

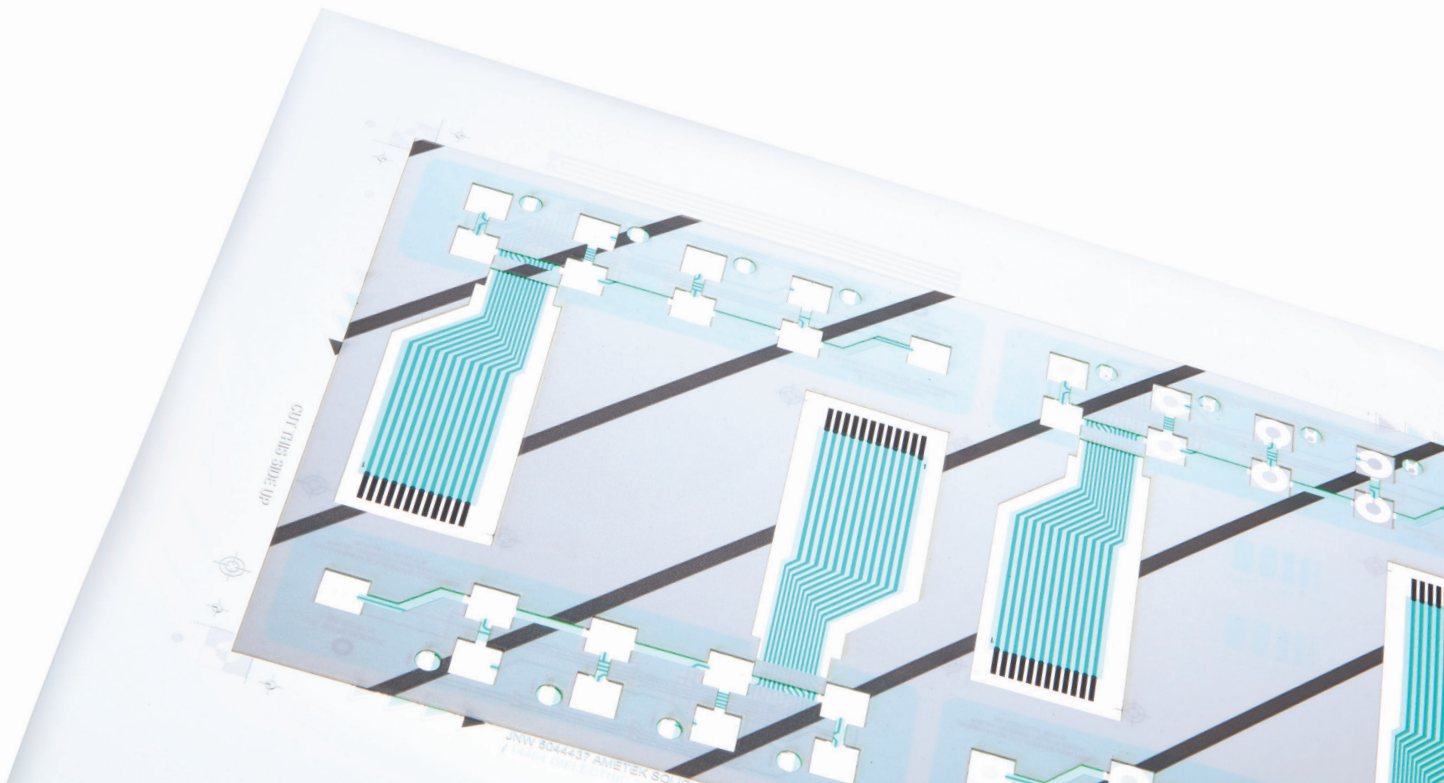
MEMBRANE SWITCH WHITE PAPER



PRIME LABELS | GRAPHIC OVERLAYS
MEMBRANE TECHNOLOGY

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MEMBRANE SWITCH DEFINITION

WHAT IS A MEMBRANE SWITCH?

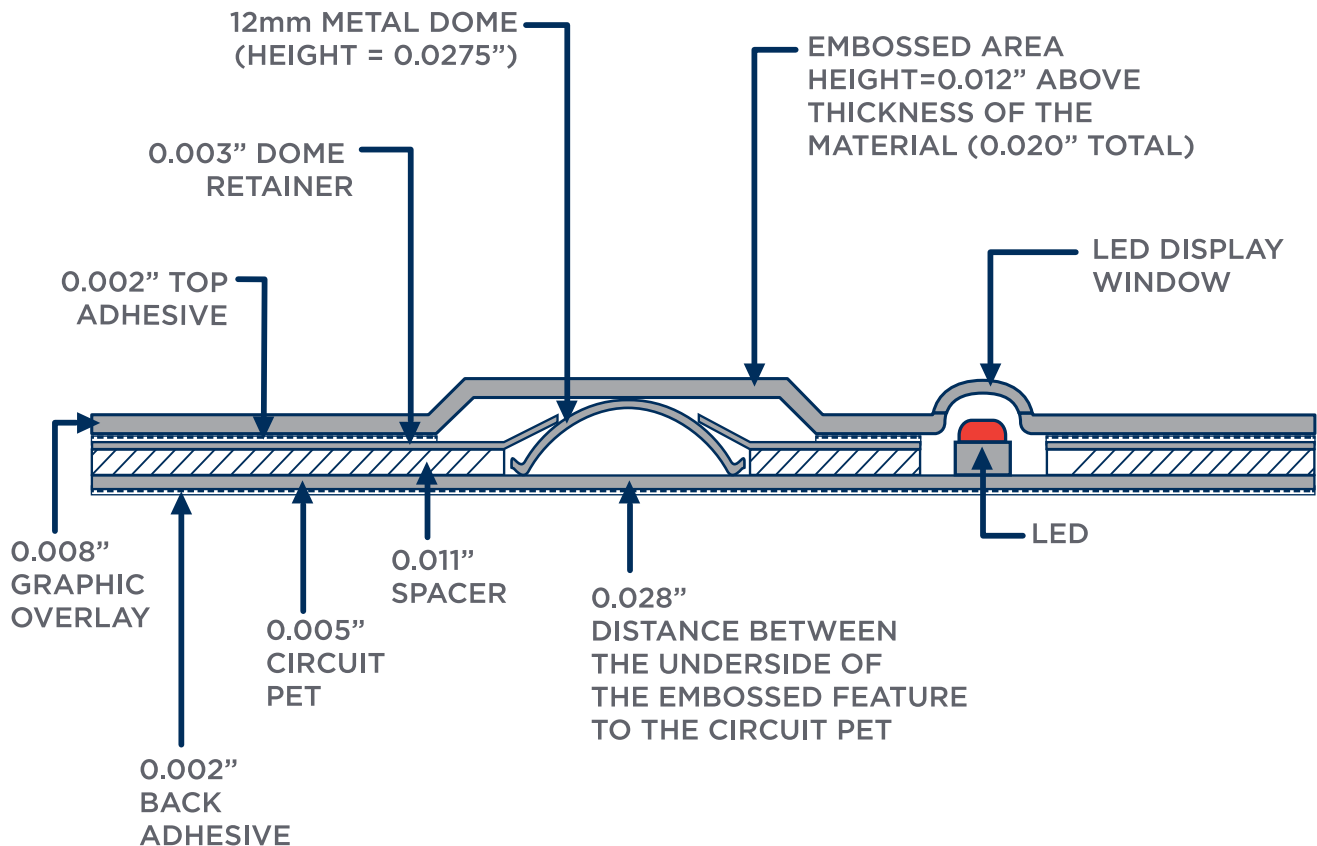
A **membrane switch** is a momentary closure device used to open and close a circuit. It differs from a mechanical switch, which is usually made of copper and plastic parts: a membrane switch is a circuit printed on PET or ITO. The ink used for screen printing is usually silver or graphite filled and therefore conductive. (Wikipedia)

This type of man machine user interface is used across a number of industries including medical,

electronic, military/DoD and aerospace. There are many parameters to consider in the development of membrane switches including the design, overlays, adhesives and use cases.

However, sometimes the best designed and produced membrane switches do not work as intended due to errors in handling and installation in the final product. Common errors can lead to sub-optimal performance or complete failure.

MEMBRANE SWITCH ILLUSTRATION



NOT TO SCALE [RELATIVE ONLY IN PROPORTIONS]

MEMBRANE SWITCH COMPONENTS

GRAPHIC OVERLAYS:

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. It is the first thing your customer sees and has to be aesthetically pleasing. Graphic Overlays can be made of polycarbonate, polyester or acrylic materials in various gloss levels, textures, pencil hardness and gages to meet your needs.

Two of the most important issues to consider with graphic overlays are durability and environmental concerns. It is essential to choose a material that will out live your application requirements; polycarbonate offers more flexibility with regard to design and processing. However, polyester is more durable due to its dimensionally stable properties.

If you have an application for < 50000 actuations, polycarbonate is a good choice; 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.

Chose 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. The colors on the overlay are screen, digital (or a combination of both) on the backside (sub-surface). 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.

ADHESIVE:

There are numerous differences in 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. Adhesives are manufactured for applications to these three surface categories: metals, high surface energy and low surface energy. Work with engineers who can help you select the correct **adhesive for your application**.

EMBOSSING:

Embossing can dramatically enhance the look and functionality of the 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.

MEMBRANE SWITCH COMPONENTS *(continued)*

CIRCUITS:

Membrane switch manufacturers offer screen printed conductive silver ink circuit, etched copper flex circuit and printed circuit boards. The conductive silver ink is printed on .005 polyester, resistance range is <10 ohms to 100 ohms with a rating of 30 volts DC. **Copper flex circuits base material is .001, .002, .003 and .005 polyimide or polyester. Minimum trace width is .004 with a pitch of .004. Copper can be either .5oz, 1.0oz or 2.0oz RA or ED copper. (confirm with Christian or PICA)**

Printed circuit board can be single or multiple layers. The base material is FR4, CEM-1 or CEM-4. Minimum trace width for gold .003 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. (confirm with Christian or pica)**

SURFACE MOUNT DEVICES:

Membrane switches can be designed with embedded LEDs, and resistors using pick and place methods. The SMD is adhered to the circuit layer with conductive epoxy and encapsulated with a UV cured polyurethane. If copper polyimide circuits are being used, the components can be soldered into place.

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 and 2) Screen printed conductive silver ink in a grid or complete coating of the first surface.

The shield can be terminated by three methods:

- 1) **Tab.** The tab can be attached to a stud or standoff on the metal backer or the metal enclosure.
- 2) **Connector.** The shield can be terminated into the pins of the membrane switch tail.
- 3) **Wrap Around.** The shield layer will wrap around the membrane switch and ground to the enclosure.

TACTILE AND NON-TACTILE:

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

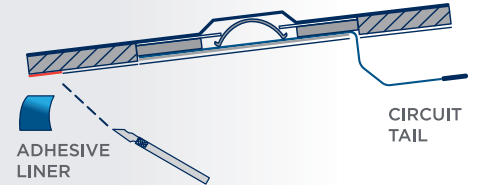
Tactile membrane switches incorporate a metal dome or a polydome to achieve the desired tactile response. Using different sizes of metal domes or polydomes will vary the actuation force. Metal domes come in a large variety of shapes and sizes with actuation forces between 180 to 700 grams; different polydome actuation forces can be achieved by changing the diameter and height of the polydome to meet your requirements.

MEMBRANE SWITCH INSTALLATION PROCEDURES

CROSS SECTION OF APPLICATION PROCESS FOR MEMBRANE SWITCH ASSEMBLIES

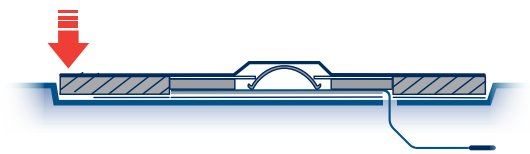
1

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



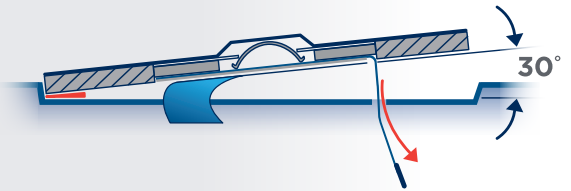
2

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.



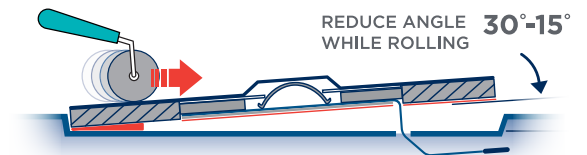
3

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.



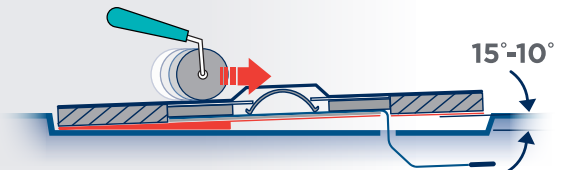
4

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.



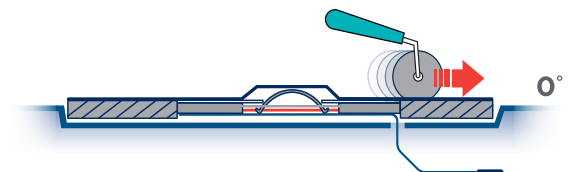
5

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



6

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.



See Next Page For Precautions

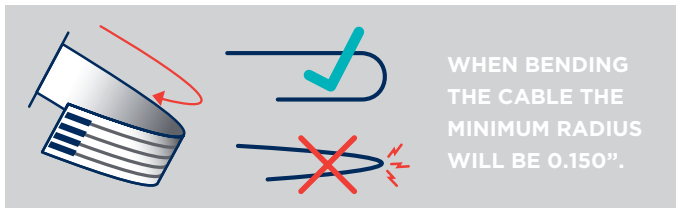
MEMBRANE SWITCH INSTALLATION PRECAUTIONS



Great care must be taken to ensure successful membrane switch installation. Failure to do so, can result in subpar or failed performance. The following list highlights the key items to remember:

1. Once the membrane switch is in place, it should NOT be lifted or repositioned! The domes may invert rendering the part non-functional. **INVERTED DOMES ARE NOT A MANUFACTURER WARRANTY ITEM.**
2. When positioning the flex tail for the final electrical connection, it is very important to not crease the cable. This could change the resistance or, in worse case, the electrical contact will be broken.
3. Only press a dome if the membrane switch is on a flat, hard surface. If pressed without a hard surface below, the dome may invert and, once again, the part may become non-functional. As mentioned in point #1, inverted domes are not a manufacturer warranty item.
4. For optimal performance, laminate the switch with a soft roller using only light pressure. Be careful to keep a minimal angle in front of the roller as to not create air bubbles between the layers.
5. **DO NOT** bend membrane switches prior to installation. Bending the component can result in inverted domes and may damage other electronic components such as LEDs.

NOTE: All the above actions may render the membrane switch non-functional and they will not be covered under a manufacturer warranty.



GLOSSARY

ABRASION RESISTANCE

Ability to resist surface wear.

ACCELERATED AGING

A test methodology that simulates long term environmental effects.

ACTUATION FORCE

Force required to collapse a metal or polyester dome.

ADHESION

The molecular force of attraction between unlike materials. The strength of attraction is determined by the surface energy of the material. The higher the surface energy the greater the molecular attraction, the lower the surface energy the weaker the attractive force.

AMPERE [AMP]

A standard unit of current. Defined as the amount of current that flows when one volt of EMF is applied across one ohm of resistance. An ampere of current is produced by one coulomb of charge passing a point in one second.

AQL

Acceptable quality level.

ASTM

American Society for Testing and Materials.

AUTOTEX

Trademark for Autotype Industrial Films polyester graphic overlay film.

BOND STRENGTH

Amount of adhesion between two surfaces.

BREAKDOWN VOLTAGE

The voltage at which the insulation between two conductors is destroyed.

CAD/CAM

Computer aided design/Computer-aided manufacturing.

CAPACITANCE

The property of conductors and dielectrics which allows the storage of an electrical charge when voltage is applied. ASTM F1663-95

CARBON/GRAPHITE INKS

Specially prepared suspensions of carbon black; these systems are employed for lower cost when the conductivity of a metal base system is not required. Often printed over silver circuitry to reduce the potential for silver migration, also employed for printed resistors.

CERTIFICATE OF COMPLIANCE (C OF C)

A certificate generated by a quality control department confirming that the product being shipped meets the manufacturing document.

CONDUCTIVITY

The ability of a material to allow electrons to flow measured by the current per unit of voltage applied.

CONTACT BOUNCE

Intermittent contact opening and closure that may occur after switch operation. See ASTM F161-95

CSA

Canadian Standards Association.

CURRENT, ALTERNATING (AC)

An electric current that periodically reverses direction of electron flow. The rate at which a full cycle occurs in a given unit of time (usually a second) is called the frequency of the current.

CURRENT, DIRECT (DC)

Electrical current whose electrons flow in one direction only. It may be constant or pulsating as long as it's movement is in the same direction.

GLOSSARY *(continued)*

DEAD FRONT

Cosmetic feature of a graphic overlay allowing for a display feature to be visible only when backlit.

DIE CUTTING

Process for blanking or cutting sheet or roll materials to predetermined shapes for membrane switch components, graphic overlays and labels.

DIELECTRIC

An insulating (nonconducting) medium.

DIGITAL PRINTING

Refers to methods of printing from a digital-based image directly to a variety of media. It usually refers to professional printing where small-run jobs from desktop publishing and other digital sources are printed using large-format and/or high-volume laser or inkjet printers (Wikipedia)

DOME RETAINER

An adhesive layer designed to hold metal domes in place

EL LAMPS

A thin (.010"-.025") illuminating device employed to light large areas, commonly used in LCD, control panel, and membrane switch backlighting. (Electroluminescent)

EMBEDDED LED

The practice of encapsulating a surface mount LED into a membrane switch construction.

EMBOSS

Mechanical and thermoforming of graphic features, providing a raised feature for accenting key surfaces, logo's, and to allow for embedding of surface mount LED's within the switch.

EMBOSS, RAIL

Creates a raised ridge around the perimeter of the key area, usually.

EMBOSS, PILLOW

Creates a raised surface in the graphic overlay over the entire key area.

EMI/RFI/ESD SHIELD

Printed conductor pattern or separate aluminum or copper film employed in membrane switch designs to reduce the effects of electromagnetic and radio frequency interference.

FIBER OPTIC BACKLIGHTING

Illuminating device employed to light large areas. Strands of clear fiber are woven and bundled, after polishing the fiber ends are illuminated by an LED or Halogen lamp.

FLAT FLEX CONNECTOR [FFC]

Connector type commonly used to terminate membrane switch circuitry.

FONT

A set of characters having a unified design.

GLOSS LEVEL

The degree of shininess of a substrate, usual specified in percentages for example 75% gloss, 90% gloss, etc.

HB-94HB

Underwriters Laboratories flame retardant specification (horizontal burn)

HSE

High surface energy.

INSERT LEGEND (INSERT GRAPHICS)

A design feature allowing for changes to nomenclature and symbols by the client or end user. The feature is accomplished by creating a pocket in the membrane switch assembly to allow for an insert card.

GLOSSARY *(continued)*

INTERNALLY VENTED

Switch openings are connected to each other but not to the outside atmosphere. This design approach is used to seal the switch from moisture and contaminants.

ISO (The International Organization for Standardization)

An independent, non-governmental organization. It is the world's largest developer of voluntary international standards and facilitates world trade by providing common standards between nations.

Use of the standards aids in the creation of products and services that are safe, reliable and of good quality. The standards help businesses increase productivity while minimizing errors and waste. By enabling products from different markets to be directly compared, they facilitate companies in entering new markets and assist in the development of global trade on a fair basis. The standards also serve to safeguard consumers and the end-users of products and services, ensuring that certified products conform to the minimum standards set internationally (Wikipedia).

ITO (Indium Tin Oxide)

A thin film conductive material vacuum deposited on the surface of a film substrate. Material is often the base material for resistive touchscreens.

KEY HEIGHT

The measured distance from the bottom (base) of the keypad to the top surface of the key.

KEY TRAVEL

The distance a switch moves to close an electrical contact, expressed in inches or MM.

LED

Light emitting diode.

LEXAN®

General Electric (GE) registered trademark for polycarbonate film.

LSE

Low surface energy.

MEMBRANE SWITCH

A momentary switching device in which at least one contact is on or made of, a flexible substrate.

METAL DOME

Stainless Steel Disc or element. One of several approaches used to produce tactile response.

MOISTURE RESISTANCE

The ability of a material to resist absorbing moisture from the air or when immersed in water.

MP

Modified performance. An adhesive classification of 3M products.

MUNSELL

Color matching system which defines color by three attributes; hue, value, chroma. Fifteen hundred color samples are available as opaque pigmented films.

MYLAR®

Dupont® trademark for polyethylene terephthalate (polyester) film.

NEMA

National Electrical Manufacturers Association.

NON-TACTILE

Membrane switch constructed without snap action.

OHM

The electrical unit of resistance. The value of resistance through which a potential difference of one volt will maintain a current of one ampere.

OVERLAY

Decorative front layer of a membrane switch or control panel.

OVER-TRAVEL

The additional travel of a rubber keypad or metal dome after making contact with the circuit.

GLOSSARY *(continued)*

PANTONE MATCHING SYSTEM (PMS)

Color matching system originally developed for the offset printing industry, commonly used in the membrane switch industry for its broad acceptance, range of colors and ease of use. Over 1000 colors are cataloged.

PCB

Printed circuit board.

PINOUT

The schematic describing the circuit output requirements for a membrane switch or other electronic device.

POLYCARBONATE

Graphic overlay film widely used for control panels

POLYESTER DOME

A spherically formed element in polyester circuit material to provide tactile response in membrane switches. Usually the domes are formed in arrays or sets to match the key configuration of the keypad. Polydomes.

POLYESTER

Bi-axially oriented polyethylene terephthalate film. (PET)

PRESSURE-SENSITIVE

Adhesive materials which bond with the application of pressure alone and do not require activation by heat or solvents.

RESISTANCE

In DC circuits, the opposition a material offers to current flow, measured in Ohms. RFI Radio Frequency Interference.

SCREEN PRINTING

Printing process using a mesh stretched over a frame allowing ink to selectively pass through by using a stencil. The process most commonly used for producing graphic overlays and membrane switch circuits.

SECOND SURFACE PRINTED

Inks are applied to the non-exposed side of the film to allow for the film to protect the inks from scratching or damage.

SELECTIVE TEXTURING

The creation of surface effects on matte or gloss films normally applied using the screen printing process.

SILICONE RUBBER

Rubber made from silicone elastomers and noted for its retention of flexibility, resilience and tensile strength over a wide temperature range.

SILVER INKS

Specially prepared suspensions of finely milled silver particles in a variety of resin systems are used widely to produce conductive patterns on flexible substrates.

SPACER

An adhesive layer of a membrane switch used to separate circuit layers and to provide key openings allowing for conductors to contact each other when depressed.

SPECTRODENSITOMETER

A densitometer that makes use of spectral data, providing densitometric readings at discrete spectral intervals (Federal Agencies Digital Guidelines Initiative)

STATIC SHIELD

Printed conductor pattern or separate aluminum or copper film employed in membrane switch designs to reduce the effects of static discharges.

STEEL RULE DIE

Consists of a .750-.875 thick die-board (plywood construction) with .937" high knives inserted into laser cut grooves.

GLOSSARY *(continued)*

TACTILE SWITCH

A switch or switch assembly providing a positive snap-action response. The response can be achieved through the use of stainless steel domes embedded in the membrane switch, or polyester domes formed in either the circuit or graphic overlay layers.

THIXOTROPY

The property of a coating or ink, which has a low viscosity when agitated, but thickens when agitation ceases.

VISIBLE LIGHT TRANSMISSION (%)

The ratio of the amount of total visible solar energy (370-780 nanometers) that is allowed to pass through a filter, to the amount of total solar energy falling on that filter.

WATT

A unit of electrical power. One Watt is equivalent to the power represented by one ampere of current with a pressure of one volt in a DC circuit.



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