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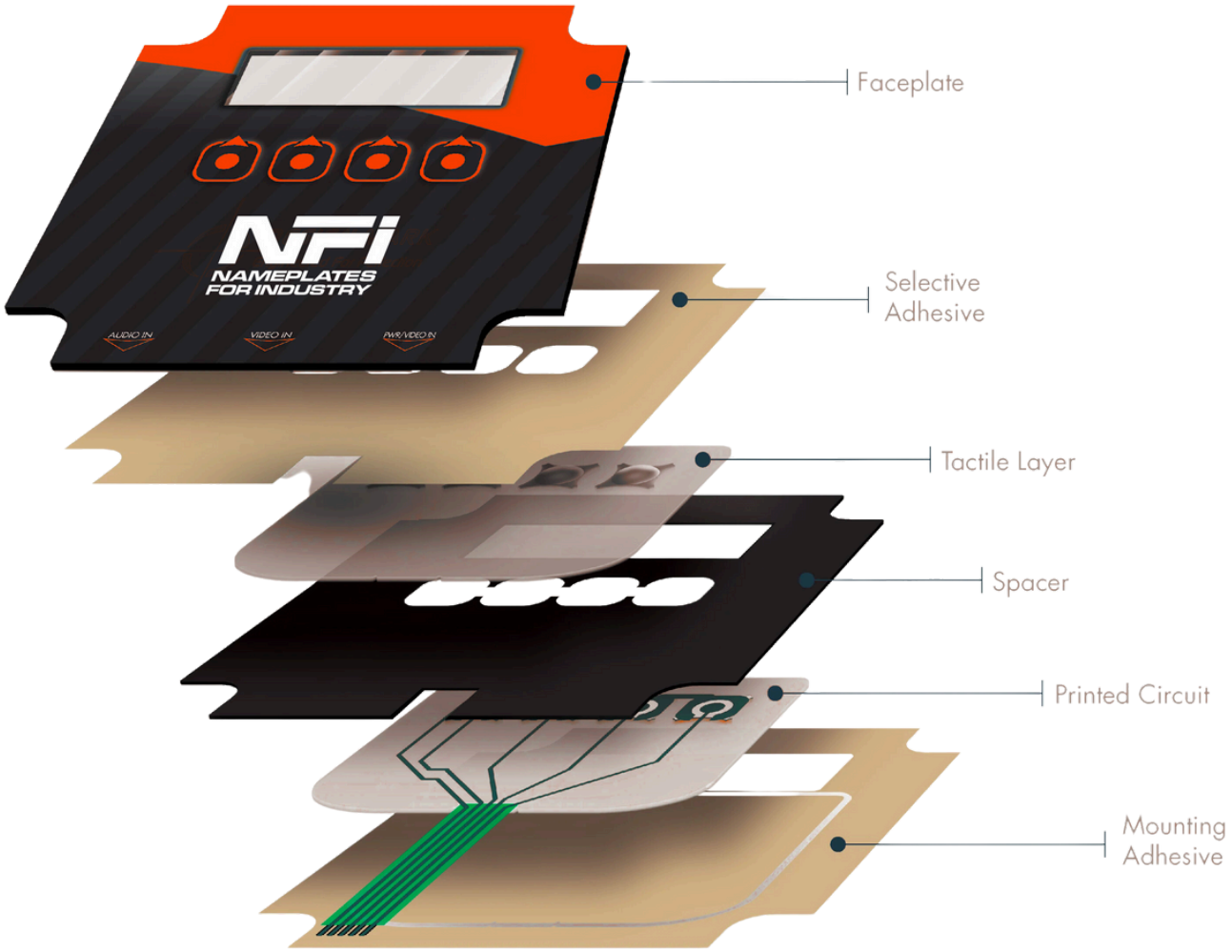



# MEMBRANE SWITCH

## DESIGN GUIDE

# INTRODUCTION

A membrane switch is a touch sensitive device created by the printing, cutting, and laminating of precision thin film plastic materials. Low-voltage, low-current momentary electrical contact is made and retained by applying finger-tip force to the front surface of the switch.

Membrane switches are primarily utilized with microprocessor based control systems found in medical, communication, instrumentation and appliance products.

In applications, where trouble free operation, ease-of-use, graphic appeal and reliability are important, you'll find NFI Corp switches in use over and over again.

This guide should provide you with necessary design criteria to determine the suitability of a membrane switch for your product. Once that is established, you will be able to cost effectively design for the process while achieving the best possible results.

There are **four sections**. The first describes the various **types** of **membrane switches** and common design guidelines.

The second section is **User Interface** and encompasses the visual portion of the switch. This is the interface between the user and the display or circuit functions.

**Equipment Interface**, the third section, explains circuit design and assembly options.

The guide closes with **membrane switch specifications** and the information needed to obtain pricing.

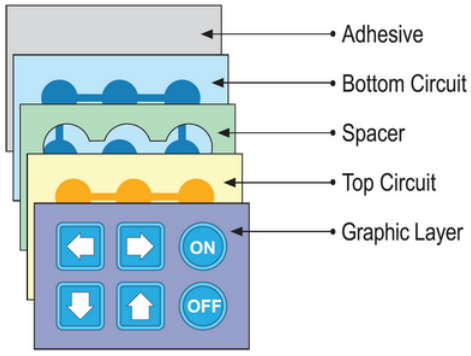
Our designers are on tap to work with your designers to create a product enhancing graphic and engineered switch that will meet the demands of today and tomorrow. NFI Corp boasts a rapid development cycle and welcomes the challenge of tight schedules or special job requirements.

# TYPES OF MEMBRANE SWITCHES

## Non-Tactile Membrane Switches

The most reliable and economical membrane switch is the non-tactile type; however, they do not give the user direct feedback from the switch. Using a sound beeper, LED indicator, or display change can sometimes overcome this drawback.

Non-tactile switches also have the advantage of easily creating custom shapes and sizes of the active keypad areas. The standard maximum size (although large switches may become more sensitive) is approximately 8 square inches and the minimum is a .25" nominal diameter.



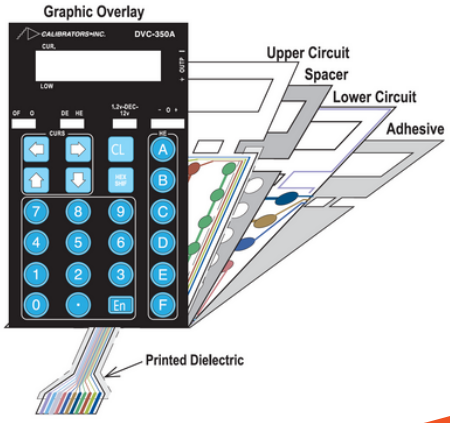

## Tactile Membrane Switches

Tactile membrane switches have a snap action that is clearly noticeable to the operator. Conductive stainless steel snap domes have the best action. They can also eliminate the need for a flexible upper circuit layer.

Formed polydomes offer a milder tactile response and a narrower operating temperature (up to 55°C/131°F) range than a metal dome.

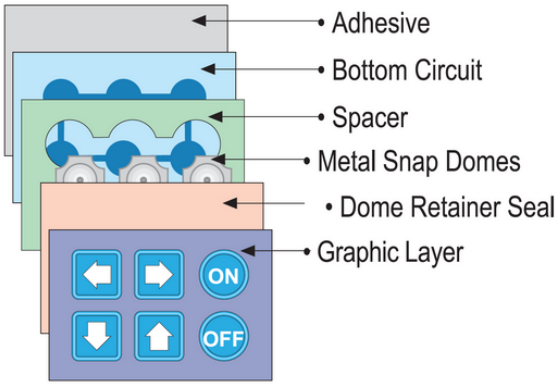
However, a cost savings can be realized when quantities, or the number of individual switches, are large.

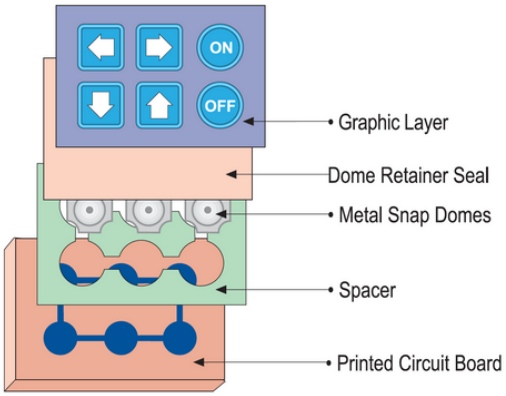
Generally, the active area of a tactile switch is limited to a .50" maximum diamater.



## Mixed Panels

Non-tactile and tactile switches can be mixed in the same panel. This can be desirable when a large active area is needed for a particular switch or perhaps hidden maintenance or programming switches.




## PCB Backed Membrane Switches

A printed circuit board can be used for the lower circuit. The board can provide structural support and incorporate numerous surface mount components.

NFI Corp can provide the overlay and snap dome array, but does not manufacture rigid printed circuit boards. This assembly can be bonded to your PCB or sub-contractors can be utilized to provide this type of construction.

### Designer Elements

- Use non-tactile keys for maximum reliability and when fast data entry is required. Use tactile keys for discrete operation
- A .10" minimum between any 2 active areas should be allowed
- Keypad graphics can be .20" larger than the active switch area
- All switches should be at least 25" from a panel edge
- Group switches with similar functions together by color or location
- Avoid positioning more active switches in potentially awkward locations
- Avoid obscuring a display when a switch is operated

# USER INTERFACE

## The Graphic Overlay

The appearance of the graphic overlay is integral to the operator's view of the equipment.
Designing for the limitations of the printing process while taking advantage of all that the process has to offer is the best approach.

Nearly any colors can be produced, including 4-color process reproductions. The next section explains some of the matching limitations and offers a few general guidelines. The finest line (or space between lines) that can be effectively printed is a .006" thickness. The maximum line screen is 230 LPI (lines per inch) for graduated halftones and process printing.

Please see the sections on material selection and selective texturing for the specific plastic specifications and surface finishes available. It's typical for the graphic overlay to be made slightly larger than the circuit layers. This will hide minor assembly variations at the edges of the panel.

# Color Matching


Sub-surface graphic production is done on the underside of transparent plastic materials through which the design is viewed. While the plastic does protect the printed image, its thickness and texture also affects the final color appearance. Colors printed behind other colors, may also affect their final appearance.

Matching precisely to a molded plastic case can be difficult due to the different pigments and light refractions encountered, especially batch-to-batch. Designing for complimentary contrast rather than seeking an exact match is a far better approach. When necessary, it's better to match to a component directly instead of communicating through PMS or other systems.

A spectrophotometer, for accurately measuring color, is oftentimes used for process control. Normal matches are considered to be within a 2.5 Delta unit LAB (an international color measurment system) difference. At a higher cost, exact matches within a 1 Delta unit difference can usually be accomplished.

The advent of digital imaging enables the use of CMYK (4-color process) printing to create full-color designs, gradients, and blends as well as enabling photographic images to be effectively utilized. Unique images that enhance the appearance and functionality of your product can be readily created.

A CMYK graphic.

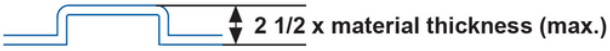
## Designer Elements

- Avoid fine serif typefaces and lines less than .006" thick
- Design for contrast rather than exact matches and allow for color tolerances when possible
- Hide color bleeds or traps behind borders or lines of a darker tone
- Use dark borders or colors around LEDs or dead front graphics to avoid color and light spread

## Embossing

Embossing is a process that raises the surface of the graphic overlay to emphasize the active key area. Accurate finger location is provided but long term flex life may be shortened.

Male and female die sets are used in conjunction with heat and/or pressure to form the plastic. The maximum recommended emboss height is 2-1/2 times the graphic material thickness (measured from its base).

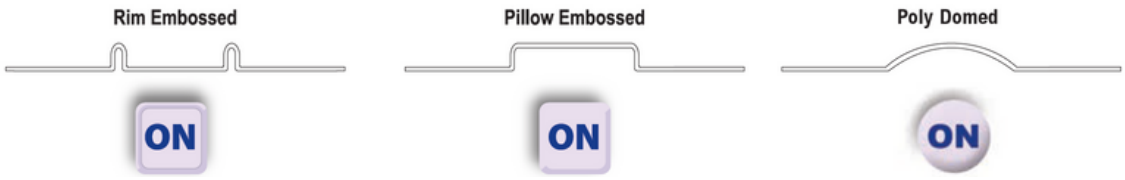



The two most popular profiles are **RIM** and **PILLOW** embossing. The perimeter of the key is raised with rim embossing whereas when pillow embossed, the entire key is raised.

Embossing can be used with either tactile or non-tactile switches, although pillow embossing alone does not give a tactile response.

To avoid excessive stressing of the material, an inside minimum radius on all corners of .040" is necessary.

Braille characters can also be formed with the embossing process.




NFI Corp has developed a simulated rim embossing that can be accomplished without tooling, via thick film screen printing.

## Designer Elements

- Allow 125* between pillow embossed buttons and 20* between rim embossed buttons
- Embossing should be inset at least 25" from panel edges
- Avoid large clusters of keys at one end with only a few singles at the other end

## Display Windows

Integral display windows and LED indicators can be easily incorporated into the membrane switch design.

Single point and block LEDs have the least limitations. They will perform well with any of the material surface finishes; however, for greater diffusion, a matte or textured surface finish is preferred. LEDs cannot come through the active area of a tactile switch, although graphically they can be made to appear as a part of the switch.

Integral (surface mounted) single point LEDs can be mounted onto the bottom layer lower circuit. A wide range of colors, including bi-color, are available. Termination can be provided from the same connector tail as the switches, (if the graphic layer is embossed) to accommodate the LEDs. The graphic does not need to be embossed if the LED termination is provided on a separate tail.

Digital windows can be designed to enhance the specific display that will be used. Texture will distort the appearance of displays that are not directly against the overlays. Matte and gloss finishes work best. Translucent filtering inks can be printed to improve a display's appearance.

For an LCD, the window will remain un-colored. The matte (anti-glare) finish is more scratch resistant than the gloss (clear) finish but may diffuse displays further than .060" away.

A red LED display's appearance will be improved with the addition of either a RED (NFI Corp #265) or SMOKE GRAY (NFI Corp #285) color. Use red to achieve higher readability in low light conditions or smoke gray when used in brighter conditions or with other colored LEDs.

The concept is the same with Green or Yellow (amber) LEDs. Use GREEN (NFI Corp #280) or AMBER (NFI Corp #270) yellow filters, respectfully, for low light conditions or smoke gray in brighter conditions.

Vaccum Fluorescent Displays (VFDs) can use blue (NFI Corp #275) for an improved appearance. Legends or words can also be designed for backlighting using the same concepts as display windows. DEADFRONTING (hidden until lit) is an additional option that can be included if the legends are against a dark background.

### Designer Elements

- Mount displays as close to the panel as possible to minimize distortion
- Dimension single point windows 040*- 060* larger diameter than the actual LED for assembly tolerance
- Windows should be larger than the actual lit display but smaller than the display unit's overall size to avoid seeing the chassis and to assure that the full display is seen
- Use selective texturing to diffuse single point LEDs and to avoid distorting digital displays

## Selective Texturing

Selective texturing is a screen-printed application of a scratch resistant surface hardcoat to the front face of the graphic overlay. The purpose is to improve the clarity of display windows or to visually emphasize specific areas.

A textured hardcoat can be applied to glossy or anti-glare material. This results in the best display windows. Another method is to apply a clear hardcoat to textured material.

Decoratively, gloss black on textured black is an excellent effect for a rich, subtle enhancement.
Buttons or logos can also be made to stand out more by leaving them untextured.

### Designer Elements

- Digital display windows should be left untextured
- Texture will improve diffusion over single point LED windows
- The contrast of dark colors with and without texture can be significant, yet when used with light colors is extremely subtle

## Material Selection

The three usual materials utilized for the graphic overlays are:
- Lexan (Polycarbonate), Mylar (Polyester), and Vinyl (PVC).

Polycarbonate offers superior weathering characteristics and ink adhesion.

Polycarbonate is superior for high temperature applications when the overlay is embossed. When embossed it will withstand 90 degrees C as compared to 60 degrees C for embossed polyester.

Polyester offers optimal flex life and chemical resistance. Therefore, it's the highest recommended material used for graphic overlays.

PVC is cost saving when the overlay is textured all over (i.e. without digital display windows) and offers excellent chemical resistance.

Surface finishes include velvet textured, anti-glare matte, gloss clear, selectively textured and anti-microbial.

## Chemical Resistance Specifications

The following chemical resistance specifications were prepared from the material manufacturers' data sheets. Manufacturers and distributors of the raw materials can be contacted directly if the explicit details are required.
An "A" rating represents no visible effect.

A "B" rating may have a visible effect not detracting from physical performance.
A "C" rating constitutes a harmful effect on the material.

Note that both the polyester and polycarbonate films are hard coated, offering considerable advantages over untreated films.

MINIMUM 1/2 HOUR CONTACT AT 70° F

| Chemical | Polyester (Marnot Melinex®) | Polycarbonate (HP Lexan®) | PVC (Veltex®) |
|---|---|---|---|
| Acetone | A | A | C |
| MEK | A | A | C |
| Tolvene | A | A | B |
| Methylene Chloride | A | A | |
| Isopropyl Alcohol | A | A | A |
| Cyclohexanone | A | A | C |
| Ethyl Acetate | A | A | B |
| Xylene | A | A | C |
| Hexane | A | A | |
| Butyl Cellosolve | A | A | B |
| Gasoline | A | A | A |

Marnot (Hardcoated Melinex®) Poylester - Tekra Corp., New Berlin, Wisconsin
HP Lexan® - GE Plastics, Pittsfield, Massachusetts
Veltex - GE Plastics, Cherry Valley, Massachusetts

MINIMUM 24 HOURS CONTACT AT 120°F

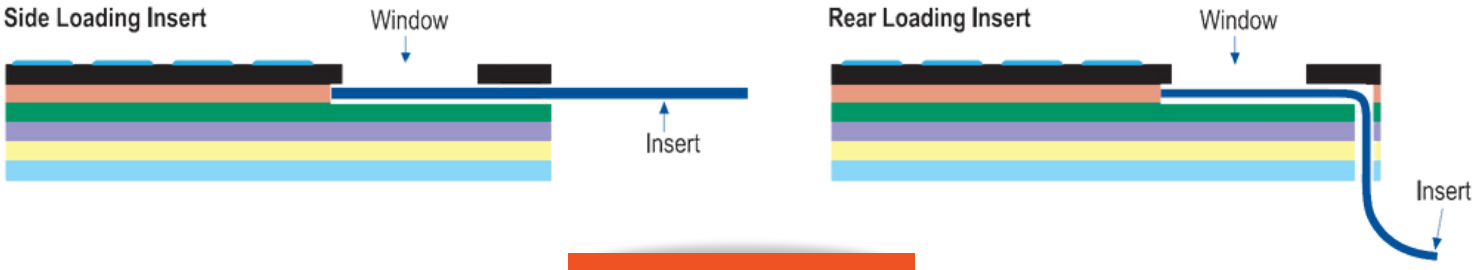
| Chemical | Polyester (Marnot Melinex®) | Polycarbonate (HP Lexan®) | PVC (Veltex®) |
|---|---|---|---|
| Coffee | A | A | A |
| Top Job[1] | A | A | A |
| Fantastik[2] | A | A | A |
| Formula 409[3] | A | A | A |
| Wisk[4] | A | A | A |
| Downy[1] | A | A | A |
| Spray'N Wash[2] | A | A | A |
| Clorox[3] | A | A | A |
| Mustard | B | A | A |
| Mr. Clean[1] | A | A | A |
| Ketchup | A | A | A |
| Tea | A | A | A |
| Tomato Juice | A | A | A |
| Lemon Juice | A | A | A |

1-Registered Trademark of Proctor and Gamble
2-Registered Trademark of Texize, Div. of Norton Norwich Products
3-Registered Trademark of Clorox Company
4-Registered Trademark of Lever Brothers Company

## Interchangeable Legends

Transparent windows can be designed into the graphics for the insertion of the changeable or customized switch legends. This is ideal for varying switch functions, different models using the same membrane switch or for different language versions.

A thinner film, with the desired legends, can be inserted from the backside or from the side of the membrane itself. Specify if a background color is required behind the window as otherwise the circuit will be seen without an insert.




### Designer Elements

- Insert legends cannot be used with pillow embossing
- Design colors of inserts for contrast rather than exact matches

# EQUIPMENT INTERFACE

## Circuit Design

### Configuration

Switches can be connected using:

1. A common line configuration malemon bus, ground, connects a number of different switches. This works well with a smaller number of switches and is generally an easier layout to engineer).
2. A matrix configuration (An X:Y onatri for interconnecting columns and rows is created. This greatly reduces the number of tracks relative to the number of switches that the connector will require).
3. A mixture of the two.

Tracking layout can affect the reliability and ease with which the membrane switch can be manufactured. Therefore, the pin-out (i.e. the order in which the tracks exit the tail) should be left to the switch manufacturer when possible. The optimal pin-out can then be provided by the manufacturer to you as part of the design preparation process.

## Shielding

The graphic overlay materials have a relatively high dielectric strength and high volume resistivity. The chart below shows these values.

A higher degree of electrical shielding, when necessary, can also be incorporated into the construction of a membrane switch. The requirements can vary significantly depending upon the intended industry the product is designed for. Therefore being specific will enable the manufacturer of the membrane switch to take appropriate manufacturing precautions.

Shields can be designed for the following:

1. ESD (Electronic Discharge)
2. EMI (Electromagnetic Interface)
3. RFI (Radio Frequency Interface)

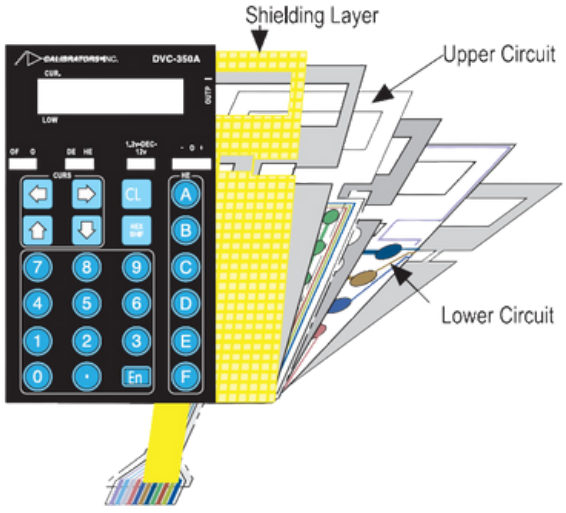
| | Dielectric Strength | Volume Resistivity |
|---|---|---|
| **Polyester** | 125V/mm | $10^9\Omega.cm$ |
| **Polycarbonate** | 67 kV/mm | $10^8\Omega.cm$ |

Conductive inks or a metalized (aluminum clad) polyester can be used to introduce an additional shield to the switch beneath the graphic layer.

The metalized foil/polyester will perform the best at a higher cost. Grounding can be accomplished with a seperate tail or using the same connector as the circuitry. Alternatively, a grounding tab can be created for connecting to a metal backing plate or support panel.

Silver ink printed on the top surface of the upper switch layer (in either a solid or grid pattern), can also create an effective barrier against ESD, EMI and RFI. Grounding can be accomplished as with the laminated polyester.

An effective ESD trace loop can be easily incorporated utilizing the conductive silver ink and terminated at the tail.



# TECHNICAL SPECIFICATIONS

| Membrane Switch Type | Keyboards-Nontactile | Keyboards-Tactile |
|---|---|---|
| **Mechanical** | | |
| Actuation Force | 6 to 12 ounces | 10 to 16 ounces |
| Switch Travel | .007 to .011 inches | .010 to .018 inches |
| Switch Life* | 1,000,000 (min.) cycles | 1,000,000 (min.) cycles |
| **Electrical** | | |
| Insulation Resistance | 10 MEG Ohm (min.) | 10 MEG Ohm (min.) |
| Contact Rating | 30 VDC, 100 mA, 1 watt | 30 VDC, 100 mA, 1 watt |
| Contact Bounce | 15 milliseconds (max.) | 15 milliseconds (max.) |
| Contact Resistance | 100 Ohms (max.) | 100 Ohms (max.) |
| Switch Capacitance | 20 picoforads (max.) | 20 picoforads (max.) |
| **Environmental** | | |
| Storage Temp. | -40° to +80°C | -40° to +80°C |
| Operating Temp. @ 95% Rh | -30° to +65°C | -30° to +65°C |

*Switches with graphics not embossed will have a 5,000,000 (min.) cycle life. Exact specifications may vary depending upon actual construction and circuitry. Please ask to clarify any specific application requirements.

## Connector Tail

The position of the tail should be carefully planned as it could have substantial impact on the design of the membrane switch. A minimum clearance of 10" from tail edges for the tracks and a .040" minimum for each track must be allowed.

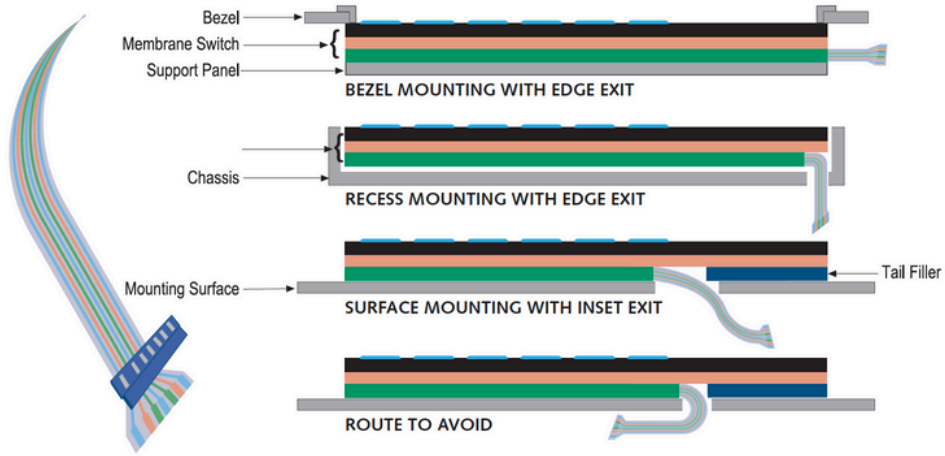
The tail is formed from the circuit layers. Therefore, no feature requiring a circuit track (i.e. switch or integrated LED) can be between the tail exit point and the edge of the panel. The easiest exit location that can be produced is to bring the tail straight out of a panel edge (edge exit). This works if a bezel will cover the panel edge. Also, easily accomplished, is the tail exiting from inside of the panel's perimeter. When the panel fits a recess, this is an excellent tail exiting position.

If the tail must exit from within the perimeter (inset exit) then a tail filler must be used to replace the missing circuit layers. Alternatively a WATER TIGHT NEMA 4 type perimeter seal can be utilized at an additional cost when necessary.

The tail is delicate and a smooth route (no sharp bends - .10" minimum radius) should be used. The longer the tail the more likely the electrical resistance and that the cost of the switch will increase.

A male or female connector can be fitted to the end of the tail. Solder pins can also be provided. A pitch of .10" is the most common. Using a ZIF type connector will reduce the membrane switch cost as the tail will not need its own connector and the pitch can be reduced to 1mm (.039") or 1.5mm (.059"). Female connectors are also available with a .05" pitch.

Exposed silver should be covered with carbon to avoid silver migration and not be adversely affected by moisture.



## Integrated LEDs

Surface mount single point LED's can be integrated into a membrane switch circuit. However they cannot be mounted within the active switch area. Bi-Color LEDs can also be utilized.

A standard membrane switch is not thick enough to accommodate the height of most surface mounted LEDs. For this reason, the overlay is generally embossed in the window area. Alternatively, extra fillers may be added to the switch construction. Silver conductive epoxies are used to mount the LEDs to the circuit. As the epoxies are not very flexible, switches with embedded LEDs should not be bent in the LED areas prior to being installed.

## Backlighting

We offer several backlighting solutions for viewing legends in no light and low light applications. The most common backlighting methods used are fiber optics, electroluminescent panels, and LEDs. Light Guide Films are designed to evenly distribute light from top or side firing LEDs. They provide uniform illumination for a variety of custom applications.

The "User Interface" section on display windows included additional pertinent LED specifications.

## Support Panels

**Chassis Housing & Support Panels**
The design of the support panels or moldings that the membrane will be applied to is integral to the success of the membrane keypad's integration with the equipment and the user.

Protecting the edges of the panel is desirable. If the membrane is rear mounted behind a bezel, using an O ring or adhesive bonding can completely seal the switch from the external environment.

Front mounted membrane panels that fit a recess or have a separate bezel assembly will also have their edges protected from demanding environments.
Ideally, the surface which the membrane switch is being bonded to should be smooth and flat (although formed angles and radii in one axis direction can usually be accommodated). If the surface is painted or powder coated, no silicone should be used. Special adhesives can be used on the back side of the membrane switch for adhesion to LSE (low surface energy) plastics, powder coated and/or textured surfaces. If the membrane is to be applied to a PCB there should not be any solder resist on the bonding surface.

## Cut-outs & Perimeters

Switch cut-outs (unless a bezel covers the opening) should be 0.030" overall larger than chassis openings. Allow at least .062" between cut-outs and active switch or window areas.

Normally, the membrane overlay is made slightly larger than the layers beneath. This will hide any minor mismatches at the edges of the panel. Also, the support panel should be 0.010" smaller all around than the graphic size of the membrane.

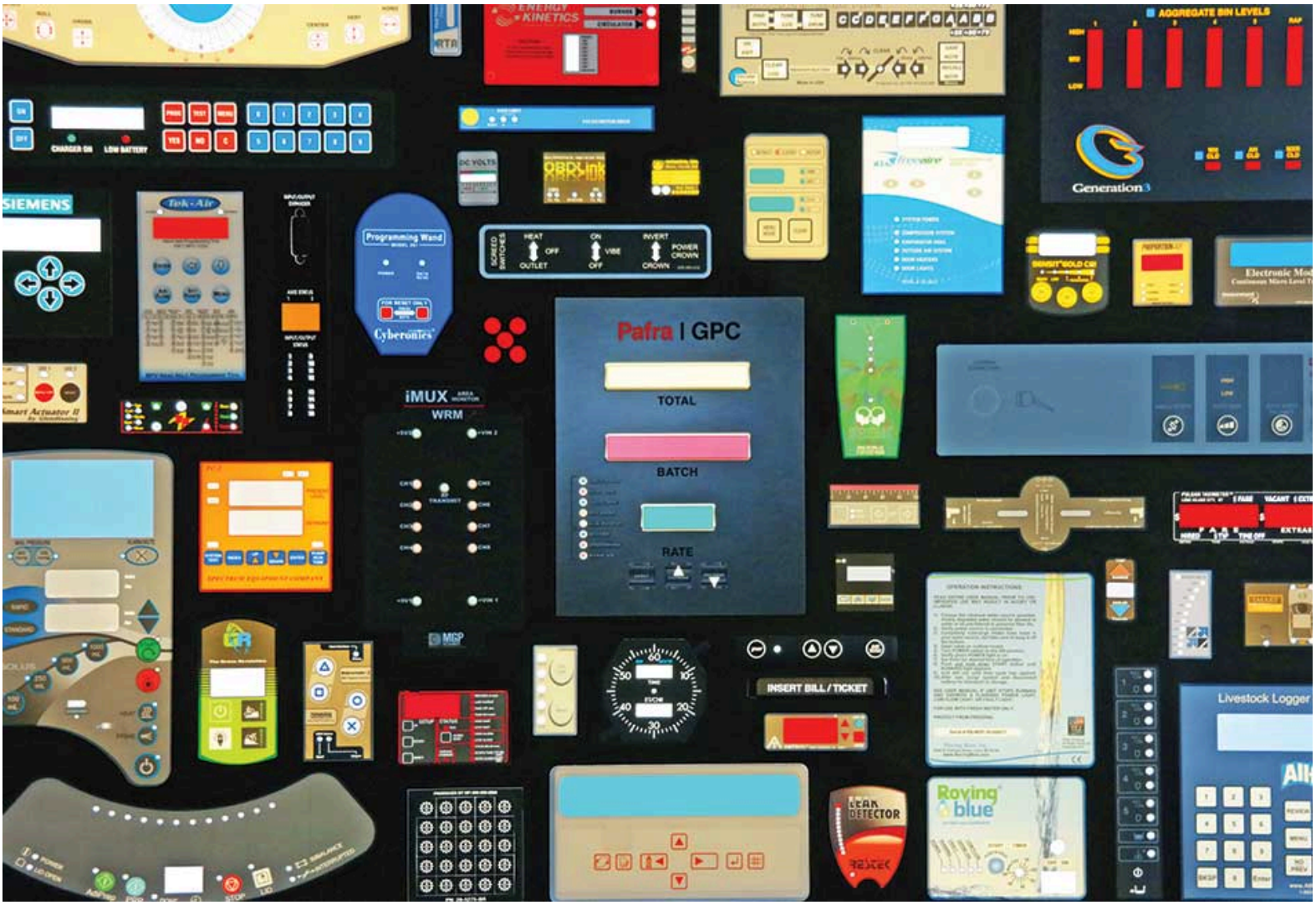
Conversely, recesses should be .010" larger all around to assure a proper fit.

Care should be taken that graphics are not obstructed with any bezels fitting around cut-outs.

## Venting

A pocket of air exists between the contacts of the switch. This air must be displaced when the overlay is depressed. Normally, venting tracks to accomodate this displacement are designed between switches as part of the spacer layer by the switch manufacturer. This will result in a completely sealed switch and is perfect under normal atmospheric conditions.

However, if extended exposure to abnormal levels of atmospheric pressure is expected, external venting into the product itself is recommended. Sometimes additional protection to the circuitry or switch contacts may be necessary.

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