TEKRA

Tek Tip

MEMBRANE SWITCH ACTUATION LIFE - PET VS PC

Polyester (PET) and polycarbonate (PC) are the most commonly used films in membrane touch switch (MTS) constructions. This is because they posses the properties - toughness, durability, processability and esthetics - required for this demanding application. The choice of films depends on several factors: switch part or component, electronic requirements, end use environment and of course the appearance and performance requirements of the application. The three major parts of a switch where films are used are the circuit layer(s), spacer and graphic overlay.

PART 1: CIRCUIT LAYER

This is the most critical part of any MTS. It has the conductive traces or circuit that carries the electric signal to and from the switch. A failure in this layer can render the device it is attached to inoperable and useless. The circuit is usually applied to the film by screen printing with conductive inks. These inks are typically solvent blends of organic (non-conductive) binders and conductive particles - usually silver or graphite. The ink usually requires high temperature (~300ºF) curing to attain the desired level of conductivity. In order for a film to function in this component it must be able to:

- Withstand the high temperatures involved in processing without excessive shrinkage and/or thermal decomposition.
- Resist cracking during multiple flexing, which can result in a break in the conductive path.
- Resist deformation during continual use that could result in a collapsed switch - one that will not open.
- Withstand the chemicals encountered in the end use environment that could lead to film cracking or conductive ink delamination.

CIRCUIT LAYER: **PET or PC?**

The overwhelming choice for the circuit layer is **PET**. It can withstand the high processing temperatures and can be heat stabilized to reduce shrinkage. PET is noted for its flex fatigue resistance and its high tensile strength, which contribute to its resistance to cracking and deformation. Its chemical resistance is well known and a wide variety of conductive inks have been proven on both print treated and non-print treated PET.

PC is not a good choice for a variety of reasons:

- It can soften and deform under ink curing conditions.
- The flex fatigue resistance of PC is not as good as PET.
- PC film may crack when exposed to the stress and chemicals encountered in a MTS environment.

PART 2: SPACER LAYER

This part of the switch is used to hold the top and bottom circuits in register and provide a separation that keeps the switch contacts apart until the switch is depressed. It usually consists of a film with a pressure sensitive adhesive on both sides. No special properties are required except that:

- the film can be die cut
- it bonds well to the adhesive
- it moves along with the circuit film in response to changes in temperature and humidity

SPACER LAYER: **PET or PC?**

Theoretically, almost anything can be used as a spacer film as long as its thermal and hygroscopic expansion is the same as the circuit film. In most cases this means that the spacer

film must of the same chemical composition as the circuit film. If the circuit film is PET than the spacer film should be **PET**. Films that do not have the same thermal and hygroscopic expansion coefficients will not move the same as the circuit film and will cause the adhesive to be displaced and interfere with the operation of the switch.

PART 3: GRAPHIC OVERLAY

This is the part of the switch that is exposed to the external environment - the part that is seen, touched, cleaned, etc. It is typically printed on the back side (2nd surface) and serves many purposes:

- shows location and function of switch keys
- is decorated to compliment the design of the device to which it is attached
- protects other switch layers and internal electronics from contamination from the external environment, i.e. liquid spills, grease, dirt, cleaning chemicals, etc.
- provides protection to the devices electronics from external static discharges
- can provide tactile feedback if embossed or selectively textured
- can provide windows for attached indicator lights or alpha-numeric displays

In order to function as above the film used for an overlay must:

- withstand the flexing that occurs during switch actuation for the designed life of the device
- resist scratching and abrasion during use and cleaning
- provide enough dielectric strength to resist electrostatic discharge (ESD)
- be resistant to the chemicals encountered in the end use environment
- must provide the appearance and processing characteristics required by the design of the switch

Failures in any of the above may detract from the appearance and functionality of the device but will usually not cause catastrophic device failure.

GRAPHIC OVERLAY: **PET or PC?**

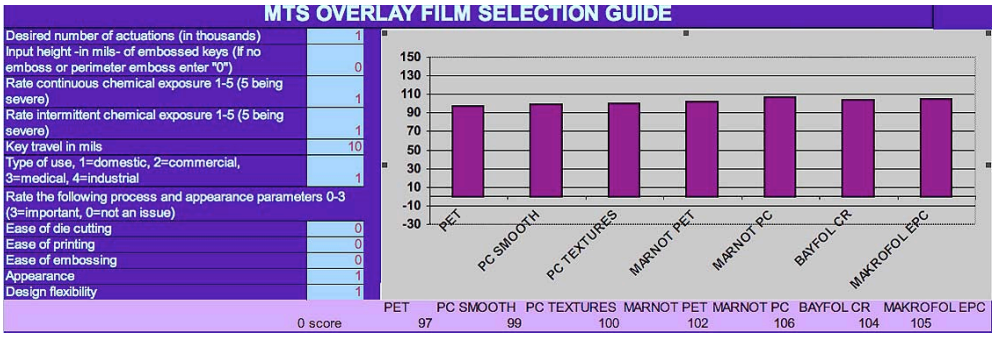
The choice of film for the overlay will depend on which of the above properties are most important in the design and function of the device. The requirements of a heart monitoring device in a hospital will be different from those of a dishwasher, which will be different from those of an inexpensive, hand held, electronic game. Each type of film has advantages that will make it an obvious top choice for certain applications. Conversely, each film will have disadvantages that will exclude it from other applications. The following is a summery of how the two films compare in performance

- **Flex life, actuation life, switch life** - used to describe how many switch actuations can be performed before an overlay will fail due to cracking or deformation that will result in some loss of appearance or functionality. Switch life is affected by many factors: film thickness, switch travel, spacer hole diameter, spacer thickness, shape of actuator, temperature, flat vs. embossed, embossed shape and height, type of inks and/or coatings used, chemicals in end use environment, etc. In almost all cases PET will out-perform PC by far as it will usually out-perform the design requirements of the device. Over 100,000,000 actuations are easily attainable for a non-embossed overlay made with PET. An overlay made of PC can also reach these high actuation levels but only under perfect conditions. Unlike PET, variations in actuation pressures and chemical exposures from inks and the environment can dramatically reduce the actuation life of PC to 5-10,000,000. Embossing the overlay will reduce the actuation life of both films. Depending on the embossed configuration and switch travel PET could drop to 10,000,000 and PC to less than 100,000 actuations.
- **Abrasion resistance**. PET is slightly harder to scratch than PC but it is still not able to survive normal use without some sort of protection usually in the form of a hard coat (Marnot). The availability of PC in textures such as suede and velvet give the film an apparent abrasion resistance that does not require a hard coat.
- **Dielectric strength**. The dielectric strength of PET is slightly greater than PC - 21Kv vs. 18Kv at a film thickness of 10 mils. However, the availability of PC in heavier gauges allows greater ESD protection - 26Kv at 20 mils.
- **Chemical Resistance**. The ability of PET to resist the effects of chemical exposure is vastly superior to PC. Hard coated (Marnot) PC will resist intermittent, 1st surface exposures but will only slow down the effects of long term exposure that can attack the unprotected edges or permeate the coating. Some inks that are applied to the 2nd surface of PC can also contribute to chemical stress cracking. The Bayfol CR film and Makrofol EPC were designed

to address this shortfall and will dramatically improve the chemical resistance of PC but not quite to the level of PET.

- **Appearance and processing**. This is the area where PC out-shines PET. The availability of PC in a wider range of gauges and textures makes it more attractive to designers. The Makrofol EPC is the only overlay film that can successfully be used outdoors. PC is also considered by many to process easier. It is clearer in heavier gauges, which makes color matching easier. It does not need to be stabilized to resist shrinking under graphic ink curing conditions (<250º F). PC die cuts easier without edge splitting. It embosses easier without the need for high temperatures to set the shape. It is easier to get inks to adhere better to PC than PET. This ease of processing can sometimes equate to lower overlay costs with PC.

As you can see, choosing a film for a graphic overlay can be somewhat complicated. It's obvious that long term, high reliability suggests PET and a low usage application where appearance is most important points to PC. All the parameters of appearance, processing and reliability in the application must be weighed in order to make the right decision.



Here is a chart that allows you to gauge the effects of varying parameters on the suitability of several types of films. Simply enter the values as indicated and you can see how these films compare to one another. A significantly higher score indicates that that particular film may be a better choice. ***This by no means is meant to replace testing of the finished switch in away that simulates the end use environment.***

Directions for chart:

- Enter values only in blue area
- Number of actuations expected during design life of the device - be realistic - the start button on a dishwasher that is used every day for 15 years needs only to survive a little over 5,000 actuations. Enter thousands, for 5000 enter "5".
- Is the overlay going to be embossed for tactile feel or to accommodate a snap dome? If so, how high? 0.015" = 15 mils. If not embossed, enter "0".
- Continuous chemical exposure: Is the end use environment a chemical factory (5) or a TV remote for home use (1)?
- Intermittent chemical exposure: Is there a possibility that strong solvents will be spilled or wiped on the switch (5) or are we expecting only mild, household cleaners (1)?
- How far does the film need to be flexed to activate the switch? 0.010" = 10 mils.
- What is the end use environment - a crane operator in a foundry (4) or a copy machine in an office (2)?
- Is processing more important than reliability? For example: if getting the ink to adhere to PET is a problem, score 3 for "Ease of printing". If not score "0".
- If eye appeal is more important than an occasional broken overlay, score higher in "Appearance".
- If the availability of a pre-textured film in a variety of gauges is more important than an occasional broken overlay, score higher in "design flexibility"