

Screen Printing Inks for Membrane Switches

Screen
2013
17. June

Marastar SR, Maraswitch MSW, and Ultraswitch UVSW

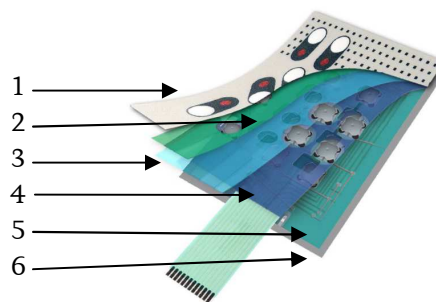
Our customers have been producing membrane switches very successfully with the solvent-based inks Marastar SR and Maraswitch MSW. The UV-curable ink Ultraswitch UVSW was introduced to round out the portfolio. With this TechINFO we would like to share the experience we have gained through the years in regard to advantages, limits, and combination possibilities of our inks for the production of multi-layered structures.

As a partner of the industry, Marabu has been certified to DIN EN ISO 9001 and DIN EN ISO 14001 for years.

Index

1. Structure of membrane switches and quality standards
 - 1.1. Main application fields
2. Modules of a membrane switch
 - 2.1. Films
 - 2.2. Adhesives
3. Ink recommendations; solvent-based
 - 3.1. Additives and auxiliaries
 - 3.2. Combination of MSW and SR
 - 3.3. MSW Special inks
4. The future belongs to UV - Ultraswitch UVSW
 - 4.1. Combination UV / solvent-based
 - 4.2. UVSW Special inks
5. Production process of membrane switches
 - 5.1. Mesh recommendations /layer thickness
 - 5.2. Drying process and tempering
6. Tests carried out by Marabu – Interaction of films/inks/adhesives
7. Combination with digital printing
8. Colorimetry
9. Outlook

1.0 Structure of membrane switches and quality standards



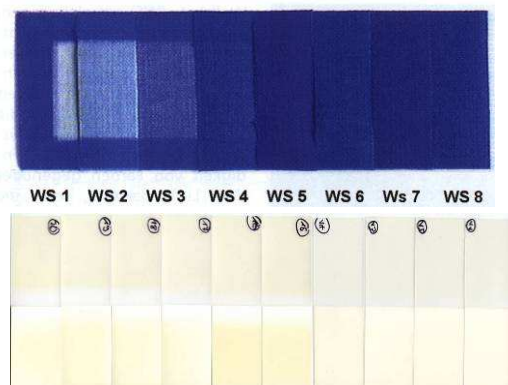
Structure:

1. Graphic overlay
2. Top membrane
3. Spacer
4. Bottom membrane
5. LED-switch (flexible circuit board)
6. Self-adhesive paper-back

Membrane switches have become an essential part of everyday life. Individually prepared films are bonded together to form a multi-layered structure. Specifically of interest to us is the screen printing decoration of films made of primed polyester and polycarbonate, which have to fulfil the following **quality standards** according to the European **Keyboard Association**, and Marabu experience:

- Very good adhesion of the ink to the film according to DIN EN ISO 2409 with cross-cut tape test, required is at least GT 1/ASTM 4B
- Peel value of the printed film to the bonded base of > 10N at a strip sample of 5 cm width
- Operational life span: > 1 Mio switching cycles; testing acc. to DIN 42115, part 1
- Sufficient flexibility of the ink film and structure for dome, flat and edge embossing

- Good printability of the ink and high opacity of colour shades and blocking layers
- Minor colour deviations per batch of < 1 dE ; constant „batch to batch“ quality
- High light fastness of colour shades (blue-wool scale 7-8), and non-yellowing whites



Xenon Test / Yellowing

- High cohesion of the multi-layered ink film, no ink splitting during peel and adhesion tests
- Compatibility with the most common films and adhesives
- Climate change and temperature resistance

1.1 Main application fields

- Membrane switches
- Flat data entry systems
- Backlit membrane switches
- Front panels
- Electronic displays
- Circuits
- Vehicle dashboards

2.0 Modules of a membrane switch

Various types of films can be combined with adhesives to create a membrane switch, here's a quick overview on common materials:

2.1 Films

In Europe, mainly primed films are used for decorated front films. Here, the primed PET

surface (second surface) is decorated. The front surface is available with different structures. Common primed PET films are:

McDermid	Autotex V207, F207 Autotex V200, F200 Autotex XE200, XE207 Autotex V157, F157 Autotex V150, F150 Autoflex EBG, EBA
InteliCoat	Reflex LT 125, LT 175
Folex	GO-MA, GO-AG DUV GO-AG/AN, GO-HC

The stability of the entire keyboard is greatly affected by the quality and adhesion of the priming to the PET film, since it is the interface for the basic adhesion of the entire printed ink film structure.

In the USA, PC films and PC/ABS compounds are more popular. These films are not primed, for example

Bayer	Makrofol DE Bayfol CR (PC/ABS)
GE Plastics	Lexan 8B35

2.2 Adhesives

The choice of the adhesive system is also an important factor with regard to its chemical formulation and adhesion properties like

- Adhesion to the substrate / carrier
- Adhesive bonding to the ink structure / final layer
- Impact on the printed ink structure and the employed type of film, and chemical interactions

Common double-sided adhesives are	
3M	467 MP und 468 MP Series 200 MP
Lohmann	Duplotac Serie Duplobond Series

Avery	FT 3025 MS 7008
Flexcon	Switchmark Series
Mactac	MACtouch T 4040

Tested and recommended printable adhesives made by Kissel & Wolf are:

Kiwoprint D 142	Water-based
Kiwoprint UV 33	UV-curable

3.0 Ink recommendations; solvent-based

The binders and solvents of inks that are used for the production of membrane switches must be attuned to common materials and the required strain. The chemical and physical interactions of the single components film-ink-adhesive must be taken into consideration. If solvent-based inks are used, solvents that remain in the printed ink film are an important factor for the stability of the entire bonded film structure.

Marabu has been able to gather a lot of experience about the compatibility of various films and adhesives in close collaboration with material suppliers and customers. Recommended solvent-based Marabu inks for membrane switches are:

Marastar SR

Marastar SR represents the first generation and has proved to be first choice for customers and applications with many special colours for the last 20 years.

Maraswitch MSW

To meet the constant advancements and growing requirements in this market, Marabu has introduced the second generation of solvent-based inks with MSW. Compared to Marastar SR, MSW offers the following advantages:

- Very good mesh opening and yet good drying properties
- Therefore, less retarder is needed, leading to a reduction of residual solvents
- Higher flexibility of the ink film for post processing steps like cutting, stamping, or die-cutting
- Very good intermediate adhesion of the single ink layers within the multi-layered structure
- Very good compatibility of the blocking layers MSW 171 and MSW 182 with the UV-curable ink Ultraswitch UVSW (see 4.0)
- MSW is cyclohexanone-free
- The characteristics of MSW generally increase the process safety and functional reliability of membrane switches

This ink system includes the following products:

17 basic shades according to System Maracolor (see Technical Data Sheet) as well as

MSW 170	Opaque white (high opacity)
MSW 171	Opaque white
MSW 182	Block-out Silver
MSW 904	Special binder

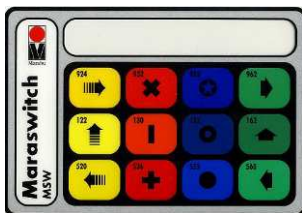
Opaque White **MSW 170** has the same pigmentation as SR 170 and both are higher pigmented than MSW 171. If MSW 170 is used purely, extensive preliminary tests as to adhesion/peeling-off and/or embossing properties are absolutely necessary.

Owing to the high pigmentation of MSW 170 we recommend the addition of Special Binder MSW 904 and tempering.

MSW 171 offers high process safety with its ideal balance between pigment concentration and related properties such as opacity, flexibility, and cohesion stability. It is best suited as a full-area pre-print white behind colour shades. Its opacity is slightly higher than SR 070 and significantly higher compared to SR 270.

Block-out Silver **MSW 182** is the last ink layer which is full-area printed onto the opaque whites. This increases the light-proof characteristic of the complete ink build-up considerably as well as its resistance to adhesives.

Special Binder **MSW 904** is either used as a varnish component for transparent HKS or PANTONE formulas, as binder for metallics, or final coat (additional barrier layer).



3.1 Additives and auxiliaries

For both ink series, it is generally important that the residual solvents have been reduced to a minimum prior to embossing and bonding. If not, a complete ink delamination and separation of the membrane switch may occur. For this reason, the use of super slow retarders such as SV 3 or SV 9 is not allowed.

Guidelines for the adjustment of MSW

Mesh opening of all MSW colour shades is by nature significantly better than that of Marastar SR. Owing to this, it is possible to use MSW either with pure thinner or a low percentage of retarder if necessary:

Full-area printing:

Fully automatic: 10,0 % UKV 2 5,0 % SV 5
Semi-automatic: 10,0 % UKV 2 5,0 % SV10

Fine details:

Fully automatic: 7,5 % UKV2 7,5 % SV 5
Semi-automatic: 7,5 % UKV2 7,5 % SV10

Guidelines for the adjustment of SR

For the fast drying SR, we recommend the following adjustments:

Full-area printing:

Fully automatic: 7,5 % UKV 1 7,5 % SV 5
Semi-automatic: 5,0 % UKV 1 10 % SV10

Fine details:

Fully automatic: 7,5 % UKV 2 7,5 % SV 5
Semi-automatic: 5,0 % UKV 2 10 % SV 10

We do not recommend the addition of any further auxiliaries or additives such as levelling agents containing silicone, plasticizers, thickening agents, or other powders and pastes.

This would have an unforeseeable and negative effect on the adhesion of the bonded foils resulting in a reduced peel-off value, and an increased embrittlement of the printed ink film (see 4.1 - damage symptoms).

3.2 Combination of MSW and SR

All MSW and SR shades are intermixable. We always favour the use of only one ink type, so that the MSW properties are not impaired. Pre-printing and overprinting of SR and MSW shades is also possible.

For more information about the differentiation between MSW and SR, please refer to the ProductINFO Maraswitch MSW.

3.3 MSW Special inks

Two MSW special inks have proved themselves for the making of membrane switches. They are available upon request:

- MSW 623 13 180R Opaque Black
- MSW 670 69 191 Press-ready Silver

Please consider that these special inks are available upon request and minimum quantities, prices, and delivery times will be different from standard products.

4.0 The future belongs to UV - Ultraswitch UVSW

UV-curable inks keep becoming more and more popular. The UVSW formulation does not contain solvents, with obvious advantages:

- Unlimited mesh opening
- Excellent reproduction of details
- Stable colour accuracy for the printing of print runs
- No residual solvents in multi-layered ink films
- Quick curing speed allows fast processing speed
- Higher quality and process safety for multi-layered ink structures
- No adjustment of the ink with thinner and retarder
- Low environmental impact, compliance with MAK values

In order to meet the delicate demands of this high tech industry only state-of-the-art raw materials were used for the formulation of UVSW. For a UV-curable ink, it is most crucial to balance the main features that are important for this application:

- high flexibility for cutting, stamping, and die-cutting processes
- high chemical resistance for the contact with adhesives
- high intercoat adhesion of multi-layered ink structures
- good opacity and complete curing
- high peel-off values

UVSW meets all of these high technical requirements. Many internal and external tests with different material combinations of film types/ink structures/adhesives have revealed excellent results.

Film types for UV-inks:

The stability and functionality of the keyboard is greatly affected by the quality of the PET or PC film, so choosing the right type of film and priming is important for the use of a UV-curable ink system.

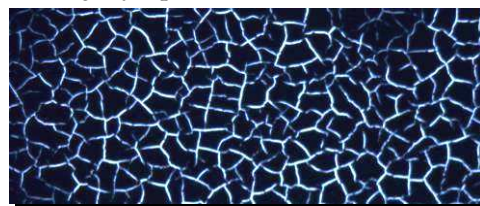
The priming must be resistant against repeated exposure to UV light during the curing process, since PC films have the tendency to react to UV light by changing their adhesive behaviour. Please follow the recommendations of the film suppliers. In terms of compatibilities, we will gladly share our experience with you if you contact us.

4.1 Combination UV / Solvent-based

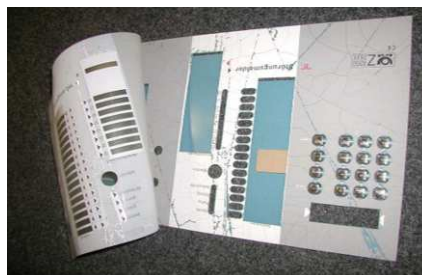
If a purely UV-curable ink structure is not opaque enough for your application, we recommend the combination with **MSW**. Use UVSW for the pre-printing of the coloured design, and MSW 171 and MSW 182 for the blocking layer.

It is **not recommended** to use UVSW for the second surface print if SR and MSW were used for the pre-print (delamination, cracks in the ink film).

Damage symptoms:



Cracked ink film



Delamination

Recommendations for the combination with Maraswitch MSW:

- Use of suitable, primed PET films
- Complete curing of the ink film structure is important
- If PC films are used which are sensitive to solvents, we recommend sufficient post curing of the UVSW ink structure before applying the second surface with MSW to avoid cracks
- Adjustment of the MSW blocking layers with fast thinners like UKV 2
- Tempering of the complete ink structure UVSW/MSW at for example 70°C/ 1-2 h in a circulating air oven prior to post-processing steps like stamping and bonding

UVSW & MSW: a winning team



4.2 UVSW Special inks

- UVSW 912 Window varnish; transparent
- UVSW 913 Window varnish; milky matt
Mesh recommendation: 120-34

Transparent shades are available upon request as special colours.

Attention!

For highest transparency, the window varnishes and the transparent shades **do not contain silicone**. Therefore, a **contamination** with silicone (containers used for mixing, contaminated printing plates and so on) **must be avoided** or otherwise wetting and flow characteristics will be impaired.

5.0 Production process of membrane switches

The manufacturing success of membrane switches is also strongly dependant upon the following additional parameters and process steps:

5.1 Mesh recommendations / layer thickness

Solvent-based inks:

A polyester mesh of 120-34 is often used for the printing of text and symbols. For large area printing, fabrics of 100-40, 90-48, and 77-55 are very common. We recommend to not exceed a maximum height of 30µm for the complete ink structure.

UV inks:

For the use of UVSW we recommend a mesh count of $\geq 140-31$. Please consider the higher layer thickness of UV inks owing to the 100% solid content (no solvent evaporation)! Thanks to the stable UVSW cohesion and the elimination of solvents we have not had any problems with thicknesses of up to 55µm.

5.2 Drying process and tempering

Solvent-based inks:

This is one of the key points for the production of membrane switches because it is decisive for the amount of residual solvents which strongly influence the functionality of the entire keyboard.

We recommend the use of a continuous dryer. Best suited is a dryer with 5 zones (3 x warm, 2 x cold) or, as more commonly used, the smaller version with 3 zones (2 x warm, 1 x cold), possibly combined with an IR drying unit. Since commercially available dryers differ considerably in the amount of circulated air per hour, the drying values of SR and MSW must be determined optimally on site for each ma-

chine. As a rough guideline, a block-resistant drying (films printed on one side only) will occur after approx. 30-40 sec at 60-80°C in the drying tunnel.

Post-curing:

Especially for thick printed ink layers, it is essential, however, to place the films after final printing on a drying rack for 10 to 15 hours (ensure good air circulation!) or to post-cure in an **oven at 80°C for 1 – 2 h**. This ensures a lasting reduction of the residual solvent content and guarantees optimum post-processing results, very good adhesive resistance, and a long service life of the keyboard.

UV inks:

A completely cured ink film is essential for the stability and resistance of the UV ink film. The concept and adjustment of the UV dryer is an important factor:

- Recommended power: 2x120 W/cm
- Reflector quality and focussing
- Adjustment: Half or full load
- Belt/production speed

Further factors are

- The printed ink layer in combination with the mesh count, printing plates, as well as quality, grind, and angle of the squeegee, and printing speed
- Formulation of the ink (Opaque shades)

Please also follow the recommendations described under 4.1, combination with MSW.

6.0 Tests carried out by Marabu – Interaction of films/inks/adhesives

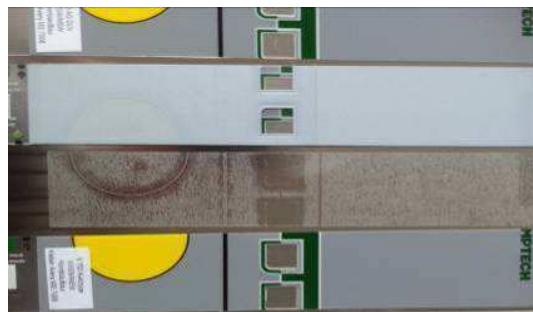
As mentioned before, Marabu has carried out extensive testing with suppliers and customers regarding the chemical interaction of the components. Here are some exemplary results

of the testing of adhesives carried out in collaboration with the company Kissel & Wolf:

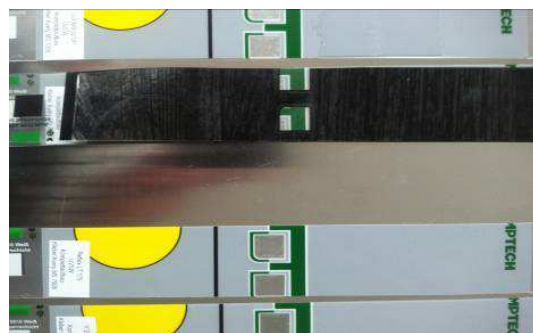


Marabu and KIWO peel tests with different double-sided adhesives / printable KIWO adhesives D 142 and UV 33

The separation properties depend upon the type of adhesive, film, and ink used for the second surface, revealing the stability of the complete „package“.



Adhesive remains on support plate, no delamination of the ink structure

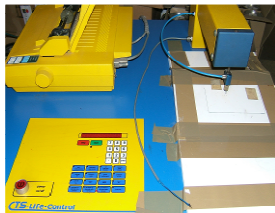


Adhesive remains on blocking layer, no delamination of the ink structure



Adhesive splits itself (cohesive failure), no delamination of the colour structure

Further test methods and options for membrane switches, which are carried out by Marabu:



Endurance test



Tensile tester



Alternating climate test



Xenon Test Chamber

Recommendations for outdoor use:

- MSW with blocking layers MSW 171,182
- UVSW with blocking layers MSW 171,182
- Film type Autotex 207 XE for UVSW
- Film type Autotex 207/200 XE for MSW

7.0 Combination with digital printing

Digital Printing is also finding its way into the membrane switch segment. It is mostly used in combination with screen printed (solvent-

based or UV-curable) blocking layers to compensate the usually insufficient opacity of digital inks. This combination is currently tested with Marabu and other digital inks, in close collaboration with material suppliers and customers.



1. Marabu Digital Inks
2. Marabu blocking layer (second surface)

8.0 Colorimetry

All current formulas such as PANTONE, HKS or RAL have been worked out in the ink series Maraswitch MSW, Marastar SR, as well as Ultraswitch UVSW, and are stored in the Marabu-ColourManager (MCM).

9.0 Outlook

The use of the recent ink generations MSW and UVSW increases the production reliability and speed for the production of multi-layer membrane switches. The advice dispensed in this TechINFO is based on Marabu experience which has been collected over the past 20 years, and we gladly share it with you. Nevertheless, before production start, the individual conditions must be considered and tested. You are, therefore, obliged to conduct your own tests with our supplied products to confirm their suitability for the desired process or purpose.

In the event of any queries, please contact us:

Technical Hotline
Phone: +49 7141 691140
technical.hotline@marabu.de