

MEMBRANE SWITCH DESIGN GUIDE

Version 1.2 | 31-Aug-2023



SYSTEM LABEL



INTRODUCTION

A membrane switch, also known as a keypad or keyboard, is an effective way to create a man/machine interface with your end product whilst retaining all the benefits of a fully printed overlay.

Comprising of a printed circuit layer, front overlay and rear adhesive, the finished membrane is both functional and informative. Combined with the sealed technology of the construction, the membrane switch is an excellent solution when environmental factors are a concern.

OVERLAY MATERIAL

The two most common materials used are polyester and polycarbonate and are available in a variety of thickness and finishes. These materials are clear in their raw state and the graphics are usually printed on the reverse face (sub-surface printing) which allows for the material texture to be retained as well as give added protection to the print. Selective surface textures can be printed on the front face (top-surface printing) of the material to allow for clear LED/LCD windows.

Polycarbonate is the most common overlay material for a number of reasons including its ease of processing and cost effectiveness. However the disadvantage of polycarbonate is that it can show signs of wear sooner than other materials under extreme conditions. Life cycle tests have shown that whilst suitable for most applications, it begins to show signs of wear as early as 40,000 cycles. Polyester by contrast shows no signs of wear at 100,000 cycles. Polyester is the material of choice when superior life cycle and chemical resistance properties are required.

ADHESIVE / SPACER MATERIAL

Multi-Color adopts 3M adhesive materials into the majority of our products but with a wide selection of suppliers at our disposal, we can utilise other materials on a case specific basis. Membrane switches are produced by laminating various layers of materials to create a functional composite. Spacer layers are used for circuit separation and are produced using a polyester carrier layer sandwiched in-between two layers of adhesive.

The rear adhesive of a membrane is a critical consideration as with any label as to ensure it adheres to the end product. In most cases, membrane switches are finished with either a 3M 467 or 3M 468 adhesive. Both adhesives have excellent adhesion properties when bonding to metal or high surface energy plastic surfaces. 3M 467 is suitable for smooth surfaces, and 3M 468 with its thicker build is recommended for rough surfaces.

ARTWORK / DRAWINGS

It is recommend to supply artworks electronically and in vector format. Multi-Color can accept a range of file formats including CDR (CorelDraw), AI (Adobe Illustrator) and EPS. We also advise that all files specify colours and dimensions, that any fonts are converted to outlines/curves, and that a PDF file is supplied along with the native file. This will ensure that your approved design transfers to us accurately and without any degradation.

In all cases, Multi-Color will supply artwork proofs in PDF format for customer approval prior to production.



COLOURS

Where possible, colours should be specified using either a Pantone® reference (PMS) or RAL reference as these are internationally recognised colour standards. Multi-Color can provide colour match samples for approval prior to production as it is important to keep in mind that different material substrates can affect the appearance of the colour under different ambient light conditions.

Where the overlay is to be digitally printed, CMYK colour references can also be supplied but please note that exact colour matching using digital print is limited so if an exact colour match is required, we recommending screen print as the optimum solution.

RGB or HEX colour references are not suitable for production as these references are used for on-screen digital content such as websites and do not have direct alternatives to other printable colour standard systems.

ULTRAVIOLET HARDCOATS

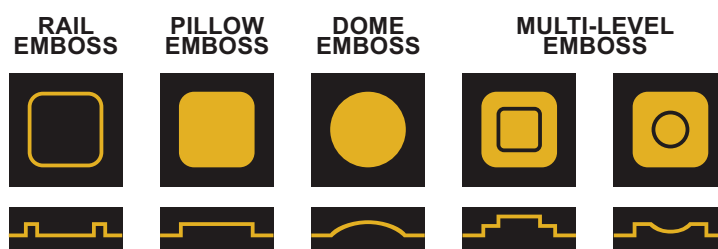
The most durable hardcoats are those that are cured by exposure to ultraviolet (UV) light. Hardcoats can be added to materials by screen printing to selected areas and therefore creating coatings for windows as well as enhancing graphics. Materials can also be supplied with full hardcoats already applied.

EMBOSSING

To give a tactile finish to a membrane switch, the overlay can be embossed to give raised details to the keypad area. There are a number of different styles of embossing but all are primarily used to give the user tactile confirmation that a button is present before it is pressed.

Embossing is typically two-dimensional and on average 0.25-0.50mm (0.010"-0.020") high.

Hydroforming can also be used and can emboss 2-3 times the material thickness as well as incorporating three-dimensional designs however hydroforming tools are significantly more expensive than embossing tools.



DIE CUTTING

Steel Rule: Steel rule dies are normally used to cut and shape the various layers for a membrane switch, especially for larger production runs. Standard tolerances are normally +/-0.25mm (+/-0.010") for critical point such as the outer perimeter and +/-0.50mm (+/-0.020") for non-critical details.

Laser and CNC Plotter Cutting: Various layers of the membrane switch can be cut using CNC processes such as laser or plotter cutting and are particularly suited to lower volume runs or prototype runs.

PINOUPS

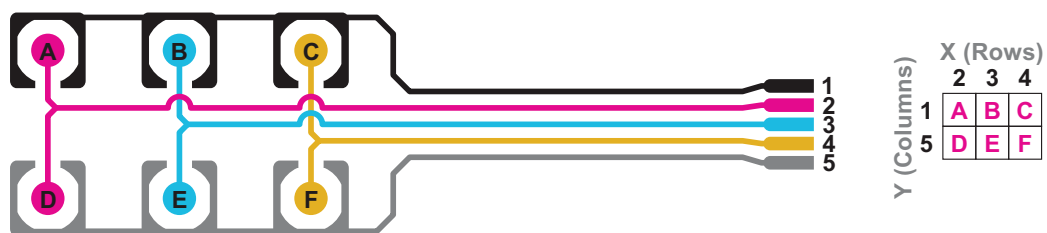
It is advisable that the customer specifies the schematic or pinout requirements of the circuit at the start of the project. This is to ensure compatibility with the end product that it will be connected to as to ensure a smooth integration of the membrane switch.

Membrane switches can be designed using either a common bus or matrix layout.

Common Bus: Mapping the circuit for this layout type uses one common track (ground) for all switch locations. Each switch has a single isolated track that completes the circuit with the common track. The advantage of this layout is that only one print layer is required to complete the full circuit. The disadvantage is the increased



Matrix: Mapping the circuit for this layout type uses tracks that run in both the "X" (rows) and "Y" (columns) direction. The advantage of this is that less tracks produce a greater number of connections which in turn reduces the pinouts and connector size. The disadvantage is that multiple print layers are required to produce



ESD/RFI/EMI SHIELDING

Many options are available for shielding membrane switches. A layer of conductive carbon or silver can be printed over the top of a circuit to create a shield or aluminium foil can be used. Carbon shields can be less expensive than silver shields. A printed grid pattern can be used to reduce cost and can be terminated to the circuit tail. Aluminium foil is the most conductive shield available, however, it adds an additional layer to the membrane switch construction and will require a separate tail for ground connection.

CIRCUIT INKS

In order to function the circuit layer of the membrane switch requires an electrical path and contact points. A screen printed silver-filled ink is typically used in printing membrane switches. Silver is the most commonly used because the resistance is low and the oxide is conductive. Carbon inks can be used as a substitute where the customer's specification allows for a higher resistance. However, more often carbon is used as an overprint of the silver to reduce the change of silver migration and sulfur attack.



BACK-LIGHTING

There are a number of different solutions for viewing legends in low or no light environments. The most common backlighting methods used are EL (Electroluminescent), Fiber Optics and LEDs. Multi-Color can assist you in determining which solution works best for your application.

TAIL EXIT POINT

Flexible membrane switches are connected by way of a flexible tail that is cut from the circuit layer. The tail can be designed to almost any length and shape to suit the end application and installation, but cannot exit under or within 5mm (0.200") of the active keypad area.

CONNECTIONS

The flexible tail that exits the membrane switch usually has a single row of pinouts with a pitch of 2.54mm (0.100"). This tail can then be connected to a circuit board with a suitable single row connector designed for flexible circuits, or designed to interface with a ZIF (Zero Insertion Force) connector. At Multi-Color, our standard construction is to use Nicomatic Crimpflex® connectors onto the flexible circuit.

The use of a ZIF connector offers the lowest cost as it does not require any additional connector to be crimped to the flexible tail. Instead, the membrane switch is designed with exposed contact pinouts at the end of the tail. The customer then inserts the tail in to the ZIF connector fitted to their circuit board. When using a ZIF connector, it is important to specify either the specific connector being used, or the requirements of the connector or tail end.

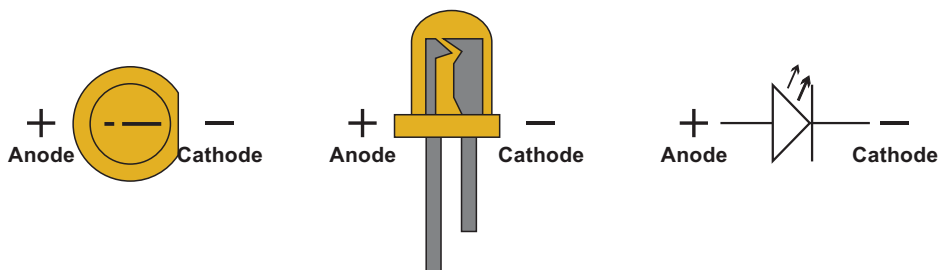
The most common approach for thin-film connections is by using Nicomatic Crimpflex® male and female pins.

LEDs (LIGHT EMITTING DIODE)

A light emitting diode (LED) is a semiconductor diode that emits incoherent narrow-spectrum light when electrically biased in the forward direction of the p-n junction, as in the common LED circuit. This effect is a form of electroluminescence.

It is common to include small surface mounted LEDs into membrane switches. A standard membrane switch is normally not thick enough to accommodate the package size of a surface mounted LED. The overlay therefore may need to be embossed or extra filler layers added to the membrane switch construction.

It is very important for the engineering group to receive drawings showing how the LED's interface with the

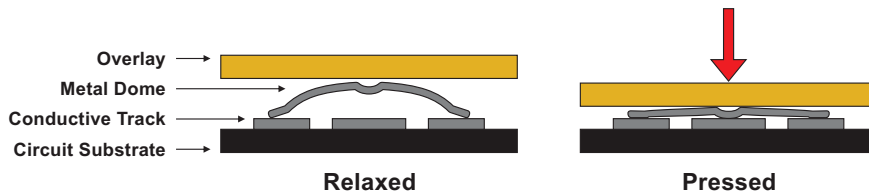




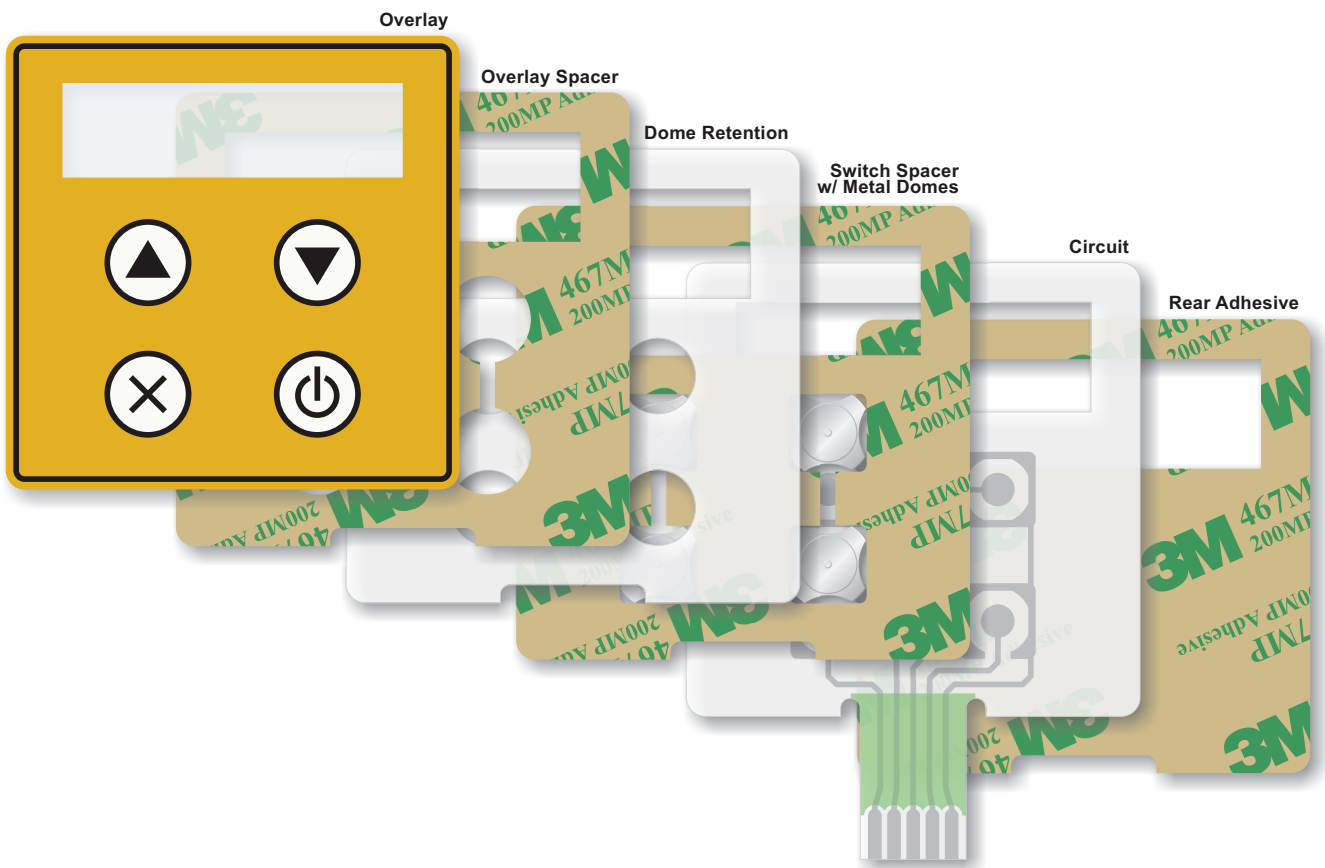
SWITCH TYPE

Tactile: In order to provide a tactile feedback to give the user physical confirmation of button actuation, stainless steel domes are used. These come in a range of sizes, shapes and actuation forces and Multi-Color can assist you in choosing a suitable dome to meet your requirements.

The stainless steel domes are momentary switch contacts that, when used in conjunction with a printed circuit board (PCB), flexible circuit of membrane switch assembly, become normally-open tactile switches. To function, the metal domes are placed within the membrane construction in contact with the circuit layer and are supported by an adhesive spacer layer. In their relaxed state, the legs of the metal dome rest on the outer edge



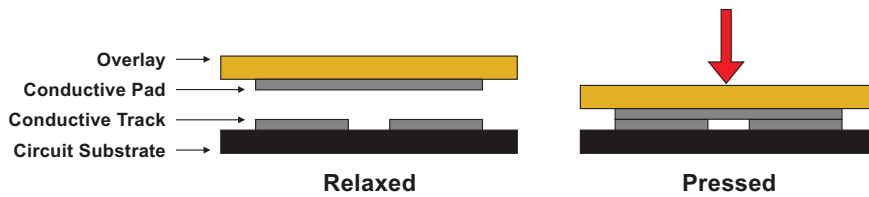
Typical Membrane Construction - Tactile:



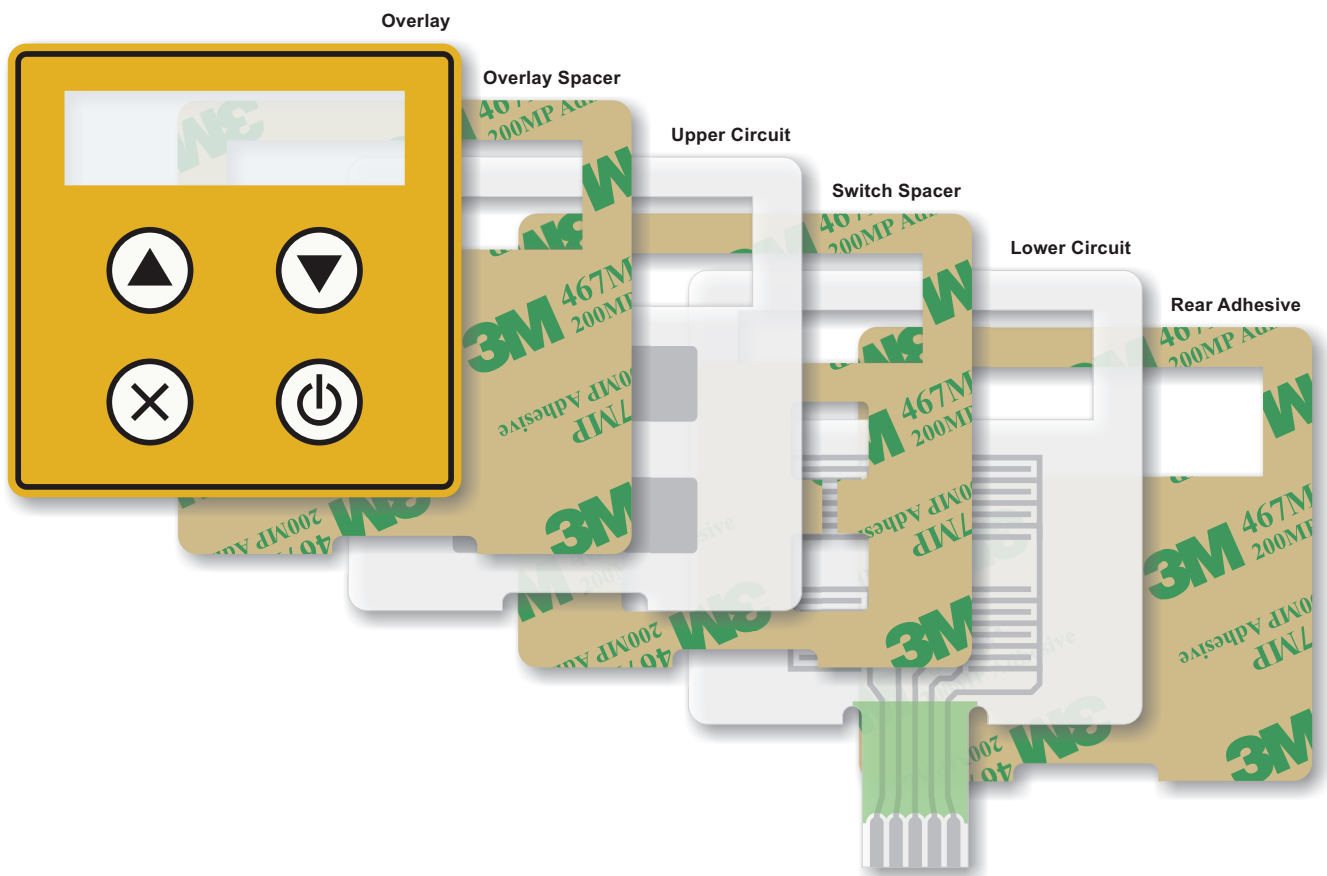


SWITCH TYPE

Non-Tactile: The non-tactile switch design is more reliable and has a longer life cycle but requires separate feedback to the user to confirm activation such as a light, sound or change in a visual display. This construction offers an efficient design option regardless of the key density.



Typical Membrane Construction - Non-Tactile:



INSPECTION

Multi-Color carry out full 100% testing of all membrane switches including individual button testing as well as visual inspection. Membranes which pass inspection are labelled accordingly on the rear of the flexible tail.

PROTOTYPES

A prototype is a cost effective method to test and validate your membrane design with minimum investment in tooling and production costs. At Multi-Color we understand that designs can change after prototyping so with our ability to digital print overlays and CNC cut the membrane layers to design, we can keep costs to a minimum and provide significant savings.



COMMON OVERLAY MATERIALS:

Material	Suitable for Outdoor Use	Type	Hardcoated Finish	Embossable	UL Flammability Rating	Thickness	
Autotex-7 V	No	Polyester	Yes	Velvet	Yes	94VTM-2*	150 - 200mics
Autotex-7 F	No	Polyester	Yes	Fine Matt	Yes	94VTM-2*	150 - 200mics
Autoflex EBG	No	Polyester	Yes	Gloss	Yes	94VTM-2*	130 - 250mics
Autoflex EBA	No	Polyester	Yes	Antiglare	Yes	94VTM-2*	130 - 250mics
Autotex XE V	Yes	Polyester	Yes	Velvet	Yes	94VTM-2*	150 - 200mics
Autotex XE F	Yes	Polyester	Yes	Fine Matt	Yes	94VTM-2*	150 - 200mics
Lexan 8010	No	Polycarbonate	No	Gloss	Yes	94VTM-2 / 94V-2	175 - 750mics
Lexan 8B35	No	Polycarbonate	No	Velvet	Yes	94VTM-2 / 94V-2	125 - 500mics
Lexan HP92	No	Polycarbonate	Yes	Gloss	No	94HB	175 - 750mics
Lexan FR63	No	Polycarbonate	No	Fine Matt	Yes	94V-0	250 - 750mics
Lexan FR65	No	Polycarbonate	No	Velvet	Yes	94V-0	250 - 500mics

*UL rating is recorded on base material

ELECTRICAL / MECHANICAL SPECIFICATIONS:

Electrical:

1. Configuration - Momentary SPST normally open
2. Current Rating - 30V - 100MA to 120V - 10MA maximum
3. Breakdown - 220 V RMS
4. Closed - 100 Ohms typical contact resistance
5. Open - 10 MEG Ohms contact resistance
6. Capacitance - 30 Picofarads
7. Life -
 - a. Flat Switch - approximately 5 million cycles
 - b. Domed (embossed) layer - approximately 5 million cycles
 - c. Domed circuit - approximately 1 million cycles
8. Contact Material - Silver or Silver/Nickel alloy. Only high quality conductive silver ink. Low quality silver may not last as long and may contribute to silver migration (the tendency of silver to spread or 'creep' especially when exposed to moisture).

Typical Switch Specifications - Electrical

	Non-Tactile	Tactile Metal Dome
Current Rating	28 VDC at 30mA	28 VDC at 30mA
Contact Resistance	<200 Ohms	<200 Ohms
Contact Bounce	<10 ms	<10 ms

Mechanical / Environment:

Typical Switch Specifications - Mechanical

	Non-Tactile	Tactile Metal Dome
Key Travel	0.35mm (0.014")	0.60mm (0.024")
Actuation Force	28-280 grams	220-420 grams
Life Cycle (up to)	5,000,000	5,000,000

Typical Switch Specifications - Environmental

	Non-Tactile	Tactile Metal Dome
Operating Temperature	-5°C to +65°C (-22°F to +150°F)	-5°C to +65°C (-22°F to +150°F)
Storage Temperature	+22°C (+72°F)	+22°C (+72°F)
Storage Life	1 Year	1 Year

GLOSSARY

Abrasion Resistance - The degree to which a membrane switch is able to withstand surface wear.

Actuation - This is the action of working a switch.

Actuation Force - The pressure required to collapse the walls of the dome on a polyester, rubber or metal keypad.

Adhesion - The molecular attraction of one material to another. The strength of the bond is determined by the surface energy in each material.

Backing Rear Adhesive - An adhesive applied to the back of a membrane switch for mounting purposes.

Breakdown Voltage - The minimum voltage at which the insulation between two conductors is destroyed.

Carbon Graphite Inks - The type of ink that consists of prepared suspensions of carbon black and is frequently printed over silver circuitry to diminish the potential of migration of silver. These are used for lessening costs when the conductivity of the metal base system is not necessary.

Conductivity - A material's ability to allow electrons to flow.

Cross-Over - A conductor intersection insulated by dielectric material. Also referred to as a "Bridge".

Dead-Front - A cosmetic feature of a graphic overlay in which a button or graphical element is only visible when backlit.

Dielectric - An insulating or non-conducting medium.

Dielectric Inks - Used for printing protective patterns on conductive print to isolate selected regions from electrical contact with other conductors. This is used for cross-overs and tail insulation on membrane switches.

Dome Cover / Dome Retention - A material layer made to hold metal domes in position within the keypad.

EL Lamp - A slender device that illuminates large areas, typically used in LCD membrane switch backlighting and control panels.

Embedded LED - Procedure of integrating a surface mount LED into a membrane switch assembly.

Emboss - A way to supply a raised characteristic to accentuate key surfaces through mechanical and thermoforming of graphical features. This also permits and embedding of a surface mount of an LED inside the switch.

Graphic Keypad - Control keypads that use graphics for button functions for navigation on machines or process operations. Typical graphics include arrows or symbols indicative of a machine process or operation.

Internally Vented - Switch openings connected to one another to seal the switch from moisture and other contaminants..

Key Height - A measure of the distance from the highest point of a key to the base of the keypad.

Light Emitting Diode (LED) - Embedded in membrane switch layers to illuminate the button or graphical detail.

Moisture Resistance - A material's ability to resist the absorption of water from the air or during complete submersion.

Overlay - The decorative front layer of a membrane switch or control panel.

Pillow Emboss - Creating a raised surface in the graphic overlay over the key area.



SYSTEM LABEL

**FOR ALL YOUR MEMBRANE NEEDS,
CONTACT US.**



+353 (0)90 6630900

info@system-label.com

www.system-label.com

System Label, IDA Business & Technology Park,
Racecourse Road, Roscommon, Co Roscommon, F42 P290, Ireland

