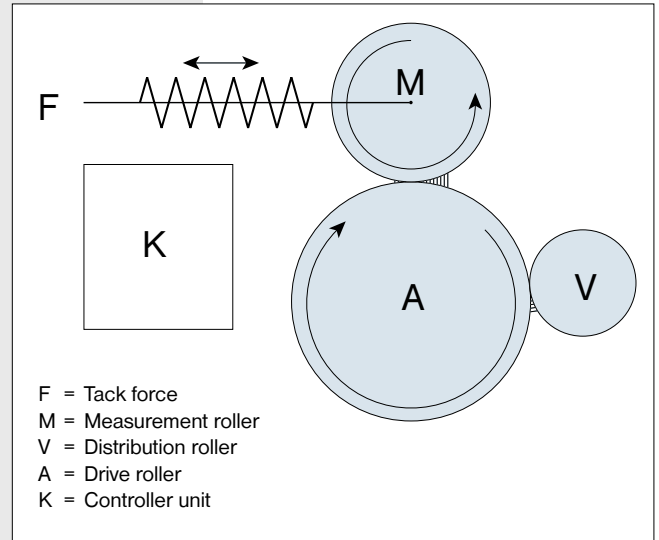


Fig. 10: Schematic diagram of tack measurement

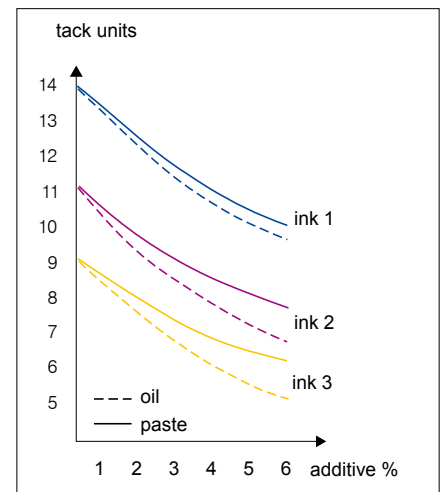


Fig. 11: Effect of ink additives (oil or paste) on printing ink tack

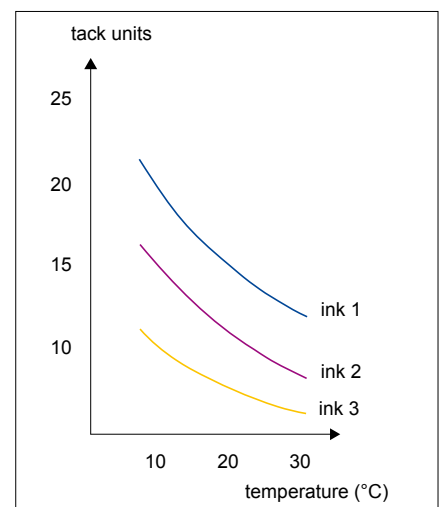


Fig. 12: Effect of temperature on printing ink tack

Working with the printability tester

A printability tester must be used to perform imprintability tests. The printability testers used by the printing ink and paper industry in Europe are almost exclusively those made by Prüfbau (multi-purpose printability tester) and by IGT (Figure 13).



Fig. 13: Multi-purpose printability tester for proof printing

With these devices, weighed print proofs can be produced. Such proofs are a prerequisite for the determination of the applied ink volume and other related physical properties, e.g. colour intensity or rub resistance.

The weighed proof – meaning printed solid with a defined quantity (in g/m²) or a defined film thickness in µm (1 µm = 1/1000 mm) – is the starting point for the tests described later in this section (Figure 14).

When a weighed proof is produced, the printing forme must be weighed before and after printing. The quantity of ink applied (in g/m²) is calculated from the following formula:

$$M = \frac{(G_1 - G_2) \times 10000}{F}$$

M = Quantity of ink in g/m²

G₁ = Weight of ink and forme before printing in g

G₂ = Weight of ink and forme after printing in g

F = Area of printing formes surface in cm²

Dividing the quantity of ink M (in grams per square meter) by the apparent specific gravity $\bar{\delta}$ yields the film thickness S (µm):

$$S = \frac{M}{\bar{\delta}} \quad 1 \mu\text{m} = \frac{1}{1000} \text{ mm}$$

Weighing requires an analytical balance (Figure 15) that can accommodate formes weighing up to 150 g. Accuracy must be ± 0,0001 g.



Fig. 14: Proof stripes: Outer pair for measurements of chromaticity coordinates, inner pair with black bar for determining the transparency.



Procedure for weighed proofing of sheet-fed offset ink using a Prüfbau multi-purpose printability tester

Ink quantity in inking unit (to produce approx. 1 µ film thickness)	0.1 cm ³
Inking time for ink unit	30 sec
Inking time for ink unit and printing forme	30 sec
Application pressure for proofing	
Rubber forme	600 N (sheet-fed offset and HS)
Printing speed	0.5 m/s
Inking unit temperature	21 °C

Deviations of proof prints

The accuracy of the weighed proof prints with an applied volume of 1 g/m^2 of ink showed that tolerance limits were in the order of $\pm 2\%$. However, this presupposed that the proof is produced on the same device, by the same person and with the same printing forme. With almost all colours, a 2% inking variation is practically impossible for the human eye to perceive.

If the proofs are made by various manufacturers, then time, instrument, balance, printing forme and executing person are mostly the accumulation of parameters, so that a tolerance of $\pm 10\%$ seems more realistic. Thus, a critical view must be taken on analysis based on figures from different sources, because the measuring tolerance of 10% of the applied ink may severely influence the assessment of the yield.

Evaluation of process inks

The standards for offset process inks ISO 2846-1:2006 and ISO 2846-2:2007 defines a range for the ink volume applied within which the colorimetric target values have to be met. Within this range, the transparency of the printing ink must also meet special requirements. Tests according to this international standard for printing inks wouldn't be possible without weighed proof prints.

The standard paper used for ink testing defined in ISO 2846-1 is 150 g APCO II/II made by "Papierfabrik Scheufelen". This paper is free from optical brighteners what was seen as a huge advantage for a long time, because optical brighteners may influence the measurement results due to their physical properties and their rapid decay. Today, all market-standard papers contain optical brighteners in favour of a high degree of whiteness and this fact has started a discussion about standard paper. However, this discussion was brought to an end by Papierfabrik Scheufelen with the decision to cease production of APCO II/II. Yet no other standard paper has been determined for the standard until now (status as of May 2013). For that reason, and because of the dwindling inventories of APCO II/II, an update of the standard ISO 2846-1 is overdue.

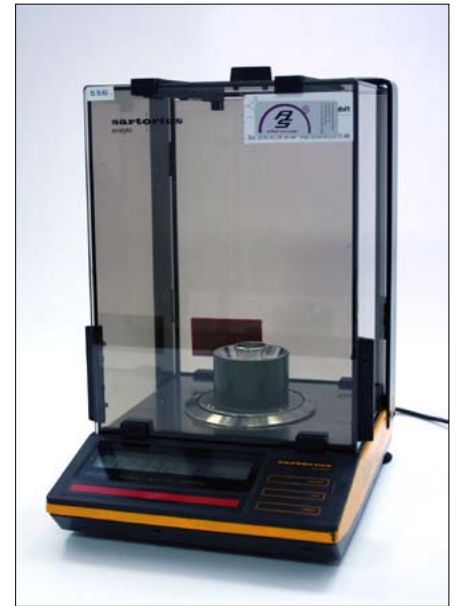


Fig. 15: Analytical balance with an accuracy of $\pm 0,0001 \text{ g}$ and a wind shield for securing accurate measuring values.

Testing methods for printing inks

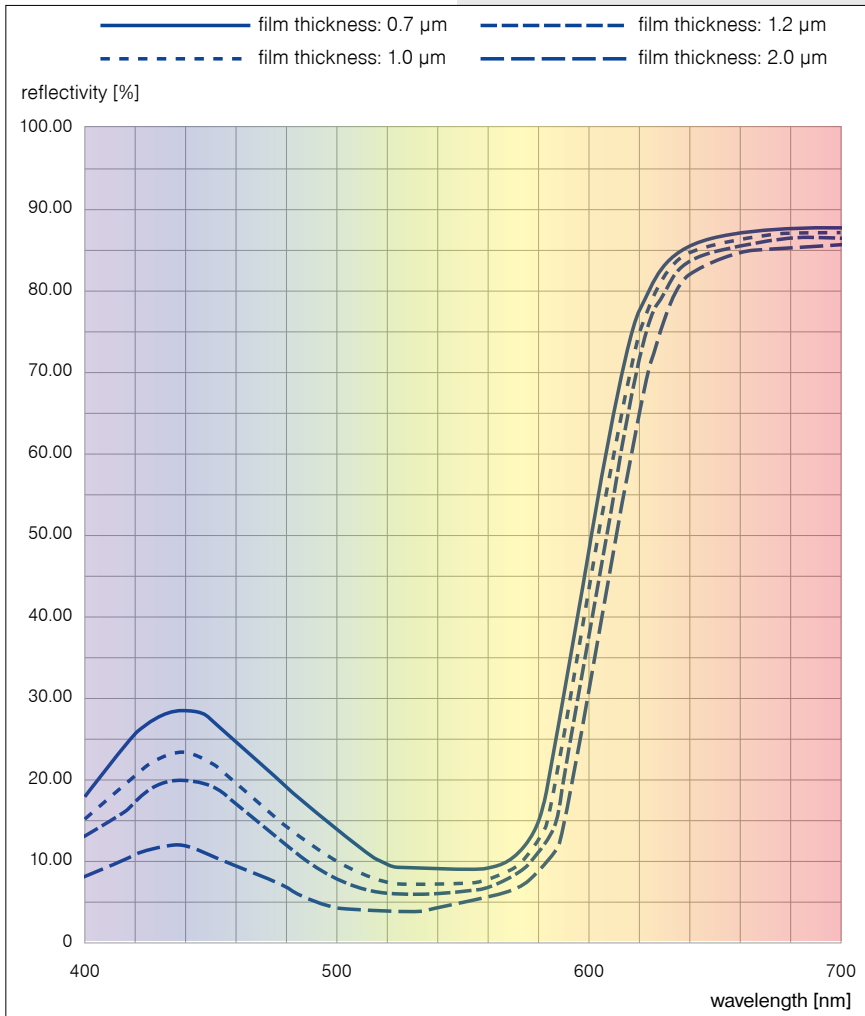


Fig. 16: Influence of film thickness on percentage reflectivity (Magenta)

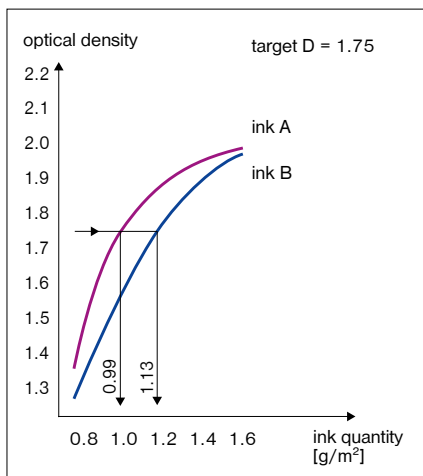


Fig. 17: Yield determination by optical density

Testing colour and yield

Printing ink colour is very strongly influenced by film thickness and quantity of ink. Defined quantities of ink must therefore be used to allow precise evaluations. *Figure 16* shows, how this influence becomes especially perceptible with the process colour Magenta.

For example, Magenta was proofprinted at four different film thicknesses. This reflection curve (*Figure 16*) represents the spectral reflectivity plotted against wavelength. The spectral reflectivity indicates the percentage of light of a particular wavelength that is re-emitted; the reflectivity of an ideal matt white surface is assumed to be 100%. With Magenta, the blue component (440 nm) increases sharply with decreasing film thickness, as is clearly evident from the reflection curves. This universally familiar effect of course also emerges in the colorimetric values if the single elements of an image decrease in size (e.g. 20 µm FM screen compared to an 80 l/cm AM screen).

Film thickness and its effect on the colour shade are sizes, which have to be consistent for compliance with standards ISO 2846-1 and -2. Yield curves are used to detect the amount of ink coverage that is standard practice, often because

of economic aspects. Yield is the area (in m²) that can be printed with a given quantity of ink (in m²/g). In practice, however, it has become more usual to indicate the ink quantity (in g/m²) at a particular density value as yield indicator; in other words, the lower the ink quantity, the greater the yield. Yield is determined by producing proofs with increasing inking (0.7 to 1.3 g/m²), and determining the density value with a densitometer or spectral photometer (ANSI E, Pol, relation: paper white). Plotting the density value against the ink quantity produces the “yield curve”.

In *Figure 17* two Heatset-Magenta offset inks, A and B, are compared to one another. In this example ink A would reach the target density value of 1.75 at an ink quantity of 0.99 g/m², and 1.13 g/m² for ink B. Ink A thus offers approximately 13% better yield.

Printing substrates have a strong impact on the ink consumption, a fact that must be considered when the ink consumption is calculated. If 1.1 g/m² are needed for a coated substrate, 1.5 g/m² may be necessary to obtain the same optical density on an uncoated substrate. There are even significant differences within the same class of substrates.

The disadvantage of the described method is the previously mentioned deviations of proof prints (see page 11) and the fact that a value about the optical density tells nothing about the exactness with which the colour coordinates meet the relevant standards for printing inks. In our example, the best match of ink A reaches only ΔE around 3.5, whereas ink B reaches $\Delta E=1.3$ (Figure 18). Both target densities of ink A and B may be different if the best achievable quality of colour coordinates is considered. If the best inking quality is the benchmark, sometimes other conclusions must be drawn than from the mere comparison based on the optical density. Common practice is to disregard the maximum achievable inking quality and to evaluate only from one optical density target value – not the most accurate but the least complex way to look at it.

Transparency

Process inks for four-colour printing

Transparency control is part of the standard ISO 2846-1; this industrial standard specifies the characteristics of sheet-fed offset and web offset-heatset process inks.

Transparency is tested by overprinting a black preprint (Figure 14) with the proper printing. The smaller the change in colour shade of the black background is, the higher is the transparency of the ink. The black on the black preprint must have special properties. It may not exceed the key figure for brightness in the LAB gamut $L^*=6$, may show only little *bronzing* and must have a neutral gloss. The standard also defines the basic proofing conditions and the most important variables for the print result: surrounding temperature, print speed, hardness of the printing forme, inking and distribution time. (For standard substrate see p. 11, "Evaluation of process inks").

Colour reference is the measured LAB value of Black without overprinted colour, measured individually on every stripe on a defined point. The colour deviation ΔE_{ab} of the proofs on Black (printed in increasing coating thickness 0.7 to 1.3 μm / calculated from ink layer and specific weight of the printed ink) are measured at the same point according to the reference value (a measuring stencil is recommended). If a coordinate system is filled with these ΔE_{ab} values against the ink layer, the determined points can be connected with a so called best fit straight line. This straight line is oriented at the course of coordinate points, but doesn't imperatively cross every coordinate.

The slope of this straight line yields the transparency value. The slope can be detected graphically or by calculation. For the graphic solution the points at the beginning and at the end of the defined layer thickness are used (in the standard called s_1 and s_2). The difference of both those values, related to the difference of the according values for colour deviation (ΔE_{ab1} and ΔE_{ab2}) yields the transparency value T (Figure 19).

$$T = \frac{s_1 - s_2}{\Delta E_{ab1} - \Delta E_{ab2}}$$

The standard ISO 2846-1:2006 defines the transparency values for process colours, and the detected value (as described before) must be higher or equal to the normative reference value (Table 1) in order for the printing ink to fulfil the transparency criteria.

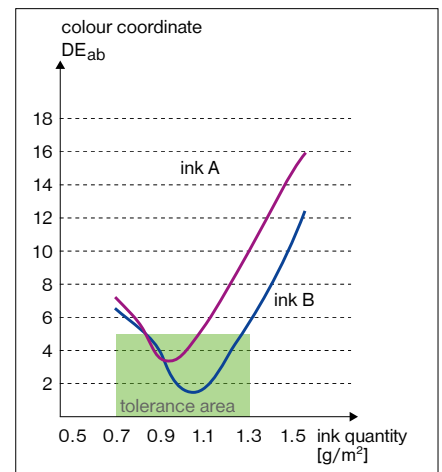


Fig. 18: Colorimetric determination of best match density or the optimum inking of two different inks printed on the same paper

Bronzing is a phenomenon that occurs when the ink shows a special colour hue (in most cases yellow-reddish) under a certain viewing angle which disappears under another viewing angle.

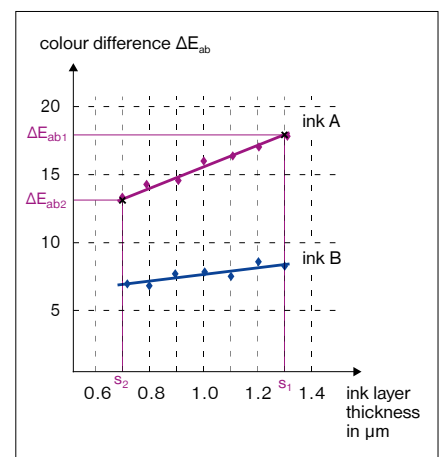


Fig. 19: Determination of value T for transparency according to standard ISO 2846-1:2006

Ink	Transparency value T
Cyan	0.20
Magenta	0.12
Yellow	0.08

Tab. 1: Transparency values according to standard ISO 2846-1:2006

Spot colours

Less efforts are made for the transparency values of spot colours. There is no standard for spot colours because every pigment has another transparency property and a lot of different pigment types are used for spot colours. A colour shade, that looks similar, can be formulated with different pigment combinations, because of the demanded properties. In most cases spot colours are printed with high area coverage and not overprinted, this is why their transparency isn't so important. But for quality tests the transparency is also an important issue. This is made with an optical comparison to a default sample, for which a black preprint stripe is overprinted.

Colour strength determination with opaque white (bleaching)

The bleaching test is designed to detect the colour strength or the pigment concentration of an ink under scrutiny. The ink to be tested is toned down in two samples with a standardised opaque white and then compared to a reference sample or value.



Description of the test method

For each of the two samples, 50 g of a special opaque white is put into small plastic twist cap containers and 2 g of the ink to be tested is added per container. Note that the ink may not be wiped off at the rim of the container but must be put on top of the white with a spatula, to have it mix entirely with the opaque white. The samples are blended for five minutes in a centrifugal mixer with about 3000 rpm. For reference, the same is (or has been) done with a master ink of well-known pigment concentration.

A steel plate with 4 calibrated holes (8 mm diameter each) is put on top of a glass plate. Each blend is filled into 2 holes with a small amount in excess. No air may be trapped as this would cause false measuring values. The plate is then covered with a PVC film and flipped. The colour is measured through the glass plate on the back of the sample (Figure 20). Two spectral measurements are taken per hole and a whole set of values can then be compared between reference sample and the two bleaching samples.

This way of measuring is a quick, very exact and easily reproducible method to detect colour strength. While testing for colour strength by means of elaborate proof prints can create deviating results in a range of +/- 8%, the test method "bleaching" shows fluctuations of only +/- 0.5%.

This test method for determining the colour strength has its technical limitations because it is only suitable for mono-pigmented systems. Direct comparison of colour strength isn't performed if more than one pigment type are involved. Moreover, only inks with the same pigment can be compared; pigments of different manufacturers may have deviating characteristics (e.g. particle sizes, particle distribution etc.) and direct comparison would create misleading results.

This method is limited to deviations of less than 5%. With increasing deviation, the relation between the difference in spectral measurement and necessary correction of the ink gets growingly inaccurate.

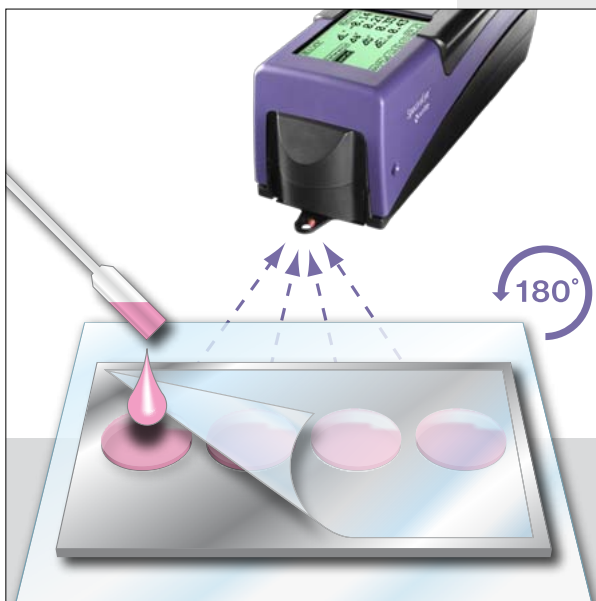


Fig. 20: Scheme of the bleaching test. Measuring is performed from the reverse side, through the glass plate.

Drying test for sheet-fed inks eliminating the influence of the substrate

In order to measure the oxidative drying properties of sheet-fed offset inks, the influence of the absorption process and of the substrate must be eliminated. Therefore non-absorbent films are used for the test.

This test method is especially helpful when developing new binder systems, evaluating specifically the oxidative drying speed compared to the benchmark ink systems. It can also be helpful for investigations in the field of daily applications, e.g. to find the reason for delayed drying. With investigations excluding single influencing factors it is usually easy to conceive how an issue came to exist.

The absence of the setting process, where liquid compounds of the ink penetrate into the stock, makes the drying time of the inks seem very long. It is not unusual to find drying times within a range of twelve to seventy-two hours, especially when non-drying oils (usually mineral oils) are part of the ink's composition. In this test, only an ink formula especially designed to be applied on films will show the same behaviour as in its established application.



Description of the test method

A defined amount of ink is applied on a film with a special draw-down spatula, creating an ink film with the defined thickness of 10 µm. This film stripe is fixed on a transport carriage (Figure 21) and a small squeezer-roll is set atop. The roll presses onto the surface of ink film and leaves a trace as long as the ink has not fully dried. Because the speed of the transport carriage is defined (1 cm/h), these marks indicate the exact time required until the ink has turned to a solid.

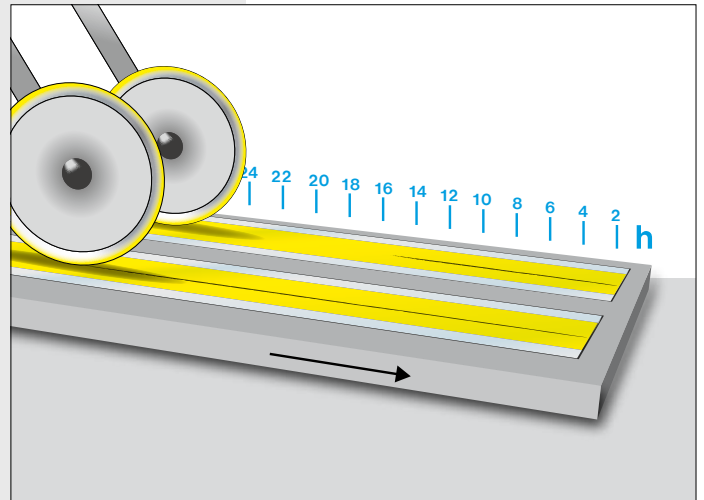


Fig. 21: Illustration of a drying test on film stripe. Two different ink formulas, with one of them dry after 14 hours and the other still wet.

(Contour or Image) Trapping is also a technical expression in the graphic industry: the intentional overlapping of colours that adjoin each other to prevent the paper from showing through when maintaining tight register on the press.

Testing methods for interaction between substrate and ink

Wet-trapping

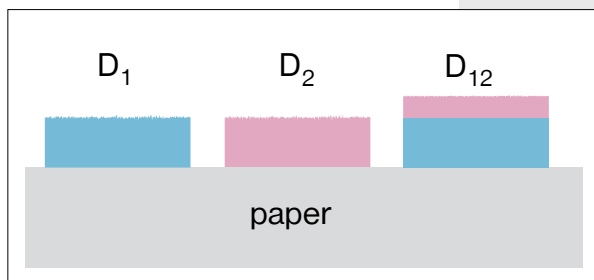
The wet-on-wet ink trapping of a subsequent ink on the ready-printed ink in multi-coloured halftone printing (*Figure 22*) influences the accurate colour of a reproduction. In order to avoid the re-split in this transfer process and to guarantee a good ink trapping, offset inks are provided with decreasing tack in print order. A bad ink trapping however often induces faults like a changed gamut or a disorder in the printed image (mottled printed image).

Faults in ink trapping are often discovered very late because they occur very infrequently. If a colour original can't be achieved although everything has been done, the colour coordinates of the full tones, the dot gain, plates and plate setters, profiles and data are examined. But sometimes the solution can simply be bad trapping. When all solid tones and colour shades in the measuring elements are good, but the secondary colours do not reach the desired colour coordinates, it is very likely that this is a result of poor ink trapping.



Procedure for the determination of trapping values

The measurement methodology features three values for optical density which are all measured through the filter of the second printed ink. Magenta is the example of *Figure 22*. The solid colour of every colour on the paper is equated with the fully transferable density. Three different formulae are used to evaluate the trapping and therefore three different solutions are possible. The most usual formula is the Preucil formula.



$$\text{Ink Trapping} = \frac{D_{12} - D_1}{D_2} \times 100 (\%)$$

NOTE: Everything is measured through the filter of the second printed ink!

D_1 = Density of the first printed ink

D_2 = Density of the second printed ink

D_{12} = Density of both printed inks on top of each other

Fig. 22: Trapping: In wet-on-wet printing the transfer of ink on ink is not the same as the transfer of ink on paper. If the difference between both values gets bigger, the trapping value gets worse.

Prof. A. Ritz and F. Brunner are the creators of the other two formulas. These are also applied in the industry and are deposited in the measuring devices. The basic measuring values are the same, only the calculation works on a more complex formula. Advantages and disadvantages of the different formulas are often discussed and each method has its proponents and opponents.

Wet-trapping values of subsequent print units in conventional sheet-fed offset are in most cases between 60 % and 75 %.

A perceivable influence on the print result usually arises not before trapping values fall noticeably below these values.

Absorption test

Absorption is a special form of physical drying, where the ink components are taken up by the substrate. This absorption process has been described in detail in the chapter "Basics – Drying of offset inks".



Procedure for absorption test

Printability tester: Prüfbau with two print units
 Proof printing with 1.5 g/m² on paper standard (a commonly used type)
 Pressure for proof printing 600 N
 Put counter stripe on the proof print – ink surface to counter surface
 Pressure for counter print 800 N, counter forme metall
 Counter times 30“, 60“, 120“, 240“

A proof is printed in the first print unit and directly covered it with a counter stripe, both still attached to the carrier (print support). The carrier is subsequently passing the second print unit segment-by-segment, following the counter times schedule. The ink that has been transferred to the counter paper is evaluated (Figure 23).

Evaluation: visually or by measuring. Visual evaluation may be complemented by measuring in relation to a default value.

Universally valid specifications for absorption behavior of an ink are not meaningful, because they still highly depend on the substrate they are finally applied to. Some real-life application conditions may require adapted absorption speed.

For exact documentation of an ink-substrate interaction (with either the ink, or the substrate remaining constant), the values for optical density are measured with an appropriate densitometer and are displayed along the time axis of a graph (Figure 24).

Stack test

The stack test is a very practicable and partly necessary addition to the absorption test. Stack means the behaviour of drying print sheets in stack. The pressure on a stack with only a few sheets is low. The pressure of a 100 g paper is 0.01 g/cm² per sheet. But the stack pressure increases very quickly in straight proportional line, 12 000 sheets/hours mean 120 g/cm² after one hour.

The stack pressure is calculated with the following formula:

$$D = \frac{P \times B \times t}{600}$$

P = Paper weight in g/m²

B = number of 1000 sheets per second

t = time in minutes after the stack pressure equals zero

D = stack pressure in g/cm² at time t

For example: P = 250 g/m²
 B = 12 000/h
 t = 10 min

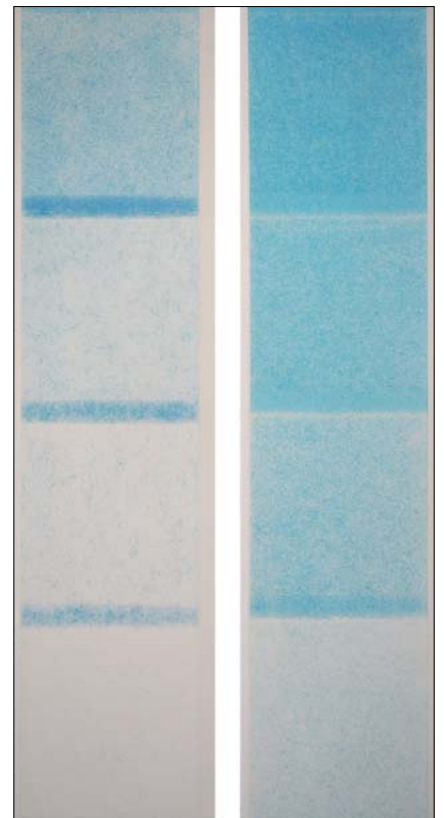


Fig. 23: Counter stripes of two inks with different absorption characteristics, printed on the same substrate.

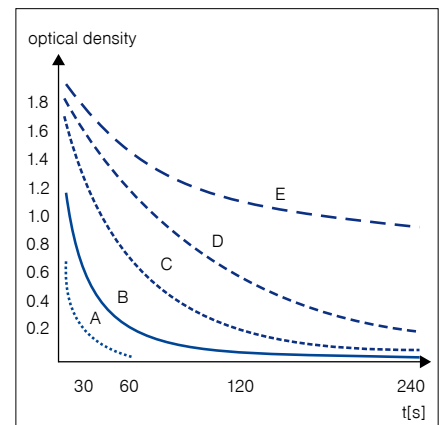


Fig. 24: Densitometric analysis of counter stripes from absorption tests, with the ink of the proof prints unchanged (A-E are different papers).

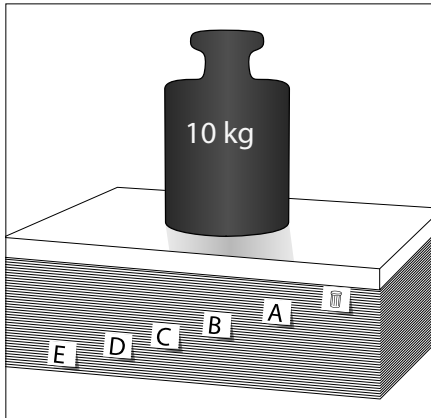


Fig. 25: Stack test with several proof prints

$$D = \frac{250 \times 12 \times 10}{600} = 50 \frac{\text{g}}{\text{cm}^2}$$

After ten minutes pressure on top of the sheet at $t=0$ equals 50 g/cm^2 .

While the pressure in the stack grows continuously (Figure 25), the ink must have cured to such an extent that no set-off is possible. This is the reason why the ink must be formulated to match two conditions:

1. the ink absorption rate as a mere interaction of paper/ink
2. the continuously growing stack pressure, depending on the print speed and the paper weight

The test method “stack test” simulates the real conditions in the press delivery.



Procedure stack test

Two test stripes are printed with 3 g/m^2 ink each. After two minutes a sheet of unprinted paper is put on top of the prints and all is covered with a small stack of maculature in the size $25 \times 30 \text{ cm}$ in order to exclude direct pressure marks. On top of the stack is a board, 3 cm thick, in the same format, loaded with a 10 kg weight. This weight corresponds $13,3 \text{ g/cm}^2$ and simulates a manufacturing condition of 16000 sheets/h with a substrate of 250 g/m^2 for a random sheet with high ink coverage after two minutes of production. After 24 h the stack is opened.

Evaluation: visual evaluation of set-off marks, sticking or blocking.

Figure 26 shows the described stack test. Ink A featured less set-off than ink B. This is caused by a combination of available amount of ink and its tack at the moment, when the printed surface of the sheet comes into contact with the back of the following sheet. The increase in tack depends on several parameters like the absorption behaviour of the ink and the ink thickness, but also of paper properties. As described before, absorption capacity, capillary diameter and wetting are essential.



Fig. 26: Comparison of two different inks in a stack test. The upper sample clearly shows set-off marks due to its slower setting speed, compared to the test sample below.

Drying test (emulsified proof)

The drying test determines parameters for the physical and chemical drying of an ink/substrate combination. Chemical drying of an ink is not only governed by its formula constituents, but also depends on additional factors:

- Delayed absorption of the oils from the binder also affects chemical drying. For example, the same ink may take 8–10 hours to dry scratch-proof (here an ink containing only drying oils) on a non-absorbent film, but only 3–5 hours on a double-coated paper with good absorption characteristics.
- Constant relative stack moisture is of particular importance for good results. Not only are flatness and accurate register very strongly affected by relative stack moisture and relative humidity in the printing hall, but higher stack moisture also results in slower ink drying. *Figure 27* illustrates the effect of stack moisture on ink drying. The delay in drying is especially noticeable when other factors inhibiting drying (to be discussed below) are also present.
- The higher the acidity of a substrate, the greater the delay in ink drying, especially at high relative humidity (above 65%). The reason is a reaction between acid residues and metal salts (drying agents) which causes inactivation of the drying agent. Uncoated papers should therefore never have a pH of less than 4.5; pH 4.5–5.0 must be regarded as the critical range. Most coated papers have a pH above 7.0. Increased use of calcium carbonate in substrates, as both a coating pigment and a filler, means that modern printing papers are becoming less and less acidic.
- Fountain solution additives also affect the drying of inks. The composition and mode of action of modern fountain solutions are described in detail in INKFORMATION “Fountain solution in offset printing”. Some of the constituents of fountain solution additives (such as acids) can influence oxidative drying of the ink. A pH value between 4.8 and 5.3 has proven to be best for offset printing. Because of the increased amount of calcium carbonate in modern printing papers, the pH value of a fountain solution is now almost never set at less than 5.0.

The following comparison shows the effect of pH on ink drying.

	Drying time (in stack)
Test ink (printed without water)	4 h
Test ink (printed with dampening at pH = 5.0)	5 h
Test ink (printed with dampening at pH = 4.5)	12 h

The degree to which the ink takes up fountain solution also plays an important role. This uptake depends on:

- Ink composition
- Chemical composition of fountain solution
- Amount of fountain solution applied
- Printing speed
- Printed motif

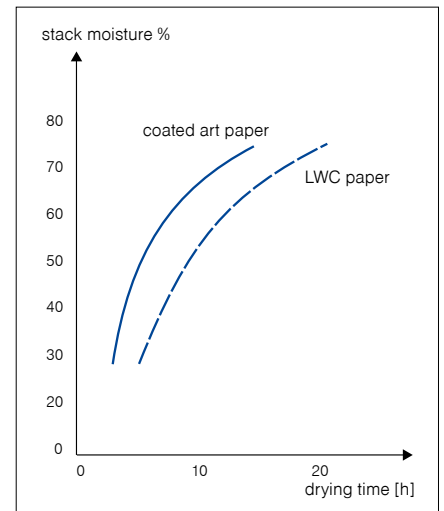


Fig. 27: Effect of stack moisture on ink drying



Fig. 28: An emulsified proof is prepared

The ink is especially likely to absorb more fountain solution with layouts that have low ink consumption. Greater water uptake means slower ink drying. The desire of an ink to pick up water is also influenced by the rheology of an ink: the lower the viscosity of the ink, the likelier a higher water uptake.

The dampening itself plays an important role in the drying of sheeted offset inks and this fact should be accounted for in drying tests. Investigations about the interaction of ink, substrate and fountain solution chemistry can be carried out with the emulsified proof. This test method can also be used to merely evaluate the influence of fountain solution additives on the chemical drying of printing inks.



Procedure for drying test (emulsified proof)

Purpose: Determining ink drying including the influence of fountain solution and substrate.

Ink quantity for inking unit: 0.14 cm^3

Once the ink rollers have been inked, a spray bottle is used to apply water (or the fountain solution used in the press) to the ink rollers and printing forme (Figure 28). About 2 g of fountain solution are sprayed into the ink unit and are emulsified for two minutes. Excess water is removed and a test print is made according to the method described on page 10. Only difference is that 1.2 g/m^2 are targeted for ink coverage.

The emulsified proofs are then placed in a stack. After specified time intervals (4, 6, 8, 24, 48 hours), the prints are temporarily removed from the stack to be tested with a manual wipe using a paper towel (Figure 29).

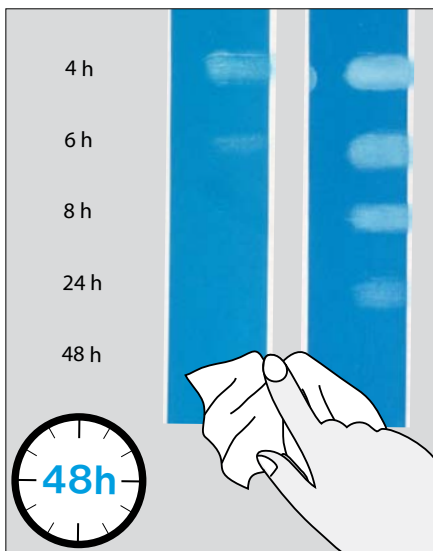


Fig. 29: Drying test, to the left without dampening solution, to the right with dampening solution

Rub resistance and carboning characteristics

(See also INKFORMATION “Rubbing and Carboning”)

“Rub-off” refers to abrasion of the ink film against unprinted (or printed) paper under a relatively low compressive load. Rub-off occurs principally when the printed sheets are being transported, or pulled out of the stack into the collator.

Matt-coated papers in particular produce increased ink abrasion.

“Carboning” means that the ink is rubbed on a microscopic scale against the white counter sheet with heavy pressure and minimal stroke; this occurs for example in a trimmer. Carboning is particularly severe when bleed images are cut and pressure is exerted against white paper. Both rubbing and carboning depend a great deal on the paper.

It is remarkable that carboning is especially noticeable on semimatt-coated papers that have comparatively good ink rub resistance.



Procedure for rub resistance testing

The preferred tester used in the **hubergroup** is the Prüfbau Quartant rub tester with 600 g weights (Figure 30). The testing device is easy to operate, and involves nothing more than defining the number of rub strokes depending on the type of substrate to be tested.

Usually the print is rubbed against white paper of choice or a paper standard. For cardboard packaging, however, it is recommended to also perform print-to-print tests.

Application	Surface condition	Number of strokes	Note
sheet-fed offset	ink	100	The countering surface for the test can be blank paper or the printed image of the adjacent sheet. The double values for strokes indicate a second round of testing for cases in which test pieces show no difference or no rateable impact.
	with oil-based varnish	100	
	with water-based coating	500	
	with UV varnish	500 + 500	
heatset / coldset	ink	20	
UV	UV ink	500 + 500	
	with UV varnish	500 + 500	

Analysis is performed visually, using a comparative rating score:

with varnish/coating	without coating (pigmented surface)
5 = no abrasion	no change of colour
4 = little abrasion	little change of colour
3 = visible abrasion	visible change of colour
2 = strong abrasion	strong change of colour
1 = very strong abrasion	severe change of colour

Documentation has to include print plus counter samples, number of performed strokes and assessment. In case of too little differences in result, optical density can be added as assessment criterion.

Carboning test

Before this tester was developed, the carboning characteristics of a test or production print could be tested only very subjectively, by bringing the unprinted substrate into contact with the print and pressing down with a ballpoint pen to make zig-zag lines back and forth, simulating micro-scale rubbing. The amount of ink transferred in the process was assessed visually. Because carboning is highly dependent on pressure, this method cannot generate reproducible, useful results, since every tester exerts a different amount of pressure on the pen.

The **hubergroup** has therefore developed a carboning tester. This unit makes it possible to simulate microscale rubbing under defined conditions. An applied weight exerts constant pressure on a small rotating metal roller, which presses on the substrate and the blank backing sheet (Figure 31).

Counterpressure is applied by a rubber roller which also rotates. Pulling the test print out generates a carboning effect that is then visible on the backing sheet and can be



Fig. 30: Rub tester Quartant from Prüfbau

Tab. 2: The number of strokes refer to the sample tested. These figures are guidance but not commonly binding. Due to the properties of the test samples or by client request, deviations from those figures may occur.

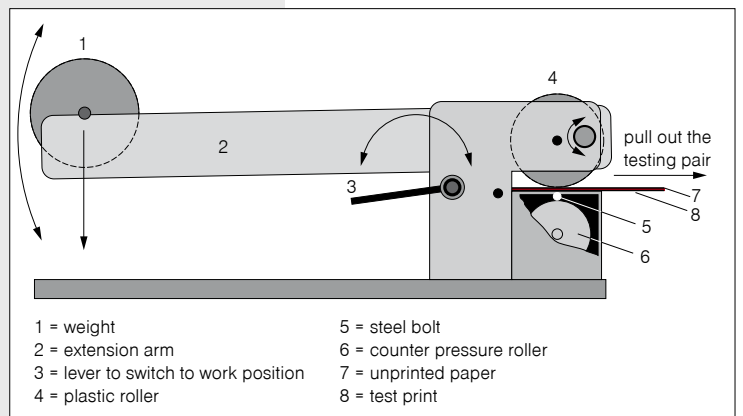


Fig. 31: System **hubergroup** carboning tester in operation position

measured densitometrically. Because test conditions are constant, the effect is reproducible. With this tester, the carboning characteristics of ink/paper combinations can be checked in advance.

As already mentioned, carboning depends a great deal on the substrate. Our investigations have shown that changes in the ink formulation have little effect on carboning.

Even completely cross-linked systems such as UV inks produce carboning on certain papers. With sheet-fed and web offset inks, ink drying constitutes another variable: poor drying means more severe carboning.

The carboning effect can only be eliminated by protecting the printed ink, either by applying an oil-based varnish or a water-based coating.

Mottling test (backtrap mottling)

In a four-colour press, uneven absorption of inks into the substrate results in uneven back splitting onto the downstream blankets. This causes a speckled appearance in the ink, usually referred to as “mottling”. On multi-colour presses the last ink applied can never exhibit mottling (*Figure 32*).

Uneven absorption of the ink has another consequence. With wet-on-wet printing, ink trapping depends on the condition of the previously printed ink. The faster this can absorb, the better the trapping of the following ink. Uneven absorption therefore also means uneven ink trapping with wet-on-wet printing, resulting in an enhanced mottling effect with overprinting.

Here is one possible cause of mottling:

Uneven vehicle migration can occur when the coating dries. Slower ink absorption takes place at points with greater proportions of vehicle in the coating surface. Although mottling is attributable to the substrate, ink characteristics (absorption behaviour, colour, pigment concentration) can influence the effect.

The problem can be successfully remedied by:

- Using a slow setting ink system
- Modifying the ink sequence, e.g. switching Cyan from second to third printing unit
- Printing text in the first units and solid areas in the last units (for package printing)



Fig. 32: Close focus image of mottling from a four-colour sheet-fed offset press.



Procedure for mottling test

Purpose: Determining mottling characteristics of printing substrates

Ink quantity for inking unit	0.10 cm ³
Elapsed time between printing and counterprinting	5 to 10 s
Applied pressure on counterprinting forme	200 N (Rubber)

In the mottling test, a counterprint is made after printing, against an uninked rubber printing forme (*Figure 33*). It is advisable to use a new printing forme for counterprinting. A number of variations in the mottling test are possible.

For example, two inks can be printed wet-on-wet and then counterprinted. The mottling effect is also enhanced if the counterprinting process is repeated several times.

Evaluation: The mottling test involves a visual assessment of ink lay. If a substrate has no tendency toward mottling, the ink film will be smooth and even.

Note: Phenomena similar to mottling (speckled, rough printed areas) can be caused by other offset printing factors, such as piling or repulsion effects. Some of these effects can also be a matter of substrate/dampening interaction (water interference mottling).

Additional tests on the weighed proof

Since the properties of an ink film are influenced to varying extents by the ink quantity, the proof with a defined ink quantity applied is a prerequisite for accurate evaluations.

Fastness properties of printing inks

“Fastness” is understood to mean the ability of an ink film to resist certain influences such as light, acids, bases, fats, solvents, etc.

The best known fastness tests are covered by the following international standards:

- ISO 12040:1997 Light fastness
- ISO 2836:2004 Resistances against water, alkali, oil and fat, cooking fat, cheese, detergents, soap, wax, spices, dissolvents, lacquers, acids and other substances

For making proof prints, please refer to ISO 2834-1:2006.

Modified Robinson test

(See also INKFORMATION “Printing inks for food packaging”)

The test method for packaging material made of paper and cardboard is described in the specification EN 1230-1 for odour, whereas the specification EN 1230-2 describes organoleptical changes in the filled good. The primary task for ink manufacturers, however, is to test printing inks. The basic deviation from the standard Robinson test is the fact that a standardised test print replaces the section of a complete package.

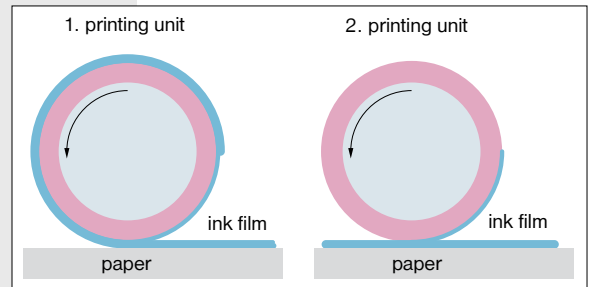


Fig. 33: Illustration of mottling test, where parts of the ink applied in the first print unit are scatteredly split-back to the rubber blanket of the second unit.

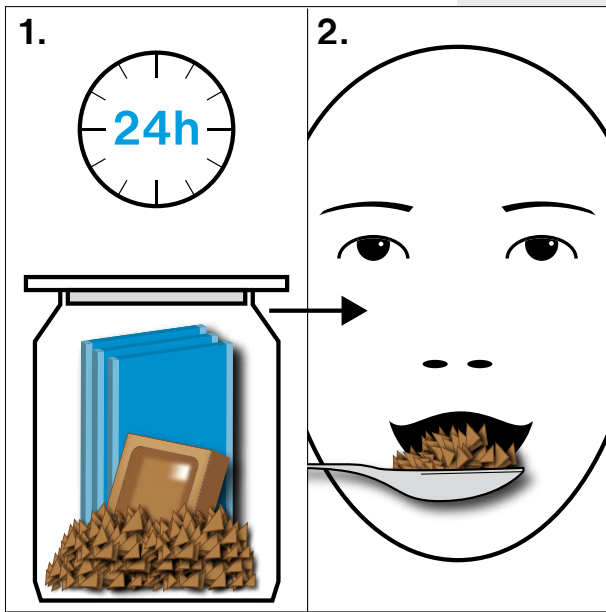


Fig. 34: Illustration of modified Robinson test, or taste test



Procedure for modified Robinson test

Ink quantity: $1.5 \pm 0.15 \text{ mg/m}^2$

Prepare eight proofs; five minutes after printing, stack them one on top of the other between two glass plates, and place two 500 g weights on top. Let stand for 24 hours.

Taste test:

Place 3 g grated milk chocolate in a glass dish approximately 7 cm in diameter, and set it in a tightly sealable 1-liter glass jar. Place two of the eight proofs in the jar so they are not in direct contact with the chocolate (Figure 34). After 24 hours, make a blind taste test in direct comparison against a control sample (consisting of chocolate stored in an identical jar without a proof strip).

The samples prepared in this fashion are then coded (including the control sample), and taste-tested by the testers (at least five). Freshly grated chocolate has to be used as an “initial taste” sample for comparison.

Evaluation is similar to that used in the Robinson test:

- 0 = No perceptible difference in taste (compared with initial taste sample)
- 1 = Barely perceptible difference in taste
- 2 = Slight off-taste
- 3 = Definite off-taste
- 4 = Strong (awkward) off-taste

Odour test:

Using the weighed test prints just described, place one strip in each of five 250-ml glass-stoppered reagent bottles, and leave for 24 hours (Figure 35). No control sample is required in this case. Evaluation is conducted as just described; 0 = no odour, while 4 = strong odour.

With these tests it is of course possible to modify the time interval or, in particular, the climatic conditions during that interval. High stack moisture levels (above 65 % RH), in particular, can cause substantial changes in Robinson values.

It is worth mentioning here that conventional sheet-fed offset inks and varnishes yield very poor Robinson test results. Special inks for packaging are always advisable. Water-based coatings are ideally suited for this application, but special formulations are recommended.

Table 3 compares taste and odour evaluations for printing varnishes, water-based coatings, and for a conventional and a low-odour offset ink (which is not a low-migration ink in this example).

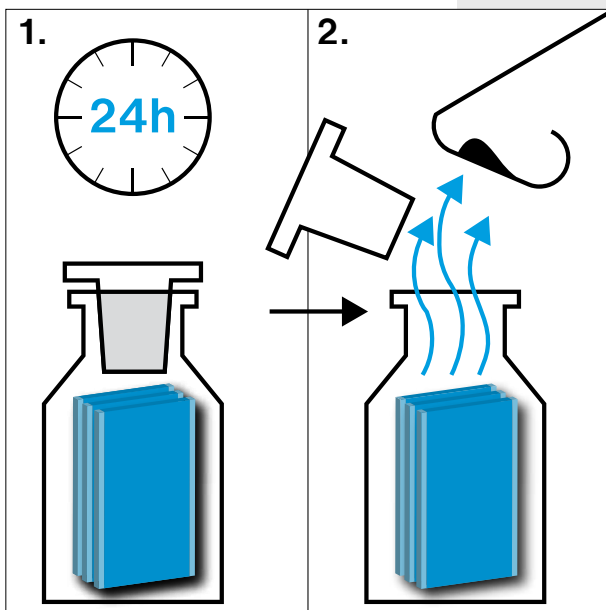


Fig. 35: Illustration of odour test procedure

	taste test	odour test
water-based coating	0	0-2
varnish	> 2.5	> 2.5
conventional offset ink	> 2.5	> 2.5
low-odour offset ink	< 1	< 1

Tab. 3: Results of Robinson tests

Test methods for substrates

In imprintability testing, similar tests are performed for both inks and substrates. A range of paper test inks has been developed specifically for substrate testing. These special test inks have been produced by the **hubergroup** until 2010, they can now be ordered at Prüfbau in their consumables section.

Ink	Tack	Purpose
Absorption test ink		Determining absorption characteristics of substrates
Picking test ink	low tack	Determining pick resistance of substrates (paper and board) for offset printing. Test inks are available in three different tacks.
	medium tack	
	high tack	

Absorption test for paper

Absorbing behaviour of paper with IGT absorbing test device (Figure 36)

- Pressure: acc. to individual standard
- Test ink: Absorption test ink
- Proofing paper: test substrates (here three different)
- Counterprinting paper: see box on page 11 (as for ISO 2846-1)
- time intervals (s): 15, 30, 60, 120, 300, 600, 900, 1800, 3600
- Evaluation: by visual comparison or measuring

Tab. 4: Paper test ink

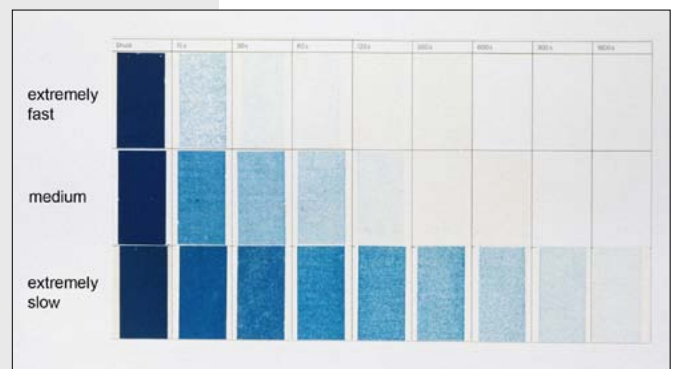


Fig. 36: Absorption test on different papers

Pick test (dry and wet pick test) for offset papers

“Picking” means damage to the paper surface caused by tensile forces exerted by the ink during separation (Figure 37). The tensile forces acting on the paper surface increase in proportion to ink tack and printing speed. An important role with regard to tack are playing both temperature and the level of emulsion of the ink in the press. Those test conditions must be kept constant in order to accurately display relations in the test procedure. Factors like contact pressure, ink layer or the surface roughness of the print blanket are also relevant. Print and ink layer can be easily considered, but the differences of the blankets can’t be reasonably integrated in the test. During the print process, picking is seen first on horizontal lines or tail ends of solid areas. The tensile forces are by trend lower in screens. The pick test should consider the fact that the paper surface also comes into contact with fountain solution in offset printing.



Fig. 37 Microscopic image of picking

The Prüfbau multi-purpose printability tester is also available with a pre-dampening unit. Configured like this, the device can produce the results of both the dry and the wet picking test at a time (a proof of 4 cm width is pre-dampened on 2 cm). Of course, the simulation only comes close to real press conditions, but it helps to get a more differentiated image in the test result (Figure 38).

Originally the pick test was made with increasing print speed, and the exact point when the picking began was detected. But it turned out that it is much easier and faster to have a pick test at constant print speed and still be in closest reference to real conditions.

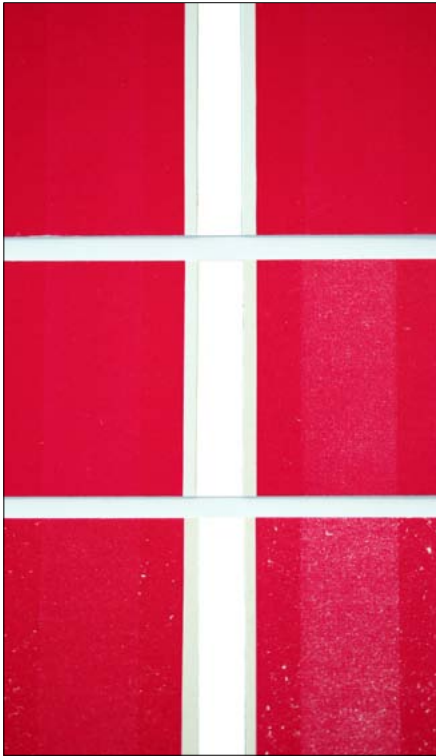


Fig. 38: Result of a wet pick test with two different test inks of low (left) and medium tack (right) printed on three different papers. The paper on the bottom shows poor pick resistance.



Procedure for dry and wet pick test

Purpose: Determining the pick resistance of paper stocks or of a substrate/ink combination

Ink supply for inking unit:

Coated papers 0.19 cm³

Uncoated papers 0.19 cm³

Pre-dampening:

Coated papers 0.02 cm³

Uncoated papers 0.03 cm³

Elapsed time between dampening

and printing (as device programming value) 0.1 s

Printing speed 1.0 m/s

Test inks (for paper test):

low tack

medium tack

Evaluation:

Look for pieces of coating or fibres on the print forme. The test print is examined visually for defects, with the aid of a stereomicroscope if necessary. Various forms of picking may be observed, such as isolated coating detachment, torn-out fibres, paper tearing, or detachment of the cellulose coating on boards.

If the medium tack ink shows picking, the test should be repeated with the low tack ink.

Contact yellowing test

Contact yellowing means partial yellowing of the reverse side of the paper at points where the printed image contacts the unprinted reverse side in the stack.

Contact yellowing is often confused with ghosting, i.e. the matt/gloss effect, in which the first printing maps on the reverse print when perfecting.

Contact yellowing is caused by an interaction between the paper coating and the degradation products which are always produced during oxidative drying of offset printing inks and oil-based printing varnishes.

Volatile and slightly yellowish degradation products from the oxidative drying process are captured in the stack. They penetrate into the unprinted, reverse side of the substrate, and are retained in the coating by absorption. Yellowing can result both from the inherent colour of the degradation products and from chemical changes of optical brighteners and vehicles from the paper coating.

The degree of yellowing depends a great deal on the coating composition of a particular paper. The intensity of discolouration also depends on the quantity and nature of the degradation products, and therefore also on the ink formula. A higher concentration of oxidatively drying vehicle also causes greater contact yellowing (Figure 39).

Suggested ways of eliminating or reducing this effect are:

- To reduce ink film thickness, heavy subjects should be given undercolour removal (UCR) to reduce the quantity of degradation products.
- Ink additives, especially drying agents, should generally be avoided.
- Bringing air into the stack has a beneficial effect.
- If a surface coating is applied, water-based coating should be given preference over oil-based varnish.



Procedure for contact yellowing test

Purpose: Determining contact yellowing for an ink/substrate combination

Ink quantity: 3.0 g/m² ± 0.15 %

Make a proof, then lay a sheet of the same substrate on it. After five minutes, place the sandwich between two glass plates and hold at 50 °C for 24 hours.

Evaluation:

After 24 hours, measure the yellowing index of the area with contact to the ink and without. The yellowing index shows the change of a sample.

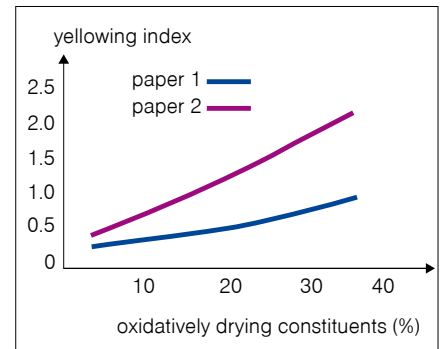


Fig. 39: Yellowing index as a function of oxidatively drying constituents in a printing ink

Conclusions

The test methods described here require the use of a printability tester with suitable accessories. Operating a printability tester demands careful procedures and practical experience. The same applies to the analysis and evaluation of test results.

Useful and realistic evaluations can be made only if conditions in the press and during subsequent processing are known. In many cases one may also need to be flexible when following procedural instructions and to adapt procedures to practical conditions. One example of this is the mottling test: evaluating this test, and applying variations when performing it, requires a certain amount of expertise about the interactions between ink and substrate that occur during printing.

We conclude by wishing you success in all your imprintability testing efforts.