Tech INFO

Marabu

Screen Printing onto Bottle Crates

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Polyethylene (PE), a thermoplastic material, has achieved a worldwide acceptance in recent decades as an ideal material for bottle crates and transport containers.

This development has been accompanied by us as manufacturers of screen printing inks. This is why we are drawing on our thirty years market experience to provide you with updated information, thus ensuring that your crates (PE and PP) are printed with maximum efficiency.

With Marapoly P and Marapoxy Y, there are two different ink systems available which are further completed with the bronze shades of the Marapur PU ink series.

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1.0 Injection moulding

Many years of practical experience have taught us that the composition of plastic pellets, combined with varying injection moulding parameters, are influencing the adhesion of the ink to the surface of the crate. As key factors, we see the master batch used for the crate, the use of new plastics or a mixture with re-grind, further additives such as UV stabilizers, antistatic agents, separating and releasing agents and - within the injection moulding process itself - variations in cycle times, e.g. at the cooling process. We, therefore, strongly recommend to carry out thorough trials before printing if any production parameters have been changed.

Further recommendations

- Due to price and environmental reasons, the addition of PE re-grind in injection moulding is steadily increasing, using up to 100 % re-ground material. In such cases, the material is often post-stabilized which means a further mixture with additives possibly resulting in a significant loss of ink adhesion to the surface of the crate. We therefore ask you to take particular care and once more to carry out preliminary trials before printing.
- Our practical experience shows that crates losing either some or all of the gloss finish du-ring flame treatment at a maximum supply of energy by flaming, can subsequently be expected to show problems with ink adhesion.
- To minimize the contamination degree of the surface of the crates, we recommend to print immediately after the injection moulding process.
- Please ensure that the print area of the crate is not contaminated with lubricating oil from conveyor belts. This would cause se-vere ink adhesion problems.
- If crates are to be flame treated with compressed air, please use only an air supply with an efficient oil trap.

2.0 Pre-treatment

Both polyethylene (PE) and polypropylene (PP) are extremely non-polar plastics from the polyolefine group to which ink will not adhere unless the surface tension is increased by a suitable method prior to printing.
The most effective method is pre-flame treatment with an oxidizing gas flame. The increase in surface tension of PE or PP obtained by this process, however, does not mean that a definite statement can be made as to adequate adhesion of the screen printing ink but "merely" indicates that a pre-treatment has taken place and that the printing ink will possibly adhere.

Another vital condition for pre-flame treatment is that the surface of the crate is absolutely clean, i.e. free of any splashes of water or oil deposits (from a conveyor belt). Even fingermarks on the later printed area will reduce the ink's adhesion.

Bottle crates from which misprints have been removed must be inspected particularly after reprinting. The same is for crates stored outdoor before being printed.

3.0 Ink systems

The following three ink systems are suitable for printing onto PE bottle crates whereas more detailed information can be found in the corresponding technical data sheets.

Marapoly P

Two-component screen printing ink containing solvents, based on an acrylic resin binder system, suitable for all colour shades, as well as black and white. Marapoly P exhibits an excellent outdoor resistance to ultraviolet rays. The Marapoly P colour range consists of 17 basic shades which are also well suited for mixing special colours.

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Marapoxy Y
Two-component screen printing ink containing solvents, based on an epoxy resin binder system, suitable for all colour shades, as well as black and white. The colour range, consists of 12 basic shades.

Marapur PU
Two-component screen printing ink containing solvents, based on an acrylic resin binder system, suitable for all bronze shades (e.g. golds and silvers).

All "House" colours such as e.g. Coca-Cola Red, can also be ordered from Marabu as special colour matches.

3.1 Hardeners

All three ink systems mentioned are chemically cross-linked, two-component systems to which the correct quantity of the appropriate hardener must be added before use (see chapter 3.2). The following types of hardener are available:

Hardener H 1
Hardener for Marapoly P and Marapur PU (polyfunctional isocyanate in solvent). H 1 is somewhat less active but has an extremely high resistance to chemicals. It is sensitive to humidity and the containers must, therefore, always be sealed well.

YH
Hardener for Marapoxy Y (polyaminoamide resin in solvent). Due to its formulation, YH is a slow-reacting hardener which, on the other hand, has an excellent pot life, a high gloss, and good resistance to humidity. This is why YH Hardener should preferably be used with the Marapoxy Y ink system.

YH9
An alternative for Marapoxy Y (polyaminoamide resin in solvent). Compared to YH, YH 9 is a faster reacting hardener requiring a shorter drying time between print passes and achieving an excellent resistance to solvents.

However, the gloss level and resistance to humidity are slightly inferior to YH. For this reason, we recommend YH 9 only if problems with intermediate drying occur during fully automatic multi-colour printing.

3.2 Ink preparation

All three types of ink are reactive two-component ink systems to which the correct type and measured quantity of hardener must be added before printing.

If too much hardener has been used for the ink mixture, Marapoxy Y will remain soft and tacky while Marapoly P and Marapur PU will become extremely hard and brittle.

An insufficient addition of hardener will always result in an incomplete cross-linking and significantly reduced resistance and adhesion.

Step 1
Firstly, hardener is added to the ink in the correct quantity and stirred to a homogenous mixture.

The type of hardener depends on the printing machine used, the drying time of the ink, and printing speed (see chapter 5.0, "Printing parameters").

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The following values are to be considered:

Ink series	Ink per unit in gs	Hardener YH in gs	Hardener YH9 in gs	Hardener H1 in gs
Marapoxy Y (all shades except black)	800	200	120	-
Marapoxy Y (Black 980)	500	300	185	-
Marapoly P (all shades)	800	-	-	100
Marapoly P (Varnish P 910)	500	-	-	100
Marapur PU (all shades)	800	-	-	200
Marapur PU (Varnish PU 910)	600	-	-	200

All above-mentioned hardeners (except YH9/ 185 gs) are available as standard units. YH9/ 185g must be weighed precisely before use.

Step 2

Immediately after adding the hardener and mixing, the viscosity of the ink must be reduced by adding thinners and/or retarders in order to achieve the correct printing viscosity and prolonging the pot life of the ink mixture. If the ink dries out too quickly in the screen, retarders can be used instead of thinners, or a mixture of both. The retarder improves screen opening and slows down the drying of the printed ink film at the same time.

Ink series	Marapoly P	Marapoxy Y	Marapur PU
Thinner, fast	-	UKV 1	PUV
Thinner, slow	PV	YV	-
Retarder, fast	SV5	SV5	SV5
Retarder, slow	SV 10	SV3	SV9
Addition%	10-20%	10%	5-10%

After the ink mixture has been prepared, it should stand for approx. 10 min. before printing in order to allow any air bubbles to rise to the surface and burst.

If using horizontal screens and pre-flooding of the ink (non vertical screen format), it is sufficient to add a max. of 10% thinner/retarder to achieve optimum ink flow.

3.3 Potlife

Pot life means the time in which the mixture of ink (or lacquer) and hardener remains in a proper condition to be processed.

Pot life depends on the colour shade, type of hardener, room temperature, and thinners/retarders added. The higher the temperature, the shorter the pot life will be. Please find below a table based on a temperature of 20 °C:

Ink series	Hardener	Pot life
Marapoxy Y	YH	24 h
Marapoxy Y	YH9	16 h
Marapoly P	H1	10 –12 h
Marapur PU	H1	8 – 10 h

The shorter pot life of Marapoly P and Marapur PU can be extended by installing a water cooling system at the ink trough.

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It is then possible to connect it to the existing cooling system of an injection moulding machine. A further recommendation for the extension of pot life is to store the pre-mixed ink (with hardener) in a refrigerator.

Thickened or activated ink

During printing, an increase in viscosity will inevitably occur due to the evaporation of solvents and the initial chemical reaction between ink and hardener. The loss of solvent can be corrected by adding thinners or by continuously adding fresh ink (press-ready mixture).

Activated inks (Y, P, PU) exhibit changed flow characteristics which can be recognized with the aid of an ink spatula; severely affected ink becomes "thick" and is almost unable to flow off the spatula (tends to "drag").

Moreover, this change cannot be reversed by a further dilution as this would seriously reduce printability, flow, and (above all) adhesion. It is impossible to give a precise period of time after which a 2-component ink becomes unusable since this depends on too many factors. In any event, the times specified above must not be exceeded.

Continuous operation is nevertheless possible if a corresponding consumption and refilling of fresh ink are provided.

4.0 Additives

Additives permit the appropriate ink adjustment for specific printing parameters.

Levelling agent

If the ink exhibits irregular ink flow characteristics during the print run, this can generally be attributed to a wrong viscosity or an incorrect machine setting. If the optimum flow is not possible to achieve, a levelling agent can be added to the ink.

Generally, each ink already contains flow agents when being produced and only in exceptional cases, should such agents be used.

It is, therefore, important to weigh the additive exactly and not to exceed the correct amount of 1-3% max. for every type of ink. The addition of a higher quantity will inevitably cause adhesion problems during overprinting.

Levellling Agent for Marapoly P: VM 2 (3%)
Levellling Agent for Marapoxy Y: VM 1 (3%)
Levellling Agent for Marapur PU : ES (1%)

The effects of thinners and retarders are further described in chapter 3.2“ Ink preparation”.

5.0 Printing parameters

A wide variety of printing machines are used to print onto bottle crates. Due to differences in drying times and printing speeds, (especially Marapoxy Y and less active Hardener YH) the print parameters must be adjusted correctly for any particular set-up.

Marapoly P and Marapur PU with their faster hardeners, do not react as sensitively to changes in the drying process.

For the adjustment of Marapoxy Y, we generally recommend the following screen and squeegee parameters:

Screen: 77-100-40 polyester screen (or nylon for crates with extremely curved surfaces)
Squeegee: Vertical, wedge-shaped squeegee blade, shore hardness 65-75
or
60-70 ° angled squeegee with rectangular blade, shore hardness 75.

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Single-colour printing
In this case, drying of the ink is generally non-critical since the goods are stacked on a pallet after printing and drying speed is irrelevant. If Marapoxy Y is used, we recommend to use Hardener YH.

Multi-color printing press (continuous)
With this type of automatic printing press, drying time between the different printing stations is reduced to 2-4 min. As a result, the drying speed of the slowest ink system – Marapoxy Y with hardener YH - may be inadequate and consequently, the printed crates will not be touch-dry when they arrive at the next printing station (screen adheres to the soft ink film and results in a poor print).

In this case, Marapoxy Y must be mixed with the faster Hardener YH 9 without any addition of retarder. For the final printing station, we recommend to use again Hardener YH.

Multi-colour printing with single-colour machines (not continuous)
In this case, drying parameters are roughly the same as for single-colour printing since the goods are stacked on pallets between the different printing operations.

For Marapoxy Y, we recommend to use Hardener YH and a retarder if necessary (SV 5, SV 3). For this production method, it is important to overprint the ink film when it has not yet fully cured.

Since the ink reaction process (basic ink with hardener) is strongly accelerated by flaming or hot air treatment, we recommend to carry out this slow production process with little or no forced drying after each printing station.

Please consider that once an ink film has fully reacted, no further adhesion can be achieved in the overprinting process.

5.1 Drying

All three ink systems are subject to two different drying processes:
a) physical drying by evaporation of the solvents
b) reactive drying by chemical reaction between the basic ink and hardener.

Physical drying means that the printed surface is touch-dry after the solvents have evaporated and can then be overprinted. For this reason, an intermediate drying of the ink is critical in the case of multi-colour presses.

The following information can only be considered as a guideline since drying times are dependant upon many different parameters.

Air drying
Normal evaporation of solvents at room temperature, without additional energy. The indications below refer to the time when overprinting can be carried out.

(fabric 90-48, temperature 20°C)

	Hardener YH	Hardener YH9	Hardener H1
Marapoxy Y	20 min	15 min	-
Marapoly P	-	-	15–30 min
Marapur PU	-	-	15-30 min

Hot air drying (Leister blower)
This method has a drying temperature of 200 - 600 °C giving a dwell time of 2-6 seconds, depending on the size of the print area and the number of fans used.

(fabric 90-48, Leister Blower at 400°C, 6 sec.)

	Hardener YH	Hardener YH9	Hardener H1
Marapoxy Y	5 min	3 min	-
Marapoly P	-	-	4 min
Marapur PU	-	-	4 min

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Flame drying (gas flame)

The flame temperature is >800 °C giving a dwell time of 1-3 seconds (depending on the size of the print area). This means that the printed ink film and the PE crate material are subject to an extremely severe shock treatment.

The below recommendations are therefore to be considered:

- Flame drying should only be used with continuous multi-colour printing since no significant time lapses occur before overprinting. The high temperatures of flame drying accelerate the reactive drying in the ink film to such an extent that ink adhesion can no longer be guaranteed during subsequent overprinting, even after a short time.

- For a fast intermediate drying of bronze shades in the Marapur PU ink series, we do not recommend flame drying since drying speed of PU is faster than Y making increased drying costs unnecessary. In general, bronze shades are very sensitive to flame drying, they soon show initial symptoms of boiling on the surface which then become evident by bubbles in the ink film. If flame drying is absolutely unavoidable, it must be carried out with an extremely soft flame under close supervision.

A monitored secondary flame treatment is possible for Marapoxy Y and Marapoly P and, with some limitations also for Marapur PU. In this case, it is essential to make sure that the gas burner is correctly adjusted so that no soot is deposited on the surface of the crate or on the printed ink film.

There is further the opinion in the market that a repeated strong post-flaming is responsible for making the crates brittle and cracking.

Infrared drying

This drying method is not only highly effective but also gentle both the material and printed ink. Whether a visible or invisible IR emitter is used, both systems generate effective drying temperatures on the surface of the crate. The subsequent discharge of solvent vapours and the cooling process are carried out by a cooling air fan. Owing to the even heat prevailing, the entire crate is only subject to minimum distortion.

General recommendation

We principally recommend forced heat drying after the last print station.

5.2 Overprinting

None of the three ink systems can be overprinted when the reactive chemical cross-linking has occured throughout the previously applied ink film.

In this process, the speed of reaction is determined by the drying temperature, method used for post-curing, thickness of the printed ink film, and type of ink and hardener used. If the overprinting station does not follow straightaway, intermediate drying must not be carried out under any circumstances.

In general, overprinting must be carried out as soon as possible and in any case, within the times as shown below:

fabric 90-48, temp. 20°C, no post-drying

	Hardener YH	Hardener YH9	Hardener H1
Marapoxy Y	24 h	16 h	-
Marapoly P	-	-	16 h
Marapur PU	-	-	8 h

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Overprinting characteristics of the different ink systems

We are able to supply the following information about adhesion and scratch resistance resulting from in-house tests:

Print of first ink as a basic layer	Overprint of 2nd layer on 1st layer	Adhesion and scratch resistance
Marapoxy Y	Marapoly P	not possible
Marapoly P	Marapoxy Y	not possible
Marapoxy Y	Marapur PU (Bronzen)	ok
Marapur PU (bronzes)	Marapoxy Y	ok
Marapoly P	Marapur PU (Bronzen)	ok
Marapur PU (bronzes)	Marapoly P	ok

5.3 Final hardening time

With hardening time, we mean the period after which the printed ink film has undergone the complete chemical reaction process and achieved its maximum chemical resistance. This is strongly dependant upon the storage temperature of the printed material.

Fabric 90-48, temperature 20°C

	Hardener YH	Hardener YH9	Hardener H1
Marapoxy Y	8 days	5 days	-
Marapoly P	-	-	8 days
Marapur PU	-	-	8 days

Only after this time, is the printed surface also resistant to caustic cleaning bath solutions (e.g. 2 % caustic soda).

Prerequisite for subsequent ultimate chemical resistance is an appropriate ink drying process together with the storage of the crates within 12 hours of printing as the reaction between the ink and hardener will be established during this time.

We strongly recommend to store crates indoors (protected from rain) for min. 12 hours at 20 °C or for 24 hours at 15 °C. The crates must not be placed outdoors until this time has passed.

If newly printed crates are stored outdoors too soon and exposed to mist, rain, or excessive atmospheric humidity during the first 12 hours, the following problems can be expected:

- Reduced adhesion of the ink film to the substrate due to variations in the coefficients of expansion of the polyethylene and the ink.
- Reduced adhesion of the printed ink film due to the formation of condensation (also rain) between the surface of the crate and the printed ink. This can cause deterioration ranging from partial flaking-off to a complete separation of the ink.
- Reaction between the inactivated content of hardener and atmospheric moisture. This means that less hardener is available to achieve an optimum cross-linking with the result that reduced chemical resistance can be expected.
- At temperatures below15 °C, the reaction between the basic ink and hardener of all three ink systems is no longer guaranteed since chemical reaction ceases. This can lead to an irreversible deterioration in the final hardening process as even if the temperature is subsequently raised, no further chemical reaction will take place again.

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6.0 Testing the adhesion of the printed ink film

Tests for adhesion of the ink are carried out on three separate crates with the aid of an adhesive tape (Sellotape, Scotch tape, etc.). The printed area is completely covered with the tape which is then to be pulled off (vertically) in a series of jerky movements after10 min. For satisfactory adhesion results, no parts of the printed ink are allowed to separate. This testing method has been specified in the Quality Assurance Standard RAL-RG 720/1, as well as in the "Special technical conditions governing the supply and purchase of polyethylene bottle crates".

Adhesion tests are only conclusive if the adhesive tape test is carried out on the fully dried ink film. This means that the printed ink must be air-dried for 12-24 h or, under unfavourable conditions, up to 48 h. When running production, however, no quality controller can risk producing crates for 48 hours without an unambiguous test on the adhesion of the printed ink.
For this reason, there are so called "rapid" test methods existing which may vary depending upon the type of operation involved and which are based on empirical values drawn up by quality inspectors.

Adhesive tape test after one hour of room-drying

Depending on the content of retarder and the drying conditions, the printed ink film may be touch-dry after one hour but is still very soft. As a result, the tape adheres poorly to the printed ink and the validity of this adhesion test is not secure.

Shock flame treatment

Newly printed crates are repeatedly flame-treated in order to accelerate the evaporation of the solvents. After cooling down, the crates are immediately tested for print adhesion with an adhesive tape.

The results obtained by this method are slightly somewhat poorer than it is actually the case since a repeated shock drying seals the solvents in the underlying layers of ink within the ink film itself. As a result, the ink layer next to the printed substrate is not thoroughly dried and the adhesion is therefore rather weak.

Pre-drying with hot air (Leister fan) or infrared radiation

In this case, newly printed crates are intensively pre-dried with a Leister fan or infrared transmitter, then cooled. Adhesion tests with adhesive tape follow immediately.

Drying for an extended period in a warming cabinet

In this case, drying at room temperature for 24-48 h is simulated by storage in a warm cabinet at 80 °C for 30 min. This test is carried out under ideal conditions for the ink system and, as a result, often provides better adhesion results than occur in reality. For this reason, an adhesion test under room-drying conditions must always be done in parallel.

The method of warming cabinet storage produces rapid, unambiguous results and is often used. For newly printed crates, we generally recommend an hourly ink adhesion test by means of the adhesive tape. This is also important if they are unavoidably stored under unfavourable conditions for the first 12 h.

7.0 Differences of the three ink systems

Marapoly P

Due to its acrylate binding agent, this new development is more resistant to the sun's ultraviolet rays and must therefore be used instead of Marapoxy Y if UV stability is required. Because of its high reactivity, Marapoly P is ideal for high speed multi-colour printing presses.

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Marapoxy Y
This ink has been used worldwide for bottle crates and transport containers for several decades, with the result that its high standard of quality is widely known and acknowledged.

Marapoxy Y distinguishes itself by the following characteristics:
- high opacity, even on dark substrates
- maximum possible pot life
- gloss
- high resistance to chemicals

It has only one known disadvantage: Due to the epoxy resin binding agent, the printed ink film tends to "chalk" under UV radiation from the sun, i.e. it loses gloss and under a prolonged UV exposure, it develops a white bloom.

In the past, this was no problem since the crates were regularly washed whenever they were re-used, thereby eliminating any possible chalkiness. Today, however, crates are often produced for stock (for logistical reasons) and then stored outdoors for e.g. one year before being used for the first time.

This has a lasting effect on the ink film of Marapoxy Y and means that crates printed with this ink series cannot be stored without being covered with tarpaulins.

Marapur PU
This binding agent is used for bronze shades since these shades exhibit the least possible oxidation from the oxygen in the air and grey discoloration from chemical cleaning agents.

7.1 Chemical resistance

Once adequately hardened (see chapter 9.0), all three ink systems will withstand the following common tests:

- water soak test
- resistance to a mixture of water with10 % alcohol
- 30 min. immersion in a 2 % caustic soda solution (70 °C)
- 3 hours immersion in a 2 % "Teepol" solution (80 °C)
- excellent general resistance to alcohols, solvents and other fillers (preliminary trials are essential).

8.0 Storage of printed crates

After printing, the crates must be stored in a dry place at 20 °C for the first 12 hours or at 15 °C for 24 hours before being placed outdoors. It is important to ensure that the minimum temperature of 15 °C is maintained even in the winter season (see chapter 5.3 “Final hardening”).

9.0 Shrink wrapping

To protect newly printed crates during transport, pallet loads are shrink wrapped with thin PE transparent plastic sheeting. It is to be kept in mind, however, that this type of packing creates a tropical climate with high temperatures and humidity inside the wrap and that the resulting condensation cannot escape.

These conditions have a negative effect on the ink adhesion. If the stored goods are then additionally exposed to frost, it is to be expected that the ink film will flake off to some extent.

It is, therefore, important to store newly printed crates for at least 12 hours at 20 °C or 24 hours at 15 °C before they are shrink-wrapped. This indication of time cannot be reduced by heat treatment.

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9.0 Production monitoring

We recommend the continuous monitoring of the flame pre-treatment quality, as well as the adhesion test of the printing ink to the PE substrate when overprinting.

Flame pre-treatment

Ink adhesion to PE largely depends upon the quality of the pre-flame treatment given. This means that a once-a-day setting or inspection of the flame is insufficient and extremely risky. We recommend to check the flaming station every 30 min. by means of a water retention test on a newly flamed crate. If a continuous film of water remains on the pre-flamed areas for more than 10 seconds, surface tension seems to be good for printing (more than 50 dyne/cm) and pre-flaming can be considered to be in order.

The water test is not a recognized scientific method of surface tension testing but a simple and practical rapid test which can be carried out next to the printing press while production is running.

If the water test provides an insufficient result, the only alternative is to use a Goniometer (Messrs. Krüss, Hamburg) which is able to determines the precise ionic content and surface tension. Since measurements with this instrument may take approx. 2 h, it is generally not suitable for use during production.

Adhesion testing

As already stated in chapter 6.0, we recommend the hourly adhesive tape test for ink adhesion during the day's production. For the following 5-7 days, one daily random sample test is sufficient.

10.0 Overprinting of used crates

Compared to new crates, printed crates which have already been in circulation or exposed to the weather for a longer period of time, exhibit the following changes to the printed area:

- contamination
- physical damage
- loss of colour from the crate through UV degradation
- possible chalkiness of the print and following reduction in adhesion when overprinted
- changes due to washing solutions

With overprinting used crates, some loss of quality in subsequent printing will possibly occur. Practical experience within the last few years, however, shows that for a considerable number of overprinted crates in circulation, the results are generally acceptable, although no guarantees can be given from our side.

11.0 Remarks

The printing of polyethylene bottle crates is an extremely demanding and complex operation. The information here given represents our present state of knowledge even if no transfer to other general applications and printing tasks can be derived from that.

Due to variations in printing parameters and substrate characteristics, we must therefore ask you to carry out own suitable trials under practical conditions before using any of the specified inks. Should you have any further questions, we will be glad to assist you at any time.

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