Indispensable – sealing compounds for sealing electrical and mechanical components

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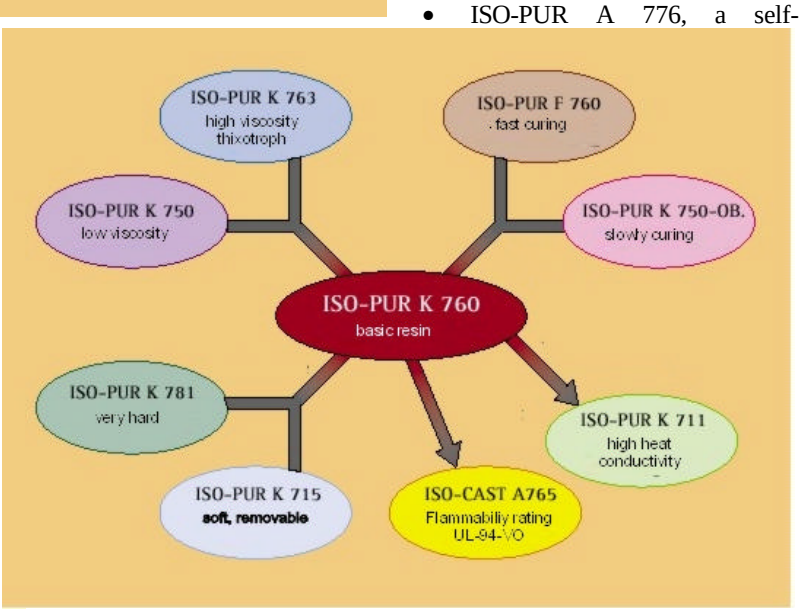
Sealing compounds are more and more used to protect electrical components against mechanical or chemical disturbance, manipulation and for personal protection. They are registered at the Physikalisch-Technische Bundesanstalt for use in explosive areas, by UL for fire retardance, and certified by VDE for high voltage applications.

Sealing compounds are more and more used to protect electrical components against negative outside disturbances. This way improvements are achieved with respect to:

- electrical insulation
- protection against mechanical disturbance like impact, push and vibrations,
- thermal resistance
- corrosion
- durability and
- elimination of wiring imitation by competitors

There is no ideal, all purpose sealing compound as requirements may differ a lot depending on the application of the sealing compound. Small transformers for example are sealed with relatively hard resins, whereas for sensors or SMD components, soft sealing compounds are generally used.

ISO-Elektra at Elze produces a big range of different electrical sealing compounds for various applications (see graphic 1).. A standard compound is the cold curing two-component resin Iso-Pur K 760 with the following properties: medium viscosity, setting time of 10 min., shore D 60 with a standard mixture ratio resin : hardener of 4:1, temperature resistance of - 40° C up to 140°C , approved by the Physikalisch-Technischen Bundesanstalt (PTB) for protective applications in explosive atmosphere, certified by VDE for high voltage applications, low sensibility against humidity while processing, suitable for handling by hand or by filling machine, standard colours beige and black, many other colours available on demand.



Graphic 1 : System of standard products of ISO-ELEKTRA

By changing the formulation, the product can be modified for various applications:

- soft elastic “W”, suitable for sealing of SMD components
- fast curing “F” for sealing by pouring devices with dispenser mixing heads
- slow curing “OB” with a setting time of at least 45 min.
- ISO-PUR K 781 is specially hard (highly mechanical resistant, but not brittle).
- ISO-PUR K 750 with a low viscosity.

New types of cast resins are

- ISO-Cast A 765 and A 765 B (flexible), fulfill flammability rating UL 94 VO.
- ISO-PUR K 711 with high heat conductivity
- ISO-PUR A 776, a self-repairing gel, highly flexible to heat and coldness,
- ISO-Epoxy resin HP 89/7, a transparent two-component-system with very good adhesion to metal.

Certain applications may require the use of one-compound-systems.

ISO RC-4000, a lacquer for circuit boards, is suitable for coating components by dipping, painting or pouring (see graphic 3), but is also available as a spray. It hardens by evaporation of a solvent.

Higher chemically resistant is IsoCure IPDI 6.2 , a one- component-polyurethane, crosslinking chemically by humidity, and liquid blocked isocyanates which are activated by heating up the one-compound system to 80° C. The product is a crosslinked coating, which is tough but elastic and has a good chemical resistance. This

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product line is available under the name ISOCure-T and thus completes the product range of coating and pouring systems in a convenient way.

On many customer demands, ISO-Elektra has developed a self-repairing. polyurethane jelly ISO-PUR A 776. The standard type of this cold-curing two-component system is colourless, can be coloured into black on demand and hardens to a softener-free gel with a permanent temperature resistance of approx. –50° C to 150°C. No mechanical stress occurs to the sealed components. Due to its hydrophobic character, the gel does not absorb any humidity, thus giving excellent permanent electrical properties. Main applications are sealing sensors, circuit-boards and plugs (see graphics 4 and 5). Resin and hardener do not need to be marked for health risc and can be easily applied by hand or by filling machine.

Choosing the suitable sealing compound

Manufacturers offer a great variety of sealing compounds, so it is not easy for users to select the best product for their individual requirements. To find the right sealing compound in a reasonable time, users and suppliers should clarify the following requirements:

- temperature and voltage range the component will be used in
- transparent or coloured sealing compound?
- type of sealed electrical component (volume and shape) to enable supplier to choose the right viscosity
- desired mechanical stability and hardness
- desired reaction time (sealing by hand or automatically)
- must the sealing compound be removable (for repairing)?
- chemical environment

There is no ideal, all purpose sealing compound, however, good communication between supplier and user enables the producer to choose a suitable one (see graphic 6). The product should satisfy the following requirements:

- easy to handle
- constant pretermined quality
- light or no toxicity
- product and package should be produced according to newest ecological knowledge.

To a certain degree a multi- purpose sealing compound is two-component-polyurethane, since it is possible so select in a wide range:

- shore hardness (jelly till hard)
- reaction time (from a few seconds to approx. one hour)
- viscosity of mixture (like water till paste)

Polyurethanes with a shore D value of approximately 50 are often combining the desired properties hard and at the same time tough. That means that the sealing compound is hard after reaction but not brittle. The housing is then only necessary to hold the liquid sealing compound until reaction is completed. Afterwards the component is mechanically stable on its own.

Concerning handling, polyurethanes are not harmless, but following a few easy regulations they are as easy to handle as household chemicals.

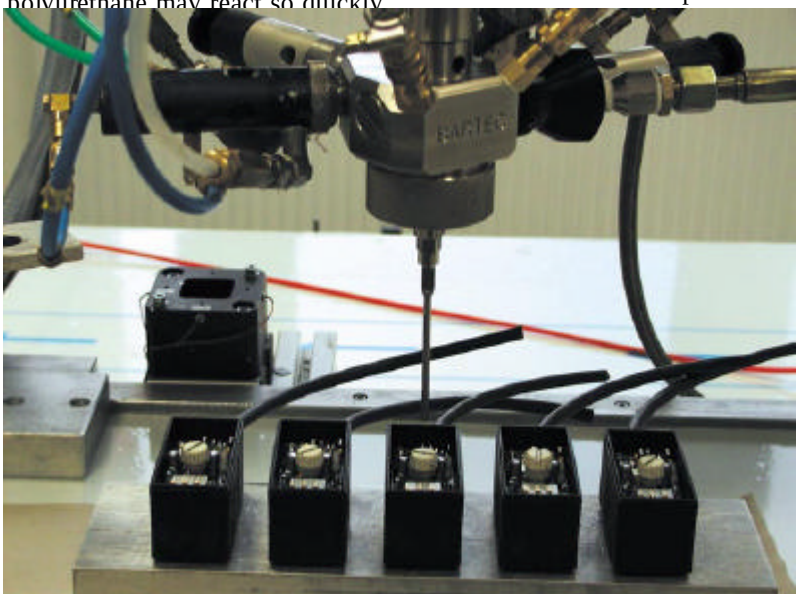
An additional advantage of polyurethane is their low reaction temperature. Due to this low temperature, big components (approx. 20 ltrs. volume) can be sealed at one step. On the other hand polyurethane may react so quickly that components with volumes from less than 1 ccm up to several liters will harden in a few seconds. The shortest possible reaction time will be the time the liquid sealing compound needs to leave the applying tool.

There are two advantages of epoxy resin compared to polyurethane: First, epoxy resin is easier to produce in a transparent manner. Second, epoxy resin is not hydroscopic and humidity-precautions during storage don't have to be taken.

Polyurethanes have to be mixed with additives (mostly porous-zeolith-minerals). That prevents undesired formation of bubbles due to reaction of diisocyanate with water. On the other hand this formation of bubbles is used to produce polyurethane foam without adding hazardous ingredients like CKW, FCKW etc.

Silicones are highly temperature resistant. Temperature has nearly no influence upon mechanical stability of silicones compared to SBR synthetic rubber (styrol-butadien-rubber). A big disadvantage of silicone is that shore D values of more than 10 can't be produced.

Since many silicones are polyaddition products, there are no by-products formed during reaction and it is there-fore possible to



Graphic 2 : Sealing by means of a dynamic mixing head of ISO-PUR F 760

Graphic 3 : Coating with circuit board lacquer ISO-RC 4000 by means of a one-component dispenser.

cast thick layers of sealing at one time. One-component-silicone does form by-products during reaction and is therefore used for thin layer applications only (e.g.: sealing cracks, dip-applications). Acetic acid can be captured during formation by adding chalk to the monomeric system. The chalk and acetic acid will be chemically transformed to stable calciumacetate and water, but there is still a smell of vinegar while the silicone is hardening. There are products on a non acetate basis available and then the problem of that unpleasant smell doesn't occur.

Polyester is (according to table no. 1) a two-component-system. Precisely, one of the two components is only an initiator of the chain reaction. During polymerization an initiator is a compound that starts the reaction but is consumed during process as a difference to a so-called catalyst.

The selection of unsaturated polyesters offered is huge. To vary viscosity, prepolymers (with low molecular weight and low viscosity) are used in combination with styrene to dilute the main component. Styrene is a cheap and effective substance to dilute reactives. Unfortunately styrene has a high vapor pressure and forms when inhaled styrenepoxyd which is definitely known to induce cancer disease.

Since polymeric reaction of polyesters is violent, a great amount of energy will be set free as heat. Therefore the use of unsaturated polyesters or acrylic resins is limited to small or flat parts with good capability to transmit heat., e.g. dental fillings from acrylic resins curing by UV-light, components of sporting aircrafts from unsaturated polyesters, reinforced by fibre optics. Similar to peroxide which will develop radicals when heated, it is possible to induce radicals by using light rays. The radicals will then be the starter of chain reaction (e.g. glues and varnishes curing by UV-rays).

Good mechanical and electrical properties – and highly flexible

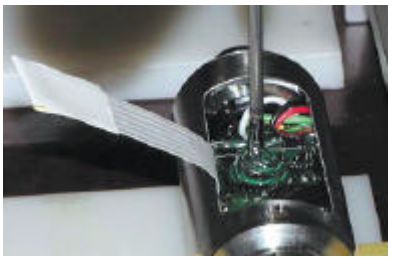
Among the polyesters, two-component systems on a polybutadien-basis have a special position: The A-component of these systems is a polybutadien-oligomer with hydroxyl end groups, the B-component forms by reaction of polybutadien and maleic acid anhydride (remark: oligomers are polymers with a low degree of polymerization and can be considered as a link between monomers and polymers).

By mixing the two liquid components, the hydroxyl groups react with the anhydride groups by forming ester combinations. The result is a synthetic rubber which however is not formed by using typical vulcanization accelerators like sulphur, zinc oxide and heat, but by reaction of functional groups which were previously added to the liquid polybutadiens.

The cured sealing compounds have a good frost flexibility. ISO-Fill BRW for example is a transparent soft resin which is applied for telecommunication and must be removable by crumbling or cutting.

However, solid castings with a shore-D-value of more than 10 can't be produced from this resin. Its permanent temperature resistance of approx. 100° C , too, does not fulfill many requirements, as they may arise for example in the automotive industry. A solution to this problem is ISO-PUR A 776, a cold-curing mixture of polyurethane and silicone with a permanent heat resistance of up to 150°C, but also with a high flexibility at –50° C.

ISO-PUR A 776 is an example



Graphic 4 : Sealing of a sensor with high-temperature gel ISO-PUR A 776.

Graphic 5 : Mobile mixing head with static mixing tube.

Material	Components	Properties	Applications
Two-component systems, chemically crosslinking			
Polyurethans	Polyoles, isocyanates	Hard-/soft elastic, highly variable, also available as foam	Sealing of components till 50 ltr. volume
Epoxy resins	Diglycidyle ether, amine hardener	Mostly hard, also transparent, high curing temperature, insensitive to humidity	Sealing of components till 0.5 ltr. volume, coatings
Silicons	Polydialkylsiloxanes with vinyl-, allyl or hydroxyl groups	Soft, high temperature resistance	Membranes, plugs, implants
Polyesters	Condensation products from polyvalent alcohols, dicarbon acids or acid anhydrides and reactive diluents, mostly styrene	Hard, partly brittle, often combined with glass fibre tissue	Boat hulls, wings of small airplanes, tanks, electric motor parts
One-component systems, chemically curing			
Polyurethan foam	Prepolymer with NCO-groups	Low compressive strength	Foam for door frames, sealing of cavities
Silicones	Acetoxydialkylsiloxanes	Soft, moderate adhesion	Crack sealing, sanitary glue
Acryl resin	Acryl- or methacrylprepolymer /vinylester), solvents	Highly reactive	Glues, industrial lacquer, dental material (UV-curing)

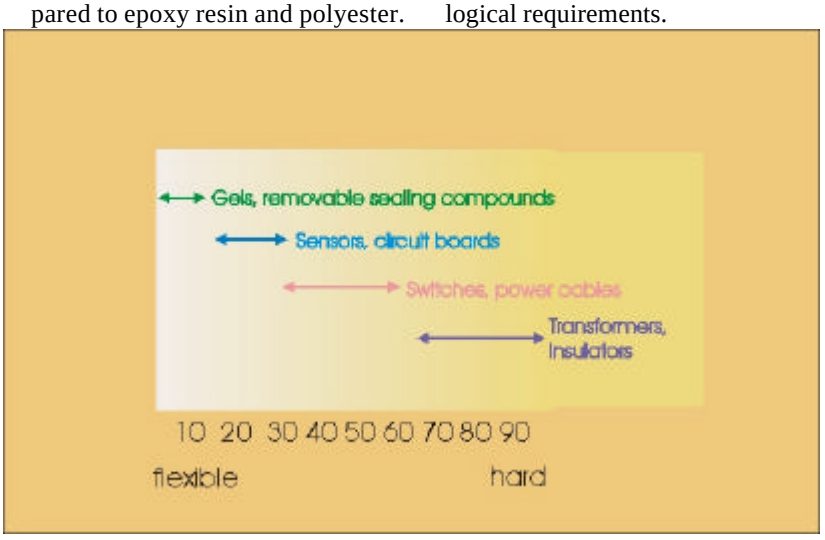
Table 1 : Description of different basic types of sealing compounds

of two-component mixtures combining the positive properties of different material groups. It has constant mechanical properties within a wide temperature range and excellent electrical properties. A typical field of application is the sealing of sensors with a low compressive strength.

A variety of applications and materials

Sealing compounds are produced for a large variety of applications. The range of materials available comprises numerous systems. Good communication between producer and user is important in order to find the right system for a certain application in moderate time. The ideal all purpose sealing compound does not exist since demands may be opposite. However, polyurethane is, taking all aspects into comparison, in a certain way outstanding. To mention is the big range of hardness, curing time, viscosity etc., their positive properties regarding ecological and toxicological aspects due to low vapour pressure and low allergic potential compared to epoxy resin and polyester.

The good durability of electrical parts, the comparatively small amount of energy used to produce polyurethanes, especially combined with mineral fillers and reusable packing will satisfy ecological requirements.



Graphic 6 : Shore D scale