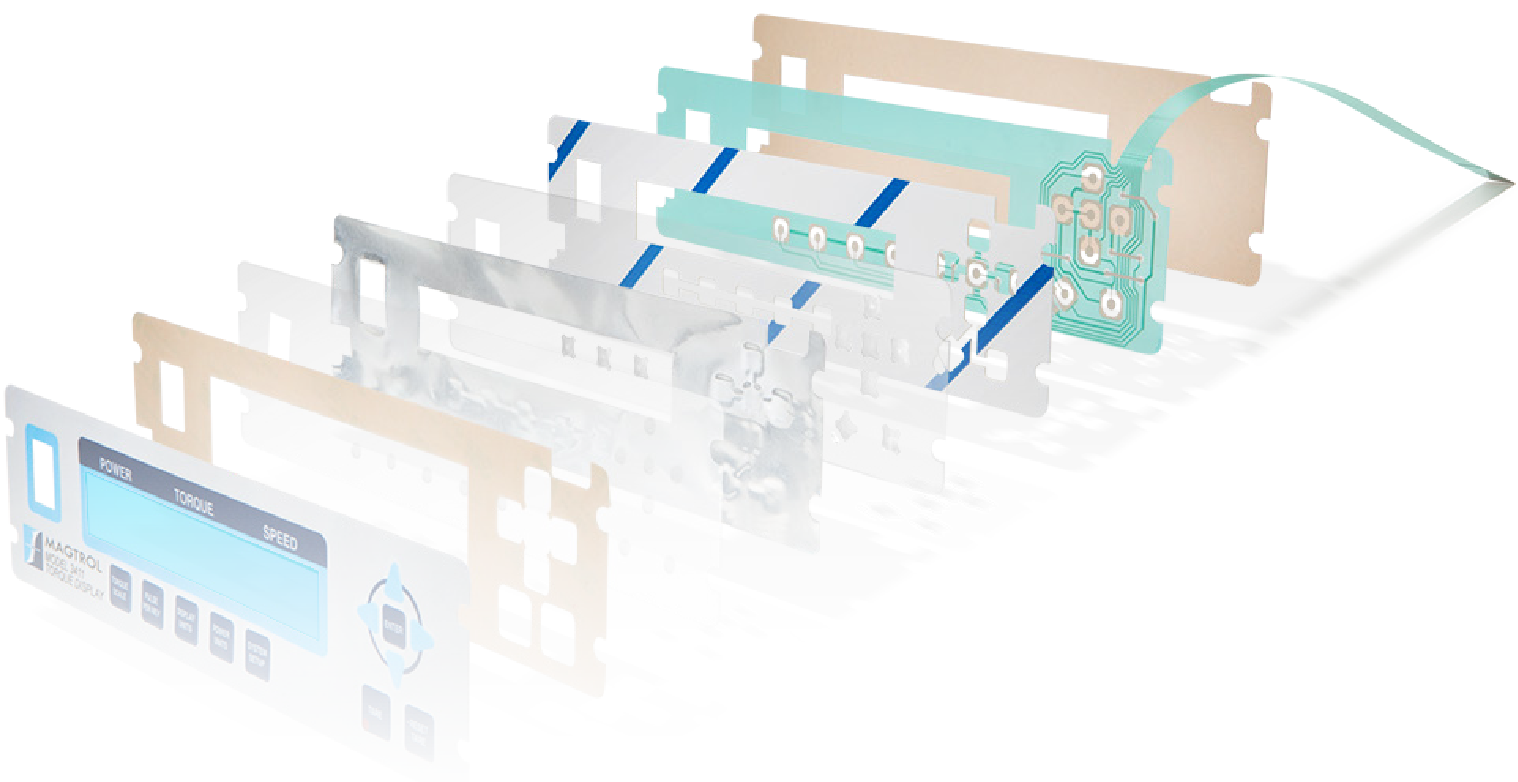
EVERYTHING YOU NEED TO KNOW ABOUT MEMBRANE SWITCHES



REV. A

TABLE OF CONTENTS

WHAT IS A MEMBRANE SWITCH?

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A membrane switch is a momentary closure device used with a normally open circuit. They are called membrane switches because they are made up of flexible graphic and internal layers (or membranes) over a circuit printed on PET or etched on polyimide.

The layered nature of membrane switches allows a great deal of freedom for engineers to design and implement a very precise customer experience. Because of this flexibility, these man/machine interfaces are used across a wide range of industries, including medical, consumer electronics, military/DoD, and aerospace.

There are many parameters to consider in membrane switch design including the graphics, overlays, adhesives, and use cases.

NOT TO SCALE [RELATIVE ONLY IN PROPORTIONS]

WHAT ARE THE PARTS OF A MEMBRANE SWITCH?

There are many parameters to consider in the development of membrane switches, including the design, overlays, adhesives, and use cases. They can vary a great deal from simple to very complex. The components of a membrane switch will vary with complexity, but all contain some combination of the following:

GRAPHIC OVERLAYS:

The overlay is the top layer of a membrane switch and is the interface between the user and the machine.

ADHESIVE:

There are numerous differences in adhesives. Selecting the proper adhesive for a membrane switch application requires consideration of environmental, surface, appearance and other performance requirements.

EMBOSSING:

There are three basic styles of embossing; pillow, rim and dome. Depending on shape and size, logos and multi-level shapes can be embossed.

CIRCUITS:

Circuits can be printed conductive silver ink, etched copper flex or printed circuit boards.

SURFACE MOUNT DEVICES:

Membrane switches can be designed with embedded LEDs if required.

SHIELDING:

Proper shielding is necessary to meet ESD, EMI or RFI requirements.

TACTILE AND NON-TACTILE:

Switches can be designed as tactile or non-tactile to achieve the desired product requirements.

IMPORTANT MEMBRANE SWITCH CONSIDERATIONS

NON-TACTILE SWITCH WITH SILVER CIRCUITY

This three-layer switch, comprised of graphic overlay, a circuit spacer, and a screen-printed silver ink circuit, is the simplest type of membrane switch. Because they tend to be the least expensive option, they are often implemented as a cost-cutting measure in the overall design.

LED BACKLIGHTING OPTIONS FOR MEMBRANE SWITCH

Designing the right backlighting technology into a membrane switch assembly can help deliver a superior user experience. A wide variety of backlighting options are available, allowing engineers to precisely manage light quality, color, intensity, and coverage, so it is important that your selected switch manufacturer understands the advantages and disadvantages of these different techniques.

WHY USE SILICON RUBBER KEYPADS?

More complex user interfaces require higher-density, more miniatured components. In these situations, printed circuit boards (PCBs) and printed circuit board assemblies (PCBAs) are often brought into play.

WHAT IS TACTILE FEEDBACK?

Tactile feedback refers to a mechanism in membrane switches that utilizes touch for operation or activation. By using different materials and sizes for these domes, you can vary the actuation force required to activate the switch.

WHAT ARE COPPER FLEX MEMBRANE SWITCHES?

Unlike screen-printed silver, copper flex circuits are manufactured by laminating copper to an underlying substrate, and then etching that substrate in a way that leaves specific conductive traces.

VISUAL CONSIDERATIONS IN MEMBRANE SWITCH DESIGN

Choose a vendor that has a computerized color formulation system to achieve consistent results from printing to printing. Good suppliers can color match to the Pantone Matching System, Federal Standard Guide, a color swatch, or to your bezel. Calibrated light booths and/or digital densitometers are then used to inspect and measure results to ensure conformance.

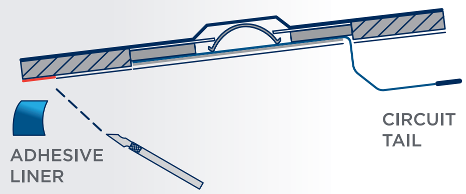
DURABILITY IN HARSH ENVIRONMENTS

More complex user interfaces require higher-density, more miniaturized components. In these situations, printed circuit boards (PCBs) and printed circuit board assemblies (PCBAs) are often brought into play.

HOW TO INSTALL A MEMBRANE SWITCH

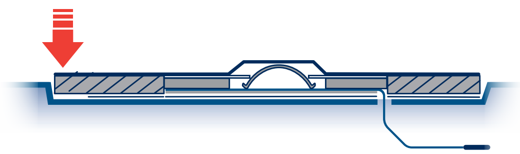
1

Very carefully cut and remove 1/8” of adhesive liner on the bottom side of the membrane switch.



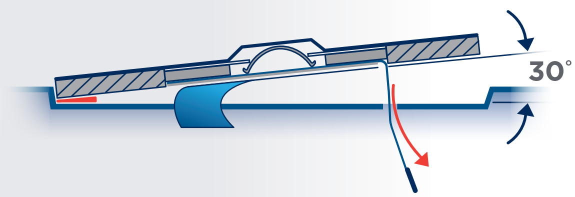
2

Turn the membrane switch over and pass the flex cable through the tail exit slot of the unit the switch will be mounted to. With precision, position the membrane on the back support recess and adhere the membrane switch to the surface of the unit with the exposed adhesive.



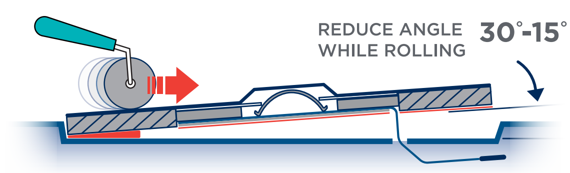
3

Position the membrane with an angle around 30 degrees, peel off the rest of the adhesive liner keeping the set up the same as before.



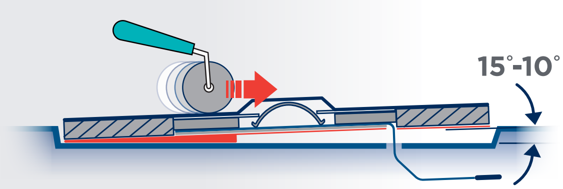
4

Gently laminate the membrane switch starting from the side with the removed adhesive liner, using a soft roller, apply slight pressure as rolled across the top surface of the membrane switch.



5

Lower the angle of the membrane switch gradually and roll out the air.



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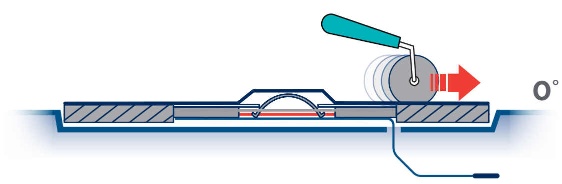
The lamination is completed. You can bend the circuit slightly without damaging the switches but use extreme caution so that the metal domes/buttons are not inverted then becoming non-functional.



NON-TACTILE SWITCH

This three-layer switch, comprised of a graphic overlay, a circuit spacer, and a screen-printed silver ink circuit, is the simplest type of membrane switch. Because they tend to be the least expensive option, they are often implemented as a cost-cutting measure in the overall design. However, because there is no tactile feel when these circuits are actuated, there is often a sound or light component put it place to indicate activation. Depending on the device and the design, electronic shielding techniques may also need to be incorporated.

Advantages	Disadvantages
• Smaller Number of Components • Affordability • Long Lifespan (up to 1 million actuations)	• Less Trace Precision (1 mm minimum pitch) • Less Design Flexibility • No Tactile Feedback

GRAPHIC OVERLAY:

The overlay is the top layer of a membrane switch and is the interface between you and the machine. The overlay creates the look and feel for your product. Graphic overlays can be made of polycarbonate, polyester or acrylic materials in various gloss levels, textures, pencil hardness and gages to meet your needs.

CIRCUIT SPACER:

Non-tactile membrane switches can be designed with a wide range of actuation forces. The actuation force is determined by the circuit spacer thickness. The thicker the spacer, the more actuation force is required. Conversely, the thinner the spacer, the less the actuation force. If required, a non-tactile membrane switch can be designed as thin as .021".

ADHESIVES:

Selecting the proper adhesive for a membrane switch application requires consideration of environment, surface, appearance and other performance requirements.

Surface contact is fundamental to adhesive performance. The strength of the bond is determined by the surface energy. High surface energy materials (like an un-waxed car) are very easy to adhere to. For low surface energy materials (which are more like a highly waxed car), special adhesives with flow agents are typically required to enhance both the initial bond and the long-term hold.

Other factors to consider when selecting an adhesive technique include whether the surface is textured or smooth, flat or curved, and painted or unfinished.

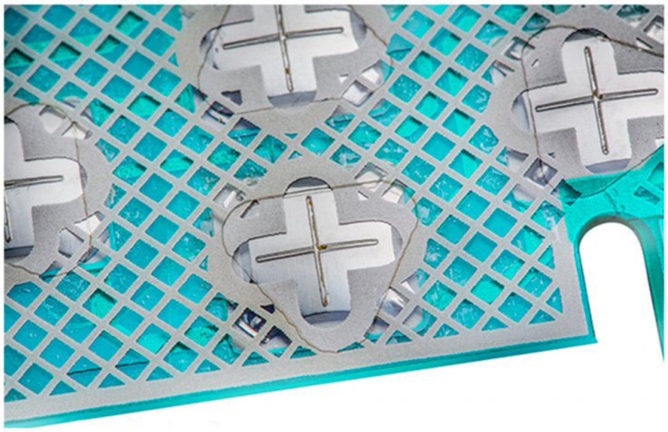
NON-TACTILE SWITCH *(continued)*

SILVER PET:

The circuity in this simplest of membrane switches typically consists of conductive silver screen-printed onto an underlying flexible surface, such as polyester. This approach is very simple, which makes it easier to design and produce, and therefore less expensive than copper flex or PCBA circuit layers.

When printed on .005 polyester, conductive silver ink's resistance range is <10 ohms to 100 ohms with a rating of 30 volts DC. These electrical properties are a key factor when determining whether screen-printed silver will be suitable for your specific project since silver-printed circuits are for low-voltage applications only.

Different conductive and dielectric inks are available to help engineers specify and manage these electrical properties more precisely.



SHIELDING:

A good membrane switch manufacturer can recommend and design the proper shielding to meet your ESD, EMI, or RFI requirements.

Most use two methods for shielding membrane switches: 1) copper or aluminum foil with or without laminated polyester to the second surface, or 2) screen printed conductive silver ink in a grid or complete coating on the first surface.

There are three common methods for grounding shields: 1) a tab can be attached to a stud or standoff on the metal backer or the metal enclosure, 2) the shield can be terminated into the pins of the membrane switch tail, or 3) the shield layer is wrapped around the membrane switch and ground to the enclosure.

TACTILE FEEDBACK

Tactile membrane switches incorporate a metal dome or a polydome into the membrane assembly to achieve a desired tactile response. By using different materials and sizes for these domes, you can vary the actuation force required to activate the switch. An additional adhesive layer – called the dome retainer – is placed just under the graphic overlay to hold the dome in place.

Advantages	Disadvantages
• Excellent Tactile Feedback • Variety of Shapes and Sizes • Variety of Actuation Forces • Long Lifespan (up to 1 million actuations)	• Higher Costs than Non-Tactile Switches • More Components to Manage

GRAPHIC OVERLAY:

For tactile switches, the material selected is determined primarily by lifespan requirements.

If you have an application that requires < 50000 actuations, polycarbonate is a good option; otherwise polyester is the material of choice. Life cycle tests show that polyester can be actuated over 1,000,000 times in a tactile switch without showing signs of wear.

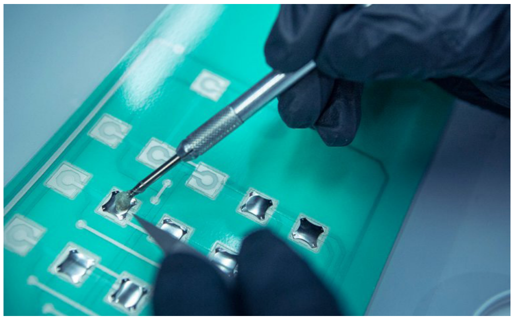
For good tactile feedback in a membrane switch, choose an overlay thickness between .006 and .010. These thickness ranges will offer the durability to meet your requirements, with the sensitivity to provide a quality tactile effect.

METAL DOMES:

Metal domes come in a large variety of shapes and sizes, with actuation forces between 180 to 700 grams. 340 grams is the most common.

Metal domes are typically stainless steel, and are nickel-, silver-, or gold-plated. The selected plating depends on the conductivity requirements of the switch, chosen based on electrical resistance. Nickel is the standard, while gold drives down the resistance. Most screen-printed silver circuits are paired with metal plated domes. Gold plating is typically reserved for copper flex or PCBA-based designs.

Another factor that can determine the plating choice is the need to match the material of the underlying circuit. For instance, gold on gold is a common approach to optimize electrical performance.



POLYDOMES:

Softer and quieter than metal domes, plastic polydomes are another option for engineers to create a desired tactile experience.

To make a polydome, a layer of polyester is screen printed with silver “shorting” pad, and then it is thermo-formed into a dome. This also allows you to create multiple buttons across a single panel, and it is a very cost-effective technique for high-volume switches (after the cost of the initial tooling).

COPPER FLEX CIRCUITRY

Unlike screen-printed silver, copper flex circuits are manufactured by laminating copper to an underlying substrate, and then etching that substrate in a way that leaves specific conductive traces. This is a more rigorous process than screen-printing, but it results in a more flexible, more durable, and more precise circuit. In addition, the base material of copper flex circuits is polyimide – a very high temperature substrate that allows you to surface mount components such as LEDs, resistors, and light sensors.

Advantages	Disadvantages
• Compact Design • Better Electrical Tolerances (less resistance) • Visual and Audible Feedback • Automation Opportunities	• More Advanced Design • Higher Manufacturing Demands • Higher Costs • Copper Flex Circuits are Typically Sourced "Off-Shore"

BASE MATERIAL:

The typical base material for a copper flex circuit is .001", .002", 0..3" and .005" polyimide or polyester. Unlike silver flex (which uses a conductive epoxy), these materials will hold up to the robust solder required to attach components.

COPPER FLEX:

The copper can be either .50z, 1.00z, or 2.00z RA or ED copper.

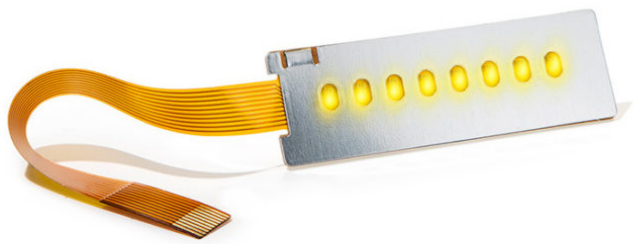
One of the key advantages of copper flex circuitry is the precision it gives engineers when managing the size and space (or pitch) between the conductive traces. With silver, the minimum pitch is 1mm. Meanwhile, the minimum trace width for copper flex is .004" with a pitch of .004". This becomes critically important in compact devices where swithc size must be as compressed as possible. It is also important when a small connection must be made on the mating PCBA, since surface area is always at a premium on small "mother boards".

Another advantage of copper flex is its ability withstand bending and creasing. This allows engineers to design extremely compact switch assemblies, leveraging flexible circuits and complex, intricate paths to solve what would otherwise be insurmountable interconnection challenges. The result is reduced weight, reduced size, and reduced overall thickness.

EMBEDDED COMPONENTS:

To enhance user feedback, membrane switches are often designed with (but are not limited to) embedded LEDs, light sensors, and resistors. These surface-mounted components can be adhered to the circuit layer with conductive epoxy and encapsulated with a UV cured polyurethane.

However, if copper polyimide circuits are being used, the components can be soldered into place, for a much more durable result. This becomes a significant advantage in manufacturing, as you can automate the application of solder and parts with pick and place methods.



BACKLIGHTING TECHNIQUE

Designing the right backlighting technology into a membrane switch assembly can help deliver a superior user experience. A wide variety of backlighting options are available, allowing engineers to precisely manage light quality, color, intensity, and coverage, so it is important that your selected switch manufacturer understands the advantages and disadvantages of these different techniques.

Advantages	Disadvantages
• Low Cost • Low Power • Highly Reliable	• Single-Point Light Sources

EL LAMPS:

Solid-state electroluminescent (EL) lamps produce light by charging phosphors with AC/DC current. They are highly efficient and provide an extremely even appearance. In membrane switch assemblies, EL lamps are typically implemented as a panel just beneath the graphic overlay. They do require an alternating current source, so they are not appropriate for all applications. However, in devices that already feature inverters, EL lamps can be an ideal backlighting option.

Advantages	Disadvantages
• Extremely Thin • Low Heat Throw • Even Visual Appearance	• Power Inverter Requirements

BACKLIGHTING TECHNIQUE *(continued)*

FIBER OPTICS:

By shining an LED through optical fibers, engineers can illuminate very specific parts of a membrane switch. This precision, combined with the low cost and low temperatures associated with fiber optics, make this a preferred technique for many applications. However, depending on the number of fibers that are brought together at an LED, there can be a bulky pigtail. To overcome this physical limitation, many designers will specify woven, fiber optic pads. These can be expensive, but they result in a compact, low-power highly controlled backlighting result.

Advantages	Disadvantages
• Cool Temperatures • Low Power Requirements • Even, Flexible Appearance • Beautiful Light Quality	• Potentially Bulky Pigtail • Potentially More Expensive

LGL:

With LGL – Light Guide Layer technology – a light-diffusing plastic material is used to evenly backlight broad areas with LED sources. LGL is more cost-effective than woven fiber optic pads. However, more LEDs are required to achieve the same backlighting effect, so while LGL can be a very good choice for high-volume, low-cost applications, this approach does require more components. Manufacturing automation can become a critical deciding factor when implementing LGL technology.

Advantages	Disadvantages
• Lower Cost than Fiber Optics • Even Lighting • Compact Design	• Requires More LEDs • Requires Surface Printing of “Black Out” Areas to Channel the Light Appropriately

SILICONE-RUBBER KEYPADS

More complex user interfaces require higher-density, more miniaturized components. In these situations, printed circuit boards (PCBs) and printed circuit board assemblies (PCBAs) are often brought into play. A wide range of layers and thicknesses are available, allowing engineers to address a wide range of design requirements. When combined with custom-molded, silicone-rubber keypads, the result is a unique and reliable user experience.

Advantages	Disadvantages
• High Component Density • Multi-Layer Electronics Available • Enhanced Electrical Performance • More Design Control • Rigid Design	• Requires Manufacturing Expertise • Not Flexible • Typically Thicker • Requires Gerber Files and a B.O.M. • Typically More Complex Design

PCBAS:

Printed circuit board assemblies (PCBAs) can be single or multiple layers (up to 16 layers typical).

Using PCBAs in the membrane switch assembly affords many advantages to design engineers. Unlike a simple membrane switch featuring a tail that plugs into a device's motherboard (which are always starved for real estate), PCBA-based switches provide another platform for electronics.

These secondary boards can be used to offload a portion of the circuitry to the switch, with the top layers of the board reserved for the interface and the bottom layers reserved for the product. Conversely, the PCBA in the switch can house all of the necessary electronics, eliminating the need for a motherboard altogether.

The typical base material for PCBAs is FR4, CEM-1 or CEM-4. A wide range of thicknesses are available, ranging from .020" to .13". Depending on the materials and thicknesses selected, PCBAs can help provide back panel support, in addition to providing a base structure for components and circuitry.

Minimum trace width for gold .003", and for hot air leveling .006". Plating thickness dependent on material can either be 1 micron to 25 microns. Plating options include copper, carbon, nickel or gold.

SILICONE-RUBBER KEYPADS:

These keypads help to deliver unique tactile feedback and a distinctive visual appearance. They can be custom-molded in different shapes, patterns, and colors to support user-friendly backlighting options.

Silicone-rubber keypads are ideal for industrial environments, where a bold look and a more rugged, robust interface is required. With the correct design features, they allow you to completely seal a product from moisture, dust, and other environmental conditions, and they can also provide a level of vibration resistance.

ENVIRONMENTAL CONSIDERATIONS

DURABILITY:

Membrane switches need to be reliable for years, all the while being used on a daily or even hourly basis. This requires active and purposeful design for lifetime actuation.

The balance between visual and tactile qualities and the need for ongoing durability can be a significant challenge, particularly when paired with ever-present budgetary constraints. By working with experienced membrane switch designers and manufacturers, engineers can leverage this supply chain expertise to optimize components to address this requirement.

MATERIALS SECTION:

Because of their many applications, membrane switches need to withstand a range of environments. Dirt and grime, moisture, and chemical cleaners can all take their toll.

By using polyester materials for the top layer graphic overlay, you can maximize environmental durability and chemical resistance. However, polyester's dimensional stability also makes it difficult to form, so visual embellishments like raised buttons and embossing can be difficult to execute.

Polycarbonate is easier to work with, but it is not as durable as polyester, so instead many manufacturers are opting for blended materials. These combinations of polyester and polycarbonate can help engineers address visual and environmental requirements across a range of dimensions.

WEATHER SEALING:

Depending on the application, membrane switches can be exposed to a range of adverse weather conditions. In these situations, the ability to seal and protect internal components from moisture becomes critical.

A variety of construction options are available (3M HV tapes, custom-designed solid gaskets, etc.) that allow engineers to design interface assemblies that meet a range of different environmental standards. For instance, membrane switches can be developed to meet IP sealing standards, to handle submersion testing applications, or to support NEMA closure requirements.

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VISUAL CONSIDERATIONS

COLOR MANAGEMENT:

Color matching is of critical importance to brand owners.

Choose a vendor that has a computerized color formulation system to achieve consistent results from printing to printing. Good suppliers can color match to the Pantone Matching System, Federal Standard Guide, a color swatch, or to your bezel. Calibrated light booths and/or digital densitometers are then used to inspect and measure results to ensure conformance.

The colors on the overlay are screen printed, digitally printed, or a combination of both, applied on the backside (sub-surface) of the clear overly material. The thickness of the overlays protects the graphics from the environment and operator wear. Selective textures and window clearing agents are printed on the first surface and UV cured to produce a very durable finish. They can also be used to create some very cool graphic enhancements.

INKS & FINISHES:

By implementing different material finishes and ink technologies, manufacturers can create visual impact and differentiation via unique textures and colors.

Surface finishes can be created by selecting appropriate materials and treatments, which provides a great deal of design freedom. Manufacturers with the latest digital printing technologies can reproduce photographs onto surface materials, allowing engineers to specify most any type of background pattern. If you can think it, digital can print it.

Inks can add another dimension to the visual appearance, and a variety of colors, tones, and reflective qualities are available to create the ideal user experience.

EMBOSSING:

Embossed features can dramatically enhance the look and functionality of the graphic overlay. There are three basic styles of embossing, pillow, rim and dome embossing. Depending on shape and size, logos and multi-level shapes can be embossed.

There are two ways to emboss an overlay. The first method is with male and female magnesium dies. This method is fine for most applications but there are height limitations: embossing height is usually 2 to 2-1/2 times the material thickness, the minimum width of a rim emboss is 0.050", the distance between embossed objects should be .100" and the minimum inside radius should be .005".

Hydroforming is the second method and has more design flexibility, but higher tooling costs.

WHY JN WHITE™?

At JN White™, we have developed deep expertise and experience as a membrane switch supplier – an expertise that our customers have come to rely on when they are trying to design and implement specific user interface objectives. Integrating features like those noted on this page, we design and develop for the most challenging panel assembly applications in the most demanding environments, including medical, electronic, military/DoD, and industrial markets.

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